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Alaska Onshore National Assessment Program—Geology and Petroleum Resource Potential of Six Onshore Alaska Provinces

by

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INTRODUCTION

The National assessment program for onshore Alaska covers 6 provinces: Kandik (province 61), Alaska interior (province 62), Interior lowlands (province 63), Bristol basin (province 64), Copper River (province 66), and Cook Inlet onshore and state offshore waters (province 67 and part of 15)(fig. 1) (U.S. Geological Survey-Minerals Management Service, 1988). Geographically, these provinces are bordered on the north by the Brooks Range, on the east by the U.S.-Canadian border, on the south by 58° North latitude, and on the west by the Bering Sea. For the purpose of this report, onshore Alaska or Alaska onshore will refer to this geographic entity. This report is based, in large part, on the paper by Kirschner (in press).

The onshore Alaska assessment was carried using the play-analysis method. In this method the play is a group of geologically related known accumulations or undiscovered accumulations and (or) prospects having similar hydrocarbon sources, reservoirs, traps, and geologic histories (U.S. Department of Interior, Geological Survey and Minerals Management Service, 1989). For this report there are two different types of plays, identified and assessed. The identified plays are those plays that based on geology, the authors felt had some hydrocarbon potential; these identified plays are described with each province. The identified plays were then lumped and renamed to become the assessed plays. All estimates for undiscovered recoverable resources are given by assessed play or province.

The geology of onshore Alaska is complex. Much of the state is made up of lithotectonic terranes that were assembled in their present positions relative to North America during the late Mesozoic and early Cenozoic. These terranes contain a myriad of lithologies comprising sedimentary and igneous rocks, some of which are deformed and metamorphosed. In onshore Alaska there are three types of basins: (1) the Kandik basin, a hinterland segment of the Cordilleran fold and thrust belt; (2) the flysch basin or terrane, a mildly to complexly deformed Mesozoic flysch deposit; and (3) the Cenozoic basin, a thick sequence of nonmarine sedimentary rocks (Kirschner, 1988) (fig. 2). The structural and stratigraphic development of these onshore basins will be discussed in the context of their petroleum potential.

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South of the Brooks Range, the deformed Mesozoic flysch basins have little petroleum potential and are considered economic basement. Throughout the Cenozoic within onshore Alaska, significant thicknesses of nonmarine sedimentary rocks were deposited over these flysch basins and over other areas as well (Kirschner, 1988). These Cenozoic sedimentary rocks contain coal, lacustrine mudstone, siltstone, sandstone, and conglomerate where microbial and thermal gas might originate and accumulate. The area generally referred to as the North American terrane in east-central Alaska is a small hinterland segment of the Cordilleran fold and thrust belt. The Paleozoic to early Mesozoic stratigraphic sequence in this terrane includes organic shales and platform carbonate and siliciclastic rocks but its petroleum potential appears to be low due to structural deformation.

Mesozoic basins, characterized as flysch belts or flysch terranes, cover extensive areas of western and southwestern interior Alaska, and are also present in the Alaska Range south of the Denali fault zone. Small fault-bounded flysch terranes are present in central and east-central interior Alaska and may represent dismembered segments of formerly larger coextensive basins. The flysch belts of onshore Alaska apparently represent volcano-plutonic arc related basin deposits.

Some common characteristics of the Cenozoic basins are: (1) the sedimentary fill is less dense than the pre-Tertiary rocks, therefore, the basins reflect 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 Tertiary sedimentation appears to be characteristic, 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 depo-center for each younger cycle is commonly displaced from the preceeding 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. This style of structural development of "pull-apart" basins or "rhomb grabens and horsts" along major strike-slip fault systems, has been aptly described by Chinnery (1965), Wilcox and others (1973), and Aydin and Nur (1982).

A conspicuous element of onshore Alaska is the suite of relatively small northeast-trending dextral strike-slip faults on the west limb of the Alaska orocline, and the suite of major southeast-trending dextral rift zones of the Tintina and Denali faults on the east limb of the Alaska orocline

(Grantz, 1966). The suite of northeast trending faults are each about 400–500 km in length and have dextral offsets in the range of 100 km (for example, Patton and Hoare, 1968). These faults are confined to the west limb of the Alaska "orocline" and thus are probably related to its development. The major Tintina and Denali fault zones, by comparision, are 1,500 to over 2,500 km in length with dextral offsets in the range of hundreds of kilometers (for example, Gabrielse, 1985). Both the Denali and the Tintina fault zones appear to end at the apex of the Alaska "orocline" in highly complex imbricate thrust systems or collision zones that must have accomodated much of the strike slip motion on these major fault systems.

Another conspicuous element of north-central onshore Alaska, and the southern Brooks Range, that probably indicates structural deformation on a major scale, are the ophiolitic terranes (Patton and others, 1977). Along the northeastern margin of the Mesozoic Yukon-Koyukuk flysch basin ophiolite assemblages form slab-like bodies that dip beneath the flysch basin. They are interpreted to represent the oceanic floor of the basin and the root zone of obducted thrust sheets that extended up to 300 km above continental margin lithologies of the central and northern Brooks Range.

The stratigraphy, structure, and petroleum plays assessed will be covered for each of the 6 onshore Alaska provinces.

KANDIK (PROVINCE 61)

The Kandik province includes the Kandik basin, the Kandik River and Manley terranes, and two Cenozoic basins, the Yukon Flats basin and Tintina trench (figs. 1 and 2).

Kandik Basin

The Kandik basin of east-central Alaska, as discussed here, is bounded by the Porcupine River on the north, the Tintina fault system on the south, the Alaska-Canada boundary on the east, and the Yukon Flats Cenozoic basin on the west. As thus defined it covers an area of over 20,000 sq km. Along the Canadian border elevations reach 600 to 1,500 m in relatively rugged terrain but drop away to the west to low elevations of less than 100 m in the Yukon Flats. The area has long been of interest to geologists and petroleum companies because it has the most complete Precambrian to early Mesozoic stratigraphic section in Alaska, and has organic shales and oil shows at several stratigraphic levels from the Ordovician to the Triassic (Jurassic?).

The Kandik basin is an upland area of low to modest relief underlain mainly by Paleozoic siliciclastic and carbonate rocks and a strongly deformed Jurassic(?)–Cretaceous flysch sequence. Three wells have been drilled in the province, one spudding in the Mesozoic flysch and two in Paleozoic limestone, dolomite, and siliciclastic rocks. Only one of the Paleozoic wells had an oil show from a dolomite section at about 2 km (6,500 ft). Structural trends strike generally northeasterly and seem to correlate with the thrust belt in Canada on the west margin of the Eagle Plains basin. For this reason, the province is characterized as a thrust belt play. *Stratigraphy*.– The stratigraphic succession in the Kandik basin includes late Precambrian rocks, overlain by a thick Paleozoic-Triassic (Jurassic?) continental margin section deposited in shelf to open marine environments (Payne and Allison, 1981), and a thick Jurassic(?)–Cretaceous (Kandik Group) flysch sequence. In Howell and Wiley (1987) and Underwood and others (1989), this stratigraphic succession is decoupled into two sections on the basis of geology and contrasting thermal histories. The flysch sequence separates the Precambrian and Paleozoic sequences in Alaska into a small triangular area (North American terrane in Jones and others, 1987) south of the flysch belt and a larger area north of the flysch belt to the Porcupine River (Porcupine terrane in Jones and others, 1987). Terrane(s) south of the flysch belt (Tatonduk terrane and others) are probably displaced parts of the North American plate (Churkin and others, 1982; Jones and others, 1987). The terrane(s) north of the flysch belt include the Porcupine, Woodchopper and Tozitna terranes shown by Jones and others (1987), or provisionally the Slaven Dane, Takoma Bluff, and Tatonduk terranes as shown by Churkin and others (1982). The Porcupine or Tatonduk(?) terrane is not as well known so the missing stratigraphic elements that suggest it may be a separate terrane could be due to facies changes, structural complication, or simply inadequate data. A notable difference between the two terranes is the apparent abscence of organic-rich shales, petroliferous limestones, or "live" oil shows in the Porcupine terrane. The Doyon No. 2 well drilled 2,783 m of Devonian sandstone and Devonian to Cambrian(?) dolomite. A minor "dead" oil show was reported in dolomite in the lower part of the well. The Doyon No. 3 well drilled 4,128 m of Devonian to Ordovician dolomite and limestone. Thrust faulting is suspected so stratigraphic thicknesses are uncertain.

Structure.– Structure of the Kandik basin is complex. However, the regional structural setting of the basin, in the adjacent hinterland to the North American Cordilleran fold and thrust belt, offers some clues to its structure by analogy to other parts of the Cordillera. Dover (1985) interprets the structural framework as resembling the classical fold and thrust belt structure of the Canadian Cordillera. The second author agrees in general with this concept and suggests an anology to the Main Ranges or Front Ranges of the southern Canadian Cordillera as shown in Bally and others (1966, plate 12).

Petroleum Potential.– There is abundant evidence for source rocks and the possible presence of reservoir rocks in the untested Paleozoic section of the Porcupine terrane. Extreme structural deformation, low grade metamorphism, and the discouraging results of one dry hole do not suggest the potential for significant or economic petroleum resources in the Kandik River terrane. Two dry holes have been drilled in Paleozoic rocks of the Porcupine terrane.

Kandik River and Manley terranes

The Kandik River and Manley terranes incorporate thick, highly deformed flysch deposits of Triassic to Early Cretaceous age. The thicknesses of the stratigraphic sections are poorly constrained but probably include at least 3.0 to 4.5 km of strata. If the stratigraphy of these two terranes are similar enough to suspect that the Manley terrane is a dismembered segment of the Kandik River terrane, then displacement of several hundred km along the Tintina fault zone since Early Cretaceous time is reasonable. However, Howell (written commun.) indicates that these Paleozoic rocks are different, and the Mesozoic rocks of the Manley terrane include intrusive bodies whereas there are none in the Kandik terrane. In addition, there is a possible correlation to similar rocks in Canada, southeast of Dawson. Brabb and Churkin (1969) have summarized the oil potential of the Kandik River terrane as negligible due to complex structure and low grade metamorphism in the Mesozoic rocks. The Manley terrane is similar and has negligible petroleum potential.

Yukon Flats Basin and Tintina Trench

The Yukon Flats basin in east-central Alaska is a large alluvial and lake-dotted lowland of over 22,000 sq km south of the southeastern Brooks Range and north of the Yukon-Tanana upland. The basin is confined on the west by the Kokrine-Hodzana highlands and on the east by the Porcupine terrane (Kandik thrust belt), a hinterland segment of the Cordilleran fold and thrust belt of Northwest Territories, Canada.

The Yukon Flats basin is a graben or half-graben complex with about 3-5 km of nonmarine Tertiary fill. The fill is inferred to be mainly upper Tertiary but if lower Tertiary sedimentary fill is present in the deeper part of the basin, the oil and gas potential would be enhanced. Based on gravity modeling and preliminary seismic data, the Yukon Flats basin may have up to 4.5 km of Cenozoic fill (Hite and Nakayama, 1980). The Tintina fault system or trench trends southeasterly from the southern margin of the basin and the northern edge of the Beaver Creek suture zone (Churkin and others, 1982). The Tintina trench contains both late Tertiary and early Tertiary to Late Cretaceous (Maastrichtian) nonmarine coal-bearing siliciclastic rocks that are about 1.0 km thick in outcrop (Brabb and Churkin, 1969) and may be as thick as 3.0 km in the Circle Hot Springs gravity low (Cady and Weber, 1983).

Stratigraphy.– Basement terranes north, west, and south of the Yukon Flats basin are low- to high-grade metamorphic terranes that have no potential petroleum source beds for overlying Tertiary reservoir rocks. One exception, however unlikely, is the presence of tasmanite in the Tozitna ophiolitic terrane near Christian in the Christian quadrangle. Tasmanite is an oil shale that may yield a significantly higher volume of oil per unit volume of rock than normal oil-shales. The occurrence near Christian has been known for many years and is reported in Mertie (1927). Apparently the outcrops are extremely small and limited in extent as follow-up efforts by geologists of the U.S. Geological Survey (Tailleur and others, 1967) and the U.S. Bureau of Mines (Donald W. Baggs and Donald P. Blasko, written commun.) have not been able to delineate additional deposits. The occurrence of the tasmanite in rocks of the Tozitna terrane is of interest because this terrane is present in outcrop along the north, west, and south margins of the basin and it has a distinctive magnetic signature that can be correlated to the outcrop pattern and traced beneath the Tertiary fill over part of the basin. Consequently if larger occurrences of tasmanite were present in the Tozitna terrane in the subsurface the potential for pre-Tertiary source beds in part of the basin is good.

Nonmarine Tertiary sediments are locally present in small but widely scattered outcrops around the margin of the Yukon Flats basin, and along the Tintina fault. Three cycles of sedimentation are suspected. An early cycle of Late Cretaceous (Maastrichtian) and early Tertiary age is represented by at least 1.0 km of conglomerate, sandstone, shale, and minor coal beds along the Tintina fault (Brabb and Churkin, 1969). These rocks are strongly folded and moderately indurated so that their densities on average are comparable to densities of the Cantwell Formation. A middle Tertiary cycle of Miocene age may be represented by coal-bearing beds at Coal and Mudbank Creeks in the Beaver quadrangle, outcrops in the Tintina fault and in the Coleen quadrangle northeast of Fort Yukon. The rocks consist primarily of conglomerate, sandstone, coal-bearing siltstone or shale, and lacustrine silt and clay. In the Coleen quadrangle lacustrine beds contain Miocene(?) clams (Brosgé and Reiser, 1969). Up to 2.0 km of section has been recognized in the Tintina trench southwest of the Preacher Creek fault. A late Tertiary cycle is probably represented by high level sand and gravel deposits of Tertiary(?) and Quaternary(?) age in the Beaver quadrangle (Brosgé and others, 1973) and by late Tertiary lake deposits in a water well at Fort Yukon (Williams, 1960).

Structure.– The Yukon Flats basin appears to represent an extensional graben complex at the northwesterly terminus of the dextral Tintina fault system (Howell and Wiley, 1987). It is interpreted to be a typical pull-apart basin or rhomb-graben. Sharp topographic breaks associated with steep gravity gradients on the northwest and southeast flanks of the regional gravity low are interpreted to represent normal faults. Beneath the Tertiary fill of the basin there are two divergent magnetic signatures. In the western-most segment of the basin the magnetic signature of the Tozitna terrane follows the northeasterly fabric of the Kokrine-Hodzana highlands. Beneath the central and eastern parts of the basin there is a distinctive northwesterly trending magnetic signature which may correspond to the Tozitna(?) terrane as well as other unknown terrane(s). The magnetic signature in the Yukon Flats basin and in the adjacent Kandik basin suggests that the thrust belt within the Kandik basin may not project southwesterly beneath the eastern part of the Yukon Flats basin. Further, this magnetic signature does not support the extension of the Kaltag fault in Canada (Norris, 1985) beneath the basin to join the Kaltag fault of west-central Alaska (Patton and Hoare, 1968) as has been proposed by numerous authors (for example McWhae, 1986). In contrast, the Tintina fault system has a strong gravity and magnetic signature (Cady and Weber, 1983) that ends in the northwest corner of the Circle quadrangle where it appears to merge with the Beaver Creek suture zone. This suggests the Beaver Creek suture zone accomodates much of the several hundred kilometers of Paleozoic to Tertiary dextral displacement on the Tintina fault.

Petroleum Potential.– Seeps or other direct indications of hydrocarbons are unknown in the Yukon Flats basin. The prospect for pre-Tertiary petroleum source rocks in the Tozitna terrane has been discussed and appears to be unlikely. Paleozoic and Triassic organic shales in the North American terrane southeast of the Kandik River terrane may be projected beneath the basin, but two test wells in the Porcupine terrane east of the Yukon Flats basin indicate that the Paleozoic rocks there have insignificant petroleum source or reservoir characteristics. Thus, the petroleum potential remains uncertain. Additional potential source beds are nonmarine Tertiary lacustrine shales or coal beds, from these, an optimistic evaluation is that gas resources of economic importance for local consumption could be present.

Identified Plays

Tertiary gas.– The Tertiary gas play is speculative and based on the coal-bearing rocks being the source of microbial methane gas. The reservoirs are fluvial sandstones in a trapping position in horst blocks and anticlines sealed by shales. The objectives are anticipated to be between 1.0 to 2.5 km in depth or more (3,000–8,000 or more ft). Presently, no exploratory holes have been drilled and there are no existing gas fields.

Thrust folds in imbricate thrust belt.– The thrust folds in imbricate thrust belt play is speculative and based on the possibility that organic shales exist in Paleozoic rocks in the Kandik basin. The petroleum would have been generated in late Paleozoic to Mesozoic and migrated into sandstone, limestone, and dolomite reservoirs in thrust folds. Shales are the most likely seals. The objectives are likely to be between 1.5 to 4.5 km (5,000–15,000 ft) in depth. Three exploratory wells have tested this play without any field discoveries.

ALASKA INTERIOR (PROVINCE 62)

Yukon-Koyukuk-Kobuk Terrane

The Yukon-Koyukuk segment of the Yukon-Koyukuk-Kobuk terrane includes a belt of strongly deformed and mildly to strongly metamorphosed flysch rocks trending northeasterly along the northwestern margin of Bethel basin in west-central Alaska. These rocks are interpreted to represent forearc deposits of the Hogatza volcano-plutonic arc. The Kobuk segment of this terrane trends easterly north of the Hogatza arc and south of the Brooks Range. The Kobuk segment represents backarc molasse derived from both the Hogatza arc and the Brooks Range and Kokrine-Hodzana upland. The stratigraphy of the terrane is comprised of a Lower and Upper Cretaceous volcaniclastic sequence including turbidites, prodelta, and deltaic coal-bearing facies (Patton and Miller, 1970). Basement rocks are andesitic volcanics of Early Cretaceous age and pre-Cretaceous metamorphic terranes. The thickness of the stratigraphic sequence is poorly constrained. Based on magnetic data, Patton and Miller (1970) suggest that the floor of the basin may be over 7.0 km deep. Structure of the Yukon-Koyukuk segment is extremely complex. The Cretaceous rocks are isoclinally folded. Locally broader synclines are flanked by sharply folded and faulted anticlines. Structure in the Kobuk back arc(?) segment is less complex and a few large anticlinal structures have been defined. For this reason it has been suggested the Kobuk segment of the province could have petroleum potential (Patton, 1973; Hite and Nakayama, 1980). However, no direct evidence of oil and gas in the form of seepages is known from the region. Speculative potential petroleum resources based on cubic km of sediment in this type of basin may be very misleading (Klein and others, 1974; Hite and Nakayama, 1980). By comparison with the Peninsular terrane, where numerous oil seeps, and oil and gas shows in wells are present, the most favorable areas of the Yukon-Koyukuk-Kobuk province may have minor gas resources.

Kuskokwim terrane

The Kuskokwim terrane covers about 60,000 sq km southeast of the Bethel basin. The stratigraphy of the terrane is similar to the Yukon-Koyukuk-Kobuk terrane and includes several thousand meters of Lower to Upper Cretaceous quartzose, lithic conglomerate, and sandstone and siltstone turbidites. Basement rocks include early Mesozoic andesitic volcanic rocks, chert, argillite, volcanogenic clastic rocks and Paleozoic carbonate terranes, amalgamated prior to the deposition of the Cretaceous flysch. Structure of the province includes both open folds and tight chevron folds. Numerous high angle faults and large strike-slip faults segment the terrane and localize many intrusive dikes and plutons. The intrusive bodies host numerous mineralized areas. Petroleum potential of the province is believed to be precluded by structural complexity, intrusive bodies, and mineralization.

Bethel Basin

The Bethel basin is a large lowland area bordered on the south and west by the Bering Sea, on the north by metamorphic and sedimentary rock uplands north of the Yukon River, and on the east by similar upland rocks east of the Kuskokwim River. The area thus defined includes about 50,000 sq km. It is a lake-dotted marshy plain rising 30 to 90 m above sea level. Numerous basalt flows and cinder cones are present in the west-central area of the plain. The basin has seen a low level of petroleum industry interest owing to the thin Tertiary section and poor petroleum source and reservoir potential in the Cretaceous and older(?) sedimentary rocks. One deep exploratory well, the Pan American, Napatuk Creek No. 1, has been drilled to a depth of 4,541 m (14,890 ft).

Stratigraphy.– Basement rock terranes north of the basin consist of Precambrian schist, gneiss and migmatite of the Ruby terrane, and an early Cretaceous volcanicalstic andesitic arc assemblage, the Koyukuk terrane (Jones and others, 1987). Southeast of Bethel in the Ahklun Mountains a similar Jurassic volcanic and volcaniclastic andesitic arc assemblage is widely exposed. North of Cape Newenham smaller disparate terranes include an early Mesozoic to Paleozoic oceanic assemblage in a tectonic melange, ultramafic rocks of the Goodnews terrane, and Precambrian gneiss and phyllite of the Kilbuck terrane.

Cretaceous and older flysch and molasse of the Yukon-Koyukuk-Kobuk sequence is extensively exposed north of the Bethel lowlands (Hoare and Condon, 1966). Similar rocks of the Kuskokwim basin are exposed east and northeast of the lowlands (Hoare and Coonrad, 1959; Decker, 1984). The flysch basins characteristically comprise very thick marine and nonmarine greywacke and siltstone sequences derived largely from andesitic arc provenance terrances, and deposited in both forearc and backarc settings. The rocks have been strongly deformed, altered, and locally metamorphosed. Hoare and others (1964), and Hoare and Condon (1966) have described extensive calcareous and laumontite diagenesis in these flysch and molasse rocks. Regional structural trends, supported in part by gravity, magnetic, and seismic data suggest similar flysch sequences underlie a thin Tertiary cover in parts of the Bethel basin and may extend southwesterly beneath the offshore waters of Kuskokwim Bay and the Bering Sea shelf. The Napatuk Creek No. 1 well penetrated 3,900 m of sedimentary rocks at least in part coeval and lithologically similar to the flysch sequences.

Tertiary sedimentary rocks in the Bethel basin are known only from the Napatuk Creek well which penetrated about 440 m of Miocene and Pliocene diatomaceous clay deposited in a near shore marine environment. A shallow gravity low surrounds the Napatuk Creek well location (Barnes, 1977). Similar lows are present northeast and southwest of the well, and indicate Tertiary fill in the basin probably does not exceed 610 m. Refraction data in Kuskokwim Bay indicate less than 1 km of low velocity (1.9 km/s) rocks that probably represent Cenozoic cover over Cretaceous flysch.

Structure.– Regional structural trends are southwesterly in the uplands around the basin, and gravity and magnetic data indicate this trend is present beneath most of the Bethel basin. However, structural trends are westerly to northwesterly at Cape Romanzof, Cape Vancouver, and Cape Newenham suggesting an orocline(?) with an axial trace trending NNW. Structure in the Cretaceous flysch of the Yukon-Koyukuk-Kobuk and Kuskokwim basins is extremely complex with sharp, commonly faulted, anticlines and isoclinal folds. Northeast-trending and northwest-trending fault sets cut both the Cretaceous flysch and older basement rocks. Extensional "rift" basins, that are the locus of late Tertiary and Quaternary basalt flows, are associated with some of the larger fault systems as for example the Hagemeister-Togiak-Tikchik system (Hoare and Coonrad, 1978). Seismic maps on the Shell and Pan American development contracts define simple southwest to west trending anticline-syncline pairs in shallow Tertiary rocks, but report incoherent deeper data. It is presumed the incoherent data reflects complex structure in Cretaceous flysch, similar to that in outcrop.

Petroleum Potential.– Thermal maturity and visual kerogen analysis of the Napatuk Creek well indicate the Tertiary rocks are immature, the Cretaceous (Campanian to Turonian) rocks are mature, and the Cretaceous(?) and older(?) rocks below 1,555 m (5,100 ft) are overmature. All samples are dominanted by cellulosic, gas type kerogens. Analysis of outcrop samples from localities around the basin are similar to the Napatuk Creek well data and additionally indicate low organic carbon content and very low porosities and permeabilities (Lyle and others, 1981). These data suggest the potential for dry gas generation in the Late Cretaceous flysch but complex structure would appear to preclude significant gas accumulations.

Identified Plays

Structural traps in thin, tight sandstone beds.– Structural traps in thin, tight sandstone beds is a speculative play in the Bethel lowlands based on mature to overmature gas prone source rocks which are low in organic carbon. The gas would have been generated in Late Cretaceous–early Tertiary time and migrated into small structural traps with thin, tight sandstones. The depth to the objective reservoirs is 1 to 3 km (3,000–10,000 ft). There is one exploratory well, no know oil or gas shows, and no existing fields.

Shallow gas on roll-over anticlines.– Shallow gas on roll-over anticlines is a speculative play in the Yukon delta area adjacent to Norton basin to the north. Source rocks contain small amounts of organic carbon and thermal maturation begins at 3 km (10,000 ft) in the adjacent Norton basin. Hydrocarbons should have been generated at the time of tensional faulting from a downdip direction. The reservoirs are thin, with low porosity and permeability, and with reservoir quality improving as the proximal location of the Yukon delta is approached. The traps are associated with faults and anticlines. Objective depth is 1 to 2 km or more (3,000–6,000+ ft). No wells have been drilled in the play area and no fields exist. The Norton basin to the north has good oil and gas shows.

Shallow gas sands in structural traps.– Shallow gas sands in structural traps is a speculative play in the Kobuk flysch belt. The gas source rocks are probably unknown shales and coals that may have generated gas in Late Cretaceous time. The reservoirs are probably thick, point-bar fluvial sandstones at 1 to 3 km (3,000–10,000 ft) depth. The gas might be trapped in large anticlines with shale seals. No exploratory wells, fields, or oil or gas shows are present in the play area.

Shallow gas in Tertiary grabens.– Shallow gas in Tertiary grabens is a speculative play in the Galena and Innoko basins. The gas prone coaly source rocks are immature but could be marginally mature in the deeper parts of the basin. The gas would have been generated and migrated by middle to late Tertiary into deltaic point-bar sandstone of variable, but good quality, at a depth range of 1 to 2.5 km (3,000 to 8,000 ft). Presently, no exploration wells, production or hydrocarbon seeps exist.

INTERIOR LOWLANDS (PROVINCE 63)

Nenana Basin, Ruby Rampart Trough, Cantwell Trough, and Northway Lowlands

The Nenana basin is a large alluvial and swampy lowland area of about 22,000 sq km north of the central Alaska Range and south and west of the city of Fairbanks and the Yukon-Tanana upland. The eastern part of the basin between Nenana and Big Delta is believed to have a thin Cenozoic section based on the local outcrop of basement monadnocks and a shallow magnetic signature (Andreason and others, 1964). Northwest of Nenana the Minto gravity low in excess of 50 milligals suggests about 3 km of late(?) Cenozoic fill. At the south margin of the basin near Healy about 700 m of the coal-bearing group, in the Nenana coal field, and up to 1,200 m of the overlying Nenana gravel are present in outcrop. The Ruby-Rampart trough northwest of the basin, and the Cantwell trough south of the basin contain significant thicknesses of early Tertiary rocks.

The Northway lowlands on the Tanana River is a lowland area of about 3,000 sq km near the Canada-Alaska international boundary, referred to by Miller and others (1959) as the upper Tanana basin. Methane trapped by permafrost was encountered in a well drilled for water at a depth of about 60 m (200 ft). A second well drilled by Alaska Propane Co., Inc. about 5 km northwest of the first well also encountered gas at about the same depth.

Stratigraphy.– Pre-Tertiary basement rocks north and south of the Nenana basin are thoroughly metamorphosed rocks of the Yukon-Tanana terrane. The Union Nenana No. 1 well bottomed in schist that is probably part of this terrane. Northwest of the basin a collage of disparate Mesozoic and

Paleozoic terranes, referred to by Churkin and others (1982) as the Beaver Creek suture zone, crops out in the Livengood and Tanana quadrangles.

Nonmarine sedimentary fill in the Tanana basin and adjacent areas represents three cycles of Tertiary sedimentation. The early cycle is represented by outcrops in the Ruby-Rampart trough and the Cantwell trough. The mid-Tertiary cycle is represented by the coal-bearing group of the Healy coal basin and the coal-bearing section in the Union, Nenana No. 1 well. The late Tertiary cycle is represented by the Nenana Gravel. The periods of deposition were punctuated by orogenic episodes in late Eocene/early Oligocene and late Miocene/Pliocene times. Following each orogenic episode the depo-center for the succeeding cycle of deposition shifted so that it cannot be predicted that the deepest part of the Nenana basin will contain early cycle sedimentary rock deposits.

Early cycle rocks of the Cantwell Formation average 600–1,500 m thick but are locally up to 3 km in thickness. The formation consists of nonmarine coal-bearing clastic and volcanic rocks in the upper part of the formation (Wolfe and Wahrhaftig, 1970). The volcanic rocks have been informally named the Teklanika Formation (Gilbert and others, 1976). The indurated strata are complexly folded. Approximately equivalent age rocks (early cycle) along the Yukon River in the Ruby-Rampart trough consists of about 900–1,500 m of conglomeratic sandstone, shale and coal in thick fluvial, fining upward sequences (Paige, 1959). Early Tertiary volcanic and volcaniclastic rocks are also recognized in the Ruby-Rampart trough (Chapman and others, 1971, 1982).

Mid-Tertiary cycle rocks of the Coal-bearing Group, now called the Usibelli Group, near Healy are subdivided into five formations (Wahrhaftig and others, 1969, Wahrhaftig, 1987). The group is about 700 m thick and consists primarily of interbedded conglomeratic sandstone, shale and coal in thick fluvial, fining upward sequences. Coal rank ranges from lignitic to sub-bituminous B. Two formations, Sanctuary Formation in the lower part of the group and the Grubstake Formation at the top of the group, are lacustrine shales that total about 60 m in thickness. Paleocurrent data indicate a northerly provenance terrane, probably the Yukon-Tanana uplands, supplied sediment to the coal-bearing group in the Healy area during the Miocene (Wahrhaftig and others, 1969).

Late Tertiary cycle rocks are represented by the Nenana Gravel that is up to 1,200 m thick in outcrop along the north front of the Alaska Range and at least 450 m thick in the Union, Nenana No. 1

well. The formation consists primarily of thick conglomerate and conglomeratic sandstone beds with minor lenticular interbeds of shale and lignite. The rocks were derived from the rising Alaska Range and deposited in large alluvial fans along the north flank of the range and are regionally unconformable on the underlying Coal-bearing Group.

Structure.– The structure of the Minto gravity low north of Nenana may be an extensional half-graben complex. Structure to the south in the Coal-bearing Group of the Healy area is a series of northeast to east-trending folds and minor faults of latest Miocene and Pliocene age. Structure in the early Tertiary in the Cantwell trough and the Ruby-Rampart trough is complex and reflects a period of strong folding and volcanism of Eocene and Oligocene age.

Petroleum Potential.– Miller and others (1959, p. 84–86) report an oil seep on Totatlanika Creek, and an analysis of oil from an oily sand and gravel sample from that locality. An oil seep near the mouth of the Nenana River and oil saturated tundra on the Wood River have also been reported but never confirmed. The most likely source rocks are lacustrine shale for oil, and coal-beds for gas. Coal rank ranges from lignite to sub-bituminous B in the Healy coal fields, so methane is the most likely hydrocarbon product the coals could generate. The lacustrine beds in outcrop are relatively thin and have rather low (up to 2 weight percent) organic carbon content, but could be thicker and have a higher organic carbon content in the unexplored subsurface. Stanley (1987a,b, 1988) has shown that (1) the Usibelli Group coals are oil-prone and gas-prone according to Rock Eval, (2) the Cantwell coals and mudrocks range from bituminous to meta-anthracite, and are mainly gas-prone but include some oil-prone samples; (3) the organic carbon content of the Sanctuary Formation is at least as high as 3.6 wt percent.

Minchumina, Holitna, and Innoko Basins

The Minchumina basin is a large Cenozoic basin of about 21,000 sq km northwest of the central Alaska Range and Mt. McKinley, and southeast of the Kuskokwim Mountains. It merges with the Nenana basin on the northeast and the Holitna basin on the southwest. The Holitna basin is a small Cenozoic basin of about 5,000 sq km astride the Farewell fault zone. The Minchumina basin has topographic and geologic similarities to the Nenana basin with local basement metamorphic rock monadnocks and local sharp gravity lows that suggest a few kilometers of Cenozoic fill in small extensional basins. The most conspicuous feature of the Holitna basin is a long narrow gravity trough localized along the trend of the Farewell fault zone, that suggests a rift-graben with a few kilometers of Cenozoic fill. Small outcrops of middle(?) and late Tertiary nonmarine coal-bearing strata are present locally along the Farewell fault zone, on trend with the Holitna basin. The Innoko basin is a lowland area of about 6,000 sq km in the Kuskokwim Mountains 150 km west of the Minchumina basin. It localizes an elongate gravity low with about 20 milligals of relief that could represent up to 2 km of Cenozoic fill. Surrounding terranes are metamorphic and volcanic rocks (Chapman and others, 1985).

Stratigraphy.– The northeastern part of the Minchumina basin is underlain by metamorphic rocks of the Yukon-Tanana terrane that crop out in monadnocks surrounded by Quaternary alluvial deposits. Southwest of the Minchumina suture zone (Bundtzen and Gilbert, 1983) the Nixon Fork and Dillinger terranes probably underlie much of the Cenozoic fill in the basin where several gravity lows suggest thick Tertiary fill. The Nixon Fork terrane represents a Paleozoic carbonate platform sequence and the Dillinger terrane a Paleozoic basinal turbidite shale out facies (Bundtzen and Gilbert, 1983; Churkin and others, 1984). Henning and others (1984) indicates that these rocks are overmature and they have poor reservoir characteristics.

Flysch of the Cretaceous Kuskokwim Group may underlie parts of the Holitna and Minchumina basins. Generally this flysch is strongly deformed and extensively intruded. Overall these flysch rocks are unlikely to have oil source rock or reservoir rock objectives, or to be the provenance terrane to the overlying Tertiary fill.

Tertiary rocks of the Minchumina and Holitna basins appear to represent three cycles of deposition. Paleocene rocks of the Cantwell Formation are only known in the Cantwell trough northeast of the basin and represent the early cycle. Although not recognized further southwest along the Farewell fault zone it would not be surprising to find early cycle rocks in the rift-graben of the Holitna basin trough. A middle Tertiary cycle is represented by nonmarine, fluvial, conglomerate, sandstone, siltstone and lignite (Dickey, 1982; Dickey and others, 1982). The middle(?) Tertiary rocks were derived from northerly metamorphic provenance terranes and deposited by southerly flowing braided streams. The late Tertiary cycle consists of conglomerate that represents alluvial fan deposition from the rising Alaska Range on the southeast. The middle(?) and late Tertiary rocks are about 1,800 m thick along the Farewell fault zone near Farewell. Smith and others (1985) interpret up to 4,500 m of Tertiary rocks in the Holitna basin trough that has a maximum of about 40 miligals negative releief. Several gravity lows in the Minchumina basin have 20 to 30 milligals negative relief so by comparison may be expected to have 1,800–3,000 m of middle to late Tertiary fill.

Structure.– Regionally the Minchumina basin lies between the dextral Iditarod–Nixon Fork fault zone on the northwest and the dextral Farewell fault zone/Denali fault complex on the southeast. Henning and others (1984) have noted that steep gravity gradients associated with basement highs suggest large displacement, high-angle block faulting and folding in the subsurface, possibly an extensional horst and graben complex with north to northeast trending structures resulting from dextral strain.

Petroleum potential.– The areas of either the Minchumina or the Holitna basins that could have 3 km or more of nonmarine Tertiary fill is less than 1 percent of the total basin area. Even though coal-bearing beds in these basins could generate gas, and fluvial sandstones are likely reservoirs, the size of any accumulation would probably be small and it is concluded that the Minchumina basin potential is limited to small gas prospects.

Identified Plays

Shallow gas in Tertiary graben.– The shallow gas in Tertiary graben is a speculative play in three areas: Minchumina basin, Nenana basin, and the Ruby-Rampart trough. The gas is probably from lacustrine or coal-bearing strata at low thermal maturity, or microbial gas. The gas would have migrated in middle to late Tertiary time into fluvial sandstone and conglomerate reservoirs at 1 to 2.5 km (3,000–8,000 ft) depth. Traps would be sealed with shales and associated with horst blocks, reservoirs between coal beds (gas source), and pinch-outs of sandstone lenses within fluvial/lacustrine shales. No wells or fields presently exist, and no hydrocarbon shows or seeps have been found or reported.

BRISTOL BASIN (PROVINCE 64)

Bristol basin

The Bristol basin (or North Aleutian basin of some authors) is a large back-arc Cenozoic basin northwest of the Alaska Peninsula magmatic arc. The basin is over 70,000 sq km in areal extent. About 75 percent of the basin lies offshore beneath the shallow water of Bristol Bay. The basin is confined on the north by metamorphic terranes in the Ahklun Mountains and on the south and east by the Peninsular terrane; and major Cenozoic volcanic peaks.

Stratigraphy.– Basement rocks in the northeastern part of the basin are probably Paleozoic and Mesozoic metasedimentary and intrusive rocks similar to the terranes exposed north of the basin, and Mesozoic granitic rocks of the Peninsular terrane exposed northeast of the basin on the upthrown side of the Bruin Bay fault. Granitic rocks were encountered beneath the Cenozoic fill in the Great Basins No. 1 and 2 wells, and the Port Heiden No. 1 well.

Cretaceous and Jurassic mainly marine sedimentary rocks of the Peninsular terrane are exposed south and west of the basin in the Black Hills-Port Moller uplift, the Chignik Bay uplift and the Wide Bay uplift. They were encountered beneath the Cenozoic fill of the basin in the David River No. 1 and the Hoodoo Lake No. 2 wells. The Sandy River No. 1 well encountered oil and gas shows in steeply dipping conglomeratic sandstone below 3,820 m (12,525 ft) that is correlated with the Stepovak Formation (Brockway, 1975) but is lithologically distinctive from younger strata and similar to the Cretaceous Chignik Formation in the David River No. 1-A well (McLean, 1977), and thus may indicate petroliferous Cretaceous rocks in the subsurface. It is speculated that Cretaceous and Jurassic petroliferous rocks are present beneath the Cenozoic fill in the southernmost and deepest part of the basin.

The Tertiary stratigraphic record includes over 16 km of Paleocene through Pliocene marine and nonmarine sedimentary, volcanic and volcaniclastic rocks exposed on the flanks of the Alaska Peninsula volcano-plutonic arc, and 5 km to possibly as much as 7 km of stratigraphically equivalent rocks deposited in the basin.

The stratigraphic record appears to indicate three cycles of deposition separated by two orogenic episodes. The early Tertiary cycle is represented by the Paleocene to Eocene Tolstoi Formation and the Eocene to Oligocene Stepovak and Meshik Formations. Oil and gas shows have been encountered in both formations. The middle cycle of Miocene age is represented by the Bear Lake Formation. The sandstone strata of the formation have porosities and permeabilities that indicate favorable reservoir characteristics to about 2,400 m but the reservoir potential declines rapidly below this depth (McLean, 1977). The late Tertiary cycle is represented by the Pliocene Milky River Formation.

Structure.– The basin trends regionally southwestward to Port Moller and turns westward along the north side of the Black Hills uplift. The 40 degree change in trend of the basin axis probably represents an oroclinal bend that warped the basin in the late Tertiary. This may correspond to a southerly extension of the orocline of the southwestern Bethel basin. The basin is strongly asymetric with a steep southwest flank subparalleling the Mesozoic uplifts on the Alaska Peninsula. It is interpreted that younger stratigraphic packages may overlap older packages on the broad, gently dipping northwest flank of the basin. Compressional folding is defined onshore and similar structures are probably present offshore (Hite and Nakayama, 1980). Stratigraphic correlations indicate onlap and thinning of early Tertiary strata on basement highs in the northeastern part of the basin, and stratigraphic thinning across faults and over structural highs in Cretaceous and early Tertiary rocks in the south end of the basin.

Petroleum Potential.– Oil and gas shows in Tertiary and Cretacous strata in wells in the southern part of the Bristol basin, and vitrinite reflectance data indicate the early Tertiary rocks are mature and capable of generating oil and gas, but organic carbon ratios of the mud rocks have a generally lean to marginal source rock potential. Coally intervals have high organic carbon ratios and indicate good source potential for dry gas. In general, the available geochemical data indicate that the source rock potential for dry gas is good, and for oil, lean to marginal.

Greywackes derived for the magmatically arc are rich in volcanic rock fragments such as plagioclase feldspar and mafic minerals; and the quartz content is low (Galloway, 1974). This type of sand is mineralogically unstable and during rapid burial, the sandstone most likely would pass through a series of diagenetic alterations producing calcite and laumontite pore-filling cement. McLean (1977) has described this type of alteration in the Tolstoi Formation.

Indicated Play

Bristol basin play.– The Bristol basin is a speculative play that involves Cretaceous and younger sedimentary strata. The Tertiary shales and coals are adequate enough to produce oil and gas shows. Shales of early Tertiary age probably generated hydrocarbons in middle to late Tertiary time that migrated into sandstone reservoirs, most likely with low porosity and permeability, at a depth range of 1 to 4.5 km (4,000–15,000 ft). The traps are most likely anticlines that are sealed with shale. Even though 9 wells have been drilled, no field has been discovered.

COPPER RIVER (PROVINCE 66)

Copper River Basin

The Copper River basin is a lowland area of about 9,000 sq km in south-central Alaska lying between the Talkeetna Mountains on the east and the high Mount Wrangell volcanic complex on the west. Elevations range from 300 m (1,000 ft) in the eastern lowland area to over 1 km (3,000 ft) in the western uplands.

Stratigraphy.– The oldest rocks in the basin are the Lower Jurassic rocks of the Peninsular and Wrangellian terranes (Jones and others, 1984), that are present in outcrop and were penetrated in several wells in the basin.

Overlying these rocks are three distinctly different stratigraphic sequences separated by regional unconformities: (1) a Middle Jurassic through early Cretaceous (Neocomian) sequence about 2,700 m thick including the Tuxedni Sandstone, the Chinitna Formation, the Naknek Formation, and the Nelchina Limestone; (2) a late Early and Late Cretaceous sequence up to 4,300 m thick, the Matanuska Formation; (3) a Tertiary sequence about 1,200 m thick of both Paleogene and Neogene age, in part equivalent to the Chickaloon Formation and the Kenai Group of the Cook Inlet basin. Pleistocene and Quaternary glacial, fluvial, and lacustrine deposits up to 180 m thick overlie all older rocks.

The Mesozoic sequences are widely exposed in the eastern foothills of the Talkeetna

Mountains west and southwest of the basin (Grantz, 1964). Jones and others (1981) include both the Jurassic and Cretaceous formations in the Peninsular terrane. A likely alternative interpretation is to restrict the Peninsular terrane sequence to the Early Cretaceous (Neocomian) and Jurassic formations and view the Matanuska Formation as an overlap sequence that was deposited on both the Peninsular and Wrangellian terranes.

A composite stratigraphic section of the Matanuska Formation in its type area, the Matanuska Valley, southwest of the Copper River basin, includes over 4,300 m of Cretaceous marine clastic sedimentary rocks ranging in age from Albian to Cenomanian or Maestrictian (Grantz, 1964), that were deposited in a forearc basin south and east of the Talkeetna Mountains. Typically the formation consists of various facies of submarine fan turbidites deposited in water depths probably ranging from shelf to bathyal depths.

Tertiary nonmarine rocks may be up to 900 m thick in the Copper River basin. The rocks consist of fluvial conglomerate and coal-bearing sandstone, siltstone and shale. Grantz (1965) reports Oligocene nonmarine rocks rest unconformably on the Paleocene Chickaloon Formation in the Talkeetna Mountains west of the basin. The Tertiary nonmarine section in the Amoco No. A-1 and the Atlantic (ATL 2) well is reported as Neogene.

Structure.– Structural development in the basin is largely inferred from outcrop data and a limited amount of unpublished reflection seismic data. Seismic record quality is generally poor to very poor so that interpretation is difficult and the structural location of wells based on the data is questionable. The limited subsurface structural data appears to be similar in style to that suggested by outcrop data west of the basin. Fold trends are northeasterly on small amplitude folds. Major thrust faults, normal and reverse strike and cross faults, and horst and graben structural blocks are common.

Petroleum Potential.– Only two wells are known to have encountered significant gas shows in the Cretaceous Matanuska Formation, the Amoco Ahtna No. 1 and No. A-1 wells. No significant oil shows have been reported from any wells. Interpretation of presently known data suggests that the most likely hydrocarbon resource would be restricted to small gas accumulations.

Identified Play

Anticlines in Cretaceous and Jurassic Flysch.– Anticlines in Cretaceous and Jurassic flysch is a speculative play involving Jurassic and younger rocks. The source rocks are Jurassic and Cretaceous shales that should have generated hydrocarbons by early Tertiary time and which would have migrated into commonly poor, fractured sandstone reservoirs. The reservoirs are probably sealed with shale at a depth range of 1 to 3 km (3,000 to 10,000 ft). The traps are expected to be anticlines. A large number of wells have tested the play without any petroleum discoveries, but with minor shows of oil and gas.

COOK INLET (PROVINCE 67)

Cook Inlet Basin

Almost 60 years of exploration preceded the discovery of the first commercial oil field in the Cook Inlet area which include onshore and state offshore (fig. 3). Exploration started on the Iniskin Peninsula in 1902, where 7 wells were drilled. Between 1921 and 1957, only 9 exploratory wells were drilled before the Swanson River oil field was discovered in 1957 (Parkinson, 1962). Over the next 15 years, 7 oil and 23 gas accumulations were discovered. Except for one oil pool (Redoubt Shoal), and 14 gas accumulations, all are still being produced. By the end of 1987, almost 1.1 billion barrels of oil and 5.3 trillion cubic feet of gas had been produced, leaving 90 million barrels of oil and 3.3 tcf of gas yet to be extracted. The history of exploration and the framework and petroleum geology in this area are discussed by many workers (Kelly, 1963, 1968; Detterman and Hartsock, 1966; Crick, 1971; Blasko and others, 1972; Kirschner and Lyon, 1973; MacKevett and Plafker, 1974; Blasko, 1974; Boss and others, 1976; Hite, 1976; Magoon and others, 1976; Young and others, 1977; Fisher and Magoon, 1978; Claypool and others, 1980; Magoon and others, 1980; Magoon and Claypool, 1981; Reed and others, 1983; Magoon, 1986; Magoon and Egbert, 1986; and Magoon and Anders, in press (figs. 4 and 5).

Stratigraphy.– In the Cook Inlet area, the pre-Late Cretaceous sequence and correlative plutonic rocks of the Alaska-Aleutian Range batholith constitute the Peninsular terrane. The Border Ranges fault separates this terrane from the Chugach terrane on the southeast. The Lower Jurassic Talkeetna Formation, a volcaniclastic sequence, and the Alaska-Aleutian batholith are economic basement for this petroleum province (fig. 6). The Tuxedni Group of Middle Jurassic age is important because it contains petroleum source rocks and is the most likely source for all the oil and some gas in the area. However, Tertiary rocks are the source of much gas and associated liquids. The Upper Jurassic Naknek Formation contains a high percentage of feldspathic sandstone and conglomerate, but because of laumontite cementation it is a poor reservoir (Franks and Hite, 1980; Bolm and McCulloh, 1986). The Cretaceous Matanuska Formation contains little organic matter, but does contain potential sandstone reservoirs. All these units in the Peninsular terrane were deposited in a coastal to deep marine environment and unconformably underlie the petroleum-bearing Cenozoic rocks.

The Cenozoic rocks in the Cook Inlet area overlap the Alaska-Aleutian batholith on the northwest and the Border Ranges fault on the southeast. Calderwood and Fackler (1972) defined and named the critical Cenozoic stratigraphic units—West Foreland Formation, Hemlock Conglomerate, Tyonek Formation, Beluga Formation, and Sterling Formation—that are regionally correlated (Alaska Geological Society, 1969a-d, 1970a,b) and mapped (Hartman and others, 1972). These rock units were all deposited in a nonmarine forearc basin setting. The provenance for the conglomerate, sandstone, siltstone, shale and volcaniclastic debris was local highs flanking the basin and interior Alaska. Each of these rock units is a reservoir for oil or gas somewhere in the basin. Throughout the section, numerous large coal deposits formed and were preserved (Barnes and Payne, 1956; Barnes and Cobb, 1959). The Cenozoic rocks are about 7.5 km in thickness.

Structure.– The tectonic evolution of the Cook Inlet area is complex because it is part of the northern Pacific margin, which has been the site of continuous convergence throughout the Mesozoic and Cenozoic (Coney and Jones, 1985). The Cook Inlet area is bounded on the northwest by the Alaska-Aleutian Range and the Talkeetna Mountains and on the southeast by the Kenai Mountains. The Jurassic and Lower Cretaceous rocks are included in the Peninsular terrane; the Upper Cretaceous and Cenozoic rocks compose a post-amalgamation overlap sequence.

In general, the Cook Inlet basin is a deep fault-bounded northeast trending trough. The major faults are high-angle reverse thrust faults; most deeper oil-producing structures are faulted anticlines while shallower gas-producing structures are northeast-trending anticlines. The severity of folding attenuates to the southwest toward lower Cook Inlet. The east-west trending Augistine-Seldovia arch is at the south end of the Tertiary basin.

Identified Plays

Hemlock Conglomerate.– In the Cook Inlet area, all the large oil fields occur in reservoirs of early Tertiary age (fig. 4; table 1). Rock units that range in age from Middle Jurassic to Holocene are involved in the Tuxedni-Hemlock petroleum system.

Two different depositional settings, separated by a period of nondeposition and deformation, were required to complete this play. The first setting, a marine environment from Middle Jurassic to Late Cretaceous, accumulated sedimentary rocks deposited in both a forearc and backarc basin associated with volcanic and plutonic rocks. The Middle Jurassic (187–163 Ma) Tuxedni Group, which contains a type III kerogen, is considered to be the source rock for the oil. The second setting, a fluvial environment, produced siliciclastic rocks deposited in a narrow forearc basin. Approximately 80 percent of the oil is contained in the Hemlock Conglomerate, a conglomeratic sandstone of Oligocene age (37–24 Ma; Magoon and others, 1976; Wolfe, 1981). The McArthur River field is the largest, with original reserves of almost 570 million barrels of oil, of which, almost 500 million barrels are from the Hemlock Conglomerate (table 6).

A typical oil pool in this play is located in a faulted anticline at a drill depth of 2,560 m (765–4,500 m). The pool covers 1,000 hectares (ranges from 195 to 5,000 ha), and has a net pay of 90 m (21–300 m). The reservoir rock is a conglomeratic sandstone with an average porosity of 17 percent (12–22 percent), an average permeability of 80 millidarcies (10–360 md), a reservoir pressure of 29,650 kiloPascals (14,045–52,071 kPa), and a temperature of 72 °C (44–102 °C). The typical oil in this reservoir has an API oil gravity of 34°±6°, a gas-oil ratio of 600 (175–3,850), a sulfur content of 0.1 percent, a pristane/phytane ratio of 2.7 (1.6–3.4), and carbon isotope values for saturated hydrocarbons of -30 permil (-30.4 to -29.6) and for aromatic hydrocarbons of -28 permil (-29.1 to -27.8). This information and biological marker data indicate that the oil originates from a marine-shale source rock (Peters and others, 1986).

Tertiary rocks include not only the reservoir rock but the overburden necessary to mature the Middle Jurassic marine source rock. Late Cenozoic oil generation is indicated by the thick Cenozoic sedimentary section east of the Middle Ground Shoal field. Oil generation probably started within the last 5 million years and continues today; thus is still active. The geographic boundary for the Tuxedni-Hemlock petroleum is restricted by known accumulations because the mature source rock is covered between the Swanson River and Middle Ground Shoal fields (fig. 9).

Beluga-Sterling.– In Cook Inlet, a cumulative production of over 6.1 tcf of dry gas is attributed to Upper Tertiary rocks, which were deposited in a forearc basin (fig. 4, table 2; Magoon and Egbert, 1986). Three stratigraphic units are involved in the Beluga-Sterling play: the Tyonek, Beluga, and Sterling Formations.

The siliciclastic Sterling Formation of late Miocene and Pliocene age is the major reservoir rock. Most of the microbial gas is in the Sterling Formation reservoirs, a medium-grained, well- to fairly well-sorted, and slightly conglomeratic sandstone (Crick, 1971; Boss and others, 1976; Hayes and others, 1976, Claypool and others, 1980). When the microbial gas ($\delta^{13}C$ –57.6 permil) that was produced through 1987 is added to the remaining reserves, the Sterling Formation reservoirs account for 3 tcf, the Beluga Formation for 0.5 tcf, and the Tyonek Formation, after removal of the thermal gas ($\delta^{13}C$ –43.7 per mil) from the McArthur River field, for 0.3 tcf. In the McArthur River field, the thermal gas in the Tyonek Formation is interpreted to have migrated from the underlying oil reservoirs in the Hemlock Conglomerate. In the Kenai field, the sandstones of the Sterling Formation contain almost 1.9 tcf or 82 percent of the gas. The siliciclastic Sterling Formation is the most important reservoir rock in the Beluga-Sterling play.

An average gas pool in this play has the following characteristics. The pool is located in a domal structure that covers 1,050 hectares (20–3,360 ha) and has a net pay of 22 m (6–65 m). The sandstone reservoir has a water saturation of 40 percent (35–50 percent), a reservoir porosity of 27 percent (10–37 percent), and permeability of 1,100 millidarcies (3.5–4,400 md). The drill depth is 1,615 m (980–2,775 m) to a reservoir under 19,300 kiloPascals (7,320–31,000 kPa) at 50 °C (35–100 °C). The natural gas produced is 99 percent methane, with a specific gravity of 0.571 (0.555–0.600) and a heating value of 251 kilogram calories (250–256 kc).

The source for the gas is unclear, but the Beluga Formation and to a lesser extent the Sterling Formation have considerable coal and type III kerogen (Claypool and others, 1980). Most of the coal and type III kerogen are below the Sterling Formation, so this source is in a good position to charge overlying reservoirs with microbial gas (Claypool and others, 1980). Because this play requires no overburden to mature the source rocks, the duration time is short—from the late Miocene to Holocene, or about 12 million years (Magoon and Egbert, 1986). The geographic boundary for the Beluga-Sterling play is presently restricted by known accumulations.

CONCLUSIONS

The National assessment program for onshore Alaska covers 6 provinces: Kandik (province 61), Alaska interior (province 62), Interior lowlands (province 63), Bristol basin (province 64), Copper River (province 66), and Cook Inlet onshore and state offshore waters (province 67 and part of 15)(fig. 1). Geographically, these provinces are bordered on the north by the Brooks Range, on the east by the U.S.-Canadian border, on the south by 60°±1° N latitude, and on the west by the Bering Sea. Each province was discussed by basin setting, stratigraphy, structure, and petroleum potential. At the end of each province discussion the identified plays were described.

The Cook Inlet is the only province both oil and gas resource potential (table 3). For the Hemlock Conglomerate oil play that was assessed, a mean of 288 million barrels of oil is yet to be discovered; for the Beluga-Sterling gas play, a mean of 1,315 billion cubic feet of gas. A mean of almost 110 million barrels of oil is assessed for the Kandik segment of the Cordillera Thrust belt play. The Alaska interior, interior lowlands, Bristol basin, Copper Briver, and Alaska Peninsula were assessed to have over 1.6 trillion cubic feet of recoverable gas yet to be discovered. Alaska onshore is assessed to have almost 400 million barrels of oil and 3 trillion cubic feet of gas yet to be discovered.

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Figure 1. Index map of Alaska showing the geologic provinces (numbered) assessed in this National assessment program. Single hatchured provinces (61, 64, 67) were assessed separately, whereas the doubly hatchured provinces (62, 63, 66) were assessed together (see table 3).

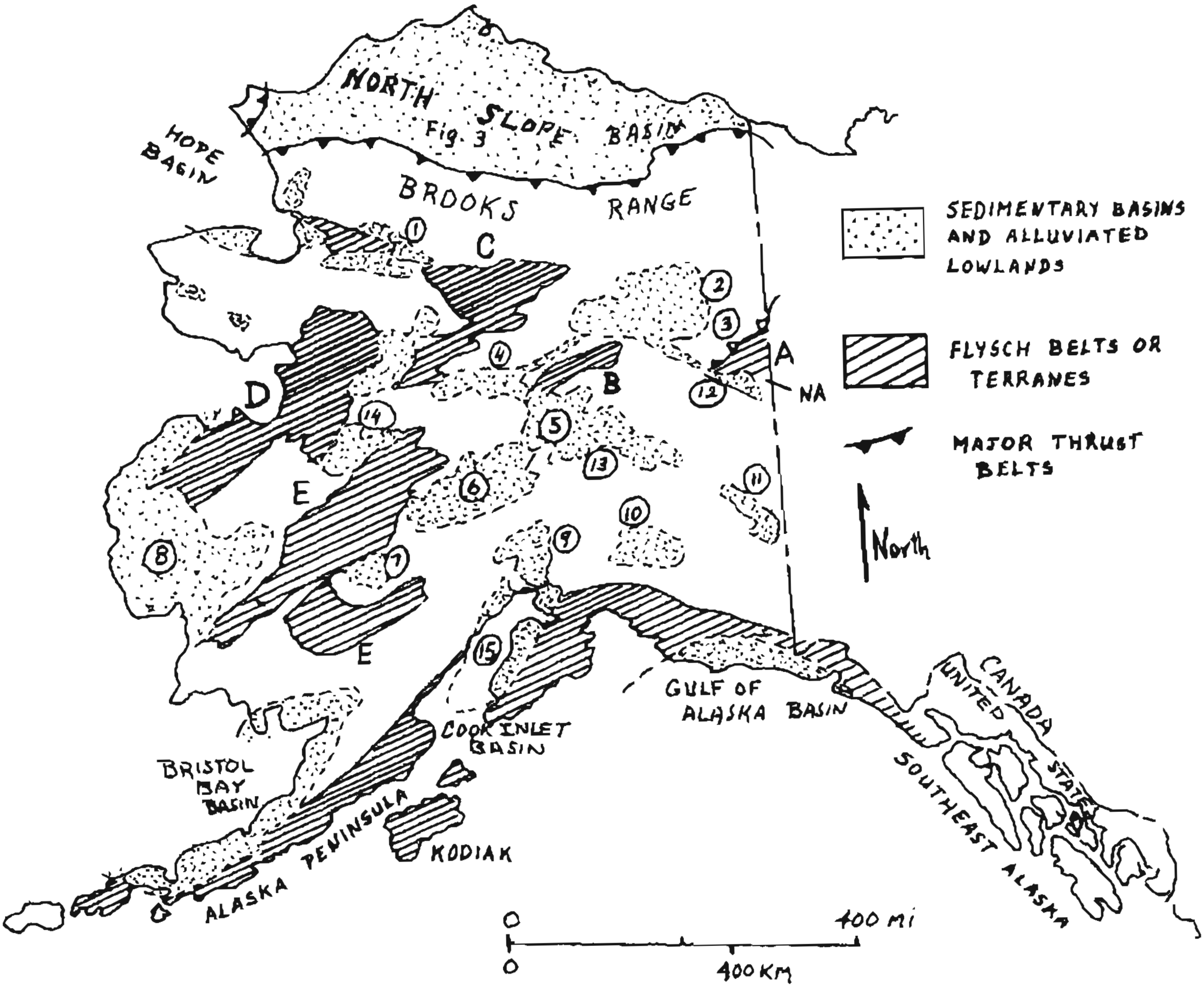

Figure 2. Map of Alaska showing the sedimentary basins: (1) Kobuk basin, (2) Yukon Flats basin, (3) Kandik basin (between 2 and A), (4) Ruby-Rampart trough, (5) Nenana basin, (6) Minchumina basin, (7) Holitna basin, (8) Bethel basin, (9) Susitna basin, (10) Copper River basin, (11) Northway lowlands, (12) Tintina trench, (13) Cantwell trough, (14) Innoko basin, and (15) Cook Inlet basin; and flysch belts: (A) Kandik, (B) Manley, (C) Kobuk, (D) Yukon-Koyukuk, (E) Kuskokwim, and (NA) North American terrane (adapted from Kirschner, 1988).

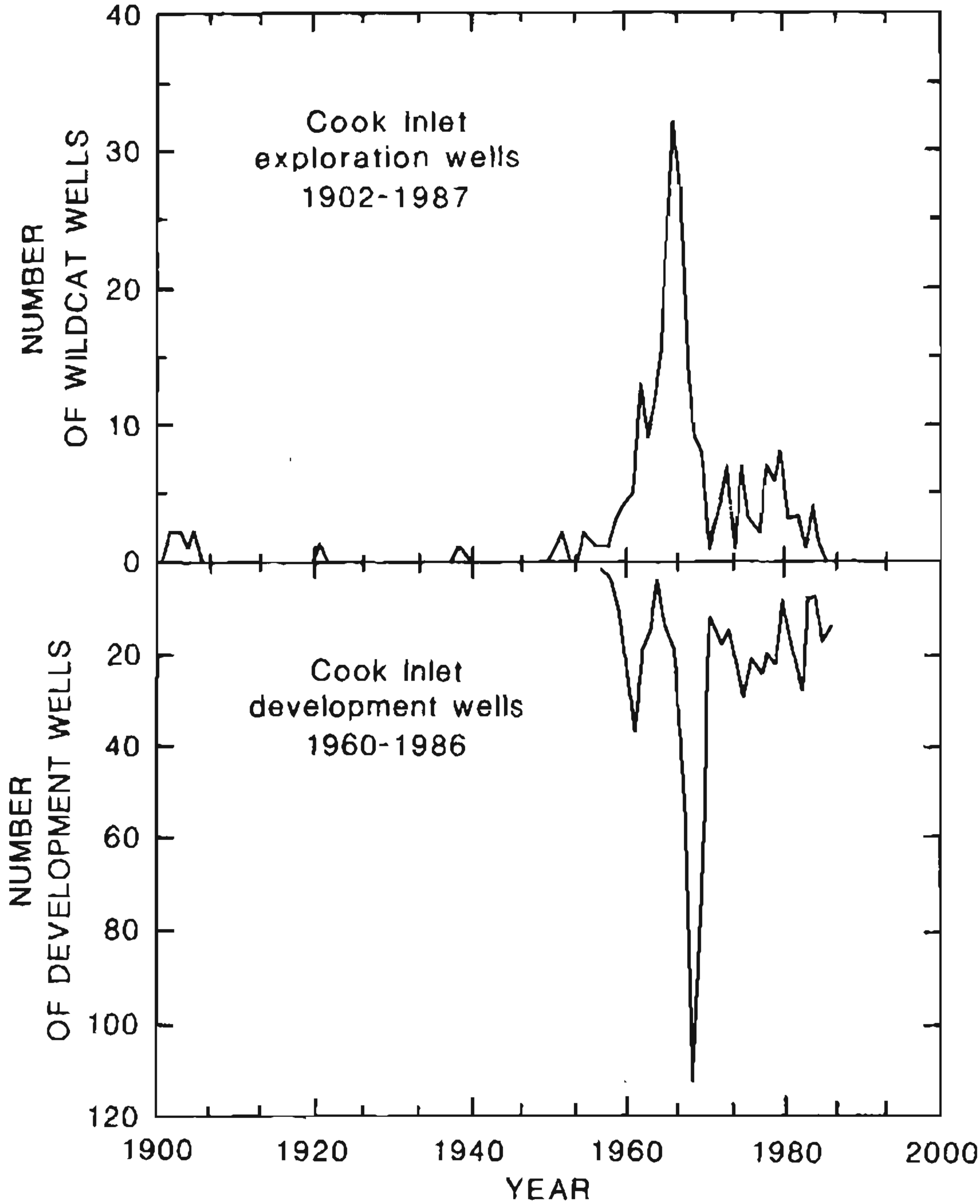

Figure 3. Exploration and development drilling history for Cook Inlet onshore and state offshore. Wells are plotted at year they reached total depth (Petroleum Information, 1988).

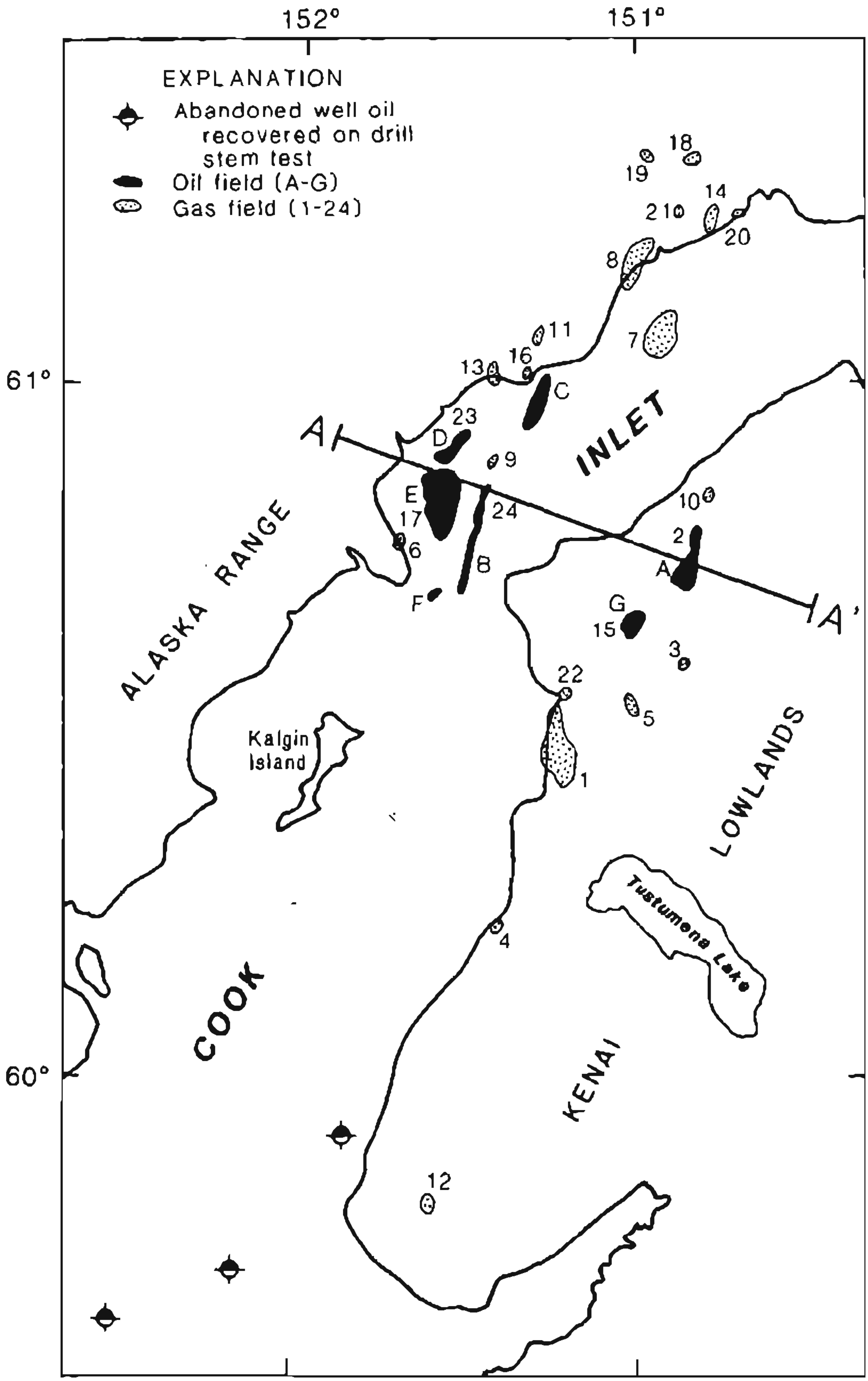

Figure 4. Cook Inlet oil and gas fields, and location of cross section A–A' (adapted from Alaska Oil and Gas Conservation Commission, 1985). Letters refer to oil fields and numbers refer to gas fields on figure 6 and in tables 1 and 2.

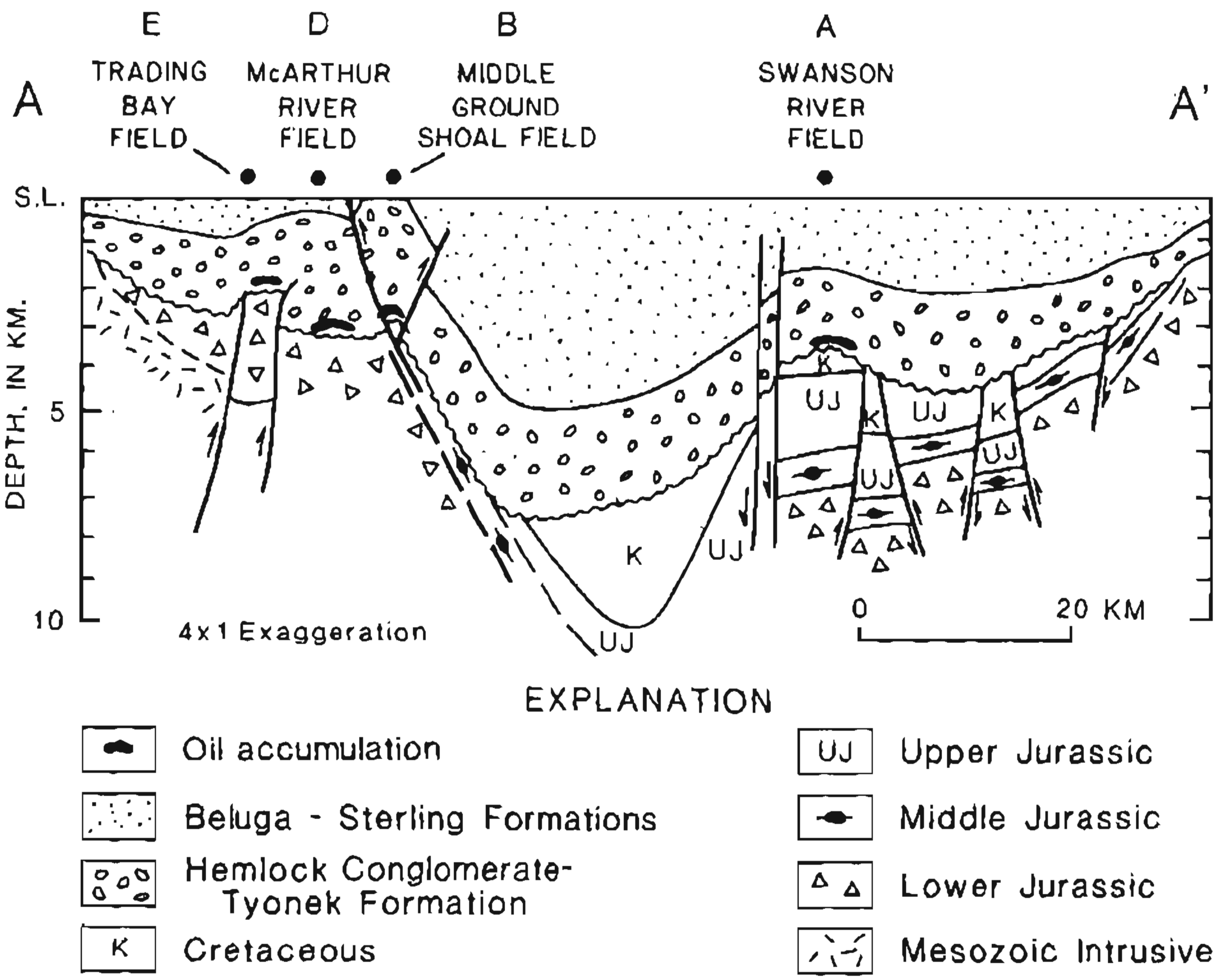

Figure 5. Cross section A–A' of Cook Inlet showing structural and stratigraphic relations and field locations (adapted from Boss and others, 1976). See figure 4 for location of section. Letters refer to oil fields on table 1.

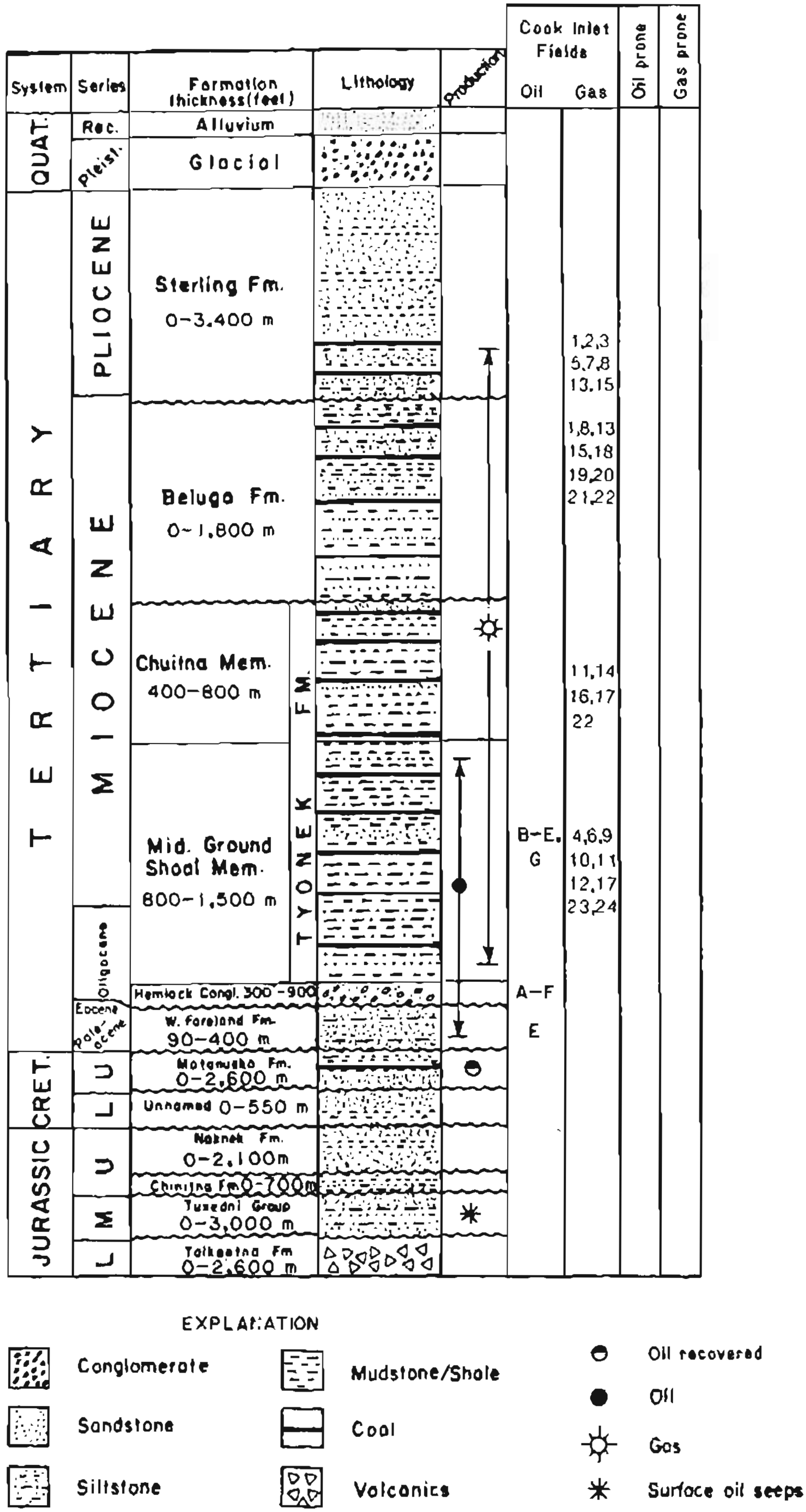

Figure 6. Generalized stratigraphic column for Cook Inlet (modified from Alaska Oil and Gas Conservation Commission, 1985, p. 182) showing petroleum in reservoir rocks, source rock intervals, overburden lithology, and letters and numbers of fields. See figures 4 and 5, and tables 1 and 2 for oil and gas fields.

Table 1. Onshore and state offshore Cook Inlet oil accumulations by discovery date indicating cumulative production as of December 31, 1987, remaining reserves, reservoir characteristics, and oil chemistry

[Accumulation letters correspond to locations shown on figure 4; references to complete this table include; Alaska Oil and Gas Conservation Commission, 1985, 1988; Crandall, R.P., written communication; Oil and Gas Journal, 1988; -, no information available; A, anticlinal trap; abd, abandoned; API, American Petroleum Institute; arom, aromatic hydrocarbons; B, biodegraded bbl, barrel; bcf, billion cubic feet; cg, conglomeratic sandstone; cum prod, cumulative production through 12-31-87; dev, developed; dis, discovery; FA, faulted anticlinal trap; fm, formation; ft, feet; GOR, gas-to-oil ratio, in SCF/STB, standard cubic feet of gas per stock tank barrel of oil; grav, gravity; let, letter; lith, lithology; MGS, Middle Ground Shoal Member of Debelius (1974); Mid Grd Shl, Middle Ground Shoal; perm, permeability; ph, phytane; por, porosity; pr, pristane; press, pressure; prod, producing; psi, pounds per square inch; remain, remaining; res, reservoir; sat, saturated hydrocarbons; SCU, Soldatna Creek unit; ss, sandstone; stat, status; temp, temperature; Ty-Hem, Tyonek Formation and Hemlock Conglomerate, undivided; W, West; and water sat, water saturation]

Map let	Accumulation name	Year dis	Prod unit	Pool	Res lith	Prod stat	Trap type	Cum prod oil ($x10^3$ bbl)	Cum prod gas (bcf)	Reserves oil ($x10^6$ bbl)	Reserves gas (bcf)	Prod depth (ft)	Orig press (psi)	Sat press (psi)
A	Swanson River	-	Hemlock	34-10	cg	prod	A	-	-	-	-	10,780	5,700	1,050
A	Swanson River	-	Hemlock	Center	cg	prod	A	-	-	-	-	10,560	5,700	1,140
A	Swanson River	-	Hemlock	SCU	cg	prod	A	-	-	-	-	10,300	5,550	1,350
A	Swanson River	1957	Field	total	-	-	-	208,469	1,752	10	250	-	-	-
B	Mid Grd Shl	-	Tyonek	A	ss	prod	FA	2,000	4	-	-	2,508	-	
B	Mid Grd Shl	-	Tyonek	B,C,D	ss	prod	FA	10,420	7	-	-	6,000	2,768	1,900
B	Mid Grd Shl	-	Ty–Hem	E,F,G	ss-cg	prod	FA	140,683	65	-	-	8,500	4,220	1,500
B	Mid Grd Shl	1962	-	-	-	Field	total	153,102	77	11	7	-	-	-
C	Granite Point	-	Tyonek	MGS	ss	prod	A	106,838	92	-	-	8,780	4,251	2,400
C	Granite Point	-	Hemlock	-	cg	prod	A	3	-	-	-	-	-	-
C	Granite Point	1965	-	-	-	Field	total	106,841	92	19	15	-	-	-
D	Trading Bay	-	Tyonek	C	ss	prod	FA	-	-	-	-	4,400	2,037	-
D	Trading Bay	-	Tyonek	D	ss	prod	FA	-	-	-	-	5,628	2,637	1,921
D	Trading Bay	-	Ty–Hem	-	ss-cg	prod	A	-	-	-	-	9,800	4,470	1,780
D	Trading Bay	-	Hemlock	-	cg	prod	FA	-	-	-	-	6,100	2,802	1,622
D	Trading Bay	1965	-	-	-	Field	total	89,424	61	2	2	-	-	-
E	McArthur River	-	Tyonek	MGS	ss	prod	A	36,769	18	-	-	8,850	4,009	1,826
E	McArthur River	-	Hemlock	-	cg	prod	A	474,421	171	-	-	9,350	4,250	1,787
E	McArthur River	-	W Foreland	-	ss	prod	A	19,317	6	-	-	9,650	4,457	1,186
E	McArthur River	1965	-	-	-	Field	total	521,689	194	47	25	-	-	-
F	Redoubt Shoal	1968	Hemlock	-	cg	abd	-	2	-	-	-	-	-	-
G	Beaver Creek	1972	Tyonek	MGS	ss	prod	-	3,521	1	1	1	14,800	7,552	-

Table 1. Onshore and state offshore Cook Inlet oil accumulations by discovery date indicating cumulative production as of December 31, 1987, remaining reserves, reservoir characteristics, and oil chemistry—Continued

Res temp (°F)	Net pay (ft)	Por (%)	Perm (md)	Orig GOR (SCF/STB)	Water sat S_w %)	Dev acres (acres)	Oil grav (API)	Sulfur (%)	$\delta^{34}S$ (o/oo)	Pr/ Ph	Pr/ nC_{17}	$\delta^{13}C$ sat (o/oo)	$\delta^{13}C$ arom (o/oo)	Map let
180	75	21	55	175	40	478	30	-	-	-	-	-	-	A
180	70	20	75	175	40	-	30	.1	-1.9	1.6	0.8	-30.0	-29.4	A
180	220	22	360	350	40	2,660	37	-	-	-	-	-	-	A
-	-	-	-	-	-	-	-	-	-	-	-	-	-	A
128	190	16	15	3,850	-	740	42	-	-	-	-	-	-	B
130	335	16	15	650	-	740	36	<.1	+2.7	3.4	.6	-30.0	-27.8	B
155	500	11	10	381	-	4,000	35	.1	+1.9	2.1	.4	-30.0	-28.2	B
-	-	-	-	-	-	-	-	-	-	-	-	-	-	B
150	600	14	10	1,110	-	3,200	42	-	-	-	-	-	-	C
-	-	-	-	-	-	-	-	-	-	-	-	-	-	C
-	-	-	-	-	-	-	41	.1	.0	2.6	.5	-29.7	-28.0	C
-	-	-	-	-	-	-	28	.1	-.6	B	B	-29.6	-28.4	D
112	1,000	24	250	268	-	1,400	28	.1	+1.7	2.7	2.2	-30.0	-28.1	D
180	215	12	12	275	36	500	36	.1	+.3	2.9	.9	-30.2	-28.5	D
136	300	15	10	318	-	1,200	31	.1	+2.5	3.1	3.6	-30.0	-28.7	D
-	-	-	-	-	-	-	-	-	-	-	-	-	-	D
163	100	18	65	297	35	2,490	36	.1	+.4	2.4	.9	-30.1	-28.7	E
180	290	11	53	404	35	12,400	35	.1	+2.5	2.9	.7	-30.1	-28.8	E
185	100	16	102	271	-	1,515	33	.1	+2.4	2.7	.7	-30.4	-29.1	E
-	-	-	-	-	-	-	-	-	-	-	-	-	-	E
-	-	-	-	286	-	160	28	-	-	-	-	-	-	F
215	100	-	-	280	-	825	35	<.1	+.9	2.7	.9	-30.1	-28.7	G

Table 2. Onshore and state offshore Cook Inlet gas accumulations by discovery date indicating cumulative production as of December 31, 1987, remaining reserves, reservoir characteristics, and gas chemistry

[Accumulation numbers correspond to locations shown on figure 4; references to complete this table include: Alaska Oil and Gas Conservation Commission, 1985, 1988; Blasko, 1974; Claypool and others, 1980; Crandall, R.P., written communication; -, no information available; A, anticlinal trap; bbl, barrels; Bel–Ty, Beluga and Tyonek Formations, undivided; bcf, billion cubic feet; btu, British thermal unit; Chuit, Chuitna Member Cum prod, cumulative production through 12-31-87; D, domal trap; dev, developed; dis, discovery; FA, faulted anticlinal trap; fm, formation; ft, feet; let, letter; Mbr, member; MGS, Middle Ground Shoal Member of Debelius (1974); No Mid Grd Shl, North Middle Ground Shoal orig press, original pressure; perm, permeability; por, porosity; prod, producing; psi, pounds per square inch; reserves, remaining reserves; res lith, reservoir lithology; res temp, reservoir temperature; sat, saturation; spec grav, specific gravity; ss, sandstone; stat, status; and Ster-Bel, Sterling and Beluga Formations, undivided]

No.	Accumulation name	Year dis	Prod unit	Mbr or pool	Res lith	Prod stat	Trap type	Cum prod oil ($x10^3$ bbl)	Cum prod gas (bcf)	Reserves gas (bcf)	Prod depth (ft)	Orig press (psi)	Gas spec grav
1	Kenai	1959	Sterling	3	ss	prod	D	-	263	-	3,700	1,862	0.577
1	Kenai	1959	Sterling	4	ss	prod	D	-	367	-	3,960	1,919	.577
1	Kenai	1959	Sterling	5.1	ss	prod	D	-	429	-	4,025	1,981	.577
1	Kenai	1959	Sterling	5.2	ss	shut-in	D	-	44	-	4,125	2,078	.577
1	Kenai	1959	Sterling	6	ss	prod	D	-	397	-	4,565	2,505	.557
1	Kenai	1959	Beluga	-	ss	prod	D	-	120	-	4,992	2,558	.555
1	Kenai	1959	Tyonek	MGS	ss	prod	D	12	210	-	9,000	4,416	.560
1	Kenai	1959	-	-	-	Field	total	12	1,831	463	-	-	-
2	Swanson River	1960	Sterling	B,D,E	ss	prod	A	-	13	-	2,870	1,335–4,500	.600
3	West Fork	1960	Sterling	-	ss	shut-in	FA	-	2	6	4,992	2,037	.560
4	Falls Creek	1961	Tyonek	MGS	ss	shut-in	-	-	-	13	7,045	3,404	.600
5	Sterling	1961	Sterling	-	ss	shut-in	D	-	2	23	5,030	2,200	.569
6	West Foreland	1962	Tyonek	MGS	ss	shut-in	-	-	-	20	-	4,265	.600
7	North Cook Inlet	1962	Sterling	-	ss	prod	D	-	-	-	4,200	2,040	.566
7	North Cook Inlet	1962	Beluga	-	ss	prod	D	-	-	-	5,100	2,478	.566
7	North Cook Inlet	1962	-	-	-	Field	total	-	820	680	-	-	-
8	Beluga River	1962	Sterling	-	ss	prod	A	-	-	-	3,300	1,635	.556
8	Beluga River	1962	Beluga	-	ss	prod	A	-	-	-	4,500	2,215	.556
8	Beluga River	1962	-	-	-	Field	total	-	253	604	-	-	-
9	No Mid Grd Shl	1964	-	MGS	ss	shut-in	-	-	-	-	9,108	4,190	-
10	Birch Hill	1965	Tyonek	MGS	ss	shut-in	-	-	-	11	7,960	3,840	.561
11	Moquawkie	1965	Tyonek	-	ss	shut-in	-	-	1	-	-	1,260–2,305	.600
12	North Fork	1965	Tyonek	MGS	ss	shut-in	-	-	-	12	7,200	3,410	.562
13	Nicolai Creek	1966	Ster–Bel	-	ss	shut-in	-	-	1	3	2,170	1,062–1,688	.575
14	Ivan River	1966	Tyonek	Chuit	ss	shut-in	D	-	-	26	7,800	4,130	.560
15	Beaver Creek	1967	Sterling	-	ss	prod	D	-	-	-	5,000	2,200	.560
15	Beaver Creek	1967	Beluga	-	ss	prod	D	-	-	-	8,100	3,800	-
15	Beaver Creek	1967	-	-	-	Field	total	-	63	177	-	-	-
16	Albert Kaloa	1968	Tyonek	-	ss	shut-in	-	-	-	-	3,213	-	-
17	McArthur River	1968	Tyonek	MGS	ss	prod	A	-	97	-	-	1,734	.564
17	McArthur River	1968	Tyonek	Chuit	ss	prod	A	-	36	-	-	-	-
17	McArthur River	1968	-	-	-	Field	total	-	134	600	-	-	-
18	Lewis River	1975	Beluga	-	ss	prod	-	-	4	18	4,700	2,760	-
19	Pretty Creek	1975	Beluga	-	ss	prod	-	-	1	25	6,000	-	-
20	Stump Lake	1978	Beluga	-	ss	shut-in	-	-	-	-	6,700	3,290–3,460	.565
21	Theodore River	1979	Beluga	-	ss	shut-in	-	-	-	-	3,700	1,681–1,903	-
22	Cannery Loop	1979	Bel–Ty	-	ss	shut-in	-	-	-	300	-	4,000	.560
23	Trading Bay	1979	Tyonek	MGS	ss	prod	FA	-	3	29	9,000	3,910	.582
24	Mid Grd Shl	1982	Tyonek	MGS	ss	prod	FA	-	2	-	3,550	1,428	.564

Table 2. Onshore and state offshore Cook Inlet gas accumulations by discovery date indicating cumulative production as of December 31, 1987, remaining reserves, reservoir characteristics and gas chemistry—Continued

Res temp (°F)	Net pay (ft)	Por (%)	Perm (md)	Water sat, S_{wi} (%)	Dev acres (acres)	Btu (Btu/ft³)	$\delta^{13}C$ methane (%)	C_1 / C_{1-5}	No.
103	88	35.5	-	35	5,025	-	-57.0	0.999	1
105	60	36.5	-	35	7,562	-	-56.7	.999	1
105	113	36.5	-	35	6,198	-	-	-	1
106	53	36.5	-	35	1,796	-	-	-	1
109	110	32	-	40	5,432	-	-56.5	-	1
115	213	15–20	-	40	1,280	-	-	-	1
143	100	18–22	-	40	2,840	-	-48.2	.998	1
-	-	-	-	-	-	1,005	-	.989	1
123	-	30	650	35	640	1,002	-57.7	.999	2
110	22	30	4,400	-	455	-	-	-	3
132	-	-	-	-	-	1,015	-	.991	4
109	20	26	-	40	1,540	991	-60.9	.998	5
171	26	-	-	-	640	929	-	.921	6
109	130	28	178	40	8,300	-	-	-	7
119	30	28	175	40	2,500	-	-	-	7
-	-	-	-	-	-	993	-60.7	.998	7
94	107	31	-	37	5,115	-	-	-	8
106	106	24	-	42	4,826	-	-	-	8
-	-	-	-	-	-	1,014	-	.997	8
144	24	-	-	-	-	-	-	-	9
136	31	25	6	-	150	1,014	-	.986	10
80–108	45–108	20–24	-	35–40	1,280	1,006	-	.990	11
140	-	18	3.5	50	50	1,002	-	.981	12
105–110	33	-	-	-	-	976	-62.2	.995	13
128	37	20	1,600	45	2,418	1,004	-	.989	14
107	110	30	2,000	40	3,165	-	-58.2	.989	15
142	20	10	-	-	640	-	-	-	15
-	-	-	-	-	-	998	-	.983	15
-	-	-	-	-	-	-	-	-	16
117	-	-	-	-	1,920	-	-	-	17
110	-	-	-	-	1,280	-	-	-	17
-	-	-	-	-	-	-	-43.7	.994	17
111	85	-	-	-	1,030	-	-	-	18
-	-	-	-	-	-	-	-	-	19
106	-	-	-	-	-	-	-	-	20
-	-	-	-	-	-	-	-	-	21
126	-	-	-	-	1,280	-	-	-	22
175	60	-	-	-	640	-	-	-	23
130	-	-	-	-	-	-	-	-	24

Table 3. Estimates of undiscovered recoverable resources for onshore Alaska as of 12/31/86

[From U.S. Geological Survey and Minerals Management Service, 1988; Kandik Seg. Cord. Thrust, Kandik Segment of the Cordillera thrust beld]t; Oil <1 MMB, oil fields less than 1 million barrels of oil; Gas <6 BCF, gas fields less than 6 billion cubic ft of gas; -, no information]

Province (no.) and Assessed plays	Oil (Millions of barrels)			Gas (Billions of cubic ft)		
	F95	F5	Mean	F95	F5	Mean
Kandik (61)						
Kandik Seg. Cord. Thrust	0.0	486.8	109.5	-	-	-
Oil <1 MMB	0.0	2.8	0.4	-	-	-
Province Total	0.0	488.9	109.9	-	-	-
Alaska Interior (62)[1]						
Interior Tertiary Basins	-	-	-	408.7	2,600.3	1,207.5
Gas <6 BCF	-	-	-	42.7	248.9	119.0
Province Total	-	-	-	451.3	2,849.3	1,326.5
Interior Lowlands (63 Incl. in 62)						
Bristol Basin (64)						
Tertiary	-	-	-	75.5	518.1	234.8
Gas <6 BCF	-	-	-	40.7	145.7	83.0
Province Total	-	-	-	113.9	665.0	317.8
Copper River (66 Incl. in 62)						
Cook Inlet (67)[2]						
Beluga-Sterling Gas	-	-	-	223.7	3,097.0	1,145.1
Hemlock Conglomerate Oil	76.9	579.8	254.9	-	-	-
Gas <6 BCF	-	-	-	82.9	299.4	170.0
Oil <1 MMB	15.4	60.6	33.3	-	-	-
Province Total	91.2	641.2	288.2	286.2	3,421.6	1,315.1
Total	-[3]	-[3]	398.1	-[3]	-[3]	2,959.4

[1] Includes Alaska Peninsula (province 68, not discussed in this report), Bethel basin, Copper River basin, Holitna basin, Kobuk basin, Minchumina basin, Ruby-Rampart basin, Susitna basin, Nenana basin, Northway lowlands, and Yukon Flats basin

[2] Includes province 67 and northern part of province 15 in offshore state waters.

[3] Fractile values are not additive.