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Applying Big Data Analysis to Efficiently Exploit the Vast Unconventional Tight Oil Reserves

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Abstract : Successful production of hydrocarbon from unconventional tight oil reserves has changed the energy landscape in North America. The oil contained within these reservoirs typically will not flow to the wellbore at economic rates without assistance from advanced horizontal well and multi-stage hydraulic fracturing. Efficient and economic development of these reserves is a priority of society, government, and industry, especially under the current low oil prices. Meanwhile, society needs technological and process innovations to enhance oil recovery while concurrently reducing environmental impacts. Recently, big data analysis and artificial intelligence become very popular, developing data-driven insights for better designs and decisions in various engineering disciplines. However, the application of data mining in petroleum engineering is still in its infancy. The objective of this research aims to apply intelligent data analysis and data-driven models to exploit unconventional oil reserves both efficiently and economically. More specifically, a comprehensive database including the reservoir geological data, reservoir geophysical data, well completion data and production data for thousands of wells is firstly established to discover the valuable insights and knowledge related to tight oil reserves development. Several data analysis methods are introduced to analysis such a huge dataset. For example, K-means clustering is used to partition all observations into clusters; principle component analysis is applied to emphasize the variation and bring out strong patterns in the dataset, making the big data easy to explore and visualize; exploratory factor analysis (EFA) is used to identify the complex interrelationships between well completion data and well production data. Different data mining techniques, such as artificial neural network, fuzzy logic, and machine learning technique are then summarized, and appropriate ones are selected to analyze the database based on the prediction accuracy, model robustness, and reproducibility. Advanced knowledge and patterned are finally recognized and integrated into a modified self-adaptive differential evolution optimization workflow to enhance the oil recovery and maximize the net present value (NPV) of the unconventional oil resources. This research will advance the knowledge in the development of unconventional oil reserves and bridge the gap between the big data and performance optimizations in these formations. The newly developed data-driven optimization workflow is a powerful approach to guide field operation, which leads to better designs, higher oil recovery and economic return of future wells in the unconventional oil reserves.

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