Effect of Clay Minerals in Oil and Gas Formation Damage Problems and Production Decline: A Case Study, Gulf of Suez, Egypt*

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Abstract

Formation damage can be observed from the production decline and injection rates. The diagnosis of formation damage requires integrated data from the geological side and the engineering side, more understanding for the reservoir characteristics, and minerals present - these are essential to define the causes of formation damage and a good treatment for a well; clay minerals have a high impact in formation damage.

In this article, two wells in the offshore Gulf of Suez were investigated to define the root causes of formation damage. The reservoir’s lithology, mineralogy and cementation were studied by scanning electron microscope, examining texture and fabric of minerals, especially clays, in addition to X-ray diffraction analysis to detect the amount and types of clays, and finally investigating the drilling fluids used and interaction between those fluids and minerals.

Study revealed that the formation damage in the well A may have resulted from deflocculatable kaolinite clay by non-equilibrium water-based fluids with the potential to severely reduce near wellbore permeability, or clay particle dispersion and pore plugging by movement with production, where the movement of fines affects the production performance of a well, especially in the sandstone formation reservoirs. Salinity shock may be responsible for the clays dispersion.

The formation damage in the well B may have resulted from the stimulation fluid used, where HCl reacted with illite and broke into fines which will block the pore throats and cause a severe permeability reduction in the well. In general, it is recommended to try acid stimulation and chemical treatment for the perforated intervals in the well using clay stabilizer. And doing Core flooding is highly recommended for the best stimulation and for more understanding of the problem.
Selected References


Radwan, A.E., (2020). Hydrocarbon Type Estimation Using the Synthetic Logs: A Case Study in Baba Member, Gulf of Suez, Egypt: AAPG/Datapages Search and Discovery Article #20475 (2020).


1- Aim of Study

This study is aiming for define the root causes of formation damage encountered problems and investigate the role of clay minerals in the formation damage problems, that happened while different oil and gas wells operation. This can be done by integration of geology, reservoir and production data.
2. Introduction

Formation damage can be observed from the production decline and injection rates, the diagnosis of formation damage required integrated data from the geological side and the engineering side, more understanding for the reservoir characteristic and minerals is essential to define the causes of formation damage and delineation of suitable treatment for a studied well, clay minerals has high impact in the formation damage studies.
2. Introduction

Fig. 1 Shows the damage and non-damaged regions around the borehole (Radwan et al, 2019a,c)
2. Introduction

Formation damage classification scheme (Radwan, 2018)
3. Area of Study

Fig. 2; the studied field location illustrated (Attia et al., 2015; Abudeif et al., 2016a, b; Abudeif et al., 2018; Radwan, 2018 a, b, c, d).

Fig. 2; Tectonic element of the Gulf of Suez where the studied field location illustrated (Radwan, 2019a, b, c, Radwan et al., 2020).
4. Methodology

Detailed study about the studied reservoirs lithology, mineralogy and cementation, the scanning electron microscope used for studying the configuration, texture, and fabric of minerals, especially clays, in addition X-ray diffraction analysis used to detect the amount and types of clays in the studied reservoirs, revising of the used fluids and interaction between fluids and minerals investigated also.
4. Methodology
5. Results Case 1

A) Photomicrograph of sample 6170, partially crossed polarized light; magnification is 30x. Showing immature quartz arenite. Medium to coarse grained with some fine matrix with dolomitic and micritic cement, high intergranular porosity.

B) Photomicrograph of sample 6070ft, partially crossed polarized light; magnification is 30x. Showing immature Arkose Sandstone. Medium to coarse grained with high feldspar content.

C) Photomicrograph of sample 6055 ft, partially crossed polarized light; magnification is 30x. Showing immature Arkose Sandstone. Medium to coarse grained with high feldspar content, with anhydritic cement mainly with some dolomitic cement.

D) Photomicrograph of sample 6100 ft, plane polarized light; magnification is 30x. Highlights potassium feldspars grains, quartz grains and clay matrix.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
<th>Unit</th>
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<tbody>
<tr>
<td>Well status</td>
<td>Water injector</td>
<td></td>
</tr>
<tr>
<td>Reservoir</td>
<td>Hamam Hammam</td>
<td></td>
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<tr>
<td>Present reservoir pressure</td>
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<td>Psi</td>
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<tr>
<td>Average water gradient</td>
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<td>Psi/ft</td>
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<tr>
<td>Average porosity</td>
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<td>Total depth</td>
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<tr>
<td>Reservoir temperature</td>
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<td>°F</td>
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<tr>
<td>Average Permeability</td>
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<td>mD</td>
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<tr>
<td>Perforated thickness</td>
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<td>Ft</td>
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<tr>
<td>Average API gravity</td>
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5. Results Case 2

<table>
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<tr>
<th>fluid</th>
<th>Sp.Gr. @ 20°C</th>
<th>Resistivity @ 20° C</th>
<th>CATIONS (PPM)</th>
<th>ANIONS (PPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completion fluid</td>
<td>1.029</td>
<td>0.13</td>
<td>13249</td>
<td>23393</td>
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<tr>
<td>Formation fluid</td>
<td>0.9</td>
<td>0.12</td>
<td>11200</td>
<td>111000</td>
</tr>
</tbody>
</table>

- **Sp.Gr. @ 20°C** is the specific gravity at 20°C.
- **Resistivity @ 20° C** is the resistivity at 20°C.
- **CATIONS (PPM)** are the concentrations of various cations in parts per million.
- **ANIONS (PPM)** are the concentrations of various anions in parts per million.

The table includes Na⁺, K⁺, Ca++, Mg++, Sr++, Zn++, Cl⁻, SO₄⁻, and HCO₃⁻ concentrations.
Conclusions

The study revealed that,

1) the formation damage in the case one may results from the used stimulation fluid, where Hcl react with illite and break it to fines and this will block the pore throats and cause a severe permeability reduction in the studied well.

2) the formation damage in case two may results from deflocculatabl kaolinite clay by non-equilibrium water-based completion fluids with the potential to severely reduce near wellbore permeability, or clay particle dispersion and pore plugging by movement with production, where salinity chock may be responsible for the clays dispersion.