The Use of Unconventional Spatial Statistics as a Predictive Tool in Conventional Petroleum Exploration: A Case Study from the Bighorn Basin, Wyoming

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ABSTRACT

Exploring mature basins for overlooked or new opportunities can be a cumbersome and time consuming process that may be an impossible task for small companies and independents with limited resources and budgets. The use of spatial statistics to analyze basin-scale datasets may provide a solution to this problem. Spatial statistics is widely used in populating advanced reservoir models, but has rarely been applied when analyzing historic data in mature basins. This study aims to test the use of a variety of spatial statistics, including spatial Fourier analysis, Lomb- Scargle periodograms, and fault proximity analysis, to quickly and objectively analyze basin-scale datasets. The Bighorn Basin, located in north-central Wyoming and south-central Montana, is used as a case study for this project. The Bighorn Basin is a proven mature basin with a long production history, making it an ideal test case for these analyses. Since its initial discovery in 1905, the cumulative production in the Bighorn Basin has reached more than 2.67 billion barrels of oil with estimated conventional reserves of 61 million barrels of oil. The basin's long history as an oil province has resulted in a considerable quantity of publicly available data for the basin that could be analyzed with these innovative spatial statistical approaches. The basin-wide spatial data analysis revealed, for example, that known large petroleum accumulations in the Bighorn Basin are not randomly distributed, but follow statistically significant patterns that are not easily discerned from maps or by using other common exploratory tools. The spatial data analysis also allowed for the distinction of interesting spatial relationships between fault geometry and a characteristic spacing of high production along major structural trends. These patterns, while non-unique, become apparent with the methods in this study and aid in understanding historical production data and geologic controls. They provide an additional set of information when predicting opportunities in areas with little to no production or when identifying undiscovered or underdeveloped fields. The approaches taken in this study are repeatable statistical methods that can be applied to a variety of datasets and basins.