One team, one objective: Production enhancement of Hassi Messaoud field, Algeria

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Outline

- Hassi Messaoud field Location / Reservoir
- Current production & Objectives
- TAO Team organization
- Approach / Workflow
- Proposed production enhancement well interventions
  - Matrix treatment (Clean out, reformat, Mud acid)
  - Perforations
  - Hydraulic fracturing
  - Multistage Fracturing Completion
  - Short Radius re-entry
  - ESP installation and Gas lift optimization
  - Well tests (Build up, PFS, Vx…), PLT, FSI, RST
- Real Time Well Surveillance / GL Automation Valves / Network modeling
- Flow Assurance Analysis and Propose solutions
- New Alternative for Water Demineralization
- Results & Way forward

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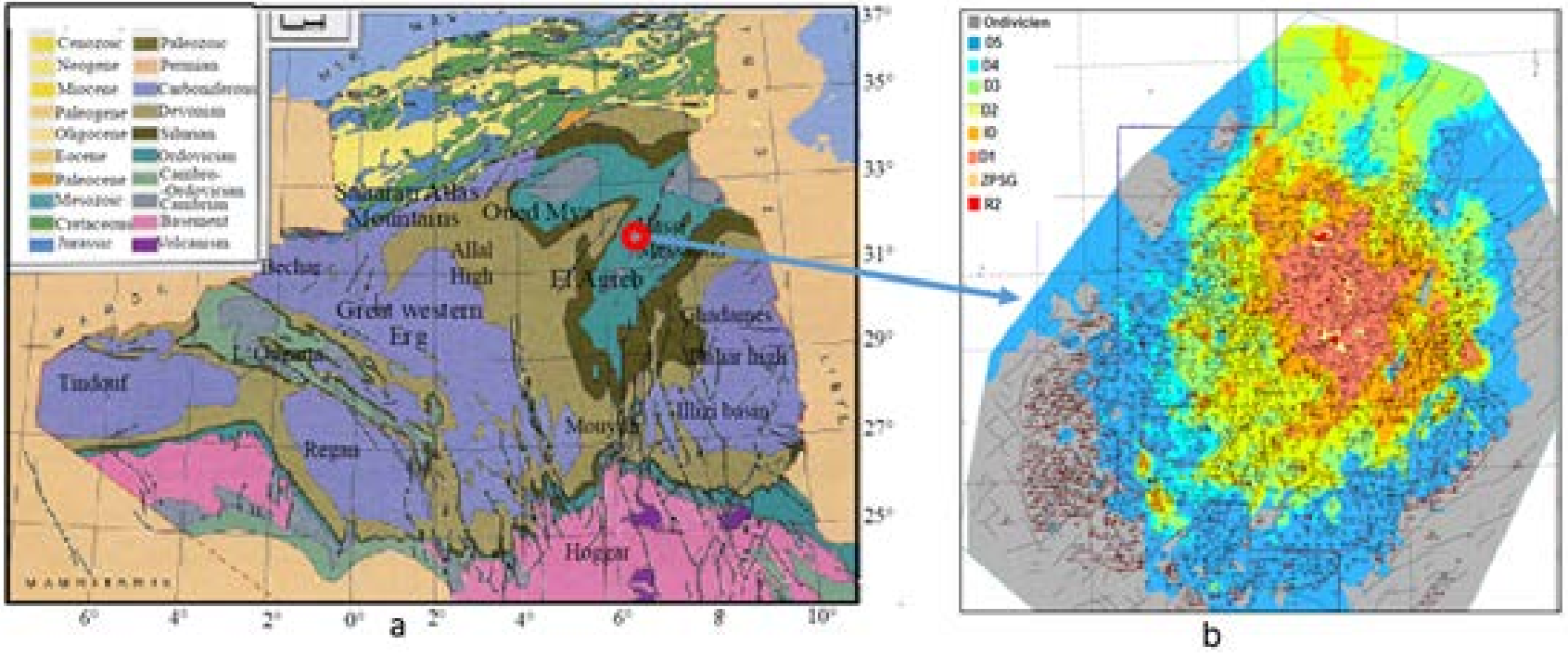
Hassi Messaoud (HMD) field location



Hassi Messaoud (HMD), one of the largest mature fields in the world is located in the Algerian Sahara Desert, 800 km south of Algiers.

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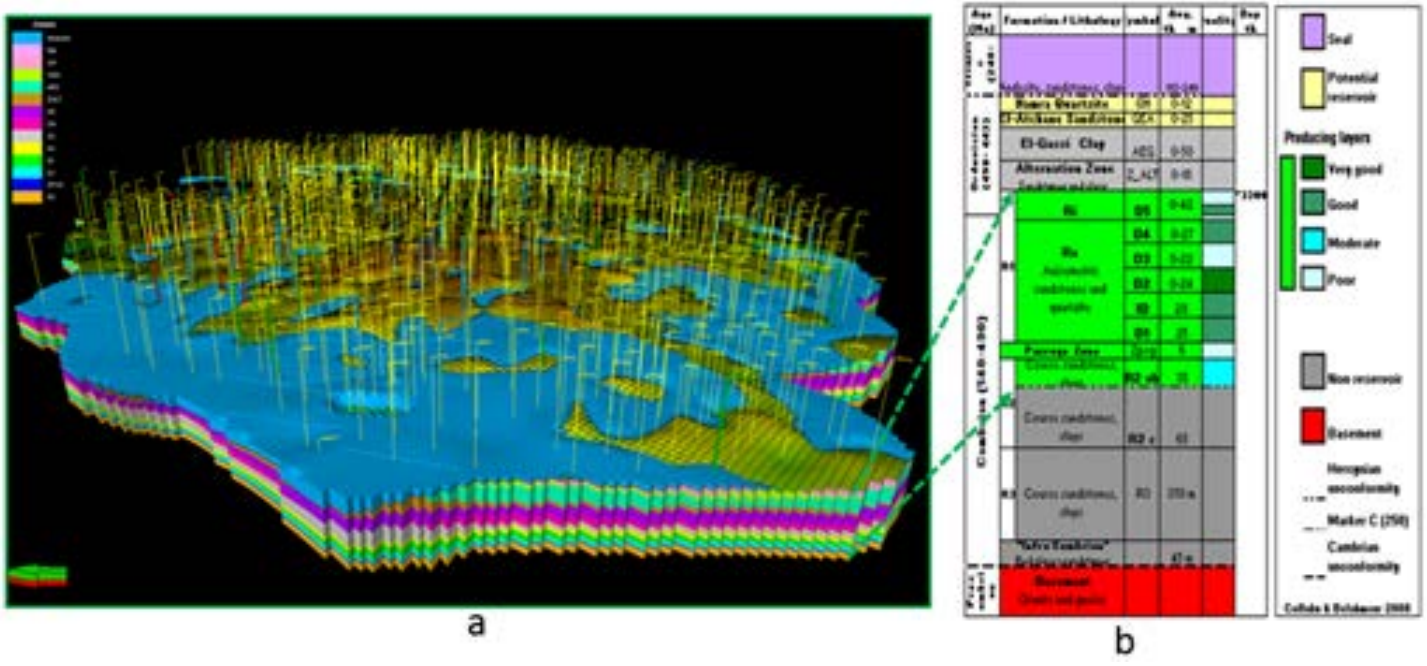
HMD Reservoirs



a b

The main reservoir is the Cambrian sandstone and second target the Quartzites of Hamra. Cambrian sandstone forms a flattened anticline. The production comes from D1, ID, D2, D3, D4, D5 and upper part of R2. The maximum thickness of producing layers is 200 m but due to Hercynian erosion (which can reach top of ID) this thickness, in some parts of the reservoir, is reduced by half, the location of which is difficult to predict due to lack of resolution of the seismic data.

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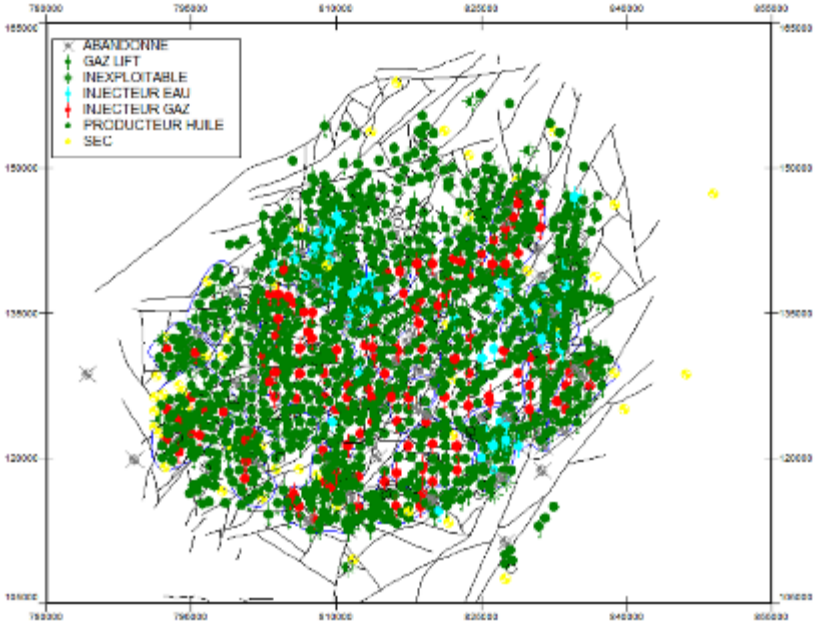
HMD Current production & Objectives

HMD field was discovered in 1957 and put on production in 1958. Since more than1500 wells have been drilled from which today: about 1120 producers (natural flow, gas lift and so called “fermés - about 300 wells mainly affected by sever gas or water breakthroughs), 120 Gas injectors, 60 water injectors, 100 dry and unexploitable and about 90 abandoned.



Maintain and Increase the production in HMD region fields is the objective of Sonatrach DP HMD.

To achieve this objective, DP is also working with the main services companies. The join team Sonatrach DP – Schlumberger called TAO (Technical Assistance on Operations) is based in our office in HMD and working in daily basis with our engineers with the moto:
“one team, one objective”.

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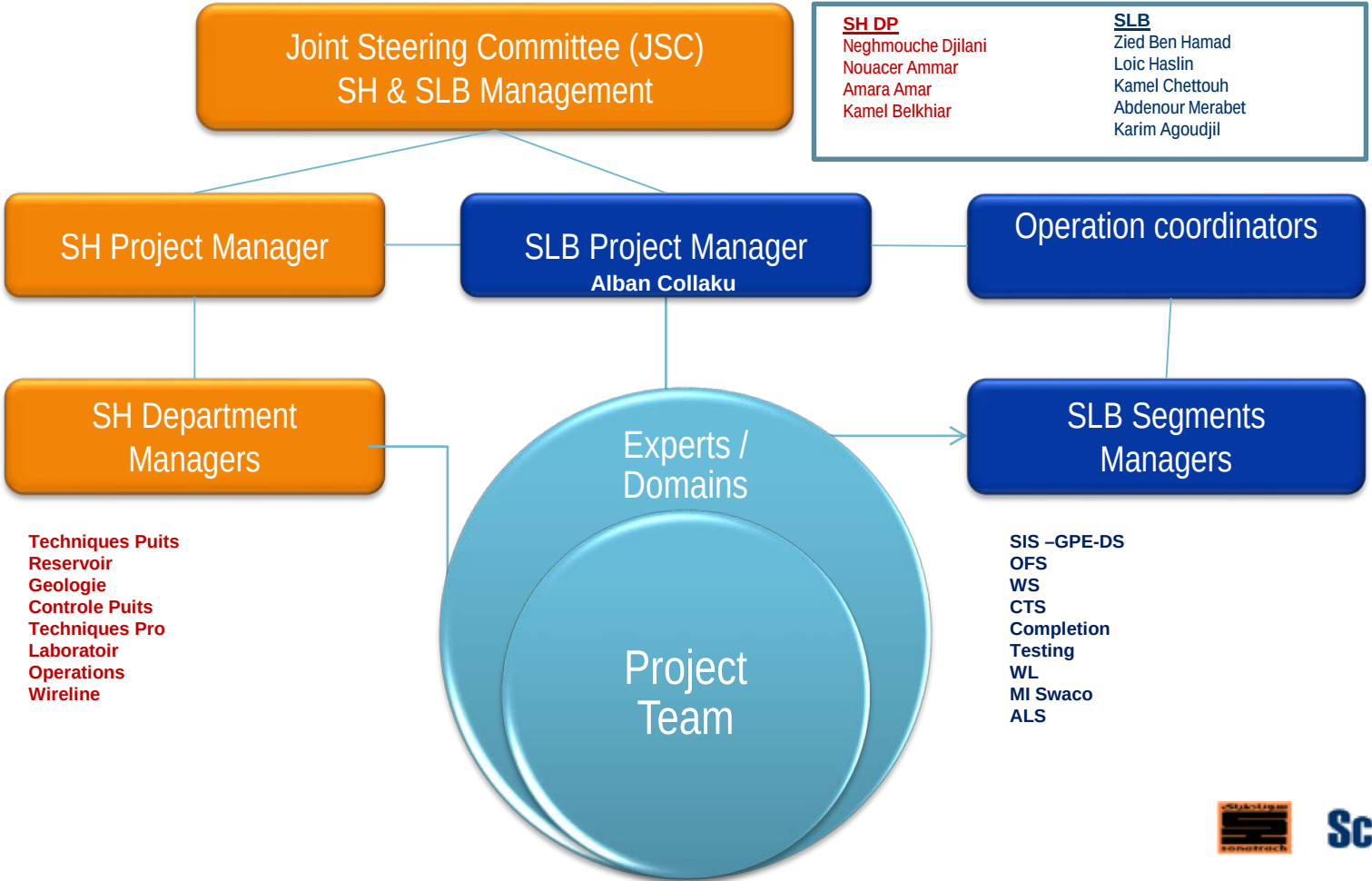
TAO Project Organization



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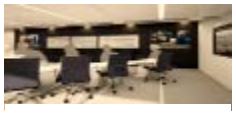
Approach

from study to implementation and from reservoir to surface network.



From study to implementation Approach

Structured Available Information

Field Challenges

Integrity & Safety
- Accessibility
- Fish, Corrosion
- Leak Detection

Well by well analysis
- Clean out, Reformat
- Acid treatment
- Perforation
- Hydraulic Fracturing
- Multistage Completions
- Short Radius Reentry

Reservoir Management
- Pressure Support
- Water Flooding,
- Gas Injection
- Reservoir Sweep,
- Water Fingering
- Enhanced Oil Recovery (EOR)

Flow Assurance
- Salt, Asphaltenes, Scales Inhibitors, Hydrates, Wax
- Instabilities, Slugging, Pigging Network simulation
- Facilities & well Interaction

Surveillance
- Instrumentation/Metering
- Virtual Metering
- Equipment Performance

Lifting & Pumping
- ESP, Gas Lift
- Multiphase Boosting

Fluids & Chemistry
- Water Demineralization to Prevent Sulphate Scales Formation

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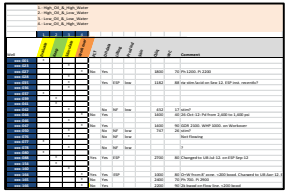
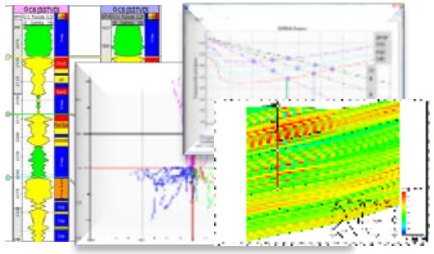
Well by well analysis workflow

Ranking



Check list of the candidates

Double Check with SH-DP



Detail analysis / Solution categories

TAO Brainstorming

Present to SH-DP

Technique Puits & Reservoir Department

Submit final proposal

Follow up the Execution

Analyze of the results

Screening | **Engineering study** | **Execution and Follow up**

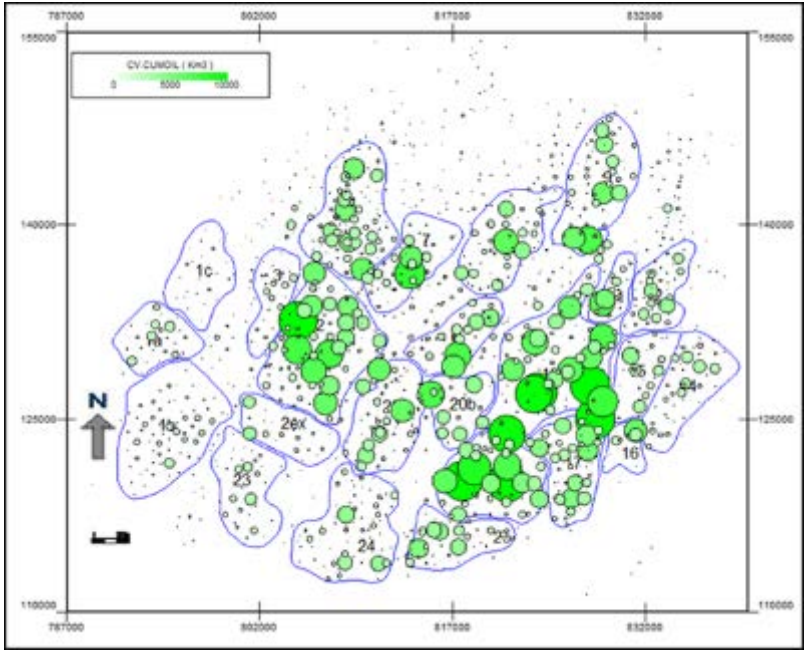
Production Enhancement Interventions

Core from the well MD 340

Heterogeneity of the reservoir, combined with sever Flow Assurance issues make the exploitation of HMD field very challenging requiring a well by well analysis for any production enhancement interventions.

Depending on the issue the recommendations can be:

- Matrix treatment (Clean out, Reformat, Acid)
- Perforations
- Hydraulic fracturing
- Multistage Fracturing Completion
- Short Radius re-entry
- ESP installation and Gas lift optimization
- Well tests (Build up, PFS, Vx…), PLT, FSI, RST



Cumulative production map of HMD field.

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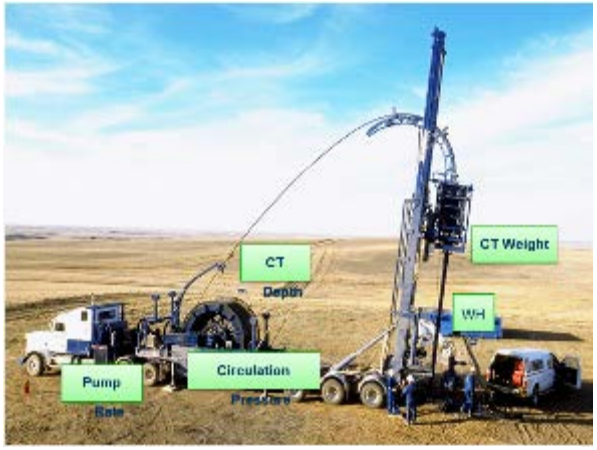
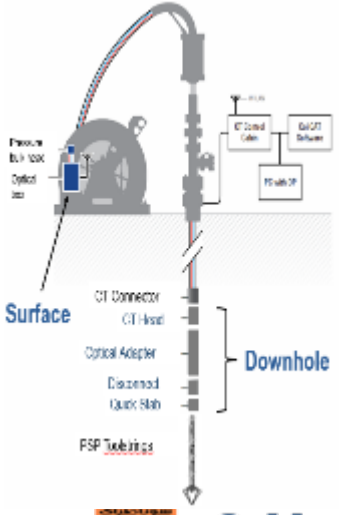
Matrix treatment **operations**

TAO Tasks:
- Selection of well candidate for Matrix treatment
- Preparation of the execution program, job procedure
- Follow up the execution



- The frequent CT operations in HMD field are:
  - TubeClean with JetBlaster
  - ScaleBlaster
  - Clean Out
  - Nitrogen Kick Off
  - Reformat Treatment
  - Mud Acid Treatment
  - MudClean
  - CleanSWEEP
  - Cement Plug
  - Sand Plug
  - Water Shut off
  - Set Plug
  - Velocity String
  - Fishing
  - ACTive casing patch for Gas shut off
  - ACTive for run FSI Logging
  - Logging with E-line
  - ACTive run CoilFLATE (Inflatable packer)
  - Bullhead pumping services



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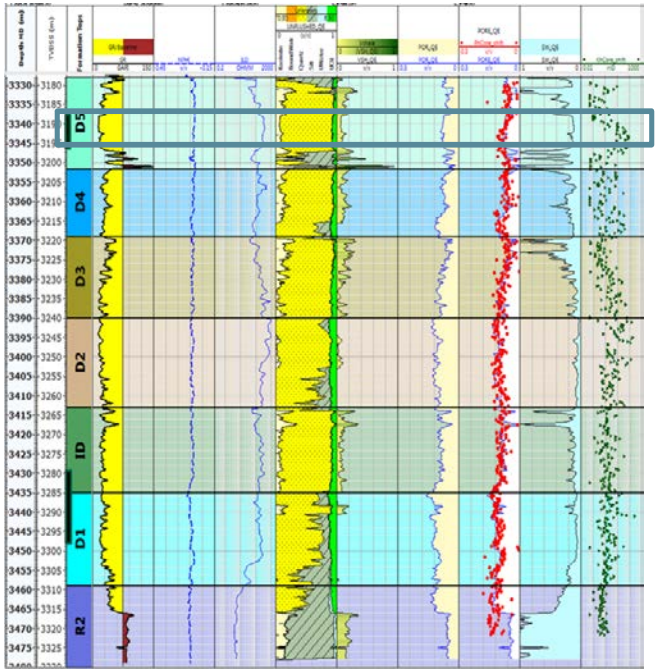
Perforations / Case study

TAO Tasks:

- Selection of the well candidates and the best intervals.
- Follow up perforations design and execution.

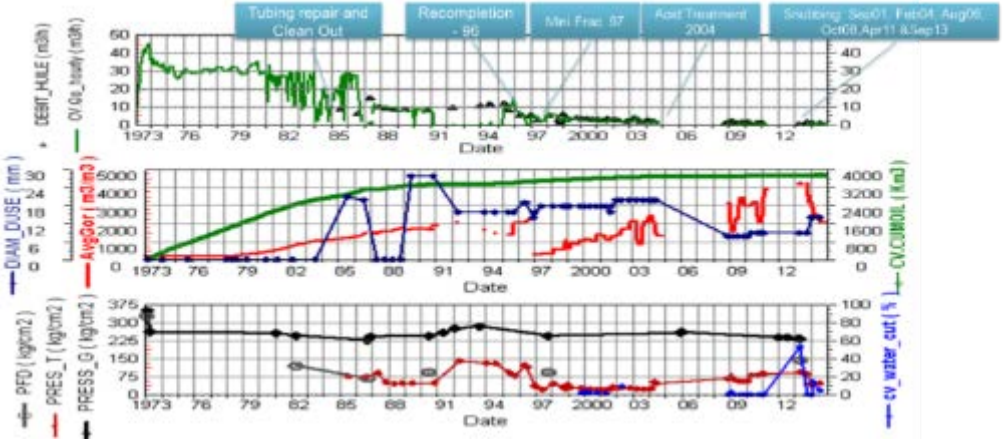


Well A Case study

Drilled in 1980. Side-track in 1996, LCP, gas breakthrough from D2 and D3 drains.

Issue: Low productivity but high GOR.

Proposed Intervention: Re-perforate D5 interval



Oil gain 2.3 m3/h

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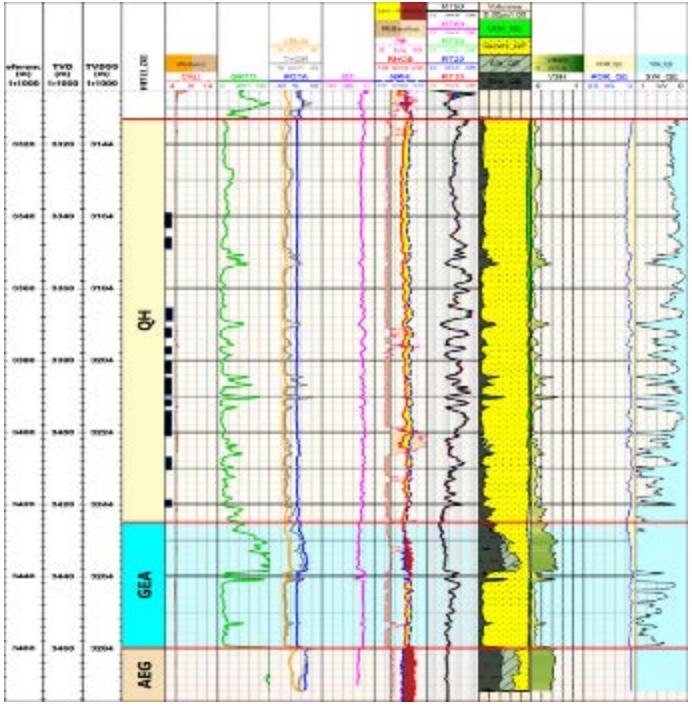
Hydraulic Fracturing / case study

TAO Tasks:

- Selection of the well candidates for HF
- Follow up on Hydraulic Fracturing design.
- Introduced HiWay HF technologies.



Well B case study

Well drilled in Sep. 2012, has not produced during its history, mainly due to poor rock quality. Some operations including clean out and reformat are performed without gain.
In order to improve the deliverability of the well it is recommended to perform Hydraulic Fracture at top HQ.

Oil production increased by 8 m3/h

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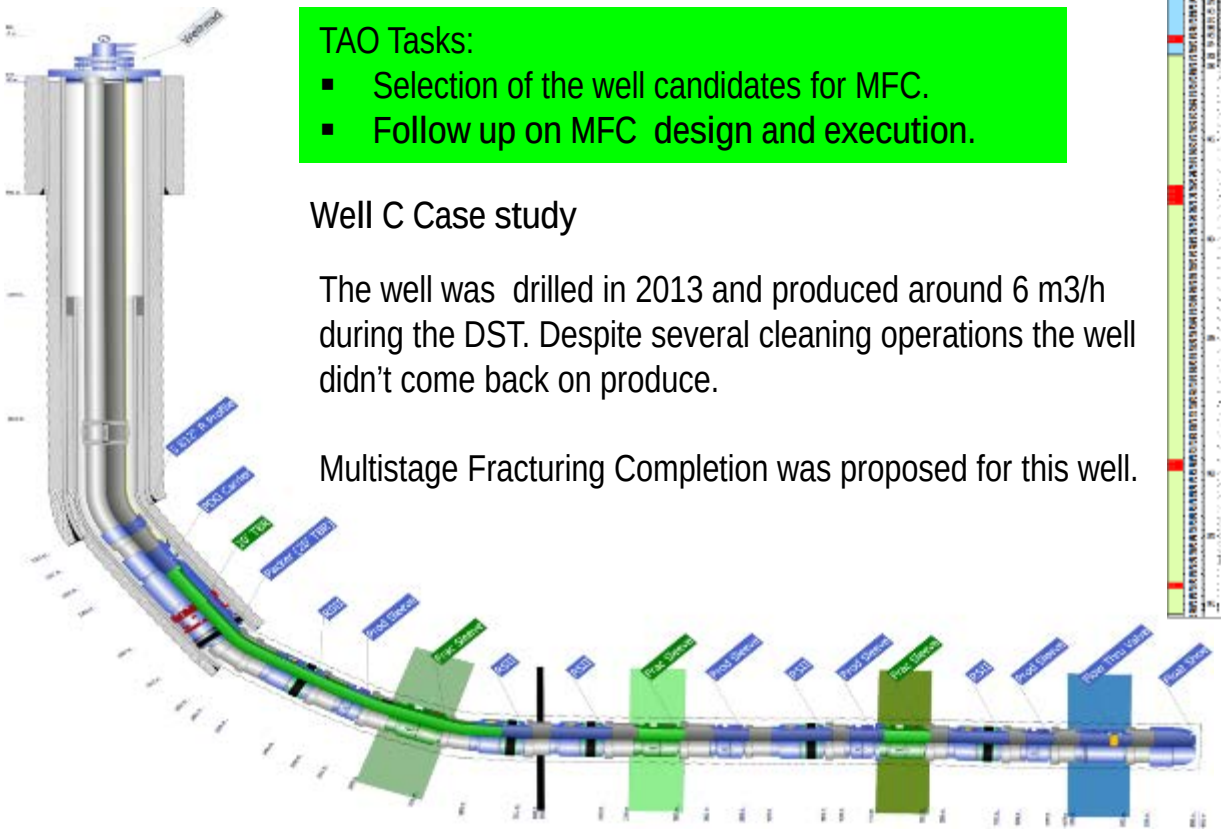
Multistage Fracturing Completion / Case study



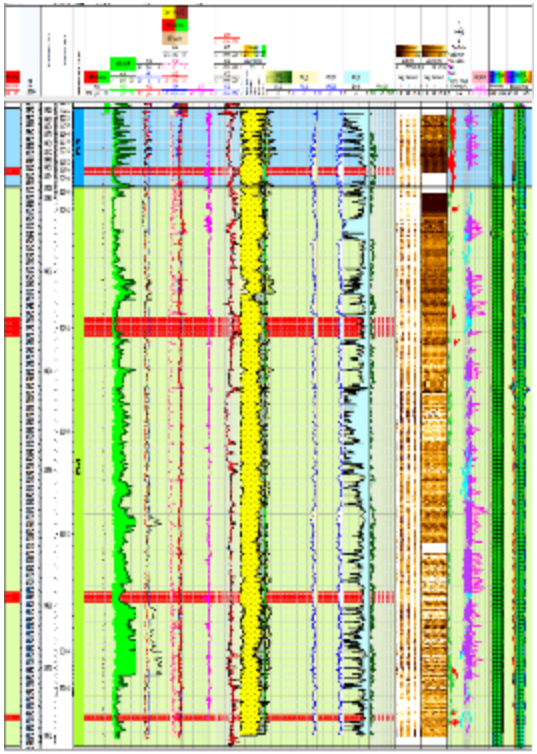
TAO Tasks:

- Selection of the well candidates for MFC.
- Follow up on MFC design and execution.

Well C Case study

The well was drilled in 2013 and produced around 6 m3/h during the DST. Despite several cleaning operations the well didn't come back on produce.

Multistage Fracturing Completion was proposed for this well.



Oil gain expected by 5 m3/h

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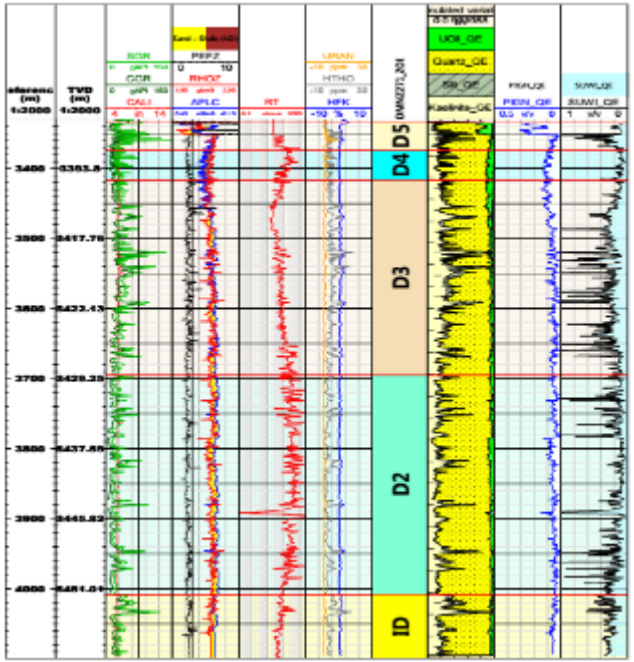
Short Radius re-entry / Case study

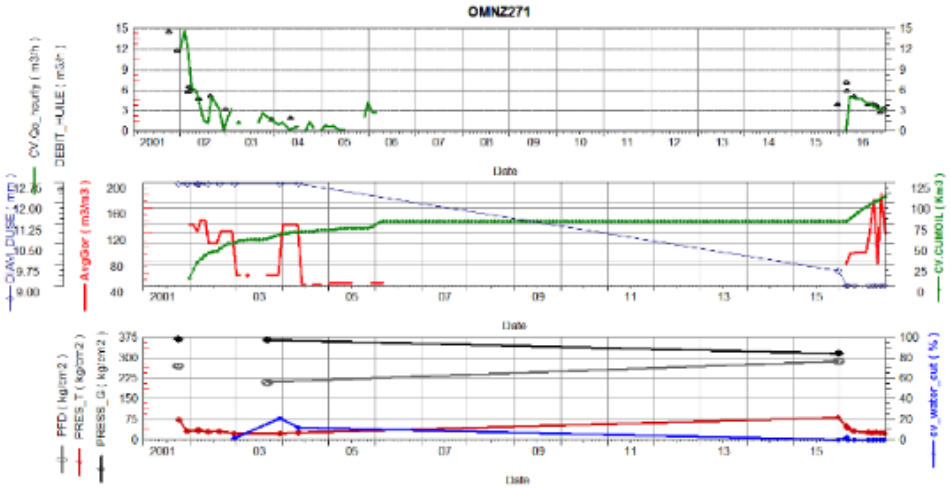
TAO tasks:

- Selection of the well candidates for SR
- Following up the execution and analyze the results



Well D case study

The well had fish in it and attempts to remove the fish was not successful, hence it was decided to complete the well as SR.



Target Interval TVD (m)	Azimuth	Horizontal extension (m)
3383 m to 3388 m	N150	400

Oil gain 6 m3/h

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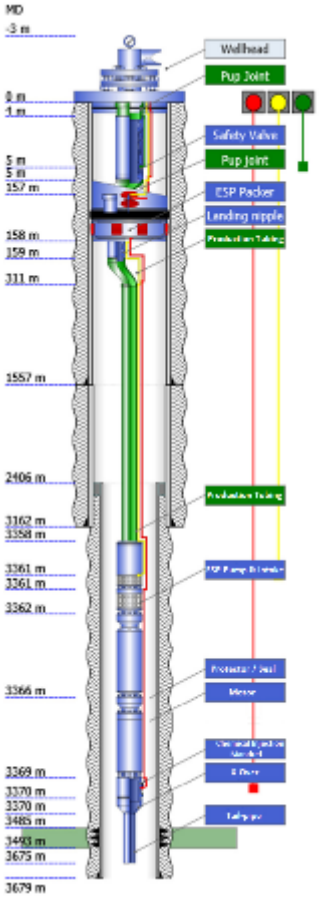
ESP Application / Case studies

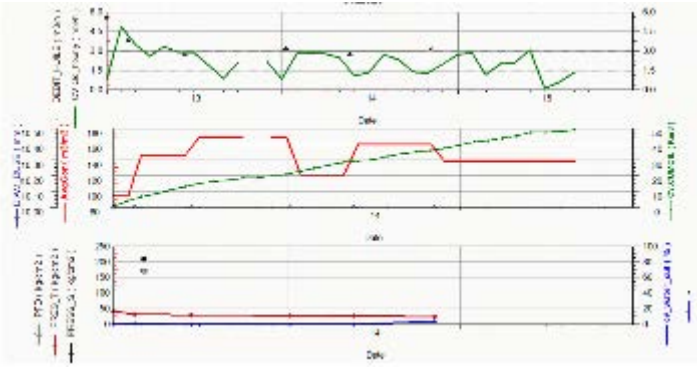


TAO tasks:

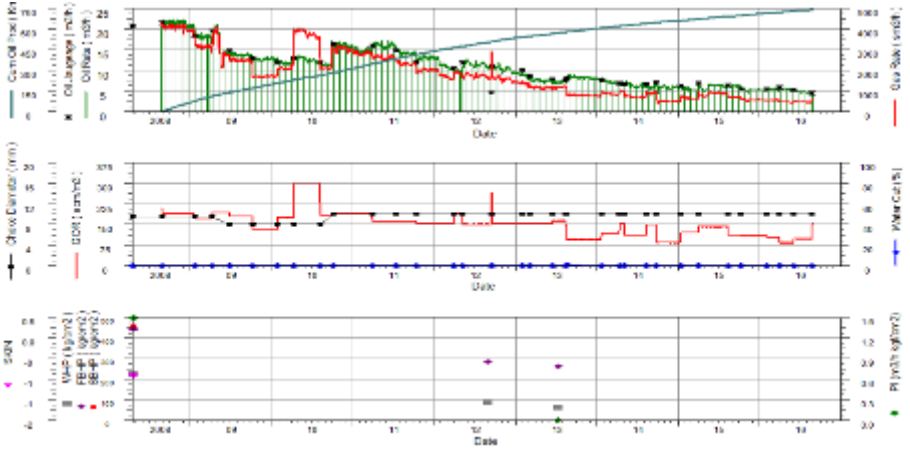
- Selection of the candidates for ESP.
- Follow up on ESP design and installation.

Well F & G case studies

Two ESP have been installed in wells F and G for the first time in HMD field based on the candidate selection by the team. They have given very good results demonstrating the efficiency of joint work between the two companies.



Production performance of the well F & G



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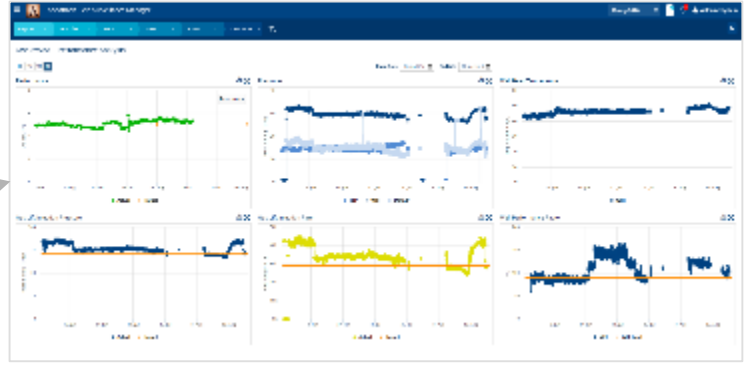
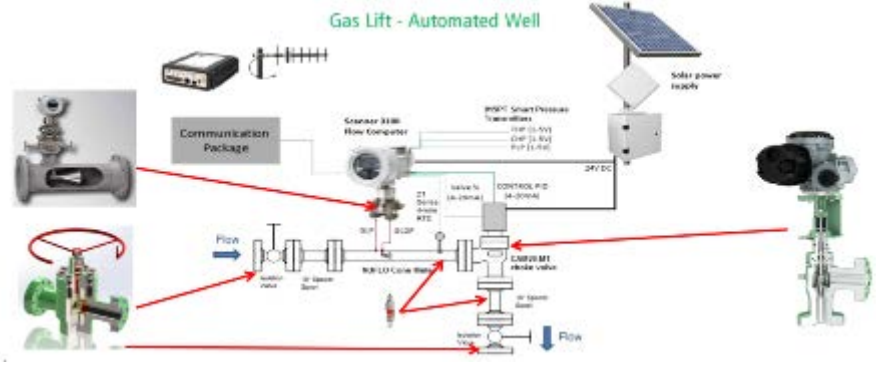
Real Time Well Surveillance / GL Automation Valves / Network modeling

Real Time Well Surveillance

WHP, WHT, FLP,
GLIP , GLIR



Proposed solution
for Gas Lift – automated well

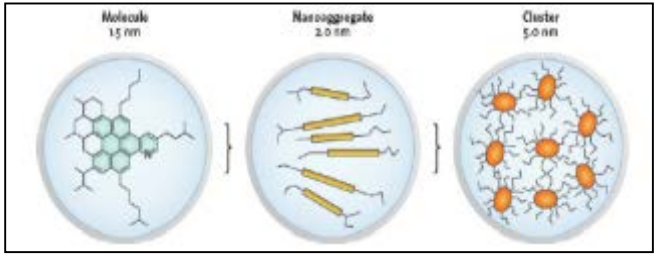


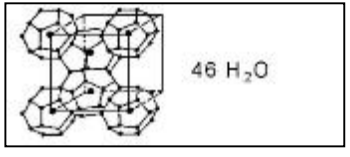
Z-CINA network modeling completed

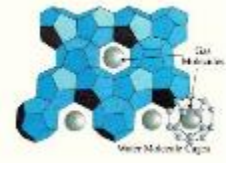
Flow Assurance Analysis and Propose solutions

Principal Flow Assurance Issues Affecting HMD field

- Asphaltene
  - Complex, high molecular weight hydrocarbon class
  - Tends to precipitate and aggregate into solids during:
    - Pressure depletion, temperature change
    - Mixture with gas or paraffinic hydrocarbons
- Salt / Halite and Barite Scales
  - NaCl solid salt forms from high-salinity water flows
  - Barium& calcium sulphates form in mixing incompatible waters
- Hydrates
  - Gas-water complexes forming at interfaces and agglomerating
  - High pressure & moderate-to-low temperature conditions
- Formation solids
  - Sediments, fines, clays, sands that migrate and/or produce from the reservoir







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Asphaltene / New dispersant & inhibitors

Example of FSI logging tools Plugged with Asphaltene in HMD

Standard treatment : Reformat and Xylene
(risky during the operations in the summer time)

New products proposed

- PI-7220 as dispersant (Batch treatment, batch clean, squeeze into formation)
- PI-7269 inhibitor Continuously as preventive solution(through the capillary system).

Status :The well has been selected for a Field Test of Asphaltene inhibitor.

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Salt and Scale BaSo4 issues / Proposed new products

Salt (NaCl) issues

HMD formation water is with high salinity 320 g/l, results on salt (halite) precipitation in the wellbore and the tubing. The precipitation increases with decreasing temperature and pressure.

Standard treatment

Frequent to continuous water clean-out with treated water. This treatment is expensive and with the time not sufficient to gain production improvement.

Alternative solution

Alternative solution for salts treatment have been proposed. One of them is the Halite inhibiting (Process number 3141). This product should be injected continuously through a capillary at rate of 300-500ppm.

Scale (BaSo4) issues

BaSo4 which is real issue for perforation, sand face, slotted liners, valves, production tubular and pipelines is created by mixture between the injection Albian water rich in SO4- (used for desalination) and formation water rich in Ba2+.

In HMD field there about 180 wells with continuous water injection for desalination.

- 74 wells in Gas-Lift and
- 106 wells on natural flow.

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New Alternative for Water Demineralization

Today situation

Antidepot (Antidepositon)-AD32

- To avoid formation of BaSO4 and CaSO4

Anticorrosion Inhibitor

- To avoid inner corrosion

Anti Bacterial Inhibitor (SRB)

(Sulphate Reducing Bacteria) - to avoid bacterial corrosion

Proposed solution

Ion Exchange Resins

-To avoid formation of BaSO4 and CaSO4

A real plant

Anticorrosion Inhibitor

- To avoid inner corrosion

Anti Bacterial Inhibitor (SRB)

(Sulphate Reducing Bacteria) - to avoid bacterial corrosion

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Results

- The production increase from the wells proposed intervention by the team was about 4000 bbls / days in 2015 and 5000 bbls / days in 2016.
- Two ESP have been installed for the first time in the field with good results.
- HF HiWay, Multistage Completion, CT ACTive, Casing patches …, and new software (Olga) have been implemented.
- Ion Exchange Resins for Albian Water demineralization, new salt / asphaltene inhibitors have been proposed.
- Real Time Well Surveillance for GL wells have been put in place.
- Z-CINA Network modeling was completed.

Way forward

In order to maintain the production Sonatrach DP is working on most advanced technology and approach with a short, medium and long term strategy for production enhancement, which can be summarized as:

- Use advanced technologies for Hydraulic Fracture in order to increase the efficiency of HF operations,
- Investigate for new products for salt, asphaltene and Sulfate Barium treatments.
- New alternative for Albian water demineralization to prevent sulphate scales formation.
- Modeling and optimization of network pipeline using advanced software with the main objective to identify and resolve the issues of production fluctuation and back-pressure.
- Diversifying the artificial lift production methods by introducing Electrical Submersible Pumps.
- Increase the number of multiphasic surface pumps,
- Implementation of Dual (parallel) Completion for the wells needed GL and continuous water injection for desalination,
- Multistage & Smart Completion for oil and water production control,
- Gas and water shut off (casing patches, polymer, cement, expandable patch)

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Thank you