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U.S. GEOLOGICAL SURVEY ENERGY RESOURCES PROGRAM NEWSLETTER
WINTER/SPRING 2009

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Thank you for subscribing to the U.S. Geological Survey Energy Resources Program Newsletter. This quarterly newsletter provides the latest news, information, and products from the USGS Energy Resources Program. In addition to recent publications, we are continuing to expand the content available through our redesigned website. Previous newsletter issues have been archived (in PDF format) and are accessible from: http://energy.usgs.gov/newsletter.html .

If you have any questions or comments regarding the ERP newsletter, please send an email to: gd-energyprogram@usgs.gov .

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ENERGY SPOTLIGHT

ASSESSMENT OF TECHNICALLY RECOVERABLE GAS HYDRATE RESOURCES OF THE NORTH SLOPE, ALASKA

http://energy.usgs.gov/other/gashydrates/

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Gas Hydrates on Alaska's North Slope Hold One of Nation's Largest Deposits of Technically Recoverable Natural Gas

The USGS assessment is the first-ever resource estimate of technically recoverable natural gas hydrates, which are naturally occurring, ice-like solids in which water molecules trap natural gas molecules in a cage-like structure known as a clathrate. Gas hydrates represent an immense energy resource underlying large portions of the world's marine continental shelves and Arctic continental areas.

The assessment estimates there are about 85.4 trillion cubic feet (TCF) of undiscovered, technically recoverable gas from natural gas hydrates on the Alaskan North Slope. This would be enough natural gas to heat more than 100 million average homes for 10 years, according to current usage rates provided by the Energy Information Administration. However, further research, including long-term production tests, still is needed to demonstrate gas hydrates as an economically producible resource.

> "The assessment points to a truly significant potential for natural gas hydrates to contribute to the energy mix of the United States and the world," former Secretary Kempthorne said at a press conference at the Interior Department headquarters in Washington. "This study also brings us closer to realizing the potential of this clean-burning natural gas resource."

The estimate of 85.4 TCF of gas in Alaska North Slope gas hydrate deposits accounts for 11.5 percent of the total estimated volume of gas within all other undiscovered, technically recoverable gas resources onshore and in the state waters of the United States. The world currently consumes about 104 TCF of natural gas a year, of which the United States uses about 23 TCF, according to the Energy Information Administration. Conventional undiscovered, technically recoverable gas resources on the North Slope of Alaska are estimated at 119.15 TCF.

> "For more than 25 years, the USGS has conducted gas hydrate research in northern Alaska, showing the investment of our agency in understanding this resource," said former USGS Director Mark Myers. "This is especially important now that a growing body of evidence indicates that concentrated gas hydrate accumulations in conventional hydrocarbon reservoirs, such as those in northern Alaska, can be produced with existing technology."

The area assessed in northern Alaska extends from the National Petroleum Reserve in Alaska on the west through the Arctic National Wildlife Refuge on the east and from the Brooks Range northward to the state-federal offshore boundary (located three miles north of the coastline).

Of the estimated 85.4 TCF of gas within hydrates on the North Slope, 56 percent is on federally managed lands, 39 percent is on lands and offshore waters managed by the State of Alaska, and 4 percent is on Native Alaskan lands. The assessment of the potential resources on the federally managed offshore regions of northern Alaska is being conducted by the Minerals Management Service.

The mean estimate of 85.4 TCF of gas within the gas hydrates of northern Alaska is considerably less than the 590 TCF reported in the 1995 USGS assessment of domestic natural gas hydrates. This difference is because the 1995 assessment included all volumes of gas, whereas this assessment deals only with what is considered to be technically recoverable gas. Also, the 1995 assessment included offshore federal waters of Alaska, which were not included in this recent assessment. The approach used in estimating the gas hydrate resources in northern Alaska followed current standard geology-based USGS methodologies developed to assess conventional oil and gas resources.

The research project in support of this assessment was a cooperative effort with the Bureau of Land Management, who provided the geologic and geophysical datasets of the Alaskan North Slope.

To learn more about USGS research on natural gas hydrates and to see results of the gas hydrate assessment please visit the Energy Resources Program Web site . The USGS fact sheet summarizing results of this assessment is accessible at: http://pubs.usgs.gov/fs/2008/3073/ **.** The USGS scientific investigations report summarizing the methodology and theoretical considerations is available at: http://pubs.usgs.gov/sir/2008/5175/ .

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GEOLOGIC CARBON DIOXIDE SEQUESTRATION ASSESSMENT METHODOLOGY
http://energy.er.usgs.gov/health_environment/co2_sequestration/

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Injecting Carbon Dioxide in Rocks Could Mitigate Climate Change Effects

WASHINGTON, D.C.--A new method to assess the nation's potential for storing carbon dioxide could lead to techniques for lessening the impacts of climate change, according to Secretary of the Interior Ken Salazar, who praised a U.S. Geological Survey report.

The USGS released the report to describe its methodology to assess the nation's potential for carbon sequestration--the injection of liquid carbon dioxide into rocks below the earth's surface.

The new methodology identifies a means to assess the volume of pore space in subsurface rocks that is able to store carbon dioxide for tens of thousand of years.

"Rather than emitting carbon into the air, our nation can and should move toward capturing carbon emissions and storing them underground," said Salazar. "The report will help us find the best

places in the country for this type of carbon sequestration. The development of this assessment methodology marks a critical first step in our understanding of how much carbon dioxide can be stored in the subsurface."

As a senator in 2007, Salazar authored the provision of the Energy Independence and Security Act that directed USGS to develop the methodology. "The USGS is uniquely qualified to undertake this effort, given their experience with national and international assessments of natural resources, such as oil and gas, and their knowledge of ground-water systems and chemistry," he said today.

The true global storage capacity of carbon dioxide in geologic formations is unknown at this point, and this method allows for an assessment that can characterize the storage potential in two types of storage units (saline formations and oil and gas reservoirs) in a uniform manner across the United States.

This assessment methodology for storing carbon dioxide focuses on the "technically accessible resource," which is the geologic resource that may be available and sequestered using present-day geological and engineering knowledge and technology. No economic factors are used in the estimation of the volume of resource.

The methodology is dependent upon building geologic models of the areas to be assessed. Statistical methods are used to incorporate uncertainty and natural geologic variability on the ranges of possible storage resources within a storage assessment unit.

This research benefited from discussions with a variety of partners and stakeholders, such as the Department of Energy and the National Energy Technology Laboratory, State Geological Surveys, the Environmental Protection Agency, and the Bureau of Land Management.

The USGS is conducting research on a number of fronts related to carbon sequestration. These efforts include evaluation of potential biological sequestration in a variety of ecosystems, potential release of greenhouse gases from Arctic soils and permafrost, mapping the distribution of ultramafic rocks for potential mineral sequestration efforts, and the possible role of gas hydrates in carbon sequestration.

For more information about USGS geologic carbon sequestration efforts and to learn more about this new methodology, visit the USGS Energy Resources Program Web site. Additional information about carbon dioxide sequestration is linked to page 10.

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FEATURES

COAL:
http://energy.usgs.gov/coal.html
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Geologic map of Upper Cretaceous and Tertiary strata and coal stratigraphy of the Paleocene Fort Union Formation, Rawlins-Little Snake River area, south-central Wyoming

This report provides a map and detailed descriptions of geologic formations for a 1,250-square mile region in the Rawlins-Little Snake River coal field in the eastern part of the Washakie and Great Divide Basins of south-central Wyoming. Mapping of the formations as well as their contained coal beds was conducted at a scale of 1:24,000 and compiled at a scale of 1:100,000. Emphasis was placed on coal-bearing strata of the China Butte and Overland Members of the Paleocene Fort Union Formation. Surface stratigraphic sections were measured and described and well logs were examined to determine the lateral continuity of individual coal beds; the coal-bed stratigraphy is shown on correlation diagrams. A structure contour and overburden map constructed on the uppermost coal bed in the China Butte Member is also provided. This USGS Scientific Investigations Map is available at: http://pubs.usgs.gov/sim/3053/ .

Petrographic and Vitrinite Reflectance Analyses of a Suite of High Volatile Bituminous Coal Samples from the United States and Venezuela

This report presents vitrinite reflectance and detailed organic composition data for nine high volatile bituminous coal samples. These samples were selected to provide a single, internally consistent set of reflectance and composition analyses to facilitate the study of linkages among coal composition, bitumen generation during thermal maturation, and geochemical characteristics of generated hydrocarbons. Five Pennsylvanian coal samples from the Illinois, Appalachian, and Black Warrior Basins, USA, two Paleocene and one Eocene-Oligocene coal samples from the Maracaibo Basin, Venezuela, and one Eocene coal sample from the Gulf of Mexico Coastal Plain, USA, compose the sample set. Understanding these linkages is important for addressing several issues, including (1) the role of coal as a source rock within a petroleum system, (2) the potential for conversion of coal resources to liquid hydrocarbon fuels, and (3) the interactions between coal and carbon dioxide during enhanced coalbed methane recovery and(or) carbon dioxide sequestration in coal beds. This USGS Open-File Report is available at: http://pubs.usgs.gov/of/2008/1230/ .

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NATIONAL OIL AND GAS ASSESSMENT

http://energy.cr.usgs.gov/oilgas/noga

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The USGS recently completed and reported on the results of geologic assessments of the potential for undiscovered petroleum resources in several research areas and provinces of the United States. These assessments are based on geologic principles and apply the total petroleum system (TPS) concepts including (1) the evaluation of source rocks (source rock maturation, organic richness, hydrocarbon generation, and migration), (2) evaluation of reservoir rocks (stratigraphy, sedimentology, continuous and conventional rock types, and petrophysical properties), and (3)

determination of hydrocarbon traps and seals (formation and timing). These elements provide the geologic framework for defining a TPS and assessment units (AU) within it.

Geologic Assessment of Undiscovered Gas Resources of the Eastern Oregon and Washington Province

!!NEW CD-ROM!!

This new report, available online and in a CD-ROM format, contains maps, associated spatial data, and assessment of the undiscovered oil and gas potential of the Eastern Oregon and Washington Province of Oregon and Washington. For this province, the USGS defined one TPS and two AUs within it, and quantitatively estimated the undiscovered gas resources within each AU. The assessment resulted in an estimated mean total of 2,400 billion cubic feet of gas and 9.8 million barrels of natural gas liquids. Undiscovered resources are considered to be within an overpressured, continuous accumulation of gas trapped within Tertiary rocks that are overlain by the Columbia River Basalt Group. The online version of this report is accessible via the following website: http://pubs.usgs.gov/dds/dds-069/dds-069-o/. For CD-ROM requests, please send an email to: eteamdisks@usgs.gov .

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

!!NEW CD-ROM!!

This new report, available online and in a CD-ROM format, contains maps, associated spatial data, and assessment of the undiscovered, technically recoverable coalbed-gas resources in Cretaceous and Tertiary rocks underlying the North Slope and adjacent State waters of Alaska. Within this province, USGS defined the Brookian Coalbed Gas Composite TPS and three coalbed gas AUs within it. Based on quantitative estimates within each AU, the mean total undiscovered coalbed gas resource in the composite TPS is18 trillion cubic feet (TCF) of gas, of which about 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. The online version of this report is accessible via the following website: http://pubs.usgs.gov/dds/dds-069/dds-069-s/. For CD-ROM requests, please send an email to: eteamdisks@usgs.gov .

Assessment of Undiscovered Oil and Gas Resources of the Williston Basin Province of North Dakota, Montana, and South Dakota – 2008

The USGS recently completed an assessment of the undiscovered oil and gas resources in

conventional and continuous accumulations of the Williston Basin Province of North Dakota, eastern Montana, and northwestern South Dakota. Detailed framework studies in stratigraphy and structural geology and the modeling of petroleum geochemistry, combined with historical exploration and production analyses, were used in estimating the undiscovered, technically recoverable oil and gas resources of the entire stratigraphic section in the U.S. part of the Williston Basin. Using this framework, the USGS defined 11 TPSs and 19 AUs within them, and undiscovered oil and gas resources were quantitatively estimated within each AU. The USGS estimated means of 3,844 million barrels of oil (MMBO), 3,705 billion cubic feet of gas, and 202 million barrels of total natural gas liquids for undiscovered continuous and conventional resources in the Williston Basin Province. The assessment indicates that most of the undiscovered oil and gas resides within the Bakken Formation as a continuous reservoir with a mean of 3,645 MMBO, whereas undiscovered oil from conventional reservoirs has a mean of 197 MMBO. A USGS Fact Sheet summarizing the results is available at: http://pubs.usgs.gov/fs/2008/3092/ .

Assessment of Undiscovered Technically Recoverable Oil and Gas Resources of the Bakken Formation, Williston Basin, Montana and North Dakota, 2008

The USGS has completed supporting data for the assessment of the undiscovered oil and associated gas resources of the Upper Devonian to Lower Mississippian Bakken Formation in the U.S. portion of the Williston Basin of Montana and North Dakota and within the Williston Basin Province. Framework studies in stratigraphy and structural geology and modeling of petroleum geochemistry, combined with historical exploration and production analyses, were used to estimate the undiscovered, technically recoverable oil resource of the Devonian-Mississippian Bakken Formation. Using this framework, the USGS defined a Bakken-Lodgepole TPS and seven AUs within the system. For the Bakken Formation, the undiscovered oil and associated gas resources were quantitatively estimated for six of these AUs. This Open-File Report is available at: http://pubs.usgs.gov/of/2008/1353/ .

Assessment of the Mowry Shale and Niobrara Formation as continuous hydrocarbon systems, Powder River Basin, Montana and Wyoming,

A recent USGS oil and gas assessment of the Powder River Basin, Wyoming and Montana, identified the Upper Cretaceous Mowry Shale and Niobrara Formation as the primary hydrocarbon sources for Cretaceous conventional and unconventional reservoirs. The Mowry and Niobrara continuous reservoirs were assessed using a cell-based methodology that utilized production data. The size of each cell was based on geologic controls and potential drainage areas in analog fields. Cumulative Mowry-sourced petroleum production is about 1.2 BBO (billion barrels of oil) and 2.2 TCFG (trillion cubic feet of gas) and cumulative Niobrara-sourced oil production is about 520 MMBO (million barrels of oil) and 0.95 TCFG. Burial history modeling indicated that hydrocarbon generation for both formations started at about 0.60 percent vitrinite reflectance (or R_o, a measure of thermal maturity) at depths of about 8,000 ft. At maximum depths, R_o for the Mowry is about 1.2 to 1.3 percent and about 0.80 percent for the Niobrara.

Mean estimates of technically recoverable undiscovered continuous resource for the Mowry are 198 MMBO, 198 BCF (billion cubic feet of gas), and 11.9 MMBNGL (million barrels of natural gas liquid), and those for the Niobrara are 227 MMBO, 227 BCFG, and 13.6 MMBNGL. This USGS Open-File Report is available at: http://pubs.usgs.gov/of/2008/1367/ .

Geologic Model for Oil and Gas Assessment of the Kemik-Thomson Play, Central North Slope, Alaska

A geologic model was developed to assess undiscovered oil and gas resources in the Kemik-Thomson Play of the Central North Slope, Alaska. In this model, regional erosion during the Early Cretaceous produced an incised valley system on the flanks and crest of the Mikkelsen High and formed the Lower Cretaceous unconformity. Locally derived, coarse-grained siliciclastic and carbonate detritus from eroded Franklinian-age basement rocks, Carboniferous Kekiktuk Conglomerate (of the Endicott Group), Lisburne Group, and Permian-Triassic Sadlerochit Group may have accumulated in the incised valleys during lowstand and transgression, forming potential reservoirs in the Lower Cretaceous Kemik Sandstone and Thomson sandstone (informal term). Continued transgression resulted in the deposition of the mudstones of the overlying Cretaceous pebble-shale unit and Hue Shale, which form top seals to the potential reservoirs. Petroleum from thermally mature facies of the Triassic Shublik Formation, Jurassic Kingak Shale, and Hue Shale (and pebble-shale unit), and the Cretaceous-Tertiary Canning Formation might have charged Thomson and Kemik sandstone reservoirs in this play during the Tertiary. The success of this play depends largely upon the presence of reservoir-quality units in the Kemik Sandstone and Thomson sandstone. This USGS Scientific Investigations Report is available at: http://pubs.usgs.gov/sir/2008/5146/ .

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OIL SHALE

http://energy.cr.usgs.gov/other/oil_shale/

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Preliminary Stratigraphic Cross Sections of Oil Shale in the Eocene Green River Formation, Uinta Basin, Utah

Oil shale units in the Eocene Green River Formation are shown on two east-west stratigraphic sections across the Uinta Basin in northeastern Utah. Several units have potential value for recovery of shale oil, especially the Mahogany oil shale zone, which is a high-grade oil shale that can be traced across most of the Uinta Basin and eastward into the Piceance Basin in northwestern Colorado. Many thin medium- to high-grade oil shale beds above the Mahogany zone can also be traced for many miles across the Uinta Basin. Several units below the Mahogany that have slow velocities on sonic logs may be low-grade oil shale. These may have value as a source for shale gas. This USGS Open-File report is available at: http://pubs.usgs.gov/of/2008/1220/ .

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WORLD PETROLEUM

http://certmapper.cr.usgs.gov/rooms/we

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Jurassic-Cretaceous Composite Total Petroleum System and Geologic Assessment of Oil and Gas Resources of the North Cuba Basin, Cuba

!!NEW CD-ROM!!

This new report, available online and in a CD-ROM, contains maps, associated spatial data, and assessment of the undiscovered oil and gas potential of the North Cuba Basin, exclusive of reserve growth. Based on the general geologic elements of a total petroleum system (TPS) – petroleum source rocks, reservoir rocks , and petroleum traps the USGS defined the Jurassic-Cretaceous TPS in the North Cuba Basin Province. Within this TPS, AUs were defined and assessed for undiscovered oil and gas resources resulting in estimated means of 4.6 billion barrels of oil (BBO), 9.8 trillion cubic feet (TCF) of natural gas (8.6 TCF of associated-dissolved gas and 1.2 TCF of nonassociated gas), and 0.9 billion barrels of natural gas liquids non-associated gas (1.2 TCF; gas in gas fields). The online version of this report is accessible via the following website: http://pubs.usgs.gov/dds/dds-069/dds-069-m/. For CD-ROM requests, please send an email to: eteamdisks@usgs.gov .

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OTHER NEWS

SECRETARY OF INTERIOR KEN SALAZAR'S REMARKS ON ENERGY:

http://www.doi.gov/secretary/speeches/012309_speech.html

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Secretary of Interior Ken Salazar emphasized the role of the Department of Interior in the energy future of the nation in remarks at an all-employees meeting on January 22, 2009. He stated that "...we must help our nation reduce its dependence on foreign oil. This is an absolute imperative of our time." Continuing, he recounted the history of energy policy in this country over the last four decades. He specified the national security, environmental, and economic opportunity drivers for our energy future and concluded, stating "As we move forward into that energy future, it will be important for all of us to understand that our oil and gas and coal resources are very much a part of the equation for that future. We cannot get from here to there without, frankly, developing the oil and gas resources that we have here in this nation – both on our lands as well as in some selected areas in the offshore area. We cannot move forward simply by turning off the lights today and turning off all the coal-fired power plants. But we can move forward with carbon capture and sequestration, and clean coal technologies. These are some of the things we will do. So as I spoke about coming here to the Department of the Interior with President Obama, I said that I would join

his team because together we are going to take the moon shot on energy and we are going to become energy independent. We are going to set America free once and for all from our addiction to foreign oil. I need your help to get that done."

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CARBON SEQUESTRATION TO MITIGATE CLIMATE CHANGE:
http://pubs.usgs.gov/fs/2008/3097/ .

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The USGS published a fact sheet on carbon sequestration in the context of mitigating the effects of global climate change caused by human activities, especially the burning of fossil fuels such as coal, oil, and gas. These fossil fuels have caused an increase in the concentration of carbon dioxide (CO_2) in the atmosphere. This increase in atmospheric CO_2 – from about 280 to more than 380 parts per million over the last 250 years – is causing measurable global warming. Potential adverse impacts include (1) sea level rise, (2) increased frequency and intensity of wildfires, floods, droughts, and tropical storms, (3) changes in the amount, timing, and distribution of rain, snow, and runoff, and (4) disturbance of coastal marine and other ecosystems. Rising atmospheric CO_2 is also increasing the absorption of CO_2 by seawater, causing the ocean to become more acidic, with potentially disruptive effects on marine plankton and coral reefs. Technically and economically feasible strategies are needed to mitigate the consequences of increased atmospheric CO_2. The United States needs scientific information to develop ways to reduce human-caused CO_2 emissions and to remove CO_2 from the atmosphere**.**

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RECENT PUBLICATIONS

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Models for Gas Hydrate-Bearing Sediments Inferred from Permeability and Elastic Velocities
U.S. Geological Survey Scientific Investigations Report 2008-5219
http://pubs.usgs.gov/sir/2008/5219/

Geologic Maps and Cross Sections of the Tuba City Open Dump and Vicinity with Implications for the Occurrence and Flow of Groundwater
U.S. Geological Survey Open-File Report 2008-1380
http://pubs.usgs.gov/of/2008/1380/

Thermal maturity patterns (CAI and %R_o) in Upper Ordovician and Devonian rocks of the Appalachian basin: A major revision of USGS Map I–917–E using new subsurface collections
U.S. Geological Survey Scientific Investigations Map 3006
http://pubs.usgs.gov/sim/3006/

Comparison of the Modified Biot-Gassmann Theory and the Kuster-Toksoz Theory in Predicting Elastic Velocities of Sediments
U.S. Geological Survey Scientific Investigations Report 2008-5196
http://pubs.usgs.gov/sir/2008/5196/

Bedrock, Borehole, and Water-Quality Characterization of a Methane-Producing Water Well in Wolfeboro, New Hampshire
U.S. Geological Survey Open File Report 2008-1333
http://pubs.usgs.gov/of/2008/1333/ .

Assessment of Appalachian Basin Oil and Gas Resources: Utica-Lower Paleozoic Total Petroleum System
U.S. Geological Survey Open-File Report 2008-1287
http://pubs.usgs.gov/of/2008/1287/

Executive Summary - Assessment of Undiscovered Oil and Gas Resources of the Jurassic-Cretaceous Composite Total Petroleum System in the North Cuba Basin, Cuba, 2004, Chapter 1
U.S. Geological Survey Digital Data Series DDS-69-M, Chapter 1
http://pubs.usgs.gov/dds/dds-069/dds-069-m/REPORTS/69_M_CH_1.pdf

Jurassic-Cretaceous Composite Total Petroleum System and Geologic Models for Oil and Gas Assessment of the North Cuba Basin, Cuba, Chapter 2
U.S. Geological Survey Digital Data Series DDS-69-M, Chapter 2
http://pubs.usgs.gov/dds/dds-069/dds-069-m/REPORTS/69_M_CH_2.pdf

A Monte Carlo Simulation Method for the Assessment of Undiscovered Conventional Oil and Gas, Chapter 3
U.S. Geological Survey Digital Data Series DDS-69-M, Chapter 3
http://pubs.usgs.gov/dds/dds-069/dds-069-m/REPORTS/69_M_CH_3.pdf

Executive Summary - Assessment of Undiscovered Gas Resources of the Eastern Oregon and Washington Province, Chapter 1
U.S. Geological Survey Digital Data Series DDS-69-O, Chapter 1
http://pubs.usgs.gov/dds/dds-069/dds-069-o/REPORTS/69_O_CH_1.pdf

Cretaceous-Tertiary Composite Total Petroleum System and Geologic Assessment of Undiscovered Gas Resources of the Eastern Oregon and Washington Province, Chapter 2
U.S. Geological Survey Digital Data Series DDS-69-O, Chapter 2
http://pubs.usgs.gov/dds/dds-069/dds-069-o/REPORTS/69_O_CH_2.pdf

Tabular Data and Graphical Images in Support of the U.S. Geological Survey National Oil and Gas Assessment - Eastern Oregon-Washington (5005), Chapter 3
U.S. Geological Survey Digital Data Series DDS-69-O, Chapter 3
http://pubs.usgs.gov/dds/dds-069/dds-069-o/REPORTS/69_O_CH_3.pdf

Evaluation of Well-Test Results and the Potential for Basin-Center Gas in the Columbia Basin, Central Washington, Chapter 4
U.S. Geological Survey Digital Data Series DDS-69-O, Chapter 4
http://pubs.usgs.gov/dds/dds-069/dds-069-o/REPORTS/69_O_CH_4.pdf

The GIS Project for the Geologic Assessment of Undiscovered Gas Resources of the Eastern Oregon and Washington Province, Chapter 5
U.S. Geological Survey Digital Data Series DDS-69-O, Chapter 5
http://pubs.usgs.gov/dds/dds-069/dds-069-o/REPORTS/69_O_CH_5.pdf

Executive Summary - Geologic Assessment of Undiscovered, Technically Recoverable Coalbed - Gas Resources in Cretaceous and Tertiary Rocks, North Slope and Adjacent State Waters, Alaska, Chapter 1
U.S. Geological Survey Digital Data Series DDS-69-S, Chapter 1
http://pubs.usgs.gov/dds/dds-069/dds-069-s/REPORTS/69_S_CH_1.pdf

Geologic Assessment of Undiscovered, Technically Recoverable Coalbed-Gas Resources in Cretaceous and Tertiary Rocks, North Slope and Adjacent State Waters, Alaska, Chapter 2
U.S. Geological Survey Digital Data Series DDS-69-S, Chapter 2
http://pubs.usgs.gov/dds/dds-069/dds-069-s/REPORTS/69_S_CH_2.pdf

Tabular Data and Graphical Images in Support of the U.S. Geological Survey National Oil and Gas Assessment - Northern Alaska Province (5001), Brookian Coalbed - Gas Composite Total Petroleum System (500101), Chapter 3
U.S. Geological Survey Digital Data Series DDS-69-S, Chapter 3
http://pubs.usgs.gov/dds/dds-069/dds-069-s/REPORTS/69_S_CH_3.pdf

The GIS Project for the Geologic Assessment of Undiscovered, Technically Recoverable Coalbed-Gas Resources in Cretaceous and Tertiary Rocks, North Slope and Adjacent State Waters, Alaska, Chapter 4
U.S. Geological Survey Digital Data Series DDS-69-S, Chapter 4
http://pubs.usgs.gov/dds/dds-069/dds-069-s/REPORTS/69_S_CH_4.pdf