Optimizing Well Pair Placement Using Biomarker Geochemistry: An Integrated Approach with 3D Geomodeling

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Summary

The McMurray Formation within the Western Canadian Sedimentary Basin (WCSB) is dominated by stacked fluvial and fluvial dominated, tidally influenced point bar deposits (Crerar, 2007; Hubbard et al., 2011; Labrecque et al., 2011). The point bar deposits consist of multiple facies including: trough cross-bedded channel sands, sandy and muddy Inclined Heterolithic Stratification (IHS), breccia deposits (derived dominantly from bank collapse and IHS erosion) and mudplug or abandoned channel facies. The heterolithic nature of these point bar deposits, along with the multiple water sources (lean zones, top water, bottom water and flank water) has generated variable degrees of biodegradation and resulting in significant viscosity changes within the bitumen column of the McMurray Formation. Due to these viscosity changes, biomarker geochemistry is a valuable reservoir characterization tool.

After integrating interpreted 3D seismic, geophysical well logs, core logging and image data from delineation wells into a detailed geomodel, there remains uncertainty on the lateral heterogeneity and vertical permeability of the facies. Biomarker geochemistry can be used to reduce that uncertainty. This case study reveals how understanding geochemical baffles, obstacles and barriers can influence the elevation of well pairs to optimize recoverable resource.

Introduction

During Steam Assisted Gravity Drainage (SAGD), many of the facies within the McMurray Formation can act as impairments or barriers to steam chamber growth. Oil geochemistry can be used as a reservoir characterization and surveillance tool to determine whether these facies will act as a barrier or baffle to steam (Fustic et al., 2011; Sereda and James, 2014; Makoon-Singh et al., 2016). Oil geochemistry, specifically Gas Chromatography – Mass Spectrometry (GCMS) analysis, can be used for many applications within the Athabasca Oil Sands including: valley and stacked point bar mapping, planning the lateral placement of well pairs, reserves mapping and fingerprinting produced oil. This study focuses on using biomarker geochemistry to optimize the lateral elevation of proposed well pairs.

Theory and/or Method

Samples can be collected through core, cuttings and/or produced oil. Samples used in this study are from core. Approximately 10mL of bitumen was extracted using Solid Phase Extraction (SPE) for each sample. The standard biomarker composition was determined through GC-MS. Either the biomarker concentration data or the chromatogram fingerprints can be used for analysis. This study examines soley the concentration data.

The biodegradation of bitumen results in a reduction of geochemical biomarker concentrations based on its proximity to a water source (dominantly bottom water) (Larter et al., 2003, 2008; Fustic et al., 2011, 2013). Discontinuities of the biomarker concentrations can indicate whether there is a baffle, obstacle or barrier present. A baffle can be defined as a discontinuity which slows the diffusion process, as is portrayed in Figure 1, Well 1 between the top 2nd and 3rd sample point. An obstacle can be defined as a small inflection within the biomarker concentration data, signifying that there may not be a direct vertical diffusion pathway but a short lateral diversion (Figure 1, Alkylnaphthalene concentrations in Well 3). A barrier is defined as a significant inflection in biomarker concentration data, signifying a stop in the diffusion process and biodegradation continues independently above and below (Sereda and James, 2014) (Figure 1, Well 2).

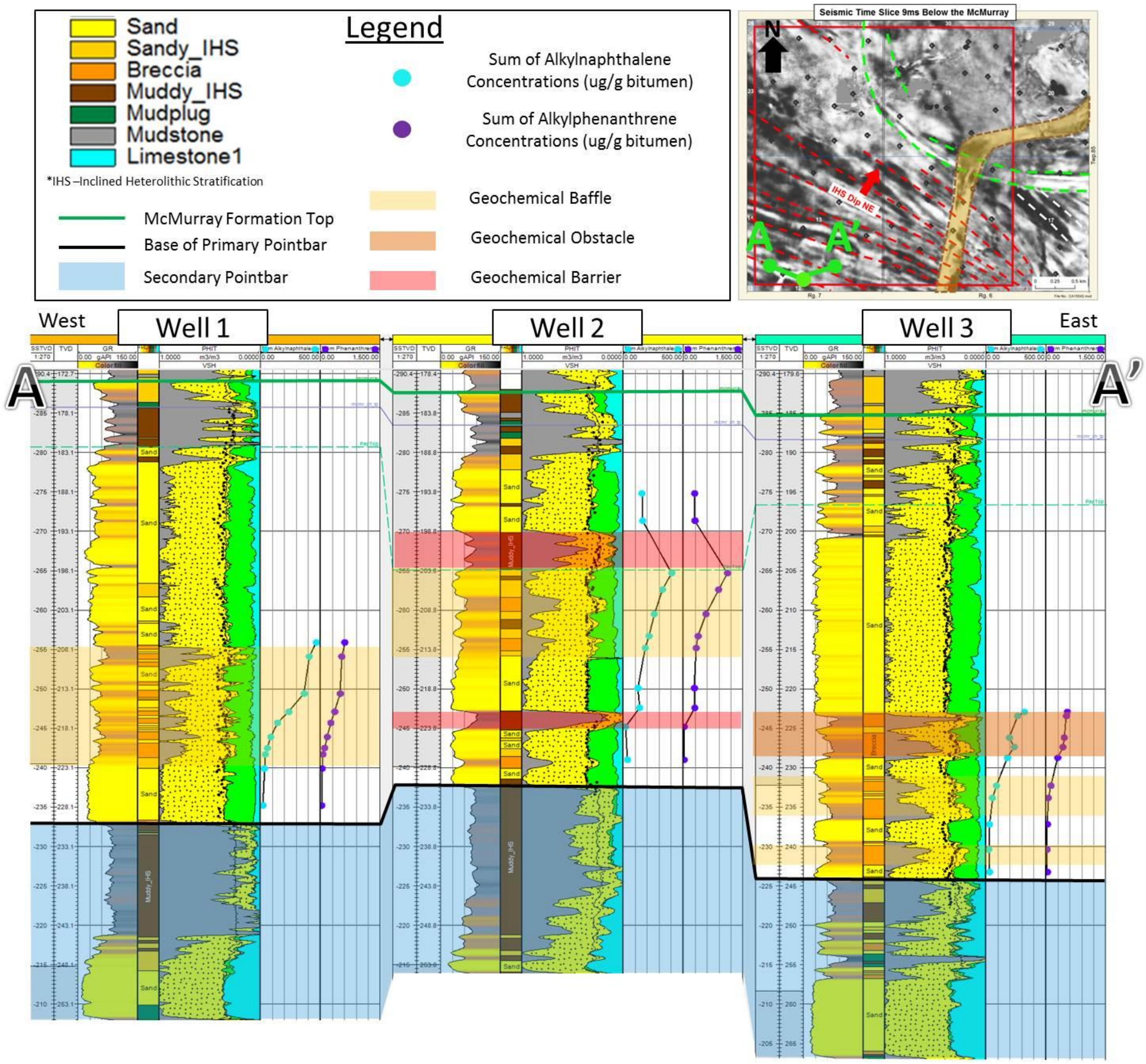

Figure 1: A structural cross-section from west to east (A to A'). Well 1 to Well 2 is parallel to the point bars strike direction and Well 2 to Well 3 is parallel to the poinbars dip direction.

Geochemical samples were strategically targeted to maximize the understanding of the influence of high-shale content facies on the diffusion process. Samples were extractly directly below and above facies of high volume of shale (and within, if bitumen present). Sample density was decreased in sections of low volume of shale or relatively homogenous channel sands.

Examples

Based on the identification of baffles, obstacles and barriers (Figure 1), the proposed well pair elevations in the direct vicinity, needed to be revisited. The interpreted biomarker geochemistry for each of the three wells influenced its respective adjacent well pair placement differently. For Well 1, the thick breccia package was interpreted to be a baffle and therefore, to capture significant additional resource the well pairs could be placed in the clean channel sands at the base of the point bar deposit (see Figure 2, Well 1). For Well 2, the muddy IHS near the base of the point bar deposit is interpreted to be a barrier and therefore, the proposed well pair was moved up to maximize resource exploitation (See Figure 2, Well 2). The barrier interpretation concurs with the 3D geomodel (note, the interpretation agrees with all geomodel realizations, including the one shown), where the muddy IHS appears to be extensive in both the strike and dip direction. For Well 3, the lower breccia packages were interpreted as baffles and the upper breccia package was interpreted as an obstacle. As a result, it was decided to leave the proposed well pair elevations, instead of lowering the well pair into the breccia and taking on risk of poor steam chamber development.

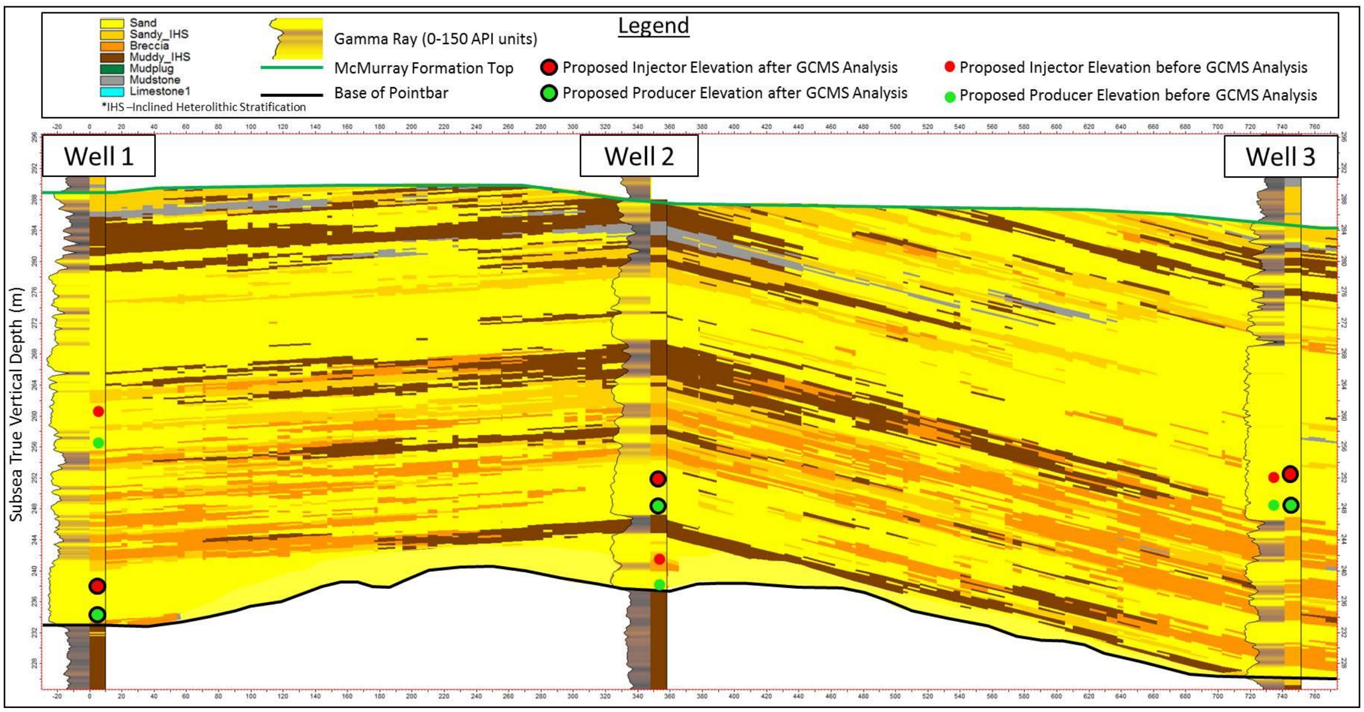

Figure 2: A structural cross-section from west to east with the modelled facies from the geomodel. The geomodel has integrated interpreted 3D seismic, geophysical well logs, core logging and image logs from delineation wells. Well 1 to Well 2 is parallel to the strike direction of the IHS and Well 2 to Well 3 is parallel to the dip direction of the IHS.

Conclusions

This case study illustrates how biomarker geochemistry can influence the placement of future well pairs within the reservoir. Biomarker concentrations can identify baffles, obstacles and barriers based on the degree of discontinuity or inflection between the values of two or more bitumen samples. By doing so, geochemical interpretation can assist with a better understanding of how the steam chamber will grow through the reservoir in time. In this study, through the integration of biomarker geochemistry as an integral reservoir characterization tool, the decision was made to move two out of three proposed well pair elevations. This will directly affect the amount of cumulative bitumen produced and the overall recovery factor of these well pairs.

Acknowledgements

The author would like to thank Nexen Energy ULC, a wholly-owned subsiduary of CNOOC Limited for granting permission to share the material; Schlumberger Reservoir Laboratories (Former Gushor Inc.) for lab work and much appreciation to Dr. David Robertson and Dr. Barry Bennett for sharing their knowledge and expertise.

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