

Chapter 1

# **Executive Summary—Geologic Assessment of Undiscovered, Technically Recoverable Coalbed-Gas Resources in Cretaceous and Tertiary Rocks, North Slope and Adjacent State Waters, Alaska**



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**Volume Title Page**

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Chapter 1 of

**Geologic Assessment of Undiscovered, Technically Recoverable Coalbed-Gas Resources in Cretaceous and Tertiary Rocks, North Slope, and Adjacent State Waters, Alaska**

Compiled By Stephen B. Roberts

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## Introduction

The North Slope of Alaska is an area of some 120,000 mi<sup>2</sup> north of the Brooks Range, extending from the Chukchi Sea eastward to the Canadian border (fig. 1). This Arctic region is known to contain extensive coal deposits and several studies have indicated that the North Slope might also have the potential for significant coalbed-gas resources (for example, Smith, 1995; Tyler and others, 2000; Flores and others, 2004). In order to address this potential, the U.S. Geological Survey (USGS) completed a detailed assessment of undiscovered, technically recoverable coalbed-gas resources beneath the North Slope and adjacent Alaska State waters. The assessment applies the total petroleum system (TPS) concept. Geologic elements within a TPS include characteristics of the hydrocarbon source rocks (maturity, hydrocarbon generation, and migration potential), the characteristics of reservoir rocks (porosity, permeability, thickness, and lateral continuity), and trap and seal formation. In the case of coalbed gas, the coal beds serve as both the primary source rock and reservoir, although the gas-resource potential within the coal beds can also be enhanced by the entrapment of migrated gas from other source rocks.

The USGS defined the Brookian Coalbed Gas Composite TPS (fig. 1) to include that area of the North Slope and adjacent State waters underlain by Cretaceous and Tertiary strata containing coal deposits with the potential for undiscovered coalbed-gas resources. The TPS encompasses about 50,000 mi<sup>2</sup> and includes a significant part of the National Petroleum Reserve in Alaska (NPRA) as well as a small part of the Arctic National Wildlife Refuge (ANWR). Assessment units (AUs) within the TPS were defined as follows (stratigraphically oldest to youngest); the Nanushuk Formation Coalbed Gas AU (Cretaceous), the Prince Creek and Tuluva Formations Coalbed Gas AU (Cretaceous–Tertiary), and the Sagavanirktok Formation Coalbed Gas AU (Tertiary). Because there is no production of coalbed gas on the North Slope, all AUs are hypothetical.

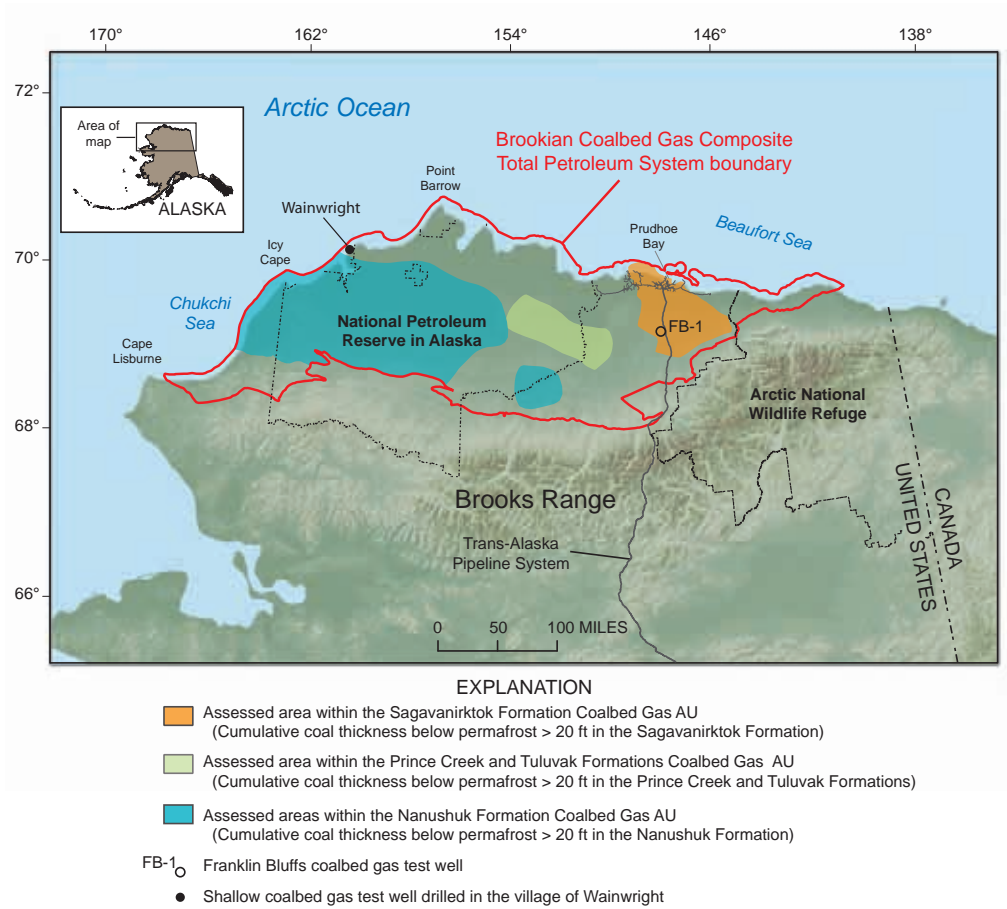
The Nanushuk Formation Coalbed Gas AU, about 40,000 mi<sup>2</sup> in the western and central part of the North Slope, includes a large portion of the NPRA. Coal beds in the AU

are distributed over the largest area relative to the other AUs. Discontinuous outcrops of the Nanushuk Formation, which are present in the southern part of the AU, contain coal beds as much as 20 ft thick; cumulative (total) coal thickness locally exceeds 200 ft. Data from numerous oil and gas exploration wells penetrating coal-bearing strata within the formation indicate the presence of gas in close association with coal beds (for example, see Collins, 1958; Tyler and others, 2000). More recently, gas in Nanushuk coal beds was documented in a shallow core hole (total depth 1,613 ft) (fig. 2) drilled in the village of Wainwright (fig. 1) in 2007. Desorption data from nineteen coal beds indicate raw gas contents ranging from less than 10 to more than 180 standard cubic feet of gas per ton of coal (SCF/ton).

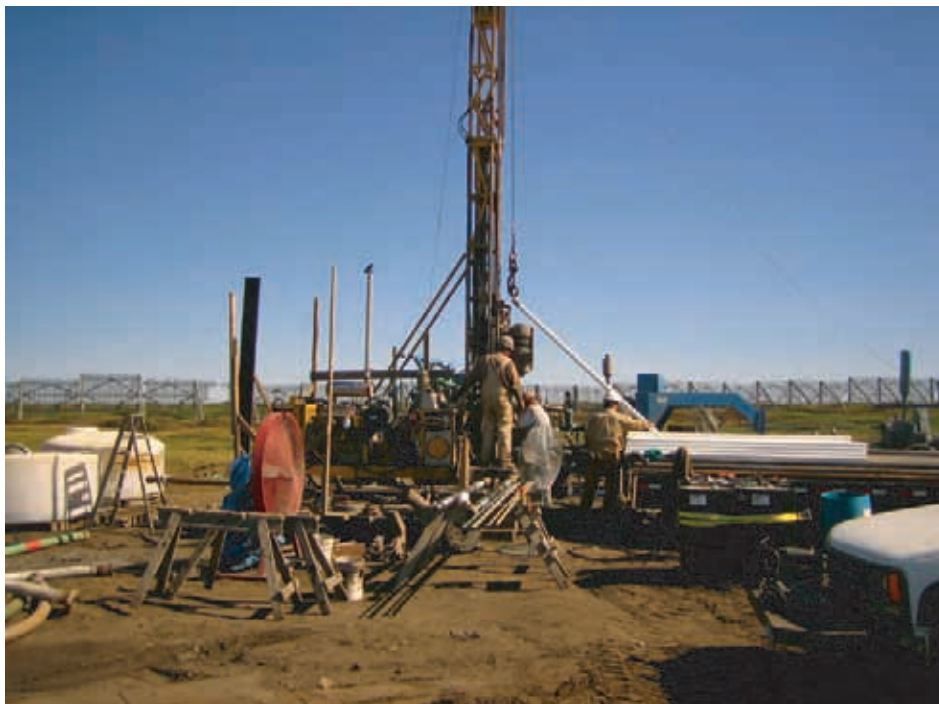
The Prince Creek and Tuluva Formations Coalbed Gas AU encompasses about 15,000 mi<sup>2</sup> in the central part of the North Slope, and includes the easternmost part of NPRA. The Tuluva and Prince Creek Formations were assessed jointly for undiscovered coalbed-gas resources because coal-bearing strata in both formations share a similar geographic area. Coal beds in the Tuluva and Prince Creek Formations have been studied much less than Nanushuk Formation coals; consequently, data detailing the characteristics of the coal (spatial and stratigraphic distribution, thickness, and quality) are sparse throughout much of the AU. Cumulative (total) coal thickness exceeds 70 ft, and individual beds are as thick as 15 ft. Limited data from oil and gas exploratory drill holes indicate gas shows in coal-bearing intervals within the Tuluva and Prince Creek Formations (D. Hayba, U.S. Geological Survey, written commun., 2001), but no wells have been drilled specifically to test for the presence of gas in coal beds in either formation.

The Sagavanirktok Formation Coalbed Gas AU, covering about 8,700 mi<sup>2</sup> in the central and eastern part of the North Slope, includes the coastal plain part of ANWR. Coal outcrops are present along river banks in the southern part of the AU (fig. 3), where there are intermittent exposures over a distance of about 50 mi in a west–east orientation. Total coal thickness in the AU exceeds 180 ft locally, with individual

## 2 Geologic Assessment of Recoverable Coalbed-Gas Resources, North Slope, Alaska



**Figure 1.** Map showing extent and location of the Brookian Coalbed Gas Composite Total Petroleum System (TPS), and areas within each assessment unit (AU) in the TPS that were assessed for coalbed-gas potential in Cretaceous and Tertiary rocks, North Slope and adjacent State waters, Alaska.



**Figure 2.** Drilling equipment used for the recovery of Nanushuk Formation coal cores analyzed for coalbed-gas content, Wainwright, Alaska. Photograph courtesy of Art Clark (U.S. Geological Survey), June 2007.



**Figure 3.** Coal bed exposed in outcrops of the Sagavanirktok Formation along the Shavirovik River in the east-central part of the North Slope, Alaska. Coal bed is 8 ft thick; view is to the north. Photograph courtesy of Steve Roberts (U.S. Geological Survey), July 1985

coal-bed thicknesses of as much as 35 ft. In 2005, the USGS drilled a shallow well (total depth 1,825 ft) south of Prudhoe Bay (FB-1; fig. 1) to test for coalbed gas in the Sagavanirktok Formation. The well included three cored intervals at depths 500–722 ft, 975–1,341 ft, and 1,488–1,617 ft. Coal samples for coalbed gas desorption were recovered from each cored interval and a total of ten samples were analyzed for gas content; the thickest coal bed sampled was 11 ft. Estimates of the raw gas contents were low, generally less than 5–10 SCF/ton (C. E. Barker, U.S. Geological Survey, written commun., 2007). However, the drill hole was terminated before coal beds anticipated at greater depths (2,000 to 2,500 ft) could be tested.

## Resource Summary

USGS assessments provide estimates of the volumes of undiscovered petroleum resources (oil, gas, and natural gas liquids) that are technically recoverable and have the potential to be added to known reserves. The concepts and operational procedures for assessing continuous petroleum accumulations by the USGS were applied in this coalbed gas assessment as per guidelines detailed in Schmoker (2005) and Klett and Schmoker (2005).

Geologic factors influencing the resource estimates include the distribution and cumulative thickness of coal beds in each AU, the thermal maturity of the coal, and key structural features (folds, faults) that might affect gas migration and entrapment. The assessment (1) considered only those coals within 6,000 ft of the ground surface because of the potential decrease in coal permeability with increasing depth, (2) focused on potential coalbed-gas resources below the permafrost interval because of the uncertainty as to the permeability of coal beds in ice-bearing permafrost and the degree to which cold temperatures within the permafrost might affect gas flow from coals (Smith, 1995; Tyler and others, 2000), and (3) restricted resource estimates in each AU to areas where the estimated cumulative coal thickness below permafrost exceeds 20 ft (fig. 1). Production data from wells in coalbed-gas fields in the Wasatch Plateau, Utah, and the Powder River Basin in Wyoming and Montana were used to gain insight into production potential that might be applied to North Slope coalbed-gas wells. The Wasatch Plateau and Powder River Basin fields are considered viable analogs for assessing North Slope coalbed-gas resources based on similarities in coal thickness, thermal maturity, and overall geologic and structural setting.

The mean total estimated undiscovered coalbed-gas resources in the Brookian Coalbed Gas Composite TPS is 18 trillion cubic feet (TCF) of gas (table 1), of which about

**Table 1.** Alaska North Slope: Coalbed gas resource assessment results.

Results shown are fully risked estimates. F95 denotes a 95 percent chance of at least the amount tabulated. Other fractiles are defined similarly. Fractiles are additive under the assumption of perfect positive correlation. TPS, total petroleum system; AU, assessment unit; CBG, coalbed gas. BCFG, billion cubic feet of gas; MMBL, million barrels of natural gas liquids.

Total Petroleum Systems (TPS) and Coalbed Gas Assessment Units (AU)	Field type	Total undiscovered resources							
		Gas (BCFG)				Liquids (MMBL)			
		F95	F50	F5	Mean	F95	F50	F5	Mean
<b>Brookian Coalbed Gas Composite TPS</b>									
Nanushuk Formation AU	<b>CBG</b>	5,834	13,279	30,225	15,047	10	28	83	35
Prince Creek-Tuluvak Formations AU	<b>CBG</b>	350	709	1,436	778	0	0	0	0
Sagavanirktok Formation AU	<b>CBG</b>	889	1,981	4,416	2,231	1	4	12	5
<b>Total Undiscovered Oil and Gas Resources</b>		<b>7,073</b>	<b>15,969</b>	<b>36,077</b>	<b>18,056</b>	<b>11</b>	<b>32</b>	<b>95</b>	<b>40</b>

84 percent (15 TCF) is estimated to be in the Nanushuk Formation, 12 percent (2.2 TCF) is in the Sagavanirktok Formation, and 4 percent (0.8 TCF) is in the Prince Creek and Tuluvak Formations.

## North Slope Coalbed Gas Assessment Team

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