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Geologic Studies of Deep Natural Gas Resources

U.S. Geological Survey Digital Data Series 67

Prepared in cooperation with the U.S. Department of Energy–National Energy Technology Laboratory, the Gas Technology Institute, and Advanced Resources International

U.S. Department of the Interior
U.S. Geological Survey

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By Thaddeus S. Dyman *and* Vello A. Kuuskraa, *Editors*

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Volume Contents

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Chapter A

Introduction

By Thaddeus S. Dyman *and* Vello A. Kuuskraa

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Introduction

By Thaddeus S. Dyman *and* Vello A. Kuuskraa[1]

In 1995, the U.S. Geological Survey estimated a mean resource of 114 trillion cubic feet of undiscovered technically recoverable natural gas in plays deeper than 15,000 feet (4,572 m) in onshore regions of the United States (Dyman and others, 1996). This estimated resource represents nearly 20 percent of the total undiscovered conventional and continuous-type (unconventional) natural gas resources of the onshore United States based on the U.S. Geological Survey 1995 National Petroleum Assessment (U.S. Geological Survey National Oil and Gas Assessment Team, 1995). Because these deep resources are widespread and occur in diverse geologic environments, they deserve special attention.

Efficiently finding and developing these deep undiscovered natural gas resources depend on improving our knowledge of the geology and reservoir characteristics of deep sedimentary basins, continued advances in exploration, drilling, and completion technologies, and improved economics. During the 1990's, deep natural gas exploration and development were strongly influenced both by advances in technology and by lower unit costs. This progress in technology and costs helped spur the development of frontier plays such as the deep Norphlet Play in the eastern Gulf Coast basin, the low-permeability deep Cretaceous plays of the Green River basin, and the deep Madison Play on Madden anticline in the Wind River basin. The importance of continued technology progress was amplified by Reeves and others (1998) when they identified current barriers to deep gas development. They suggested the need to reduce well costs through improving drilling practices, reducing dry-hole rates with more focused exploration technologies, optimizing completion practices, and developing new technologies to better process sour gas.

In 1997, the U.S. Geological Survey published Bulletin 2146, comprising 12 chapters dealing with geologic, geochemical, and assessment issues related to deep gas resources (Dyman and others, 1997). A primary goal of that bulletin was to provide geology-based information that might aid in future improvements to technology for deep gas exploration and development. Chapters of this report represent a continuation of that work funded by the U.S. Geological Survey, Denver, Colo. The current work is funded by the U.S. Department of Energy, National Energy Technology Laboratory, Morgantown, W. Va. (contract No. DE-AT26-98FT40032), and Gas Technology Institute (formerly Gas Research Institute (GRI)), Chicago, Ill. (contract No. 5094-210-3366 through a Cooperative Research and Development Agreement with Advanced Resources International, Arlington, Va.). Two GRI-sponsored deep gas workshops were held in 1998 (Oil and Gas Journal, 1998). These workshops provided an opportunity for industry participants to discuss the improved economic outlook for deep drilling, present case studies of deep exploration and development in key deep gas regions, outline how new technologies are being used to better define deep drilling opportunities, and introduce new deep gas resource assessments.

Chapters in the present report summarize major conclusions of this ongoing work. Chapters B and C address the areal extent of drilling and the distribution of deep basins. Chapter B provides an update of deep drilling in the U.S. during the 1990's, and Chapter C summarizes the distribution of deep sedimentary basins and the potential for deep gas in the Former Soviet Union.

Chapters D and E are geochemical papers addressing source-rock issues and deep gas generation. Chapter D presents gas generation kinetic models based on laboratory pyrolysis methods and examines them for hypothetical basin scenarios based on end-member heating rates of 1° and 10°C/m.y. Chapter E presents gas:oil ratios (GOR) from hydrous-pyrolysis experiments conducted on immature source rocks and summarizes how they are affected by kerogen type. The quantity of expelled oil and the gas generated during hydrous pyrolysis allows for the calculation of GOR's for a particular source rock at hydrous-pyrolysis temperatures representing different stages of oil generation.

Chapters F and G discuss assessment issues related to deep gas. In Chapter F, a probabilistic method is developed for subdividing gas resources into depth slices. This is important for deep natural gas assessments because gas plays often range across many depth intervals, and estimating the amount of gas in each interval aids in both geologic and economic analysis of the play and province. In Chapter G, the relative uncertainty of estimates of deep gas in plays in the Gulf Coast region is analyzed. More than 60 plays in the Western Gulf and Louisiana-Mississippi Salt Basins provinces are compared and analyzed for their conditional uncertainty.

Chapter H evaluates the mechanism of hydrogenation of deep, high-rank spent kerogen by water, with subsequent generation of methane-rich HC gas.

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