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Enhancing Reservoir Understanding in Oil Fields using the Adjoint-State Technique applied to PUNQ-S3 model

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Abstract

History matching (HM) with available observed data requires that the model captures important reservoir processes and behaviours occurring beneath the surface. Reservoir models deprived of these processes and behaviours are unsatisfactory replica of reality. Normally, fitting these models to observed data demands unwarranted use of parameter distortion to obtain meaningful history-matched results. To tackle this problem, an efficient and evolving approach for enhancing reservoir understanding is introduced that probes hidden reservoir behaviour at field, region or well level.

The model screening approach utilizes static grid reservoir properties to screen unmatchable models for hidden reservoir behaviour. Permeability and/or porosity is specified as input(s) for the HM problem with predetermined uncertainty ranges allowed to vary from zero to default maximum value or higher. Afterwards, the Adjoint-state technique is applied to fit simulation models to historical data. Impractical history-matched results are achieved at this point which cannot be used for forecasting reservoir performance. Following that, rational explanations are generated on why the Adjoint-state method will require such extreme permeability and/or porosity updates to obtain a match. Feedbacks from devised explanations are then employed to enhance reservoir understanding. The PUNQ-S3 model is used to assess proposed model screening approach.

The Adjoint-state technique implemented in an unconstrained fashion showed its effectiveness in revealing hidden reservoir behaviour. A number of indications that attracts attention to hidden behaviour were noticed in permeability and/or porosity distribution. In a scenario where a fault is hidden, the permeability distribution of affected wells encounters a noticeable contrasting change; the high permeability region searches for more oil to meet production demand while the low permeability region restricts oil production to match observed data. In addition, in a scenario where the aquifer is hidden, we spotted an extreme vertical permeability update proceeding downwards through all layers into the fluid contact zone. The most significant finding is that historical data must account for physical processes occurring in the representative reservoir. In contrast, production data with noise or field measurements containing errors limit the capability of the Adjoint-state method to reveal hidden reservoir behaviour.