Petrophysical Analogue Trends from Core Property Data for Emerging Play Evaluation*

Gregor Bächle¹ and Brian Tepper¹

Search and Discovery Article #41171 (2013)**
Posted August 12, 2013

*Adapted from oral presentation given at AAPG Annual Convention and Exhibition, Pittsburgh, Pennsylvania, May 19-22, 2013
**AAPG © 2013 Serial rights given by author. For all other rights contact author directly.

¹Shell International Exploration and Production Inc. (gregor.baechle@shell.com)

Abstract

Petrophysical relationships are difficult to establish in emerging play areas where core measurements are limited or not available, and quality information on TOC and mineralogy may be sparse. A major challenge in unconventional reservoirs is often the determination of porosity, hydrocarbon saturation and the resulting net reservoir thickness. However, deriving accurate ranges for key volumetric parameters is essential for risking and assessing an economic value for these plays. Unfortunately, basic legacy wireline logging measurements (Resistivity, Gamma Ray, Density, Neutron, Sonic) are often the primary source to derive rock property information.

This study shows petrophysical relationships of a number of basic core analog data from established unconventional plays. The trends shown have the potential to aid in the emerging play evaluation. Core analog information from the Eagle Ford, Utica, Marcellus, Barnett, and Haynesville will be presented. We show that difficulties arise due to the low porosities typically present in these reservoirs and the significant impact of kerogen on fundamental petrophysical rock properties such as grain density. This presentation will be useful to those evaluating unconventional reservoirs in emerging play areas where core data is limited.
PETROPHYSICAL ANALOGUE TRENDS FROM CORE PROPERTY DATA FOR EMERGING PLAY EVALUATION

Gregor Bächle & Brian Tepper
Shell International Exploration and Production Inc.

Acknowledgement:
Jim Keller, Robert Walsh, Shell International Exploration and Production Inc., Edwin Quint, Shell Exploration & Production Company
DEFINITIONS AND CAUTIONARY NOTE

The companies in which Royal Dutch Shell plc directly and indirectly owns investments are separate entities. In this presentation “Shell”, “Shell group” and “Royal Dutch Shell” are sometimes used for convenience where references are made to Royal Dutch Shell plc and its subsidiaries in general. Likewise, the words “we”, “us” and “our” are also used to refer to subsidiaries in general or to those who work for them. These expressions are also used where no useful purpose is served by identifying the particular company or companies. “Subsidiaries”, “Shell subsidiaries” and “Shell companies” as used in this presentation refer to companies over which Royal Dutch Shell plc either directly or indirectly has control. Companies over which Shell has joint control are generally referred to “joint ventures” and companies over which Shell has significant influence but neither control nor joint control are referred to as “associates”. In this presentation, joint ventures and associates may also be referred to as “equity-accounted investments”. The term “Shell interest” is used for convenience to indicate the direct and/or indirect (for example, through our 23% shareholding in Woodside Petroleum Ltd.) ownership interest held by Shell in a venture, partnership or company, after exclusion of all third-party interest.

This presentation contains forward-looking statements concerning the financial condition, results of operations and businesses of Royal Dutch Shell. All statements other than statements of historical fact are, or may be deemed to be, forward-looking statements. Forward-looking statements are statements of future expectations that are based on management’s current expectations and assumptions and involve known and unknown risks and uncertainties that could cause actual results, performance or events to differ materially from those expressed or implied in these statements. Forward-looking statements include, among other things, statements concerning the potential exposure of Royal Dutch Shell to market risks and statements expressing management’s expectations, beliefs, estimates, forecasts, projections and assumptions. These forward-looking statements are identified by their use of terms and phrases such as “anticipate”, “believe”, “could”, “estimate”, “expect”, “goals”, “intend”, “may”, “objectives”, “outlook”, “plan”, “probably”, “project”, “risks”, “schedule”, “seek”, “should”, “target”, “will” and similar terms and phrases. There are a number of factors that could affect the future operations of Royal Dutch Shell and could cause those results to differ materially from those expressed in the forward-looking statements included in this presentation, including (without limitation): (a) price fluctuations in crude oil and natural gas; (b) changes in demand for Shell’s products; (c) currency fluctuations; (d) drilling and production results; (e) reserves estimates; (f) loss of market share and industry competition; (g) environmental and physical risks; (h) risks associated with the identification of suitable potential acquisition properties and targets, and successful negotiation and completion of such transactions; (i) the risk of doing business in developing countries and countries subject to international sanctions; (j) legislative, fiscal and regulatory developments including regulatory measures addressing climate change; (k) economic and financial market conditions in various countries and regions; (l) political risks, including the risks of expropriation and renegotiation of the terms of contracts with governmental entities, delays or advancements in the approval of projects and delays in the reimbursement for shared costs; and (m) changes in trading conditions. All forward-looking statements contained in this presentation are expressly qualified in their entirety by the cautionary statements contained or referred to in this section. Readers should not place undue reliance on forward-looking statements. Additional risk factors that may affect future results are contained in Royal Dutch Shell’s 20-F for the year ended December 31, 2012 (available at www.shell.com/investor and www.sec.gov). These risk factors also expressly qualify all forward looking statements contained in this presentation and should be considered by the reader. Each forward-looking statement speaks only as of the date of this presentation, May 22nd, 2013. Neither Royal Dutch Shell plc nor any of its subsidiaries undertake any obligation to publicly update or revise any forward-looking statement as a result of new information, future events or other information. In light of these risks, results could differ materially from those stated, implied or inferred from the forward-looking statements contained in this presentation.

We may have used certain terms, such as resources, in this presentation that United States Securities and Exchange Commission (SEC) strictly prohibits us from including in our filings with the SEC. U.S. Investors are urged to consider closely the disclosure in our Form 20-F, File No 1-32575, available on the SEC website www.sec.gov. You can also obtain these forms from the SEC by calling 1-800-SEC-0330.
OUTLINE

- Introduction
- Learning Model for Unconventional Plays
- Unconventional Play Continuum
- Evaluation Workflow For Emerging Plays Using Analogs
- Petrophysical Relationships using Core Data
- Summary
INTRODUCTION

- Determination of porosity, hydrocarbon pore volume and reservoir thickness is a major petrophysical challenge in unconventional shale oil and gas reservoirs.

- Core data and test data are very limited in emerging plays.

- Enhancing the petrophysical characterization of shale plays is important for assessing the economic value of these plays, where uncertainties are typically large.
LEARNING MODEL FOR UNCONVENTIONAL PLAYS

Play Maturity

Emerging
- Legacy wells
- Sparse data
- Regional models

Developing
- Some Pilot Wells
- Experimental Trials
- Modern logs
- Fresh Core data

Mature
- Many Producing wells
- Surveillance data
- Known technical limit

Analog trends, Stimulation practices

EURs, Sweet spots, Analog Tends
UNCONVENTIONAL PLAY CONTINUUM

Resource Plays continuum

Self Sourced

Locally Sourced/hybrids

Externally Sourced

Hydrocarbons

Migration
Identify Petroleum System Boundaries and Source Rock

Quality Check Logs and Data

Evaluate Mineralogy/Lithology

Thermal Maturity

Identify Reasonable Analogs
  - Basic log responses (density, sonic, resistivity)
  - Mineralogy, Maturity

Develop and Utilize Petrophysical Trends
  - RHOB vs TOC
  - RHOB vs Porosity
  - Bulk Volume Hydrocarbon vs. Porosity
Mineralogy comparison of a number of carbonate dominated plays
Mineralogy comparison of a number of quartz/clay dominated plays
Core data from a number of mature plays suggest trends relating Bulk Density to Total Porosity.
Core data from mature plays suggests trends relating Porosity to Bulk Volume Hydrocarbons.
Weaker correlation between TOC and Bulk Density.
TIGHT ROCK CLASSIFICATION

- Sand/Silt Dominated
- Clay Dominated
- Carbonate Dominated

2.65 g/cm³

Mixed Lithology

2.71 – 2.86 g/cm³
- Eagle Ford (Cretaceous)
- Utica (Ordovician)

2.6 g/cm³
- Barnett (Mississippian)
- Marcellus (Devonian)
Carbonate dominated lithology trend shows best correlation.
Carbonate dominated lithology shows low TOC at low Phi.
ANALOG CORE DATA: BULK DENSITY VS TOC

Mixed Lithology
Sand/Silt Dominated
Clay Dominated
Carbonate Dominated
ANALOG CORE DATA: PHI VS GRAIN DENSITY

Mixed Lithology
Sand/Silt Dominated
Clay Dominated
Carbonate Dominated
At a given Porosity, TOC content has a major effect in lowering Grain Density.
Potential to derive TOC content from Bulk Density – Porosity trend.
Eagle Ford log motif is similar to Vaca Muerta as are other attributes.
Core based petrophysical trends derived from the Eagle Ford core data were used to predict TOC, Porosity and Bulk Volume Hydrocarbons in the Vaca Muerta Well.
**SUMMARY**

- Evaluation Can Be Improved in Emerging Plays Using Learning’s Model and Analogs.

- Reasonable Analogs Can Often Be Identified.

- Petrophysical Trends Can Be Derived From Analog Core Data and Are Helpful in Evaluating Emerging Play Areas.