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COALBED METHANE—POTENTIAL ENERGY SOURCE FOR RURAL ALASKA

by **J.G. Clough,** *Alaska Division of Geological & Geophysical Surveys*

Introduction

In 1996 the State of Alaska established a new energy program and directed the Division of Geological & Geophysical Surveys (DGGS) to evaluate the potential for coalbed methane (CBM) to meet the energy needs of roadless rural communities that currently depend on fuel oil for heating and electrical power generation. The cost of electricity for rural customers is generally three to five times higher than for urban customers in Anchorage, Fairbanks and Juneau. Electrical power is partially subsidized by the State in rural Alaska through the Power Cost Equalization (PCE) program at approximately $15.7 million in the year 2000. However, funding levels for PCE have decreased over the past decade. To sustain a village through the entire winter, large oil storage facilities hold diesel fuel delivered by barges or air transport during the summer, presenting the potential for catastrophic fuel spills during transportation and transfer, and surface and ground-water pollution from leaking storage tanks.

The Division of Geological & Geophysical Surveys evaluated the resource potential of frontier sedimentary basins using a coalbed methane producibility model developed by the Texas Bureau of Economic Geology (TBEG). A small coalbed gas field in a remote basin, that may be sub-commercial by industry standards, could represent a long-term energy resource for a village or a major mine site. For development to occur, the costs of exploration, development, and production of coalbed gas must compare favorably to the existing cost of the current diesel fuel-based system. Proximity of the gas to rural customers is critical and economic studies indicate the resource must be beneath or immediately adjacent to the community.

What is Coalbed Methane?

Coal is the most abundant energy source in the world and Alaska, with estimated coal reserves as high as 5.5 trillion short tons, contains at least half of the coal resources of the United States (Merritt and Hawley, 1986). The coalification process, whereby plant material is gradually converted to coal, generates large volumes of methane-rich gas. Until recently, this gas was a nuisance that produced deadly explosions in underground mining operations. To cope with the dangerous methane, underground mines were ventilated with large volumes of air to lower the gas to safe levels, an expensive and energy intensive procedure. In the early 1980s the mining industry began to produce mine gas commercially rather than releasing it to the atmosphere. A new CBM industry thus emerged, with production of commercial quantities of methane gas from subsurface coal seams, resulting in a significant and previously undeveloped "unconventional" energy resource for the United States. Since 1984 the domestic CBM industry has experienced rapid growth, illustrated by an increase from only 284 producing CBM wells in 1984 to 7,354 producing CBM wells in 1996. Coalbed methane now accounts for 5 percent (1 trillion cubic feet) of total annual gas production in the United States (*The American Oil & Gas Reporter,* March 1999).

How is coalbed methane different from conventional gas?

Unlike conventional natural gas, coal seams serve as the reservoir rock as well as the source rock for CBM. Coal is a microporous solid with little permeability, yet coal can store up to seven times more gas than the equivalent rock volume of a conventional gas reservoir. Coalbed gas content increases with coal rank, depth of burial, and with reservoir pressure. Coalbed gas is mainly composed of methane and, like conventional natural gases, it may contain small quantities of other hydrocarbons such as ethane and propane. Coalbed methane is often considered to be a 'sweet gas' as it typically contains very few impurities such as hydrogen sulfide and carbon dioxide, both normally found in natural gas. Coalbed methane is comparable in heating value (~1,000 Btu/scf) to conventional natural gas, and in some instances it can be input directly into natural gas pipelines or other gathering systems with limited removal of impurities.

How is coalbed methane produced?

Coalbed methane is produced directly from generally shallow (<3,500 feet), low-pressure, underground coal formations rather than from underground sandstone or carbonate rock formations as is conventional natural gas. The producibility of gas from coalbed reservoirs is primarily controlled by the physical properties of naturally occurring microfractures, named 'cleats', that provide the primary plumbing system for fluid flow through the reservoir. In order for gas to be released from the coal, its partial pressure must be reduced by removing water from the coalbed through a process known as 'dewatering'. CBM production wells are drilled by percussion, rotary (air and mud), and coiled tubing methods. Typically, dewatering of

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coal seams for gas production results in large quantities of water that must be either surface discharged or reinjected into the ground. Coal seam water quality and disposal is monitored and governed by regulation in the same manner as formation waters from hydrocarbon reservoirs.

How much gas is required for rural energy needs?

A medium-sized community of 700 people uses approximately 250,000 gallons of diesel fuel per year, roughly half for electricity and half for home heating. This translates to about 34.5 million cubic feet of gas per year for equivalent energy needs. Thus, a 30-year supply of gas for a medium-sized community will require a CBM field with 1.04 billion cubic feet of producible gas reserves. For comparison, the Barrow gas fields (Walakpa, South Barrow, and East Barrow) have about 218.5 billion cubic feet of gas and the Cook Inlet gas fields (Beluga and North Cook Inlet) contain about 3.6 trillion cubic feet of gas. Estimates of hypothetical CBM resources suggest the entire state may hold more than 1,000 trillion cubic feet of coalbed methane (Smith, 1995; Clough and others, 2000).

Alaska CBM History

In 1994 the State of Alaska funded and drilled the first exploratory coalbed methane bore-hole northwest of Wasilla, operated by the Department of Natural Resources/Division of Oil & Gas. This project demonstrated that significant CBM resources are present at shallow depths in the Cook Inlet basin and helped spur new and ongoing private-sector coalbed gas exploration in the northern part of the basin.

A new program instituted in 1999 by the State of Alaska's Division of Oil and Gas holds promise for increased commercial exploration of Alaska's coalbed methane resources. This non-competitive shallow gas leasing program allows industry to explore for and develop natural gas reservoirs (including coalbed methane) located within 3,000 feet of the surface. To encourage participation in this program, there is no bonus payment to the state for the right to explore a lease, the application fee is $500, annual rental payments remain at 50 cents per acre (rather than increasing from $1 to $3 per acre, as with a conventional oil and gas lease), and the lessee need only post a bond of $25,000 versus the $1 million bond required for traditional exploratory drilling.

Areas of high coalbed methane potential

Using the coalbed methane producibility model and published geologic and geographic data, DGGS and TBEG determined that at least 25 roadless communities in Alaska have potential for coalbed methane resources (Tyler and others, 2000). Three highly prospective CBM coal basins were identified: (1) western North Slope Basin near Wainwright, (2) Alaska Peninsula near three Chignik Bay communities, and (3) Yukon Flats Basin at Fort Yukon (fig. 1). Each site has the potential for thick beds of coal or lignite below the village so that shallow drill holes would intersect the thickest section of coal possible at an appropriate depth for gas production. This positioning will reduce the cost of drilling as well as the cost of building a pipeline to the nearby village. The sites are placed to assess the problems of extreme climate, variations in geology, and drill rig access that would face any subsequent Alaska coalbed methane development program.

Priority site assessments

Wainwright, a community of almost 600 residents, is in northwestern Alaska on the Chukchi Sea coast 3 miles north of the Kuk River estuary (fig. 1). In July 1999, a team composed of geologists from DGGS and the U.S. Geological Survey (USGS) evaluated coal exposures in the Wainwright area. Coal quality analyses along with coal cleat data and gas isotherm studies suggest that subsurface coals beneath Wainwright have favorable methane gas generation and holding capacity. An existing

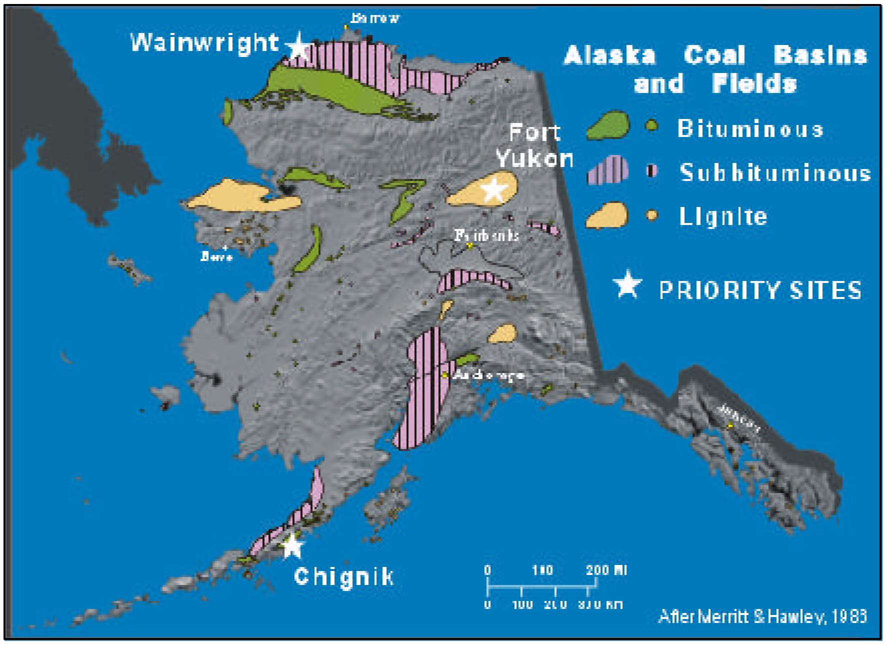

Figure 1. *Alaska coal basins and coalfields; priority drill sites indicated by star symbol.*

seismic line along the coast was reprocessed to emphasize shallow coal beds that underlie Wainwright.

The Chignik area represents three communities: Chignik, Chignik Lagoon, and Chignik Lake, on the Pacific side of the Alaska Peninsula, 450 miles southwest of Anchorage (fig. 1). Although the year-round population of this area is small (total population 360), it supports two large fish processing plants seasonally and a robust summer commercial fishing industry. Planning is currently underway to connect the three Chignik-area communities with a road system; a local energy source and subsequent power grid could meet the needs of the area and encourage future commercial fisheries industrial development. At Chignik, the bituminous coals are thin to medium-thick beds deposited in a near-shore environment within a back-arc basin. After burial, the coal section was tilted, block faulted and eroded, exposing the coals along the coastline. The block faulting appears to have compartmentalized the reservoirs and this may have preserved coalbed gas in this deeply incised basin. Coal beds exposed at the surface have favorable coal quality and gas-holding capacity for coalbed methane.

Fort Yukon, a community of 700 people, is on the north bank of the Yukon River at its junction with the Porcupine River, about 145 air miles northeast of Fairbanks (fig. 1). The closest outcrop of Tertiary coal-bearing rocks is approximately 80 miles west of the community. In 1994 the USGS encountered 28 feet of gaseous lignite near the base of a climate test hole drilled to 1,280 feet. Coal quality analyses and gas isotherm studies of core from the climate test hole suggest that the lignite has favorable methane gas generation and holding capacity. However, the lateral extent and thickness of the lignite interval has remained an important unanswered question. Before expensive drilling to test any CBM resource could be considered for Fort Yukon, a shallow seismic survey was necessary.

FORT YUKON SHALLOW SEISMIC STUDY

In April 2001, DGGS and the Kansas Geological Survey (KGS) conducted a high-resolution shallow reflection seismic survey of Fort Yukon to determine the lateral extent and thickness of the lignite and to assess the presence of shallow geologic structures that would impede CBM production. The project was funded by State and U.S. Department of Energy funds; DGGS, KGS, and the USGS participated in the study.

A seismic reflection survey works a bit like an ultrasound. The technique uses an energy source to generate and send compressional, or sound, waves into the ground that bounce off boundaries between different types of rock. We “listen” with geophones, spring-mounted electric coils moving within a magnetic field, which generate electric currents in response to ground motion. Geophones are sensitive enough to pick up noise from the vibrations of generators, automobiles, snowmachines, footsteps, and even running dogsled teams. During our seismic reflection survey, cables with geophone receivers attached at regular intervals were laid out along roads and trails in Fort Yukon (fig. 2). Our energy source was an articulated tractor-mounted mini-vibrator that hydraulically transmits compressional wave energy with 4,000 to 8,000 foot-pounds of force (fig. 3). The total energy for each shot point is equivalent to one-quarter stick of dynamite, yet it feels and sounds like a sewing machine motor. The energy source moves along the seismic line and generates seismic waves at regular intervals. The reflections received by the geophones are recorded on computers and plotted as dark lines on a seismic section (fig. 4) to resolve mappable features such as faults, folds, and lithologic boundaries. A seismic section resembles a geologic cross-section, but it still needs considerable digital data analyses, noise reduction, and interpretation. We conducted approximately 8.5 line-miles of seismic survey with 1,296 shot points. Our project received considerable community support and four Fort Yukon residents were hired to assist in cable laying and geophone placement. At the end of our fieldwork, we talked in the classrooms of Fort Yukon high school science students and 7th and 8th graders and gave a demonstration of how seismic reflection works in the school courtyard.

Figure 2. *Seismic cable laying and geophone drilling on side of Fort Yukon road, April 2001.*

THE NEXT STEP

Following the completion of site assessment, the next step is to drill and test CBM resources. In 1997, DGGS began a cooperative effort with the U.S. Geological Survey to develop a drilling program that would fully assess gas producibility for each of the above sites. We propose drilling two wells per site; the first well is used for determining the stratigraphic position

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Figure 3. *Articulated tractor-mounted mini-vibrator with hydraulic pad (arrow) used for generating compressional waves. Fort Yukon, April 2001.*

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of coals for subsequent coring in the nearby second well. Coals in the second well will be cored and measured for gas content by canister desorption. The two wells would be used for hydrologic testing by pumping one well to stimulate gas flow for subsequent flow testing and monitoring water table response in the other well. Water disposal environmental concerns would be assessed by chemical analysis of the coalbed water produced during these tests. Finally, a pilot gas-flow test would be conducted to demonstrate the existence of long-term gas resources at each site. The data gathered by this project would quantitatively estimate the gas in place, pumping requirements for production, and the disposal limitations for the produced water.

DGGS has proposed joining with the U.S. Department of Energy, Los Alamos National Laboratory to promote development of coiled-tubing microhole drilling technology that would have the capability to drill to depths of 3,500 feet at approximately one-third the cost of conventional coalbed gas drilling, estimated to be as high as $1.8 million per site. The University of Alaska would participate with DGGS, Los Alamos, USGS, and U.S. Bureau of Land Management–Alaska in the development and implementation of this new technology.

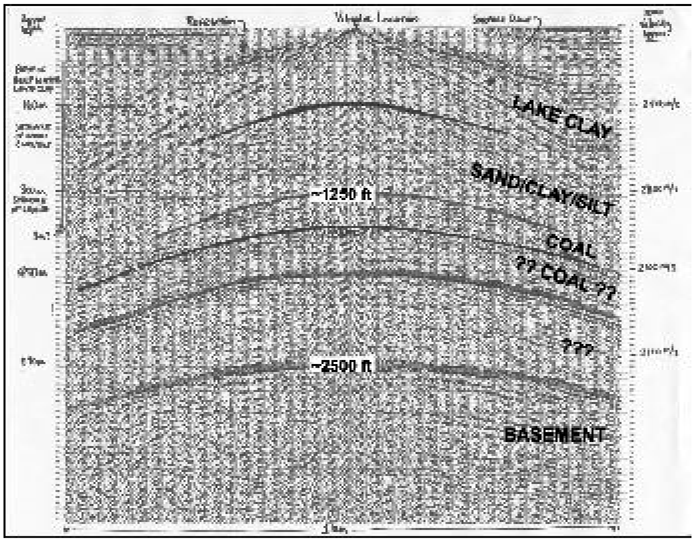


Figure 4. *Seismograph printout for single shotpoint (#8457) in Fort Yukon shallow seismic program. Top of coal interval is at approximately 1,250 feet depth. Preliminary field interpretation by Rick Miller, KGS.*

Dear Readers:

You may have noticed that Martha Murphree, who provided exceptional service and a cheerful, friendly voice to you since 1987, no longer occupies our publications contact desk. Martha happily retired May 1. Although it may take some time to find someone else to permanently replace Martha, we strive to continue the friendly, helpful service to which you have become accustomed. We are grateful for your patience during the transition. We are pleased that June Campbell, who came to us from private industry, has very capably stepped in to help with publications until the end of June. And Jana Reynolds, who impressed us as a student intern last summer, has returned for the summer to tackle some publications projects we have had to postpone. We wish Martha all the best that retirement has to offer.

In the same vein, we extend best wishes to Gil Mull, who transferred to the Division of Oil and Gas in late April after nearly 20 years of distinguished service to DGGS and the State. Gil has been involved in North Slope geology since the early 1960s, including mapping the bedrock geology of the Brooks Range foothills in the years leading up to the discovery of the giant Prudhoe Bay oil field, and serving as wellsite geologist for Prudhoe Bay State #1, the well that firmly established the oil industry on Alaska's North Slope. We wish Gil success as he continues to work at defining Alaska's oil and gas resources.

This issue of Alaska GeoSurvey News summarizes the latest DGGS activities that seek to develop sources of local energy near rural communities. We have learned a lot about coalbed methane since we started this project in 1996. It soon became apparent that to successfully conclude this program, it would be necessary to drill test holes into favorable targets. The financial risks of any wildcat drilling project are high. Jim Clough's work has done much to reduce those risks, but they are still significant. To date, we have been unable to acquire the resources or partnerships that will allow us to conduct the final drill tests at the Chignik, Fort Yukon, and Wainwright sites.

Spring is always a time of hectic activity and anticipation at DGGS as reports and maps from last year's projects are brought to a conclusion and the logistics for the coming field season get underway. By the time you receive this newsletter, the first of our field teams will have left for their project areas. This year we will have teams on the North Slope of the Brooks Range, in the Yukon-Tanana uplands of east-central Alaska, and southcentral Alaska near Anchorage. Our field geologists compress an incredible amount of data generation into a relatively short season by working many hours each day. In spite of the extra demands associated with field studies, each year there is a heightening of anticipation as the field season draws near. I believe this is because DGGS geologists are truly committed to their profession and because they understand the importance of their work in advancing the knowledge of Alaska's mineral and energy resources, and geologic hazards for the benefit of us all. I know that the readers of this newsletter will join me in wishing them success in their work this summer and a safe field season.

Sincerely,

Milton A. Wiltse
Director and State Geologist

NEW PUBLICATIONS

GPR 2001-1. Edcon Land Gravity Survey, Holitna Basin, Southwest Alaska, by Edcon, Inc., 2001, 1 CD ROM. $10.

IC 47. Alaska's mineral industry 2000: a summary, by D.J. Szumigala and R.C. Swainbank, 2001, 14 p. Free.

MP 41. Coalbed methane prospects of the Upper Cook Inlet—Field trip guidebook, by C.E. Barker, J.G. Clough, and T.A. Dallegge, 2001, 1 CD-ROM. $10.

Note: **MP 41** and **MP 42** are separate reports but are included on the same CD-ROM for $10. If you order one of the reports, you will automatically receive the other.

MP 42. Opportunities in Alaska coalbed methane, Anchorage, Alaska, March 1-3, 2000—Proceedings, 2001, 1 CD-ROM. $10.

PIR 2001-3a. Geologic map of the Eagle A-2 Quadrangle, Fortymile mining district, Alaska, by M.B. Werdon, R.J. Newberry, and D.J. Szumigala, 2001, 1 sheet, scale 1:63,360. $13.

PIR 2001-3b. Bedrock geologic map of the Eagle A-2 Quadrangle, Fortymile mining district, Alaska, by M.B. Werdon, R.J. Newberry, D.J. Szumigala, and D.S. Pinney, 2001, 1 sheet, scale 1:63,360. $13.

PIR 2001-3c. Surficial-geologic map of the Eagle A-2 Quadrangle, Fortymile mining district, Alaska, by D.S. Pinney, 2001, 1 sheet, scale 1:63,360. $13.

PIR 2001-3d. Engineering-geologic map of the Eagle A-2 Quadrangle, Fortymile mining district, Alaska, by D.S. Pinney, 2001, 1 sheet, scale 1:63,360. $13.

PIR 2001-4. Palynology of Tertiary Holitna outcrops, McGrath and Talkeetna quadrangles, by Pierre A. Zippi, 2001, 22 p. $2.20.

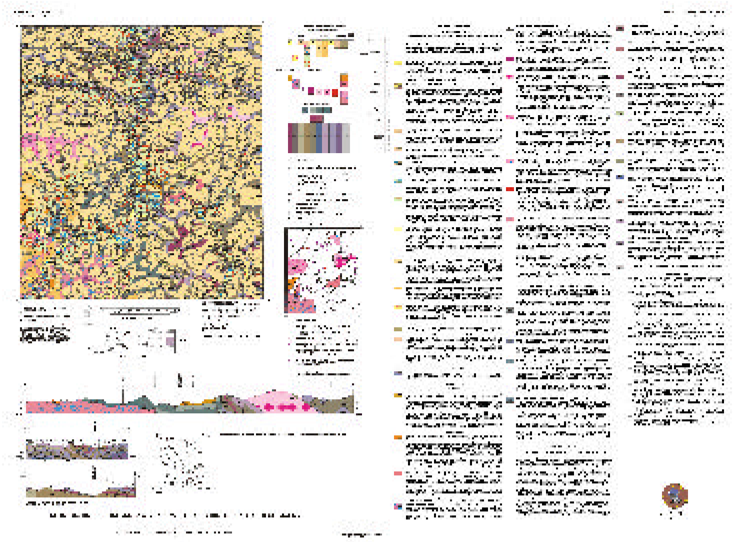
PIR 2001-5. Reconnaissance bedrock geology map of the Pogo area, Big Delta B-2 and B-3 Quadrangles, Alaska, by M.B. Werdon, R.J. Newberry, D.J. Szumigala, and L.E. Burns, 2001, 1 sheet, scale 1:63,360. $13.

RDF 2001-1. Major oxide, minor oxide, trace element, and geochemical data from rocks collected in the Salcha River–Pogo area in 2000, Big Delta and northwestern Eagle quadrangles, Alaska, by M.B. Werdon, J.E. Athey, D.J. Szumigala, R.J. Newberry, J.C. Grady, and W.C. Munly, 2001, 19 p., 1 sheet, scale 1:250,000. $15.

RDF 2001-2. Whole-rock oxide and trace element analyses for rock samples from the Delta mineral belt, Tok mining district, Alaska, by C.F. Schaefer and S.S. Dashevsky, 2001, 3 p., 1 disk, 1 sheet, scale 1:63,360. $15.

RDF 2001-3. ^{40}Ar/^{39}Ar analyses from the Iron Creek area, Talkeetna Mountains Quadrangle, Alaska, by Jeff Drake and Paul Layer, 12 p. $2.

PIR 2001-3a



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