Johan Sverdrup Field - Origin of sulphate-rich formation water and impact on scale management strategy

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Abstract

The Johan Sverdrup field will at maximum production contribute 25% of total oil production from the Norwegian continental shelf. Geochemical formation water interpretation and development of scale management strategy have been performed to ensure high well productivity and process regularity of the field.

Uncertainty in the formation water compositions challenged the decision to inject seawater or low sulphate seawater into the reservoir for pressure support. Water compositions in samples obtained from appraisal wells were unusual for the Norwegian North Sea, being sulphate-rich with negligible barium. This was suspected to be an artefact of drilling fluid contamination and corrections were applied to obtain representative estimates. These confirmed that the formation waters had variable salinity (24-41 g/L chloride), and were indeed sulphate-rich (94-602 mg/L) and barium-depleted (<6 mg/L). The compositions may reflect (a) mixing of formation waters across the field over geological time and (b) interactions with the underlying Zechstein Group (anhydrite).

Three appraisal wells showed barium-rich formation water outside the main reservoir zone where no underlying Zechstein Group was present. Initially, there were concerns about the scaling risks associated with mixing sulphate- and barium-rich formation waters. However, updated geological understanding indicated insignificant aquifer volumes with barium, implying that full field development and scale strategy did not need to consider barium-rich water.

Scale predictions were performed for various strategies; formation water production, seawater injection, produced water re-injection and low salinity/low sulphate water injection. Moderate SrSO4 and $CaCO_3$ scaling are expected in the production wells. If third party barium-rich waters are tied-in, the topside $BaSO_4$ scaling risk increases.

This work has shown:

- Careful evaluation of formation water samples/analyses reduces uncertainties associated with water compositions and increases confidence in results and decisions.
- Underlying geology can influence formation water compositions.
- Good quality water sampling is important for later phase field development and scale management.

The implications for Johan Sverdrup field development Phase 1 are:

- Seawater will be injected into the reservoir for pressure support with no need for sulphate removal plant.
- Produced water re-injection will gradually replace seawater to minimize environmental impact.
- Downhole scale inhibitor injection has been recommended to protect the upper completion.