Burgan 3SU Reservoir - A Success Story in Development Planning and Reservoir Management*

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Abstract

Burgan 3rd Sand Upper (3SU) is one of the secondary units in the Burgan clastic sequence future production from SEK is dependent on the 3SU development. BP has been providing extended support to SEK through working jointly with the KOC team to identify and progress artificial lift optimization and reservoir management for the 3SU reservoir over an 8 month period in 2016; the objectives were to deliver immediate production improvement options and improve resource, reservoir and well performance understanding to the support current and future development planning of the reservoir. This collaboration resulted in over 31,000 bpd additional barrels of oil added from production optimization activities and a further >80 well intervention opportunities awaiting execution. Initial support focused on developing a short-term activity hopper of both artificial lift optimization opportunities and reservoir management activities, which later was expanded to include framing of medium to longer term development plan requirements.

Future development of the 3SU reservoir is dependent on water injection support for pressure maintenance; project work focused on defining the surveillance and reservoir management activity required to optimize the location of future injection and to improve understanding of reservoir heterogeneity and complexity. Integration of the geological understanding was key to the identification of opportunities and assistance in optimizing the long term reservoir management strategy for the 3SU. Close collaboration between the teams and between KOC and BP was vital to the success of this project, not only for the 3SU depletion planning but for identification and communication of the potential interactions/interdependencies with other reservoir development plans which needed to be incorporated for field planning. A work plan was developed to integrate and enhance the
subsurface description, performance prediction and activity plans for the 3SU reservoir and for identification of opportunities to maximize production through prudent reservoir management. This article describes the achievements from the project and how the successes will lead to the long term reservoir work plans, the methods that developed the products, and recommendations for process improvements to increase efficiency. Descriptions of the tools developed and methodologies used to integrate and analyze data are discussed in this article.
Burgan 3SU Reservoir; A Success Story in Development Planning and Reservoir Management

Wafaa Al-Ghanim, Sasi Rajan, Sethu Madhavan, Mishari Al-Qattan & Giles Duvivier
Agenda

• Objectives and deliverables
• Geological Introduction
• Production Optimization and Hopper
• Reservoir management and Development planning
Objectives and Deliverables

1. Deliver immediate production improvement options for upper sand in Greater Burgan Field.
2. Improve resource, reservoir and well performance understanding.
4. Maximize Production South & East Kuwait group (Greater Burgan Field)

Burgan 3rd Sand Upper (3SU) is currently 2nd largest producing reservoir in Greater Burgan Field SEK.

Presenter’s notes:  Burgan 3rd Sand Upper (3SU) is currently 2nd largest producing reservoir in Greater Burgan Field SEK. This presentation describes the successes of delivering a project for 3SU reservoir

With the objective of
- identifying production improvement options to 3SU reservoir in Burgan field by following prudent reservoir management strategies
- improving the resource, reservoir and well performance understanding to the support current and future development planning of the reservoir

The presentation also focusses on
- descriptions of the tools developed and methodologies used to integrate and analyse data
- optimising the long term reservoir management strategy for the to maximize production of Greater Burgan Field
The Greater Burgan Field Complex, Kuwait

- **BGSU** is more marine and contains higher % of glauconitic, burrowed sandstones and mudstone and bedded carbonates. Avg. thickness of 100ft.
- BGSU is divided in to BGSU1 & BGSU2

**Presenter’s notes:**
Greater Burgan is the world's largest sandstone oil field, and the second largest overall. The field is 40 km x 20 km in size. Geographically the field is divided into three, that is Magwa, Ahamadi and Burgan.
A typical log showing major reservoirs in Burgan is shown here. BGSU is located below Maddud, a limestone reservoir. BGSU is more marine and contains higher % of glauconitic, burrowed sandstones and mudstone and bedded carbonates. BGSU is divided in to BGSU1 & BGSU2. The average thickness of the reservoir is about 100ft.
Presenter’s notes: In order to improve the understanding of the subsurface, picked key major flood surfaces at top of Maddud, at top of BGSM and at top of BGSL reservoir.
The picture shows correlation panel of all major reservoirs, starting from South – West to North East.
The correlation panel pass through Burgan, Magwa and Ahmadi areas.
Presenter’s notes: The schematic cartoon of Burgan and BGSU reservoir. The southern part is dominated by amalgamated channel sands having very high permeability (Shown inside the red box).
The BGSU2 layer is getting pressure support from BGSM, as it is in direct communication with BGSM, mainly in the southern part. Degradation of reservoir properties is seen when moving to the North-East direction. The sands are more isolated and thinner. The sands are separated by shale (Shown inside the Purple box). This has a huge impact on pressure communication within BGSU and communication with lower sands. Therefore, there is large pressure depletion in the Northern part of the reservoir.
Presenter’s notes: The map shows a comparison of reservoir pressure in the BGSU1 & BGSU2 layers of BGSU. The “orange” colour shows the highest pressure, “green” represents the medium pressure and the “blue” represents the lowest pressure in the reservoir. The map shows the relatively high pressure depletions in the Magwa –Ahmadi area, compared to Burgan area. There are some pressure depletion areas in the Burgan dome in both layers (BGSU1 & 2). It is very clear that the pressure depletion in BGSU1 is more than the BGSU2.
That is why, we need to have different offtake strategy for BGSU1 & 2.
Also, it is better to treat the 2 layers as 2 different reservoir management units.
Presenter’s notes: The Process of rate adding options starts with the recommendations by 3SU team. Before finalising the recommendations, the team use the workflow as shown here and check the well potential, Pressure support, reservoir quality and continuity and risk of drastic change in water cut. Then the recommended option is discussed between 3SU and GC team -> Follow up with GC to finalise. Once it is finalised, the option is forwarded to Production optimisation unit (POU) for implementation.
Status of Rate Adding Options

- Executed: 38 jobs identified by the 3SU Team have been executed to date. Total production realized: ~31mbod
- 86 jobs handed over to POU
- Forecasted incremental gain: 35 - 50mbod

Presenter’s notes: 38 jobs identified by BGSU team have been executed resulting in a oil gain of 38000 bbls. 86 jobs identified by the 3SU Team have been handed over to POU for further integration with the GC teams and follow through on execution. Forecasted incremental production: 35 - 50mbod from 86 jobs
Rigless Job

**WSO:** Set BP@ 3953 ft, TOC: 3948 (isolate water producing 3SM)

**Reperf:** 3934-3945'(3SU, 5 spf)

**Add perf:** 3906-3918; 3856-3880' & 3840-3850'(3SU, 10spf)

**Results**
- Before rigless (August 2016): 727bopd, 63% Wcut
- After Rigless (October 2016): 2462bopd, 0% Wcut
- Oil Gain: 1735 bopd
3SU Hopper Example – Well No-D Rig WO

- Well No-D is a single string ESP producer completed in 3SU and 3SM
- **Pump upsizing** opportunity was identified and implemented.

<table>
<thead>
<tr>
<th></th>
<th>Liquid Rate, bpd</th>
<th>Water Cut, %</th>
<th>Oil rate, bpd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before WO</td>
<td>4000</td>
<td>75%</td>
<td>1000</td>
</tr>
<tr>
<td>After WO</td>
<td>6000</td>
<td>75%</td>
<td>1500</td>
</tr>
</tbody>
</table>

- 500 bopd gain
3SU Hopper Example – Well No-C Choke Up

- Well No-C is a dual string producer completed in 3SU and 3SL
- Opportunity to open up the choke was identified and implemented.

<table>
<thead>
<tr>
<th>Choke size</th>
<th>Liquid Rate, bpd</th>
<th>Water Cut, %</th>
<th>Oil rate, bpd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before</td>
<td>24</td>
<td>1400</td>
<td>1400</td>
</tr>
<tr>
<td>After WO</td>
<td>42</td>
<td>2400</td>
<td>16%</td>
</tr>
</tbody>
</table>

- 616 bopd gain
3SU Hopper Example – Well No-B Rig WO

- Well No-B was a 100% water Hartha well. (shallow)
- ESP recompletion to 3SU was recommended and implemented

- Av. allocated liquid rate 5000 bpd
- Av. water cut ~50%
- Av. oil rate 2500
High level 3SU Development Planning

**Approach** develop highest potential areas first, phased development to maximise value of injection.

- Waterflood Burgan area as top priority
  - Protect current offtake in crestal areas
  - Allow higher withdrawal with increasing Wcut
  - Quick future ramp up (New wells, higher offtake with WI)

- Synergies with Wara development (Commingle, align drilling program)
  - Low Sal in AH/MG areas

- Leverage learnings from WF pilots
- Early injection in graben area, Ahmadi area dumpflood.

**Requirements**

- Ahmadi/Magwa areas production curtailed for reservoir management. Production from Burgan areas optimised to meet targets.
- Voidage/pressure understanding for various areas to define injection needs.

Presenter’s notes: The short term-strategy for BGSU is to
- Increase production from sweet spots in higher pressure areas first, protect reservoirs in high GOR/ lower pressure areas by curtailing production
- Seek synergies with Wara development by identifying opportunities to commingle and align the Wara drilling program to Burgan depletion strategy.
- Collect more surveillance data of injectivity, pressure, WCUT development to design waterflood for BGSU
Summary and Conclusion

• > 31,000 bpd oil realised from production optimisation activities. Further opportunities awaiting execution.

• Optimisation and prioritisation of areas for 3SU Waterflood in progress.

• Developing an improved understanding of reservoir layering / architecture helped in formulating reservoir management strategies and managing production.

• 3SU EOR study suggests incremental recovery from low salinity WF. Scope to quantify benefit with improved 3SU understanding.