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A Brief Overview of Alaska Petroleum Systems

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INTRODUCTION

It is no exaggeration to say that energy resource issues are among the defining questions of our time. Debate rages over whether we can depend on oil and gas to fuel our economy over the long term. How will we be able to afford to use fossil fuels as demand increases and supplies dwindle? How long will fossil energy supplies last? How does our ever-increasing consumption impact national security and the global environment?

As pressing as these questions are to all Americans, they are perhaps even more critical to Alaskans. We rely on hydrocarbon fuels not only to survive our long, cold, dark winters, but also as the state's dominant revenue source. Nonetheless, many of us have vague or incorrect conceptions about the formation and distribution of oil and gas in the natural world.

To understand and predict petroleum occurrences, geologists and geophysicists now follow what is known as a "petroleum systems approach," considering and quantifying each of the interdependent processes required for the accumulation of hydrocarbons. This article briefly outlines this analytical approach and highlights key aspects of the petroleum systems at work in Alaska's sedimentary basins (fig. 1).

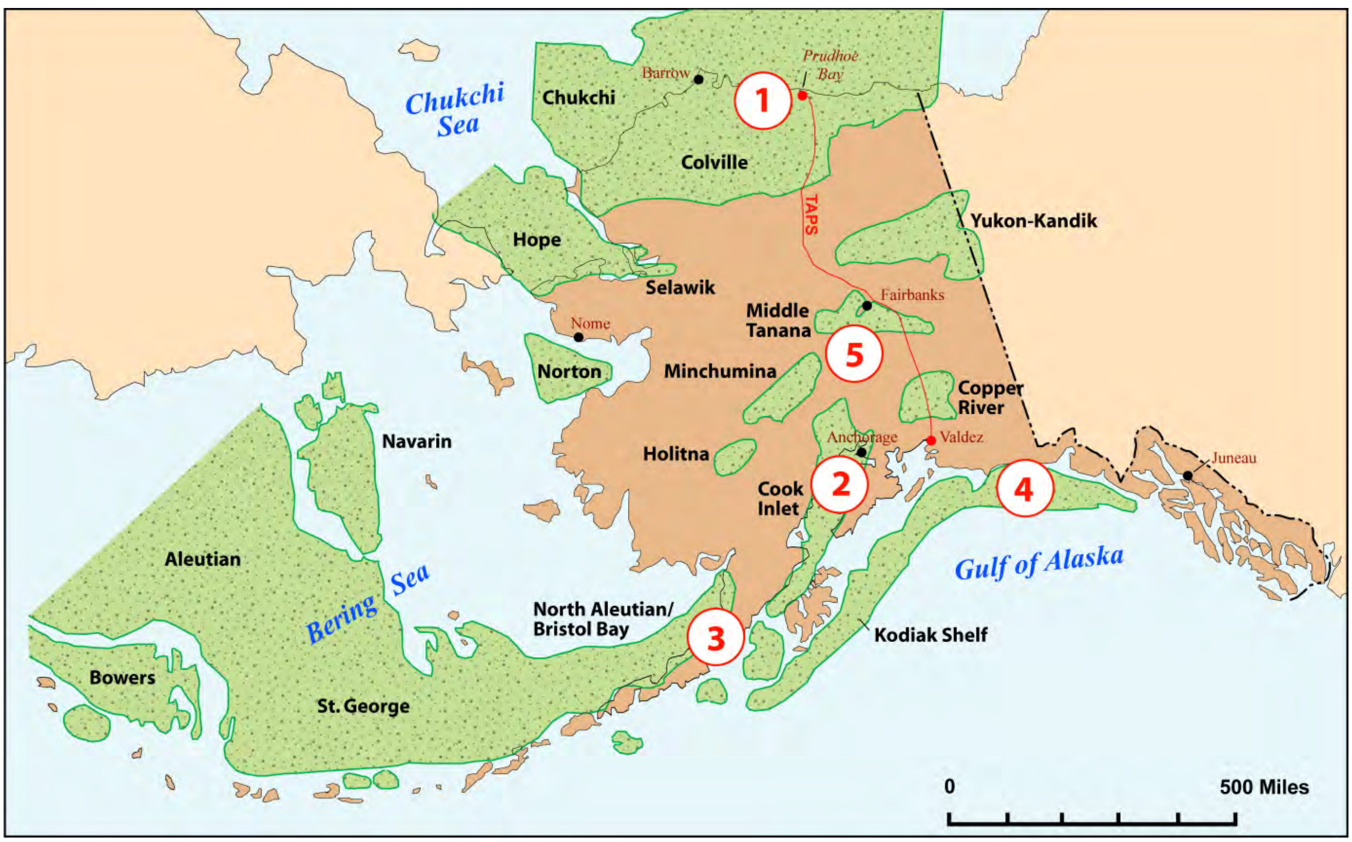

Figure 1. *Map showing sedimentary basins in Alaska. Multiple petroleum systems are established oil and gas producers in the North Slope province (1) and Cook Inlet basin (2). The Alaska Peninsula (3) and Gulf of Alaska (4) regions are known to possess all of the elements of petroleum systems, but they remain underexplored and commercially unproven. Most of the basins in Interior Alaska (5) are challenged by a variety of issues, though all appear to possess coarse, reservoir-quality sandstones.*

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ELEMENTS OF PETROLEUM SYSTEMS

The basic elements of a functional petroleum system are source rock, reservoir rock, trapping configuration, and seal rock. But it is not enough to simply have each of these components present in a given sedimentary basin—they also have to be in the right places at the right time, and interact in such a way that the whole system can operate properly.

Oil source rocks (usually black shales or limestones) contain elevated levels of organic molecules rich in carbon and hydrogen that, when heated slowly to the right temperature, react to form the mix of chainlike hydrocarbon molecules we call crude oil. The part of a basin that is buried deeply enough to cause this thermal conversion is called "the kitchen." With continued burial and increased heating in the kitchen, these same rocks release less oil and increasing amounts of the lighter, smaller hydrocarbon molecules that make up natural gas. Source rocks that start out rich in carbon but leaner in hydrogen (including coals as well as many shales and limestones) can generate natural gas but not the more hydrogen-rich liquid hydrocarbons. When hydrocarbons are created in the kitchen, their buoyancy quickly drives them to migrate out of the area, following the path of least resistance through the most permeable strata they encounter.

Reservoir rocks are porous and permeable formations that can store oil and gas in the pore spaces between grains (fig. 2) and later allow them to flow out of the rock into wellbores, where they can be extracted. Some of the most efficient petroleum systems have high-quality reservoir formations closely overlying the source rock strata where they act as conduits for hydrocarbons migrating up and out of the kitchen area toward traps closer to the basin edge. Only where these porous, permeable rocks are enclosed in trapping geometries does oil and gas stop migrating and accumulate in the reservoir rock to form fields.

Effective traps consist of reservoir rock layers overlain and/or laterally bounded by impermeable seal rock, and are of two basic types. *Structural traps* occur where the rock layers are deformed by folding or faulting to form large, concave-downward shapes capable of containing buoyant fluids such as oil and gas. *Stratigraphic traps* occur where porous, permeable reservoir rocks are encased in impermeable seal rocks as a result of non-uniform deposition of sediments.

For example, clean sands on a wave-worked beach may grade laterally into a muddy offshore setting, and with time, the muddy offshore zone may migrate over the older beach sand, setting up a possible future stratigraphic trap. Structural traps are usually much easier to identify and generally host the initial oil and gas discoveries in a given basin. Stratigraphic traps are much harder to target, and their successful prediction normally requires more detailed mapping of the subsurface geology. This might be based on either an abundance of previously drilled wells or advanced processing and interpretation of high-quality three-dimensional seismic data. In any case, in order for traps to host oil and gas fields, they must be created prior to hydrocarbon generation, expulsion, and migration from the kitchen. Moreover, they must then remain intact, uncompromised by later folding, faulting, or excessive burial.

NORTH SLOPE PROVINCE

Alaska's North Slope is one of the most prolific petroleum provinces in North America. One reason for this is that the region encompasses effective petroleum systems in each of the three main stratigraphic sequences that developed across the region over the last 350 million years (fig. 3). From oldest to youngest, these first-order geologic packages are called the Ellesmerian, Beaufortian, and Brookian megasequences. In some cases, the three major systems operate independently of one another, with source, reservoir, and sealed traps all occurring in closely related strata. In other cases, the systems overlap, combining elements from two or more stratigraphic sequences.

Overall, the North Slope is sometimes described as 'supercharged' by oil and gas generated in its multiple, high-quality,

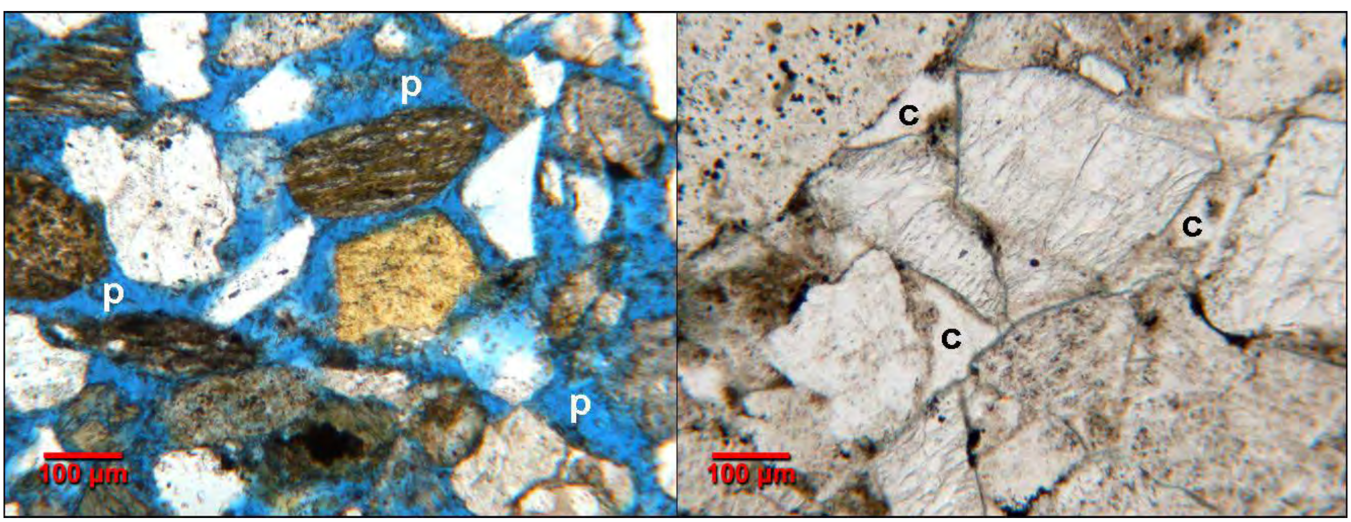

Figure 2. *Microscopic views contrasting reservoir- and non-reservoir-quality sandstones from the Alaska Peninsula–Bristol Bay region. High-quality sandstone at left is from the Tertiary Bear Lake Formation, and has abundant, large, well connected pores (p) capable of storing hydrocarbons and allowing them to flow to producing wells. Non-reservoir sandstone at right from the Jurassic Naknek Formation, with tightly-fitted sand grains and cement-filled pores (c), has essentially no porosity or permeability.*

widespread source rocks in kitchens underlying a large percentage of the region. As a regional generalization, the greatest barrier to oil and gas production on the North Slope is reservoir quality, commonly jeopardized by the presence of too much pore-clogging mud in the system when the strata are deposited. Also, reservoirs that start out as clean sands or limestones often suffer from destruction of the pore system through compactional collapse of relatively weak grains or the chemical precipitation of cements during deep burial by overlying strata.

A brief look at an accumulation produced by each of the North Slope's main petroleum systems provides insights into the characteristic elements, strengths, and risks of each stratigraphic sequence. Remember that many of the North Slope fields would not exist without mixing elements from two or more of these petroleum systems.

Ellesmerian petroleum system. By far Alaska's largest and most widely known oil field, Prudhoe Bay is also the premier product of the Ellesmerian petroleum system, though its oil and gas is a mixture that includes contributions from younger sources. Current estimates of ultimate recovery from the main Prudhoe Bay field are 13.77 billion barrels of oil, plus natural gas liquids and 27.3 trillion cubic feet of natural gas. Of this total, more than 80 percent of the oil has already been produced, while about 85 percent of the gas remains in the ground. The Triassic Ivishak Formation is the major reservoir, consisting of fluvial and deltaic sandstones and conglomerates. Most of the oil and gas was sourced from shaly limestones of the Triassic Shublik Formation, though portions came from the Jurassic Kingak Formation (lower part of the Beaufortian sequence) and from the lower Cretaceous HRZ shale (base of the Brookian sequence). The Prudhoe trap is an enormous container created in two stages during early Cretaceous time: (1) rift margin faulting that uplifted the Barrow Arch, and (2) the erosion and shale deposition that followed; as such it is a hybrid structural/unconformity trap. Despite numerous faults that cut the reservoir, the trap is securely sealed by two thick shale units, the Jurassic Kingak Formation and the Cretaceous Pebble Shale.

Although the Ellesmerian sequence includes spectacular reservoir quality at Prudhoe Bay and several other nearby fields, geologic conditions were less favorable for depositing and preserving high-quality reservoirs over many parts of the North Slope, making reservoir formation the riskiest element of the Ellesmerian petroleum system in a regional sense. The Ellesmerian's greatest asset is the source component; Shublik and older oil- and/or gas-prone source rocks are believed to be present and thermally mature for hydrocarbon generation across most of the North Slope.

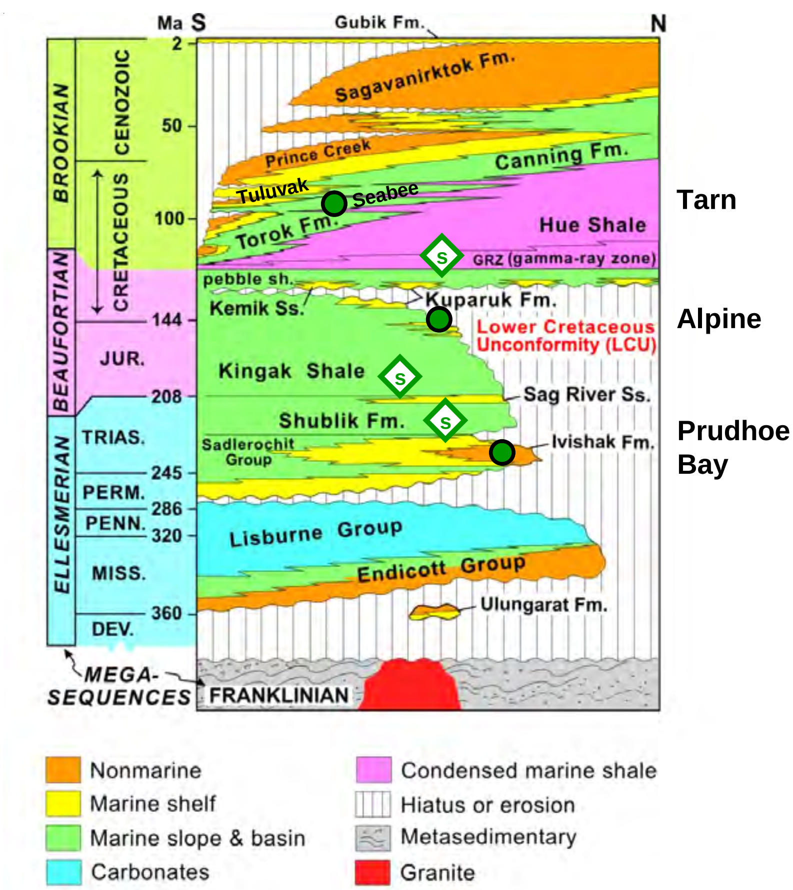

Figure 3. *Chronostratigraphic chart for the North Slope petroleum province showing the major stratigraphic sequences, geologic time scale, stratigraphic column, and the oil and gas fields (dots) and source rocks (diamonds) discussed in text. Note that GRZ (gamma-ray zone) is synonymous with HRZ (highly radioactive zone), and describes the gamma-ray well log response of this Lower Cretaceous shale. Modified from Garrity and others (2005).*

Beaufortian petroleum system. The surprise 1994 discovery of oil-saturated sandstone of latest Jurassic age in the Colville River Delta opened a new exploration play in northern Alaska and established the presence of a self-contained petroleum system in the Beaufortian sequence. This is the suite of strata deposited during the initial rifting phases that led to the opening of the Beaufort Sea. The Alpine sandstone, reservoir unit for the oil field of the same name, is the only confirmed Beaufortian rock of latest Jurassic age. This unit is anomalous compared to the rest of the Kingak Formation, which is dominated by older shales and poor quality sandstones. It now appears likely that Alpine-aged sandstones were deposited in the shallow water rimming much of the uplifted Barrow Arch rift shoulder, but were eroded away across large portions of its original extent before deposition of lowermost Cretaceous shales. However, prior to the Alpine discovery, rocks from the latest Jurassic time interval were not known to be present at all, much less to be shorezone sandstones with fair to good reservoir quality.

Just as intriguing was the recognition that the Alpine's oil is stratigraphically trapped. The reservoir sandstone is encased in sealing mudstones, and can in many cases only be imaged using relatively recent advances in 3D seismic processing. Subsequent drilling indicates the trap is tightly sealed and much larger than originally estimated, containing an oil column at least 600 feet thick comprising estimated ultimate recoverable reserves of 465 million barrels with no overlying gas cap and no underlying water-saturated zone.

Yet another unforeseen aspect of the Alpine discovery is the quality and source of its oil. Its density and viscosity, as well as its asphaltene and sulfur content are all much lower than oils from Prudhoe Bay and Kuparuk fields. These favorable attributes make the oil more valuable and more efficiently recovered and are now known to be characteristic of oil sourced from the pure shales of the lower Jurassic part of the Kingak Formation. Somehow, despite the Kingak's shaly makeup, the source rocks of the lower part are directly linked with a migration route to the reservoir sandstones in the upper part.

Although the Beaufortian sequence also includes the Kuparuk Formation and the related Point Thomson sandstone, most of its reservoir-quality sandstones are of only local extent. Elsewhere, equivalent strata typically lack porosity and permeability because they are either too fine grained, too rich in clay matrix, or damaged by cementation, making reservoir quality the greatest overall exploration challenge. On the other hand, trap and seal are normally a safe bet in the Beaufortian sequence, a consequence of the high proportion of shales relative to coarser-grained rocks.

Brookian petroleum systems. The Brookian sequence is the youngest major package of sedimentary rocks in northern Alaska. These sediments were derived by erosion of the Brooks Range, and filled in the Colville Basin north of the range, eventually spilling over the old Beaufortian rift shoulder and into the Beaufort Sea. The Brookian hosts oil and gas accumulations spanning a broad range of trap types and reservoir sandstones. So-called "topset" sandstones were laid down in nearshore shallow marine or onshore nonmarine environments, whereas "turbidite" reservoirs were deposited from turbidity currents in deep water at or near the base of the continental slope.

The Tarn Field is a good example of the Brookian petroleum system supplying all the components independently of the other systems. Its reservoir is a turbidite known as the Bermuda sandstone of the mid-Cretaceous Seabee Formation. Like most turbidites, the Bermuda interval comprises reservoir-quality sandstones across only a fraction of its full extent. Fortunately, the porosity and permeability thresholds for a viable reservoir are extended at Tarn by the presence of very light oil, similar to the Alpine oil, but sourced from the lower Cretaceous HRZ shale that blankets much of the bottom of the Brookian basin. All told, Tarn is now expected to ultimately yield 120 million barrels of oil and 34 billion cubic feet of gas. Because the better turbidite sandstones pinch out laterally into siltstones and shales, Brookian turbidite reservoirs are commonly stratigraphically trapped. The fairway for the turbidite exploration play is thus much broader than for topset plays, which require either structural traps or special circumstances to form stratigraphic traps.

Strengths and risks of the Brookian petroleum system vary greatly by play. The critical risk in exploring for Brookian turbidites is that the sandstone may lack sufficient porosity and permeability—being either too fine-grained, too muddy, or too compacted and cemented due to deep burial—to host a reservoir. The stratigraphic traps encasing the turbidite reservoirs are the play's greatest strength. Prospecting for Brookian topsets is completely different. Since the topset sands are widespread and have not been as deeply buried as their deepwater counterparts, reservoir presence and effectiveness is normally the greatest strength. Regionally, the greatest risk associated with the topset play is oil quality. The shallow depth of many keeps them cool enough that hydrocarbon-metabolizing bacteria can thrive and biodegrade the oil, making it viscous, more expensive to recover, and less valuable.

COOK INLET BASIN

For a number of years prior to the discovery of vast oil resources at Prudhoe Bay, southern Alaska's Cook Inlet basin was a hotbed of exploration, resulting in numerous commercial oil and gas discoveries that were quickly brought online. This phase of active drilling rapidly proved up what are now recognized as two independent hydrocarbon systems, while a more speculative third system has remained an elusive target. The established systems are both contained in Tertiary-aged reservoirs, but have entirely different source and migration histories (fig. 4). The unproven system would depend on the older Mesozoic rocks maintaining adequate reservoir quality, which appears to occur very rarely in this basin.

Tertiary-reservoired oil system. All the oil fields in Cook Inlet have one thing in common: Their production comes from reservoir formations in the lower part of the nonmarine Tertiary succession. Tertiary strata blanket a regional angular unconformity that beveled off the more deformed Mesozoic succession below. Along the eastern and western edges of the basin, Tertiary reservoirs consist largely of gravelly alluvial fans and sandy braided channels shed from the adjacent upland areas. Toward the basin axis, south-flowing river channels migrated side to side across their floodplains, depositing sandy fluvial reservoirs interlayered with overbank silts, clays, and coals.

Carbon isotopes and biological marker compounds found in Cook Inlet oils trace them back to the Jurassic Tuxedni Group and/or Triassic Kamishak Formation, oil-prone marine source rocks in the Mesozoic succession below the angular unconformity in the deep, central part of the basin. The oil migrated up out of this central kitchen, across the unconformity, up the flanks of the basin into nearby anticlinal traps, and probably into a number of yet-to-be-discovered stratigraphic traps. Some of these oil fields produce modest amounts of associated gas dissolved in the oil, but the fields do not have free gas caps.

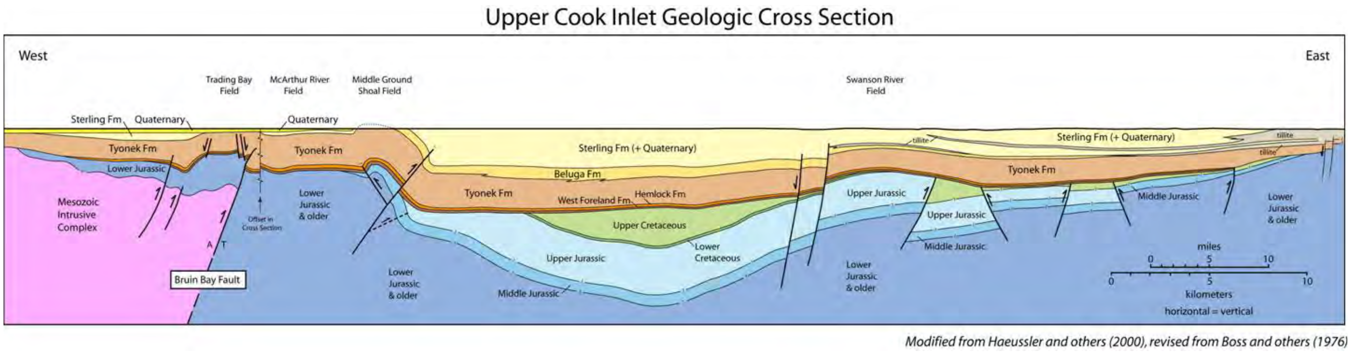

Figure 4. *Geologic cross section through upper Cook Inlet, modified from Haeussler and others (2000), revised from Boss and others (1976). Oil sourced from the Middle Jurassic Tuxedni Group migrated across the angular unconformity into lower Tertiary reservoirs of the West Foreland, Hemlock, and Tyonek formations. Biogenic gas sourced by bacterial degradation of coals forms commercial accumulations in the upper Tertiary sandstones of the Tyonek, Beluga, and Sterling formations.*

Tertiary-reservoired gas system. Cook Inlet's gas reserves occur in some of the same Tertiary formations as the oil, but are produced mainly from the upper formations in which no oil has been discovered. Unlike the oil, which was generated from thermal maturation of the Mesozoic sources, almost all of the basin's dry methane gas was generated as a by-product of bacteria feeding on the Tertiary coals in the subsurface. Initially, this biogenic gas dissolved in the water, saturating the coals. Late-stage folding and anticlinal uplift throughout the basin, together with the even more recent disappearance of thick glaciers, caused a drop in the pore pressure, which allowed the dissolved methane to bubble out of solution as a free gas phase. Only then could the biogenic gas begin to migrate out of the coals and accumulate in nearby sandstone reservoirs. The northern edge of the Cook Inlet basin has seen recent coalbed methane exploration, targeting gas still contained in the microporous structure of the coals themselves. Up to this point, coalbed methane projects have been thwarted by subsurface structural complexity. Extensive faulting and folding have broken and jostled the coal seams into small, tilted compartments that are difficult to drain efficiently.

Mesozoic-reservoired oil and gas system. For decades, companies have hoped to find Mesozoic sandstones that have maintained sufficient porosity and permeability to serve as reservoirs. To this point, there has been only minor encouragement on this front; in nearly all cases, the older sandstones are too tightly cemented to serve as conventional reservoirs. However, there is ongoing interest in exploring for Mesozoic-sourced oil and gas that never migrated very far beyond the kitchen. Locally, conventional sandstone reservoirs might have escaped destruction if their pores were filled with oil early enough to shut down chemical cementation. Alternatively, the source rocks themselves may serve as unconventional reservoirs, as is the case in some other sedimentary basins. Both scenarios carry substantially more exploration risk, and any current contribution to production from beneath the Base Tertiary unconformity is minor at best. For now, an independent Mesozoic petroleum system remains unproven.

NONPRODUCING BASINS – STRENGTHS AND RISKS

Several regions of the state host sedimentary basins that have no current commercial oil or gas production. As outlined below, many of the critical petroleum system elements are present, but the lack of economic success to date makes it unclear whether these elements are interacting as needed to make up functional petroleum systems.

Alaska Peninsula. The long peninsula separating the Cook Inlet and Bristol Bay basins was first explored in the early 1900s with wells drilled on the southeast side near active oil and gas seeps. Exploration shifted to the northwest side of the Alaska Peninsula in the late 1950s through early 1980s before being halted by concerns over fisheries protection. Regular leasing was renewed in 2005 with the establishment of the Alaska Peninsula areawide sale, encompassing nearly 5 million gross acres. This area is dramatically underexplored, especially by modern methods. All the necessary components appear to exist for both Tertiary and Mesozoic petroleum systems, but it remains to be seen whether they are properly integrated to result in major hydrocarbon accumulations that can be economically developed in this remote region.

Oil- and gas-prone source rocks are clearly present and functioning in areas with prolific oil and gas seeps, but their subsurface distribution and maturity is uncertain in other areas. The region has a complex thermal and tectonic history due to the evolution of a plate boundary dominated by oblique subduction of the Pacific plate, creating further uncertainties regarding reservoir quality, thermal maturity, and the location and integrity of both structural and stratigraphic traps. Recent industry interest focuses on natural gas as more likely than oil, and recognizes that much of the gas potential is offshore beneath the federal waters of Bristol Bay.

Gulf of Alaska. As on the Alaska Peninsula, the Gulf of Alaska saw early exploration activity driven by prolific oil seeps. The Katalla area enjoyed a brief era of minor oil production from shallow wells in the early 1900s, but more recent drilling has turned up no oil or gas accumulations that would be commercial today. Again, the key elements of petroleum systems are shown to exist, with excellent Tertiary source rocks and reservoirs, and a plate-boundary tectonic setting favorable for creating structural and stratigraphic traps. Nonetheless, the modern explorationist faces a serious challenge connecting all the different elements in definable prospects of commercial size. Much of the Gulf of Alaska region suffers from low thermal maturity, elusive stratigraphic traps, or extreme deformation and destruction of reservoir quality.

Interior Basins. A number of unproven sedimentary basins developed in Interior Alaska during Tertiary time, including the Yukon Flats, Nenana, Minchumina, Holitna, Copper River, and Susitna basins. Most are thought to have developed either as subsiding pull-apart basins related to large strike-slip displacements on the Denali–Farewell, Tintina–Kaltag, Iditarod, and Border Ranges–Castle Mountain fault systems. In general, Alaska's Interior basins contain relatively thick sandy or gravelly intervals that would serve as oil and gas reservoirs. They are challenged either by lack of traditional oil- and gas-prone source rocks, low thermal maturity, structural complexity, questionable seal integrity, or some combination of these issues. Coals are developed in many of the basins, and might source biogenic gas, as is the case in Cook Inlet, but the Interior basins lack the significant late-stage uplift-related depressurization required to break the gas out of solution to allow migration and accumulation.

CONCLUSIONS

Alaska is an enormous state comprising a number of very different geologic provinces (fig. 5). Not surprisingly, the oil and gas productivity of its sedimentary basins is equally variable. The petroleum systems approach used by oil and gas explorers provides a simple but powerful tool for gaining insight into why some of Alaska's basins are world-class producers, whereas others have yet to produce any commercial hydrocarbons. This discussion has focused mainly on the geologic realities of Alaska's petroleum systems—perhaps mere accidents of nature and geologic time—that determine how much oil and gas are created and reservoired in a basin. Without a doubt, dozens of other factors are also at play in determining whether and when a basin's oil and gas resources become commercially developed. Transportation infrastructure, proximity to local and export markets, global supply and demand, and the balance between resource development and environmental protection are just a few items on what could be a very long list. But aren't these really cultural and societal issues that might change with time? There is perhaps one thing we can count on—the future can't change Alaska's geologic past.

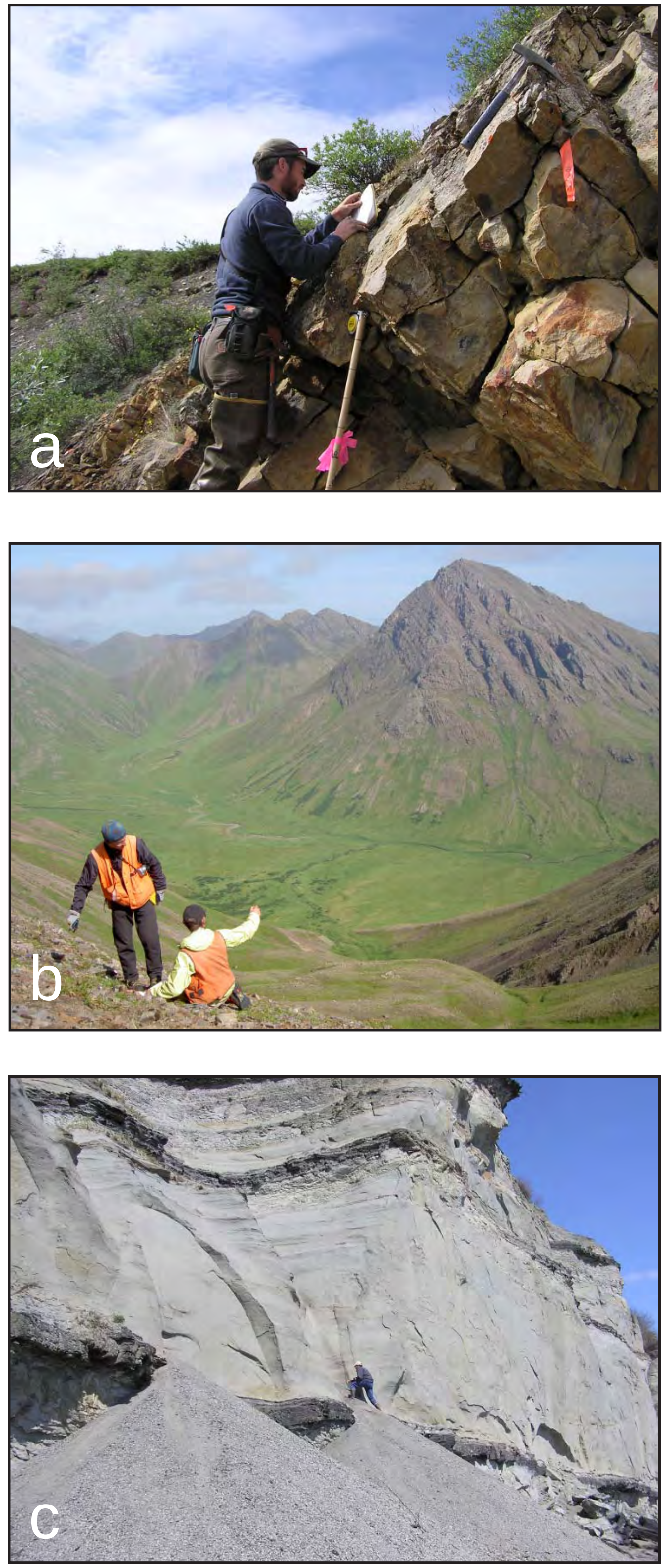

Figure 5. *Recent DGGS-led geologic field programs on the North Slope (a), Alaska Peninsula (b), and in the Cook Inlet basin (c) remain a cornerstone of petroleum systems studies in Alaska. Projects include collaboration with geologists and geophysicists of the Alaska Division of Oil & Gas, U.S. Geological Survey, University of Alaska, and other universities, and are increasingly focused on integrating outcrop data with subsurface well and seismic data.*

NEW DGGS PUBLICATIONS

GEOPHYSICAL MAPS & REPORTS

GPR 2006-6. Line, grid, and vector data, and plot files for the airborne geophysical survey of the Alaska Highway corridor, east-central Alaska, by Burns, L.E., Fugro Airborne Surveys, and Stevens Exploration Management Corp., 2006, 1 disk. DVD format. Line data in ASCII format; gridded data in Geosoft and ER Mapper formats; vector files in AutoCAD version 13 dxf files. Includes maps listed below as GPR 2006-6-xy as plot files in both HPGL/2 format and as Adobe Acrobat format files. The HPGL2 files will only plot with software that has ability to plot HPGL2 files produced for an HP Design Jet 5000/5500 series plotter. $10.

GPR 2006-6-1A. Total magnetic field of the Alaska Highway corridor, east-central Alaska, parts of Big Delta and Mt. Hayes quadrangles, by Burns, L.E., Fugro Airborne Surveys, and Stevens Exploration Management Corp., 2006, 1 sheet, scale 1:63,360. Full color; contains topography. $13.

GPR 2006-6-1B. Total magnetic field of the Alaska Highway corridor, east-central Alaska, parts of Mt. Hayes Quadrangle, by Burns, L.E., Fugro Airborne Surveys, and Stevens Exploration Management Corp., 2006, 1 sheet, scale 1:63,360. Full color; contains topography. $13.

GPR 2006-6-1C. Total magnetic field of the Alaska Highway corridor, east-central Alaska, parts of Tanacross Quadrangle, by Burns, L.E., Fugro Airborne Surveys, and Stevens Exploration Management Corp., 2006, 1 sheet, scale 1:63,360. Full color; contains topography. $13.

GPR 2006-6-1D. Total magnetic field of the Alaska Highway corridor, east-central Alaska, parts of Nabesna and Tanacross quadrangles, by Burns, L.E., Fugro Airborne Surveys, and Stevens Exploration Management Corp., 2006, 1 sheet, scale 1:63,360. Full color; contains topography. $13.

GPR 2006-6-1E. Total magnetic field of the Alaska Highway corridor, east-central Alaska, parts of Nabesna and Tanacross quadrangles, by Burns, L.E., Fugro Airborne Surveys, and Stevens Exploration Management Corp., 2006, 1 sheet, scale 1:63,360. Full color; contains topography. $13.

GPR 2006-6-1F. Total magnetic field of the Alaska Highway corridor, east-central Alaska, parts of Nabesna Quadrangle and Canada 115K, by Burns, L.E., Fugro Airborne Surveys, and Stevens Exploration Management Corp., 2006, 1 sheet, scale 1:63,360. Full color; contains topography. $13.

GPR 2006-6-2A. 140,000 coplanar apparent resistivity of the Alaska Highway corridor, east-central Alaska, parts of Big Delta and Mt. Hayes quadrangles, by Burns, L.E., Fugro Airborne Surveys, and Stevens Exploration Management Corp., 2006, 1 sheet, scale 1:63,360. Full color; contains topography. $13.

GPR 2006-6-2B. 140,000 coplanar apparent resistivity of the Alaska Highway corridor, east-central Alaska, parts of Mt. Hayes Quadrangle, by Burns, L.E., Fugro Airborne Surveys, and Stevens Exploration Management Corp., 2006, 1 sheet, scale 1:63,360. Full color; contains topography. $13.

GPR 2006-6-2C. 140,000 coplanar apparent resistivity of the Alaska Highway corridor, east-central Alaska, parts of Tanacross Quadrangle, by Burns, L.E., Fugro Airborne Surveys, and Stevens Exploration Management Corp., 2006, 1 sheet, scale 1:63,360. Full color; contains topography. $13.

GPR 2006-6-2D. 140,000 coplanar apparent resistivity of the Alaska Highway corridor, east-central Alaska, parts of Nabesna and Tanacross quadrangles, by Burns, L.E., Fugro Airborne Surveys, and Stevens Exploration Management Corp., 2006, 1 sheet, scale 1:63,360. Full color; contains topography. $13.

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GPR 2006-6-2F. 140,000 coplanar apparent resistivity of the Alaska Highway corridor, east-central Alaska, parts of Nabesna Quadrangle and Canada 115K, by Burns, L.E., Fugro Airborne Surveys, and Stevens Exploration Management Corp., 2006, 1 sheet, scale 1:63,360. Full color; contains topography. $13.

GPR 2006-6-3A. 40,000 coplanar apparent resistivity of the Alaska Highway corridor, east-central Alaska, parts of Big Delta and Mt. Hayes quadrangles, by Burns, L.E., Fugro Airborne Surveys, and Stevens Exploration Management Corp., 2006, 1 sheet, scale 1:63,360. Full color; contains topography. $13.

GPR 2006-6-3B. 40,000 coplanar apparent resistivity of the Alaska Highway corridor, east-central Alaska, parts of Mt. Hayes Quadrangle, by Burns, L.E., Fugro Airborne Surveys, and Stevens Exploration Management Corp., 2006, 1 sheet, scale 1:63,360. Full color; contains topography. $13.

GPR 2006-6-3C. 40,000 coplanar apparent resistivity of the Alaska Highway corridor, east-central Alaska, parts of Tanacross Quadrangle, by Burns, L.E., Fugro Airborne Surveys, and Stevens Exploration Management Corp., 2006, 1 sheet, scale 1:63,360. Full color; contains topography. $13.

GPR 2006-6-3D. 40,000 coplanar apparent resistivity of the Alaska Highway corridor, east-central Alaska, parts of Nabesna and Tanacross quadrangles, by Burns, L.E., Fugro Airborne Surveys, and Stevens Exploration Management Corp., 2006, 1 sheet, scale 1:63,360. Full color; contains topography. $13.

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GPR 2006-6-3F. 40,000 coplanar apparent resistivity of the Alaska Highway corridor, east-central Alaska, parts of Nabesna Quadrangle and Canada 115K, by Burns, L.E., Fugro Airborne Surveys, and Stevens Exploration Management Corp., 2006, 1 sheet, scale 1:63,360. Full color; contains topography. $13.

GPR 2006-6-4A. 8200 coplanar apparent resistivity of the Alaska Highway corridor, east-central Alaska, parts of Big Delta and Mt. Hayes quadrangles, by Burns, L.E., Fugro Airborne Surveys, and Stevens Exploration Management Corp., 2006, 1 sheet, scale 1:63,360. Full color; contains topography. $13.

GPR 2006-6-4B. 8200 coplanar apparent resistivity of the Alaska Highway corridor, east-central Alaska, parts of Mt. Hayes Quadrangle, by Burns, L.E., Fugro Airborne Surveys, and Stevens Exploration Management Corp., 2006, 1 sheet, scale 1:63,360. Full color; contains topography. $13.

GPR 2006-6-4C. 8200 coplanar apparent resistivity of the Alaska Highway corridor, east-central Alaska, parts of Tanacross Quadrangle, by Burns, L.E., Fugro Airborne Surveys, and Stevens Exploration Management Corp., 2006, 1 sheet, scale 1:63,360. Full color; contains topography. $13.

GPR 2006-6-4D. 8200 coplanar apparent resistivity of the Alaska Highway corridor, east-central Alaska, parts of Nabesna and Tanacross quadrangles, by Burns, L.E., Fugro Airborne Surveys, and Stevens Exploration Management Corp., 2006, 1 sheet, scale 1:63,360. Full color; contains topography. $13.

GPR 2006-6-4E. 8200 coplanar apparent resistivity of the Alaska Highway corridor, east-central Alaska, parts of Nabesna and Tanacross quadrangles, by Burns, L.E., Fugro Airborne Surveys, and Stevens Exploration Management Corp., 2006, 1 sheet, scale 1:63,360. Full color; contains topography. $13.

GPR 2006-6-4F. 8200 coplanar apparent resistivity of the Alaska Highway corridor, east-central Alaska, parts of Nabesna Quadrangle and Canada 115K, by Burns, L.E., Fugro Airborne Surveys, and Stevens Exploration Management Corp., 2006, 1 sheet, scale 1:63,360. Full color; contains topography. $13.

GPR 2006-6-5A. 1800 coplanar apparent resistivity of the Alaska Highway corridor, east-central Alaska, parts of Big Delta and Mt. Hayes quadrangles, by Burns, L.E., Fugro Airborne Surveys, and Stevens Exploration Management Corp., 2006, 1 sheet, scale 1:63,360. Full color; contains topography. $13.

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Dear Readers:

One can count on many things in Alaska: Termination dust in the fall, dark winters, dog teams howling at feeding time, mosquitoes in the field, and—one of my favorites—continual and dynamic change. DGGS starts this new year with a number of changes including new personnel, new administration, old volcanoes erupting anew, and high commodity prices that are spurring exploration activity across the state. The challenge of change is what keeps the staff at DGGS pushing hard to keep up with the demand for data and expertise on geologic hazards, oil and gas potential, and mineral resources across the state. We are meeting these challenges.

This issue's feature article, by Paul Decker of the Division of Oil & Gas, is an excellent example of how your survey is retooling its approach to geologic investigation. On the energy front, we have embarked on a number of new projects that will incorporate all the publicly available subsurface data to apply a systems approach to understanding the geologic history of an area. Diane Shellenbaum, who was recently hired by the Division of Oil & Gas, is helping us build a database of seismic reflection data that will dramatically increase our interpretation capabilities. We have completed our first year in the field on the Cook Inlet project and are already documenting some important finds relating to the basin-edge geometry of that complex system. The future for this group is very exciting.

The engineering geology section is continuing their work on many collaborative projects in volcanic hazards, tsunami-inundation mapping, and gas pipeline corridor mapping to address hazards, material sites, and bedrock geology. The group is also nearly finished with development of a cooperative teaching program, MapTEACH, which is taking modern geologic mapping techniques to the rural classroom and showing the students how understanding the natural environment is key to a sustainable future. Please visit our website to see some of these exciting programs.

Our minerals section has had a very busy year and is putting the final touches on inch-to-the-mile mapping on the Seward Peninsula. New data coming out of these mapping efforts are providing a much more detailed look at the complex metamorphic history of the area, which will dramatically improve our understanding of the mineralization and regional tectonics. The geophysics acquired through our mineral inventory program has proven to be crucial to providing this level of mapping and geologic knowledge. Our annual minerals report attests that the industry is seeing an unprecedented amount of activity and providing both revenue and jobs across the state.

Our publications section is working on getting all the new data and reports available to the public through our website and also expanding our digital database to include legacy data, the GMC geologic collection, and the many new maps and reports that are the keystone of our work.

We at DGGS hope you have a safe and festive holiday season and look forward to hearing from you in the coming year.

Sincerely

Bob Swenson
Acting Director & State Geologist

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