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Water wells completion design optimization through geomechanics solutions

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Water wells are being drilled in different clusters to maintain injection pressure across reservoir. The target formation appears to be “strong” rock based on geological understanding and regional knowledge. Gravel pack with selective perforations has been the standard method to complete the wells. Recent intake pressure data suggests sharp drop in Injectivity which threatens commercial viability of the water wells project.

This paper describes the use of geomechanical studies to optimize perforation depths and completion design taking into considerations grain size variation of target formation across different clusters. The process was integrated into the decision-making process during water well design. The geomechanical studies assisted in the successful completion of the water wells drilled in four different clusters through isolation of specific layers for perforations to avoid sand production and planning appropriate screen size for gravel pack or standalone screen if applicable.

A Mechanical Earth Model was constructed to represent the state of stress and mechanical properties of the overburden and reservoirs. The model incorporated data from many sources including open hole logs, leak-off tests, petrophysical interpretation, borehole image, fracture closure & breakdown pressures collected from the different wells. Review of formation evaluation data and image suggested variation in the pore size distribution with thin layers having lower effective porosity within thick sand package. This indicated the presence of silty layers and the need to understand grain size variation.

The geomechanical data provided input in many critical decisions in the water well completion design: layers with lower UCS has smaller grain size in range of 30micron to 40micron which are prone to sand production with 50% depletion. Ratio of maximum horizontal stress to minimum horizontal stress is 1.10 to 1.22 and the sanding analysis suggest that perforation orientation parallel to minimum horizontal stress will allow higher critical drawdown. Review of grain size distributions in term of D10/D95, D40/D90 and sub-mesh 325micron suggested gravel pack to be installed for 2 clusters and another cluster to be completed with premium standalone screen. Overall 90% of the target formation has no sand production issues and gravel pack design needs to be optimized for lower UCS layers taking into consideration grain size distribution and Geomechanical input including perforation orientation optimization.

Although the early water wells had lower intake pressures measured in ESP, re-perforation of selective layers in those wells and new water wells with better gravel pack design have achieved better water intake. There has been no sand production issue after perforations in the new water wells with optimum perforation orientation.

Introduction

Intake pressure measured in ESP showed sharp decline in Injectivity which threatens commercial viability of the field development. Key Challenges:

- Understanding the geomechanical behavior of Barik formation in terms of rock strength, stress profile and elastic properties.
- Understand grain size variation vertically and laterally in the field
- Re-visit existing perforation diameter/orientation design
- Gravel-pack size optimization

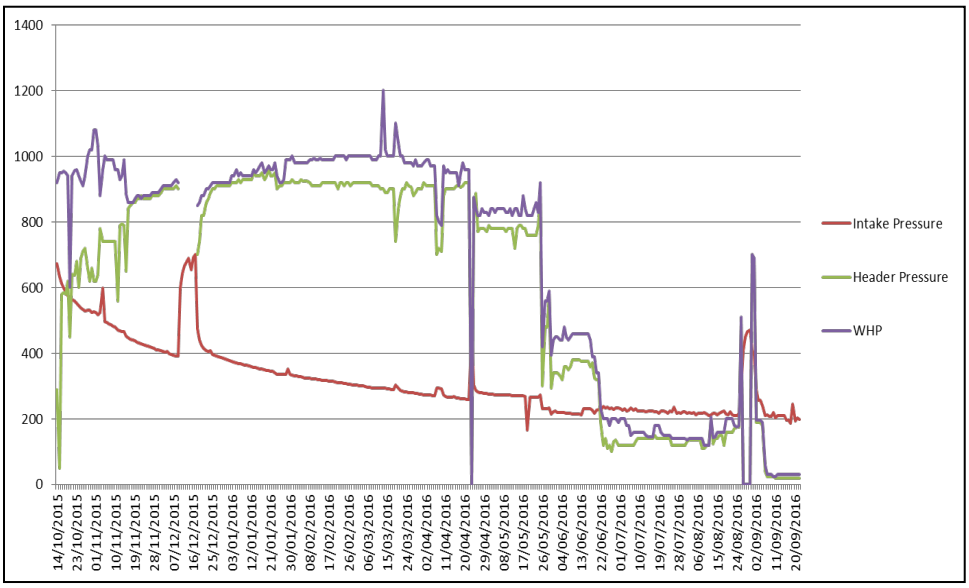
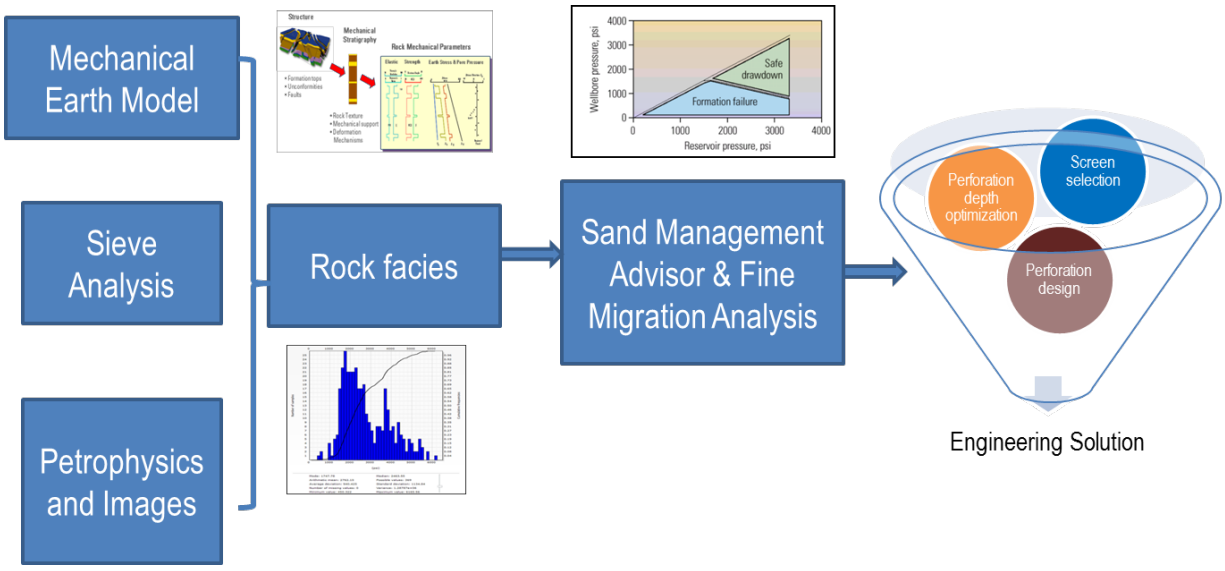


Figure1: Well A pressure profile with time

Workflow

Integrated approach of evaluating Geomechanical parameters, sieve analysis, geophysical logs and engineering design was proposed to identify root cause of the issue.



Findings

- Layers with lower UCS has smaller grain size in range of 30micron to 40micron which are prone to sand production with 50% depletion.
- Ratio of maximum horizontal stress to minimum horizontal stress is 1.10 to 1.22.
- Sanding analysis suggest that perforation orientation parallel to minimum horizontal stress N135E will allow higher critical drawdown.
- Even with 90% depletion, risk of sand production in competent rocks is low except few high porosity layers.

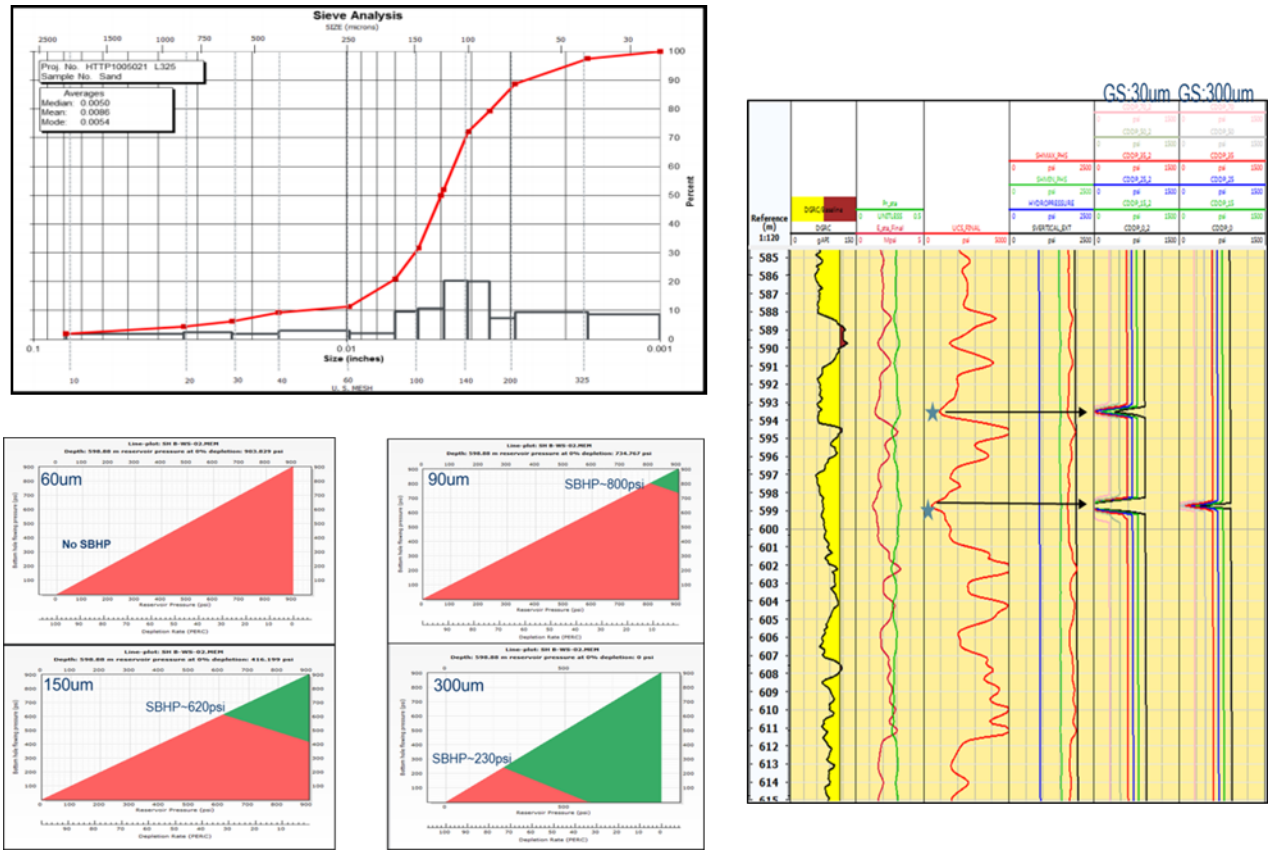


Figure2: Critical drawdown pressure and Stable Bottom Hole Pressure analysis

Solution

Based on analysis, different layers of proposed water wells were identified with substantial risk of sand production. It was found that different fields had varying requirements for completion against existing process of gravel pack in each field same way. Perforation shot density with optimum orientation was proposed on existing well. Based on analysis, there has been considerable improvement in water production with minimal sanding issues over last 1year.

	D10/D95	D40/D90	Submesh 325 or Fine (%)	Comments
Field A	**7.5**	**2.037**	**2.53**	**Standalone Premium**
Field B	**4**	**2.5**	**9 (lower UCS values)**	**Optimized Gravel Pack**