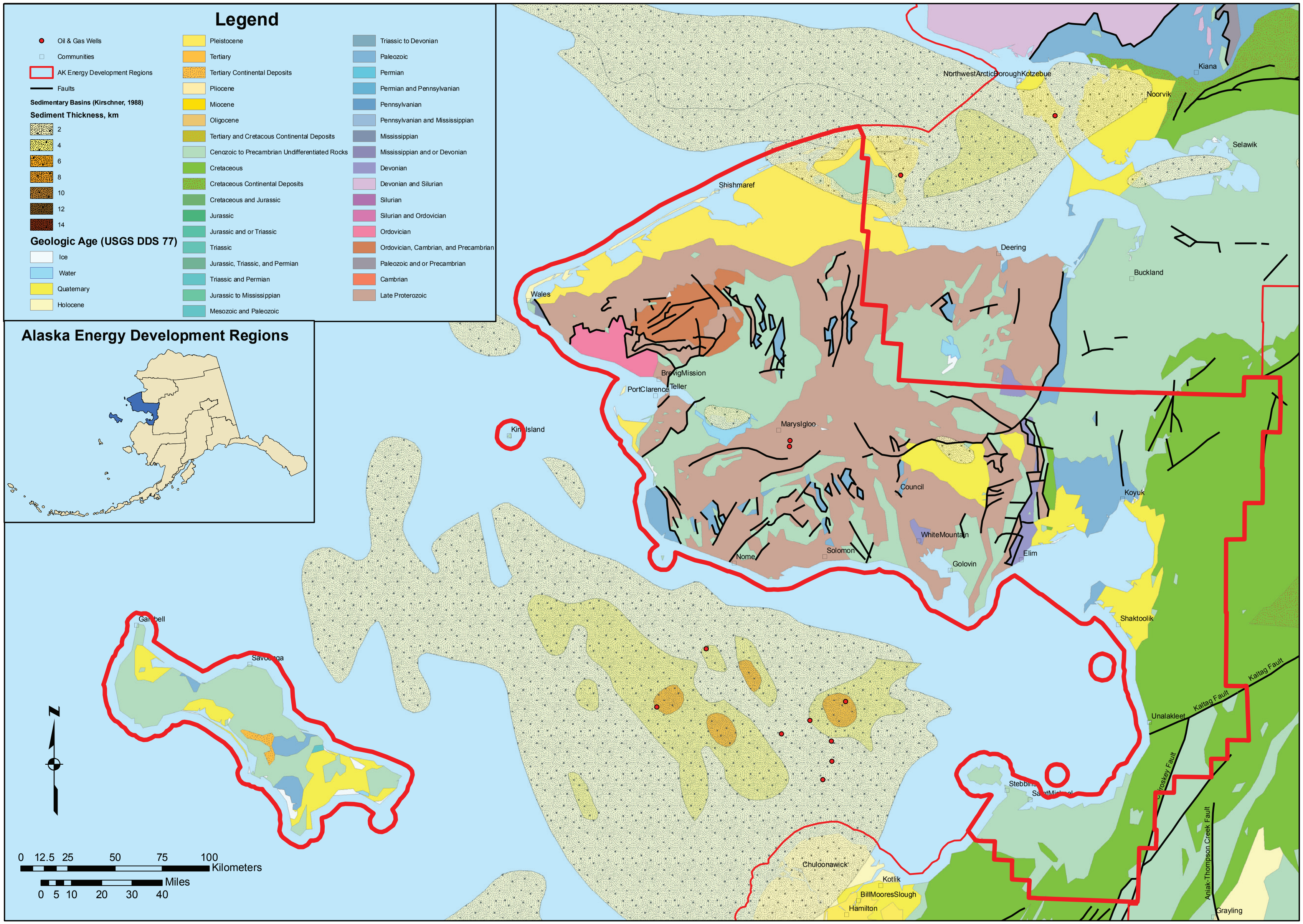
Geology of the Bering Straits Energy Region, Alaska



Bering Straits

SUMMARY OF FOSSIL FUEL AND GEOTHERMAL RESOURCE POTENTIAL IN THE BERING STRAITS ENERGY REGION

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INTRODUCTION

Purpose of this report

Economic growth and stability in Alaska's rural and urban areas hinges partially, if not primarily, on the availability of affordable and sustainable energy supplies. Recent price increases in oil and gas commodities have created severe economic hardship in many areas of the state that are dependent on diesel and heating oil as their primary source of energy. All sectors of Alaska's economy rely on affordable energy sources with limited price volatility, highlighting the need to diversify the energy portfolio by developing locally available and sustainable resources that are not tied to the global market. Unfortunately, all areas are not created equal in energy accessibility; the resources available for local exploitation vary widely across the state. It is critical that funding decisions for expensive programs to reduce the dependence on diesel for heat and electricity take into account information concerning the entire suite of natural resources that exist in a given area.

This report draws from existing information to provide community and state leaders an objective summary of our current knowledge concerning the potential of locally exploitable fossil fuel and geothermal energy resources in the Bering Straits Energy Region (fig. C1), one of 11 regions recognized by the Alaska Energy Authority in their Energy Plan (AEA, 2009). The potential geologically hosted energy resources considered here include exploitable coal, conventional and unconventional oil and gas, and geothermal resources. This report concludes with recommendations as to what additional data or strategies, if any, would provide the most leveraging in helping to develop new energy resources in the region.

Readers without geological training are encouraged to peruse the geologic summaries of fossil fuel resources and geothermal energy in chapter A. They provide an overview of the geologic elements that must be present in an area to economically develop coal, conventional oil and gas, unconventional oil and gas, and geothermal resources. These summaries will provide the necessary background to more fully understand the information presented in this chapter.

Geographic and geologic setting

The Bering Straits Energy Region is located along the western coast of Alaska (sheet 1). It encompasses the northwest and southern portions of the Seward Peninsula, extends south along the Norton Sound coast to a few miles north of Point Romanof and spans south and eastward 10 to 60 miles from the coast. The region also includes Saint Lawrence Island, King Island, and various other nearshore islands. The region's largest community is Nome, with a current population of nearly 3,500 residents. Other sizable communities include Unalakleet, Savoonga, Gambell, Shishmaref, and Stebbins, with populations ranging from nearly 800 to less than 600 residents. Smaller populations occupy 11 other permanent villages.

Much of the Bering Straits Energy Region's landscape consists of rolling highlands with gentle slopes. Exceptions include several rugged mountain ranges on the Seward

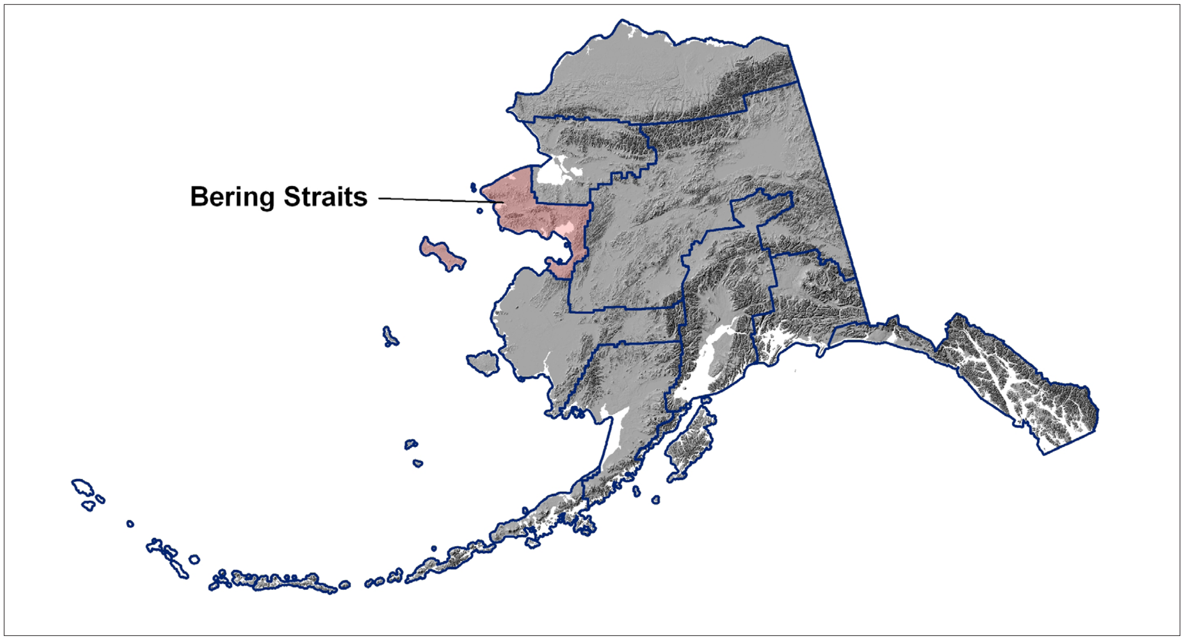

Figure C1. Location map of Bering Straits Energy Region.

Peninsula, including the York Mountains, Kigluaik Mountains, Darby Mountains, Bendeleben Mountains, and the Midnight Mountain area. Plains and lowlands containing numerous small lakes occur along the coastline, along the valleys of the larger rivers and in isolated basins north and south of the Bendeleben and Darby mountains. There are volcanic remnants in the Devil Mountain area of the Seward Peninsula and on Saint Lawrence Island, south of Savoonga (Wahrhaftig, 1965).

The geologic history of the Bering Straits Energy Region is complicated, and in many areas the details are poorly understood. Till and others (2011) compiled available geologic data for the region and present a useful, up-to-date summary of the geologic evolution of the Seward Peninsula. Rock types include sedimentary, igneous, and metamorphic varieties and range in age from Paleozoic through Cenozoic. However, major stratigraphic, lithologic, and structural discontinuities indicate that the geologic history of the region involves large-scale tectonic displacements interspersed with periods of erosion, deposition, and volcanism (Patton and others, 1994). The exposed bedrock of most of the region comprises intensely deformed and/or metamorphosed Precambrian, Paleozoic, and Mesozoic sedimentary and volcanic rocks (Till and Dumoulin, 1994). Numerous stocks and plutons of granitic rocks of Cretaceous and possibly Tertiary age intrude these older units and basalts of Pliocene and Quaternary age cover substantial parts of the region. Significant fault zones include the Kugruk fault zone, which parallels the eastern extent of the Seward Peninsula, and the Kaltag fault, which transects the Bering Straits Energy Region south of Unalakleet. In various places throughout the region, localized structural or topographic basins contain deposits of Cretaceous and Tertiary age coal, shale, sandstone, and conglomerate (sheet 2).

GEOLOGIC ENERGY RESOURCE POTENTIAL IN THE BERING STRAITS ENERGY REGION

Mineable coal resource potential

Coal quality and extent depend on geologic age, depositional setting, and tectonic history. The formation of thick, widespread coal packages requires long time periods of vegetation growth and accumulation in boggy, terrestrial basins sheltered from significant influxes of clastic sediments and accompanied by steady basin subsidence resulting in burial (see Chapter A). Available geophysical evidence, subsurface data, and geologic mapping suggest that most of the Bering Straits Energy Region is underlain by Mesozoic and older igneous, metamorphic, and volcaniclastic sedimentary rocks (Till and others, 2011). Surface exposures of younger, nonmarine siltstone and sandstone lithologies are deposited in fluvial to lacustrine environments that have associated coal deposits. More often these younger, Tertiary-age rocks are eroded or are present in subsiding graben-like structures and covered by Quaternary sediments. Along a number of riverbanks the eroded remnants of the coal deposits are found as small to large fragments of coal ‘float’ in the river gravels. However, localized coal deposits do exist and drilling has identified some subsurface coals in the region. During the 1980s, several northwest Alaska coal exploration field programs were conducted to ascertain the lateral and/or subsurface extent of known coal exposures throughout the region. Localities selected for detailed investigation within the region were: the Kutzitrin River, McCarthy’s Marsh, Death Valley, and Boulder Creek coal districts (fig. C2) and the Sinuk River and Koyuk coal occurrences on the Seward Peninsula; the Unalakleet coal occurrence (fig. C3); and the Niyrakpak Lagoon coal occurrence on St. Lawrence Island (fig. C4).

In the early 1900s, lignite was mined from a bed of coal up to 12 feet thick exposed in a pingo near Turner Creek in the Kuzitrin basin (fig. C2; Hopkins, 1963). In 1982, DGGS visited this locality and collected a sample for coal quality analyses and looked at other outcrops of the Tertiary-age Noxapaga Formation for additional coal seams (Clough and others, 1995). The apparent rank of the coal here is lignite (Clough and others, 1995) and no other substantial coal seams were located. Dames & Moore (1980) suggest that the coal-bearing sediments may extend to the northeast beneath Tertiary-age basalt flows, based on a gravity anomaly associated with the Kuzitrin basin shown in a gravity map by Barnes and Hudson (1977).

Unnamed coal-bearing strata occur at the southernmost edge of the Kiwalik River basin in the Candle Quadrangle (fig. C2). These locations of Tertiary-age coal were first reported by Harrington (1919) and later located by precious-metal exploration in the area and summarized in Dames & Moore (1980). Clough and others (1995) report that extensive areas of the Kiwalik and adjacent Buckland and Koyuk basins are covered by extensive basalt flows that hide the suspected coal-bearing rocks below. The linear shape of the Kiwalik and Buckland basins suggests that they are fault controlled (Dames & Moore, 1980), suggesting they may be similar to other fault-bounded Tertiary basins on the Seward Peninsula. Resource Associates of Alaska examined a 20- to 30-foot-long slumped outcrop of clay and coal on Wilson Creek (fig. C2), a tributary to the Kiwalik River and located a visible 3-foot-thick bed of coal (Fankhauser and others, 1978). Samples of coal float collected from the Wilson Creek area by DGGS in 1982 are lignite in apparent rank based on coal quality analyses (Clough and others, 1995).

The Death Valley basin and its southern extension, Boulder Creek basin (fig. C2), that lie east of the Darby Mountains in the southeastern Bendeleben Quadrangle, contain the thickest documented Tertiary-age coal seams on the Seward Peninsula. Eocene-age coals here are up to 175 feet thick, their discovery in the subsurface the result of exploration drilling for uranium in 1980 (Dickinson and

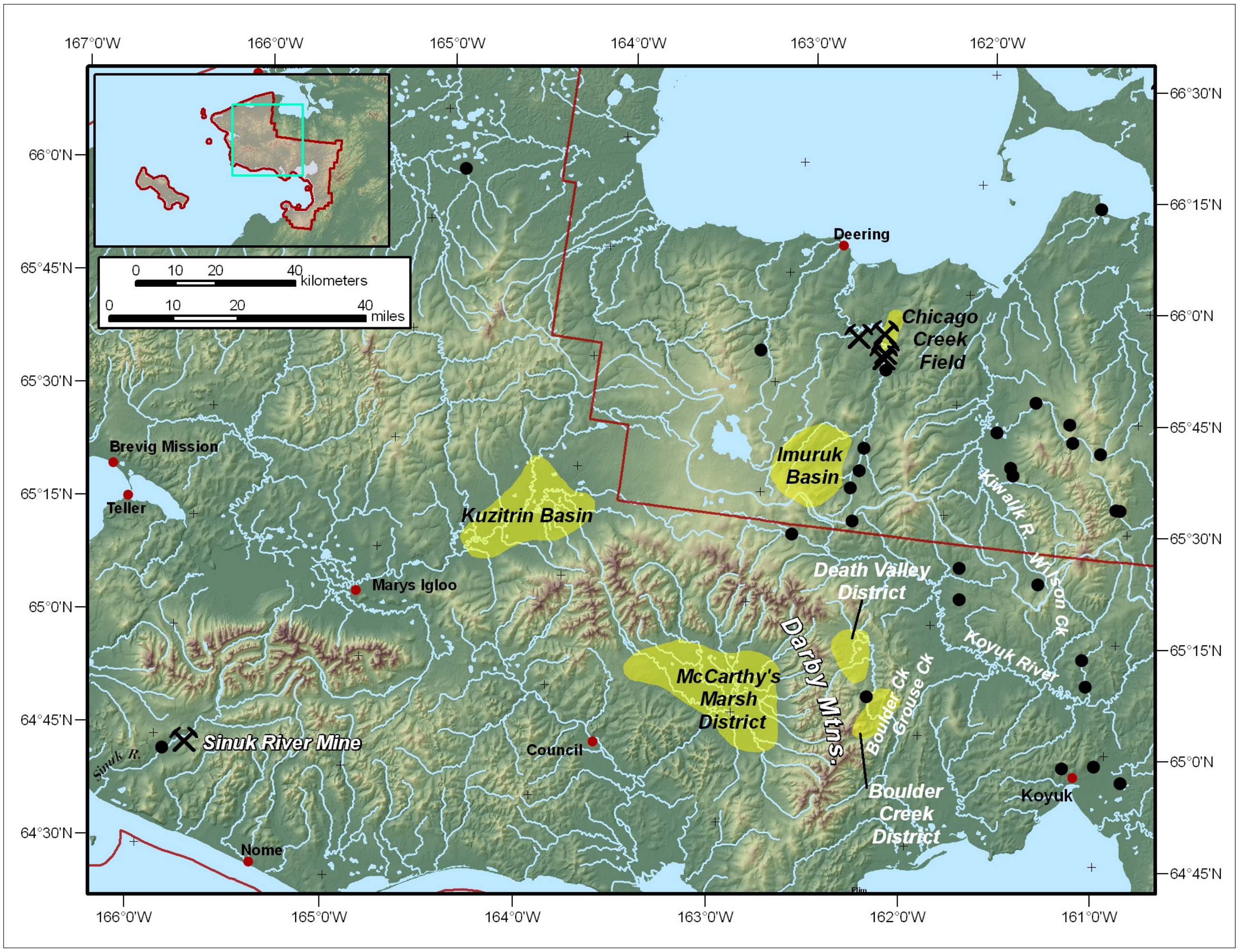

Figure C2. Location map of the central Bering Straits Energy Region, showing selected geographic references noted in the text. Red line shows border of Bering Straits Energy Region; black dots indicate reported coal occurrences; yellow shaded areas are inferred to be underlain by coal-bearing rocks.

others, 1987). These coals are overlain by thick Tertiary basalt flows and were deposited in a graben that formed in the north–south-oriented Kugruk fault zone described by Till and others (1986). A 35-foot-thick outcrop of coal on Grouse Creek, on the east side of Boulder Creek, was first described by West (1953). Coal from this locality is lignite in rank and this outcrop is believed to be a surface expression of the coals encountered in the deep mineral exploration holes (Clough and others, 1995). The Boulder Creek subsurface coal deposit has a very high uranium content (Stricker and Affolter, 1988) and questionable lateral continuity due to extensive faulting evident in the lithology logs from exploration drilling (Clough, 2007). However, the thickness of the coals encountered in the Boulder Creek exploration drilling and at Chicago Creek immediately to the north, and described in the Northwest Arctic Energy Region, suggests that the other Tertiary basins on the Seward Peninsula may have thick coal seams at depth.

A small outcrop of low rank coal at the Sinuk River bridge crossing, about 32 miles west of Nome on the Nome–Teller Highway (fig. C2). Natives from the village at the mouth of the Sinuk River brought this coal occurrence to the attention of gold prospectors in 1902, and efforts to mine this coal were attempted that year (Collier and others, 1908). Although there are small-gauge rails leading from a collapsed adit, rail carts, a boiler, remains of a small cabin and other mining materials present at the site, there is no record of actual production. In the fall of 1982, DGGS drilled 16 exploratory drill holes to depths of up to 77 feet. The actual coal was shown to be very thin, less than 1 inch in thickness, and interbedded with carbonaceous shale and decomposed schist pebbles and clay (Clough and others, 1995). Herreid (1970) considered this coal to be Tertiary in age based on the results of their field examination and drilling; Clough and others (1995) concurred.

Residents of the village of Koyuk have picked up coal along the Norton Bay beach for many years and sometime before 1909 coal was prospected on a creek informally called "Coal Creek" by the local residents (fig. C2). Harrington (1919) indicated that second-hand reports suggested the presence of a 2- to 4-foot-thick coalbed exposed near the mouth of the Koyuk River and that a coal mining permit was issued in 1919 for somewhere on the Koyuk River. During 1982–1983, the State of Alaska explored for coal in the area around Koyuk with subcontractors. This program drilled a number of exploratory rotary drill holes and conducted surface mapping and geophysics on approximately 230 acres near the mouth of the Koyuk River (see Manning and Stevens, 1982; Ramsey and others, 1986; Clough and others, 1995). Results from this program indicate that the coals are in irregularly-shaped lenses rather than laterally continuous coal seams and most of the subbituminous coals are less than 1.5 feet thick (Ramsey and others, 1986; Clough and others, 1995).

At least 300 short tons of coal were mined from a shallow adit on the beach near Unalakleet in 1918 for steamship use (fig. C3; Cathcart, 1920). In 1982 DGGS conducted field studies in the Unalakleet region and in 1983 a subcontractor for the State of Alaska drilled 12 rotary drill holes along the coast at the top of the bluff (Ramsey and others, 1986; Clough and others, 1995). Thin lenses of lignite were intercepted in seven of the drill holes, with the thickest lignite, 2 feet, encountered in a single drill hole (Ramsey and others, 1986; Clough and others, 1995). The thickest exposure of coal is at the mouth of Coal Mine Creek, where a 6-foot-wide pod of clayey lignite pinches out laterally within approximately 20 feet. This pod of coal is probably the bed mined in 1918; it now contains very limited reserves (Clough and others, 1995). The 1983 drilling results indicate that the subsurface coals encountered in the bluffs dip at a steep angle of 40° to 45° east (Ramsey and others, 1986) and would therefore be at deep, unmineable depths within a short distance onshore (Clough and others, 1995). Additionally, the minimum

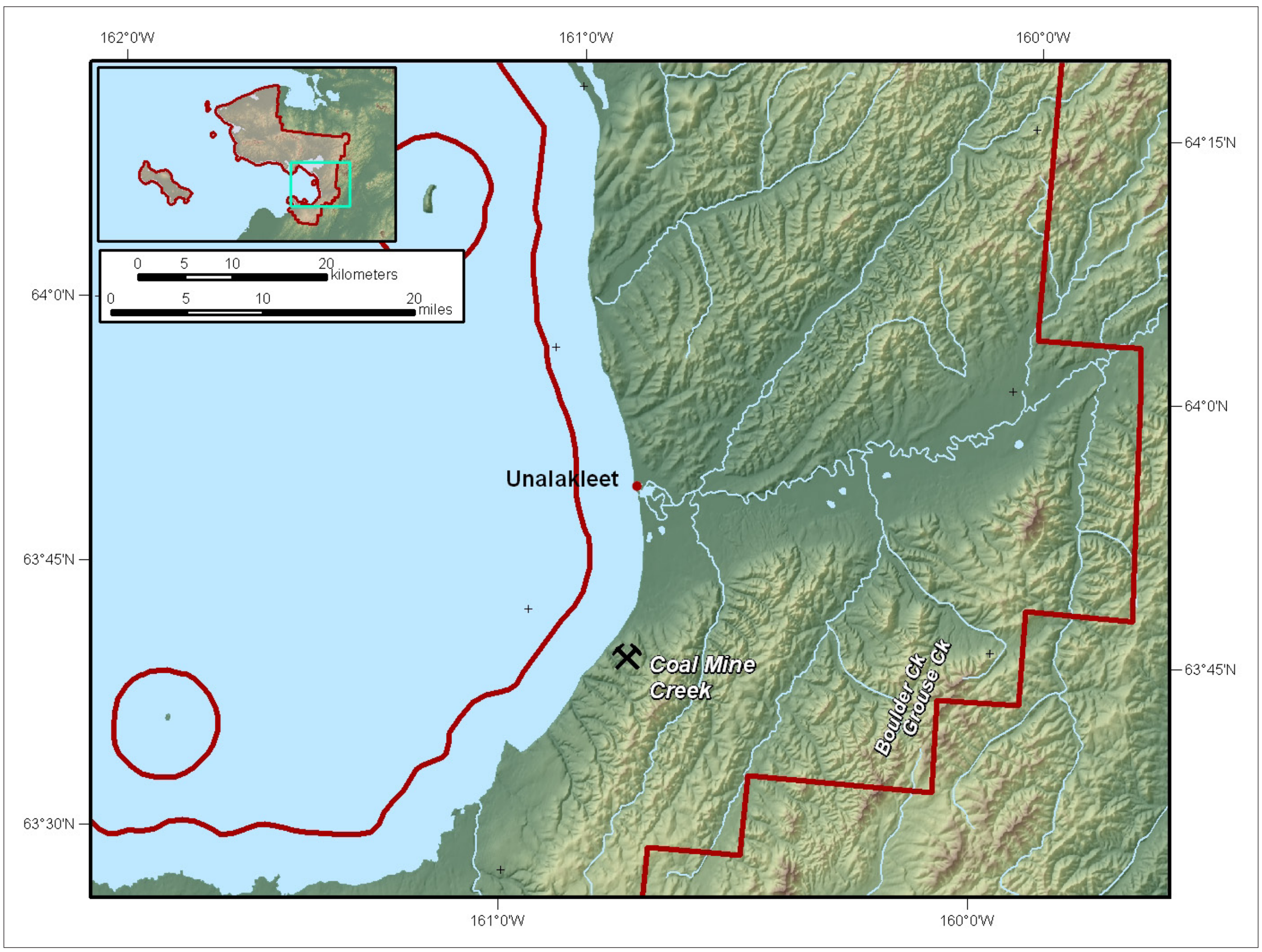

Figure C3. Map of the Unalakleet area, showing the location of a historic coal mine (pick-axe symbol) discussed in the text.

thickness of lignite that is considered to be economically mineable is 30 inches.

On St. Lawrence Island, coal was occasionally used by the local Natives to burn with driftwood in campfires and communal homes (fig. C4). In 1981, the State of Alaska and consultant Dan Renshaw explored the western part of the island for coal occurrences, and a promising site at the western shore of Niyrakpak Lagoon east of Gambell was chosen to conduct a small-scale limited drilling program in 1982 (Renshaw, 1981, 1982; Clough and others, 1995). Here, Tertiary-age lignitic coal up to 18 inches thick is exposed in the shore bluff. Results from 12 auger holes drilled during the summer of 1982 demonstrated that the coal exposed in the lagoon's bluff did not extend very far inland (Renshaw, 1982; Clough and others, 1995). There are a few smaller exposures around the island with thin lenses of coal, up to 6 inches thick, associated with volcanic-derived sediments, and likely formed in small basins that developed between episodes of volcanic eruptions (Renshaw, 1982).

Conventional oil and gas resource potential

As explained in the discussion of requirements for exploitable oil and gas resources (Chapter A), functioning petroleum systems occur in thick sedimentary basins, and require three basic elements: Effective source rocks, reservoirs, and traps. Each of the elements must be in existence and connected at the time hydrocarbons are generated and migrated. This section provides an overview of the various basins in the Bering Straits region then considers each of the necessary elements of petroleum systems in turn to evaluate the role conventional oil and gas resources may play in supplying rural energy to the region.

Overview of sedimentary basins. Most of the Bering Straits Energy Region is underlain by crystalline rocks (igneous and metamorphic) that are inconsistent with the presence of functioning hydrocarbon systems (Ehm, 1983; Patton and others, 1994; Till and Dumoulin, 1994; Troutman and Stanley, 2003). Two small east–west-trending sedimentary basins, the Imuruk and Bendeleben basins (sheet 2), developed on this crystalline basement. No subsurface data are available for these basins, but they are probably filled with Tertiary-age nonmarine sedimentary rocks. Gravity data suggest the deepest parts of both basins may include up to 10,000 feet of sedimentary rocks, but the areal extent of these thick deposits is small (Barnes and Hudson, 1977).

The offshore Norton basin is south of Nome (sheet 2), in the Bering Sea and represents the only basin in the region known to be capable of generating significant hydrocarbons. The Norton basin is a large extensional basin filled with well over 20,000 feet of Tertiary marine and nonmarine sedimentary rocks (Fisher and others, 1981). The tectonic driver for basin subsidence is enigmatic, but inferred to be related to strike-slip movement on the Kaltag fault (Fisher and others, 1982). Seismic mapping indicates the presence of two subbasins separated by a large fault block (Turner and others, 1986. Knowledge of the geology of this offshore

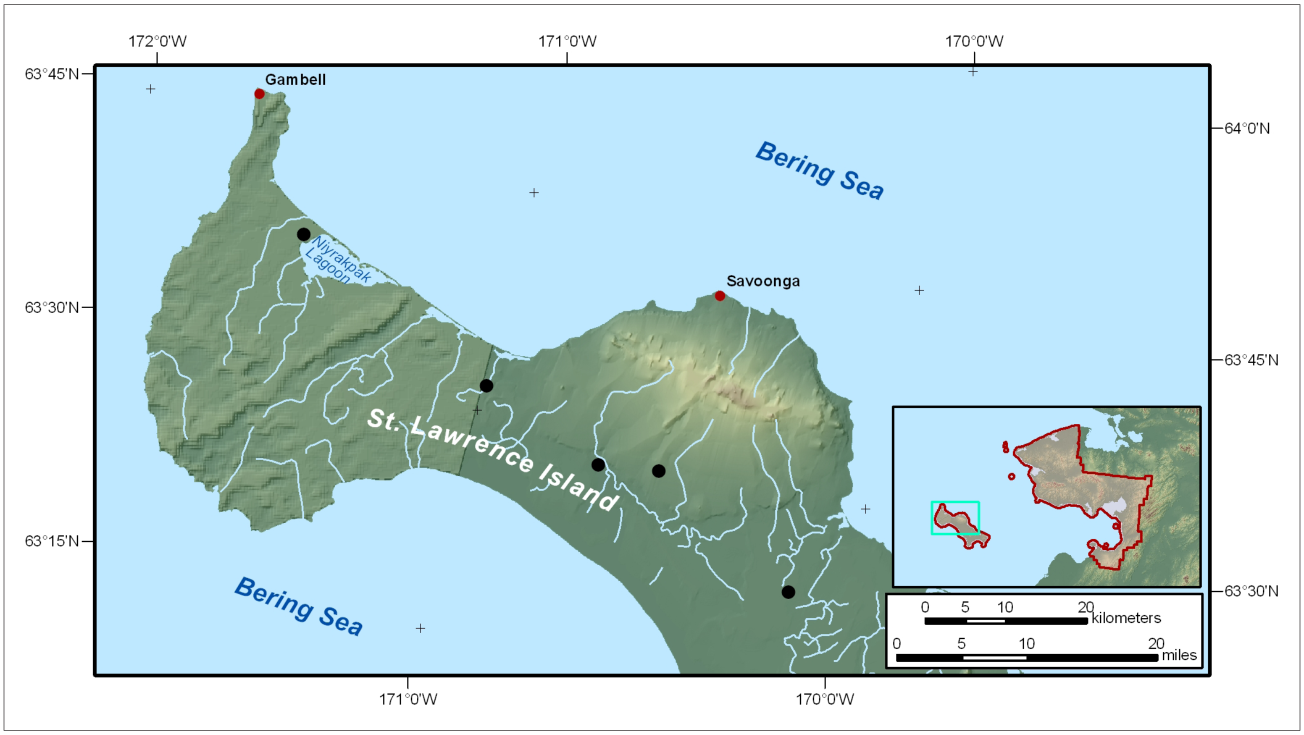

Figure C4. Map of the St. Lawrence Island area, showing reported coal occurrences (black dots) discussed in the text.

region largely comes from publicly available reports on data from two wells drilled in the early 1980s (Norton COST No. 1 and No. 2; Turner and others, 1983a; 1983b). Biostratigraphic data (microfossils and pollen) indicate the basin-filling succession is probably no older than Paleocene at its base.

The Kotzebue basin lies mostly outside of the Bering Straits Energy Region, north of the Seward Peninsula. Similar to the Norton Basin, the Kotzebue basin is an extensional basin filled with a thick succession of Tertiary-age sedimentary rocks. The thinner part of the basin is penetrated by two onshore wells, which indicated volcanic-rich sediments in the lower part of the section and a dominantly nonmarine depositional environment for basin fill (Decker and others, 1987; Fisher, 1988). Further discussion of this basin can be found in the chapter for the Northwest Arctic Energy Region.

Source rocks. Eight deep exploration wells were drilled in the offshore Norton basin south of Nome between 1980 and 1985, all of which were abandoned as dry holes. Although none of the wells discovered commercial hydrocarbons, all encountered moderate to strong shows of gas, often associated with coal-rich sediments, and three encountered weak oil shows. None of the shows were deemed promising enough to warrant a drill stem test (see summary and references in Troutman and Stanley, 2003). These well data demonstrate that the basin locally contains source rocks at depth that have generated some hydrocarbons. Extensive geochemical data collected from the two COST wells show that the deeper parts of the basin (mostly Eocene age) are sufficiently mature to generate thermogenic hydrocarbons (Turner and others, 1986). Most of the sediments are low in total organic carbon and the type of organic matter is prone to generating gas. The gas-generating potential of the Norton basin is also supported by the discovery of a large submarine gas seep originating approximately 30 miles south of Nome (Cline and Holmes, 1977). Although 98 percent of the gas was CO_2 (non-hydrocarbon), analyses indicated the presence of small amounts of light hydrocarbons of probable thermogenic origin (Kvenvolden and Claypool, 1980).

Reservoir rocks. Potential reservoir sandstones in the Norton basin are rich in metamorphic and volcanic rock fragments that are susceptible to compaction and reduced reservoir quality with increased burial depth (Turner and others, 1986). This effect is observed in conventional and sidewall core data from the COST wells. For example, in the COST No. 1 well, permeabilities are generally less than 1 millidarcy below 6,000 feet (Turner and others, 1983a). These low permeabilities limit the potential for conventional oil reservoir below this depth, although gas reservoirs may remain viable. There are notable exceptions to the trend of decreasing reservoir quality with depth, particularly in the Oligocene-age section in the COST No. 2 well where high-energy fluvial to shallow-marine deposits have a higher quartz content and have preserved adequate reservoir quality despite deep burial (Turner and others, 1986).

Traps. The extension that created the Norton basin resulted in a variety of potential trapping mechanisms, including structural, depositional, and erosional processes. Elements of these trapping styles have been tested in the eight unsuccessful exploration wells, although available seismic mapping suggests many untested traps remain, particularly those associated with normal faults creating complex horst and graben structures (Minerals Management Service [MMS], 2006).

Summary of conventional oil and gas resource potential. Sedimentary basins known to be capable of generating hydrocarbons are limited to the offshore portion of the Norton basin. Based on regional geology and the results from eight unsuccessful exploration wells, the U.S. Department of the Interior does not project undiscovered crude oil resources in the basin, although small amounts of liquid condensate are inferred to be present (MMS, 2006). Their mean estimate of natural gas in the basin is 3.06 TCF. Although this estimate indicates significant potential for undiscovered natural gas, the actual amount of this hypothetical resource that could be produced would be significantly smaller because many of the potential discoveries would not prove economically viable due to the high costs of offshore development.

The potential for conventional oil and gas in the small Imuruk and Bendeleben basins is unknown, but likely to be very low. If hydrocarbons are present in these small nonmarine basins, it is most likely to be uneconomic amounts of biogenic gas.

Unconventional Gas Potential

Coalbed methane. Coal resources in the Bering Straits region are relatively poorly known. Most coal occurrences are relatively thin and low grade, which led authors of previous analyses of statewide coalbed methane potential to discount the Bering Straits region as a viable target for this type of rural energy (Tyler and others, 2000). The Boulder Creek basin area does contain locally developed thick coals of appropriate rank, particularly in the subsurface where uranium exploratory drilling has identified a 175-foot-thick coalbed (Dickinson and others, 1987). However, the anomalous rank results from localized thermal alteration by overlying lava flows and is not a basinwide trend (Stricker and Affolter, 1988). Further, the small size of the basin, its structural complexity, and its lateral variability suggest the potential for viable coalbed methane resources is very low.

Tight gas sands. The potential for tight gas sands in the Imuruk and Bendeleben basins is unknown, but considered unlikely due to insufficient burial depth for the generation of thermogenic gas. Well data from the Norton basin suggest that tight gas sands could be present in the basin, particularly at depths greater than 6,000 feet where compaction reduces porosity and permeability (Turner and others, 1986). Data from the two COST wells indicate that the deeper parts of the section are sufficiently mature to generate gas, although most of the sediments are low in total organic carbon (Turner and others, 1983a; 1983b). Tight gas plays typically require closely-spaced wells and artificial stimulation to be effectively produced; this type of unconventional resource would likely be challenging to develop economically in an offshore setting.

Shale gas. Two of the primary requirements for gas to be producible from an organic-rich source rock (shale) are previous heating via burial into the thermogenic gas window and being sufficiently brittle to host a natural fracture system (see Chapter A). Thermally mature organic-rich shales do not appear to be present in the Imuruk and Bendeleben basins and are considered unlikely given the depth of the basin inferred from gravity data (Barnes and Hudson, 1977). Thermally mature gas-prone source rocks are present in the offshore Norton basin, as demonstrated by shows in several wells (Troutman and Stanley, 2003). Most organic matter in this basin consists of woody and coaly matter, which is gas prone (Turner and others, 1986). The presence of this material in brittle rocks capable of hosting a fracture system has not been studied. Similar to tight sands, the infrastructure footprint for this type of unconventional play suggests it would be not be economic to develop in an offshore setting.

Gas hydrates. The main occurrences of gas hydrates in nature are in modern marine sediments and in arctic regions with well-developed, continuous permafrost. Permafrost is not well developed in the Bering Straits Energy Region and, where locally present, is discontinuous. Consequently, the potential for economic concentrations of gas hydrates in the region is low.

Geothermal

The central and eastern Seward Peninsula area lies within a broadly defined belt of west-central Alaska that may be favorable for the discovery of shallow thermal waters (Motyka and others, 1983). The presence of young volcanic rocks and evidence for recent extensional faulting (Till and others, 2011) are consistent with an elevated regional thermal gradient. However, only a few examples of shallow thermal waters have been documented in the region, all apparently associated with fractured plutonic bodies (Miller and others, 1973; Sainsbury and others, 1970; Economides and others, 1982; Kolker and others, 2007). With limited available subsurface drilling data, evaluation of the region's potential is based largely on information from known hot springs localities.

Hot Springs with surface temperatures greater than 122°F (50°C) (the temperature typically cited as a minimum for direct heat applications) in the Bering Straits Energy Region are Lava Creek, Clear Creek, Serpentine Hot Springs, and Pilgrim Hot Springs (fig. C1). Serpentine Hot Springs, Lava Creek, and Clear Creek have reported temperatures of 167°F, 127°F, and 149°F (75°C, 53°C, and 65°C), respectively, but are distant from communities and ground transportation (Miller and others, 1973; Motyka and others, 1983). Pilgrim Hot Springs is approximately 60 road miles north of Nome and has reported surface temperatures ranging from 145°F to 160°F (63°C–71°C) (Miller and others, 1973; Motyka and others, 1983). Due to the proximity to a large community, this potential resource has witnessed a long history of investigative work, including drilling, geologic and geophysical mapping, and preliminary feasibility studies (see Dilley, 2007, for detailed references). The Alaska Center for Energy and Power (ACEP) at the University of Alaska Fairbanks is currently conducting a resource assessment project at Pilgrim Hot Springs that will further evaluate the geothermal potential via remote sensing techniques and by drilling additional exploration wells. The data from this type of study will be critical in determining the viability of geothermal power generation for local or regional use. In addition to the springs noted above, development of Granite Mountain Hot Springs has also recently been considered as a possibility for further geothermal exploration. Although the surface temperature data indicate a sub-optimal resource (120°F [49°C]), geochemical evidence suggests higher temperatures may exist in the near subsurface (Kolker, 2009). ACEP is also evaluating this locality further to assess whether development of this geothermal resource for rural energy is possible and/or economically feasible.

RECOMMENDATIONS

Conventional oil and gas recommendations

The geology of the Bering Straits Energy Region suggests that no functioning petroleum systems are present in the onshore part of the region. However, the geology of the Norton basin, located a short distance offshore in the shallow waters of the northeastern Bering Sea and Norton Sound, suggests significant natural gas potential (MMS, 2006). The lack of correlative strata exposed onshore limit the relevance of additional field stratigraphic studies. However, data from the Seward Peninsula suggest significant Tertiary extensional faulting (Till and others, 2011). Additional detailed mapping of older, pre-Cenozoic bedrock exposures could improve tectonic models for the origin and evolution of the adjacent Norton basin. In addition, further analytical studies could be conducted on material from the COST wells, particularly using newly developed laboratory techniques that were not available in the 1980s. Ultimately, significant new constraints on the natural gas potential of the Norton basin will require additional exploratory drilling. The large capital costs associated with offshore exploration suggests this type of future work will be conducted by industry as part of a search for commercially viable accumulations.

The discovery of an economic gas field could result in the availability of natural gas for local energy needs. Exploration risk could be reduced with the acquisition of modern three-dimensional (3-D) seismic data that can potentially directly image hydrocarbon accumulations.

Geothermal resource recommendations

The Seward Peninsula hosts a number of surface expressions of elevated shallow heat flow; however, the precise geologic origin and extent of these geothermal phenomenon remain poorly understood. Many of the potential geothermal resources are isolated from population centers and not economically feasible to develop; assessing the potential in these areas would require significant and expensive subsurface data. Promising data from the Pilgrim Hot Springs and Granite Mountain areas will require additional investigation to determine their ultimate energy potential and economic viability. Future work to characterize and delineate these prospects includes geochemical and geophysical studies as well as exploration drilling (Dilley, 2007; Kolker, 2009). The University of Alaska Center for Energy & Power has recently acquired new geophysical information and has initiated a temperature probe and drilling program in the Pilgrim area. These new data will help delineate the potential resource and potentially lead to development.

Coal resource recommendations

Available information indicates that, aside from the deposits in the Boulder Creek basin, none of the currently available data on coal occurrences in the region suggest sufficient quantity and rank to meet the U.S. Geological Survey minimum standards for mineable coal resources (see discussion of requirements for exploitable resources for additional explanation). In the Boulder Creek basin, near the lower Tubutulik River area, there exists low to moderate potential for mineable coal to serve as a local energy source for nearby potential uranium mining operations, however, the coal is high in uranium content, making this deposit likely uneconomic (Stricker and Affolter, 1988; Clough, 2007). Investigations in the Koyuk area suggest that, at its thickest, the deposit does not meet the minimum U.S. Geological Survey standards for depth, thickness, and rank for mining. Additionally, drilling results indicate that the deposit is of limited lateral extent (Manning and Stevens, 1986; Ramsey and others, 1986). If new evidence is found for thicker, laterally-continuous coal seams in the Koyuk Basin and near Unalakleet, then these areas might be considered for a second look at coal as a potential local energy source. At present, given the paucity of surface exposures of coal in these areas, without expensive exploratory drilling based on sound science, the potential for coal in these areas is low.

Unconventional oil and gas resources

The geology of the Bering Straits Energy Region strongly suggests that onshore unconventional oil and gas resources are not present. However, the geology of the Norton basin, located a short distance offshore in the shallow waters of the northeastern Bering Sea and Norton Sound, suggests tight gas sands could be present in the basin. Nevertheless, development of unconventional oil and gas resources require significant amounts of expensive technology to test and produce. A full economic analysis should be performed before attempting exploration and development of this type of resource in such a remote and high-risk setting.

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