



CARBONATE RESERVOIRS IN ALAMEIN YIDMA AREA

CARBONATE WORKSHOP, GPC 2021



AGENDA

YIDMA ALAMEIN AREA BACKGROUND
CARBONATE RESERVOIRS HISTORY

> ALAMEIN DOLOMITE RESERVOIR (ALAMEIN, YIDMA FIELDS)

> ABU ROASH "G" DOLOMITE RESERVOIRS (NE ALAMEIN FIELD)

Summary & Conclusion

Yidma/Alamein Development Lease Producing Fields



Production Performance Of EHO Fields

Production started in <u>1968</u> by well AL#1X after the successful discovery of Alamien field , reached to production peak with 43,000 BOPD , declined to 2,000 BOPD in <u>1999</u>, currently the average oil rate is 4,250 BOPD after cumulative oil production of



Yidma/Alamein Area Carbonate Stratigraphy



EHO Carbonate Reservoirs

- Carbonate reservoirs were encountered successfully in EHO fields. The key reservoirs were <u>Alamien Dolomite</u> and <u>Abu Roash "G" Dolomite.</u>
- The cumulative oil production of carbonate reservoirs is 94 MMSTB which represents 75 % of the total oil company production.



	Alamein Dolomite	ARG Dolomite		
Datum depth , ft.MD	8200	5800		
thickness , Ft	270	25		
Porosity , %	15	24		
Permeability , md	500-3500	50		
Drive mechanism	very strong water drive	Weak water drive		
OOIP , MMSTB	300	33		
Rem. Res. , MMSTB	1.9	1.4		
Cum. oil , MMSTB	um. oil , MMSTB 89 5			
RF , %	30	15		
Oil rate , BOPD	160	800		
No. Producing wells	4	7		

Total Oil Produced from All Reservoirs 126 MMSTBO

Carbonate Reservoirs Characterization

ALAMEIN DOLOMITE RESERVOIR

Alamein Dolomite reservoir in Yidma/ Alamein Area





Alamein Dolomite Reservoir in Alamein Field



The Alamein Field was discovered in August 1966 with the drilling of Alamein# 1x that started production with 8000 BOPD of 34.5° API.

□ 31 wells penetrated the Reservoir

□ 20 wells produced from Al. Dol. Reservoir



Alamein-1X Well

Alamein Dolomite Conventional Core Alamein 28 Well

AL-28 Well **Alamein Dolomite Log Analysis**

Horizontal Permeability, mD



Core Porosity, Percent

Alamein Dolomite Conventional Core Alamein 28 Well_WL/UV Core Photo



Alamein Dolomite Reservoir in Yidma Field



Alamein Dolomite Conventional Core Yidma# 10 Well









Alamein Dolomite reservoir Production Performance

- The early period of production is characterized by high production rates by natural flow then after the wells cease to flow naturally & Artificial lift is implemented WC increase significantly.
- The challenge of Alamein dolomite is to maintain the life of the reservoir during 50 years of production by optimizing the production rates and drilling wells targeting the attic oil of the high structure areas.



Alamein Dolomite Remaining Reserve (Alamein Field)

- EHO succeeded in drilling of well AL#44 as an offset to the crestal well (AL#1x) which was shut in due to mechanical problems, aiming to produce the attic oil from Alamein Dolomite in Alamein field.
- □ The log analysis revealed good oil potential and it is expected to turn into production after the current deeper target Aptian sand watered out.





Alamein Dolomite Remaining Reserve (Yidma Field)

- The successful drilling on high structure areas of Alamein dolomite reservoir was done also in Yidma field by drilling of well Yidma#11 that started production with 140 BOPD & 10% WC therefore the field turned again into production after shut in for 2 years because of the uneconomic production rates of the other Alamein dolomite producers Yid#4 & Yid#6.
- The other challenge of Alamein dolomite in Yidma field was the high recovery factor that reached 53 % after cumulative production of 25 MMSTB that indicated more oil volume should be recalculated.



Alamein Dolomite Reservoir Yidma# 11 Well_FMI Carbonate Study



- Many productive carbonates have complex dual porosity systems with widely varying proportions of primary and secondary porosity.
- FMI acquired to enhance understanding of depositional processes and reservoir geometry using sedimentary dip data and characterization of sub-seismic deformation features (faults, fractures, syn-sedimentary deformation).



Alamein Dolomite Reservoir_Yidma# 11 Well **FMI Carbonate Study**



The analysis of BorTex involves computation of a background conductivity and setting a resistivity contrast threshold to identify heterogeneities. The heterogeneities include:



POROSPECE methodology for FMI porosity estimation



The analysis of POROSPECE (Newberry, et. al., 1996) involves converting the electrical borehole image into a porosity map of the borehole wall. Using the following equation:

FMI $\phi = \text{ext } \phi^*$ (SRES * Ci) ^{1/m}

- Where: FMI ϕ = image porosity
- ext ϕ = external porosity
- SRES = scaled FMI resistivity log Ci

m

- = conductivity of each FMI button
- = cementation factor
 - Frequency

Porosity distribution in Carbonates

Total Porosity = Primary + Secondary

Alamein Dolomite Reservoir_Yidma# 11 Well FMI Carbonate Study





A/R "G" MEMBER RESERVOIRS:1) A/R "G" DOLOMITE RESERVOIR
2) UPPER A/R "G" RESERVOIR

A/R "G" Dolomite reservoir in Yidma/ Alamein Area





A/R "G" Dolomite Reservoir in NE Alamein Field



A/R" G" Dolomite Special Core NE Alamein 6 Well_WL/UV Core Photos













ARG Dolomite : Core Analysis

- SCAL was performed for core plugs and wettability test indicated that AR"G" dolomite is an oil-wet reservoir which may be one of the causes of the low reservoir recovery.
- Compressibility measurements showed considerable variation in rock compressibility due to the large variation in quality between the different layers of ARG dolomite.



Table ((4):	Wettability	' by	Amott	method
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C#	Sample No.	Depth, ft	Water Wet Index	Oil Wet Index	Wettability Type
1	1WR	6285.75	0.25	0.10	Fractional (generally weakly water wet)
	2WR	6286.72	0.40	0.07	Fractional (generally weakly water wet)
	4WR	6288.39	0.02	0.33	Weakly oil wet
	5WR	6289.43	0.00	0.72	Oil wet
	6WR	6290.56	0.00	0.96	Strongly oil wet
	11WR	6294.92	0.04	0.74	Oil wet
	20WR	6304.2	0.32	0.50	Fractional (generally weakly oil wet)

ARG Dolomite : PVT Analysis

PVT analysis of ARG Dolomite surface sample showed that the reservoirs is highly under saturated black oil with very low saturation pressure and very low solution gas-oil ratio.

Pressure	Oil Density	Gas Gravity	Z- Factor	Oil F.V.F.	Adjusted Oil F.V.F.	Gas F.V.F.	Solution Gas/oil ratio	Adjusted Solution Gas/oil ratio	Oil Viscosity	Gas Viscosity	Compressibility
				βο	βο	βg	Rs	Rs			Co
psig	g/cc	Air=1.000		bbL/STB	bbL/STB	CF/SCF	SCF/STB	SCF/STB	ср	ср	psi ⁻¹ x10 ⁻⁶
2575.0	0.87611			1.00424	1.00424		9.739	9.378	9.9407		
2000.0	0.87222			1.00872	1.00872		9.739	9.378	7.8493		7.7464
1500.0	0.86781			1.01384	1.01384		9.739	9.378	6.4234		10.1634
1000.0	0.86238			1.02022	1.02022		9.739	9.378	5.3259		12.5908
750.0	0.85943			1.02373	1.02373		9.739	9.378	4.8941		13.7592
500.0	0.85622			1.02756	1.02756		9.739	9.378	4.5426		14.9678
300.0	0.85351			1.03084	1.03084		9.739	9.378	4.3265		15.9225
100.0	0.85643			1.03185	1.03432		9.739	9.378	4.1886		16.8889
60.0	0.85965			1.02764	1.03502		9.739	9.378	4.1756		17.0356
52.5	0.85323	1.15794	0.97998	1.03185	1.03082	0.25848	8.614	8.295	4.2127	0.01057	
45.0	0.85643	1.17357	0.98168	1.02764	1.02662	0.29146	7.489	7.212	4.2504	0.01050	
37.5	0.85965	1.18920	0.98351	1.02344	1.02241	0.33395	6.364	6.129	4.2889	0.01044	
30.0	0.86289	1.20482	0.98547	1.01923	1.01821	0.39076	5.240	5.045	4.3282	0.01038	
22.5	0.86615	1.22045	0.98756	1.01502	1.01401	0.47054	4.115	3.962	4.3682	0.01032	
15.0	0.86944	1.23608	0.98979	1.01082	1.00981	0.59070	2.990	2.879	4.4090	0.01026	
7.5	0.87275	1.26200	0.99216	1.00661	1.00560	0.79215	1.865	1.796	4.4507	0.01020	
0.0	0.87690	1.31422	0.99419	1.00120	1.00020	1.19876	0.000	0.000	4.5204	0.00999	
Saturation pressure											

ARG Dolomite : Start Production

□ A/R "G" DOL started production artificially from Well NEAL-2X from the lower part of the reservoir in <u>December 2010</u> with initial rate of 180 BOPD and 20 % water cut .

□ The upper part of the reservoir was added in <u>August 2012</u> to improve the productivity. The production rate increased by 25 BOPD and continue producing till shut in <u>September 2015</u> after cumulative oil production of 135 MSTB.



ARG DOLOMITE : Pressure History

- □ Static pressure surveys and RFT pressure analysis conducted in ARG dolomite reservoir showed more pressure depletion with production.
- The average reservoir pressure was decreased by about 1000 psi indicated weak water drive reservoir.
- □ It was observed from RFT plots that there is a partial communication across the dolomite reservoir intervals.





ARG DOLOMITE : Development Strategy

- Increasing the production rates from ARG dolomite reservoir was a big challenge because of the small thickness and tightness of the formation, facies quality variation and the high depletion rate of the reservoir that affected the production performance of the vertical well NEAL#2.
- EHO succeeded in drilling the first horizontal well NEAL#15 targeting ARG dolomite reservoir in <u>July</u> <u>2015</u> with a lateral section of 1200 FT. mainly in the lower part of the reservoir.



Horizontal Drilling in A/R "G" Dolomite Reservoir NE Alamein # 15H Well



Horizontal VS Vertical Well Performance

- □ The horizontal well started production with 400 BOPD and 5% water cut , this oil rate is <u>eight times</u> the rate of the vertical well in that time.
- □ The horizontal well produced more than twice the cumulative oil from the vertical well with the same cumulative water production which saved the reservoir energy and extended reservpor production life.



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Improving Recovery

DCA of both vertical and horizontal well indicated improving the recovery of AR"G" dolomite reservoir where the EUR increased from (0.2 to 0.5) MMSTB and the annual decline rate decreased from (25 to 15)%.



Continued Horizontal Drilling

- Successful results from the first horizontal well NEAL#15H encouraged EHO Management to develop the upper part of ARG Dol. reservoir in the southern area by drilling the second horizontal well NEAL#23H with lateral section of 2200 FT.
- □ Appling the horizontal drilling technique for developing the other similar carbonate reservoir (Upper AR"G") by drilling of two Horizontal wells NEAL#19H & NEAL#29H with total horizontal section of 2300 & 2100 FT across the total area of the reservoir.



Production Performance Of AR"G" DOLOMITE & UAR"G"

□ The production performance of AR"G" Dolomite & UAR"G" reservoirs shows the continue developing of carbonate reservoirs of NEAL field and the effect of horizontal wells on increasing the productivity, four horizontal wells are currently producing from AR"G" Dolomite & UAR"G" reservoirs with 750 BOPD that represents 40% of NEAL field production and the total oil production by these wells reached 0.8 MMSTB.



Summary & Conclusion

□ The cumulative oil production of carbonate reservoirs from Alamein/Yidma area is 94 MMSTB which represents 75 % of the total oil company production.

For Alamein Dolomite reservoir:

- Maintaining the production life of Alamien dolomite reservoir was by optimizing the production rates and drilling of wells targeting the attic oil of the high structure areas.
- Running FMI log in carbonate reservoir is useful for minimizing the uncertainty of porosity calculations and re-evaluating of the original oil in place.

For AR "G" Dolomite reservoir:

- □ The greatest challenge in the A/R G Dolomite reservoir is to maximize the reservoir productivity through drilling horizontal wells in depleted reservoir with very thin layers, low quality carbonate reservoir .
- Horizontal wells outperformed the nearby vertical wells in terms of economics, reservoir energy, improving recovery factor and production performance.

