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

Gregor Bächle[1] and Brian Tepper[1]

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

Abstract

Petrophyiscal 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, Gama 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.

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OUTLINE

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

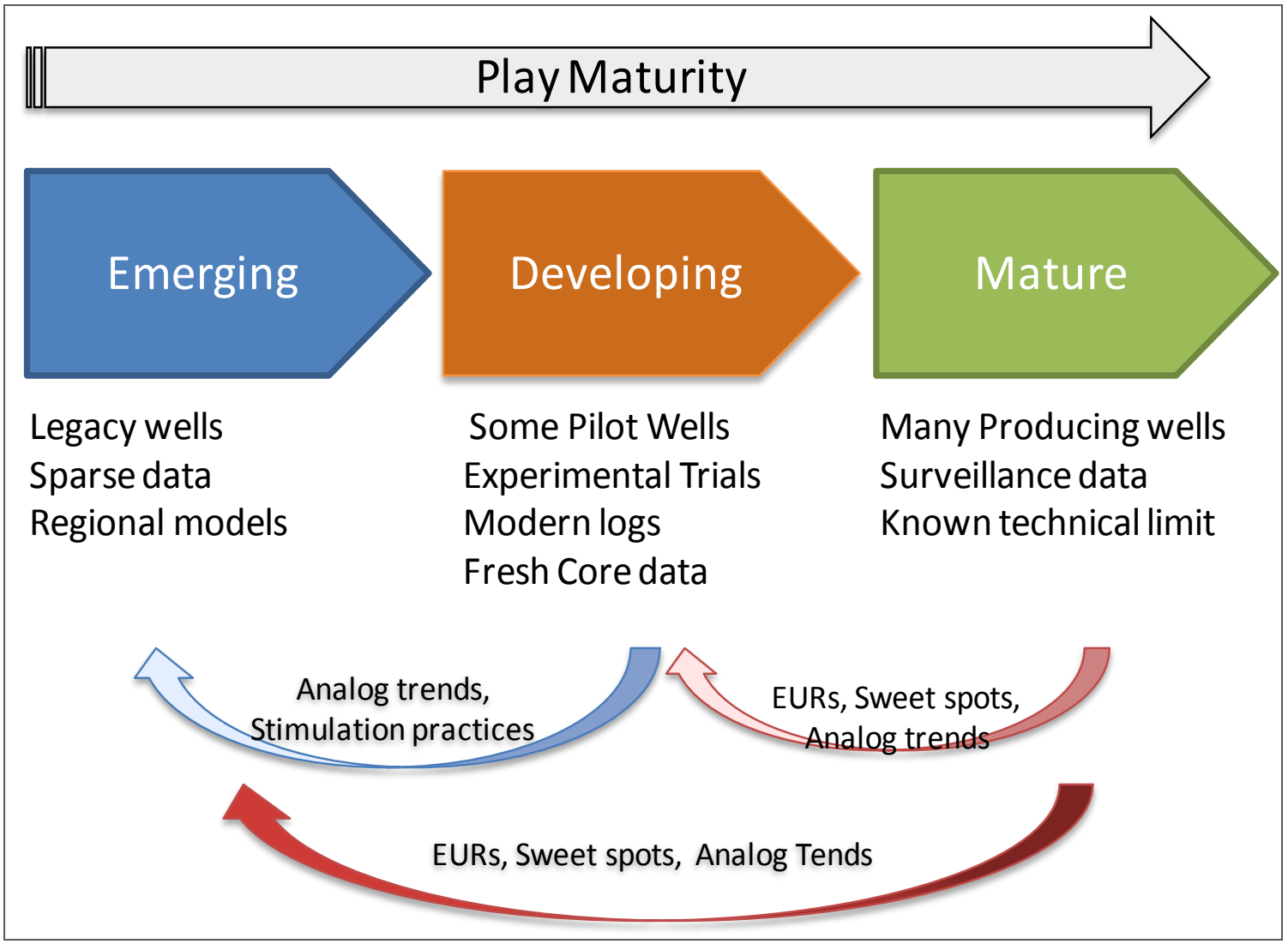
INTRODUCTION

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

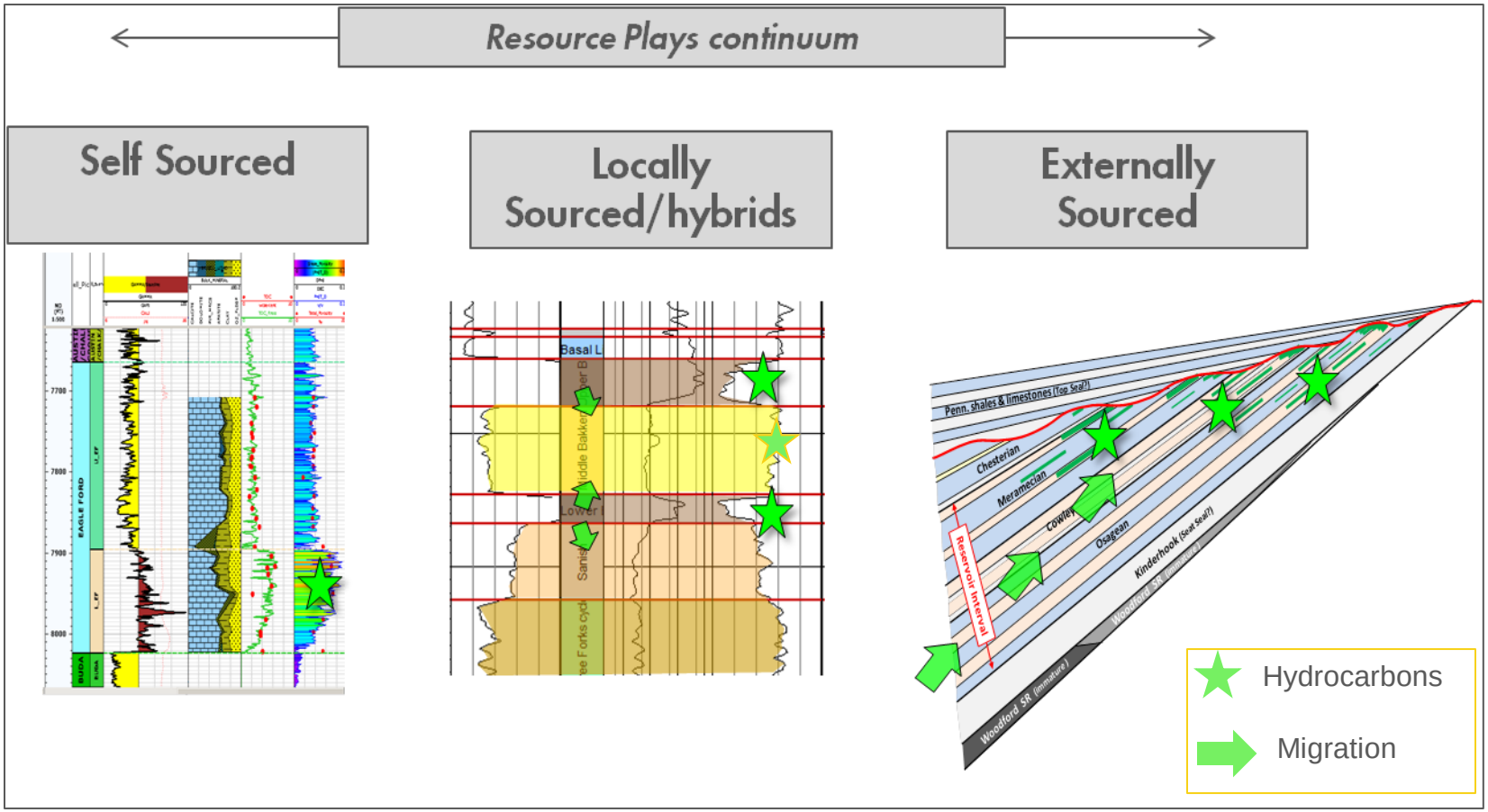
- Core data and test data are very limited in emerging plays.

- 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



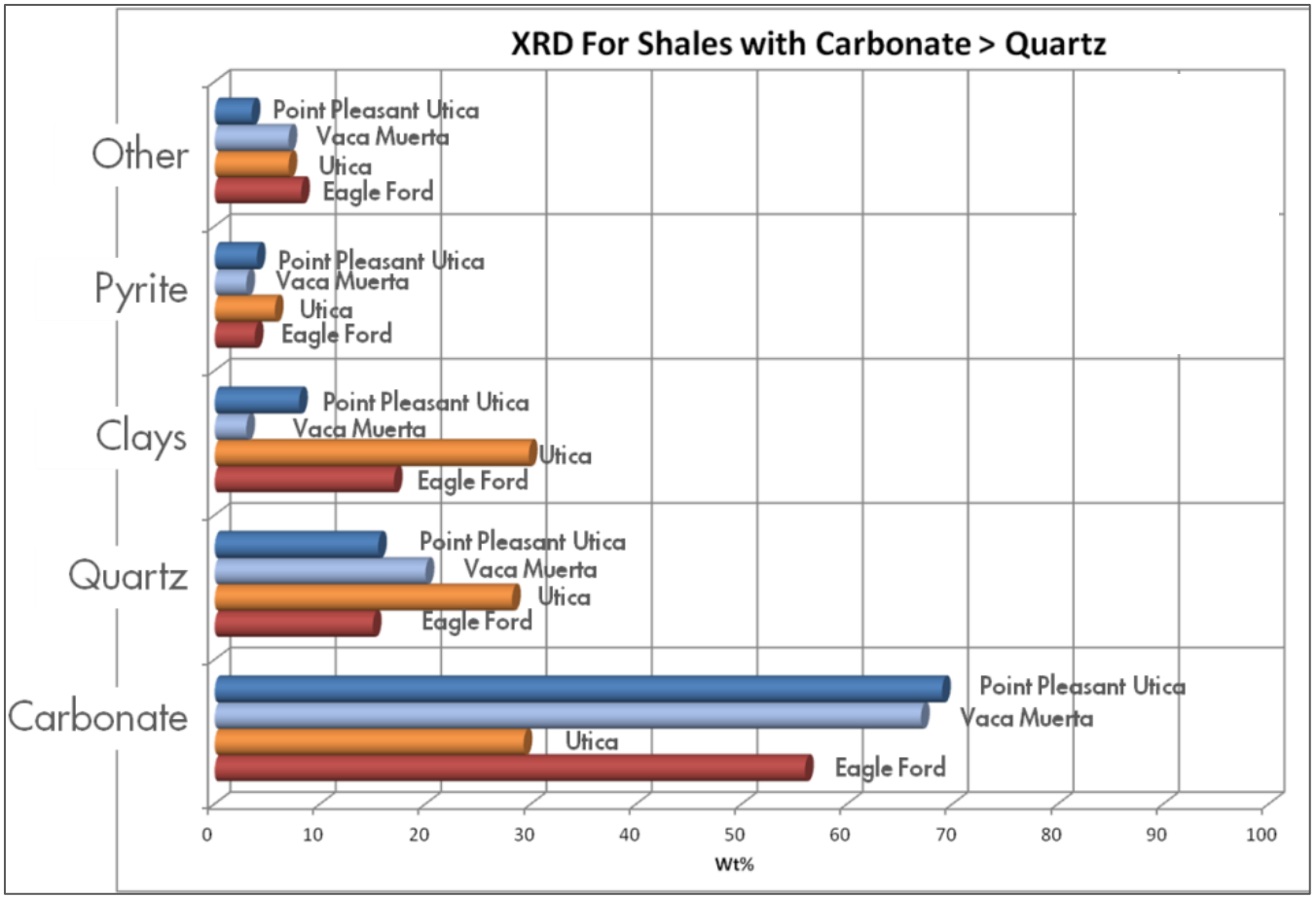
UNCONVENTIONAL PLAY CONTINUUM



EVALUATION WORKFLOW FOR EMERGING PLAYS

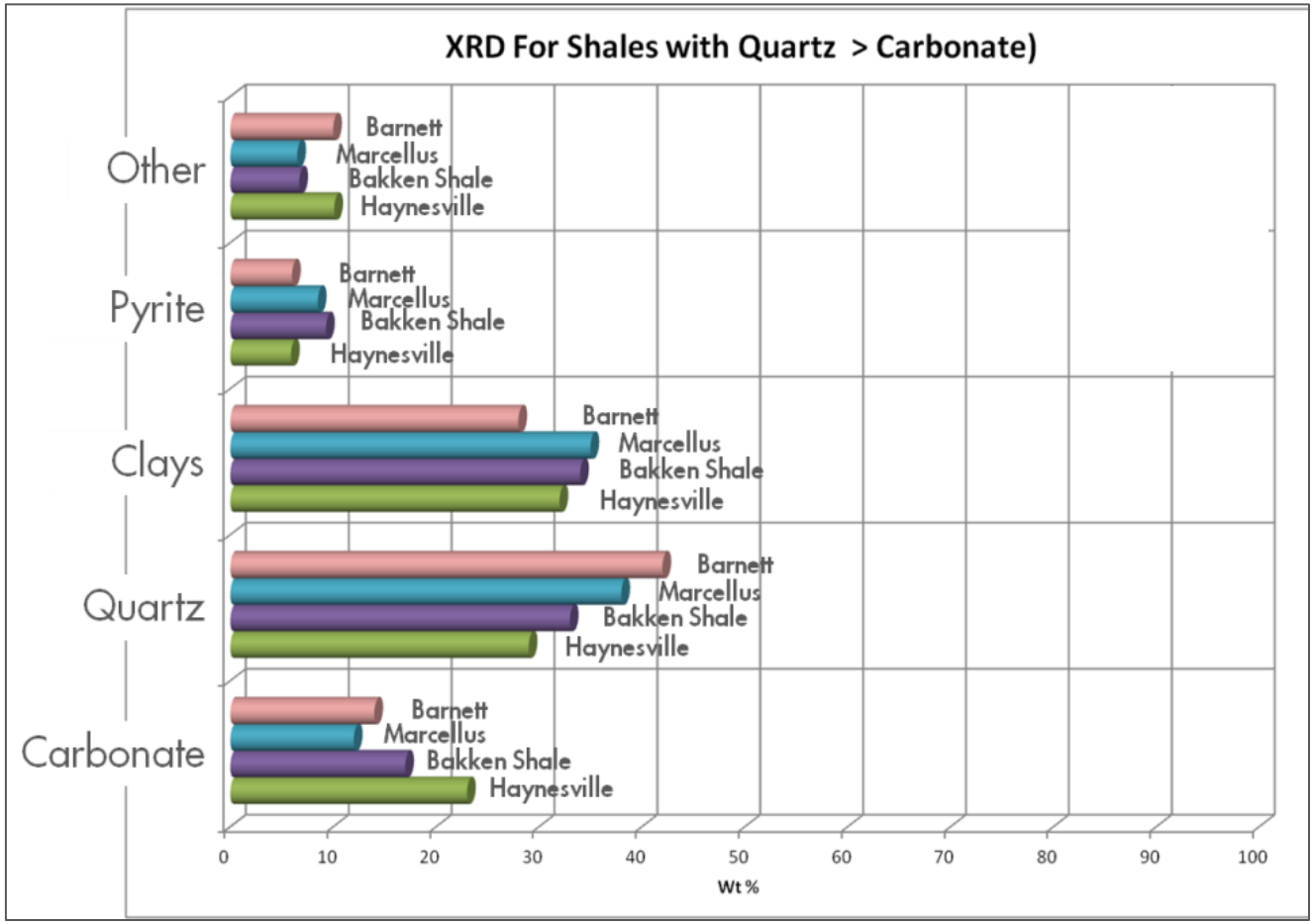
- Identify Petroleum System Boundaries and Source Rock
- Quality Check Logs and Data ✓
- Evaluate Mineralogy/Lithology ✓
- Thermal Maturity
- Identify Reasonable Analogs ✓
  - Basic log responses (density, sonic, resistivity)
  - Mineralogy, Maturity
- Develop and Utilize Petrophysical Trends ✓
  - RHOB vs TOC
  - RHOB vs Porosity
  - Bulk Volume Hydrocarbon vs. Porosity

MINERALOGY/LITHOLOGY COMPARISONS



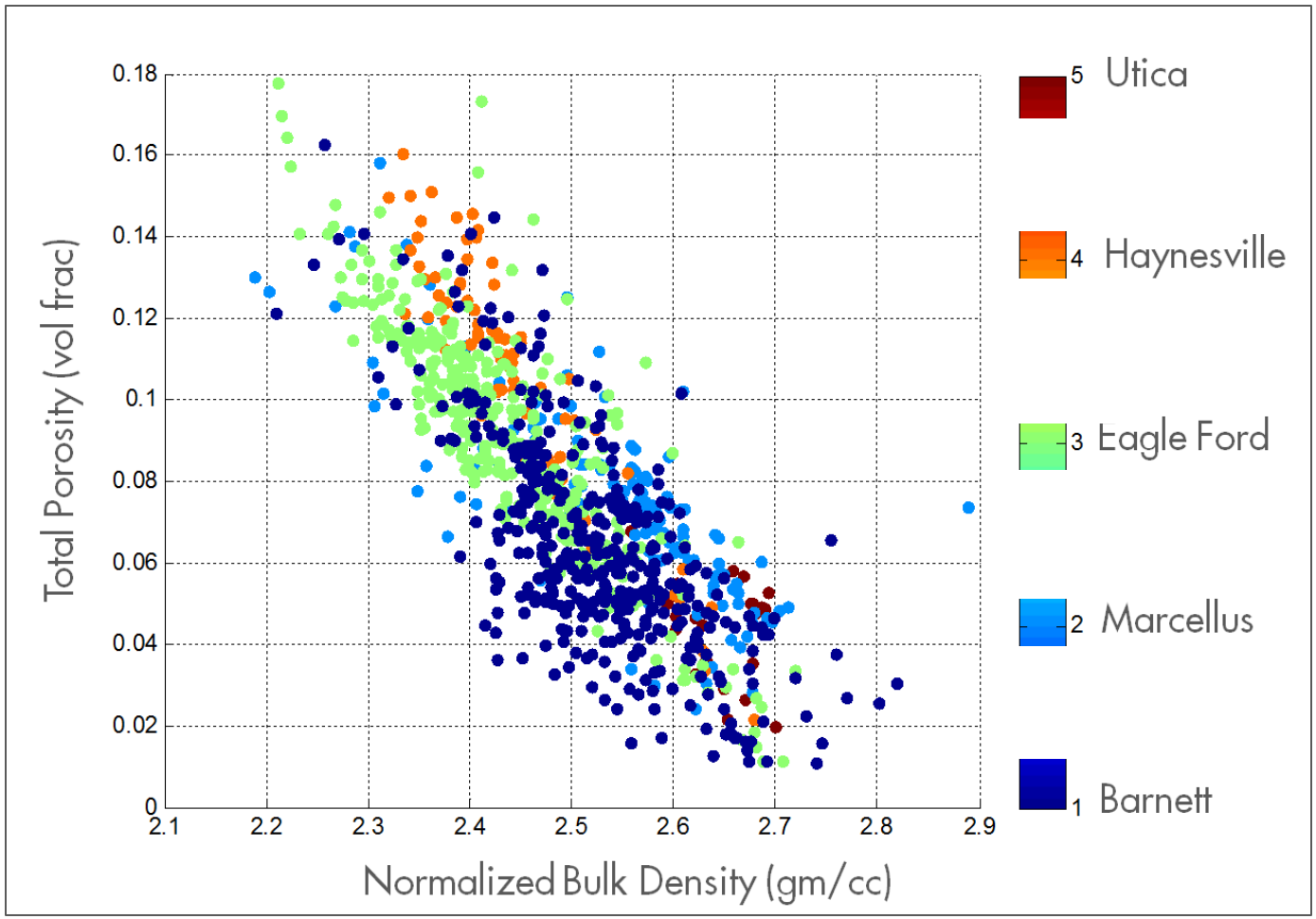
Mineralogy comparison of a number of carbonate dominated plays

MINERALOGY/LITHOLOGY COMPARISONS



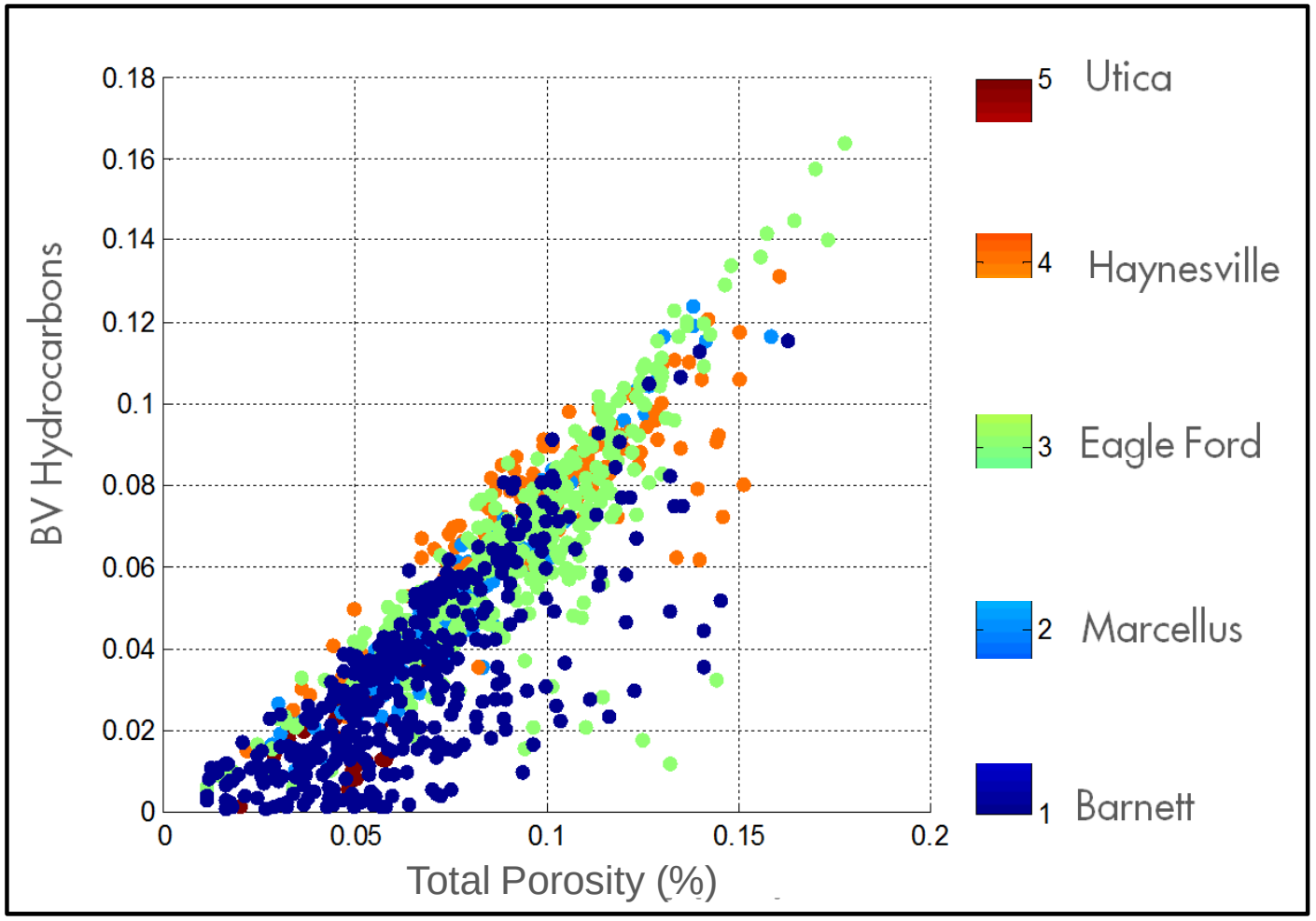
Mineralogy comparison of a number of quartz/clay dominated plays

ANALOG CORE DATA: BULK DENSITY VS PHI



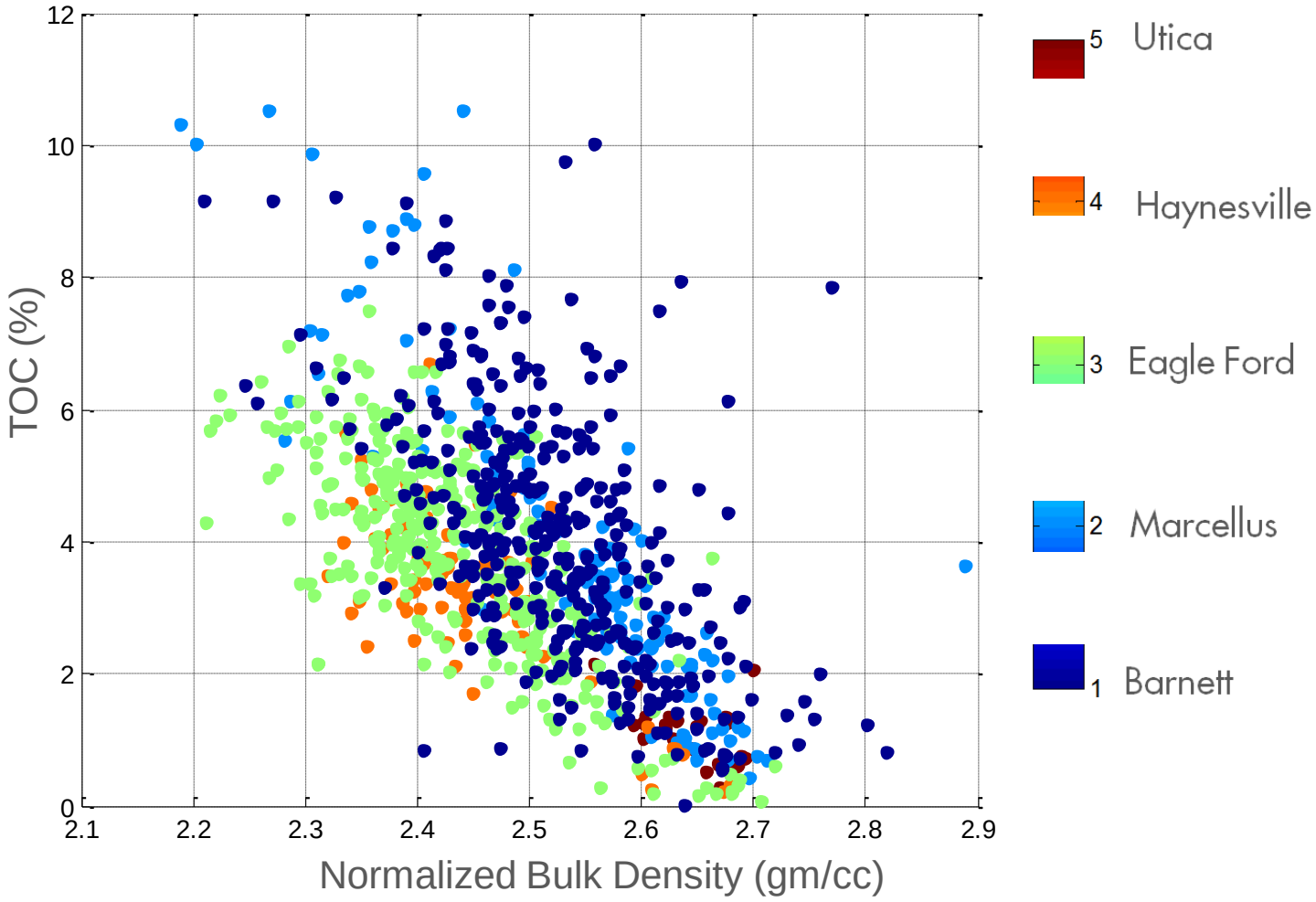
Core data from a number of mature plays suggest trends relating Bulk Density to Total Porosity.

ANALOG CORE DATA: TOTAL POROSITY VS BVHC



Core data from mature plays suggests trends relating Porosity to Bulk Volume Hydrocarbons.

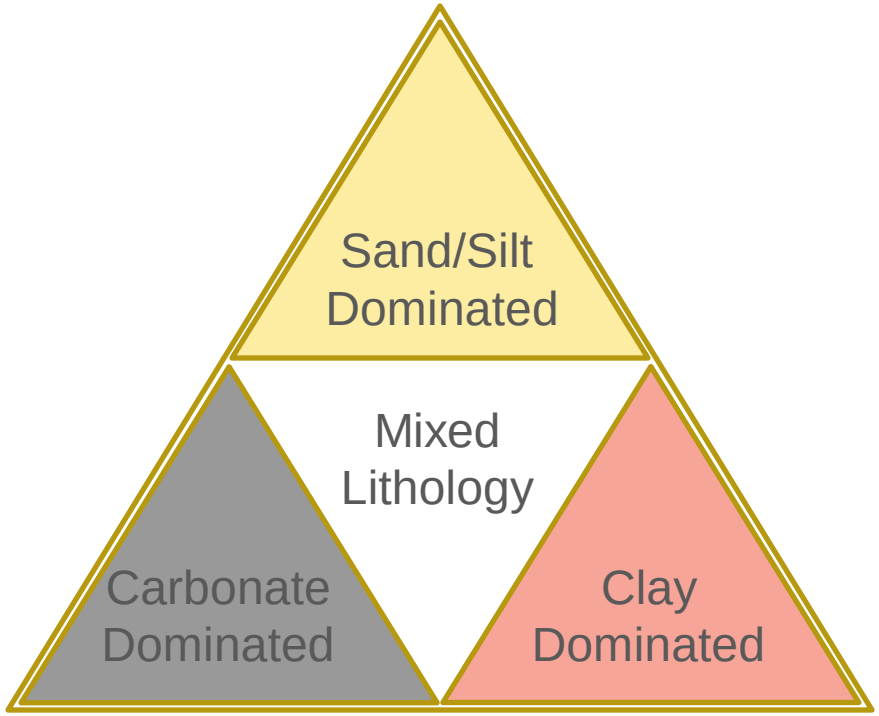
ANALOG CORE DATA: BULK DENSITY VS TOC



Weaker correlation between TOC and Bulk Density.

TIGHT ROCK CLASSIFICATION

2.65 g/cm3



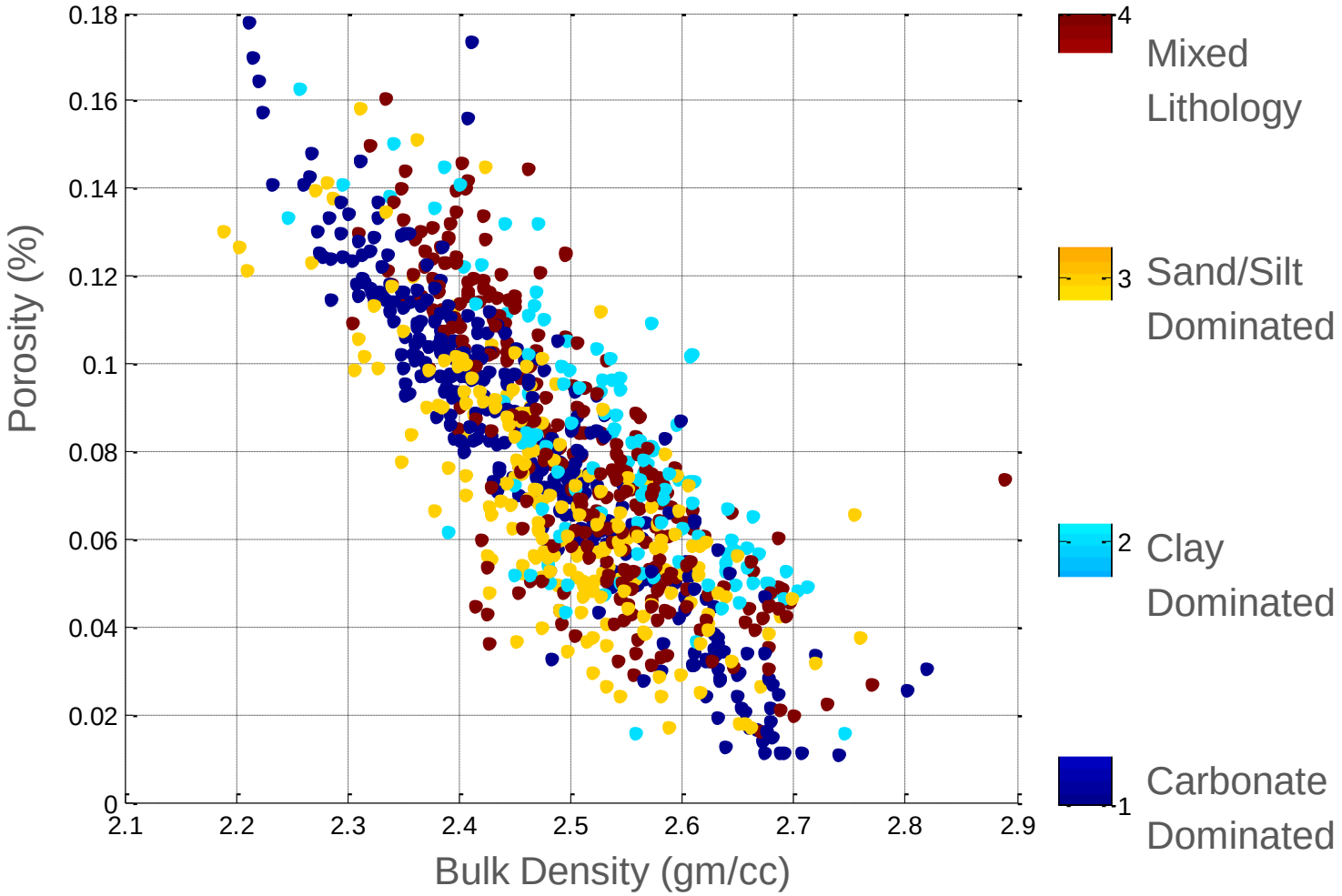
2.71 – 2.86 g/cm3

Eagle Ford (Cretaceous)
Utica (Ordovician)

2.6 g/cm3

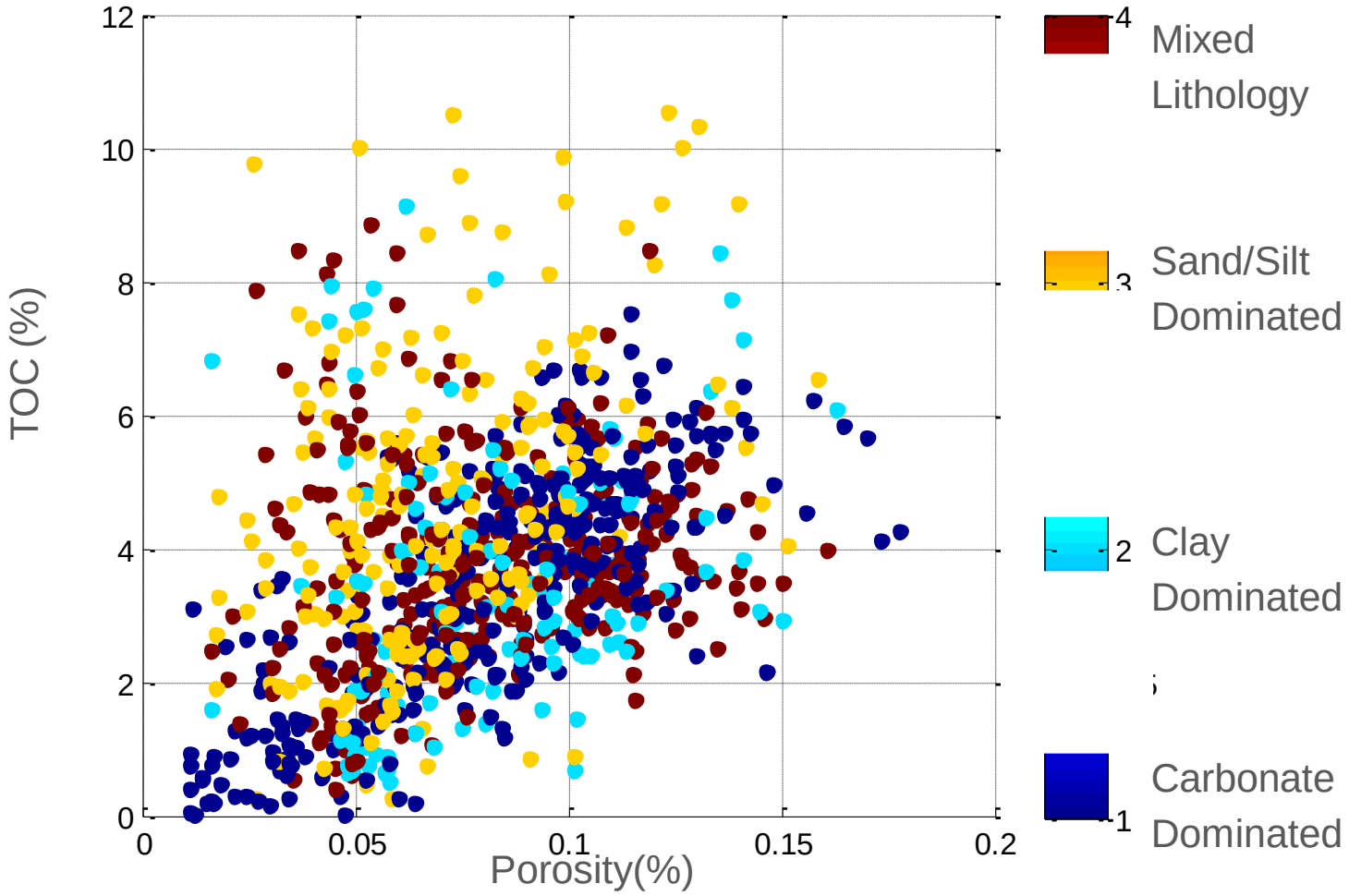
Barnett (Mississippian)
Marcellus (Devonian)

ANALOG CORE DATA: PHI VS BULK DENSITY



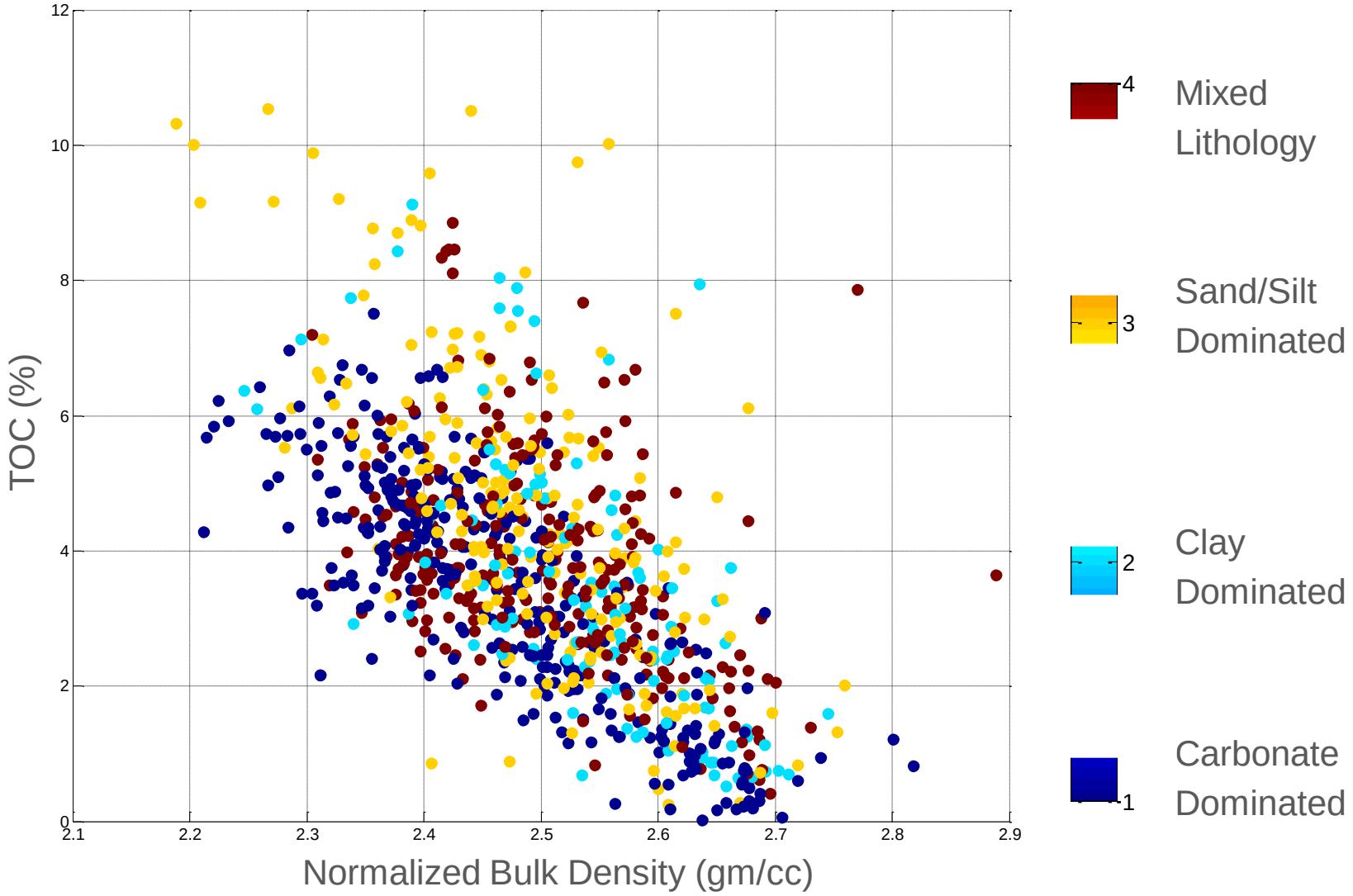
Carbonate dominated lithology trend shows best correlation.

ANALOG CORE DATA: TOC VS PHI

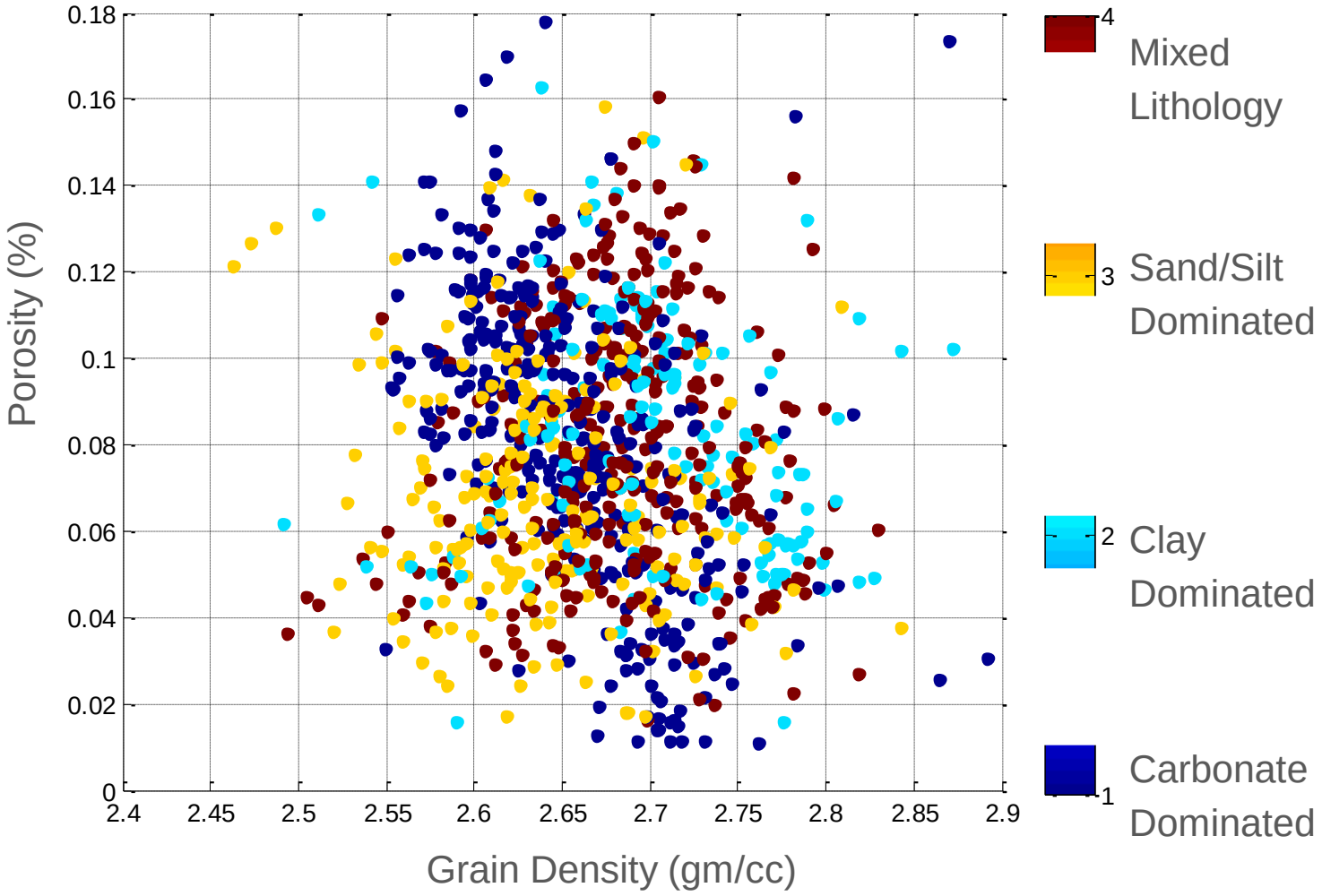


Carbonate dominated lithology shows low TOC at low Phi.

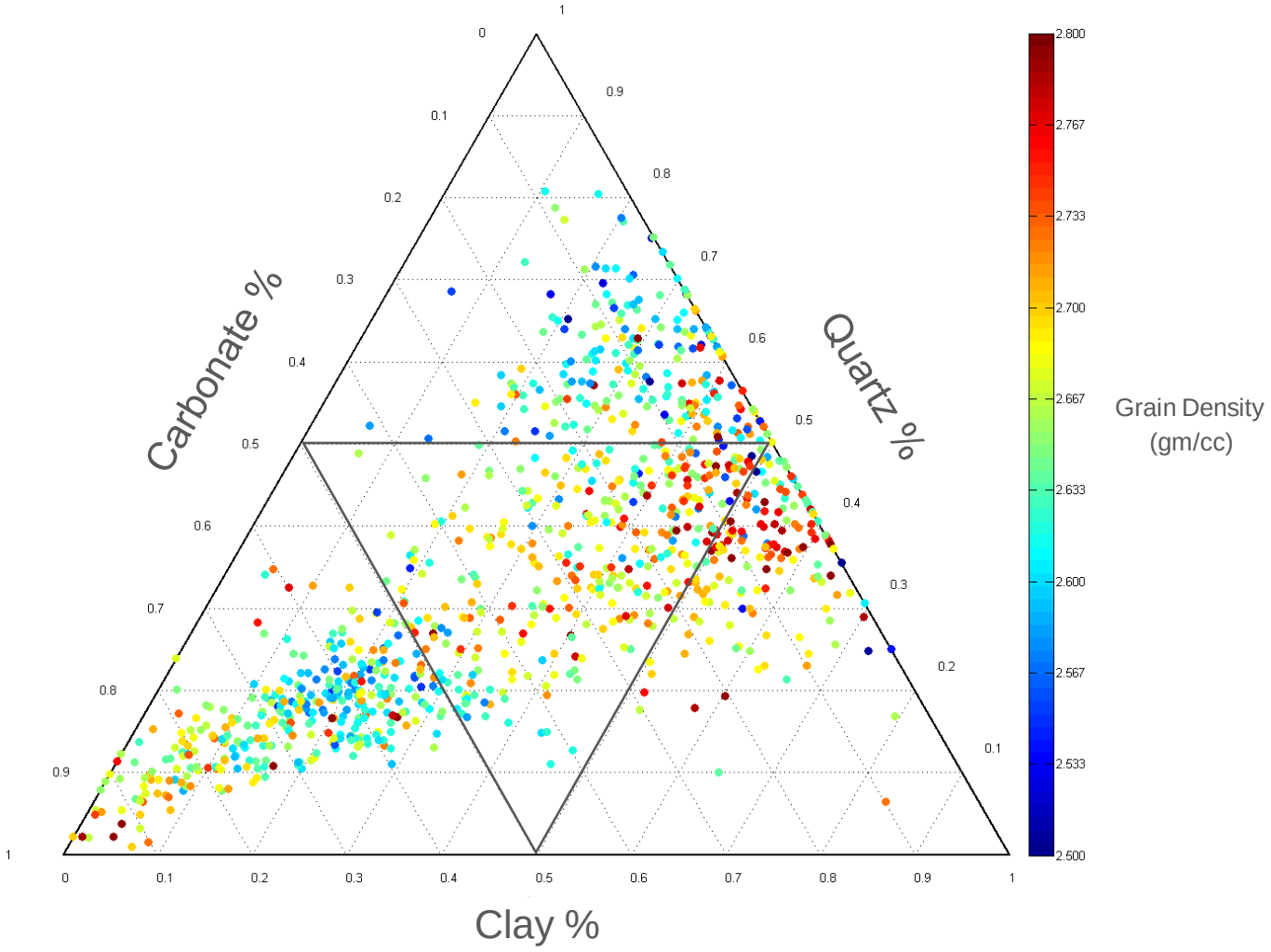
ANALOG CORE DATA: BULK DENSITY VS TOC



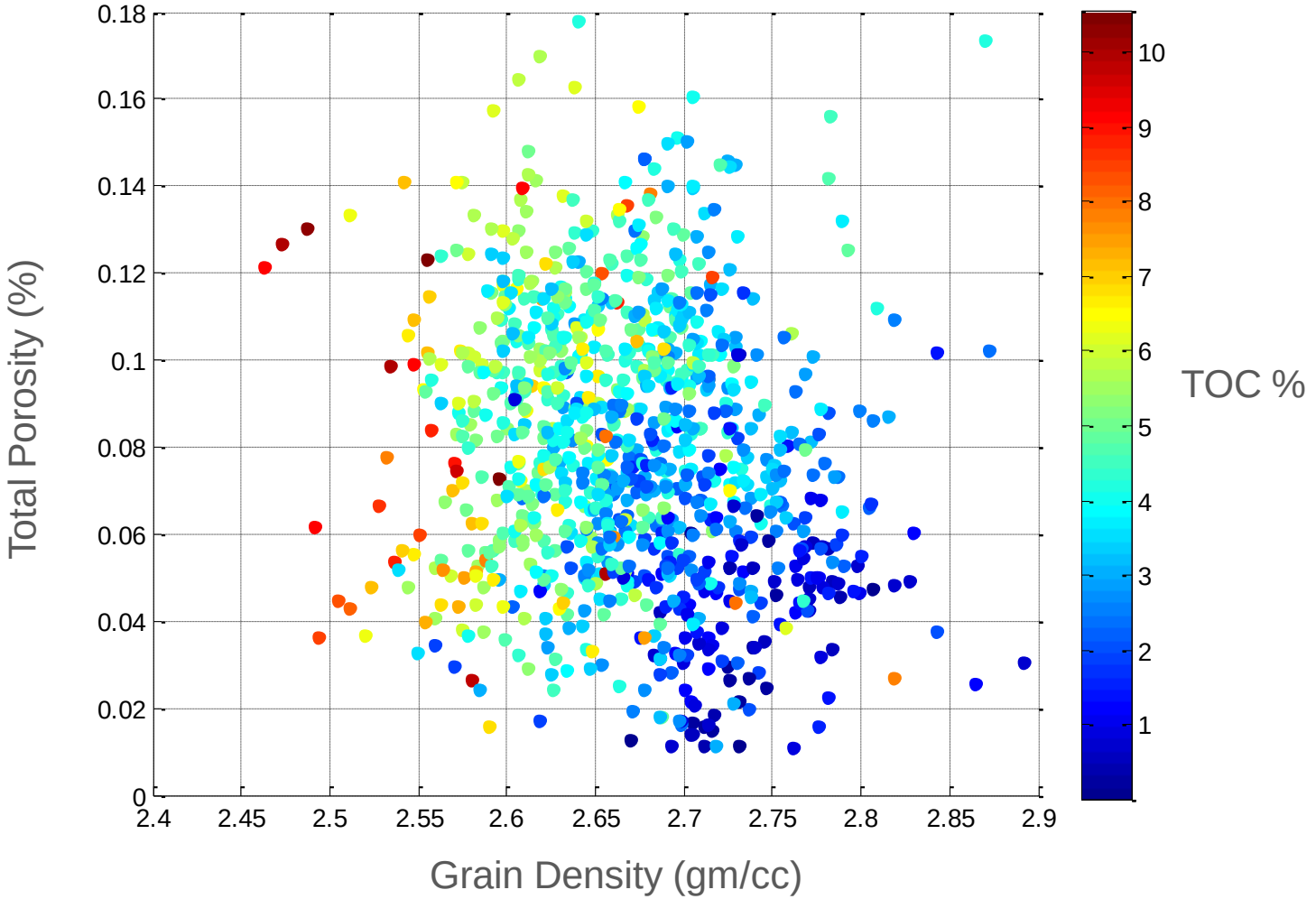
ANALOG CORE DATA: PHI VS GRAIN DENSITY



TERNARY DIAGRAM

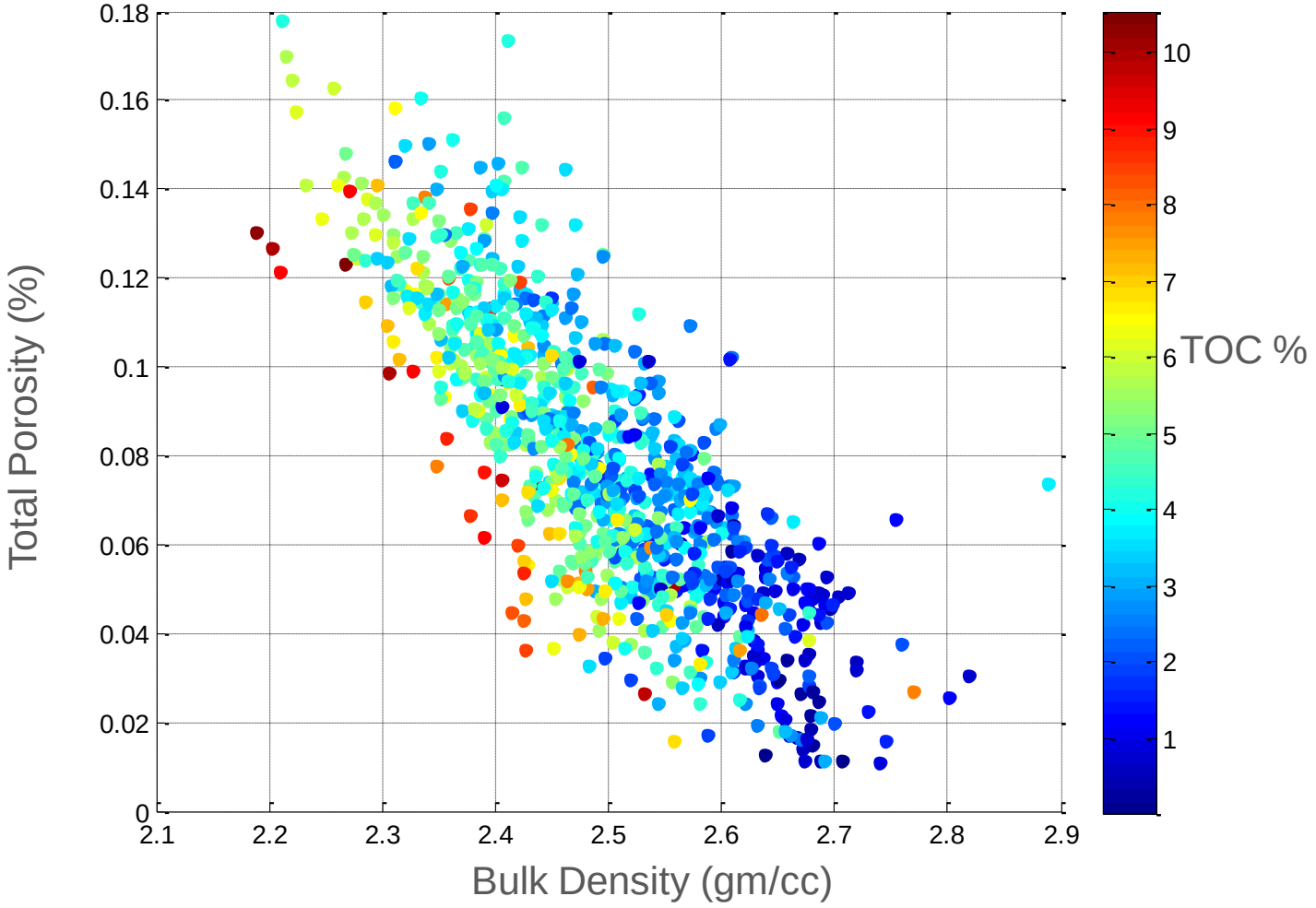


ANALOG CORE DATA: PHI VS GRAIN DENSITY



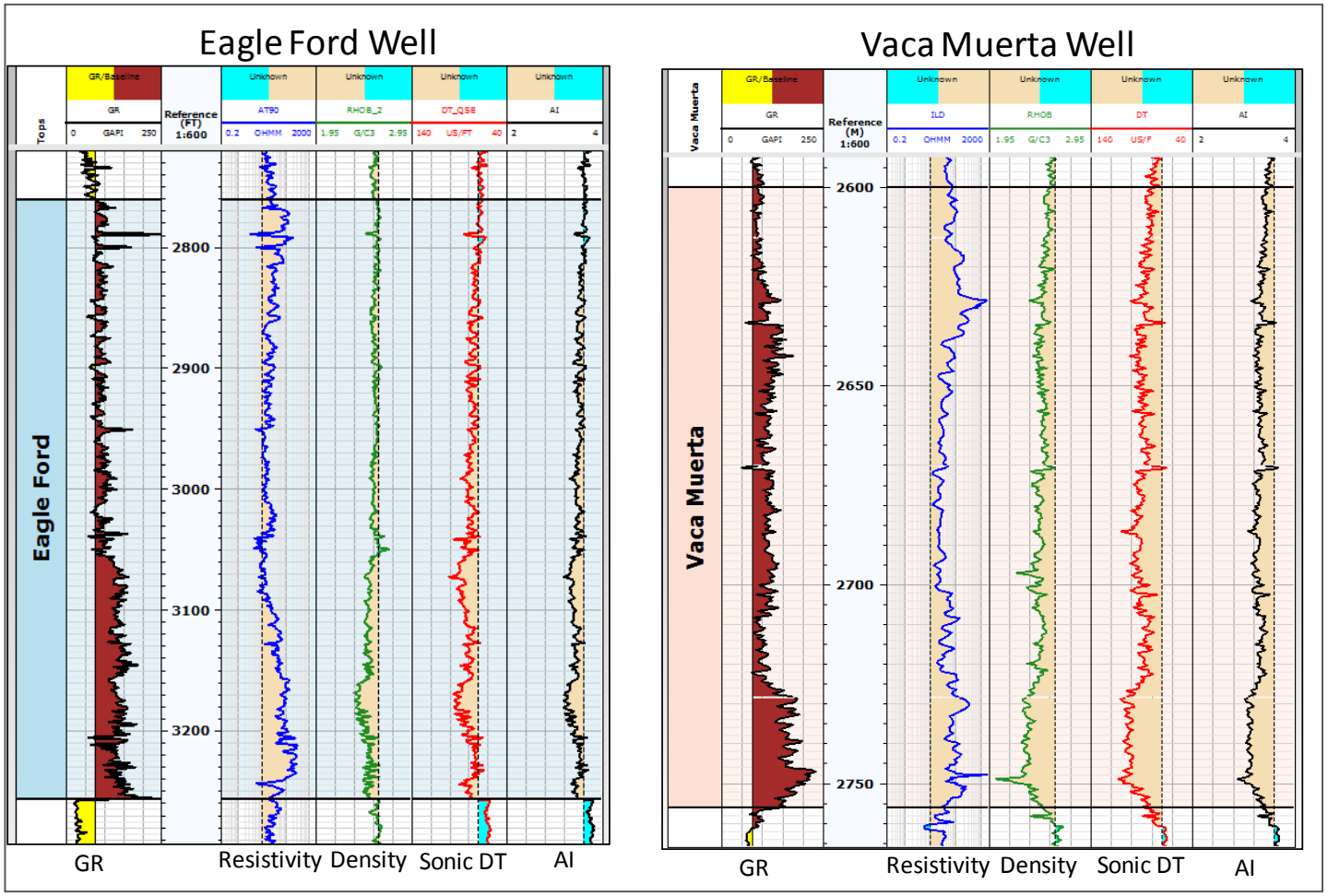
At a given Porosity, TOC content has a major effect in lowering Grain Density.

ANALOG CORE DATA: PHI VS BULK DENSITY



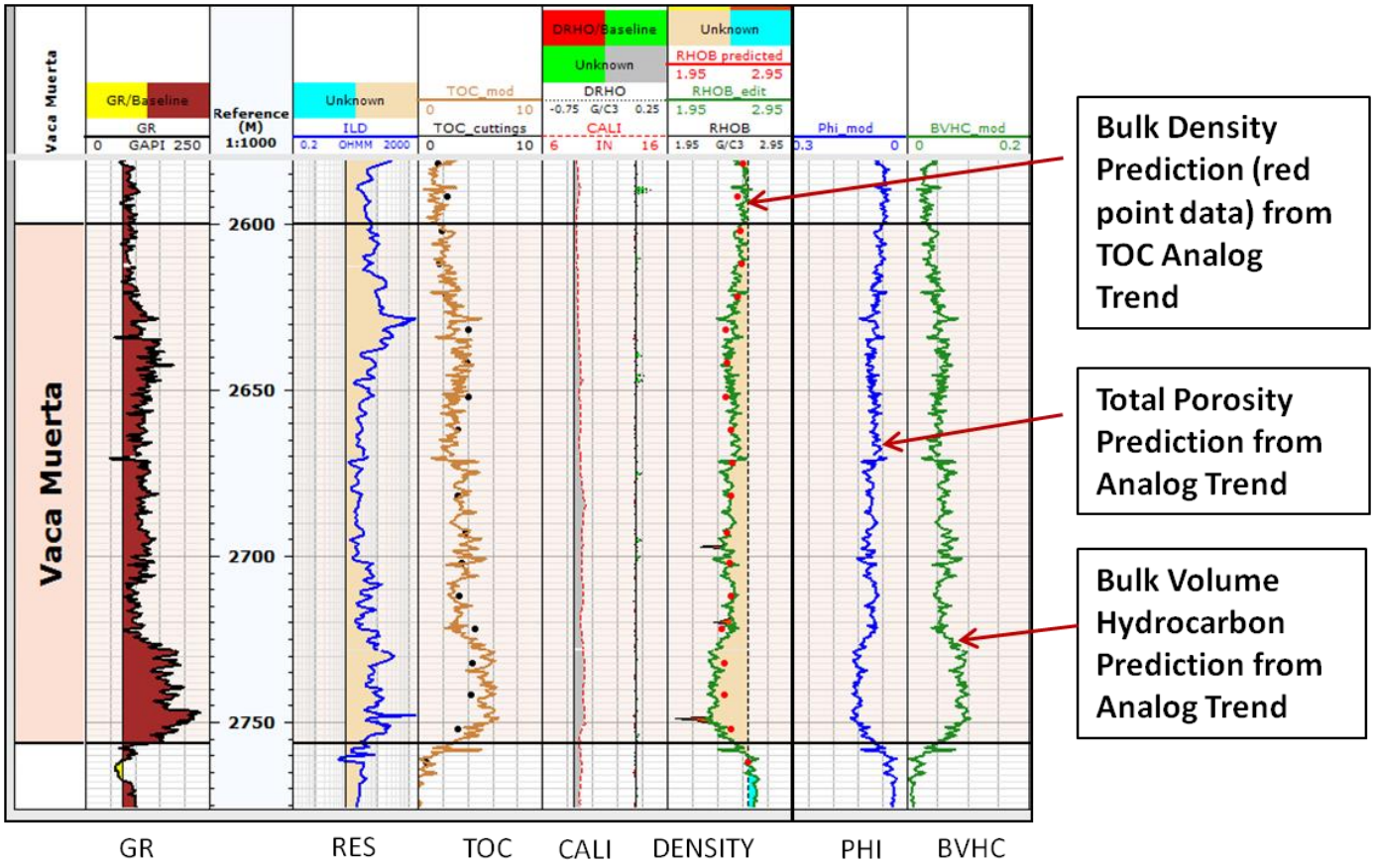
Potential to derive TOC content from Bulk Density – Porosity trend.

LOG MOTIF: EAGLE FORD AND VACA MUERTA WELLS



Eagle Ford log motif is similar to Vaca Muerta as are other attributes.

EVALUATION EXAMPLE USING ANALOG TRENDS



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.