

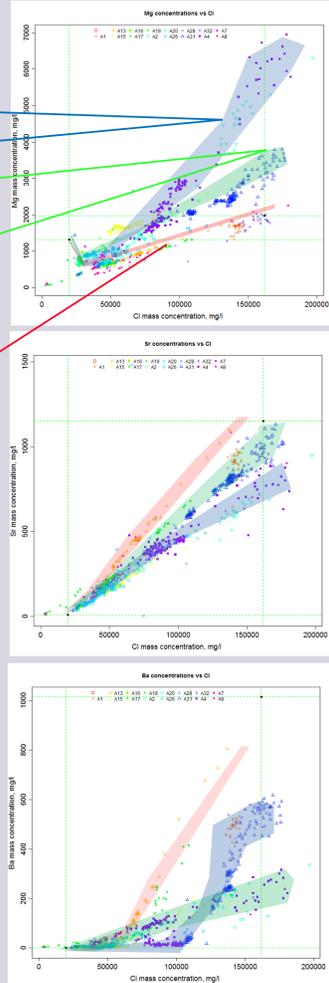
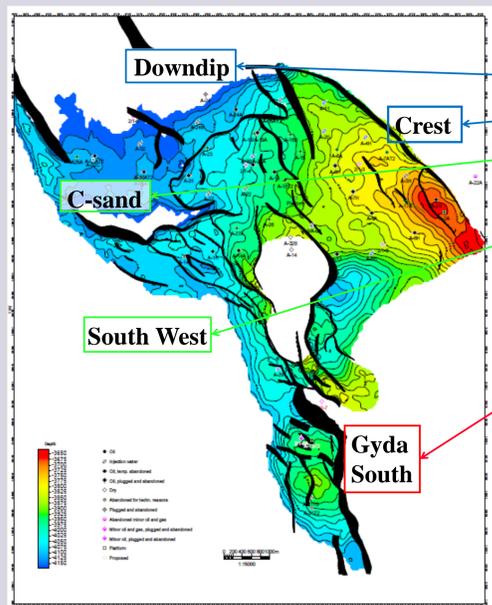
SPE 179911 - Analysis of Mineral Reactions Occurring in the Gyda Field under Seawater Injection with the Help of Geochemical Non-Isothermal Model and Produced Water Data

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Abstract

The evidence from the produced brine chemistry suggests that the Gyda field has experienced a variety of geochemical reactions due to the high temperature and initial calcium concentration, and so it is worth reviewing the produced water dataset and studying what in situ geochemical reactions may be taking place. Produced brine chemistry data from 16 wells in the Gyda field are plotted and analysed in combination with general geological information and the reservoir description. A one dimensional reactive transport model is developed to identify the possible geochemical reactions occurring within the reservoir triggered by seawater injection, then extended with the inclusion of thermal modelling and also to be a two dimensional vertical cross section model.

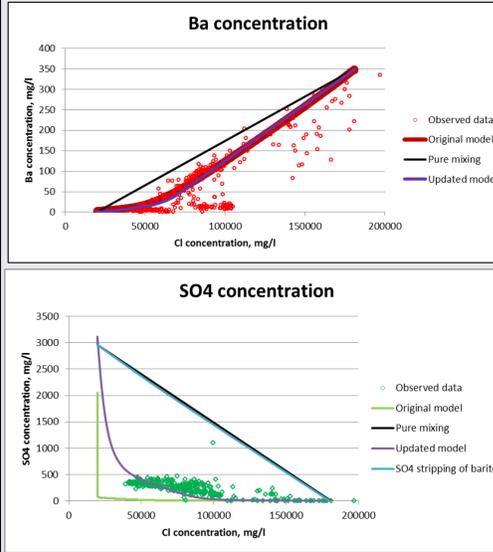
Behaviours of ions in produced brine



	FW1	FW2	FW3	Seawater
Na	65340	54560	65340	11470
K	5640	6000	5640	460
Ca	36900	36900	36900	428
Mg	7000	1970	3700	1368
Ba	350	1015	610	0.1
Sr	880	1290	1085	8.2
Cl	181000	162000	176100	19700
SO4	0	0	0	2960
HCO3	79	79	79	124
pH	5.46	4.75	5.46	8

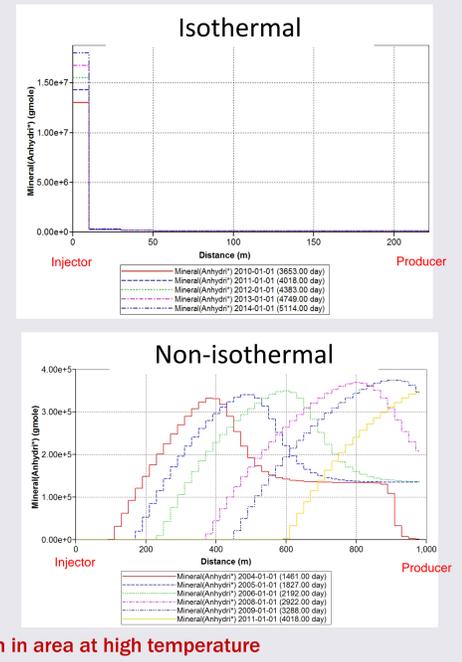
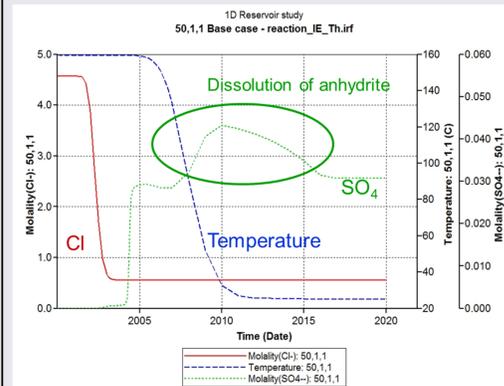
- Ba, Sr and Mg concentrations vary across the field, but the concentrations of other ions are more or less similar.
- Na and Sr pure mixing
- Mg, Ba and SO4 stripping

One-dimensional reactive transport modelling results



- Multicomponent ion exchange
- Dolomite precipitation
- Combined effect
- BaSO4 + CaSO4
- >95% of sulphate depleted by anhydrite deposition

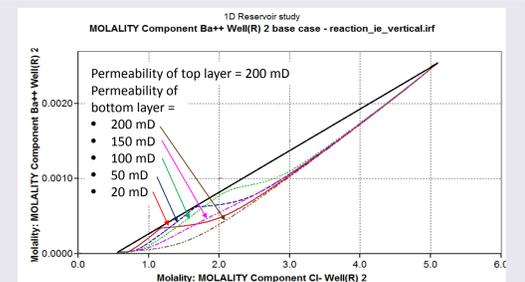
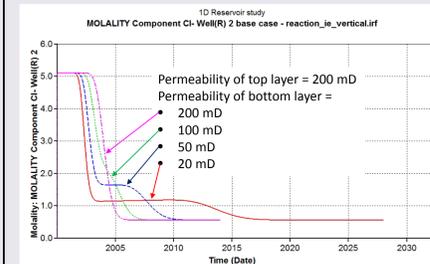
Anhydrite in isothermal & non-isothermal cases



Amount of anhydrite mineral in each block

- Isothermal: precipitated in region close to injector as soon as seawater is injected
- Non-isothermal:
 - Anhydrite deposited in area close to injector before this zone is cooled
 - Then is dissolved as local reservoir temp is lowered
 - Dissolved anhydrite then re-precipitates downstream in area at high temperature

2-D vertical case



- The bigger the difference in permeability, the longer the plateau
- "Plateau" where injection water produced from high permeability layer and formation water produced from low permeability layer, with mixing in the production wellbore

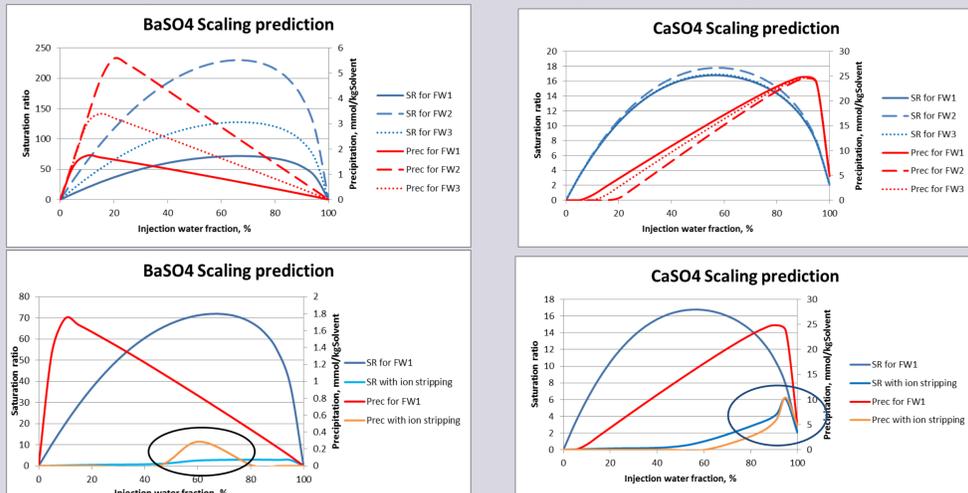
Conclusions

- Anhydrite and barite precipitation were the two dominant mineral reactions taking place deep within the reservoir. Sulphate is the limiting ion, with barium and calcium in excess during barite and anhydrite deposition.
- Celestite mineral reaction was not predicted, although the strontium concentration in the formation water is very high relative to other North Sea sandstone reservoirs. This is because strontium is unable to compete successfully with barium and calcium in the sulphate mineral precipitation reactions.
- Magnesium stripping may be a result of multi-component ion exchange, dolomite precipitation or a combination of both. The occurrence of dolomite precipitation depends on calcite dissolution, so the dolomite can only be precipitated in or close to the calcite stringers.
- Reservoir temperature was lowered by cold water injection. The solubility of anhydrite increases at lower temperature, and anhydrite will gradually dissolve in response to the movement of the temperature front, which is much slower than the formation/injection water mixing front.
- The extent of mineral precipitation within the reservoir can be reduced by the heterogeneity, leading to more severe scaling risk in the production wells.

Acknowledgments

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Thermodynamic (Zero-dimensional) modelling



- Dominant scaling potential: BaSO4 and CaSO4 precipitation
- SrSO4 Saturation ratio > 1, but no SrSO4 formation due to SO4 being limiting ion
- Reduced BaSO4 and CaSO4 scaling at wells due to in situ ion stripping