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An Integrated Approach to Geochemical Reservoir Connectivity Evaluation

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Understanding connectivity of reservoir fluids at an early stage in field evaluation and during production is critical for cost-effective development and production planning, especially with exploration moving into deeper waters and higher cost environments. Geochemical analyses of pre-production fluids are routinely used in static reservoir connectivity reflecting geologic time-scale fluid flow (e.g. Kaufman et al. 1990; Mankiewicz et al. 2009). More recently, geochemical analysis of time-series samples are being applied to the evaluation of dynamic connectivity related to fluid flow during production (e.g., time-series geochemistry; Milkov et al. 2007). A common uncertainty in many of these studies is the significance of geochemical differences, and the applicability of pre-production analyses to early evaluation of dynamic connectivity. This talk presents a methodology to consistently evaluate these differences, and to integrate both pre-production and time-series samples in the context of production-scale connectivity.

Geochemical evaluations of reservoir connectivity are based on the principle that fluids from separate production compartments show distinctly different fluid compositions, as a result of different source, maturity and/or alteration. This simplistic approach ignores cases where compositional differences are related to disequilibrium or to compositional gradients within a single compartment. A state of disequilibrium, which occurs when the rate of fluid compositional change (e.g. through recent charge or biodegradation) is greater than the rate of mixing, results in geochemical differences within a compartment. More homogenous compositions are generally observed in reservoirs where mixing rate is greater than the rate of change, but equilibrium gradients may still exist (e.g., density gradients). Because of this, evaluation of potential intra-compartment gradients is critical in the evaluation of connectivity-significant differences.

In order to fully utilize geochemical analyses and develop realistic connectivity scenarios, we present a workflow that integrates consistent evaluation of geochemical differences in multiple molecular weight ranges with models of mixing, charge, and alteration and monitoring of compositional changes through time-lapse geochemistry (Figure 1). This workflow contributes to early evaluation of production time-scale connectivity, even in the absence time-series samples, based on geochemical differences and mixing phenomena in key molecular weight ranges.

Evaluation of significant differences requires rigorous sampling protocols, followed by high resolution geochemical characterization using instruments such as GCxGC-TOFMS, C_4-C_{19} high resolution GC and ICP-MS, and must include evaluation of analytical uncertainties and sampling errors. Significant geochemical differences between samples are defined as those exceeding sampling and analytical errors. Because rates of mixing are related to molecular weight, significant geochemical differences are evaluated relative to key molecular weight ranges (e.g. gas, extended gasoline, biomarkers and C_{40+}). Tracking different molecular weight ranges allows quantitative evaluation of mixing phenomena and gradients and an assessment of potential equilibrium state and/or ongoing mixing. This in turn is the basis for development of multiple geochemical connectivity scenarios. The scenarios are subsequently validated by evaluation of relative rates of fluid compositional change induced by in-reservoir alteration processes or charge through forward modeling (Walters et al. 2009), modeling of mixing processes and their relative rates within the reservoir and monitoring of compositional changes with time-lapse geochemistry. The high-graded scenarios may then be further integrated with map- and pressure-based reservoir connectivity analysis (Vrolijk et al. 2005).

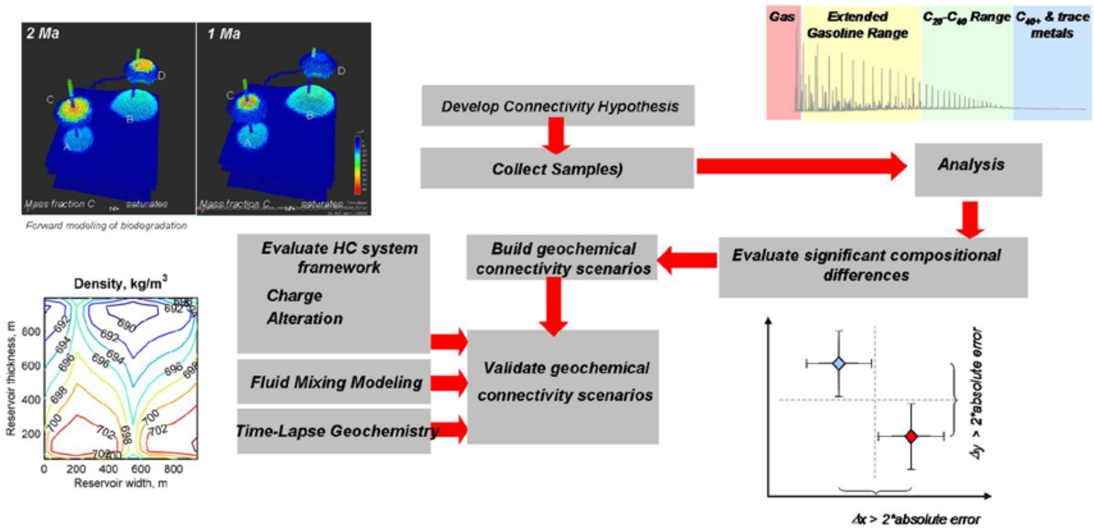

Figure 1. Integrated workflow for more consistent geochemical reservoir connectivity scenario development, including evaluation of significant geochemical differences, and evaluation of alteration and mixing processes.

References:

Kaufman, R.L., Ahmed, A.S., Elsinger, R.J., 1990. Gas chromatography as a development and production tool for fingerprinting oils from individual reservoirs: Applications in the Gulf of Mexico. GCSSEPM Foundation Ninth Annual Research Conference Proceedings, October 1, 1990, 263-282.

Mankiewicz, P.J., Pottorf, R.J., Kozar, M.G., Vrolijk, P., 2009. Gas geochemistry of the Mobile Bay Jurassic Norphlet Formation: Thermal controls and implications for reservoir connectivity. AAPG Bulletin 93 (10), 1319-1346.

Milkov, A.V., Goebel, E., Dzou, L., Fisher, D.A., Kutch, A., McCaslin, N., Bergman, D.F., 2007. Compartmentalization and time-lapse geochemical reservoir surveillance of the Horn Mountain oil filed, deep-water Gulf of Mexico. AAPG Bulletin 91 (6), 847-876.

Vrolijk, P., James, W., Myers, R., Maynard, J., Sumpter, L., Sweet, M., 2005. Reservoir connectivity analysis. Defining reservoir connections and plumbing: Society of Petroleum Engineers Middle East Oil and Gas Show and Conference, SPE Paper 93577.

Walters, C.C., Freund, H., Kelemen, S.R., Braun, A.L., Wenger, L.M., 2009. Simulating reservoir alteration processes. International Meeting on Organic Geochemistry. Book of abstracts, 8.