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.

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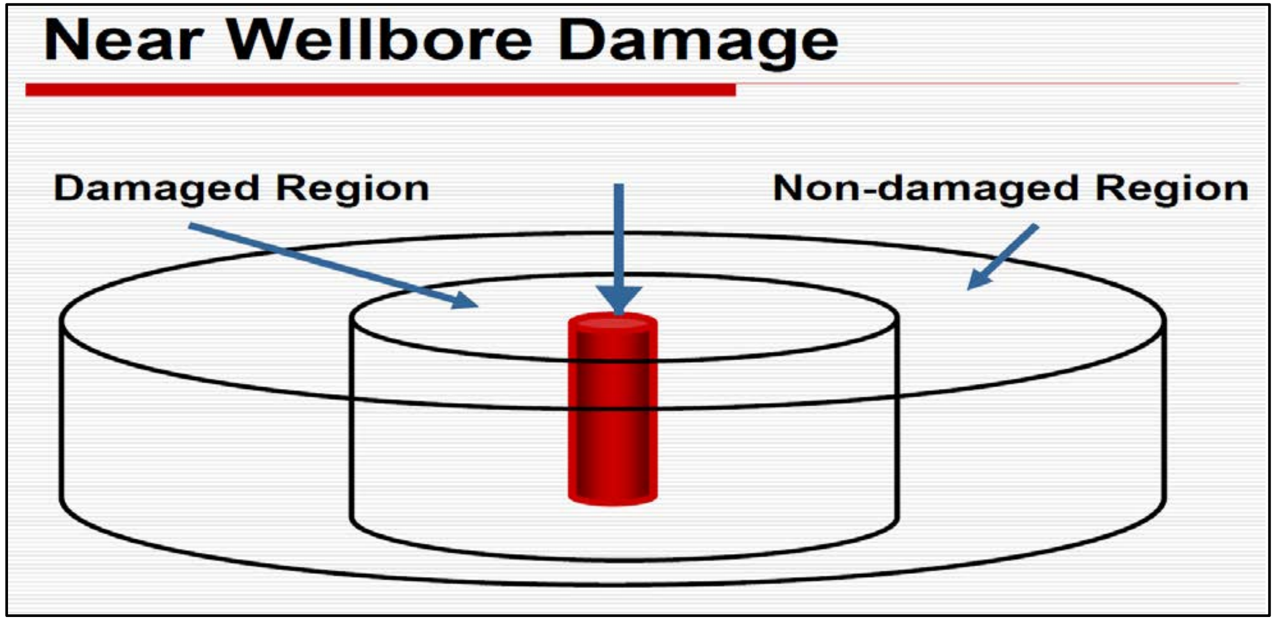
1- Aim of Study

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

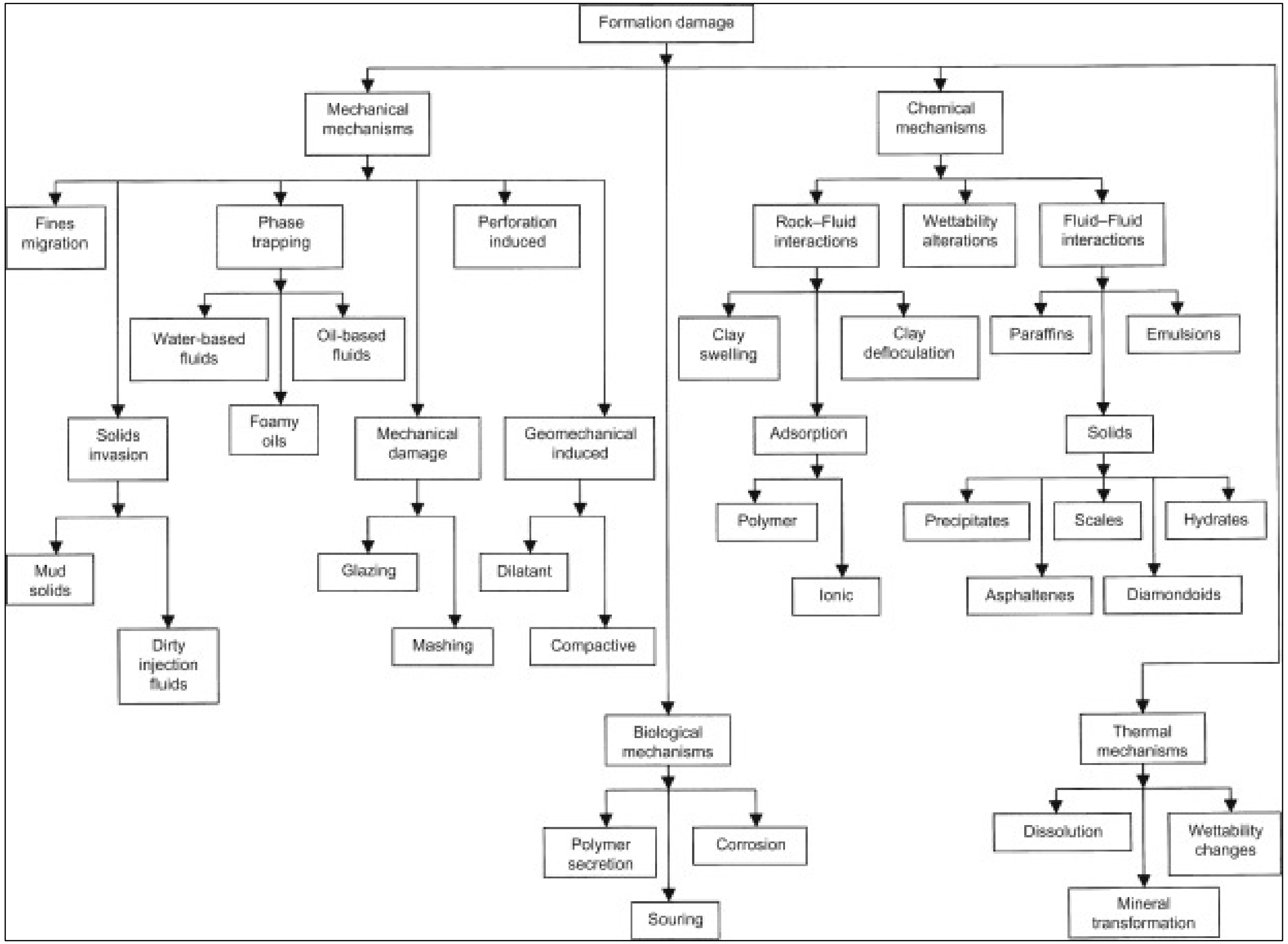
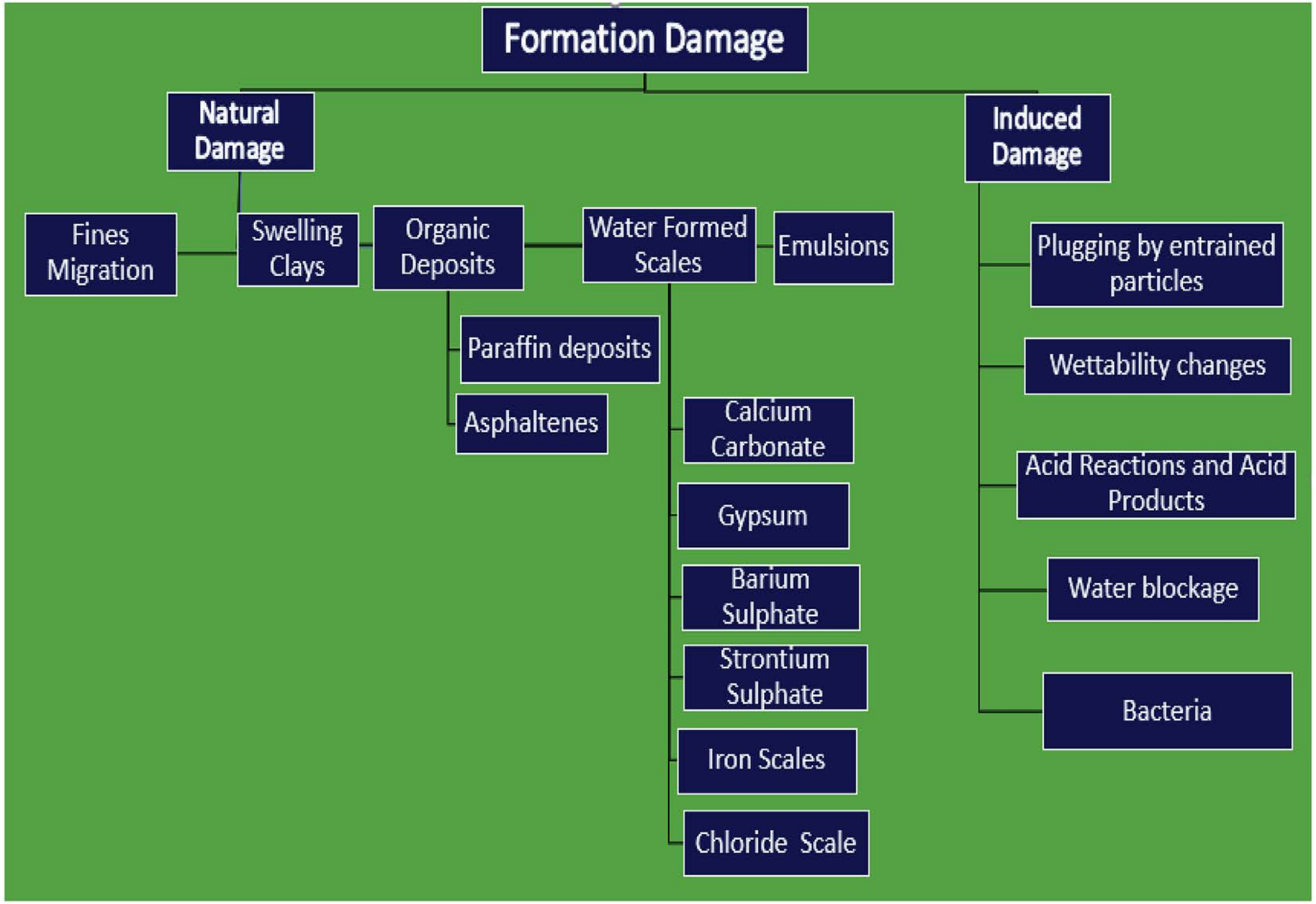


Fig. 1 Shows the damage and non-damaged regions around the borehole (Radwan et al, 2019a,c)

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).

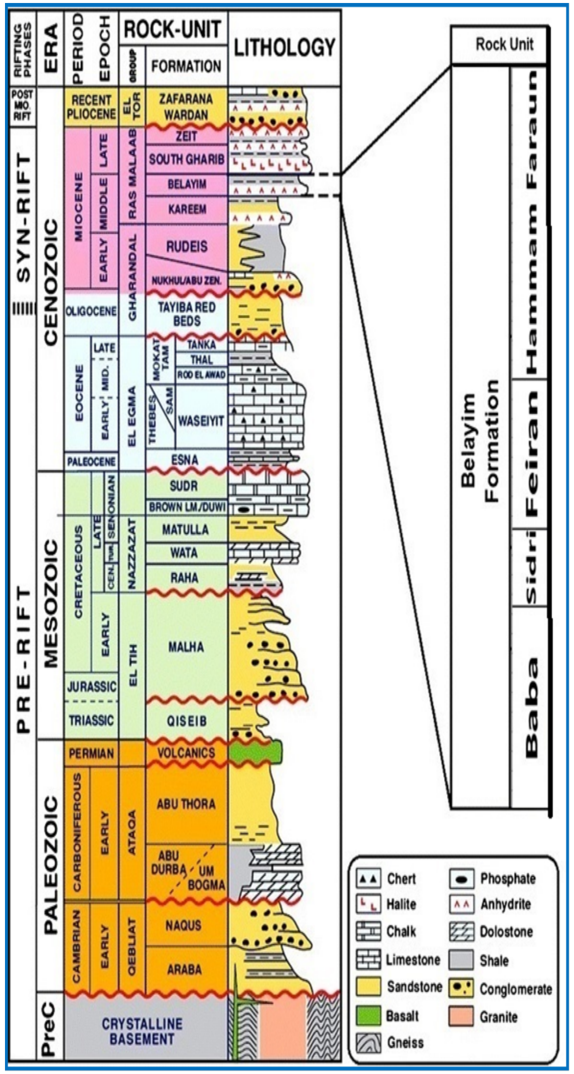
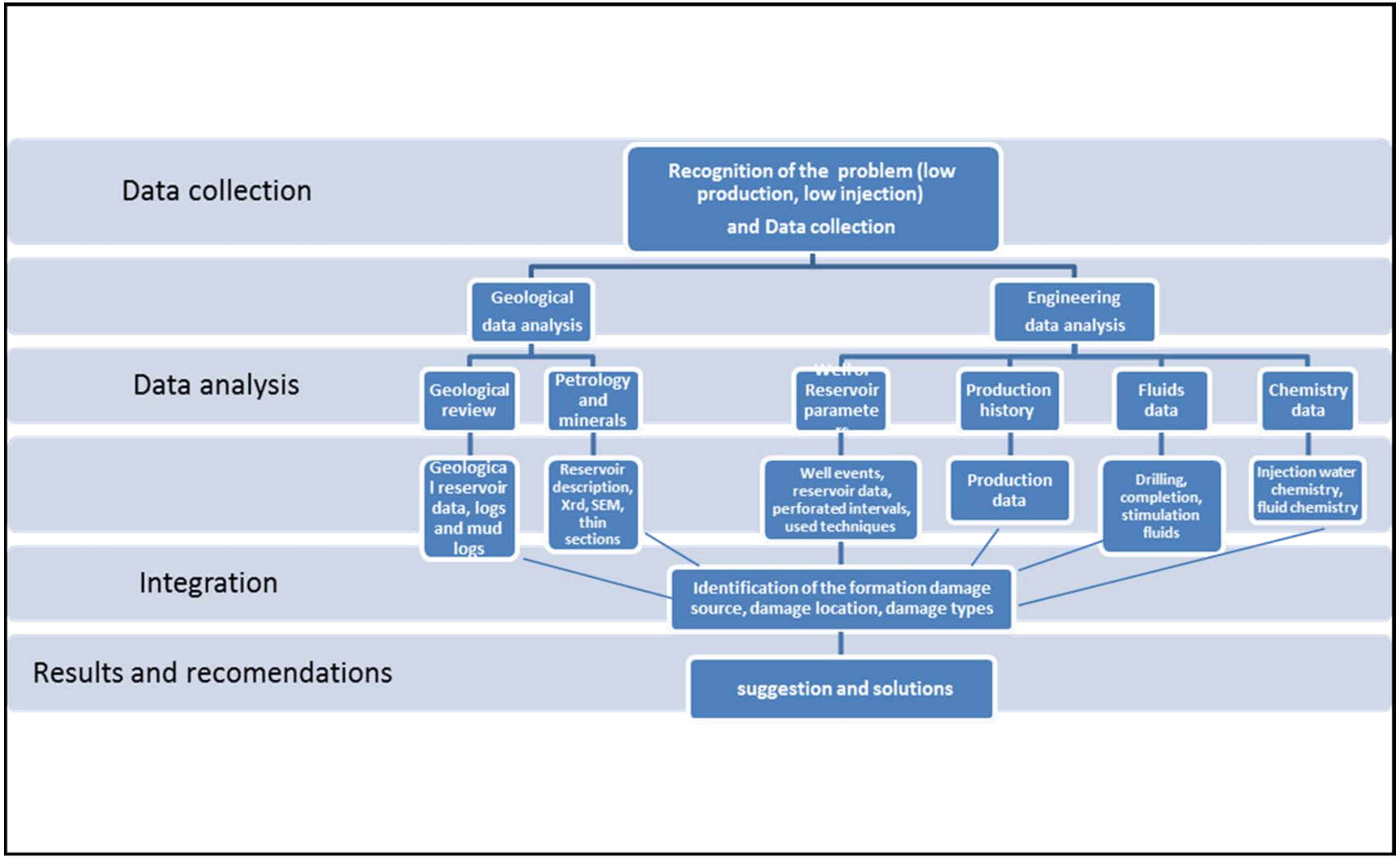


Fig.2; Tectonic element of the Gulf of Suez where the studied field location illustrated (Radwan, 2019a,b,c, Radwan et al., 2020).

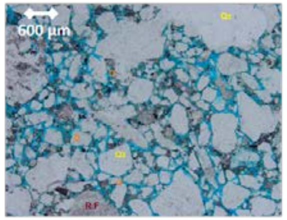
4. Methodology

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.

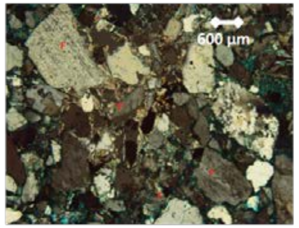
4. Methodology



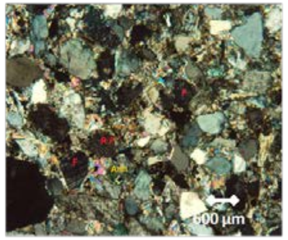
5. Results Case 1



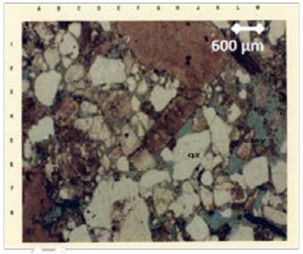
A) Photomicrograph of sample 6170, partially crossed polarized light; magnification is 30x. showing Immature quartz arenite
Medium to coarse grained with some fine matrix with dolomitic and micritic cement, high intergranular porosity.



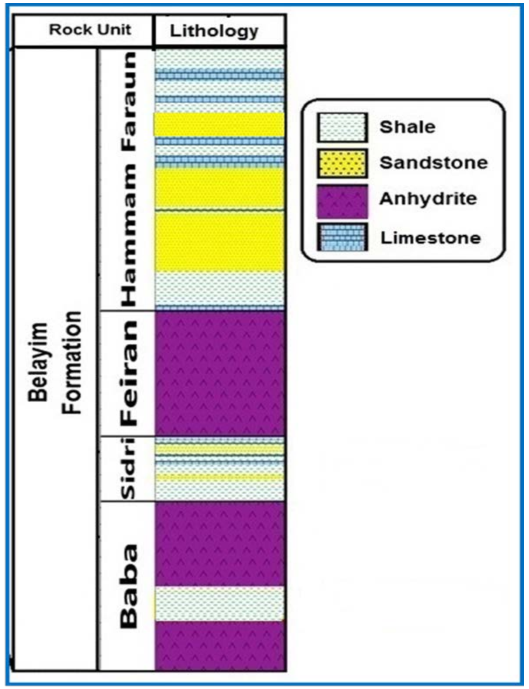
B) Photomicrograph of sample 6070ft, partially crossed polarized light; magnification is 30x. Showing Immature Arkosic Sandstone
Medium to coarse grained with high feldspar content.

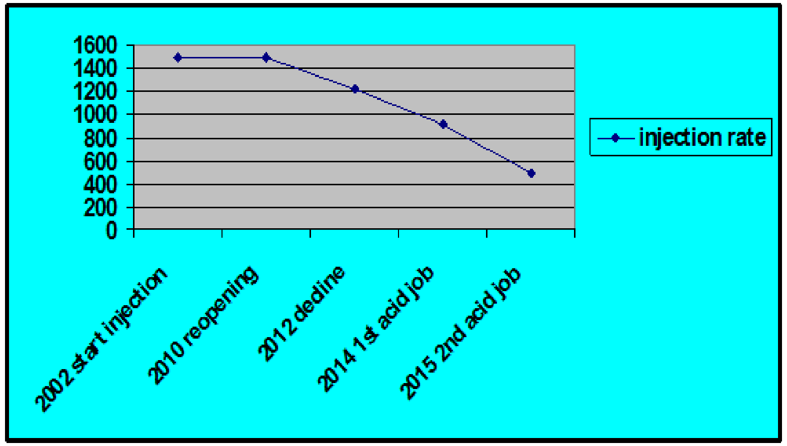


C) Photomicrograph of sample 6085 ft, partially crossed polarized light; magnification is 30x. showing Immature Arkosic Sandstone Medium to coarse grained with high feldspar content, with anhydritic cement mainly with some dolomitic cement.



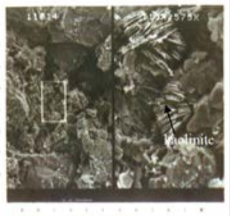
D) Photomicrograph of sample 6100 ft, plain polarized light;magnification is 30x. highlights potassium feldspars grains, qrtz grains and clay matrix.



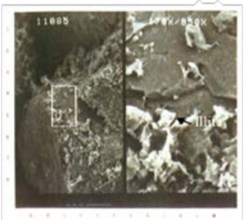


Parameters	Value	Unit
Well status	Water injector	
Reservoir	Hammam Faraun	
Present reservoir pressure	2300	Psi
Average water gradient	0.454	Psi/ft
Average porosity	25	%
Total depth	8691	Ft
Reservoir temperature	152	F°
Average Permeability	200	mD
Perforated thickness	263	Ft
Average API gravity	26	API

5. Results Case 2

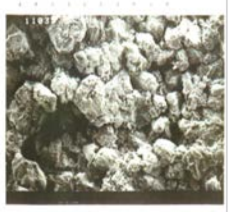


A) Scanning electron micrograph of sample 11014ft, showing pore filling clays and quartz overgrowths Clays consist almost entirely of kaolinite in the form of vermi-form booklets ,Magnifications 115x/575x.

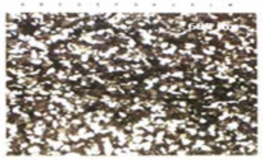


B) Scanning electron micrograph of sample 11085ft, showing illite flakes growing on grain surfaces and quartz overgrowths, Magnifications 170x/850x.

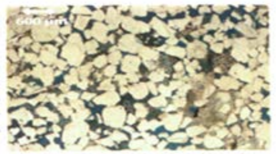
C) Scanning electron micrograph of sample 11130 ft, showing authigenic clays present within an almost completely leached grain. Platy illite is present . Fibrous chlorite is coating grain surface. Magnification 820x.



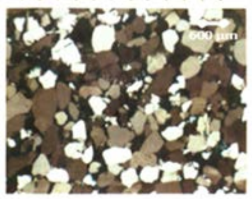
D) Scanning electron micrograph of sample 11035ft, showing Inter-granular porosity. Porosity is reduced predominantly by clays. Magnifieation 45x.



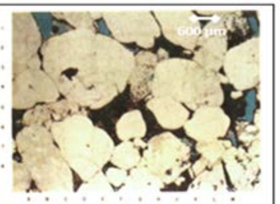
C) Photomicrograph of sample 10285ft, partially crossed polarized light; magnification is 30x. showing Clays, organics and pyrite, Lack of intergranular porosity and Microporosity.



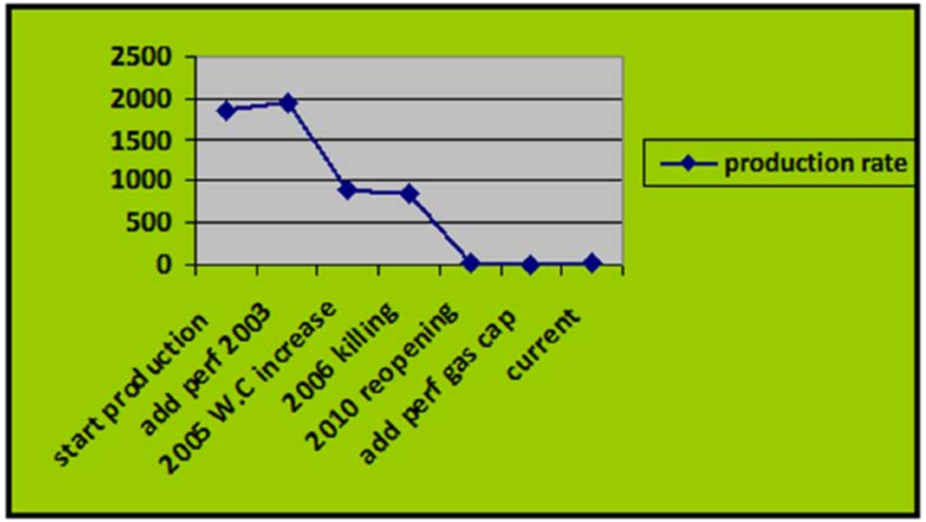
D) Photomicrograph of sample 10500ft, plain polarized light;magnification is 30x. showing moderately sorted, medi um-grained quartz arenite, Enlarged secondary intergranular pores -Authigenie kaolinite



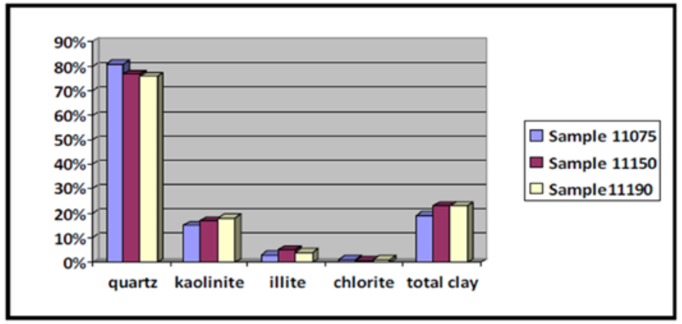
A) Photomicrograph of sample 10280ft, partially crossed polarized light; magnification is 30x. showing well-sorted, medium-grained quartz arenite.



B) Photomicrograph of sample 11150ft, partially erossed polarized light; magnifieation is 30x. Showing coarse-grained, poorly sorted quartz arenite sandstone and Amorphous organic matter (dead oil) in pores.



fluid	Sp.Gr. @ 20°C	Resistivity @ 20° C	CATIONS (PPM)						ANIONS (PPM)		
			Na^+	K^+	Ca^{++}	Mg^{++}	Sr^{++}	Zn^{++}	Cl^-	$So4^-$	$HCO3^-$
Completion fluid	1.029	0.13	13249	455	501	1490	9	1.3	23393	3350	230
Formation fluid	0.9	0.12	11200	500	390	700	6	1	111000	1000	100



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.**