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Modeling of Nakhla Oil Field by using water flooding (EOR), Sirt Basin (Libya).

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Abstract

The Nakhla Oilfield is located in concession 97 within the Sirte Basin about 60 km south of concession 96. The field was discovered by drilling G1-97 in 1970. 13 wells were drilled to date nine of them are producing on natural flow, there found volcanic or volcanoclastic sediments replacing the entire or at least the oil-bearing, upper part of the reservoir.

All wells are producing from the Lower Cretaceous Sarir Sandstone. Low porosities of 10 to 14 % and poor permeabilities ranging from 0.1 to 20 md only allow a moderate production. Therefore hydraulic fracture stimulation of seven vertical wells was performed between 1995 and 2002.

State-of-the-art real-time analysis was performed in all hydraulic fracture stimulations to evaluate and optimize the fracture operation on-the-fly. Hydraulic fracture simulation findings were compared to post-fracture well test results obtained from pressure buildup analysis. Within their limits of accuracy the fracture parameters obtained by both methods match reasonably well.

Prepared for the Future.

Nakhla Oil field is produced from a solution gas drive reservoir generally are considered the best candidates for water floods. Because the primary recovery will usually be low, the potential exists for substantial additional recovery by water injection. In effect, we hope to create an artificial water-drive mechanism. The typical range of water-drive recovery is approximately double that of solution gas drive. As a general guideline, water floods in solution gas-drive reservoirs frequently will recover an additional amount of oil equal to primary recovery In the Sarir sandstone, which is subdivided into three distinct producing horizons, Field tectonics are Complex, with a major field bounding fault to the southwest and other faults which subdivide the Reservoirs into numerous compartments. Wintershall has drilled and fracture stimulated a number of vertical wells in the Lower Cretaceous Sandstone ,Formation at a depth of approximately 12000 feet, Nakhla model was done and modeled by consists of zones, Layers and Faults, wells tops well heads, well location, well stratigraphy and logs with total number of cells 7779130,by using commercial software petrel 2009.1.1 (Static geological model) and then up scaled and Exported to commercial software Eclipse 2009 .1.1 for (dynamic model EOR Method).

The model includes 8 wells, for each well a complete set of electrical logs, deviation, core and facies related data is available. The reservoir sections of all wells have been completely petrophysically re-evaluated, and for giving many results facies model has been established by the sequential indicator simulation methodology. The data was extensively analyzed, transformations applied and variograms estimated and modeled. Parameters for porosity, permeability, flow zone indicator and water saturation were co-simulated. Hundred of realizations were run to better quantify uncertainty, then used 5 pattern and 7 pattern in Eclipse for this thesis with 2000, 3000, 4000 ft distance between producers to injectors and 6 cases were run to see the optimum flow rates and optimum water breakthrough with small amount of residual oil left behind .

Geology

Located in the Hameimat Trough in the South-East of the Sirte Basin in the Concession 97 (Fig. 1), the Nakhla Oilfield was found by drilling well G1-97 in 1970. The development of the field started in 1993.

The main productive formation is the so-called Upper Sarir Sandstone, which is forming the uppermost layer of the Sarir Group. The Sarir Group consists of two sandstones (Upper and Lower Sarir Sandstone), which are separated by the Sarir Shale Member. The Upper Sarir Sandstones is well consolidated sandstone, which can be described as deposits of an ephemeral fluvial system, with channels, sheet flood and interchannel sand flats. Thus, clean sandstone layers alternate with shale streaks. It was deposited in the Early Cretaceous (eventually Late Jurassic) age.

Reservoir Parameters.

The Upper Sarir Sandstone in the Nakhla oilfield is at a depth of 11,700 to 12,500 ft. The net pay is in the range of 130to400 ft, the porosity is 10 % to14 %.Reservoir parameters and especially average permeabilities are improving from NW to SE, while higher pay heights have been drilled in the Northwest compared to Southeast. The permeability range is from tight (0.1 md) to fair (20 md). The main reservoir parameters are summarized in Table 1.

Oil Properties.

The oil is a light oil API gravity of about 42°. Due to paraffins and waxes pour point is high with about100°F. Live oil viscosity is low, 0.35 cp at initial reservoir conditions. The oil properties are summarized in Table 2.

Conclusions and Recommendations.

1. The uses of dynamic model is applicable for field water flooding in future .

2. Water flooding is more used worldwide because is cheap and availability of water sources and also improves the economics of field development and even enhances the recoverable oil reserves.

3. Best results can be expected from water flooding if the mobility ratio was preferable and residual oil saturation was zero in optimum cases.

4. From stochastic sequential indicator many variograms were calculated with sill and nugget

5. Hydraulic fracturing should be applied early in the Lifetime of a well.

However, 5 patterns and 7 patterns wells locations have to put in consideration the cost of number new wells drilled and converting from injector to producer

and also with a strong underlying aquifer and/or existing gas cap water conning and gas conning problems Have to be studied carefully to avoid those happened and otherwise squeezing the perforations must be done, since changing (oil-water or gas-oil) fluid levels will at a point in time cone into the frac with max flow rate production . If this occurs the unwanted phase might be preferentially be produced instead of the oil.

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Иллюстрации

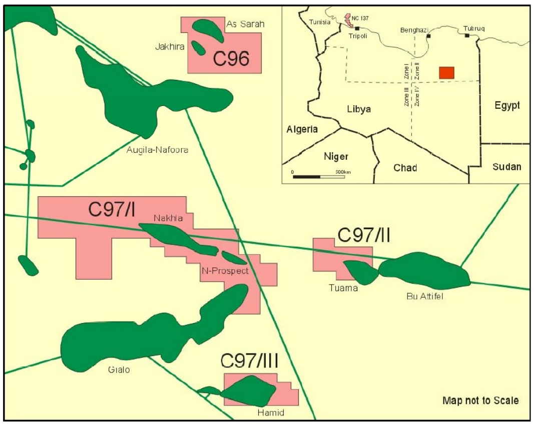

Рис. 1: location map of Nakhla Oilfield and the adjacent oilfields within Libya.

SI Metric conversion Factors

bbl	× 1.58984	E-01	= m³
cp	× 1.0*	E-03	= Pa · s
ft	× 3.048*	E-01	= m
lbs	× 4.53592	E-04	= ton
lbs/ft²	× 4.8824		= kg/m²
ppg	× 1.19826	E-01	= ton/m³
psi	× 6.89476	E-02	= bar
rb/stb	× 1.0*	E-00	= m³ (V_n)/m³
scf/stb	× 1.781	E-01	= m³/m³
(°F - 32)/1.8*			= °C
141.5 / (131.5 + °API)*			= g/cm³

*Conversion factor is exact.

TABLE 1-RESERVOIR PARAMETERS OF UPPER SARIR SANDSTONE (NAKHLA OILFIELD)

Age	Lower Cretaceous (or Late Jurassic)	
Depth	3565 – 3760 m ss	11,700 to 12,330 ft ss
Area above OWC	60 km²	14,700 acres
Net Pay	40 – 125 m	130 – 400 ft
Porosity	10 – 14 %	0.10 – 0.14
Permeability	0.1 – 20 md	0.1 – 20 md
Initial Water Saturation	30 – 55 %	0.30 – 0.55
Initial Reservoir Temperature	140 °C @ 3703 m ss	284 °F @ 12,150 ft ss
Init. Reservoir Pressure	414 bar @ 3703 m ss	6000 psi @ 12,150 ft ss
Initial Oil In Place[1]	148 MM m³	933 MMstb

Рис. 2: TABLE 1-RESERVOIR PARAMETERS OF UPPER SARIR SANDSTONE (NAKHLA OILFIELD)

Status July 2002.

TABLE 2-OIL PROPERTIES (NAKHLA OILFIELD)

Oil Gravity	0.810 – 0.816 g/cm³	42 – 43 °API
Pour Point	+40 °C	+104 °F
Viscosity @ In Situ Conditions	0.35 mPa · s	0.35 cp
Gas-Oil-Ratio	223 m³ (V_n)/m³	1250 scf/stb
Formation Volume Factor	1.65 m³/m³	1.65 rb/stb

Рис. 3: TABLE 2-OIL PROPERTIES (NAKHLA OILFIELD)