Bakken Oil-Generation Kinetics by Hydrous Pyrolysis and its Testing in 1-D Model*

Hui Jin¹, Michael Lewan², and Steve Sonnenberg¹

Search and Discovery Article #41907 (2016)***
Posted October 3, 2016

*Adapted from poster presentation given at AAPG 2016 Annual Convention and Exhibition, Calgary, Alberta, Canada, June 19-22, 2016
***Datapages © 2016 Serial rights given by author. For all other rights contact author directly.

¹Colorado School of Mines, Golden, Colorado, United States (jinhu.carl@gmail.com)
²U.S. Geological Survey, Golden, Colorado, United States

Abstract

The lower and upper Bakken shales are world-class source rocks in the Williston Basin, sourcing reservoirs in the Bakken, upper Three Forks, and lower Lodgepole formations, which comprise the economically significant Bakken Petroleum System (BPS). A good understanding of the thermal-burial history of Bakken shales, with oil-generation kinetics as the key thermal dynamic parameter, is essential to achieve realistic charge history, which closely relates to Bakken oil presence in reservoirs of BPS across the Williston Basin. The maturation of immature Bakken shales under a hydrous closed-system setting was implemented by the method of hydrous pyrolysis (HP) in a temperature- and time-series. This method provides a conceivable analogue for natural oil generation and expulsion. The derived kinetics for Bakken shales includes activation energy at 53.79 kcal/mole and frequency factor at 1.25×10^27 m.y.^-1 for an oil-generation reaction. These kinetic parameters were tested in a well-constrained 1D thermal-burial history model. The modeled extent of oil generation correlates well with transformation ratios of Bakken shales from independent analysis. The HP oil-generation kinetics were also applied to other thermal-burial histories in the basin, and further modeling results indicate very minimal oil generation from Bakken shales in the Parshall Field and early oil generation in the Sanish Field. This agrees with measured thermal maturity indices and transformation ratios determined by atomic H/C ratios of isolated kerogens for those areas. The discovery of significant oil reserves in the Parshall/Sanish area suggests that, instead of charging from in-situ Bakken shales, the majority of discovered oil may have been laterally migrated from more mature down-dip Bakken shales adjacent to the Parshall/Sanish area.

References Cited


Bakken Oil-Generation Kinetics by Hydrous Pyrolysis and its Testing in 1D Model

Hui Jin¹, Mike Lewan², Stephen A. Sonnenberg³
¹Colorado School of Mines; ²University of Pittsburgh, Pennsylvania; ³Corresponding author: jinhui.carl@gmail.com

Background

Lewan, M.D., 1985, Evaluation of petroleum generation by hydrous pyrolysis
Lewan, M.D., 1994, Assessing Natural Oil Expulsion from Source Rocks by Laboratory Pyrolysis, in L.B. Lewan

Objectives

Bakken oil presence in reservoirs of FPS across the Williston Basin. Bakken shales (lower-upper) are world class source rocks in the Williston Basin. Bakken oil generation takes place by means of expulsion, migration, and accumulation. Bakken shales are significant source rocks for WBB oil. The Bakken shales are of great interest in the oil and gas industry due to the extensive horizontal drilling performed in the Williston Basin.

Methods

Methods involved in this study are hydrous pyrolysis experiments and analyses of kerogen and whole rock bitumen. Hydrous pyrolysis experiments were conducted in the Organic Geochemical Laboratories, University of Pittsburgh, Pennsylvania. The experiments were conducted in a hydrous pyrolysis apparatus (HP) using 100 mg of sample at 200ºC for 60 h. The samples were collected from different locations in the Williston Basin, including the Bakken shale, and analyzed by gas chromatography (GC) and mass spectrometry (MS) for HI. The HI values were compared to those obtained from the literature. The HI values were then used to assess the maturity of the Bakken shales.

Results

Figure 1 shows the location of the Williston Basin with major structures and oil fields in the basin. Figure 2 illustrates the geologic column for the Bakken Petroleum System. The lower and upper Bakken shales are world class source rocks in the Williston Basin. The lower Bakken shale is composed of siltstones, sandstones, and shales, while the upper Bakken shale is composed of siltstones, sandstones, and mudstones. The Bakken shales are important source rocks for WBB oil.

Conclusions

The Bakken oil generation kinetics were determined by hydrous pyrolysis experiments, and the results were used to develop a kinetic model for predicting the maturity of the Bakken shales. The model was validated using data from the literature and from the authors’ own experiments.

References


Absorption


Introduction

Bakken oil presence in reservoirs of FPS across the Williston Basin. Bakken shales (lower-upper) are world class source rocks in the Williston Basin. Bakken oil generation takes place by means of expulsion, migration, and accumulation. Bakken shales are significant source rocks for WBB oil. The Bakken shales are of great interest in the oil and gas industry due to the extensive horizontal drilling performed in the Williston Basin.

Methods

Methods involved in this study are hydrous pyrolysis experiments and analyses of kerogen and whole rock bitumen. Hydrous pyrolysis experiments were conducted in the Organic Geochemical Laboratories, University of Pittsburgh, Pennsylvania. The experiments were conducted in a hydrous pyrolysis apparatus (HP) using 100 mg of sample at 200ºC for 60 h. The samples were collected from different locations in the Williston Basin, including the Bakken shale, and analyzed by gas chromatography (GC) and mass spectrometry (MS) for HI. The HI values were compared to those obtained from the literature. The HI values were then used to assess the maturity of the Bakken shales.

Results

Figure 1 shows the location of the Williston Basin with major structures and oil fields in the basin. Figure 2 illustrates the geologic column for the Bakken Petroleum System. The lower and upper Bakken shales are world class source rocks in the Williston Basin. The lower Bakken shale is composed of siltstones, sandstones, and shales, while the upper Bakken shale is composed of siltstones, sandstones, and mudstones. The Bakken shales are important source rocks for WBB oil.

Conclusions

The Bakken oil generation kinetics were determined by hydrous pyrolysis experiments, and the results were used to develop a kinetic model for predicting the maturity of the Bakken shales. The model was validated using data from the literature and from the authors’ own experiments.

References


Bakken Oil-Generation Kinetics by Hydrous Pyrolysis and its Testing in 1D Model

Hui Jin¹, Mike Lewan², Stephen A. Sonnenberg³
¹Colorado School of Mines; ²University of Pittsburgh, Pennsylvania; ³Corresponding author: jinhui.carl@gmail.com

Introduction

Bakken oil presence in reservoirs of FPS across the Williston Basin. Bakken shales (lower-upper) are world class source rocks in the Williston Basin. Bakken oil generation takes place by means of expulsion, migration, and accumulation. Bakken shales are significant source rocks for WBB oil. The Bakken shales are of great interest in the oil and gas industry due to the extensive horizontal drilling performed in the Williston Basin.

Methods

Methods involved in this study are hydrous pyrolysis experiments and analyses of kerogen and whole rock bitumen. Hydrous pyrolysis experiments were conducted in the Organic Geochemical Laboratories, University of Pittsburgh, Pennsylvania. The experiments were conducted in a hydrous pyrolysis apparatus (HP) using 100 mg of sample at 200ºC for 60 h. The samples were collected from different locations in the Williston Basin, including the Bakken shale, and analyzed by gas chromatography (GC) and mass spectrometry (MS) for HI. The HI values were compared to those obtained from the literature. The HI values were then used to assess the maturity of the Bakken shales.

Results

Figure 1 shows the location of the Williston Basin with major structures and oil fields in the basin. Figure 2 illustrates the geologic column for the Bakken Petroleum System. The lower and upper Bakken shales are world class source rocks in the Williston Basin. The lower Bakken shale is composed of siltstones, sandstones, and shales, while the upper Bakken shale is composed of siltstones, sandstones, and mudstones. The Bakken shales are important source rocks for WBB oil.

Conclusions

The Bakken oil generation kinetics were determined by hydrous pyrolysis experiments, and the results were used to develop a kinetic model for predicting the maturity of the Bakken shales. The model was validated using data from the literature and from the authors’ own experiments.

References


Bakken Oil-Generation Kinetics by Hydrous Pyrolysis and its Testing in 1D Model

Hui Jin¹, Mike Lewan², Stephen A. Sonnenberg³
¹Colorado School of Mines; ²University of Pittsburgh, Pennsylvania; ³Corresponding author: jinhui.carl@gmail.com

Introduction

Bakken oil presence in reservoirs of FPS across the Williston Basin. Bakken shales (lower-upper) are world class source rocks in the Williston Basin. Bakken oil generation takes place by means of expulsion, migration, and accumulation. Bakken shales are significant source rocks for WBB oil. The Bakken shales are of great interest in the oil and gas industry due to the extensive horizontal drilling performed in the Williston Basin.

Methods

Methods involved in this study are hydrous pyrolysis experiments and analyses of kerogen and whole rock bitumen. Hydrous pyrolysis experiments were conducted in the Organic Geochemical Laboratories, University of Pittsburgh, Pennsylvania. The experiments were conducted in a hydrous pyrolysis apparatus (HP) using 100 mg of sample at 200ºC for 60 h. The samples were collected from different locations in the Williston Basin, including the Bakken shale, and analyzed by gas chromatography (GC) and mass spectrometry (MS) for HI. The HI values were compared to those obtained from the literature. The HI values were then used to assess the maturity of the Bakken shales.

Results

Figure 1 shows the location of the Williston Basin with major structures and oil fields in the basin. Figure 2 illustrates the geologic column for the Bakken Petroleum System. The lower and upper Bakken shales are world class source rocks in the Williston Basin. The lower Bakken shale is composed of siltstones, sandstones, and shales, while the upper Bakken shale is composed of siltstones, sandstones, and mudstones. The Bakken shales are important source rocks for WBB oil.

Conclusions

The Bakken oil generation kinetics were determined by hydrous pyrolysis experiments, and the results were used to develop a kinetic model for predicting the maturity of the Bakken shales. The model was validated using data from the literature and from the authors’ own experiments.

References