Integration of Geochemical Signals into Reservoir Simulation

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With recent advances in reservoir modelling software, it is feasible to incorporate geochemical processes into reservoir simulations. These capabilities have been used principally to undertake generic modelling of reaction induced changes to reservoir chemistry associated with CO_2-EOR. However, they can also be integrated into traditional reservoir models for the purpose of modelling the evolution of aqueous solution compositions within reservoirs actively undergoing EOR.

Model inputs (boundary conditions) for traditional reservoir modelling are limited to fluid injection and production rates; the quality of a reservoir model is determined by the comparison of the calculated rates of the production of oil, water and/or gas. These rates are gathered as a matter of course during normal field operations. Required inputs for the more complex geochemical descriptions include the composition of injected water; these are generally not known beyond a description of the source of the water.

Geochemical components can be divided into two general classes: conservative and non-conservative. Conservative components do not participate in reactions within the reservoir. These classifications are not unique; elements which behave conservatively within one reservoir may not be conservative in others. For instance, sodium will be conservative in most carbonate hosted reservoirs but will probably be non-conservative in clastic reservoirs with minor clay contents. The concentration of conservative components in produced waters arises from the mixing of injected and connate waters. Complications arise when modeling non-conservative components because of poorly defined to in-situ production rates reactions.

As part of the Weyburn Phase 2 project, a history matched reservoir simulation which had been developed in the prior Phase 1 phase was adapted to simulate the transport of a number of conservative tracers within the reservoir during primary recovery, water flooding and CO2-EOR. These tracers were assigned to vary with the age of the water (i.e. original formation water, or date of injection), as well as the location of the water injector. The waters compositions generated by these simulations are very well mixed, with compositions changing only on a scale of years. In contrast, field observations demonstrate much more rapid (i.e. monthly) changes in the composition of conservative components. Based on this observation, the original single porosity model was modified to incorporate a dual porosity reservoir description. The results obtained with this updated model were much more responsive to changes in injected solution chemistry, with variations associated with both the age of the water, and source well.

Reservoir modeling provides possible realizations of subsurface processes. Field observations of produced water chemistry at the Weyburn CO2-EOR field have provided further constraints on reservoir simulations of the field and new insights into reservoir processes.