Oil Production Surveillance in Heavy Oil Accumulations

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We have made significant improvements to the previously published methods for geochemical allocation of commingled oil production and/or commingled gas production. This new method has allowed allocation of commingled production from wells at less than 2-5% of the cost of production logging. Several case studies showing applications to heavy/viscous oil accumulations are shown which illustrate how geochemical allocation can be used to:

- Quantify Zone Contributions for Royalty Calculations or Regulatory Requirements.
- Monitor Effects of MBE’s.
- Test if IsoSleeves are Set.
- Control Water Production.
- Monitor Effects of Water or Steam Injectors.
- Optimize Production From Multilaterals.
  - Identify Sanded Out Intervals for FCO
  - Identify Competition Between Laterals
- Monitor Effect of Initiation of Gas Lift.

There are many advantages to using oil geochemistry instead of production logging to allocate commingled production, including:

- **Cost advantages relative to conventional e-line PLT**: Geochemical techniques for allocating commingled production from multiple zones in a single well typically result in a >95% cost savings relative to conventional e-line production logging. The greater cost of the production logging approach is due not only to the costs of running the log, but also to the associated rig costs and the costs of lost production during logging. These costs are not applicable to the geochemical approach.

- **Advantages relative to coiled tubing or tractor-conveyed e-line PLT**: Cost savings from the geochemical approach are even more dramatic when compared to the costs of coiled-tubing-conveyed or tractor-conveyed PLT’s. Furthermore, the success rate of obtaining meaningful PLT data with a tractor conveyed e-line PLT is substantially less than 100%, a problem that does not affect geochemical allocation.

- **Detection of zone performance problems at any point during the life of a well**: The low cost of the geochemical techniques for production allocation allows field engineers to monitor production frequently over long periods (e.g., weekly, monthly, quarterly). This ability to monitor continuously the relative performance of discrete pay zones allows early identification of zone performance problems. The much higher cost of production logging limits that technique to infrequent use; therefore, production logs typically provide only a "snap shot" of the production origin at the time the log was run, and not a continuous performance history.

- **Applicability to vertical, deviated and horizontal wells**: Geochemical techniques are applicable to highly deviated and horizontal wells in addition to vertical wells. In contrast, production logging interpretation is problematic in highly deviated wells. In some multi-
lateral wells, where laterals off of laterals exist, there are often issues with lateral re-entry and thus production logging may not be capable of determining contribution from all zones.

- **Applicability to pumping wells:** Geochemical techniques can be applied to all types of pumping wells (including those with tubing-deployed electrical submersible pumps, and progressive cavity pumps). In contrast, most pumping wells (except those with unusual completion styles, such as Y-block completions) cannot accommodate a production logging tool because the pumping apparatus prevents access of the logging tool to the underlying perforated interval.

- **Ability to quantify uncertainty:** Geochemical techniques provide multiple, independent solutions to the allocation problem, allowing one to quantify accurately the uncertainty of an allocation result. In contrast, the uncertainty associated with logging results is more difficult to quantify.

- **Zonal Production vs. wellbore entry:** Production allocation between zones is often used to assess oil remaining in the various layers for future development targets; therefore, it is critical to understand the source of the oil, and not just the section it entered the wellbore. Channels, near wellbore faults, and failed bores from initial drilling can create pathways by which oil from one zone can enter the wellbore at a depth associated with a different zone. Misallocation of oil can result in these situations if only wellbore entry is considered. Geochemical techniques are able to distinguish production from the various zones regardless of entry points.

- **No risk of sticking a logging tool:** Because the geochemical approach relies only on produced oil samples, obtained at surface, there is no risk of sticking a tool in the well.