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Optimisation of Development Plan of Serie Inferior (Triassic Inferior) In Hassi R'Mel South, Algeria

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Abstract

The Hassi R'Mel South field was discovered in 1971 with drilling of HRS1.

Additional delineation wells were drilled and production from the oil rim started in 1991 from wells HRS 8 – HRS13 and HR162.

Currently the field is producing from 7 wells and two separated oil accumulations.

The field is a highly faulted system; where the major fault directions are NNW – SSE, with high through; witch result in a horst-grabben system.

We note that the facies and the sandstone thickness of the Serie Inferieure (Triassic Inferieur) are variable, especially in the Northern part of the field where the sandstone disappear and shale and siltstone take place.

A geological model was necessary for the estimation of the oil in place.

The RFT test obtained from HRS4, HRS7, and HRS11 helped in the determination of the fluid contacts in the following sector.

The GOC obtained by the RFT on well HRS7 was at the depth of 2185.56 m (-1482 m).

The WOC obtained from well HRS4, HRS8, and HRS11 by RFT was at a 2259.4 m (-1511 m) and 2166.44 m (-1513 m)

According to the RFT results; the oil accumulation in the Serie Inferieure is mainly concentrated on the sector contains wells : HRS4 , HRS7 , HRS11 , HRSI3 , HRS21 and probably HRS1, those last wells have been a subject of detailed sedimentologic and petrophysic study.

The sequential analysis based on the core data description of the studied wells and log data, have permitted to put in evidence four main units (sequences: S1 - S2 – S3 – S4), and each sequence is subdivided into sub sequences to constitute a group of 12 positive sequences.

The development plan optimisation of the Serie Inferieure based upon the geological model, rock characterizations; PVT, fluid contacts and build up from HRS7 have permitted to determine the optimum number of wells and adequate spacing between wells.

For the purpose of the study A BLACKOIL simulator has been used; where the geological model has derived from two different platforms: RC2 and RML

A lot of sensitivities have been run to obtain reasonable results during 20 years of exploitation for cast.

As conclusion, an optimum development programme is derived from this study, this help us for a better development of the **SERIE INFERIEUR** in Hassi R'Mel South field.

A new well has been drilled (HRS25) based on the new development plan and the results were: Net thickness = 6 m of oil. It is encouraging to drill another wells.

Objective of the Study

The predominant objective of this study is to characterize the Triassic reservoir Serie Inferieure of Hassi R'Mel south Algeria and adding another wells to development plan to improve the oil recovery and have the best economic profile.

Introduction

Hassi R'mel South is a north/south trending faulted anticline located on the southern flank of the giant Hassi R'Mel field located approximately 500 Km South of Algeria in Northern Grand Erg occidental of Algerian Sahara.

Producing testing and pressure data indicate that HRS is not in communication with Hassi R'Mel field through the hydrocarbon column. The reservoir **SI** sandwiched between reservoir **A** and Cambro-ordovician There are a large gas cap support and a bottom aquifer through out the entire oil rim. The net thickness of the oil column ranges from 2 to 6 meters with an average permeability of 50 md.

All those factors made the necessity to develop the reservoir Serie Inferieur in Hassi R'mel South field

by implementing horizontal wells, in addition to vertical wells (Mixed Development Strategy), to improve the oil recovery in one hand, and to reduce water and gas coning problems.

OVERVIEW OF THE SERIE INFERIEUR (SI) :

The **SI** formation is formed about an alternation of shale and clean sand on the bottom and on the top of reservoir we have the Andesite.

The **SI** is located in south and on the easthern flank of Hassi R'mel field.

It is sometimes discordant on the Silurian black shale (Gothlandian) and sometimes on the sand- quartzite of Cambro-ordovician.

The sandstone thickness of Serie Inferieur is between 2m and 28m.

The RFT analysis disclose two fluids contacts in this area:

OGC = -1482 m (sub-sea)

OWC = -1513m

The **SI** pressure is about 311kg/cm2.

STRUCTURAL ASPECT

The structural map on the sandstone top of reservoir **SI** shows anticlines structures where the top is on the front of well HRS04 on the hand and HRS08 in the other hand.

These structures are trancated by normal faults that formes compartiments on the HRS sector (fig 1).

SEDIMENTOLOGIE CHARACTERIZATION

1-SEQUENTIELLE ANALYSIS

From the RFT results, it shows the oil accumulations of the **SI** are delimited by the sector of wells: HRS4, 7,11,3,13,21 and probably HRS1.

All these wells were subjected to detailed sedimentological and petrophsical study.

The sequentielle analysis based on the core description of the studied wells and log curves have permetted to put in evidences four (4) major Units:

(Sq1, Sq2, Sq3, Sq4) each one of them is subdived in Sub-Units, resulting in a total of twelve (12) positive sequences (tab1).

The **SI** formation started in the top by the grey fine sand,whith trough at the bottom of the sequence and ripples marks at the top.

Then the silstone and green shale on the top.

Silt and green shale in the top

Grey fine sandstone with trough in the bottom and ripples marks in the top

This alternation of sand and shale is crown by andesite.

The stratigraphical correlation from the North – west to South – East of the serie Inferieure sandstone reservoir shows the lateral extension of the different sequences and their lateral thickness variations (fig 3).

The serie inferieure formation is rarly complete. As it is showed by the composite log (fig 2) and cross sections; that means the 12 sequences aren't evident to be detected on the overall wells, this is due probably on the deposition mode and/or tectonic events, sedimentary tectonic, that affect the formation during or after the sedimentation.

2- DEFINITION OF THE DIFFERENT LAYERS

The sequentielle analysis has denealed that the serie inferieure is composed by 12 positive sequences formed by sandy banks at the base surmont by siltstone and shale .

The petrophysical characterization of these sandy banks of the **SI** has permetted the estimation of the oil reserves in place (tab 1 , 2).

Units	Sub-units	layers	HRS 1	HRS 3	HRS 4	HRS i3	HRS 7	HRS 9	HRS 11
S4	S4.4	L4.4				x			
	S4.3	L4.3		x	x	x	x		x
	S4.2	L4.2		x	x	x	x		x
	S4.1	L4.1	x	x	x	x	x	x	x
S3	S3.3	L3.3		x		x		x	
	S3.2	L3.2		x	x		x	x	x
	S3.1	L3.1	x	x	x	x	x	x	x
S2	S2.3	L2.3	x		x	x	x		
	S2.2	L2.2	x	x	x	x	x		x
	S2.1	L2.1	x	x	x	x	x	x	x
S1	S1.2	L1.2	x		x				
	S1.1	L1.1	x		x				

Tab1: The differents sequences and layers of serie inferieure

RESERVOIR CHARACTERISATION

1-LOG INTERPRETATION

The petrophysical interpretation of 8 wells spreaded along the Hassi R'Mel field showed a good petrophysical parameters (fig 4).

In fact the porosity of each layer varie from 10% to 17%.

The volume of clay (VCL) is between 8% to 37%.

The water saturation (SW) varie from 31% to 62% This saturation can explain the high volume of shale .

The permeability (K) is not too high .It varies from 0.1 to 127 md. In fact it is affected by shally ciment.

In particular part of the field, the presence of salt in the matrix has been put in evidence by differents cross plots, this factor affects the permeability too.

After application of differents cut off (VCL< 40% , porosity>4% , SW<65% and K>1md) the net thickness calculated varies from 5m to 11m.

The petrophysical analysis showed clearly that the reservoir parameters are acceptable and could be more interesting one moment been taken into account.

2- BUILD UP INTERPRETATION

HRS7 was the well chosen to be tested on basics that it's the only well completed in the serie inferieure. The goal of this build up is to know what is the average permeability in the study sector,and the production potential of this serie inferieure (fig 10).

LAYER 1-1 and LAYER 1-2

These layers are determined only in HRS1 and HRS4. They present a bad characteristics.

WELLS	HRS1				HRS 2			
Parameters	HT	PH	K	HU	HT	PH	K	HU
LAYER L1.1	3.12	14.6	4	1.7	1.13	<4	<0.1	0
LAYER L1.2	3	10.5	0.1	0.22	2.45	<4	<0.1	0

LAYER 2-1

The gross thickness varies from 0.93 to 2.84m.
The porosity is good.
The permeability varies from 1md to 20 md.
The net thickness varies from 0.5 to 1.73m.

LAYER 2-2

The gross thickness varies from 1.63 to 3.85m.
The porosity is good.It is about 17%.
The permeability is about 129 md in the well HRS21 but it is average in the rest of the area.
The net thickness varies from 0.1 to 3.85m.

LAYER 2-3

The gross thickness varies from 0.91 to 2.31m.
The porosity is average.
The permeability is about 1md.
The max imum net thickness is 0.98m in HRS1.

LAYER 3-1

The gross thickness varies from 1.06 to 3.6m.
The porosity is good, it's > 10%.
The permeability is about 33md.
The net thickness varies from 1.06 to 2.9m.

LAYER 3-2

The gross thickness varies from 0.77 to 5.74m.
The porosity is good and the maximum value of it is about 16.5%.
The permeability varies from 2md to 118 md.
The max imum net thickness is 5.74m in HRS7.

LAYER 3-3

The maximum gross thickness of this layer is about 3.91m.
The effective porosity of this layer in his lateral extension is about 12.23%.
The average permeability is 65md.
The average net thickness is 2.51m.

LAYER 4-1

The gross thickness varies from 2.17 to 3.38m.
The average effective porosity is 11.64%.
The average permeability is about 23.33md.
The averagenet thickness is about 1.92m.

LAYER 4-2

The gross thickness varies from 0.55 to 1.46m.
The porosity is good and his max value is 16% in HRS4.
The permeability is about 48md.
The net thickness varies from 0.27 to 1.26m.

LAYER 4-3

The gross thickness in average about 2.28m.
The porosity is 10.46%.
The permeability is between 1md and 14 md.
The average net thickness is 1.99m .

LAYER 4-4

This layer is detected only in HRSI3.
The petrophysical parameters of this layer are medium (tab).

	HT(m)	PH(%)	K(md)	HU(m)
L4.4				
	1.35m	8.7%	0.1md	0m

OPTIMISATION OF THE DEVELOPMENT PLAN

2- ROCKS PROPRETIES

8 samples of HRS4 are shosen to laboratory study. The results are very different from one sample to another. Therfore, we have apply the STANDING correlation .

IN PUT DATA :

Kair	= 93.26 MD
KL	= 79. MD
KO @ SWI	= 21.38 MD
Kg @SWI@ SOR	= 2.6 MD
µO	= 18.6 CP
µO	= 0.O1782
Dg	= 0.0013
DO	= 0.8425
Swi	= 33.77 %
Sor	= 31.88

2- FLUIDS PROPRETIES

The laboratory analysis are typical, then we have used the following correlation :

- Standing to FVF estimation.
- Standing to GOR estimation.
- Lee- Gonzales Eakins to the viscosity

IN PUT DATA :

Oil gravity	= 30.51
Pb	= 311
Gas gravity	= 0.68
Water density	= 1g/cc
The water compressibility	= 4.267^{E}-5 1Kg/Cm^2
Water viscosity	= 0.5 cp
Water FVF	= 1.001 Rm^3/m^3

3- GRID

The choice of Grid is based on the following parameters :

- Optimisation between the count of the time and the error.
- The maximum refining in the study area.

The Grid geometry of the model is :

X	= 37
Y	= 65
Layer	= 6
Cells size	= 250 * 250
Direction	= 30°

4 – RESERVES ESTIMATION

All those parameters and study cases help us to estimate reserves in place of the reservoir serie inferieure in Hassi R'mell south field.
OOIP = 17 millions m 3.

5- OPTIMISATION OF WELLS NUMBER

The economic study shows for drill a vertical well the cost is about 3millions Dollars and 6 millons Dollars to horizontal well.
The reserves in place is 17 millions m^3 and we hope recover about 20% of the oil as the potential of the serie inferieure is 70 m^3/ Day (Build up interpretation).
The question is how many wells is necessary to be drilled to have a better oil recovery and economic profit?
Several computer runs were made to choose the optimum number of well will be add to the development plan;
The best scenario consists of adding 7 wells to the base case development.

CONCLUSION

The sedimentological study and sequentielle analysis based on the core description and log curves of the serie inferieure formation are permetted to put in evidence four units .These units were subdivided into 12 positive sequences.
The isoporosity, isopermeability, isosaturation and iso net thickness map show the irregular variation of the petrophysical characterization (fig , 6, 7, 8, 9).

The PVT study isn't representative, it's necessary to use a different correlations (fig 5).

The optimum number of well to be drilled is 7,they have been selected according to the saturation map (fig 11).

The best result of this study is the new well HRS 25 which is drilled in this area and the principal results are :

Net thickness of oil = 6m
Porosity = 15%
Permeability = 80 MD

We recommend to drill the next 6 wells with the new geological model built with PETREL logiciel.

Acknowledgement

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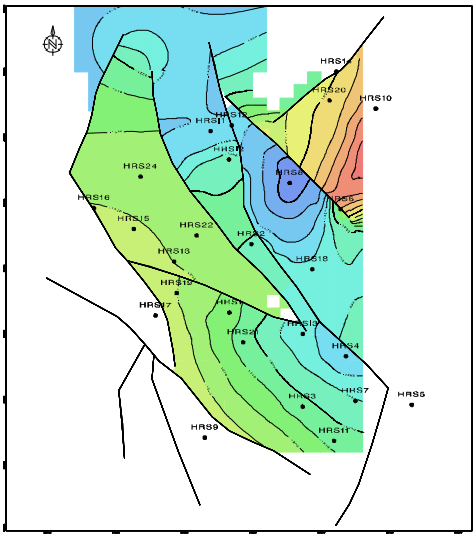

Fig 1: Isobathes Map

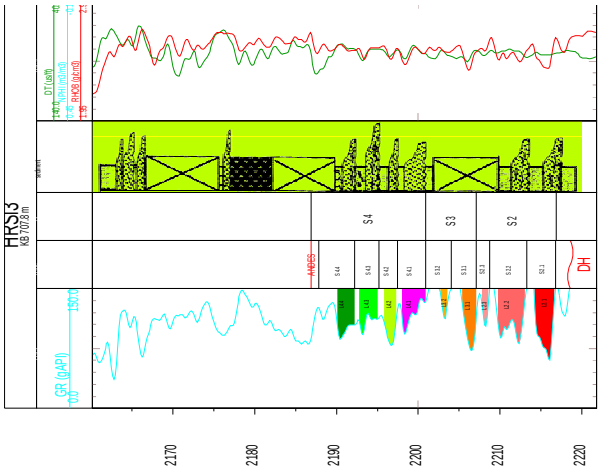

Fig 2 :Well composite of HRS I3

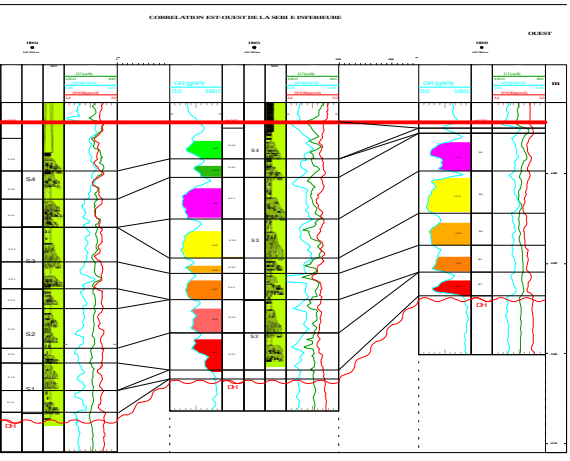

Fig 3 : Cross section

SONATRACH_DP Project : **M.STASAID**
DIVISION : P.E.D Field : **HASSI -RMEL**
DEPARTEMENT : EVALUATION Operator : **SONATRACH**
SERVICE : PETROPHYSIQUE Well : **HRS**
reservoir : **SERIE INFERIEURE**

HRS # 4

Zone / Interval Data				NET RESERVOIR			NET PAY				
Zone Name	Top (m)	Bottom(m)	Gross Thick (m)	Thick (m)	Avg PH (%)	Avg Clay (%)	Thick (m)	Avg Φ	Avg Sw	Avg VCL	Avg K
L 1,1	2209 ,47	2210 ,6	1,13	0	***	***	0	***	***	***	***
L 1,2	2205 ,43	2207 ,88	2,45	0	***	***	0	***	***	***	***
L 2,1	2204 ,17	2205 ,1	0,93	0	***	***	0	***	***	***	***
L 2,2	2199 ,66	2202 ,84	3,18	1,27	12,6	28,5	1,27	13%	42%	28%	1
L 2,3	2197 ,81	2198 ,54	0,73	0,65	8,5	33,4	0	***	***	***	***
L 3,1	2195 ,49	2196 ,55	1,06	1,06	14,6	7,6	1,06	15%	36%	8%	33
L 3,2	2191 ,91	2194 ,43	2,52	1,71	12	23,9	0,95	14%	45%	18%	6
L 4,1	2187 ,21	2189 ,99	2,78	2,62	12,8	21,8	2,29	13%	38%	20%	20
L 4,2	2184 ,16	2185 ,42	1,26	1,26	16,0	10,9	1,26	16%	35%	11%	48
L 4,3	2182 ,57	2183 ,76	1,19	1,19	10,8	7,5	1,19	11%	42%	8%	14

HRS # 1

Zone / Interval Data				NET RESERVOIR			NET PAY				
Zone Name	Top (m)	Bottom(m)	Gross Thick (m)	Thick (m)	Avg PH (%)	Avg Clay (%)	Thick (m)	Avg Φ	Avg Sw	Avg VCL	Avg K
L 1,1	2245 ,84	2248 ,96	3,12	1,70	14,6	37,8	1,70	15%	39%	26%	4
L 1,2	2241 ,68	2244 ,68	3,00	0,22	10,5	33,6	0,22	11%	46%	37%	0
L 2,1	2239 ,49	2241 ,22	1,73	1,73	10,7	24,4	1,58	11%	42%	23%	3
L 2,2	2234 ,52	2237 ,98	3,46	0,61	17,3	33,6	0,61	17%	31%	34%	1
L 2,3	2230 ,82	2233 ,13	2,31	0,98	13,6	37,8	0,83	14%	46%	37%	0
L 3,1	2226 ,43	2230 ,03	3,60	0	***	***	0	***	***	***	***
L 4,1	2219 ,73	2222 ,62	2,89	0	***	***	0	***	***	***	***

Tab : 2 Petrophysical parameters

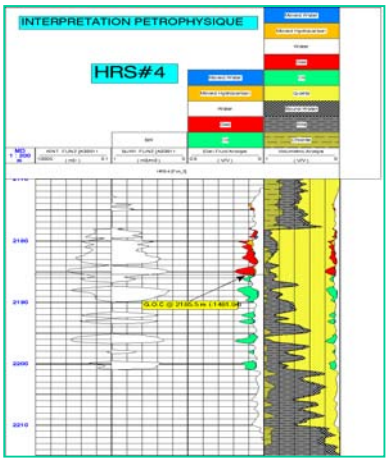

Fig 4 : Petrophysic interpretation

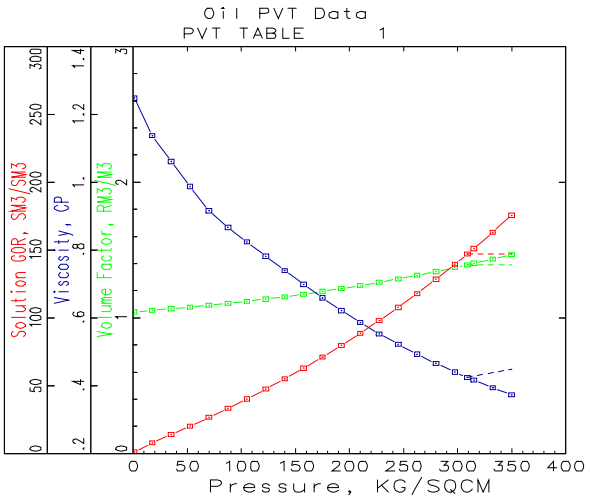

Fig 5 : PVT interpretation

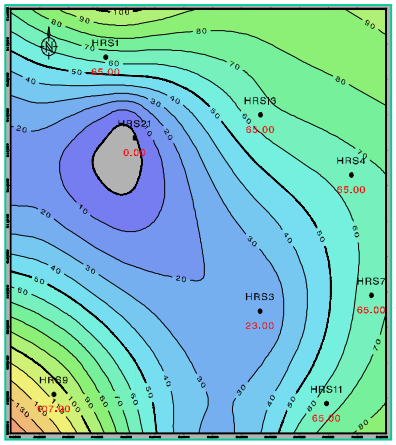

Fig 6 :Isopermeability map

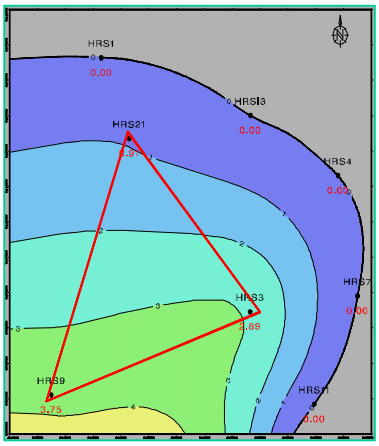

Fig 9 : Iso net thickness map

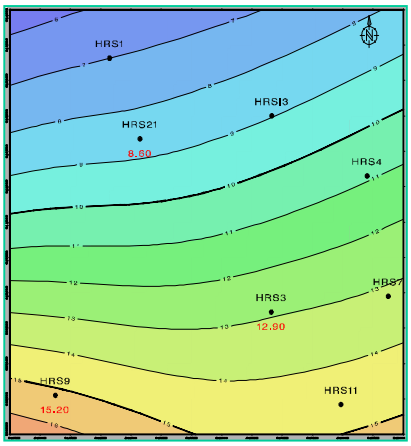

Fig 7: Isoporosity map

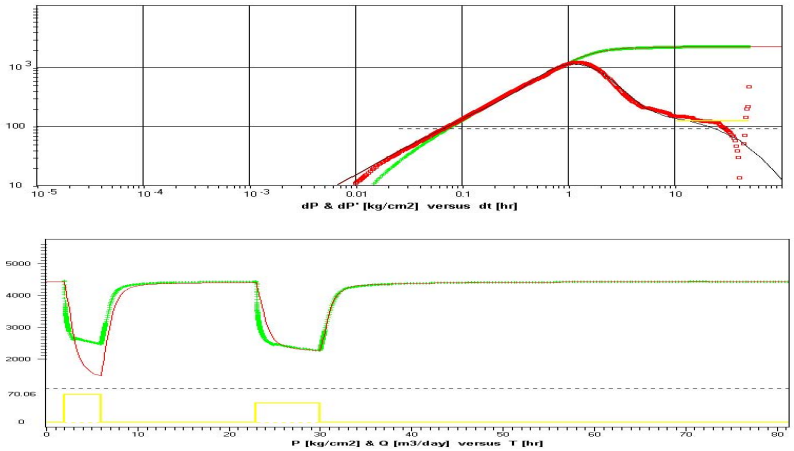

Fig 10: BUILD UP Interpretation

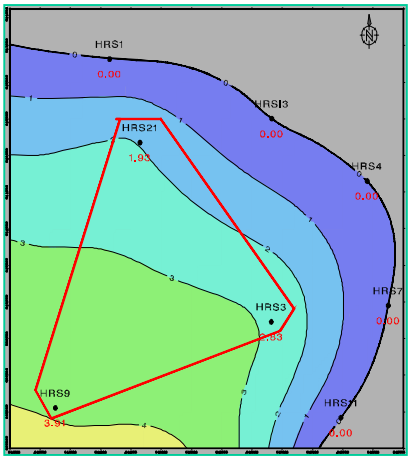

Fig 8: Iso Gross thickness map

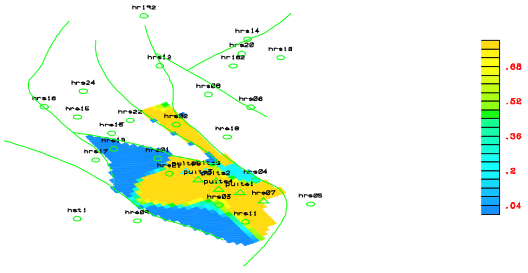

Fig 11 : Saturation map