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An Integrative Approach to Geochemical Production Allocation in the Northern Denver Basin Using Quantitative Chromatographic Fingerprinting

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Abstract

Geochemical fingerprinting techniques have increased in analytical ease and decreased in cost over the last decade as a tool for characterizing produced fluids. Specifically, the adoption of comprehensive methods with increased statistical rigor makes Whole Oil Gas Chromatography (WOGC) a highly cost competitive approach for allocating produced oil reservoirs. Using WOGC peak ratios to allocate produced oils is a well-established alternative to conventional production logging techniques. However, several challenges have limited the scope of its application in the past: an inability to compare raw data taken from laboratories using different analytical methods and software outputs, and the laborious manipulation of data required to compare results from different studies.

This study proposes a systematic, statistics-based mixing model using WOGC peak height ratios to solve production allocation problems. Within the model, an algorithm consolidates raw geochemical data, solves mixing equations with variable input parameters, and identifies possible endmember production streams. The model uses height ratios between neighboring peaks across the entire chromatogram, rather than only comparing a few manually selected peak pairs. Each ratio's importance in satisfying a set of linear mixing equations is weighted by statistical variance, allowing for an accurate, high- resolution characterization of mixed production oils. Error profiling provides a quantifiable means of justifying endmember selection and assessing soundness.

This method was applied to a set of 198 oils from wells producing in Hereford Ranch Field in Weld County, Colorado. The wells range from 5,800 to 7,800 ft in vertical depth and target 5 pay zones, with primary zones being the Niobrara Shales and the Codell Sandstone. HCA and PCA multivariate statistical analyses on 117 common WOGC peak ratios exhibited significant resource and production data differences across the dataset. The proposed method defined endmembers representing the two major pay zones and geochemically characterized zone contributions in production samples throughout time. The analysis of synthetic oil mixtures that range from a pure combination of assumed endmembers to a combination of unrelated oils provided quality assurance and quality control to these characterizations.

The proposed method aims to utilize a maximal amount of information from WOGC analysis without compromising efficacy or being a "black box". The algorithm provides the functionality necessary for the long-term integration and comparison of fingerprinting results across different studies and different laboratories. The case study demonstrates how correlating production data with mixing model results may characterize source contribution and draw-down of production wells over time. The results provide insight into how the proposed fingerprinting technique may inform allocation and spacing decisions as well as increase development efficiency for operators

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