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Applications and use of Time Lapse Geochemistry in Unconventional Resource Appraisal and Development

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Summary

Key concepts from geochemistry are applied to unconventional resource appraisal and development, specifically for optimized well landing zones and spacing & stacking configurations. Variability in the reservoir stack of hybrid-unconventional resource play types and tight reservoirs will be discussed, and its application to optimized field development.

Theory / Method / Workflow

The use of time-lapse geochemistry (TLG) has been used in conventional reservoirs for several years, but much less in unconventional tight sand or shale reservoirs. The use of TLG has multiple applications for unconventional reservoirs, such as monitoring for the source of H_2S (DuBois et al, 2014) or the production allocation of drainage from multiple layers (Baskin et al., 2013, Jweda et al., 2017, Liu et al., 2017). Here we focus on using TLG to understand vertical drainage and identify from which zones production is occurring over time. The production allocation by zone over time is critical for optimization of the completions and optimizing the spacing and stacking for field development. Dimensions of the drained rock volume (DRV) versus the stimulated rock volume (SRV) can be established using the TLG method.

There are distinct advantages of employing the time-lapse reservoir geochemistry technology compared to previous methodologies, including injected tracers, micro-seismic event distribution, pressure monitoring and mechanical flow monitoring. First, time-lapse reservoir geochemistry is inexpensive relative to the other methods. Geochemical monitoring of a single well (depending on the duration and type of analytical program) is approximately $30-80K US/well per year, whereas other methods cost upwards of $80-500K US/well per year. Second, this type of monitoring is also advantageous in that produced fluid sampling does not burden or delay rig schedules and can be flexible with production maintenance. Thus, it is not inconvenient to deploy the method. Third, geochemical compositions are fingerprints of the actual produced hydrocarbons. The time-lapse reservoir geochemistry method is therefore not a remote sensing-based technology, but a direct measurement technology. It can thus be used quantitatively in determining vertical and horizontal effective drainage lengths and how they can vary over time.

Aims and Objectives

This paper will illustrate the use of production allocation to quantify zonal contribution of hydrocarbons in a hybrid system and potential modifications to future well landing targets, in order to effectively drain the resource. Reservoir interval contribution is not only a function of resource density, but also of hydrocarbon mobility (permeability/viscosity). This fact is more pronounced in unconventional/tight reservoirs where the viscosity and permeability contrast may be substantial between shale and reservoir intervals (e.g. Liu et al., 2017). Simple use of resource density derived from core and petrophysics may not be enough for well placement if certain intervals have substantially reduced mobility. Landing zone optimization requires combining both resource density and mobility considerations.

Materials and Methods

Illustrations from the Bakken and Montney formations will be discussed; both formations are examples of hybrid unconventional plays. Production allocation techniques will be displayed using end members from core extracts and produced fluids.

The ConocoPhillips Time-Lapse Geochemistry (TLG) program involves the simultaneous collection of produced oil, gas, and water samples from individual well separators over varying collection frequencies. Typical 12-month sample programs on project wells consist of high frequency sampling during early production, to capture changes in the early life cycle of the wells (e.g., first few months) and reduced sampling frequency in later months. Several wells are selected for long-term surveillance at reduced sampling rates beyond the first year of production. Field collection procedures and laboratory workflows have been established to maintain quality and consistency of data. The TLG program is cost-effective, non-invasive, and is considerably flexible to operational constraints.

Results, Observations, Conclusions

Geochemistry and production allocation can show the vertical drainage of different zones and help optimize the spacing/stacking of pads to maximize recovery and value. Geochemical assessment allows the understanding of vertical variability and constraints on production well deliverability by zone.

Geochemistry can be used in a cost effective and timely manner to influence development plans of unconventional reservoirs. Specifically, geochemistry of produced fluids can be used to estimate the drained rock volume per well, leading to optimization of completion design and well spacing (vertical and lateral) for unconventional reservoirs. Time-lapse geochemistry data can be used to determine production allocation from different intervals within the target formation, and the data can infer information on the flow regime (e.g., 1 or 2 phases, linear vs. boundary dominated flow). Data allow monitoring of non-hydrocarbon gases (CO_2 & H_2S) and provide information that can be used to predict inert gases.

Future developments of the applications of geochemistry, and of ConocoPhillips' TLG program, involve the expansion of water chemistry use (Jweda et al., 2019) and the modification of fracture fluids to either enhance or avoid damaging fluid-fluid or fluid-rock interactions. In addition, the generation and integration of large TLG and production datasets has opened up the potential of machine learning to predict production metrics (e.g. 90day yield/GOR, water cut) based on early fluid sample acquisition.

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