

Reactive transport modelling of mud filtrate invasion during drilling and application to mud contamination corrections on formation water analyses

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Abstract

When a well is drilled with water-based mud (WBM), it is not unusual for formation water samples collected from the well to be contaminated with mud filtrate that has invaded the formation during drilling. This can make the composition of these water samples unrepresentative of formation water in the reservoir. Under these circumstances, a common approach is to apply a tracer to the drilling mud during drilling, analyse mud filtrate and the formation water samples, and then attempt to correct the formation water analyses for mud filtrate contamination. Corrections are normally made assuming simple mixing between mud filtrate and formation water. But, reactions can occur between the formation, mud filtrate and formation water during invasion and there is a risk that these might cause the corrections to be erroneous.

A series of mud-contaminated formation water samples have been obtained from wells drilled with potassium chloride WBM (with sodium thiocyanate tracer) on Field X. Given the location of the field, these water samples were unusual in that they contained significant concentrations of sulphate and it was suspected that this might be an artefact of mud contamination. To confirm whether simple mixing-type corrections could be applied to the water analyses, a 1-D reactive transport model was used to simulate mud filtrate invasion and its mixing with formation water. This allowed the resulting reactions occurring in the reservoir and their effect on the water samples to be evaluated.

The model results showed that the most significant reaction expected in the reservoir was potassium↔sodium ion exchange between the mud filtrate, mud filtrate/formation water mixtures and clays/micas in the reservoir. Minor calcite and barite precipitation/dissolution were also predicted. The contaminated formation water compositions predicted by the model are consistent with those of the water samples supporting the predictive capability of the model for this field. Based on the model results, it was established that a simple mixing-type correction model could indeed be used to estimate the formation water composition from mud contaminated samples. These mud contamination corrections were subsequently applied.

The model results also showed that if circumstances had been different (i.e. higher clay content of reservoir rock, different mud contamination levels), a simple mixing-type correction model would not have been appropriate for some constituents.

This work has shown how 1-D reactive transport modelling can both reduce and highlight uncertainties in estimated formation water compositions when mud contamination has occurred. In each case, the risks associated with the use of mud-contamination corrected formation water compositions (e.g. for injection water selection, scale management planning, etc) are reduced.