Petroleum Exploration Plays and Resource Estimates, 1989, Onshore United States— Region 1, Alaska; Region 2, Pacific Coast

RICHARD B. POWERS, *Editor*

U.S. GEOLOGICAL SURVEY BULLETIN 2034–A

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1993

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
Robert M. Hirsch, Acting Director

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Library of Congress Cataloging-in-Publication Data

Petroleum exploration plays and resource estimates, 1989, onshore United States / Richard B. Powers, editor.
p. cm. — (U.S. Geological Survey bulletin ; 2034)
Includes bibliographical references.
Contents: ch. A. Region 1, Alaska ; Region 2, Pacific Coast
1. Petroleum—Geology—Alaska. 2. Petroleum—Geology—Pacific Coast (U.S.) 3. Petroleum reserves—Alaska. 4. Petroleum reserves—Pacific Coast (U.S.). I. Powers, Richard Blake. II. Series.
QE75.B9 TN870.5
557.3 s—dc20 92-28878
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Richard B. Powers, *Editor*

INTRODUCTION

By Richard B. Powers

This study provides brief discussions of the petroleum geology, play descriptions, and resource estimates of 220 individually assessed exploration plays in all 80 onshore geologic provinces within nine assessment regions of the continental United States in 1989; these 80 onshore provinces were assessed in connection with the determination of the Nation's estimated undiscovered resources of oil and gas. The present report covers the 25 provinces that make up Region 1, Alaska, and Region 2, Pacific Coast. It is our intention to issue Region 3, Colorado Plateau and Basin and Range, and Region 4, Rocky Mountains and Northern Great Plains, in book form as well. Regions 5 through 9 (West Texas and Eastern New Mexico, Gulf Coast, Midcontinent, Eastern Interior and Atlantic Coast) will be released individually, as Open-File Reports.

The report is an outgrowth of, and is based on, studies that led to the publication of "Estimates of undiscovered conventional oil and gas resources in the United States—A part of the Nation's energy endowment" (Mast and others, 1989). That report, a cooperative effort by the USGS (U.S. Geological Survey) and MMS (Minerals Management Service), presented estimates of undiscovered conventionally recoverable oil and gas for both the onshore and offshore geologic provinces of the Nation. The data sources, assumptions, and methodologies used in the development of these estimates are summarized in Mast and others (1989) and described in more detail in a joint USGS-MMS Working Paper, U.S. Geological Survey Open-File Report 88-373 (1988). The plays discussed in this present report are those that are located exclusively within the onshore United States and adjoining State offshore areas, as assessed by the USGS. All estimates of undiscovered oil and gas resources are as of January 1, 1987; additional data received after that date were not incorporated into the assessment.

In the 1989 National appraisal of undiscovered oil and gas resources, plays were the basic unit for quantitative estimates; this report presents not only the play estimates, but also the framework and petroleum geology for each of these basic units. Play discussions here summarize the open-file reports which were prepared by the geologists assigned to each assessment area. We are presenting the resource estimates and narrative descriptions at this basic play level because of the great interest shown by the public, State Geological Surveys, the oil and gas industry, and workers involved in oil and gas appraisal.

Sources of information for province studies included published and purchased data, data from USGS studies in progress, data from previous resource assessments, data from State Geological Surveys, and analysis of geological, geochemical, and geophysical data from various sources utilized in developing and defining plays. Computerized drilling and well completion data from oil and gas exploratory and development wells came from PI WHCS (Petroleum Information Corporation's Well History Control System). In addition, data on oil and gas fields were obtained from the "Significant oil and gas fields of the United States" file of NRG Associates, Inc., of 1986, and from the PI PDS (Petroleum Data System) computerized file of 1986. Additional statistical information on field production and reserves was obtained from yearly publications of various State oil and gas commissions, or their equivalents.

Uncertainties are inherent in estimating undiscovered quantities of oil and gas. Play estimates presented here are judgmental and are based upon a variety of geologic data, records of exploration successes and failures, production histories, assumptions of economic and technical conditions, and appraisal methods. Methodologies were developed to aid in making decisions under conditions of

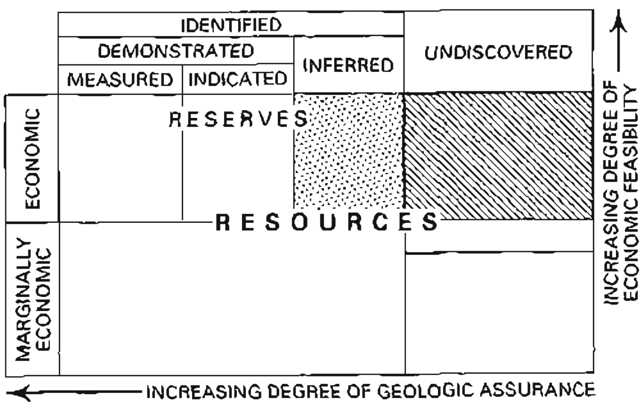

Figure 1. Diagrammatic representation of petroleum resource classification (from Mast and others, 1989) representing conventional oil and gas resources. Area within heavy frame on upper right represents the undiscovered recoverable resources estimated in this study.

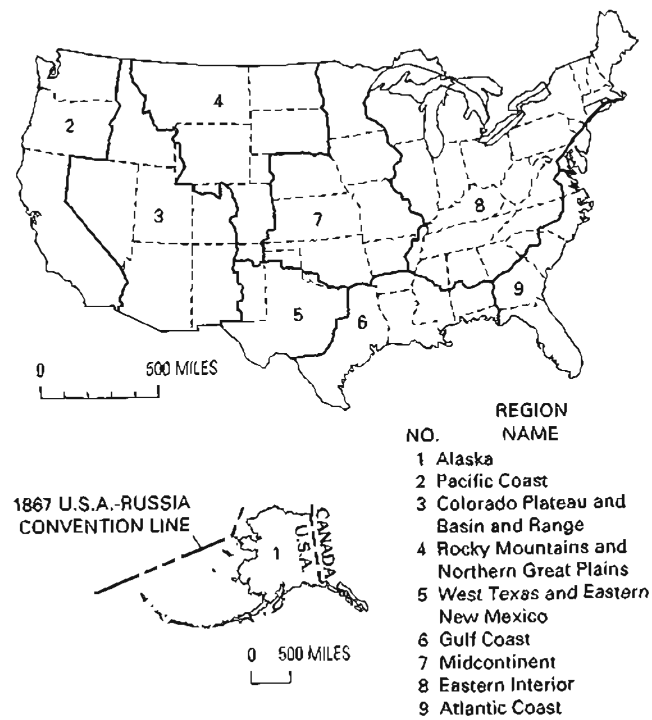

Figure 2. Index map showing petroleum regions assessed in this study. Heavy lines are region boundaries; short-dashed lines are State boundaries.

uncertainty, and the results are presented as ranges of values with associated probabilities of occurrence. The estimates should be viewed as indicators, not absolutes, of the petroleum potential of the plays. The plays range from those in mature, established producing basins, to highly speculative, frontier-type plays in provinces that have experienced scant exploration or wildcat drilling.

COMMODITIES ASSESSED

Commodities assessed in this study are crude oil, natural gas, and natural gas liquids that exist in conventional reservoirs. Terms defined here are standard usage of the oil and natural gas industry and of resource estimation.

Undiscovered recoverable resources.—Resources in undiscovered accumulations analogous to those in existing fields which are producible with current recovery technology and efficiency, but without reference to economic viability. These accumulations are considered to be of sufficient size and quality to be amenable to conventional recovery technology. These resources occupy the area of the heavily framed box in figure 1.

Conventional resources.—Resources included in this category are crude oil, natural gas, and natural gas liquids that exist in reservoirs or in a fluid state amenable to extraction techniques employed in traditional development practices. They occur as discrete accumulations. They do not include oil occurring within extremely viscous and intractable heavy oil deposits, tar deposits, or oil shales, or gas from low-permeability "tight" sandstone and fractured shale reservoirs having *in situ* permeabilities to gas of less than 0.1 millidarcy, coal bed methane, gas in geopressured shales and brines, or gas hydrates.

AREAS OF STUDY

The primary organization of this report is by region (fig. 2); the nine regions described correspond to those in Mast and others (1989). Discussion of each region begins with description of its geologic framework, modified from Mast and others (1989). Discussion of provinces in the region follows; the format for each province includes an introduction covering the geologic setting, exploration history, age of sediments, and a generalized stratigraphic chart. (No stratigraphic chart is provided for a province where no individual plays were assessed; a map of the province is substituted, because no specific stratigraphy is given in that province.) Following each province introduction is systematic discussion of its individual plays. The play format includes the play name, narrative discussion, and two illustrations, (1) a province map with the area of the particular play emphasized, and (2) a tabular form showing the original input data for the play appraisal.

Areas of State but not Federal waters are included in the assessment of adjacent onshore regions and provinces.

The boundaries of State waters are 3 nautical miles offshore for the Pacific and Atlantic coasts and for the Alabama coast of the Gulf of Mexico. Louisiana and Mississippi have decreed State water boundaries that vary slightly from 3 nautical miles. For the Texas and Florida coasts of the Gulf of Mexico, the boundaries of State waters are 3 marine leagues (10.36 statute miles) offshore. In addition, all maritime boundaries and limits depicted on maps in the report are for initial planning purposes only, and do not prejudice or affect United States jurisdiction in any way.

Regions are basically geographic in character; however, their outlines reflect an attempt to group individual provinces along broad geologic lines. Provinces are constructed around natural geologic entities and may include a single dominant structural element, or a number of contiguous elements; they are named for structural or geographic features within their boundaries. These boundaries, following State and county lines wherever possible, facilitate the use of production, reserve, and other reported data. A play is named after the most dominant feature or characteristic of a structural, stratigraphic, or geographic nature that best identifies it. Its name can also apply to a concept. Many plays described herein are recognized from their titles by the petroleum industry, but play titles are in no way formal geologic or stratigraphic names.

PLAY DISCUSSION FORMAT

Individual plays described and assessed in this report include only those that were estimated to have undiscovered accumulations greater than 1 MMBO (million barrels of oil) or 6 BCFG (billion cubic feet of gas). Plays judged to have undiscovered accumulations that fell below that threshold were assessed separately for the provinces as a whole, and are not described in the report. A play is defined as a group of geologically related known or undiscovered accumulations and (or) prospects having similar characteristics of hydrocarbon source, reservoir, trap, and geologic history.

In order to achieve some degree of consistency in narrative discussions of a great number and variety of plays, a topical outline based on the definition of an exploration play has been used. Each play discussion notes the play characteristics, followed by descriptions of (1) reservoirs, (2) source rocks and related geochemistry, (3) timing of generation and migration of hydrocarbons, (4) traps (types, sizes, seals, and drilling depths), (5) exploration status (history, discovered volumes, field sizes, and hydrocarbon types), and (6) qualitative future hydrocarbon potential and factors limiting that potential. Although the discussions adhere to the order of the topical outline, it will be apparent that some inconsistency occurs in the amount of detail and coverage of each topic from one play to another. This is due to the relative abundance or lack of data pertinent to each play and is unavoidable in a report of this scope.

Play discussions here are, of necessity, brief summaries. More detailed play information can be found in the province open-file reports, which are listed in the references at the close of each region. The number of individually assessed plays in each province ranges from 1 to as many as 13; however, most provinces contain 3–5 plays. Each play title is followed by a sequence number (for example, Topset Play (020)), and these also appear on the table of resource estimates at the close of each region. Table 1 (Region 1) is on page A68; table 2 (Region 2) is on page A137.

ASSESSMENT PROCEDURES AND METHODS

Assessments of undiscovered recoverable oil and gas in the individual plays in each province, and resources in small (<1 MMBO or <6 BCFG) accumulations were based upon review and analysis of the petroleum geology and exploration history of each province that incorporated the most recent geologic and geophysical information available as of January 1, 1987. In the National assessment, 220 plays covering the onshore and State offshore areas were identified, and for each individually assessed play, undiscovered oil and gas resources were estimated. Plays judged to contain more than 1 MMBO or 6 BCFG were individually assessed; plays judged to contain less than those amounts were treated differently, as described following. See Mast and others (1989) and USGS-MMS (1988) for a detailed discussion of this assessment, its assumptions, methods, and results.

In the play analysis method, geologic settings of oil and gas occurrence are modeled. The play is treated as a collection of accumulations (pools, fields) of similar geologic risk sharing common geologic characteristics that include reservoir and source rocks and known or suspected trapping conditions. A team of geoscientists made judgments as to the probability of the occurrence of those geologic factors necessary for the formation of hydrocarbon accumulations, and quantitatively assessed each factor as a geologic attribute of the play; the team then estimated the numbers and sizes of accumulations as probability distributions, conditional on favorable play attributes. All of this information was entered on the play data input form, which is included in each play discussion in this report. A computer program then performed the resource calculations on the basis of the assessment information in the input form, employing an analytical method based on probability theory. Final, undiscovered oil and gas estimates for each play, based on this method, are shown on a table of estimates at the end of the discussion for each region.

Probabilistic estimates of recoverable oil and gas in accumulations smaller than the established size cut-off (1 MMBO, 6 BCFG) were made separately. These estimates of small accumulations were based primarily on log-geometric extrapolations of numbers of fields into field-size classes smaller than the cut-offs. Estimates of undiscovered resources for these small fields were made for the province as a whole, rather than for the individual plays. These are shown in the tables of estimates as: Oil <1 MMB and Gas <6BCF. In addition, minor plays and very mature, or nearly depleted plays not assessed individually are included in the tables of estimates as: Other Occurrences >1 MMBO and Other Occurrences >6 BCFG. Ratios of associated-dissolved gas to oil, and NGL (natural gas liquids) to gas, were estimated from historical production data and used for calculation of these components.

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GLOSSARY

Play. A group of geologically related known or undiscovered accumulations and (or) prospects having similar characteristics of hydrocarbon source, reservoir, trap and geologic history.

Field. A single pool or multiple pools of hydrocarbons grouped on, or related to, a single structural or stratigraphic feature.

Prospect. A geologic feature having the potential for trapping and accumulating hydrocarbons.

Crude oil. A mixture of hydrocarbons present in underground reservoir rocks in a liquid state that remains in a liquid state as it is produced from wells.

Associated gas. Free natural gas, occurring as a gas cap, in contact with and above an oil accumulation within a reservoir.

Dissolved gas. Natural gas dissolved in crude oil within a reservoir.

Nonassociated gas (NA). Natural gas that is neither associated with nor in contact with crude oil within a reservoir.

Natural gas liquids (NGL). Those portions of reservoir gas that are liquified at the surface in lease separators, field facilities, or gas processing plants. NGL is reported only in the tables of estimates in this report.

MMBO. Millions (10^6) of barrels of oil (standard stock tank barrels of crude oil, 42 gallons per barrel).

BBO. Billions (10^9) of barrels of oil.

BOPD. Barrels of oil per day.

BCFG. Billions (10^9) of cubic feet of gas (standard cubic feet of gas at 14.73 pounds per in.^{2} and 60 °F). Hydrocarbon gases only.

TCFG. Trillions (10^{12}) of cubic feet of gas.

MMBOE. Millions of barrels of oil equivalent (conversion factor utilized is 6,000 ft^3 of gas=1 BOE).

REGION 1, ALASKA

GEOLOGIC FRAMEWORK

By Richard B. Powers

Region 1 is subdivided into 14 provinces (numbers 058–071) (fig. 3), which contain a total of 19 individually assessed plays; however, 1 play was common to 4 provinces, the Tertiary Basins play, and was treated collectively. In this particular case, the play was included and described in the Alaska Interior Province (062) discussion.

The geology of Region 1 is varied and complex. Much of the region is composed of a mosaic of crustal terranes that have accreted to the ancestral North American cratonic margin. Associated with this mosaic are sedimentary basins, some of which have been strongly deformed and contain altered rocks of little petroleum potential. However, many younger, less deformed basins contain significant potential. The most significant in terms of petroleum are the composite basins, such as the North Slope basin, which encompasses the northern part of the Brooks Range, the Foothills, and the Arctic Coastal Plain, including parts of State offshore waters. Large quantities of oil and gas are present in Triassic reservoirs at Prudhoe Bay field (the largest oil field in North America), Mississippian reservoirs at the Lisburne and Endicott fields, and Cretaceous reservoirs at Kuparuk River field. Significant additional potential is estimated in Paleozoic, Mesozoic, and Tertiary reservoirs in this basin, including the folded and faulted rocks of the northern Brooks Range.

Basins containing nonmarine Cenozoic rocks constitute the most numerous of the Alaskan basins but are poorly known because of extensive alluvial cover. In general, they occupy the interior parts of Alaska. The Cook Inlet basin (067), the best known example, contains large accumulations of oil and gas onshore and in State waters. These basins are characterized by nonmarine fill and are often associated with major faulting. Reservoirs are primarily sandstone units. Most of these basins are considered to be gas prone, and undiscovered resources are estimated to be small.

Basins containing Cenozoic marine rocks are most commonly found on the Bering Shelf and Pacific margins of Alaska. They include the Bristol (064) and Gulf of Alaska (069) basins. Basins of the Pacific margin generally lie in a forearc setting and have accumulated thick sequences of Tertiary marine sediments, and include transported terranes. Significant hydrocarbon accumulations have not yet been discovered in these areas, and the potential appears limited by poor reservoir and source-rock characteristics.

The considerable petroleum potential of onshore Alaska is localized in the North Slope area, concentrated mainly in the Arctic Coastal Plain (058), but also in the Foothills provinces (059, 060). Development of future discoveries on the North Slope and elsewhere in onshore Alaska will be dependent on their proximity to the existing pipeline system.

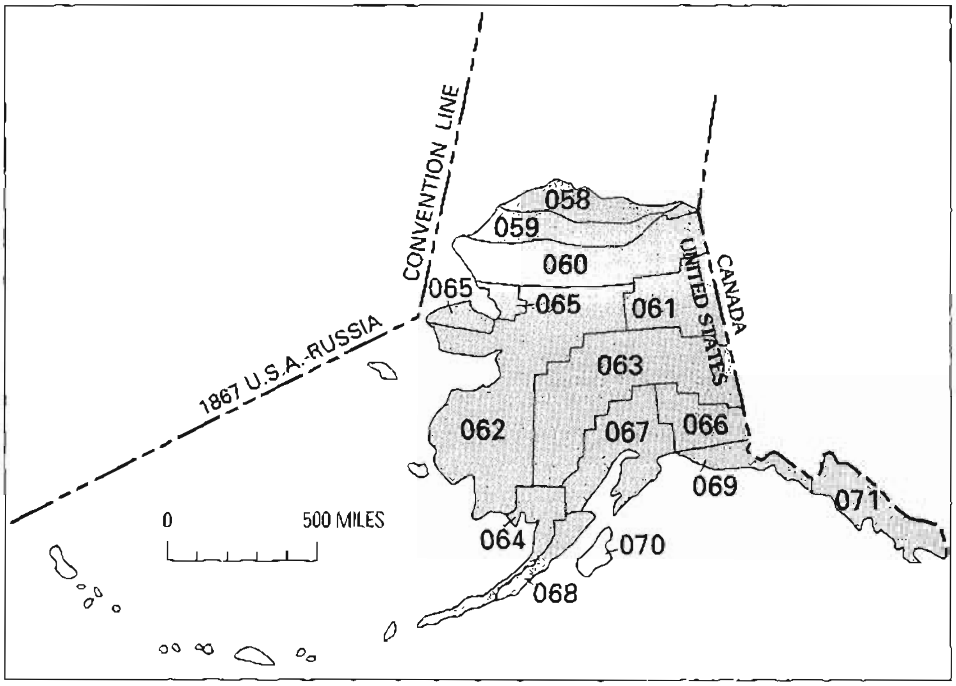

Figure 3. Index map of Region 1, Alaska, showing provinces assessed (shaded). Names of provinces are listed by number in the table of estimates (p. A68).

ARCTIC COASTAL PLAIN PROVINCE (058)

By Kenneth J. Bird

INTRODUCTION

The Arctic Coastal Plain province is the northernmost of the three provinces that make up the Alaskan North Slope. This province extends 500 mi from the Chukchi Sea on the west to near the Canadian border on the east. Its maximum width is about 100 mi. Offshore, the State 3-mile limit forms the seaward boundary of the province. The total area of the province is about 26,000 mi^2. The North Slope is a Cretaceous and Tertiary foreland basin developed on a Mississippian to Early Cretaceous passive margin (fig. 4). Most of the Arctic Coastal Plain province occupies the undeformed foreland region; in its easternmost part, the Arctic National Wildlife Refuge (ANWR), it includes part of the Brooks Range fold-and-thrust belt. The Arctic Coastal Plain province was the site of the earliest North Slope exploration in large part because of the presence of oil seeps. The first well was drilled near Point Barrow in the National Petroleum Reserve by the U.S. Navy in 1944. Since then more than 200 exploratory wells have been drilled by industry and government on the coastal plain and adjacent State waters. Twenty-four oil and gas accumulations have been found in the province, five of which are commercial. Among these are the Prudhoe Bay and Kuparuk River fields, the two largest producing fields in the United States. The Prudhoe Bay field is the largest in North America with in-place volumes of 23 BBO and 27 TCFG. The province contains more than 95 percent of all discovered North Slope oil and accounts for all current North Slope production; further, it accounts for about 25 percent of total U.S. oil production, about 2 MMBO per day. As of January 1, 1987, cumulative gross oil production was slightly more than 5 billion barrels out of a total ultimate recovery of about 12 billion barrels.

A total of eight plays were defined and individually assessed. These include Topset, Western Turbidite, Eastern Turbidite, Barrow Arch, Ellesmerian Clastics, Lisburne, Lisburne Unconformity, and Endicott. The plays are described in approximate geographic order from north to south and stratigraphically from youngest to oldest. In addition, oil and gas resources were apportioned to the Coastal Plain province on a percentage basis from certain plays in provinces 059 and 060 that cross province boundaries and extend into the Coastal Plain province.

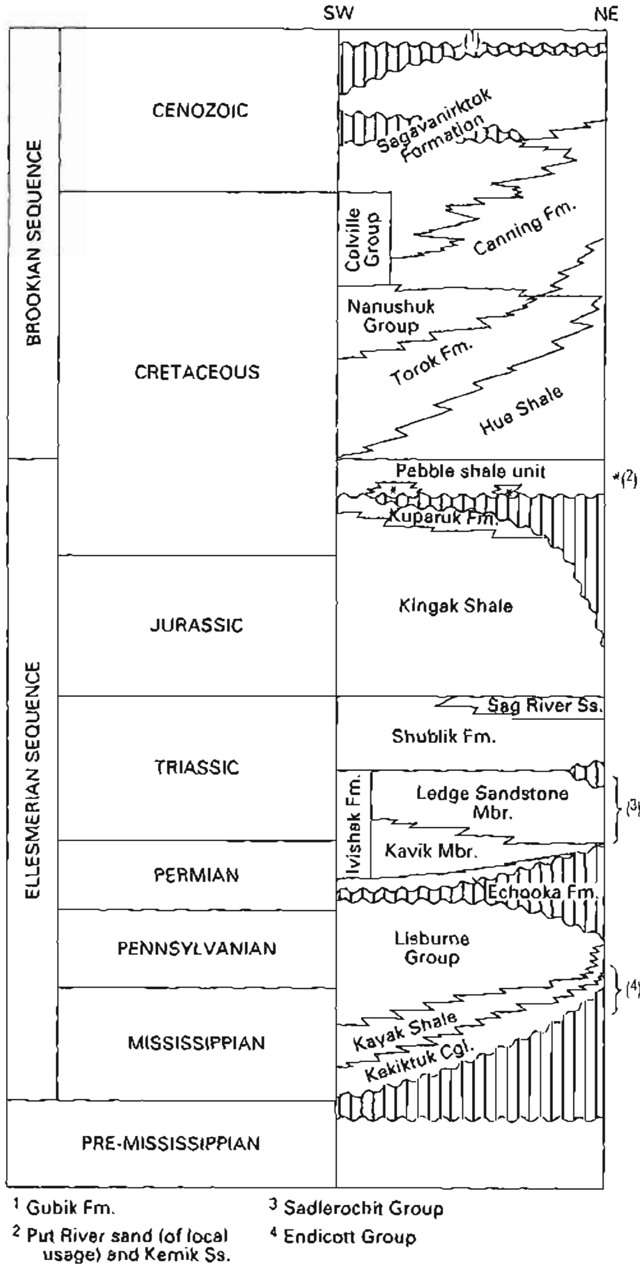

Figure 4. Generalized stratigraphic column for the Arctic Coastal Plain province (058), Alaska. Vertical line pattern, hiatus.

TOPSET PLAY (020)

The Topset play consists of stratigraphic traps in sandstone reservoirs of Cretaceous and Tertiary age and includes those rocks represented on seismic records in the topset position of a clinoform sequence. These rocks, the Nanushuk Group and Sagavanirktok Formation, consist of marine and nonmarine deltaic sandstone, siltstone, shale, conglomerate, and coal (fig. 4). These are the youngest petroleum prospective rocks in the province. Their total thickness, about 10,000 ft, is also the maximum drilling depth in the play area. The play is limited to the area of relatively flat lying strata within the coastal plain.

Reservoir rocks consist of sandstone and conglomerate and may comprise as much as half of the total thickness of the play interval, even though individual beds seldom exceed 50 ft. Fair to good reservoir continuity is expected parallel to depositional strike (northwesterly), but marked changes may occur over short distances perpendicular to strike. The expectation is that porosity increases eastward, from 10 to 20 percent in the western part of the play to >20 percent in the eastern part.

Potential source rocks are interbedded deltaic shales and mudstones which are immature and probably gas prone. Beneath the play interval are marine foreset and bottomset shales and the informally designated pebble shale unit; these rocks are fair to good oil source rocks and are thermally immature to marginally mature in the play area. Oil shows are reported in several wells just west of the ANWR (Arctic National Wildlife Refuge) from the lower part of the Sagavanirktok Formation. The multi-billion barrel West Sak and Ugnu heavy oil and tar accumulations (Nos. 1 and 2, fig. 5) just west of the Prudhoe Bay field are within this play as are the smaller oil accumulations, Fish Creek and Simpson (Nos. 3 and 4, fig. 5), located in the northeastern part of the NPRA (National Petroleum Reserve in Alaska).

Postulated traps are mostly stratigraphic and are related to facies changes, cut-and-fill structures, or traps formed against small-displacement normal faults. Faults and interbedded shales are expected to provide only fair to poor seals. Because of the poor sealing characteristics, hydrocarbon accumulations are expected to consist of oil rather than gas. Although thousands of wells (exploratory and development) have penetrated the rocks of the play, relatively few have been drilled for prospects. Future potential is excellent for oil and fair to good for gas.

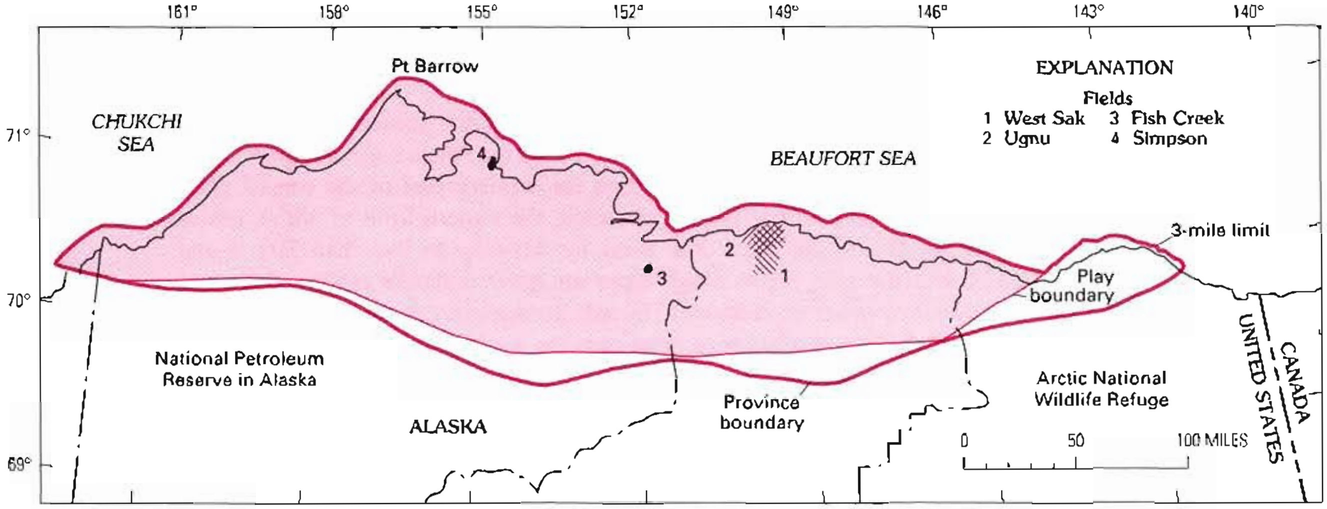

Figure 5. Map of Topset play (058–020). Fields numbered and labeled.

OIL AND GAS PLAY DATA

PLAY TOPSET
PROVINCE ARCTIC COASTAL PLAIN — CODE 01-058-020

Play attributes

	Probability of attribute being favorable or present
Hydrocarbon source (S)	1.00
Timing (T)	1.00
Migration (M)	1.00
Potential reservoir-rock facies (R)	1.00
Marginal play probability (MP) (S x T x M x R = MP)	1.00

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1×10^6 BBL; gas, 6×10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	1.00

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

	Probability of occurrence
Reservoir lithology	
Sandstone	X
Carbonate rocks	
Other	
Hydrocarbon type	
Oil	0.9
Gas	0.1

Fractiles * (estimated amounts)

Fractile percentages *	100	95	75	50	25	5	0
Accumulation size							
Oil ($\times 10^6$ BBL)	1	2.5	10	25	75	400	4000
Gas ($\times 10^9$ CFG)	6	15	50	125	300	1000	6000
Reservoir depth ($\times 10^3$ ft)							
Oil	0.1			6			10
Gas (non-associated)	0.1			6			10
Number of accumulations	5	8	12	15	20	28	40

Average ratio of associated-dissolved gas to oil (GOR)	10	CFG/BBL
Average ratio of NGL to non-associated gas	0	BBL/10^6 CFG
Average ratio of NGL to associated-dissolved gas	0	BBL/10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated.

WESTERN TURBIDITE PLAY (030)

This play consists of stratigraphically trapped deep-marine sandstone reservoirs of Cretaceous age, and includes those rocks represented by the foreset and bottomset seismic reflectors in the clinoform sequence beneath the western part of the coastal plain (fig. 6). The play is limited to the Torok Formation, the eastern limit of which lies at about long 150°30′ W., where the Torok thins by downlap to less than 300 ft and grades laterally into the Hue Shale. Rock types are predominantly marine shale and siltstone with minor amounts of sandstone. Maximum thickness in the play interval is about 6,000 ft, and drilling depths range from near the surface in the Barrow area to a maximum depth of about 10,000 ft.

Reservoir rocks may occur anywhere within the Torok, but they are most frequently encountered in the lower half as toe-of-slope or basin-plain turbidites. Individual sandstone bodies are expected to be thin, and laterally discontinuous; aggregate reservoir thickness may be on the order of 100 ft or more. Porosity in Torok sandstones is expected to be in the 5–15 percent range.

Source rocks include the marine shale of the Torok, which is expected to be relatively gas prone, and the underlying Hue Shale, pebble shale unit, Kingak Shale, and Shublik Formation, all of which are relatively more oil prone shales. All of these shales are marginally mature to mature. Oil and gas indications have been found in numerous wells; however, no accumulations are known in the play.

Postulated traps are stratigraphic and are related to facies changes or traps formed against small-displacement normal faults. Faults and the surrounding thick marine shales are expected to provide fair to good seals. Several dozen exploratory wells have been drilled; most wells were drilled for targets beneath the play interval—a reflection of the difficulty in mapping prospects within the play. Future oil potential is fair and the potential for gas is very good.

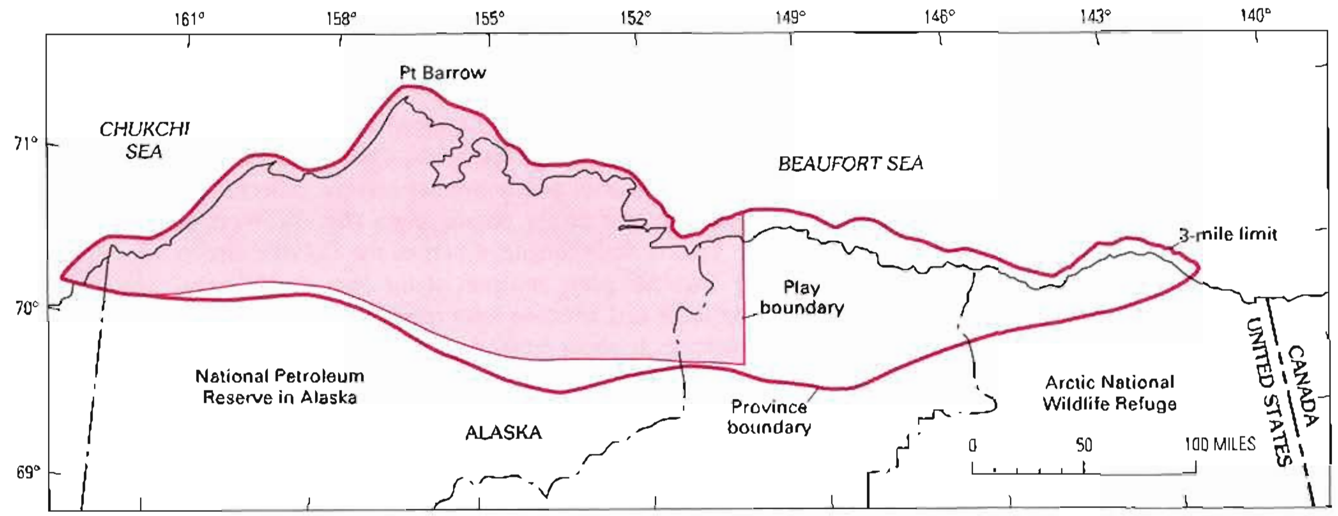

Figure 6. Map of Western Turbidite play (058–030).

OIL AND GAS PLAY DATA

PLAY WESTERN TURBIDITE
PROVINCE ARCTIC COASTAL PLAIN CODE 01-058-030

Play attributes

	Probability of attribute being favorable or present
Hydrocarbon source (S)	1.00
Timing (T)	1.00
Migration (M)	1.00
Potential reservoir-rock facies (R)	1.00
Marginal play probability (MP) (S x T x M x R = MP)	1.00

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1×10^6 BBL; gas, 6×10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	1.00

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

	Probability of occurrence
Reservoir lithology	
Sandstone	
Carbonate rocks	
Other	
Hydrocarbon type	
Oil	0.2
Gas	0.8

	Fractiles * (estimated amounts)						
Fractile percentages *	100	95	75	50	25	5	0
Accumulation size							
Oil (x 10^6 BBL)	1	1.1	3	6	14	48	150
Gas (x 10^9 CFG)	6	7	13	25	55	180	1000
Reservoir depth (x10^3 ft)							
Oil	1			7.5			15
Gas (non-associated)	1			7.5			15
Number of accumulations	5	10	20	30	40	50	60

Average ratio of associated-dissolved gas to oil (GOR)	1500	CFG/BBL
Average ratio of NGL to non-associated gas	20	BBL /10^6 CFG
Average ratio of NGL to associated-dissolved gas	0	BBL /10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated.

EASTERN TURBIDITE PLAY (040)

The Eastern Turbidite play consists of stratigraphically trapped deep-marine sandstone reservoirs of Late Cretaceous and Tertiary age, primarily the Canning Formation, and includes those rocks represented by the foreset and bottomset seismic reflectors in the clinoform sequence beneath the eastern part of the coastal plain (fig. 7). West of long 150°30′ W., the play includes a marine shale tongue, a part of the Colville Group which overlies rocks of the Western Turbidite play, and part of the Nanushuk Group. Rock types are predominantly marine shale and siltstone with minor amounts of sandstone. The maximum play interval thickness is about 6,000 ft, and drilling depths range from near the surface in the westernmost part of the play to a maximum depth of about 15,000 ft.

Reservoir rocks may occur anywhere within the play interval, but are most frequently encountered in the lower half as toe-of-slope or basin-plain turbidites. Individual sandstone bodies are expected to be thin and laterally discontinuous; aggregate reservoir thickness may be on the order of 100 ft or more. Porosity in Canning sandstones is expected to be in the 10–30 percent range. Abnormally high fluid pressures are present in the easternmost part of the play, and as a result, porosities should be better than normally expected for rocks at these depths.

Source rocks include the marine shale of the Canning, which is expected to be relatively gas prone, and the underlying Hue Shale, pebble shale unit, Kingak Shale, and Shublik Formation, which are relatively more oil prone shales. All these shale units are marginally mature to mature. Oil and gas have been recovered from turbidite reservoirs in several wells in the Point Thomson–Flaxman Island area (No. 1, fig. 7) adjacent to the ANWR. The upper of two oil-bearing reservoirs in the recently discovered Point McIntyre field (No. 2, fig. 7), located in State waters in Prudhoe Bay, may be in this play.

Postulated traps are related to facies changes or formed against small-displacement normal faults. Faults and the surrounding thick marine shales are expected to provide fair to good seals. It is estimated that more than 100 exploratory wells have been drilled; however, most wells were drilled for targets beneath the play interval—a reflection of the difficulty in mapping prospects within the play. The future potential is estimated to be excellent for both oil and gas.

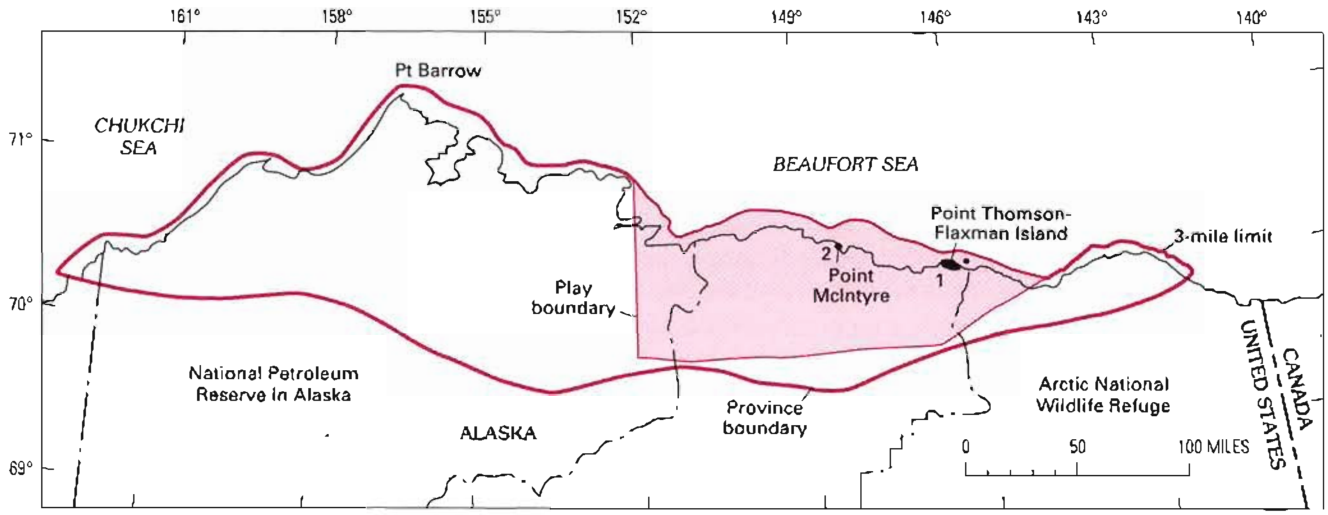

Figure 7. Map of Eastern Turbidite play (058–040). Fields numbered and labeled.

OIL AND GAS PLAY DATA

PLAY EASTERN TURBIDITE
PROVINCE ARCTIC COASTAL PLAIN CODE 01-058-040

Play attributes

	Probability of attribute being favorable or present
Hydrocarbon source (S)	1.00
Timing (T)	1.00
Migration (M)	1.00
Potential reservoir-rock facies (R)	1.00
Marginal play probability (MP) (S x T x M x R = MP)	1.00

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1×10^6 BBL, gas, 6×10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	1.00

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

	Probability of occurrence
Reservoir lithology	
Sandstone	
Carbonate rocks	
Other	
Hydrocarbon type	
Oil	1
Gas	0.3

Fractiles * (estimated amounts) — Fractile percentages *	100	95	75	50	25	5	0
Accumulation size							
Oil (x 10^6 BBL)	1	1.8	5.9	15	40	180	900
Gas (x 10^9 CFG)	6	13	40	100	250	1100	4500
Reservoir depth (x10^3 ft)							
Oil	4			12.5			22
Gas (non-associated)	4			12.5			22
Number of accumulations	5	10	20	30	40	50	60

Average ratio of associated-dissolved gas to oil (GOR)	1000	CFG/BBL
Average ratio of NGL to non-associated gas	40	BBL /10^6 CFG
Average ratio of NGL to associated-dissolved gas	0	BBL /10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated.

BARROW ARCH PLAY (050)

The Barrow Arch play consists of Mississippian to Early Cretaceous rocks in broad, anticlinal structures with an important component of faulting and erosional truncation in a relatively narrow strip along the northern coast of Alaska (fig. 8). The northern limit of the play is approximately the outer limit of State offshore waters. The southern limit is the downdip limit (on the south flank of the Barrow arch) of the characteristic structural-stratigraphic trapping mechanism.

Potential reservoir rocks include both sandstone and carbonate rocks (fig. 4). Sandstone reservoirs (Kekiktuk Conglomerate, Sadlerochit Group, Sag River Sandstone, unnamed Jurassic sandstones, Kuparuk Formation, and Put River sand (of local usage) and its equivalents) predominate over carbonate reservoirs (Lisburne Group). The most important reservoir is expected to be nonmarine to shallow-marine sandstone in the Sadlerochit Group. Porosity in sandstone reservoirs is expected to average more than 20 percent; limestone porosity is expected to be less than 5 percent, with that in the dolomite variable, but potentially 20 percent or more. All potential reservoirs have oil shows or are oil productive. Drilling depths range from 1,500 ft to 15,000 ft.

Potential source rocks include marine shale of Triassic to Early Cretaceous age including the Kavik Member of the Ivishak Formation, Shublik Formation, Kingak Shale, pebble shale unit, and Hue Shale. Lacustrine shale, mudstone, and coal of Mississippian age may also be source rocks. All potential source rocks are at least marginally mature within the play area, but are mature to overmature to the south; and where present to the north, they are also overmature.

Traps are generally combinations of structure and stratigraphy. Closure is generally achieved by faulting and partial truncation of the reservoir in broad, gentle anticlines. Truncation is usually the result of a regionally prevalent Lower Cretaceous unconformity, and sealing is accomplished by the overlying pebble shale unit and younger marine shales. All currently productive North Slope fields are located in this play and are identified by number in figure 8; they are Endicott (1), Kuparuk River (2), Lisburne (3), Milne Point (4), Prudhoe Bay (5) oil fields, and South Barrow (6), and East Barrow (7) gas fields. Numerous subeconomic oil and gas accumulations include Gwydyr Bay (8), North Prudhoe Bay (9), Seal Island (10), Sandpiper (11), Tern Island (12), Point Thomson (13), Colville Delta (14), Niakuk (15), and Point McIntyre (16). This is the most intensely explored play on the North Slope with about 200 exploratory wells, some of which date from the beginning of North Slope drilling in 1946. Future potential for both oil and gas is considered to be excellent.

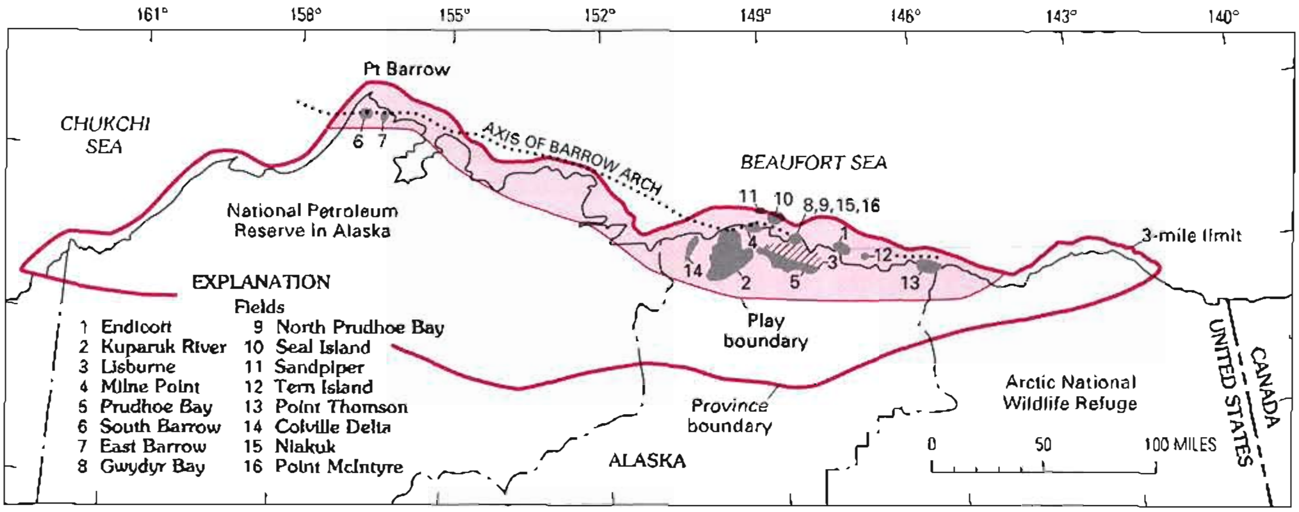

Figure 8. Map of Barrow Arch play (058–050). Fields numbered and labeled.

OIL AND GAS PLAY DATA

PLAY BARROW ARCH
PROVINCE ARCTIC COASTAL PLAIN CODE 01-058-050

Play attributes

	Probability of attribute being favorable or present
Hydrocarbon source (S)	1.00
Timing (T)	1.00
Migration (M)	1.00
Potential reservoir-rock facies (R)	1.00
Marginal play probability (MP) (S x T x M x R = MP)	1.00

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1 x 10^6 BBL; gas, 6 x 10^9 CFG

	Conditional Probability of
At least one undiscovered accumulation of at least minimum size assessed	1.00

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

	Probability of occurrence
Reservoir lithology	
Sandstone	X
Carbonate rocks	X
Other	
Hydrocarbon type	
Oil	0.8
Gas	0.2

Fractiles * (estimated amounts)

Fractile percentages *	*100*	*95*	*75*	*50*	*25*	*5*	*0*
Accumulation size							
Oil (x 10^6 BBL)	1	3	12	30	75	360	2000
Gas (x 10^9 CFG)	6	18	70	165	400	1800	10000
Reservoir depth (x 10^3 ft)							
Oil	2			10			25
Gas (non-associated)	2			10			25
Number of accumulations	5	10	15	20	25	33	50

Average ratio of associated-dissolved gas to oil (GOR)	750	CFG/BBL
Average ratio of NGL to non-associated gas	40	BBL/10^6 CFG
Average ratio of NGL to associated-dissolved gas	0	BBL/10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated

ELLESMERIAN CLASTICS PLAY (060)

The Ellesmerian Clastics play consists of stratigraphic, structural, and combination structural-stratigraphic traps in sandstone reservoirs in the gently south dipping Permian to Early Cretaceous part of the Ellesmerian sequence (strata above the Lisburne Group). The play interval consists mostly of siltstone and shale with as much as 10 percent sandstone at the northern boundary, which coincides with the southern boundary of the Barrow Arch play; the play interval may be as thin as 400 ft (fig. 9). The southern boundary lies within the northern part of the Northern Foothills province (059), where the play interval may be as thick as 6,000 ft and occurs at depths greater than 15,000 ft.

Reservoir rocks consist of sandstone deposited primarily in shallow-marine environments. Also present are minor amounts of fluvial sandstone in the northernmost areas of the play and turbidite sandstone of northern derivation in the southernmost areas. Potential reservoirs include the Echooka Formation, Ivishak Formation, Sag River Sandstone, several unnamed sandstone units in the Kingak Shale, Kuparuk Formation, and stratigraphic equivalents of the Kemik Sandstone. Porosities may reach 25 percent in the northern parts of the play area, but are anticipated to decrease to less than 10 percent in the southern parts. Drilling depths range from 2,000 ft in the north to 20,000 ft at the southern play boundary. Most reservoirs, particularly those with the best porosity, are expected to occur beneath the Arctic Coastal Plain province (058), where drilling depths are generally less than 12,000 ft.

The play interval contains many of the richest source rocks on the North Slope, including the Kavik Member, Shublik Formation, Kingak Shale, pebble shale unit, and Hue Shale. These shale units are mature throughout most of the play, but range from marginally mature in the northernmost part to overmature in the southern part, where vitrinite reflectance values exceed 2 percent. Oil and gas shows are reported in several wells, and a gas accumulation of undetermined size is present immediately south of Barrow (Walakpa field, fig. 9).

Because of the homoclinal south dip of strata comprising this play and the rarity of structural reversals, oil and gas accumulations are expected to be trapped in stratigraphic or combination structural-stratigraphic traps. Shale units within the play interval are expected to provide adequate seals. A few dozen exploratory wells have been drilled, only a few of which were drilled for prospects in the play interval. Estimates of oil and gas resources in this play have been apportioned as follows: 80 percent to the Arctic Coastal Plain province (058) and 20 percent to the Northern Foothills province (059). Future oil potential is fair, and future gas potential is considered to be excellent.

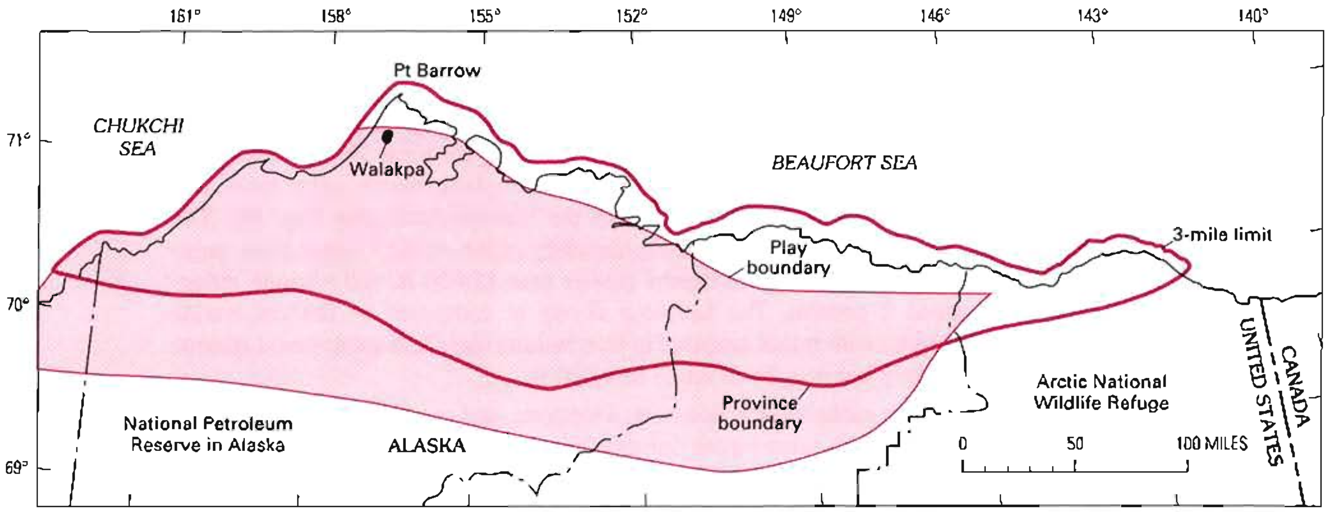

Figure 9. Map of Ellesmerian Clastics play (058–060), showing Walakpa field.

OIL AND GAS PLAY DATA

PLAY ELLESMERIAN CLASTICS
PROVINCE ARCTIC COASTAL PLAIN CODE 01-058-060

Play attributes

	Probability of attribute being favorable or present
Hydrocarbon source (S)	1.00
Timing (T)	1.00
Migration (M)	1.00
Potential reservoir-rock facies (R)	1.00
Marginal play probability (MP) (S x T x M x R = MP)	1.00

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1×10^6 BBL; gas, 6×10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	1.00

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

	Probability of occurrence
Reservoir lithology	
Sandstone	X
Carbonate rocks	
Other	
Hydrocarbon type	
Oil	0.2
Gas	0.8

Fractile percentages*	100	95	75	50	25	5	0
Accumulation size							
Oil (x 10^6 BBL)	1	1.2	2.4	5	12	55	300
Gas (x 10^9 CFG)	6	7	15	30	100	600	8000
Reservoir depth (x10^3 ft)							
Oil	3			9			15
Gas (non-associated)	3			11			20
Number of accumulations	10	13	17	20	26	36	50

(Fractiles* (estimated amounts))

Average ratio of associated-dissolved gas to oil (GOR)	2000	CFG/BBL
Average ratio of NGL to non-associated gas	15	BBL/10^6 CFG
Average ratio of NGL to associated-dissolved gas	0	BBL/10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated.

LISBURNE PLAY (070)

The Lisburne play consists of structurally and stratigraphically trapped hydrocarbons in carbonate or clastic reservoirs in the gently south dipping Lisburne Group. The northern boundary within the north-central part of the NPRA is the Lisburne onlap limit; east of long 154° W., it is the southern boundary of the Barrow Arch play (fig. 10). The southern boundary is approximately the south boundary of the Arctic Coastal Plain province, where the Lisburne is buried to depths greater than 15,000 ft, and vitrinite reflectance values exceed 2 percent. The Lisburne Group is composed of shallow-marine limestone and dolomite with minor amounts of interbedded shale and sandstone. Lisburne thickness varies widely but may be as much as 4,000 ft.

Potential reservoir rocks include dolomite, limestone, and sandstone. Dolomite is the most important reservoir; in some places dolomite porosity reaches 25 percent. Dolomite is expected to occur most abundantly in the Late Mississippian part of the Lisburne, as in the Prudhoe Bay area. Limestone porosity in the Lisburne is expected to average less than 5 percent; thus limestone constitutes a poor potential reservoir. Sandstone, which may be common along the northern onlap edge in the NPRA, may be partially to completely calcite cemented and, thus, a marginal reservoir. Depth to the top of the Lisburne ranges from 9,000 ft to 20,000 ft.

Potential source rocks include marine shale in the overlying Sadlerochit Group, marine shale and limestone within the Lisburne, and marine to lacustrine shale and coal in the underlying Endicott Group. Where truncated by the regional Lower Cretaceous unconformity, such as along the west edge of the ANWR, the pebble shale unit and the Hue Shale overlie the unconformity and may be important source rocks for the Lisburne. Limited geochemical data suggest that all except the pebble shale unit and Hue Shale are fair to poor, gas-prone source rocks that are mature in the northern part of the play and overmature in the southern part. Oil residue is often encountered in porous dolomite in the Lisburne, and hydrogen sulfide gas was encountered in interbedded limestone and shale near the Lisburne-Endicott boundary at a depth of about 17,500 ft in the Inigok-1 well, near the southern play boundary in the eastern NPRA (fig. 10).

Stratigraphic traps related to the Lisburne onlap edge and facies changes are expected in the northern part of the play area. Structural traps are relatively rare, although in the NPRA folding and faulting during Mississippian, Pennsylvanian, and Permian(?) time produced some structures, such as that drilled by the Inigok exploratory well. Seismic reflection records in the northwestern part of the NPRA suggest that carbonate buildups may be present. Interbedded shale and impermeable limestone are expected to provide adequate seals. Only a few exploratory wells have been drilled for prospects in this play, and no hydrocarbon accumulations are known. Future oil potential is poor, but the gas potential is thought to be significant.

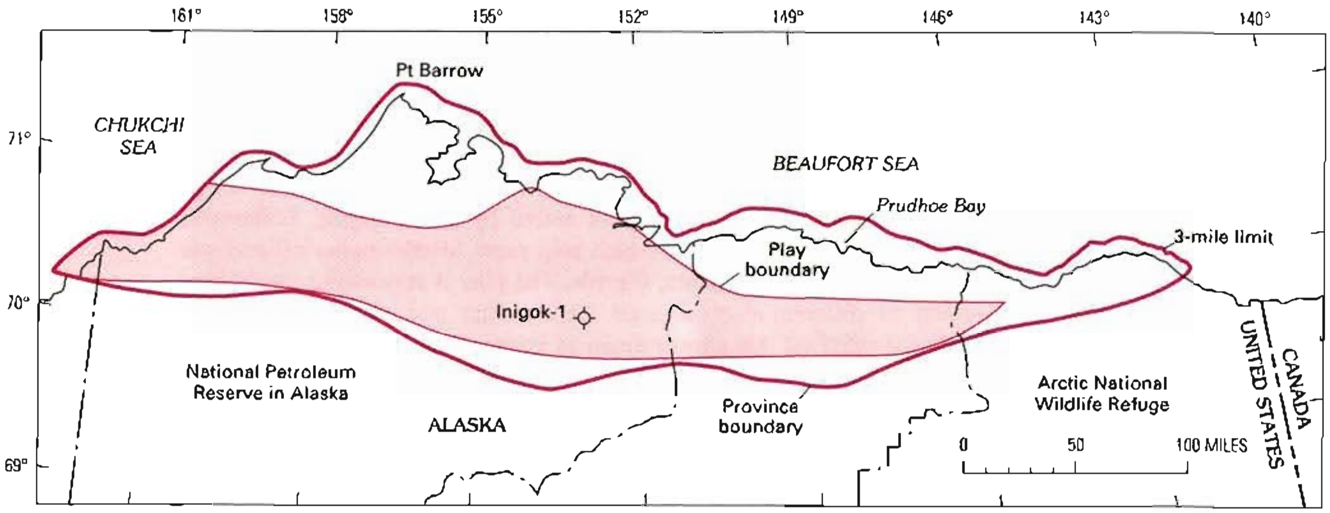

Figure 10. Map of Lisburne play (058–070). Inigok-1 exploratory well shown.

OIL AND GAS PLAY DATA

PLAY LISBURNE
PROVINCE ARCTIC COASTAL PLAIN CODE 01-058-070

Play attributes

	Probability of attribute being favorable or present
Hydrocarbon source (S)	1.00
Timing (T)	1.00
Migration (M)	1.00
Potential reservoir-rock facies (R)	1.00
Marginal play probability (MP) (S x T x M x R = MP)	1.00

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1×10^6 BBL; gas, 6×10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	1.00

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

Reservoir lithology	Probability of occurrence
Sandstone	
Carbonate rocks	X
Other	
Hydrocarbon type	
Oil	0
Gas	1

Fractiles * (estimated amounts)

Fractile percentages *	*100*	*95*	*75*	*50*	*25*	*5*	*0*
Accumulation size							
Oil ($\times 10^6$ BBL)	0	0	0	0	0	0	0
Gas ($\times 10^9$ CFG)	6	11	35	100	240	1200	10000
Reservoir depth ($\times 10^3$ ft)							
Oil	0			0			0
Gas (non-associated)	8			14			20
Number of accumulations	3	4	6	7	10	14	18

Average ratio of associated-dissolved gas to oil (GOR)	0	CFG/BBL
Average ratio of NGL to non-associated gas	15	BBL/10^6 CFG
Average ratio of NGL to associated-dissolved gas	0	BBL/10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated.

LISBURNE UNCONFORMITY PLAY (080)

The Lisburne Unconformity play consists of stratigraphic traps developed as a result of differential erosion on the regional Permian unconformity at the top of the Lisburne Group (fig. 11). Postulated traps are envisioned to consist of erosional scarps and remnants of porous Lisburne carbonate rocks sealed by the overlying Sadlerochit Group. These traps are analogous to those which trap most Mississippian oil and gas accumulations beneath the plains of Alberta, Canada. The play is considered speculative because the amount of differential erosion on the Permian unconformity is largely unknown. Evidence for relief on this unconformity is known from outcrops in the eastern Shublik Mountains of the ANWR, where conglomerate-filled channels cut into the uppermost part of the Lisburne Group.

The play encompasses the entire area of the Lisburne Group beneath the Permian unconformity, including that area overlying the Barrow arch (fig. 8). The Barrow arch area is included in this play because the size distribution of oil and gas accumulations in the play is likely to be significantly different from that in the Barrow Arch play. The southern limit of the play coincides with the southern limit of the Lisburne play.

Reservoir rocks and source rocks are expected to be the same as for the Lisburne play. Depth to the Lisburne unconformity in the play area ranges from about 8,000 ft to 20,000 ft. As many as 50 exploratory wells may have penetrated this play, but most were drilled for targets beneath the play interval. Future potential for undiscovered oil is low, but gas potential is very good.

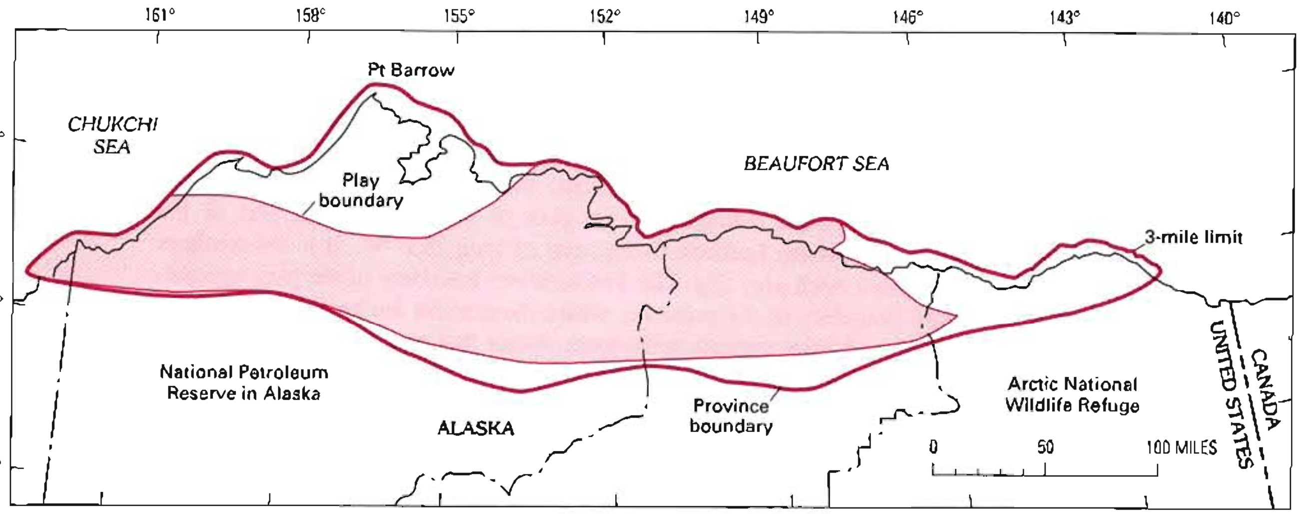

Figure 11. Map of Lisburne Unconformity play (058–080).

OIL AND GAS PLAY DATA

PLAY LISBURNE UNCONFORMITY
PROVINCE ARCTIC COASTAL PLAIN CODE 01-058-080

Play attributes	Probability of attribute being favorable or present
Hydrocarbon source (S)	1.00
Timing (T)	1.00
Migration (M)	1.00
Potential reservoir-rock facies (R)	1.00
Marginal play probability (MP) (S x T x M x R = MP)	1.00

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1×10^6 BBL; gas, 6×10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	0.50

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

	Probability of occurrence
Reservoir lithology	
Sandstone	
Carbonate rocks	
Other	
Hydrocarbon type	
Oil	0.1
Gas	0.9

Fractile percentages *	100	95	75	50	25	5	0
Accumulation size							
Oil ($\times 10^6$ BBL)	1	1.2	2	4	9.5	45	350
Gas ($\times 10^9$ CFG)	6	7.2	12	25	60	250	2000
Reservoir depth ($\times 10^3$ ft)							
Oil	8			14			25
Gas (non-associated)	8			14			25
Number of accumulations	10	16	24	30	40	56	100

(Fractiles * (estimated amounts))

Average ratio of associated-dissolved gas to oil (GOR)	750	CFG/BBL
Average ratio of NGL to non-associated gas	25	BBL/10^6 CFG
Average ratio of NGL to associated-dissolved gas	0	BBL/10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated.

ENDICOTT PLAY (090)

The Endicott play consists of structural, stratigraphic, and combination traps in sandstone reservoirs in the Mississippian Kekiktuk Conglomerate and sandstone or dolomite reservoirs in the overlying Kayak Shale, both formations belonging to the Endicott Group. The northern boundary of the play in the north-central part of the NPRA is the onlap edge of the Endicott Group; east of long 155° W., it is the southern boundary of the Barrow Arch play (fig. 12). The southern boundary of the play approximates the southern boundary of the province, where these rocks are buried to depths of more than 20,000 ft and have vitrinite reflectance values that exceed 2 percent. Thickness of the Endicott Group generally ranges from 100 to 1,000 ft but locally may be as much as 10,000 ft.

Reservoir rocks consist primarily of fluvial to shallow-marine(?) quartzose sandstone and conglomerate within the Kekiktuk Conglomerate. Minor amounts of shallow-marine dolomite and sandstone are present in the overlying Kayak Shale. Porosity is generally expected to be less than 10 percent because of burial depths ranging from 7,000 to greater than 20,000 ft. Increased porosity in the Kekiktuk may be present beneath the Lower Cretaceous unconformity, along the west edge of the ANWR.

Source rocks include coal and lacustrine shale in the Kekiktuk, marine shale in the Kayak, and, where truncation is present, the pebble shale unit and the Hue Shale. Throughout most of the play area these rocks are overmature. Accordingly, few oil and gas shows are known from this play. However, in the Inigok-1 well, located near the southern play boundary in the eastern part of the NPRA (fig. 12), hydrogen sulfide gas occurred in the uppermost part of the Kayak Shale, at a depth of about 17,500 ft.

Traps are expected to be mostly combination traps related to faulting. Locally, folds and faults were developed during the formation of Endicott basins in Mississippian, Pennsylvanian, and Permian(?) time. The Kayak Shale is expected to provide adequate seals for any reservoirs which may occur in the play. Less than a dozen exploratory wells have been drilled, and the potential for undiscovered gas resources is thought to be moderate.

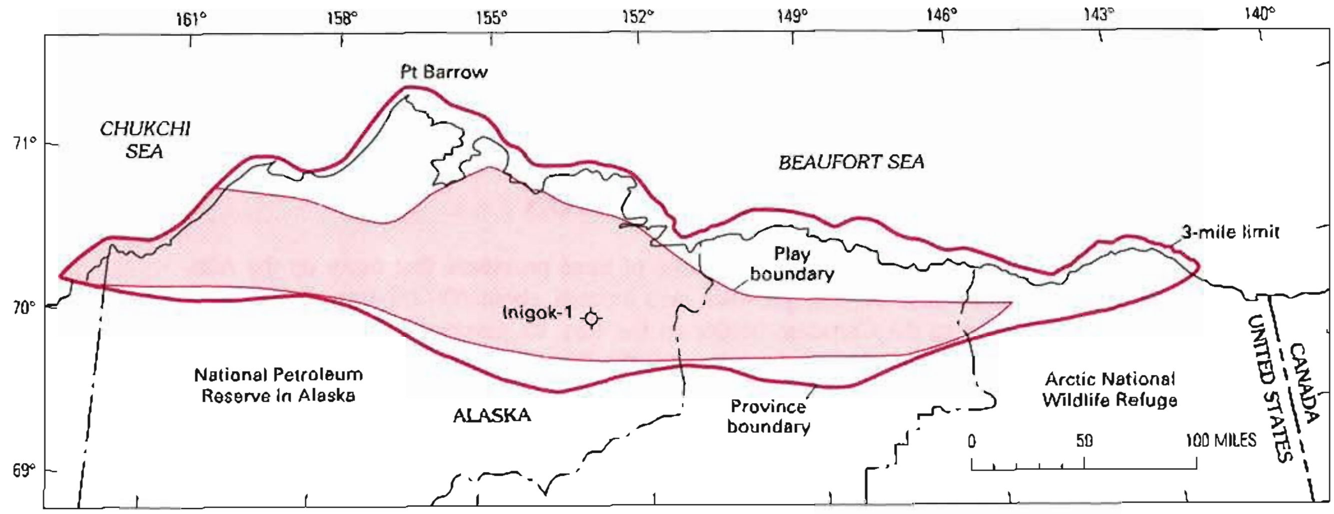

Figure 12. Map of Endicott play (058–090), showing Inigok-1 well.

OIL AND GAS PLAY DATA

PLAY ENDICOTT
PROVINCE ARCTIC COASTAL PLAIN CODE 01-058-090

Play attributes

	Probability of attribute being favorable or present
Hydrocarbon source (S)	1.00
Timing (T)	1.00
Migration (M)	1.00
Potential reservoir-rock facies (R)	1.00
Marginal play probability (MP) (S x T x M x R = MP)	1.00

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1×10^6 BBL; gas, 6×10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	0.90

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

	Probability of occurrence
Reservoir lithology	
Sandstone	X
Carbonate rocks	
Other	
Hydrocarbon type	
Oil	0
Gas	1

Fractile percentages *	Fractiles * (estimated amounts) 100	95	75	50	25	5	0
Accumulation size							
Oil (x 10^6 BBL)	0	0	0	0	0	0	0
Gas (x 10^9 CFG)	6	7	10	20	40	120	500
Reservoir depth (x 10^3 ft)							
Oil	0			0			0
Gas (non-associated)	8			7			20
Number of accumulations	1	2	4	5	7	11	20

Average ratio of associated-dissolved gas to oil (GOR)	0	CFG/BBL
Average ratio of NGL to non-associated gas	15	BBL/10^6 CFG
Average ratio of NGL to associated-dissolved gas	0	BBL/10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated.

NORTHERN FOOTHILLS PROVINCE (059)

By Kenneth J. Bird

INTRODUCTION

The Northern Foothills province is one of three provinces that make up the Alaskan North Slope (fig. 3). The province area extends about 600 mi from the Chukchi Sea on the west to the Canadian border on the east. Its maximum width is about 100 mi. Along the west edge of the province, the State 3-mile limit forms the seaward boundary. The total area of the province is about 29,000 mi^2. The North Slope is a Cretaceous and Tertiary foreland basin developed on a Mississippian to Early Cretaceous passive margin; the stratigraphy is detailed in figure 13. The province occupies the distal part of the Brooks Range fold-and-thrust belt. Deformation involves mostly foreland basin strata, except in the ANWR, where deformation extends to deeper stratigraphic levels and involves pre-foreland basin rocks. The province was the site of the first North Slope oil discovery, Umiat field, made in the NPRA by the U.S. Navy in 1946. Since then about 50 exploratory wells have been drilled by industry and government resulting in the discovery of six hydrocarbon accumulations—one oil and five gas. All accumulations are noncommercial. Umiat, the only oil field, is estimated to have about 70 MMB of recoverable oil. The largest gas field is Gubik with an estimated 295 BCF of recoverable gas. Two plays were individually assessed: Fold Belt West and Fold Belt East.

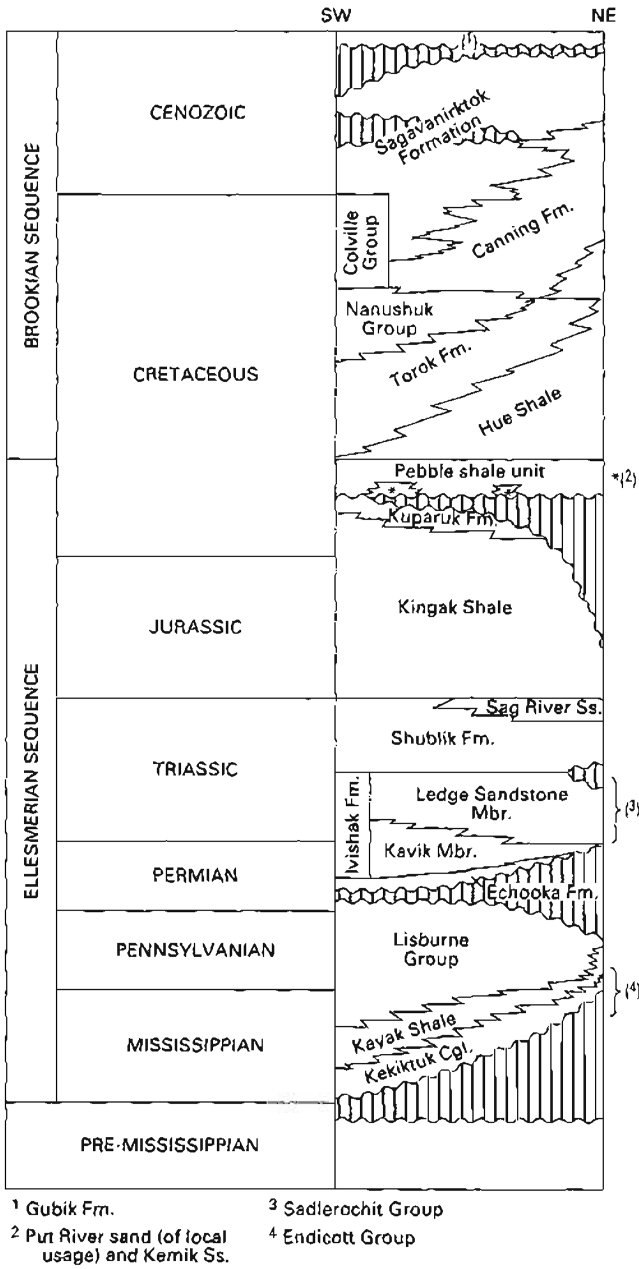

Figure 13. Generalized stratigraphic column, Northern Foothills province (059).

FOLD BELT WEST PLAY (020)

The Fold Belt West play consists primarily of anticlinal traps in Cretaceous and Tertiary sandstone reservoirs in the northern part of the Brooks Range fold-and-thrust belt. The play is situated north of the Thrust Belt West play of the Southern Foothills province (060), and south of undisturbed deposits of the Brookian sequence of the Arctic Coastal Plain province (058); its western border is the State 3-mile limit in the Chukchi Sea; its eastern border lies a short distance east of the Trans-Alaska Pipeline, where the structural style changes (fig. 14). This play encompasses rocks of the Nanushuk Group, Torok Formation, Hue Shale, pebble shale unit, and sandstones correlative with the Kemik Sandstone; in the eastern quarter of the play, parts of the Sagavanirktok and Canning Formations are also included.

Potential reservoirs are sandstones, representing deltaic, shallow-marine, and turbidite environments. Sandstone porosity is expected to range from 5 to 20 percent and to increase eastward across the play. Drilling depths range from the near-surface to greater than 20,000 ft.

Potential source rocks include generally gas prone shale units of the Nanushuk Group and the Sagavanirktok, Torok, and Canning Formations and the underlying more oil prone shale units of the Shublik Formation, Kingak Shale, pebble shale unit, and Hue Shale. Gas-prone source rocks within the play range from immature to mature, whereas most oil prone source rocks range from mature to overmature. Both oil and gas seeps are known, and six subeconomic accumulations have been discovered: the Umiat oil field (1), and the Gubik (2), East Umiat (3), Wolf Creek (4), Square Lake (5), and Meade (6) gas fields. These are identified in figure 14.

Traps are fault-cored anticlines related to Brooks Range thrusting. Stratigraphic traps, such as updip pinchouts on the flanks of anticlines, may also be present. Shales are expected to provide fair to good seals, although their effectiveness may be reduced by faulting and related fracturing. Approximately 40 exploratory and delineation wells have tested 30 structures in the play; however, the number of untested structures may exceed 100. Estimates of oil and gas resources in the play have been apportioned 98 percent to the Northern Foothills province (059), and 2 percent to the Southern Foothills–Brooks Range province (060). Future potential for both oil and gas is excellent.

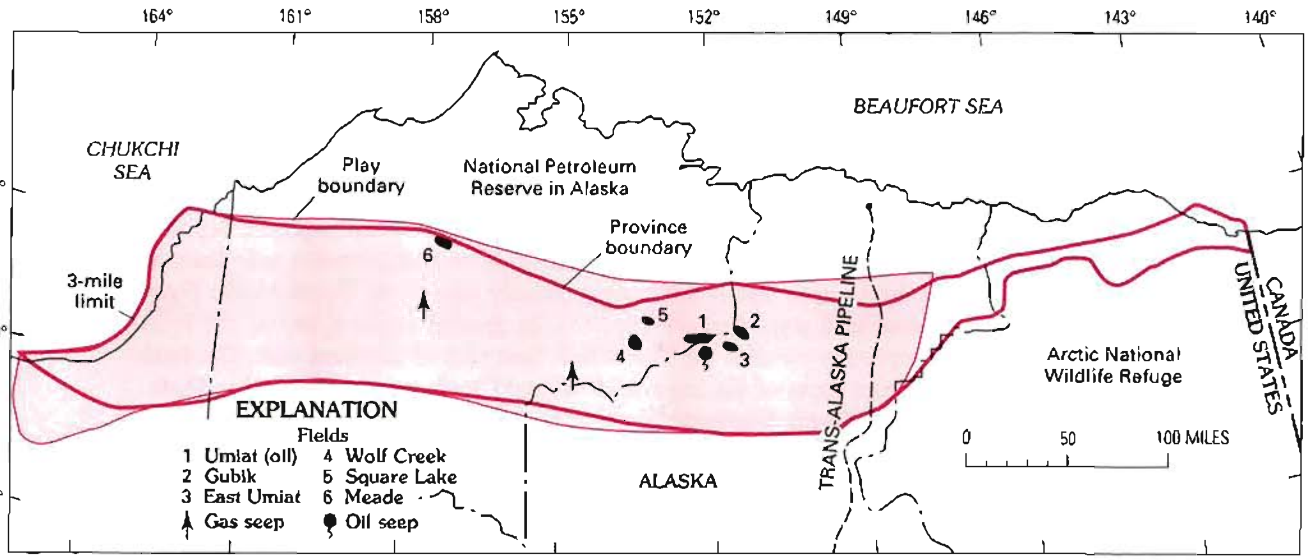

Figure 14. Map of Fold Belt West play (059–020). Fields numbered and labeled.

OIL AND GAS PLAY DATA

PLAY FOLD BELT WEST
PROVINCE NORTHERN FOOTHILLS CODE 01-059-020

Play attributes

	Probability of attribute being favorable or present
Hydrocarbon source (S)	1.00
Timing (T)	1.00
Migration (M)	1.00
Potential reservoir-rock facies (R)	1.00
Marginal play probability (MP) (S x T x M x R = MP)	1.00

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1 x 10^6 BBL; gas, 6 x 10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	1.00

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

Reservoir lithology	Probability of occurrence
Sandstone	X
Carbonate rocks	
Other	
Hydrocarbon type	
Oil	0.3
Gas	0.7

Fractile percentages *	Fractiles * (estimated amounts) 100	95	75	50	25	5	0
Accumulation size							
Oil (x 10^6 BBL)	1	4	16	40	65	350	1000
Gas (x 10^9 CFG)	6	24	90	160	250	1400	4000
Reservoir depth (x10^3 ft)							
Oil	0.1			8			20
Gas (non-associated)	0.1			8			20
Number of accumulations	10	14	20	25	35	50	80

Average ratio of associated-dissolved gas to oil (GOR)	1500	CFG/BBL
Average ratio of NGL to non-associated gas	15	BBL /10^6 CFG
Average ratio of NGL to associated-dissolved gas	0	BBL /10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated.

FOLD BELT EAST PLAY (030)

The Fold Belt East play consists primarily of anticlinal traps in Cretaceous and Tertiary sandstone reservoirs in the northern part of the Brooks Range fold-and-thrust belt. The play is situated north of the Thrust Belt East play of the Southern Foothills–Brooks Range province (060), and south of the undisturbed Brookian sequence deposits of province 058. The east half of the play extends offshore to the State 3-mile limit in the Beaufort Sea. Its western border lies a short distance east of the Trans-Alaska Pipeline, where the structural style changes (fig. 15). In general regional terms, the Fold Belt East play structurally overlies the Thrust Belt East play of province 060. The Fold Belt East play includes rocks of the Sagavanirktok and Canning Formations, Hue Shale, pebble shale unit, and Kemik Sandstone.

Potential reservoir rocks are sandstone units, representing deltaic, shallow-marine, and turbidite environments. Porosity is expected to increase eastward across the play (by 10 to 30 percent or more) because of lesser burial and shorter duration of burial in that direction. Drilling depths range from the near-surface to greater than 20,000 ft.

Potential source rocks include gas-prone shale in the Sagavanirktok and Canning Formations and oil-prone shale in the Hue Shale, pebble shale unit, Kingak Shale, and Shublik Formation. This play is considered more oil prospective than the Fold Belt West play because of the presence of a thicker section of the oil-prone Hue Shale. Gas-prone source rocks are immature to mature, whereas oil-prone source rocks are immature to overmature. Oil seeps and oil-stained sandstones are known, but no oil or gas accumulations have been discovered.

Traps are fault-cored anticlines related to Brooks Range thrusting. Stratigraphic traps, such as updip pinchouts on the flanks of anticlines, may also be present. Shales within the play are expected to provide fair to good seals, although their effectiveness may be reduced by faulting and related fracturing. About 10 exploratory wells have penetrated rocks assigned to this play; however, most wells are believed to have been drilled for objectives assigned to the underlying Thrust Belt East play. Untested structures may number more than 100. Estimated undiscovered oil and gas resources in the play have been apportioned 73 percent to the Arctic Coastal Plain province (058), 25 percent to the Northern Foothills province (059), and 2 percent to the Southern Foothills–Brooks Range province (060). Future potential for oil and gas is considered excellent.

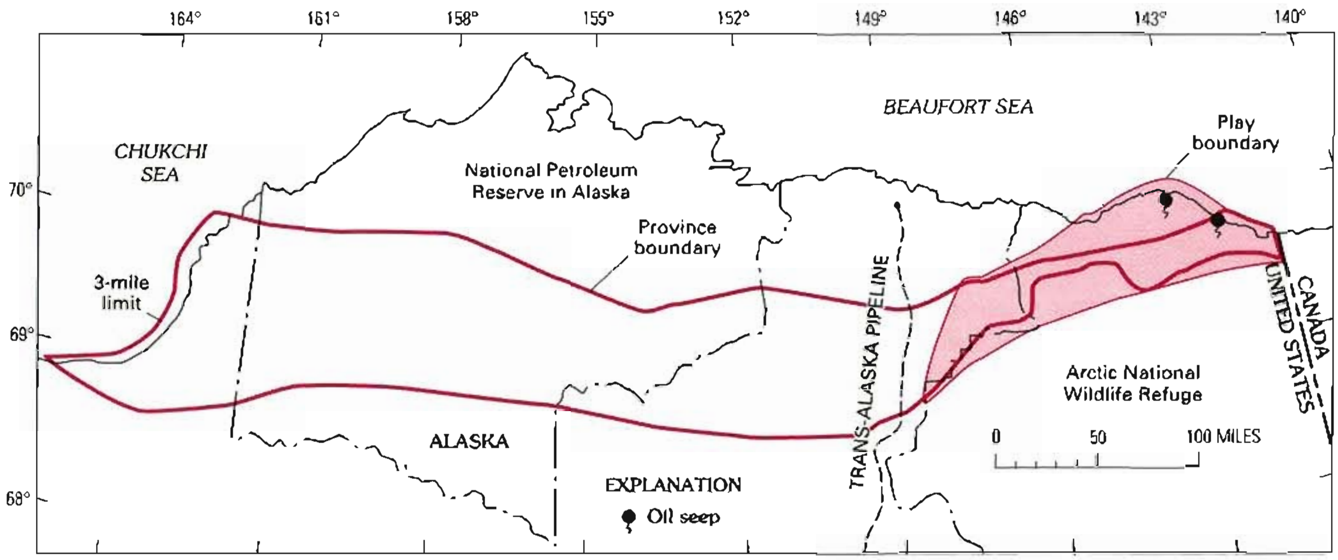

Figure 15. Map of Fold Belt East play (059–030).

OIL AND GAS PLAY DATA

PLAY FOLD BELT EAST
PROVINCE NORTHERN FOOTHILLS CODE 01-059-030

Play attributes

	Probability of attribute being favorable or present
Hydrocarbon source (S)	1.00
Timing (T)	1.00
Migration (M)	1.00
Potential reservoir-rock facies (R)	1.00
Marginal play probability (MP) (S x T x M x R = MP)	1.00

Accumulation attributes, conditional on favorable play attributes

Minimum size assessed: oil, 1 x 10^6 BBL; gas, 6 x 10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	1.00

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

	Probability of occurrence
Reservoir lithology	
Sandstone	x
Carbonate rocks	
Other	
Hydrocarbon type	
Oil	0.8
Gas	0.2

	Fractiles * (estimated amounts)						
Fractile percentages *	*100*	*95*	*75*	*50*	*25*	*5*	*0*
Accumulation size							
Oil (x 10^6 BBL)	1	2.2	7.8	20	50	200	800
Gas (x 10^9 CFG)	6	9	30	80	200	800	3000
Reservoir depth (x10^3 ft)							
Oil	0.1			7			26
Gas (non-associated)	0.1			7			26
Number of accumulations	5	10	18	25	35	50	65

Average ratio of associated-dissolved gas to oil (GOR)	600	CFG/BBL
Average ratio of NGL to non-associated gas	30	BBL/10^6 CFG
Average ratio of NGL to associated-dissolved gas	0	BBL/10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated.

SOUTHERN FOOTHILLS–BROOKS RANGE PROVINCE (060)

By Kenneth J. Bird

INTRODUCTION

The Southern Foothills–Brooks Range province is the southernmost of the three provinces that make up the Alaskan North Slope (fig. 3). This province extends 670 mi from the Chukchi Sea on the west to the Canadian border on the east. Its maximum width is slightly more than 100 mi. The western limit fronts on the Chukchi Sea, where the State 3-mile limit forms the seaward boundary. The total area of the province is about 45,000 mi^2. The North Slope is a Cretaceous and Tertiary foreland basin developed on a Mississippian to Early Cretaceous passive margin; stratigraphy is given in figure 16. The Southern Foothills–Brooks Range province occupies the proximal part of the Brooks Range fold-and-thrust belt. Structure is complex, and deformation involves both foreland basin and pre-foreland basin strata. This province was the last of the North Slope provinces to be explored; the first well was drilled in 1968. Since then, only 14 exploratory wells have been drilled by industry and government, resulting in the discovery of two noncommercial gas fields, the sizes of which remain confidential. Two plays were individually assessed: Thrust Belt West and Thrust Belt East.

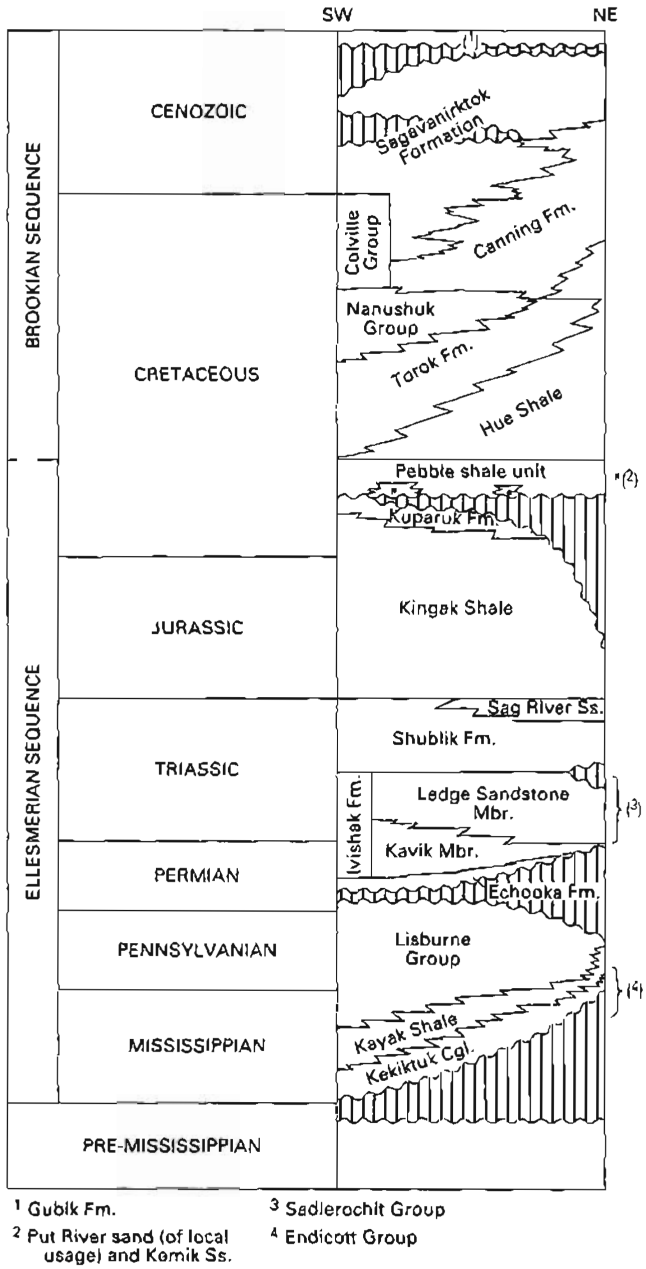

Figure 16. Generalized stratigraphic column, Southern Foothills–Brooks Range province (060).

THRUST BELT WEST PLAY (020)

The Thrust Belt West play consists primarily of structural traps in Mississippian carbonate reservoirs in the Brooks Range thrust belt. The northern boundary of the play, guided by seismic reflection data within the NPRA, is drawn far enough north to encompass all the estimated occurrences of thrust sheets of carbonate rocks of the Lisburne Group. The southern boundary is arbitrarily placed about 30 mi into the Brooks Range. The area farther south is expected to have negligible petroleum potential based on the observed southward increase in the level of thermal maturity. The western play boundary is the State 3-mile limit in the Chukchi Sea. The eastern boundary is a short distance east of the Trans-Alaska Pipeline, where the structural style changes (fig. 17). Greatest potential for petroleum in the Thrust Belt West play is expected to be along the immediate range front and the foothills to the north. The thickness of rocks in the play may exceed 20,000 ft.

Lisburne Group carbonate rocks are the primary reservoir rock. Other potential reservoir rocks include graywacke sandstone of Jurassic and Cretaceous age and fractured chert and siliceous shale of Mississippian to Jurassic age. The structural style of potential prospects and the physical nature of potential reservoir rocks are exemplified by the Lisburne-1 well, which encountered five thrust repetitions of the Lisburne Group (fig. 16). Each repetition is about 1,200 ft thick, and each has some intervals with indicated porosity in the 10–15 percent range.

Potential source rocks include marine shale units of Mississippian to Cretaceous age. Oil shale of Mississippian, Triassic, and Jurassic age is known to occur, but these units are considered representative of local occurrences and not characteristic of the entire play. Preliminary data from the Lisburne-1 well (fig. 17) indicate that Triassic and Jurassic rocks are fair to good source rocks. Most source rocks are expected to be mature to overmature, although the data are sparse and the geologic relationships complex. Pyrobitumen (dead oil) appeared in the Lisburne well along with minor indications of gas. Veins of bitumen are known from outcrop localities.

Traps in the play are large anticlinal structures composed of multiple thrust sheets of carbonate rocks. Shale beds within the play are expected to provide fair to good seals, although their effectiveness may be reduced by faulting and related fracturing. Only four exploratory wells have been drilled in the entire play area; information on three of the four remains proprietary. Large, untested structures remaining in the play may number in the dozens. Future potential appears good for oil and excellent for gas.

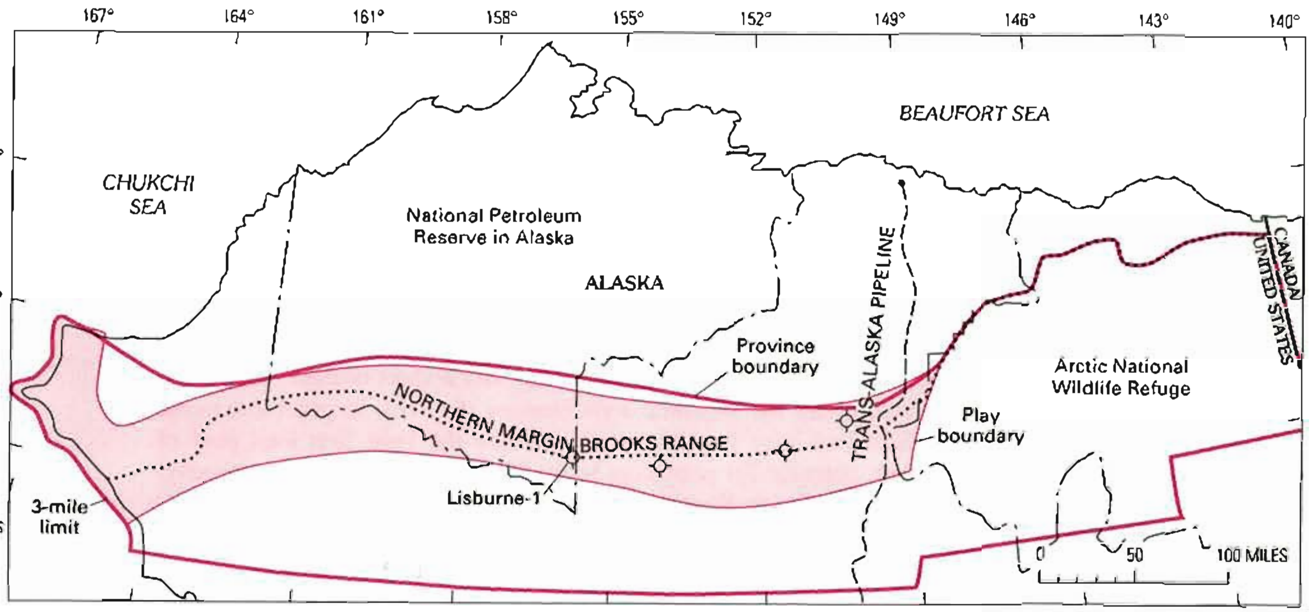

Figure 17. Map of Thrust Belt West play (060–020), showing four exploratory wells.

OIL AND GAS PLAY DATA

PLAY THRUST BELT WEST
PROVINCE SOUTHERN FOOTHILLS-BROOKS RANGE CODE 01-060-020

Play attributes

	Probability of attribute being favorable or present
Hydrocarbon source (S)	1.00
Timing (T)	0.75
Migration (M)	1.00
Potential reservoir-rock facies (R)	1.00
Marginal play probability (MP) (S x T x M x R = MP)	0.75

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1×10^6 BBL; gas, 6×10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	0.90

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

Reservoir lithology	Probability of occurrence
Sandstone	
Carbonate rocks	X
Other	
Hydrocarbon type	
Oil	0.3
Gas	0.7

Fractile percentages *	100	95	75	50	25	5	0
Accumulation size							
Oil ($\times 10^6$ BBL)	1	2	15	30	100	350	4000
Gas ($\times 10^9$ CFG)	6	10	75	135	450	1575	18000
Reservoir depth ($\times 10^3$ ft)							
Oil	1			8			20
Gas (non-associated)	1			8			20
Number of accumulations	2	3	5	7	9	12	15

(Fractiles * (estimated amounts))

Average ratio of associated-dissolved gas to oil (GOR)	1000	CFG/BBL
Average ratio of NGL to non-associated gas	10	BBL/10^6 CFG
Average ratio of NGL to associated-dissolved gas	0	BBL/10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated.

THRUST BELT EAST PLAY (030)

The Thrust Belt East play consists primarily of structural traps in carbonate and clastic reservoirs of the Ellesmerian and pre-Mississippian sequences in the Brooks Range thrust belt. The northern boundary of the play, guided by seismic reflection data within the ANWR, is drawn far enough north to encompass all the estimated occurrences of thrust blocks of Ellesmerian and older rocks. The southern boundary is arbitrarily placed about 30 mi into the Brooks Range. The area farther south is expected to have negligible petroleum potential, based on the observed southward increase in the level of thermal maturity. The eastern one-third of the play extends offshore to the State 3-mile limit in the Beaufort Sea. The western boundary lies a short distance east of the Trans-Alaska Pipeline, where the structural style changes (fig. 18). In general regional terms, the Thrust Belt East play lies structurally beneath the Fold Belt East play of province 059. Greatest potential for petroleum in the Thrust Belt East play is expected to be north of the Brooks Range front, beneath the foothills and coastal plain of the ANWR.

The most important reservoir rocks are expected to be carbonate rocks of the Lisburne Group, although other Ellesmerian reservoir rocks, such as the Sadlerochit Group, may be of nearly equal importance in the northern parts of the play. Part or all of the Ellesmerian sequence may be missing from structures in the northernmost part of the play because of erosional truncation by the regional Lower Cretaceous unconformity. Pre-Mississippian-Pennsylvanian carbonate rocks are also considered potential reservoirs. Depth to these reservoir rocks ranges from near-surface to greater than 20,000 ft.

Potential source rocks include a continuous section of organic, carbon-rich marine shales that primarily range in age from Middle Triassic to Late Cretaceous (Shublik Formation, Kingak Shale, pebble shale unit, and Hue Shale). Thermal maturity decreases northeastward across the play, ranging from mature and overmature in the southwest to mature and submature in the northeast. Minor oil staining in sandstone and carbonate rock is known from wells and outcrop, and two subeconomic gas accumulations, Kemik and Kavik, have been discovered.

Traps are broad, thrust-faulted anticlinal structures that involve Ellesmerian and pre-Mississippian basement rocks, and typically produce only a single repetition of the stratigraphic section. Stratigraphic traps, such as updip pinchouts on the flanks of anticlines, may also be present. Shales, including those in the basal part of the Brookian sequence, are expected to provide fair to good seals, although their effectiveness may be reduced by faulting and related fracturing. Ten exploratory wells have tested eight structures; at least several dozen structures still remain to be tested. Estimates of oil and gas resources in this play have been apportioned 66 percent to the Arctic Coastal Plain province (058), 30 percent to the Northern Foothills province (059), and 4 percent to the Southern Foothills–Brooks Range province (060). Future potential for both oil and gas is excellent.

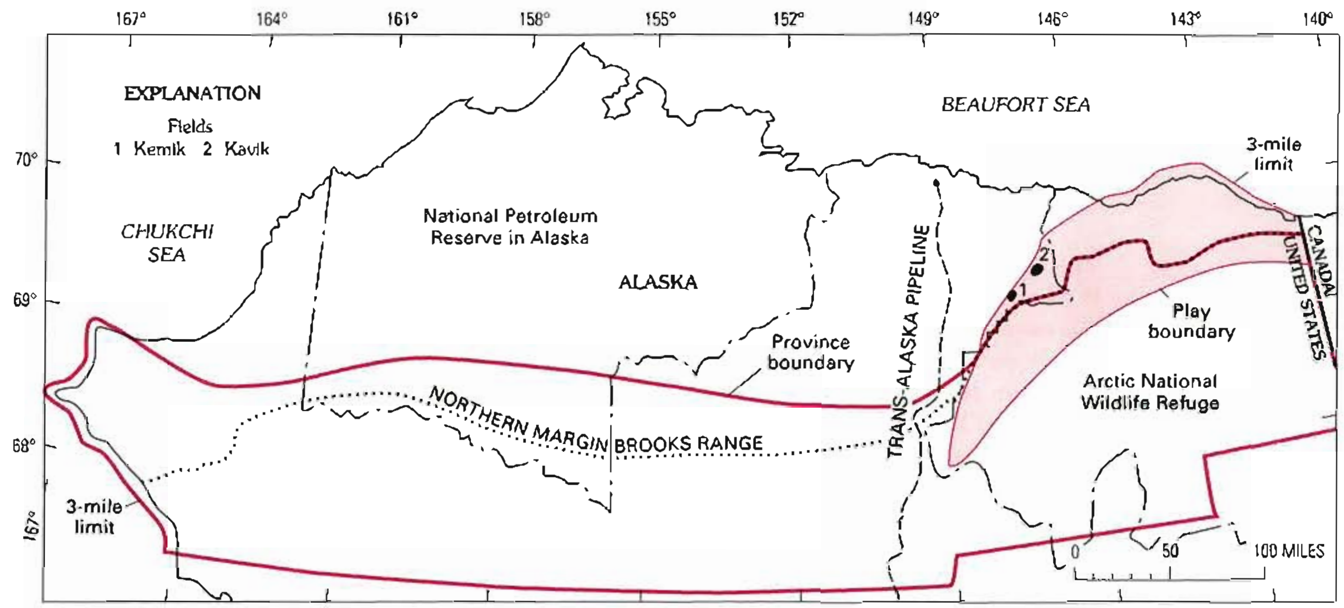

Figure 18. Map of Thrust Belt East play (060–030). Fields numbered and labeled.

OIL AND GAS PLAY DATA

PLAY THRUST BELT EAST
PROVINCE SOUTHERN FOOTHILLS - BROOKS RANGE CODE 01-060-030

Play attributes

	Probability of attribute being favorable or present
Hydrocarbon source (S)	1.00
Timing (T)	1.00
Migration (M)	1.00
Potential reservoir-rock facies (R)	1.00
Marginal play probability (MP) (S x T x M x R = MP)	1.00

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1×10^6 BBL; gas, 6×10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	1.00

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

	Probability of occurrence
Reservoir lithology	
Sandstone	X
Carbonate rocks	X
Other	
Hydrocarbon type	
Oil	0.6
Gas	0.4

Fractile percentages *	100	95	75	50	25	5	0
Accumulation size							
Oil (x 10^6 BBL)	1	5	20	75	250	1000	10000
Gas (x 10^9 CFG)	6	30	150	400	1200	5000	50000
Reservoir depth (x 10^3 ft)							
Oil	2			13			25
Gas (non-associated)	2			13			25
Number of accumulations	3	6	9	13	20	30	35

Fractiles * (estimated amounts)

Average ratio of associated-dissolved gas to oil (GOR)	1000	CFG/BBL
Average ratio of NGL to non-associated gas	15	BBL/10^6 CFG
Average ratio of NGL to associated-dissolved gas	0	BBL/10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated.

KANDIK PROVINCE (061)

By Leslie B. Magoon

INTRODUCTION

The Kandik province lies in east-central Alaska (fig. 3) adjacent to Yukon Territory in Canada and covers an area of 42,500 mi^2. Most of the province, the Yukon Flats basin, is covered by Quaternary alluvium (stratigraphic column, fig. 19). This area was assessed as part of the Tertiary Basins play, which is common to four provinces (see Alaska Interior province 062). The area straddles the drainages of the Yukon and Porcupine Rivers and lies north of the Yukon-Tanana crystalline highlands and south of the Brooks Range (fig. 20). The east-central part of the province is considered to be part of the greater Cordilleran thrust belt of western Canada and the United States; this area was defined and assessed as the Cordilleran Thrust play (040). All exploratory drilling in the province (three wells) has been conducted in the Cordilleran Thrust play. These wells, all drilled during the 1970's, found no commercial hydrocarbons.

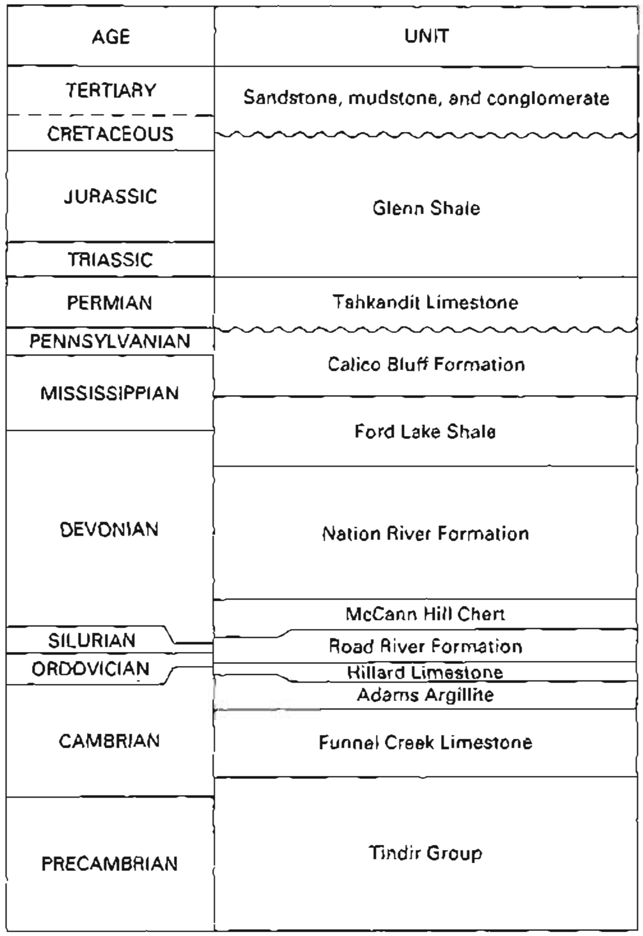

Figure 19. Generalized stratigraphic column, Kandik province (061).

CORDILLERAN THRUST PLAY (040)

The Cordilleran Thrust play (fig. 20) is structural and is characterized by thrust-faulted anticlines affecting clastic and carbonate reservoirs of Paleozoic, Mesozoic, and Tertiary age. The east edge of the play coincides with the Canadian border. The play area is part of the greater Cordilleran thrust belt and is truncated on the southwest by the Tintina fault, an important right-lateral shear. The structural grain of the thrust belt trends northeastward and the direction of thrusting southeastward.

Potential reservoirs include Devonian turbidite sandstone units of the Nation River Formation, Mississippian and Pennsylvanian carbonate turbidites of the Calico Bluff Formation, shallow marine limestone of the Permian Tahkandit Limestone, and unnamed sandstone units of Cretaceous and Tertiary age (fig. 19). Reservoir properties are not known for these units.

Potential source rocks include marine shale in the Late Paleozoic Ford Lake Shale and Calico Bluff Formation, and the Mesozoic Glenn Shale. The organic matter included in these units is of marine origin, and is either thermally mature or overmature. Three wildcat wells have been drilled in the play, with a minor "dead" oil show reported in one well. Active seeps are unknown, but a petroleum odor is conspicuous in the Calico Bluff section on the Yukon River.

Anticipated traps are thrust-related folds. Adequate seals in the form of shale and siltstone cover the anticipated siliciclastic sandstone and carbonate reservoirs. Drill depths range from 1,000 to 15,000 ft. The future petroleum potential of the play is estimated to be moderate.

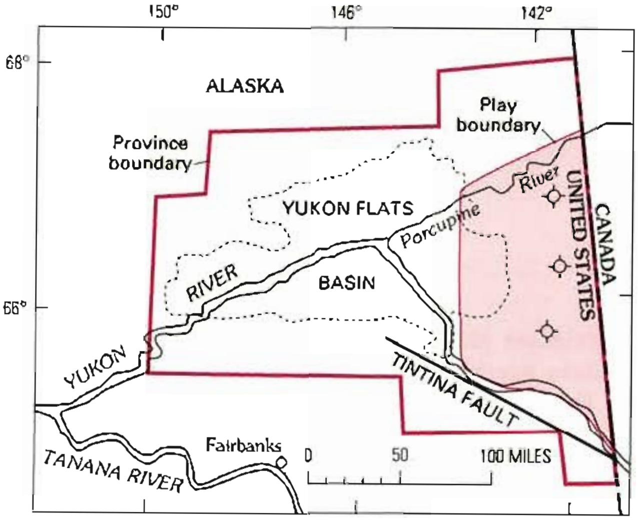

Figure 20. Map of Cordilleran Thrust play (061–040), showing three (dry hole) exploratory wells.

OIL AND GAS PLAY DATA

PLAY CORDILLERAN THRUST
PROVINCE KANDIK CODE 01-061-040

Play attributes

	Probability of attribute being favorable or present
Hydrocarbon source (S)	1.00
Timing (T)	0.50
Migration (M)	0.80
Potential reservoir-rock facies (R)	1.00
Marginal play probability (MP) (S x T x M x R = MP)	0.40

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1 x 10^6 BBL; gas, 6 x 10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	1.00

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

Reservoir lithology	Probability of occurrence
Sandstone	X
Carbonate rocks	X
Other	
Hydrocarbon type	
Oil	1
Gas	0

	Fractiles * (estimated amounts)						
Fractile percentages *	*100*	*95*	*75*	*50*	*25*	*5*	*0*
Accumulation size							
Oil (x 10^6 BBL)	1	30	100	200	350	750	1000
Gas (x 10^9 CFG)	0	0	0	0	0	0	0
Reservoir depth (x 10^3 ft)							
Oil	1			8			15
Gas (non-associated)	0			0			0
Number of accumulations	1	1	1	1	1	1	1

Average ratio of associated-dissolved gas to oil (GOR)	1000	CFG/BBL
Average ratio of NGL to non-associated gas	0	BBL/10^6 CFG
Average ratio of NGL to associated-dissolved gas	0	BBL/10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated.

ALASKA INTERIOR (062), KANDIK (PART) (061), INTERIOR LOWLANDS (063), AND COPPER RIVER BASIN (066) PROVINCES

By Leslie B. Magoon

INTRODUCTION

The four contiguous provinces that make up the interior part of Alaska are the Kandik (061), Alaska Interior (062), Interior Lowlands (063), and Copper River Basin (066) provinces. They lie south of the Brooks Range and north of the provinces bordering the Pacific Ocean, and extend from the Canadian border on the east to the Bering Sea on the west. The provinces are characterized by numerous mountain ranges and low-relief uplands composed of Precambrian to Cenozoic igneous and metamorphic rocks, which are separated by broad, alluviated lowlands (fig. 21). Some parts of the lowland areas are underlain by Cenozoic nonmarine sedimentary basins, as indicated by negative gravity anomalies, a few exploratory wells, and limited surface exposures. At least 10 such basins are present (fig. 22).

Common characteristics of these Cenozoic basins are the following: (1) the sedimentary fill is less dense than the surrounding rocks, and therefore, the basins are reflected as distinct gravity lows; (2) the fill consists mainly of nonmarine fluvial and coal-bearing sedimentary rocks deposited in numerous fining-upward sequences; (3) a pattern of three cycles of sedimentation appears to be present—an early cycle of Paleocene to early Eocene age, a middle cycle of late Eocene to late Miocene age, and a late cycle of late Miocene and Pliocene age; (4) the depocenter for each younger cycle is commonly displaced from the preceding cycle as a result of deformation and uplift; and (5) structure is commonly extensional, but folding related to thrust faulting, high-angle reverse faulting, or transpression by dextral faulting is also recognized.

Only 12 exploratory wells have been drilled in these interior provinces—2 each in the Bethel and Nenana basins and 8 in the Copper River basin. Only minor gas indications were reported. Because of the apparent similarities of the interior Alaskan basins, they were grouped together and assessed as a single play, the Tertiary Basins play.

AGE	UNIT
QUAT.	Alluvium and glacial deposits
TERTIARY	Unnamed sedimentary rocks
PRE-TERTIARY	Unnamed igneous, metamorphic, and sedimentary rocks

Figure 21. Generalized stratigraphic column for Alaska Interior (062), Kandik (part) (061), Interior Lowlands (063), and Copper River Basin (066) provinces.

TERTIARY BASINS PLAY (020)

The Tertiary Basins play is characterized by speculative gas accumulations in structural (mainly domal) traps in sandstone reservoirs of Tertiary age. The Beluga-Sterling play in the Cook Inlet province (067) is considered to be an analog for the play, in that expected gas would be primarily microbial in origin, but would include minor amounts of thermally generated gas. The Tertiary Basins play includes those basins in the four provinces that are filled with Tertiary sediments (fig. 22). Expected source rocks are coal, or rocks containing closely associated humic kerogen (Type III). Shale and siltstone that overlie the sandstone reservoirs would provide adequate seals.

Reservoirs include nonmarine fluvial channel sandstones similar to those known in the analog Tertiary Beluga and Sterling Formations. Sandstone reservoirs in these formations have water saturations that range from 35 to 50 percent, porosities that range from 10 to 37 percent, and permeabilities that range from 3.5 to 4,400 millidarcies. Thickness of net pay ranges from 20 to 213 ft.

Because overburden is not required to create microbial gas from source rocks, undiscovered gas accumulations may be found wherever a thin but adequate seal rock in a trapping situation exists. Additional thermogenic gas may be present in basins with sedimentary fill greater than 10,000 ft thick. The future gas potential, at least for local usage, is estimated to be fair to good.

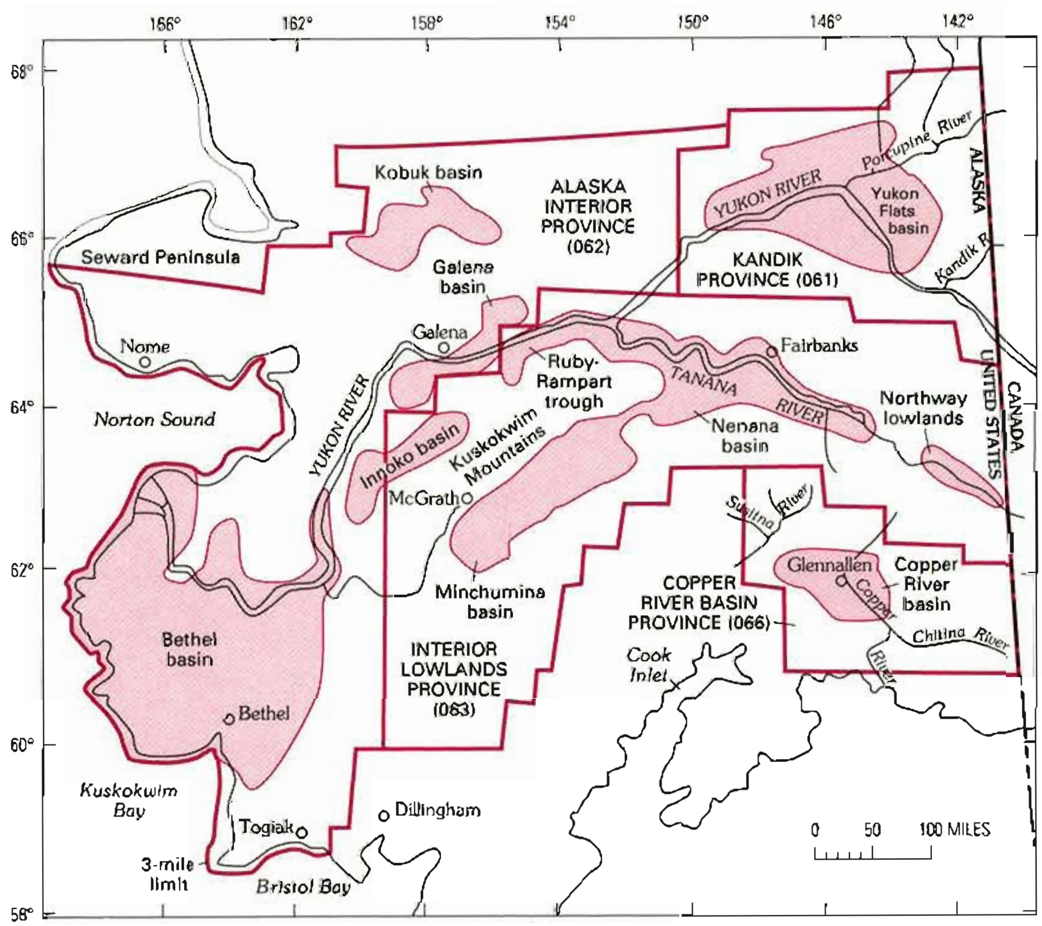

Figure 22. Map of Tertiary Basins play (020) in provinces 061, 062, 063, and 066.

OIL AND GAS PLAY DATA

PLAY TERTIARY BASINS
PROVINCE ALASKA INTERIOR CODE 01-062-020

Play attributes	Probability of attribute being favorable or present
Hydrocarbon source (S)	1.00
Timing (T)	1.00
Migration (M)	1.00
Potential reservoir-rock facies (R)	1.00
Marginal play probability (MP) (S x T x M x R = MP)	1.00

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1×10^6 BBL; gas, 6×10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	1.00

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

	Probability of occurrence
Reservoir lithology	
Sandstone	X
Carbonate rocks	
Other	
Hydrocarbon type	
Oil	0
Gas	1

Fractiles * (estimated amounts) — Fractile percentages *	100	95	75	50	25	5	0
Accumulation size							
Oil ($\times 10^6$ BBL)	0	0	0	0	0	0	0
Gas ($\times 10^9$ CFG)	100	300	700	1000	1600	2400	4000
Reservoir depth ($\times 10^3$ ft)							
Oil	0			0			0
Gas (non-associated)	0			0			0
Number of accumulations	1	1	1	1	1	1	1

Average ratio of associated-dissolved gas to oil (GOR)	0	CFG/BBL
Average ratio of NGL to non-associated gas	0.06	BBL/10^6 CFG
Average ratio of NGL to associated-dissolved gas	0	BBL/10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated

BRISTOL BASIN PROVINCE (064)

By Leslie B. Magoon

INTRODUCTION

The Bristol Basin province is elongate in configuration and fringes Bristol Bay, covering about 25,000 mi^2 in area. The province extends 500 mi from Unimak Island on the southwest to Illiamna Lake in the northeast. Part of it borders the Alaska Peninsula province (068) and Pacific Ocean on the southwest, the Cook Inlet province (067) on the east, and the Alaska Interior province (062) on the north (fig. 3).

The province includes part of the Alaska Peninsula fold belt—a broadly folded sequence of mostly Mesozoic sedimentary and volcanic rocks (fig. 23) more than 20,000 ft thick—and the onshore part of the Tertiary Bristol basin. The Bristol basin and contiguous North Aleutian basin are back-arc basins that began to form in early Tertiary time and were filled with more than 12,000 ft of mostly marine siliciclastic sediment. Basin fill was probably derived from the Aleutian volcanic arc to the south and from the complex of igneous, metamorphic, and sedimentary rocks that make up the southwest part of Alaska, located to the north and northeast of the basin. The lower Tertiary section consists of coal-bearing sandstone and mudstone, the Eocene part of which is volcaniclastic. The upper Tertiary part of the section consists of shallow marine to nonmarine coal-bearing sandstone and mudstone grading upward to nonmarine sand and gravel.

Sporadic exploration has been conducted in the province since 1959 with the drilling of 11 wells, 9 of which are located in the Bristol basin (fig. 24). The most recent well was drilled in 1985. Indications of gas are reported in some wells with minor oil indications in early Tertiary and pre-Tertiary rocks. No hydrocarbon accumulations have been found. One play, the Tertiary play, was individually assessed.

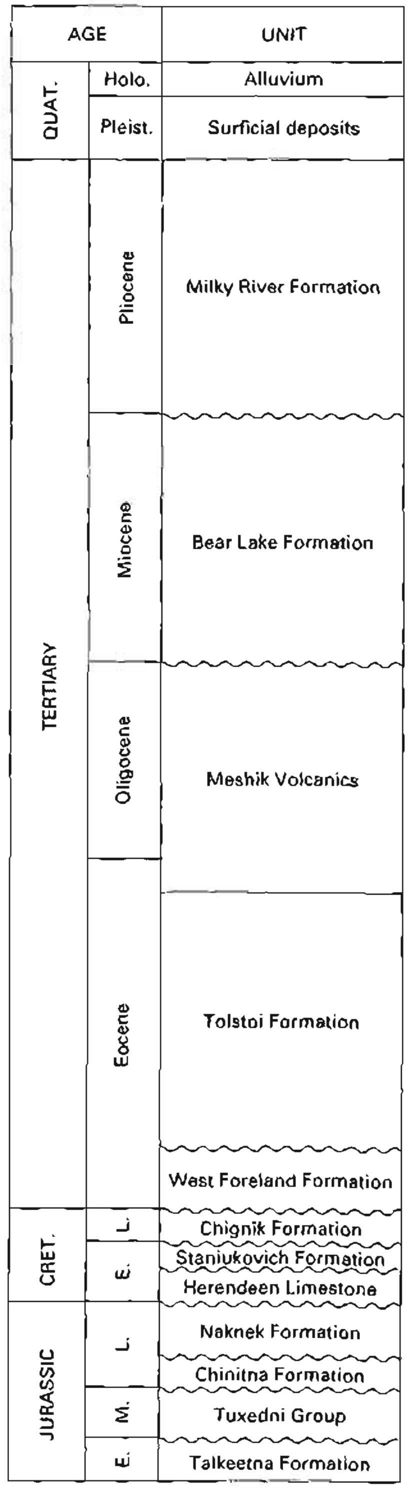

Figure 23. Generalized stratigraphic column, Bristol Basin province (064).

TERTIARY PLAY (020)

The Tertiary play involves structural (mainly domal) traps for gas in sandstone reservoirs of Tertiary age. The Beluga-Sterling play in the Cook Inlet province (067) is an analog for the play, because the expected gas is primarily microbial in origin with only minor amounts of thermal gas. The play includes only those areas that are covered by Tertiary sediments. Expected source rocks for the play are sediments containing coal or humic kerogen (Type III). Adequate seals are shale and siltstone that overlie the sandstone reservoirs.

Reservoirs may include nonmarine sandstone units similar to those in the Beluga and Sterling Formations as well as some shallow marine sandstone. The analog reservoirs have water saturations of 35–50 percent, porosities of 10–37 percent, and permeabilities of 3.5–4,400 millidarcies. Net pay thickness ranges from 20 to 200 ft.

Because overburden is not required to create microbial gas from source rocks, undiscovered gas accumulations may be found wherever thin but adequate seal rock exists in association with reservoirs in a trapping condition. In addition, thermogenic gas is from humic or coaly source rocks, the anticipated type of sediments in the play, at depths greater than 10,000 ft. The future gas potential is estimated to be fair.

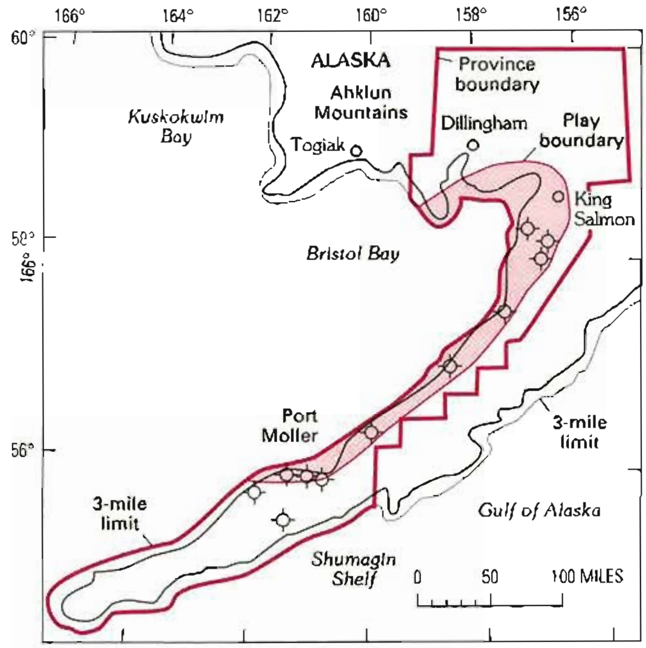

Figure 24. Map of Tertiary play (064–020), showing exploratory wells.

OIL AND GAS PLAY DATA

PLAY TERTIARY
PROVINCE BRISTOL BASIN CODE 01-064-020

Play attributes

	Probability of attribute being favorable or present
Hydrocarbon source (S)	1.00
Timing (T)	1.00
Migration (M)	1.00
Potential reservoir-rock facies (R)	1.00
Marginal play probability (MP) (S x T x M x R = MP)	1.00

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1×10^6 BBL; gas, 6×10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	1.00

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

Reservoir lithology	Probability of occurrence
Sandstone	X
Carbonate rocks	
Other	
Hydrocarbon type	
Oil	0
Gas	1

Fractiles * (estimated amounts)

Fractile percentages *	100	95	75	50	25	5	0
Accumulation size							
Oil ($\times 10^6$ BBL)	0	0	0	0	0	0	0
Gas ($\times 10^9$ CFG)	6	6.4	8.2	12	20.6	55	150
Reservoir depth ($\times 10^3$ ft)							
Oil	0			0			0
Gas (non-associated)	1.5			7			11
Number of accumulations	3	4	7	10	15	23	30

Average ratio of associated-dissolved gas to oil (GOR)	0	CFG/BBL
Average ratio of NGL to non-associated gas	0	BBL / 10^6 CFG
Average ratio of NGL to associated-dissolved gas	0	BBL / 10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated

HOPE BASIN PROVINCE (065)

By Michael A. Fisher

The onshore part of the structural Hope basin lies east and south of Kotzebue Sound, and together with the associated Kotzebue basin, underlies the northern Seward Peninsula and the lowlands that fringe the east and north sides of the Chukchi Sea (fig. 25). The main part of Hope basin lies offshore, where Cenozoic rocks range from 16,000 to 20,000 ft thick. The Hope basin could contain rocks as old as Paleocene, but shoreward parts of the basin include a progressively thinner, younger section.

The Hope Basin province encompasses a land area of 15,600 mi^2. Two wildcat exploratory wells have been drilled onshore, both by Standard Oil Company of California. The #1 Nimiuk Point well was spudded in 1974 and reached a total depth of 6,310 ft; the #1 Cape Espenberg well was spudded in 1975 and reached a total depth of 8,320 ft. Rocks in the Cape Espenberg well are richly volcanogenic from total depth up to about 5,000 ft; above 5,000 ft, the volcanic fraction decreases, and the section includes much sandstone and shale.

Seismic reflection data show that the sedimentary fill within the overall Hope basin is as thick as ≈10,000 ft, and the fill thins and onlaps shoreward. In onshore areas, wells and scattered proprietary seismic sections show that probable Cenozoic fill is less than 3,300 ft thick, but thicker (6,000 ft) Cenozoic rocks are present in isolated half-grabens. To search for hydrocarbons with much expectation seems unrealistic except in the areas of the half-grabens; the onshore and nearshore parts of the basins include thin basin fill, most of which is not associated with oil source rocks—if any exist—in the main part of the basin.

The Hope Basin province overlies two types of basement rock: (1) deformed and metamorphosed Paleozoic rocks that crop out on the Seward Peninsula, and (2) strongly deformed Cretaceous turbidite sequences and volcanic rocks, which are exposed east of the province. The Cretaceous volcanogenic turbidite sequences and andesitic volcanic rocks are characterized by poor porosity and permeability, and laumontite completely occludes pore spaces in rocks exposed over large areas.

Rocks as old as Eocene penetrated by the two wells drilled in the Hope Basin province are thermally immature. Pyrolysis data show that these rocks have a poor potential to generate liquid hydrocarbons, because the kerogen is gas prone, primarily Type III, which requires a burial depth of about 5,600 ft to achieve a vitrinite reflectance of 0.6. The sediment fill would need to be at least as thick to generate oil; however, biogenic gas may be present. Both the Paleozoic and the Cretaceous basement rocks penetrated by the wells are thermally overmature and are not likely to be source rocks for hydrocarbons. No plays were identified, and no assessment of resources was made.

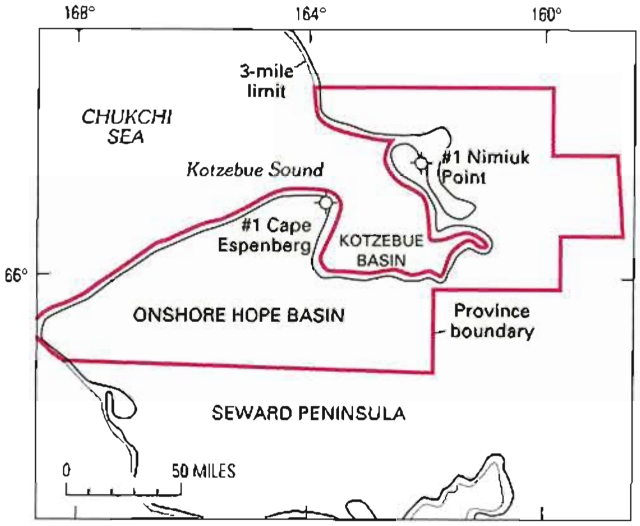

Figure 25. Map of Hope Basin province (065), showing exploratory wells.

COOK INLET PROVINCE (067)

By Leslie B. Magoon

INTRODUCTION

The Cook Inlet province is located in southern Alaska (fig. 3) and is 450×270 mi in extent. It comprises several tectonostratigraphic terranes with complex stratigraphy and structure, the result of its position on the tectonically active north Pacific margin. This area has been the site of continuous convergence throughout the Mesozoic and Cenozoic. Its prominent feature, the Cook Inlet embayment, is located in the middle of a Tertiary sedimentary basin, 175 mi long by 70 mi wide, which trends in a northeasterly direction. The Tertiary Cook Inlet basin, bordered on the west and northwest by the Alaska and Aleutian Ranges and on the southeast by the Chugach and Kenai Mountains, is a deep fault-bounded trough filled with nonmarine sedimentary rocks (fig. 26) more than 20,000 ft thick. Oil and gas accumulations are found in sandstone reservoirs in structural traps that formed in Pliocene time. Oil in this province is identified as coming from Jurassic marine shale that lies unconformably beneath the basin. The thick sedimentary fill of the Cook Inlet basin is required to mature these source rocks.

Exploration has been conducted in the province since 1902, when seven wells were drilled into pre-Tertiary rocks on the southwest margin of the basin. The first commercial oil accumulation was not discovered until 1957. During the following 15 years, 7 oil and 23 gas accumulations were discovered. The largest oil field is McArthur River with about 570 MMB of recoverable oil; the largest gas field is Kenai with 2.3 TCF of recoverable gas. By the end of 1986, about 1.1 BBO and 5.3 TCFG had been produced from the basin. Two plays, the Beluga-Sterling and Hemlock Conglomerate, were individually assessed. Most of the area of the province assessed lies in State waters.

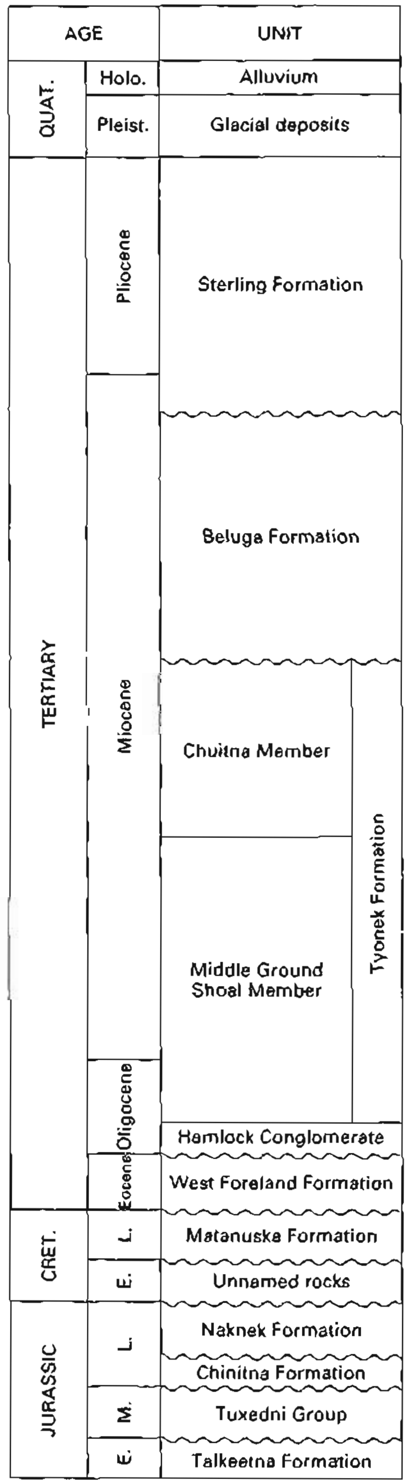

Figure 26. Generalized stratigraphic column, Cook Inlet province (067).

BELUGA-STERLING PLAY (020)

In the Beluga-Sterling play, gas accumulated in structural (mainly domal) traps that include siliciclastic reservoirs of Tertiary age. The play is approximately 130 mi long by 50 mi wide (fig. 27). Maximum thickness of sedimentary rocks in the play is 14,000 ft.

Known reservoirs include nonmarine fluvial channel sandstones of the Miocene Beluga and Miocene and Pliocene Sterling Formations (fig. 26). These reservoirs have water saturations of 35–50 percent, porosities of 10–37 percent, and permeabilities of 3.5–4,400 millidarcies. Net pay thickness ranges from 20 to 213 ft.

The source of the gas is uncertain, but the Beluga Formation and, to a lesser extent, the Sterling Formation contain considerable coal and Type III kerogen. This source is in a good stratigraphic position to charge the overlying reservoirs with microbial gas. Because no overburden is required to mature the source rocks, undiscovered gas accumulations may be found throughout the play.

Traps are expected to be domal structures, and adequate seals exist in the form of shale and siltstone that overlie sandstone reservoirs. Drill depths may be as deep as 10,000 ft. Dry gas exceeding 3.1 TCF from 14 fields in the play has been produced to the end of 1986, and an additional 10 fields that are shut-in contain an unknown amount of gas. The largest fields in the play are Kenai and North Cook Inlet. The future gas potential of the play is good.

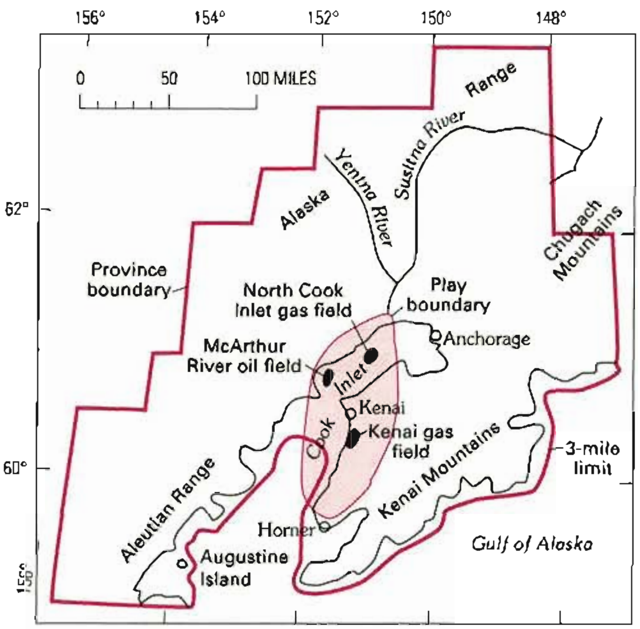

Figure 27. Map of Beluga-Sterling play (067–020).

OIL AND GAS PLAY DATA

PLAY BELUGA-STERLING
PROVINCE COOK INLET CODE 01-067-020

Play attributes	Probability of attribute being favorable or present
Hydrocarbon source (S)	1.00
Timing (T)	1.00
Migration (M)	1.00
Potential reservoir-rock facies (R)	1.00
Marginal play probability (MP) (S x T x M x R = MP)	1.00

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1×10^6 BBL; gas, 6×10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	1.00

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

Reservoir lithology	Probability of occurrence
Sandstone	X
Carbonate rocks	
Other	
Hydrocarbon type	
Oil	0
Gas	1

Fractile percentages *	Fractiles * (estimated amounts) 100	95	75	50	25	5	0
Accumulation size							
Oil (x 10^6 BBL)	0	0	0	0	0	0	0
Gas (x 10^9 CFG)	6	6.6	9.6	17	37	190	2000
Reservoir depth (x10^3 ft)							
Oil	0			0			0
Gas (non-associated)	2			4			10
Number of accumulations	3	5	9	12	17	24	30

Average ratio of associated-dissolved gas to oil (GOR)	0	CFG/BBL
Average ratio of NGL to non-associated gas	0.06	BBL/10^6 CFG
Average ratio of NGL to associated-dissolved gas	0	BBL/10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated.

HEMLOCK CONGLOMERATE PLAY (030)

The play is structural and involves oil fields that produce from siliciclastic reservoirs of Oligocene age in faulted anticlinal traps. The play is approximately 170 mi long by 50 mi wide, and its area is limited approximately to where Middle Jurassic rocks subcrop beneath Tertiary age reservoir rocks (fig. 28). Maximum thickness of the sedimentary section involved is 8,000 ft.

Productive reservoirs include nonmarine sandstone units of the Oligocene Hemlock Conglomerate and Oligocene and Miocene Tyonek Formation (fig. 26). Minor reservoirs include the Upper Cretaceous Matanuska Formation, and the Eocene West Foreland Formation. In these reservoirs, water saturations range from 35 to 40 percent, porosities range from 11 to 24 percent, and permeabilities range from 10 to 360 millidarcies. Net pay thickness ranges from 70 to 1,000 ft.

The source of the oil is shale in the Middle Jurassic Tuxedni Group. Organic matter included in the source rock is marine Type II kerogen; the source rock is unconformably overlain by Tertiary reservoir rocks. Throughout the Cook Inlet area, burial depths in excess of 15,000 ft are required to achieve thermal maturation of source rocks. In late Pliocene time the Tuxedni Group was buried deeply enough to generate oil with associated gas that migrated across the unconformity where Tertiary rocks truncate the source rock. Migration and accumulation occurred at the same time, or shortly before anticlinal structures formed. Because some of the oil is in sandstone reservoirs within the Matanuska Formation, it is possible that faults were also migration conduits.

Anticipated traps are probably anticlinal structures and stratigraphic traps of limited areal size. Adequate seals in the form of shale and siltstone cover the sandstone reservoirs. These reservoirs are known to contain oil to depths of 16,000 ft, but could contain oil to depths of 18,000 ft because of the very low geothermal gradient. More than 1.17 BBO from five fields in the play has been produced to the end of 1986, and one additional field that contains an unknown amount of oil is shut-in. The size of the oil fields ranges from 90 MMBO to 570 MMBO; however, the future undiscovered potential of the play is low.

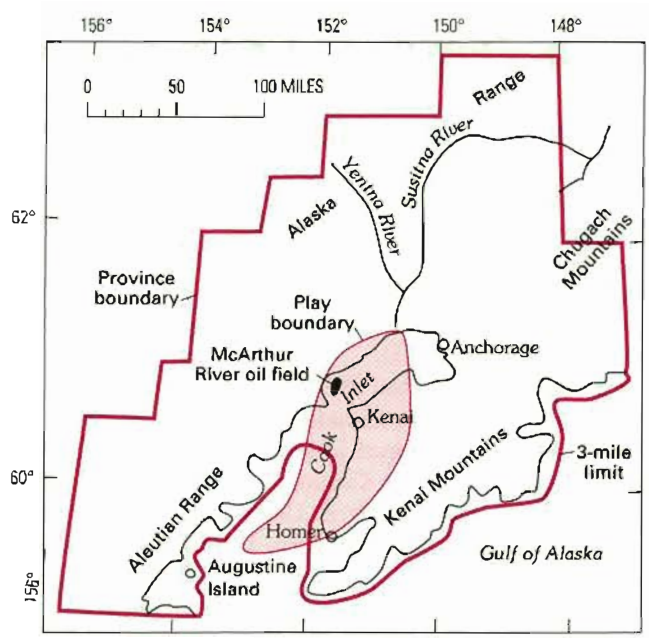

Figure 28. Map of Hemlock Conglomerate play (067–030).

OIL AND GAS PLAY DATA

PLAY HEMLOCK CONGLOMERATE
PROVINCE COOK INLET CODE 01-067-030

Play attributes

	Probability of attribute being favorable or present
Hydrocarbon source (S)	1.00
Timing (T)	1.00
Migration (M)	1.00
Potential reservoir-rock facies (R)	1.00
Marginal play probability (MP) (S x T x M x R = MP)	1.00

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1×10^6 BBL; gas, 6×10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	1.00

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

	Probability of occurrence
Reservoir lithology	
Sandstone	X
Carbonate rocks	
Other	
Hydrocarbon type	
Oil	1
Gas	0

Fractile percentages *	100	95	75	50	25	5	0
Accumulation size							
Oil ($\times 10^6$ BBL)	1	1.6	4.3	10	23	75	230
Gas ($\times 10^9$ CFG)	0	0	0	0	0	0	0
Reservoir depth ($\times 10^3$ ft)							
Oil	5			10			15
Gas (non-associated)	0			0			0
Number of accumulations	2	4	7	10	15	20	25

(Fractiles * (estimated amounts))

Average ratio of associated-dissolved gas to oil (GOR)	750	CFG/BBL
Average ratio of NGL to non-associated gas	0	BBL /10^6 CFG
Average ratio of NGL to associated-dissolved gas	0	BBL /10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated.

ALASKA PENINSULA PROVINCE (068)

By Leslie B. Magoon *and* Hugh McLean

The Alaska Peninsula province is long and narrow and includes the southeastern two-thirds of the Alaska Peninsula, an area of about 12,000 mi^2. The province extends 320 mi from Kamishak Bay in the northeast to Stepovak Bay on the southwest. The northwestern boundary coincides with the approximate onshore edge of the Tertiary Bristol Basin province. The southeastern boundary is the State-Federal 3-mile offshore boundary in the Pacific Ocean (fig. 3).

The province contains more than 20,000 ft of sedimentary and volcanic rocks of Permian to Quaternary age that are intruded by Jurassic and younger igneous rocks. Mesozoic sedimentary rocks, deformed in broad, open folds, are widely exposed and make up most of the province. Early Cenozoic sedimentary and volcanic rocks generally lie along the margins of the province. Late Cenozoic stratovolcanoes, part of the Aleutian arc, overlie Mesozoic rocks and form a distinctive but relatively minor geologic feature of the province.

Potential reservoir rocks are primarily sandstone of Jurassic, Cretaceous, and Tertiary age; bioclastic limestone of Early Permian and Late Triassic age is of lesser importance. Sandstone units of Early and Middle Jurassic and Tertiary age are generally volcaniclastic with poor reservoir characteristics. Upper Jurassic rocks derived from erosion of a nearby granitic source comprise the thickest and most widespread potential reservoirs. However, petrographic studies show that these rocks are cemented with laumontite and have low conventional porosity. Areas that have not been intruded by large igneous bodies have limited potential due to widespread intrusion of volcanic dikes and sills of late Tertiary and Quaternary age.

Much of the Mesozoic sequence of the Alaska Peninsula contains marine shale and mudstone suitable for both source rocks and seal rocks. Black shale is especially abundant in Late Cretaceous rocks in the southwestern part of the peninsula. The Triassic limestone and chert section at Puale Bay is thermally mature, and, in the same area, oil seeps emanate from Middle Jurassic shale and mudstone. In general, Mesozoic source rocks lie within the window for oil and gas generation, except locally where igneous intrusion renders them overmature.

Most of the broad open folds on the peninsula formed in Pliocene time, which may help explain why the major structures tested by drilling have been dry. By Pliocene time, Mesozoic rocks would have been subjected to diagenesis associated with late Tertiary arc volcanism and plutonism that caused potential reservoirs to be hard and tight and closed potential migration pathways.

The Mesozoic section on the Alaska Peninsula has been sporadically explored without commercial success for nearly 90 years. The earliest exploration effort, in 1904, consisted of several shallow wells drilled near oil seeps. The six deep test wells in the province (fig. 29) were drilled on large-scale structures between 1940 and 1981; indications of oil and gas were encountered in several of these wells. The most recent wildcat, Chevron's Koniag No. 1, was drilled in 1981 on the Pacific Coast side of the peninsula near Amber Bay. Prospects for drilling additional wells on the Alaska Peninsula should be viewed with guarded optimism. No assessment of resources was made for this province.

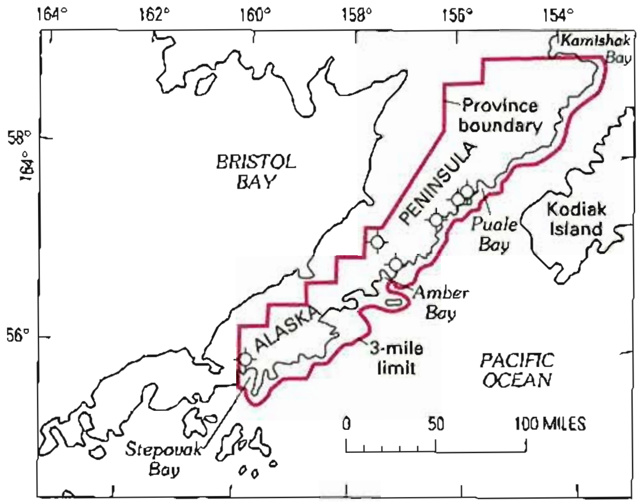

Figure 29. Map of Alaska Peninsula province (068), showing six deep test wells.

GULF OF ALASKA PROVINCE (069)

By Terry R. Bruns

INTRODUCTION

The Gulf of Alaska province stretches about 350 mi from Prince William Sound on the west to Lituya Bay on the east. It extends seaward from lat 61° N. and the Canada/United States border and includes Middleton Island and State waters 3 mi seaward of the shoreline (fig. 3). Sedimentary rocks with hydrocarbon potential are exposed in a band as much as 6 mi wide along the shoreline near Lituya Bay. These rocks have been sampled in exploratory wells near Yakutat Bay and beneath the adjacent coastal plain east of Yakutat Bay, and crop out in an area as much as 45 mi wide of the coastal plain and foothills from Yakutat Bay to west of Kayak Island. Cenozoic sedimentary rocks (fig. 30) are also found beneath Middleton Island and in State waters surrounding it. The area within the province underlain by Cenozoic rocks measures about 7,240 mi^2.

Paleocene through Oligocene rocks within the coastal sedimentary belt are known to include some sections with favorable hydrocarbon characteristics, including thermally mature source rocks and reservoirs. Miocene and younger rocks may have some reservoir potential but include no *known* good source rocks. The structural complexity and the young development age of potential traps within the province have apparently prevented commercial hydrocarbon accumulations in the anticlines that have so far been tested. Thus, major reasons for the lack of oil or gas discoveries include the young age and complexity of structures, poor source-rock potential of the thick Miocene and younger overlying sequence, and a lack of reservoir rocks in the lower Tertiary sections tested by drilling. Certain attributes indicative of hydrocarbon potential in the province include extensive oil and gas seeps and numerous anticlinal structures. The most positive attribute was the discovery of a small field at Katalla that produced minor amounts of oil between 1902 and 1933 before being abandoned. Two plays were identified and individually assessed in the province: Tertiary Gas and Tertiary Oil.

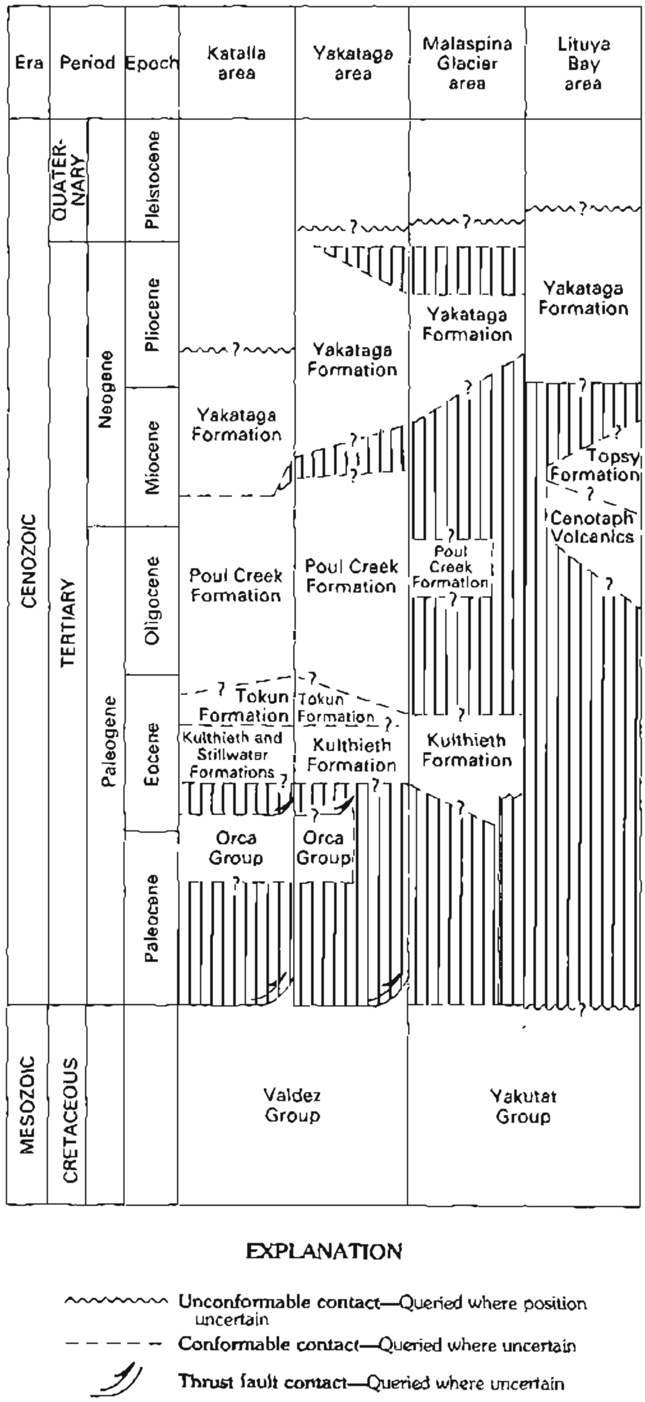

Figure 30. Generalized stratigraphic column, Gulf of Alaska province (069). Vertical line pattern, hiatus; queried where extent uncertain.

TERTIARY GAS PLAY AND TERTIARY OIL PLAY (020) (030)

The two plays are treated for this discussion as a single play in that they have a common play area; however, for purposes of resource estimation, they were assessed as individual plays, differentiated only by the commodities assessed. The play is characterized by Paleocene to Miocene age clastic reservoirs and shale source rocks in complexly faulted anticlinal traps. The play area trends west to southeast, covers about 20,000 mi^2, and is bounded by the Ragged Mountain, Chugach-St. Elias, and Fairweather fault systems and the State-Federal 3-mile offshore boundary (fig. 31). Rocks beneath Kayak and Middleton Islands are also included in the play.

Reservoirs are primarily barrier beach and deltaic sandstones in the Eocene Stillwater, Kulthieth, and Tokun Formations (fig. 30). Maximum thickness of these formations is about 10,000, 9,000, and 3,000 ft, respectively. Fractured Oligocene and Miocene shale units in the Poul Creek Formation, as much as 6,000 ft thick, also act as reservoirs. Also included in the total rock sequence is the Miocene and younger Yakataga Formation, which consists mainly of marine diamictite and reaches a maximum thickness of 20,000 ft. Reservoir sandstones in Paleogene formations are mostly poorly sorted and mineralogically unstable; diagenetic alteration of grain matrix has produced widespread zeolite cement and pseudomatrix. The sandstones have been strongly deformed during burial, causing extensive grain alteration and interpenetration. As a result, quality of reservoirs is generally poor.

Potential source rocks are shale units in the Stillwater, Kulthieth, Tokun, and Poul Creek Formations. Total organic-carbon content in selected, organic-rich samples ranges from 0.42 to 1.87 percent, but this includes substantial reworked kerogen. The organic matter is predominantly herbaceous, with subordinate amounts of woody and amorphous kerogen, and can generate both oil and gas. In outcrops and well samples, the rocks are thermally immature to marginally mature. Organic carbon in the Yakataga Formation rarely exceeds 0.5 percent, and it is immature; these rocks have poor source-rock characteristics. Hydrocarbon generation and migration from Paleogene rocks most likely occurred during the late Cenozoic, concurrent with (1) thermal heating and expulsion of generated hydrocarbons during burial by the thick Yakataga Formation, and (2) anticlinal deformation. Migration of hydrocarbons in seeps appears to be largely fault controlled. The present heat-flow regime is relatively cool, with the geothermal gradient estimated at 1.1–1.65 °F/100 ft based on temperatures measured in wells.

The play area is underlain by a late Cenozoic fold-and-thrust belt in which faulted anticlines provide potential hydrocarbon traps. Paleogene or early Neogene anticlines may have been present, and could have been overprinted by later Cenozoic deformation. Traps could also be formed by structural or stratigraphic closure against faults. However, structural complexity onshore is so extreme as to make trap potential unfavorable on many if not most structures. Shale units in both the Poul Creek and Yakataga Formations could provide seals for underlying reservoir rocks.

The play is moderately explored. The small Katalla field produced the only commercial oil from the Gulf of Alaska, about 154,000 barrels between 1902 and 1933, from shallow fracture zones in shale of the Poul Creek Formation. Elsewhere, 25 dry holes and coreholes have been drilled, mainly on major anticlines, and one additional well was drilled near Middleton Island. In the adjacent offshore, 11 dry holes were drilled between 1976 and 1983 on the most promising structures. Thus, the most favorable accessible structures throughout the Gulf of Alaska have apparently been tested. The failure to find commercial hydrocarbons apparently results from complicated structure, poor reservoir quality, and immature or poor source rocks. Future potential for gas and oil is estimated to be moderate, and exploration may be largely for hard-to-define traps lying below the surface structures and thrust faults that cut the play area.

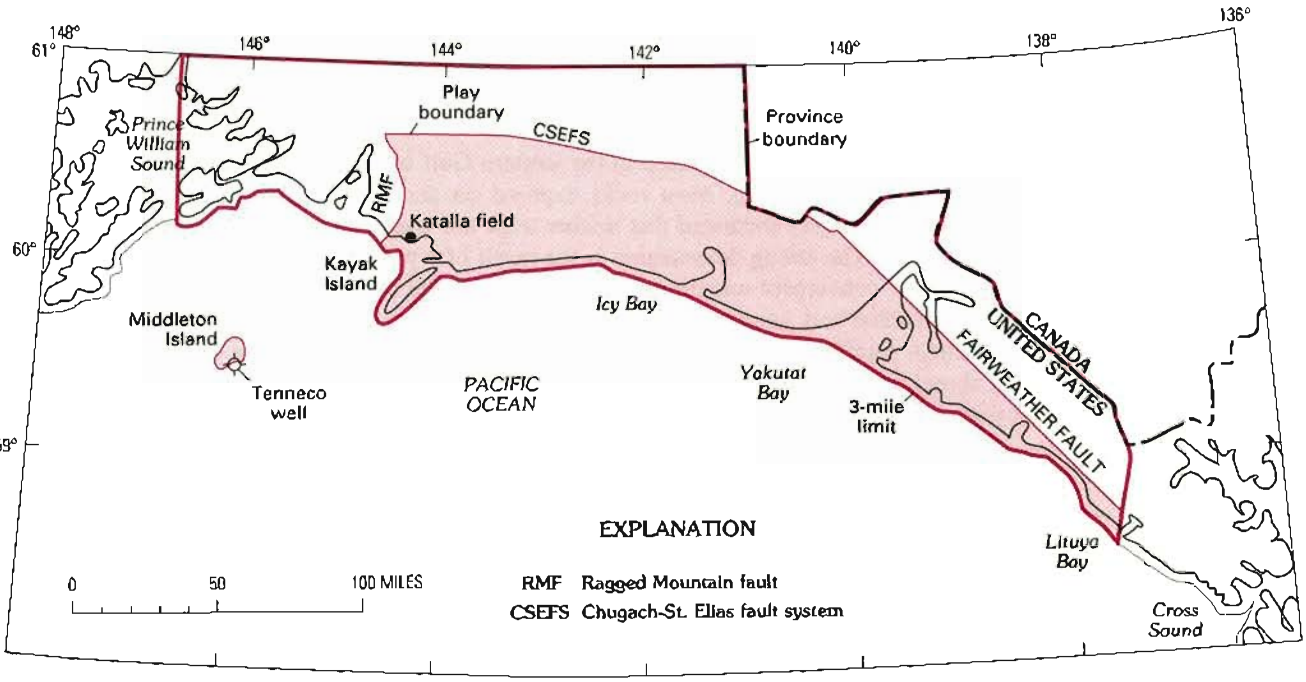

Figure 31. Map of Tertiary Gas play and Tertiary Oil play (069–020, 030).

OIL AND GAS PLAY DATA

PLAY TERTIARY GAS
PROVINCE GULF OF ALASKA CODE 01-069-020

Play attributes

	Probability of attribute being favorable or present
Hydrocarbon source (S)	1.00
Timing (T)	1.00
Migration (M)	1.00
Potential reservoir-rock facies (R)	1.00
Marginal play probability (MP) (S x T x M x R = MP)	1.00

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1 x 10^6 BBL; gas, 6 x 10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	0.25

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

	Probability of occurrence
Reservoir lithology	
Sandstone	X
Carbonate rocks	
Other	
Hydrocarbon type	
Oil	0
Gas	1

Fractiles * (estimated amounts)

Fractile percentages *	100	95	75	50	25	5	0
Accumulation size							
Oil (x 10^6 BBL)	0	0	0	0	0	0	0
Gas (x 10^9 CFG)	60	120	300	600	1200	4200	5000
Reservoir depth (x10^3 ft)							
Oil	0			0			0
Gas (non-associated)	2			7.5			15
Number of accumulations	1	1	1	1	1	1	1

Average ratio of associated-dissolved gas to oil (GOR)	0	CFG/BBL
Average ratio of NGL to non-associated gas	4	BBL/10^6 CFG
Average ratio of NGL to associated-dissolved gas	0	BBL/10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated.

OIL AND GAS PLAY DATA

PLAY TERTIARY OIL
PROVINCE GULF OF ALASKA CODE 01-069-030

Play attributes

	Probability of attribute being favorable or present
Hydrocarbon source (S)	1.00
Timing (T)	1.00
Migration (M)	1.00
Potential reservoir-rock facies (R)	1.00
Marginal play probability (MP) (S x T x M x R = MP)	1.00

Accumulation attribute, conditional on favorable play attributes

Minimum size assessed: oil, 1 x 10^6 BBL; gas, 6 x 10^9 CFG

	Probability of occurrence
At least one undiscovered accumulation of at least minimum size assessed	0.80

Character of undiscovered accumulations, conditional on at least one undiscovered accumulation present

	Probability of occurrence
Reservoir lithology	
Sandstone	X
Carbonate rocks	
Other	
Hydrocarbon type	
Oil	0
Gas	0

Fractiles * (estimated amounts)

Fractile percentages *	100	95	75	50	25	5	0
Accumulation size							
Oil (x 10^6 BBL)	10	20	50	100	350	700	800
Gas (x 10^9 CFG)	0	0	0	0	0	0	0
Reservoir depth (x10^3 ft)							
Oil	2			7.5			0.5
Gas (non-associated)	0			0			0
Number of accumulations	1	1	1	1	1	1	1

Average ratio of associated-dissolved gas to oil (GOR)	1000	CFG/BBL
Average ratio of NGL to non-associated gas	0	BBL/10^6 CFG
Average ratio of NGL to associated-dissolved gas	0	BBL/10^6 CFG

* For example, fractile percentage 95 represents a 19 in 20 chance of the occurrence of at least the fractile tabulated.

KODIAK ISLAND PROVINCE (070)

By Michael A. Fisher

The Kodiak Island province is located in the western Gulf of Alaska and covers an area of about 7,800 mi^2 (fig. 32). Most rocks exposed on the Kodiak islands are so strongly deformed and highly indurated that neither traps nor reservoir rocks for hydrocarbons are expected. The strong deformation is the result of a protracted Mesozoic and Cenozoic history of convergent-margin tectonics. Although the bleak assessment does not pertain to Miocene and younger rocks, their limited onshore exposure means that they could contain significant hydrocarbons only in offshore areas. Furthermore, within 3 mi of the shoreline (State-Federal boundary) seismic reflection data indicate that these rocks are thin and unlikely to contain hydrocarbons in economic quantities.

Values of vitrinite reflectance and thermal alteration index from samples obtained on the islands suggest that Eocene and Oligocene rocks, as well as Neogene rocks, are either immature or just barely mature for generating hydrocarbons. These rocks generally have less than 0.4 percent organic carbon, which is contained in woody and herbaceous kerogen. Paleocene and older rocks are thermally overmature for hydrocarbon generation. Scattered measurements of porosity and permeability indicate that rocks of nearly all ages would make poor reservoirs for hydrocarbons.

The Kodiak group of islands are underlain by the Peninsular, Chugach, and Prince William tectonostratigraphic terranes. Along the northwest coasts of the islands, the Peninsular and Chugach terranes lie sutured along the Border Ranges fault. The Peninsular terrane includes Triassic sandstone and greenstone as well as Early Jurassic plutonic and metamorphic rocks. The Chugach terrane includes Cretaceous melange and strongly deformed, uppermost Cretaceous turbidite sequences. The Prince William terrane crops out along the southeast coasts of the islands and is represented by Paleogene, strongly deformed turbidite sequences, melange and locally exposed basalt. Post-Eocene rocks form an overlap sequence that crops out in scattered patches, and the sequence unconformably overlies the Eocene and older turbidite sequences. The overlap sequence includes Oligocene nonmarine and Miocene marine sandstone as well as upper Miocene sandstone and conglomerate.

Six COST (Continental Offshore Stratigraphic Test) wells were drilled offshore, but these wells led to no sustained offshore exploration activity, and the onshore area of this province has rightly been ignored. No plays were identified in the province, and no assessment of resources was made.

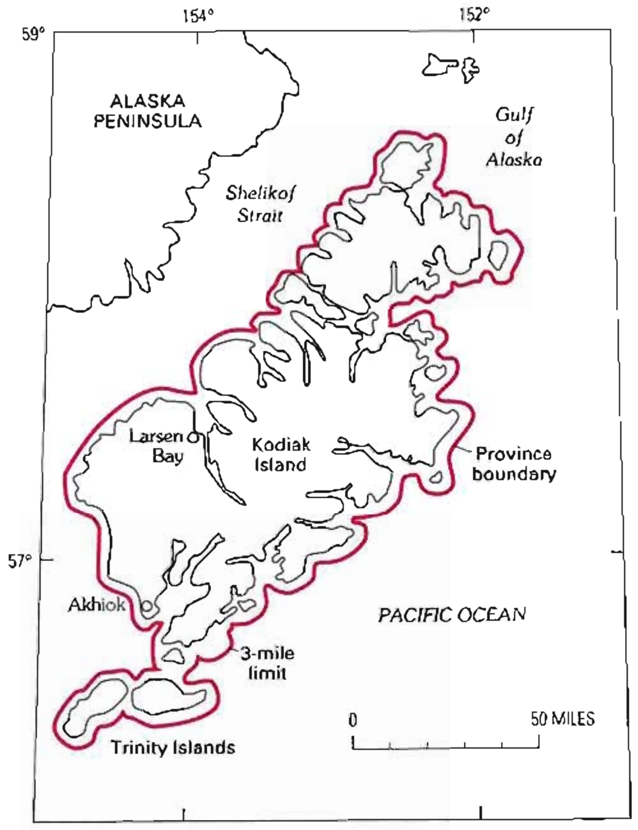

Figure 32. Map of Kodiak Island province (070).

SOUTHEASTERN ALASKA PROVINCE (071)

By Terry R. Bruns

The Southeastern Alaska province, about 400 mi long by 125–150 mi wide, encompasses all islands and lands of southeastern Alaska from Dixon Entrance to northwest of Cross Sound and seaward of the United States/Canada border (fig. 33), and includes State waters that extend 3 mi seaward of the islands. The province is covered dominantly by heavily forested, mountainous terrain, and deep channels separate the mainland from the offshore islands. The entire onshore province and contiguous State waters are underlain by a diverse assemblage of moderately to highly metamorphosed, intruded, and deformed Paleozoic and Mesozoic rocks comprising parts of five fault-bounded tectonostratigraphic terranes. Cenozoic rocks consist of numerous plutons and local, thin nonmarine or deltaic rocks.

No hydrocarbon exploration has occurred in the province, and no evidence of hydrocarbons in the form of seeps is known. None of the criteria required for petroleum generation and accumulation are known to be present onshore, or in the immediately adjacent State offshore in southeastern Alaska. Except for the thin nonmarine and deltaic Cenozoic deposits, all the rocks underlying the islands or beneath the State 3-mile limit surrounding the islands are intruded, indurated, metamorphosed, and (or) deformed to a degree that makes these rocks effective economic basement for hydrocarbons. No potential source or reservoir rocks are known. Cenozoic rocks present in adjacent offshore basins around the province do not crop out onshore, and the petroleum potential of these offshore Cenozoic basins is also considered to be poor. Thus, little potential exists for migration of hydrocarbons from these Cenozoic basins updip into the onshore area, even if reservoir rocks and traps exist onshore. No hydrocarbon plays were identified, and no assessment of resources was made.

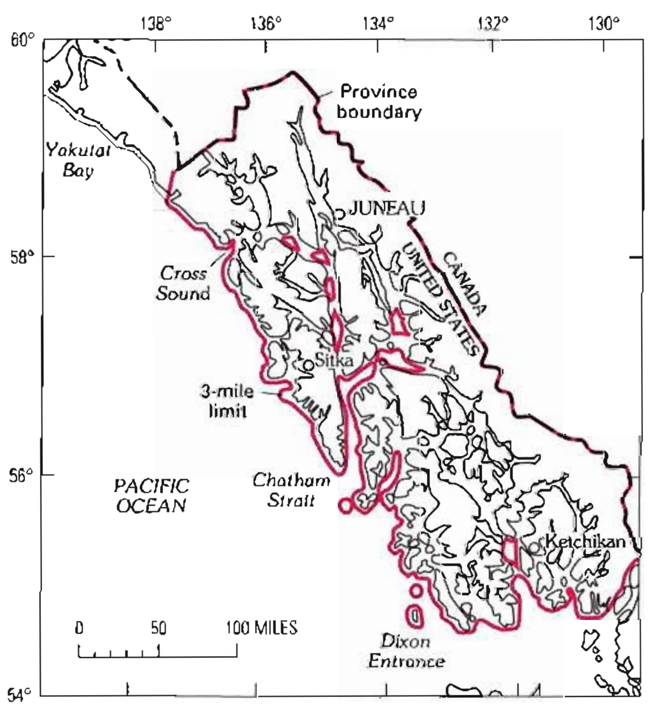

Figure 33. Map of Southeastern Alaska province (071).

SOUTHEASTERN ALASKA PROVINCE (071)

By Terry R. Bruns

The Southeastern Alaska province, about 400 mi long by 125–150 mi wide, encompasses all islands and lands of southeastern Alaska from Dixon Entrance to northwest of Cross Sound and seaward of the United States/Canada border (fig. 33), and includes State waters that extend 3 mi seaward of the islands. The province is covered dominantly by heavily forested, mountainous terrain, and deep channels separate the mainland from the offshore islands. The entire onshore province and contiguous State waters are underlain by a diverse assemblage of moderately to highly metamorphosed, intruded, and deformed Paleozoic and Mesozoic rocks comprising parts of five fault-bounded tectonostratigraphic terranes. Cenozoic rocks consist of numerous plutons and local, thin nonmarine or deltaic rocks.

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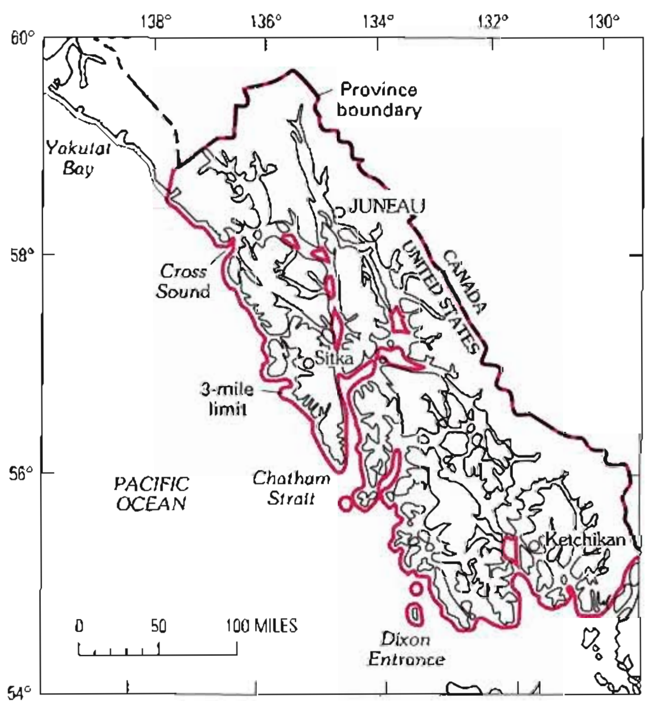

Figure 33. Map of Southeastern Alaska province (071).

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Table 1. Region 1, Alaska—Estimates of undiscovered recoverable conventional oil, gas, and natural gas liquids (NGL) in onshore provinces and adjacent State waters, by play—Continued.

		Crude oil (Millions of barrels)			Total gas (Billions of cubic feet)			NGL (Millions of barrels)		
		F_{95}	F_5	Mean	F_{95}	F_5	Mean	F_{95}	F_5	Mean
068 Alaska Peninsula		-	-	-	-	-	-	-	-	-
069 Gulf of Alaska										
020	Tertiary Gas	0.0	0.0	0.0	0.0	1,645.8	288.5	0.0	6.6	1.2
030	Tertiary Oil	0.0	571.5	180.2	0.0	571.5	180.2	0.0	0.0	0.0
320	Oil <1 MMB	4.6	25.7	12.5	4.6	25.7	12.5	0.0	0.0	0.0
330	Gas <6 BCF	0.0	0.0	0.0	23.8	176.6	78.0	0.1	0.7	0.3
	Province total	26.9	578.4	192.7	32.7	2,001.5	559.2	0.1	5.5	1.5
070 Kodiak		-	-	-	-	-	-	-	-	-
071 Southeastern Alaska		-	-	-	-	-	-	-	-	-
	REGION TOTAL	3,605	31,289	13,177	15,562	138,640	57,935	296	2,481	1,056

[a] Play estimate shown has been apportioned to the Coastal Plain province (80 percent) and the Northern Foothills province (20 percent).

[b] Play estimate shown has been apportioned to the Northern Foothills province (98 percent) and the Southern Foothills–Brooks Range province (2 percent).

[c] Play estimate shown has been apportioned to the Coastal Plain province (73 percent), the Northern Foothills province (25 percent), and the Southern Foothills–Brooks Range province (2 percent).

[d] Estimates shown have been apportioned to the Coastal Plain, Northern Foothills, and Southern Foothills–Brooks Range provinces.

[e] Play estimate shown has been apportioned to the Coastal Plain province (66 percent), the Northern Foothills province (30 percent), and the Southern Foothills–Brooks Range province (4 percent).

[*] Estimates for North Slope provinces are not totalled individually because several plays are apportioned among the provinces, as indicated in the lettered footnotes.