Hybrid Data-Physics Analytics for Integrated Characterization of Unconventional Plays

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Summary

Due to their complex nature, unconventional plays usually require integrand characterization techniques that incorporate data and interpretations from different sources and disciplines. 'Hybrid Data-Physics Analytics' is designed based on coupling of machine learning algorithms with physical models to provide more reliable results for characterization of these plays, as demonstrated by a regional case study from Alberta, Canada.

Introduction

Accurate subsurface characterization is critically important for identifying sweet spots, optimization of completion/production practices and prediction and mitigation of induced risks. The increasing amount of hard data available nowadays along with the exceeding number of tools and techniques for analyzing and learning from these data provide great opportunities for implementing machine learning algorithms for characterization of subsurface reservoirs and operations. These algorithms, nevertheless, can become much more meaningful and efficient if supported or trained by validated physical models. This presentation will review some applications of 'Hybrid Data-Physics Analytics' for integrated characterization of an unconventional play in Alberta, Canada.

Methodology

Hybrid data-physics analytics for characterization of unconventional plays (Figure 1) is based on the coupling of semi-supervised or supervised machine learning algorithms with physical models. The data can potentially cover a wide range such as:

(i) Rock data (e.g., different logs, core data, lab experiments, well tests and geological, geochemical, geophysical interpretations, etc.),

(ii) Operational data (e.g., completion technology, fracturing fluid type, pressureand rate, proppant type and rate, perforation data, well trajectory, drilling parameters, etc.),

(iii) Economic Data (e.g., costs of drilling, completion and infrastructures, variations in oil and gas prices, etc.), and

(iv) Hazard and Risk Data (e.g., induced earthquakes, leakage incidents, ground movement records, soil/water pollution cases, etc.)

Some of the physical models that can be used in this technique are petrophysical, geomechanical, hydraulic fracturing, drilling and borehole stability, reservoir simulation and rock physics models. Depending on the applications, time and budget, these models may vary from simpler analytical models to more complex numerical ones.

Hybrid data-physics analytics can be used for either of descriptive modeling (e.g., finding sweet spots), prescriptive modeling (e.g., determining the best drilling/completion/fracturing practices), or predictive modeling (e.g., forecasting production decline curves or risk of induced seismicity).

Case Study

The case study presented here discusses the preliminary results of the application of hybrid data-physics analytics for integrated characterization of the Duvernay play in Alberta, Canada. It is important to note that this study is still a work in progress. At the moment the study includes full sets of operational and economic data for about 400 hydraulically fractured cased horizontal wells and it is supported by several datasets from geomechanical, petrophysical, and hydrogeological modeling and characterization. Feature engineering and data analysis have been used to identify potential correlations, significant parameters and most efficient algorithms. The preliminary results of the study provide information on the location of sweet spots, best completion practices and forecasting production.

Acknowledgements

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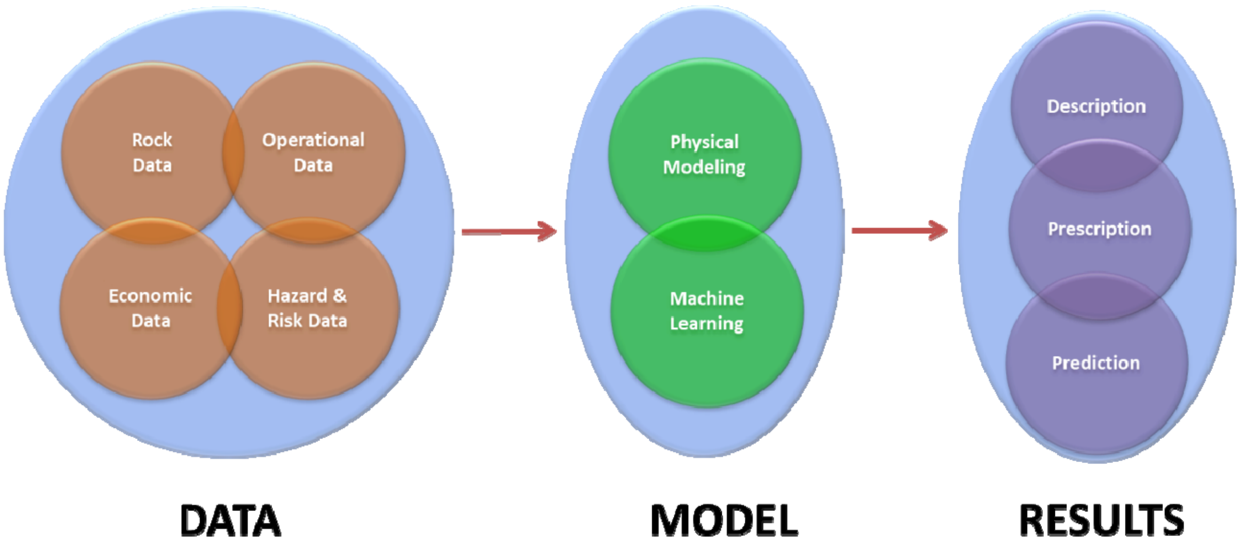

Figure 1. Schematic workflow for Hybrid Data-Physics Analytics

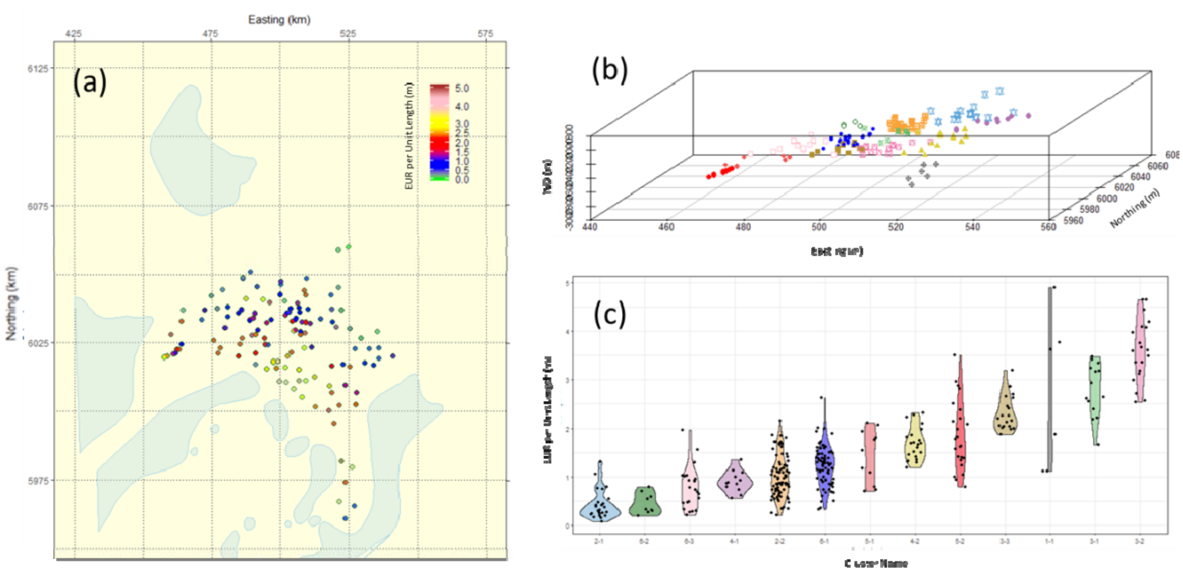

Figure 2. (a) Distribution of the wells and their normalized unit-length Estimated Ultimate Recovery (EUR) values, (b) Three-dimensional representation of semi-supervised clusters for the same wells, and (c) Statistical distribution of unit-length EUR values for different clusters.

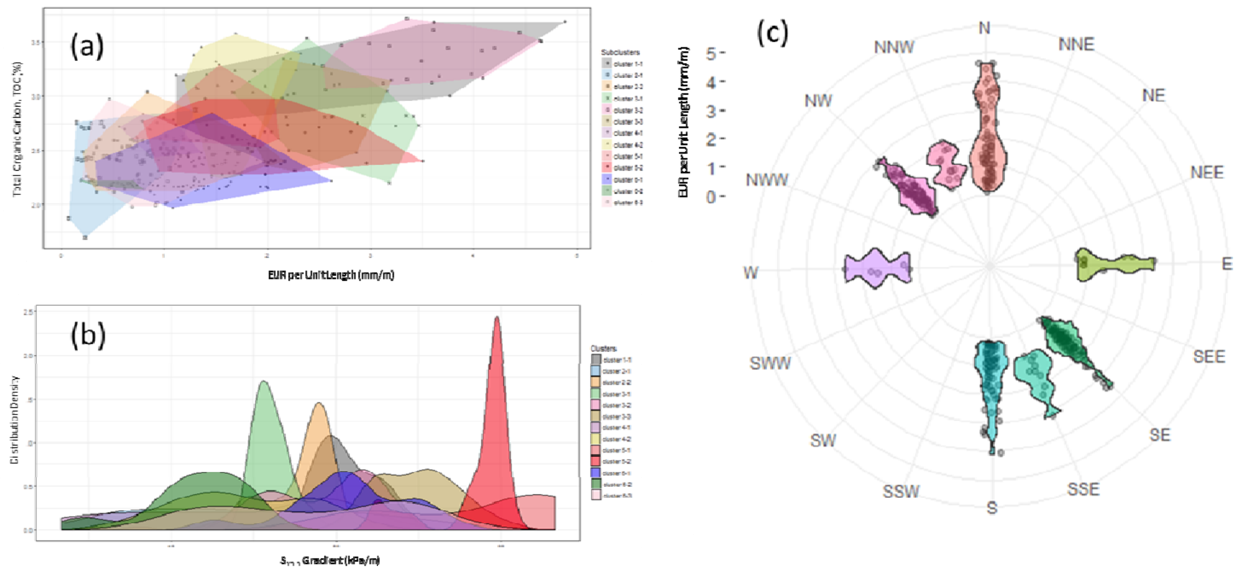

Figure 3. (a) EUR variation versus Total Organic Carbon (TOC) from petrophysical modeling for different well clusters, (b) Variation of minimum in-situ stress gradient from geomechanical characterization for different clusters, and (c) variation of EUR with the trajectory of horizontal well sections.