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USING TIME-LAPSE GEOCHEMISTRY FOR RESERVOIR PRODUCTION SURVEILLANCE: CONCEPT AND LEARNINGS FROM THE GULF OF MEXICO

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Reservoir surveillance is a key activity during production of oil and gas from reservoirs. The main objective of reservoir surveillance is to understand petroleum fluid behavior (e.g., phase changes) and movements within a reservoir during production. Surveillance data and interpretations are applied mainly to validate and update pre-production reservoir models, understand compartmentalization, predict and optimize reservoir performance, manage well placement and interventions, and locate un-swept portions of reservoirs. Petroleum industry deploys a variety of technologies for reservoir surveillance. The most commonly used technologies include interpretations of individual well production histories, pressure and transient analysis, temperature logging, production logging, interference testing, tracer analysis, and, in more recent years, 4D (time-lapse) seismic.

Time-lapse geochemistry (TLG) is a novel technology that helps to visualize fluid flow during oil and gas production by monitoring changes in fluid compositions across a reservoir. The general idea has been known in petroleum industry for many years, but few published case studies exist. McKinney and Bland (2003) outlined a general TLG approach and an application at the Ursa field (Gulf of Mexico) in a poster. In the TLG technology, pre-production and "first oil" fluid samples are analyzed to define and map fluid types across a static reservoir. The differences in fluid compositions or/and fingerprints are explained by involving fluid flow barriers and baffles, charge model, insufficient mixing time, and/or post-accumulation processes (e.g., biodegradation). Then, a surveillance program in which fluids are sampled from producing wells at regular time intervals is designed and executed. Geochemical compositions or/and fingerprints of obtained production samples are analyzed and compared with pre-production fluids from the same wells and surrounding wells.

Interpretation of TLG data helps to visualize dynamic fluid flow pathways, determine reservoir areas that do or do not contribute to the production, and recognize broken or continuously sealing fluid flow barriers and baffles. Information derived from TLG allows a subsurface team to sustain production by placing new wells into un-swept portions of the field, avoid drilling new wells in areas which already have been swept, optimize producer/injector pairing etc. The TLG results should be integrated with results from engineering models, 4D (time-lapse) seismic, tracers and other approaches in reservoir surveillance to reduce the uncertainties associated with each individual method.

Application of TLG for surveillance of several reservoirs in the Gulf of Mexico showed that this technology has many advantages relative to other conventional reservoir surveillance approaches. TLG is safe because it does not involve much operations and man power. TLG does not interfere with production and geochemical analyses are inexpensive, which makes this technology highly cost-effective. In contrast to proxy-based approaches such as 4D (time-lapse) seismic surveillance, TLG is a direct approach of monitoring fluids movement across the reservoir by investigating compositional changes in these fluids. TLG may be globally applicable because fluids commonly vary in composition across oil and gas reservoirs as a result of complex charge history, post-accumulation processes and compartmentalization. Finally, TLG can be performed for reservoirs with various and most complicated well/completion designs because fluids can be collected from well-heads and separators at the surface.

The main limitation of TLG is that fluids in the reservoir under surveillance must be measurably different. Pre-production feasibility studies utilizing fluids from down-hole tools (e.g., MDT) and production tests (e.g., Drill-Stem Tests, flow tests) aim to establish fluid variability within reservoirs and identify geochemical compounds (natural tracers) that can be used for surveillance. Modern high-resolution gas chromatography can help to distinguish even minor changes in oil compositions based on fingerprinting of inter-paraffin peaks. However, it is possible that in some reservoirs (e.g., small well-mixed oil fields, pure microbial gas fields) fluid differences would be smaller than the reproducibility of geochemical analyses, and TLG would not be applicable to such reservoirs. Geochemical surveillance also may be more complicated or not feasible when production samples are obtained from commingling wells. Finally, application of TLG allows to “see” fluids that already arrived to the point of measurements (i.e., producing well), but not the ones that are moving towards it. Thorough integration of various surveillance approaches reduces uncertainties associated with each individual technology and provides the most reliable picture of fluid movements across a reservoir during production.

REFERENCES

McKinney, D., Bland, K., 2003. Time lapse geochemistry at the Ursa field: a surveillance tool for understanding complex, heterogeneous reservoir fluids: 21st International Meeting on Organic Geochemistry, Krakow, Poland, p. I/96.