CARBONATE RESERVOIRS IN ALAMEIN YIDMA AREA

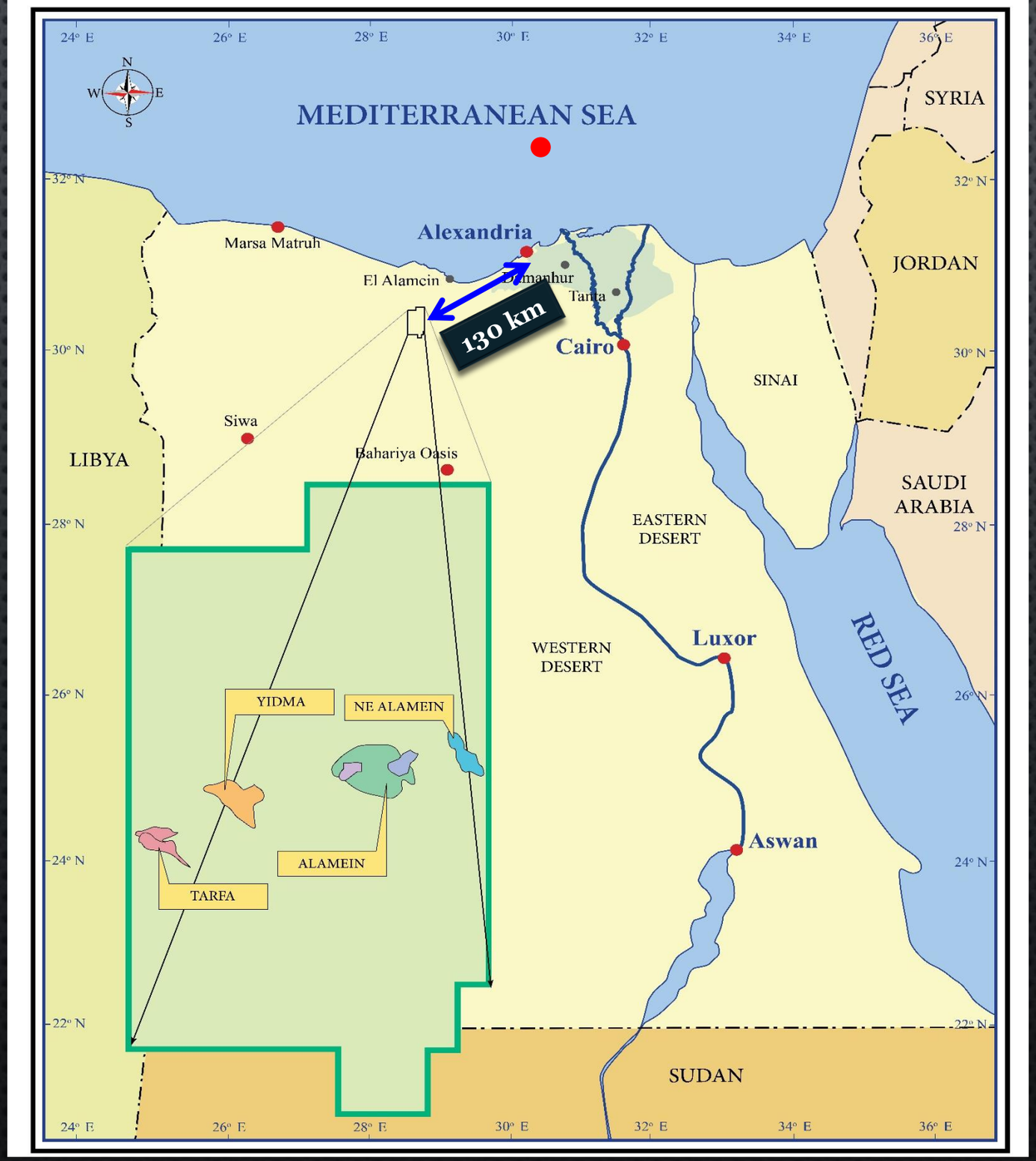
CARBONATE WORKSHOP, GPC 2021

November, 2021

AGENDA

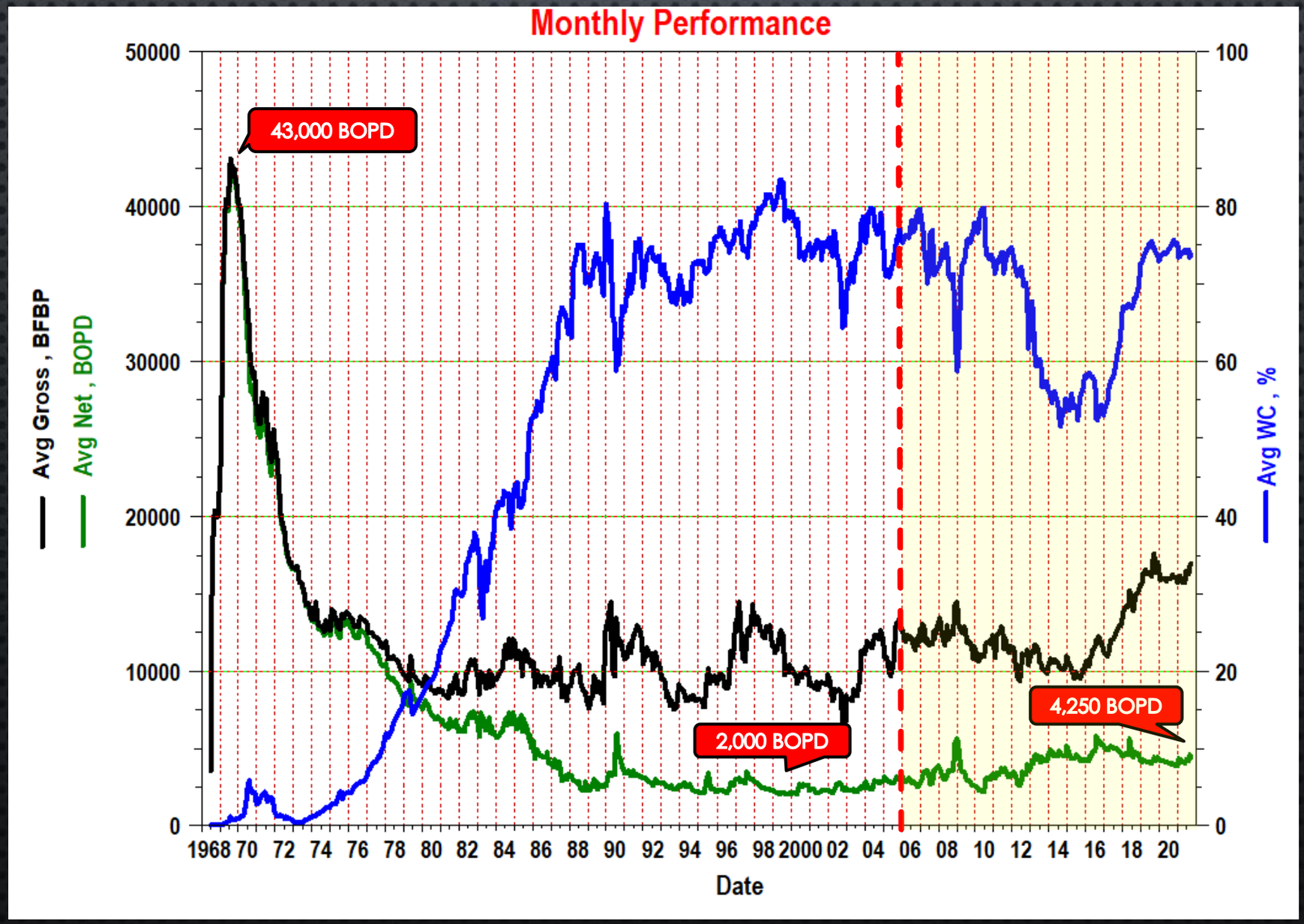
- Yidma Alamein area Background
- Carbonate Reservoirs history
- Alamein Dolomite Reservoir (Alamein & Yidma Fields)
- Abu Roash "G" Member Reservoirs (NE Alamein Field)
- Summary & Conclusion

Yidma/Alamein Development Lease Producing Fields

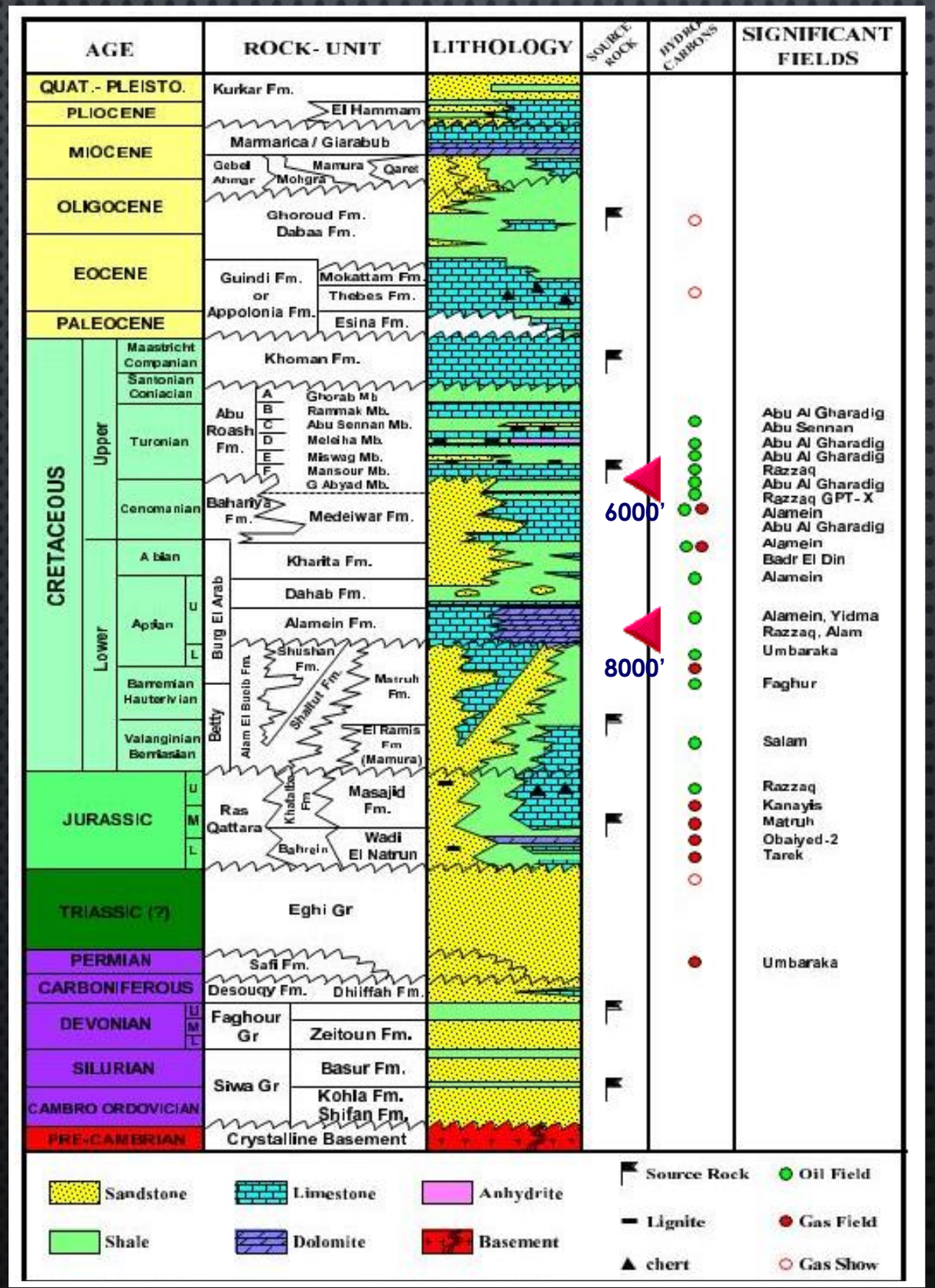


Production Performance Of EHO Fields

- Production started in 1968 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 1999, currently the average oil rate is 4,250 BOPD after cumulative oil production of 126 MMSTB .



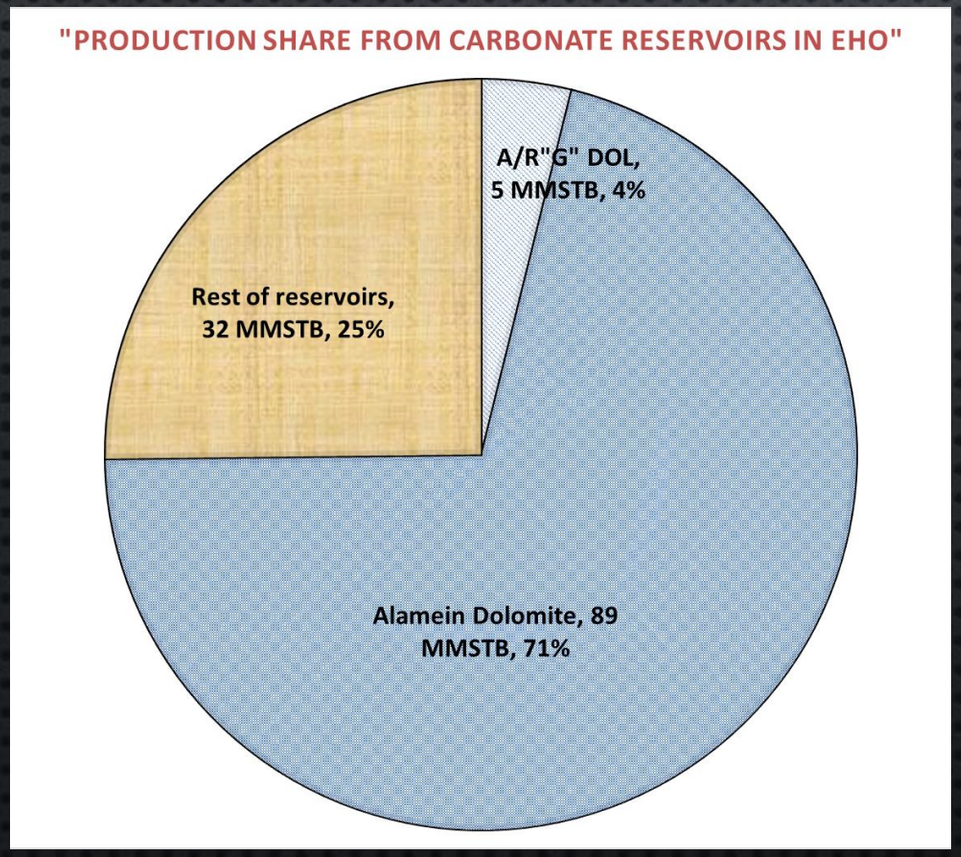
Yidma/Alamein Area Stratigraphy



Carbonate Reservoirs Production

- Carbonate reservoirs were encountered successfully in EHO fields. The key reservoirs were Alamien Dolomite and Abu Roash "G" Dolomite.

- The cumulative oil production of carbonate reservoirs is 94 MMSTB which represents 75 % of the total oil production.



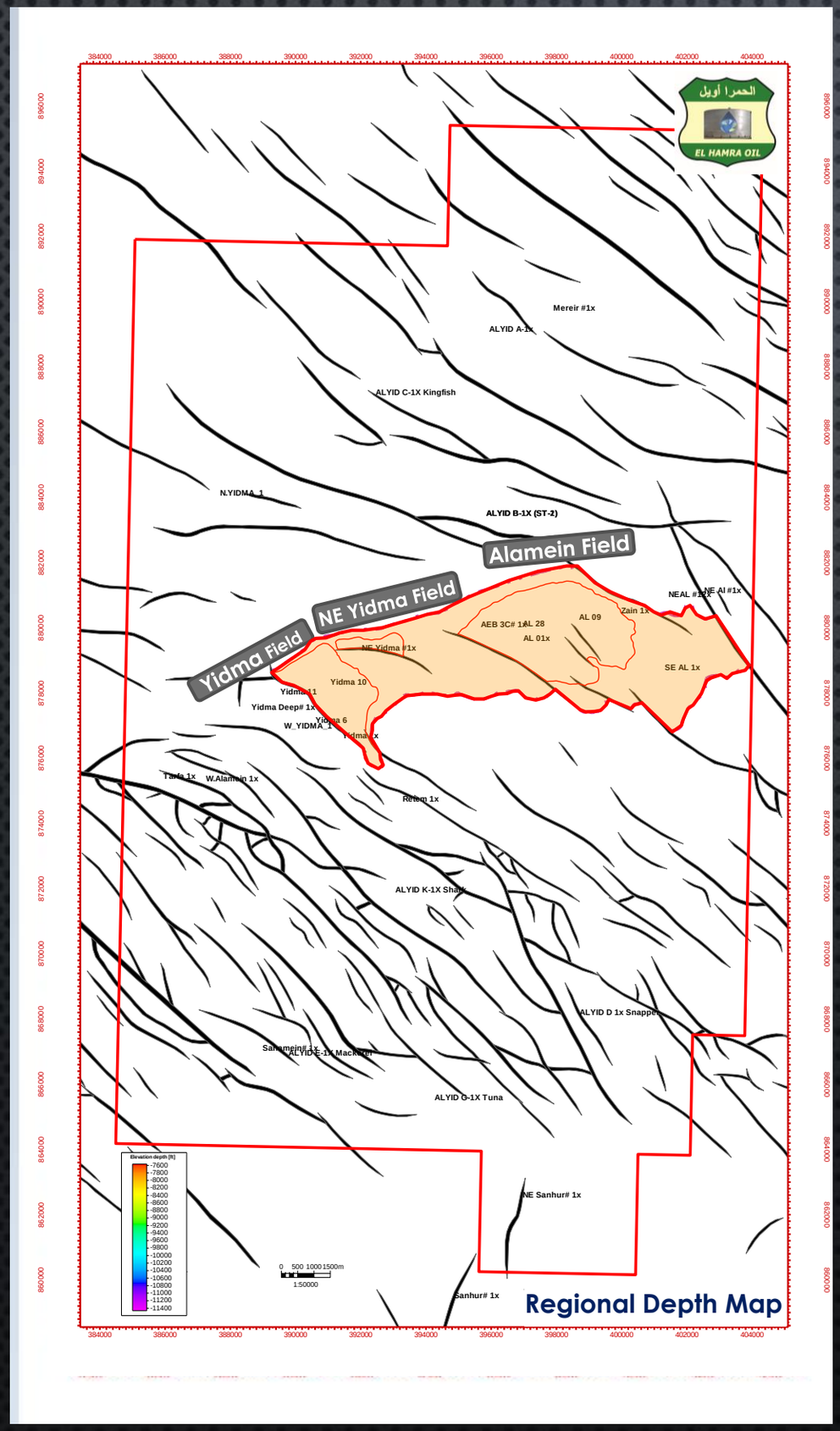
Total Oil Produced from All Reservoirs 126 MMSTBO

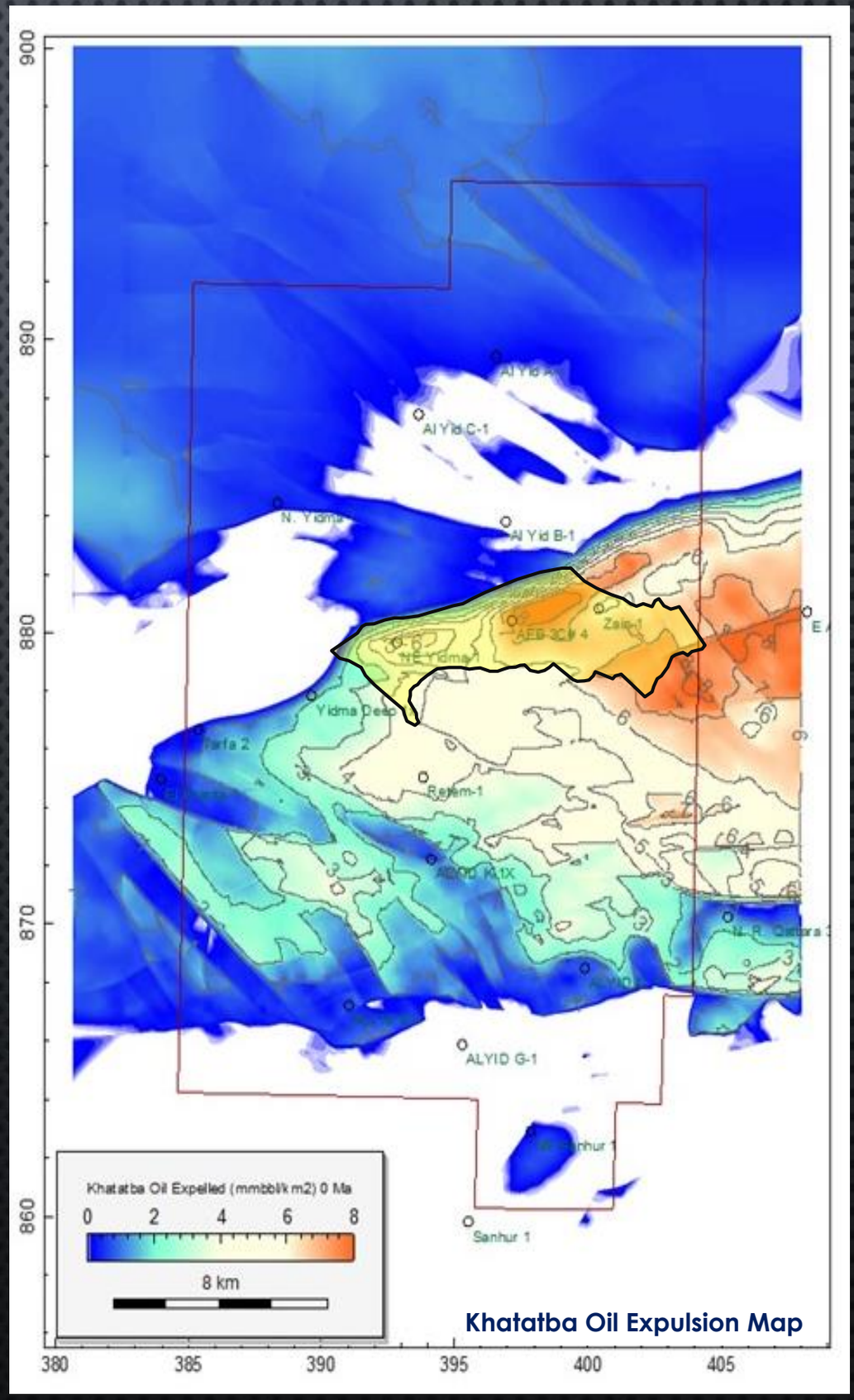
	Alamein Dolomite	ARG Dolomite
Datum depth , ft.MD	8200	5800
thickness , Ft	270	25
Porosity , %	15	24
Permeability , md	500-3500	50
Drive mechanism	very strong water drive	Weak water drive
OOIP , MMSTB	300	33
Rem. Res. , MMSTB	1.9	1.4
Cum. oil , MMSTB	89	5
RF , %	30	15
Oil rate , BOPD	160	800
No. Producing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

Carbonate Reservoirs Characterization

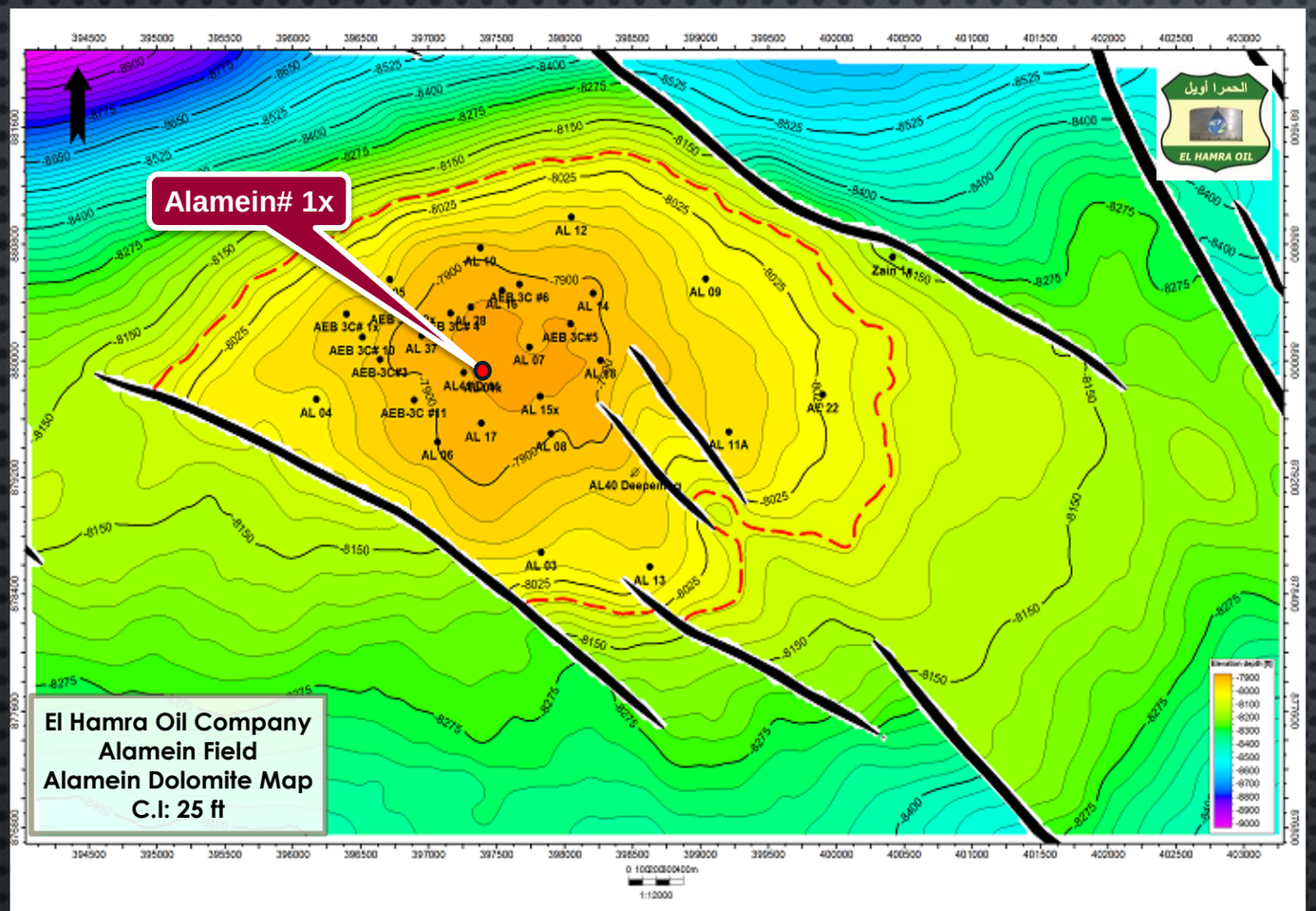
ALAMEIN DOLOMITE RESERVOIR

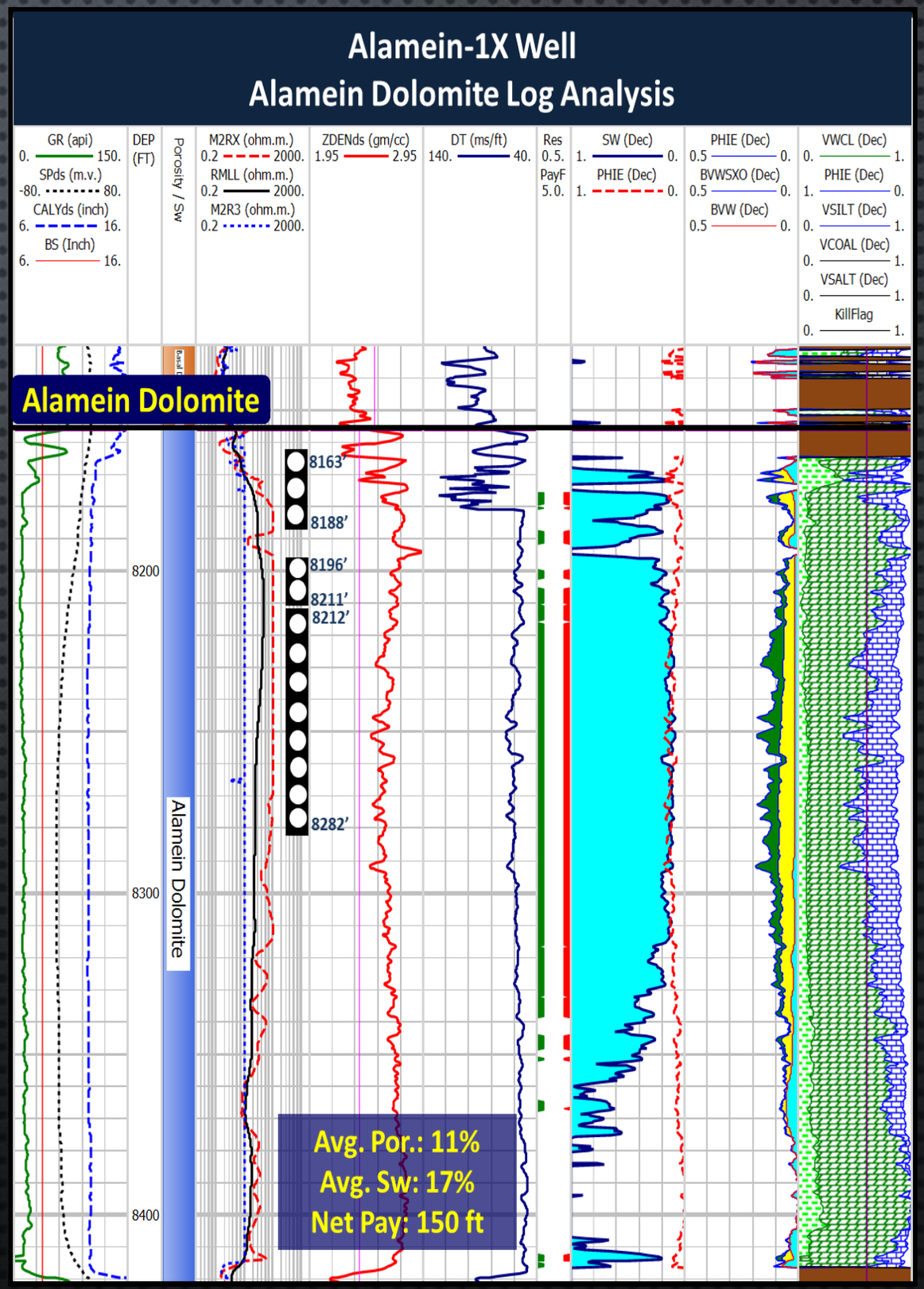
Alamein Dolomite reservoir in Yidma/ Alamein Area





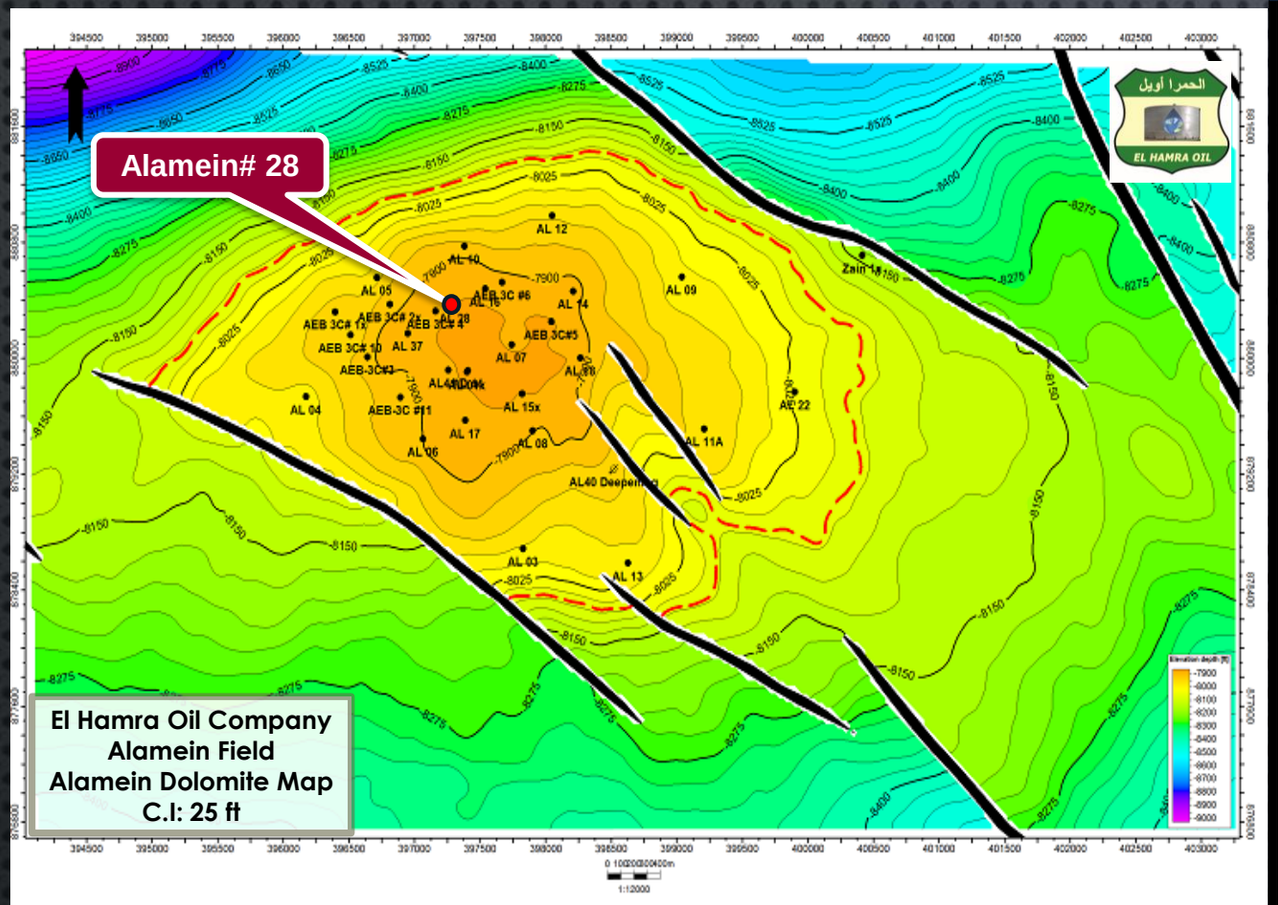
Alamein Dolomite Reservoir in Alamein Field

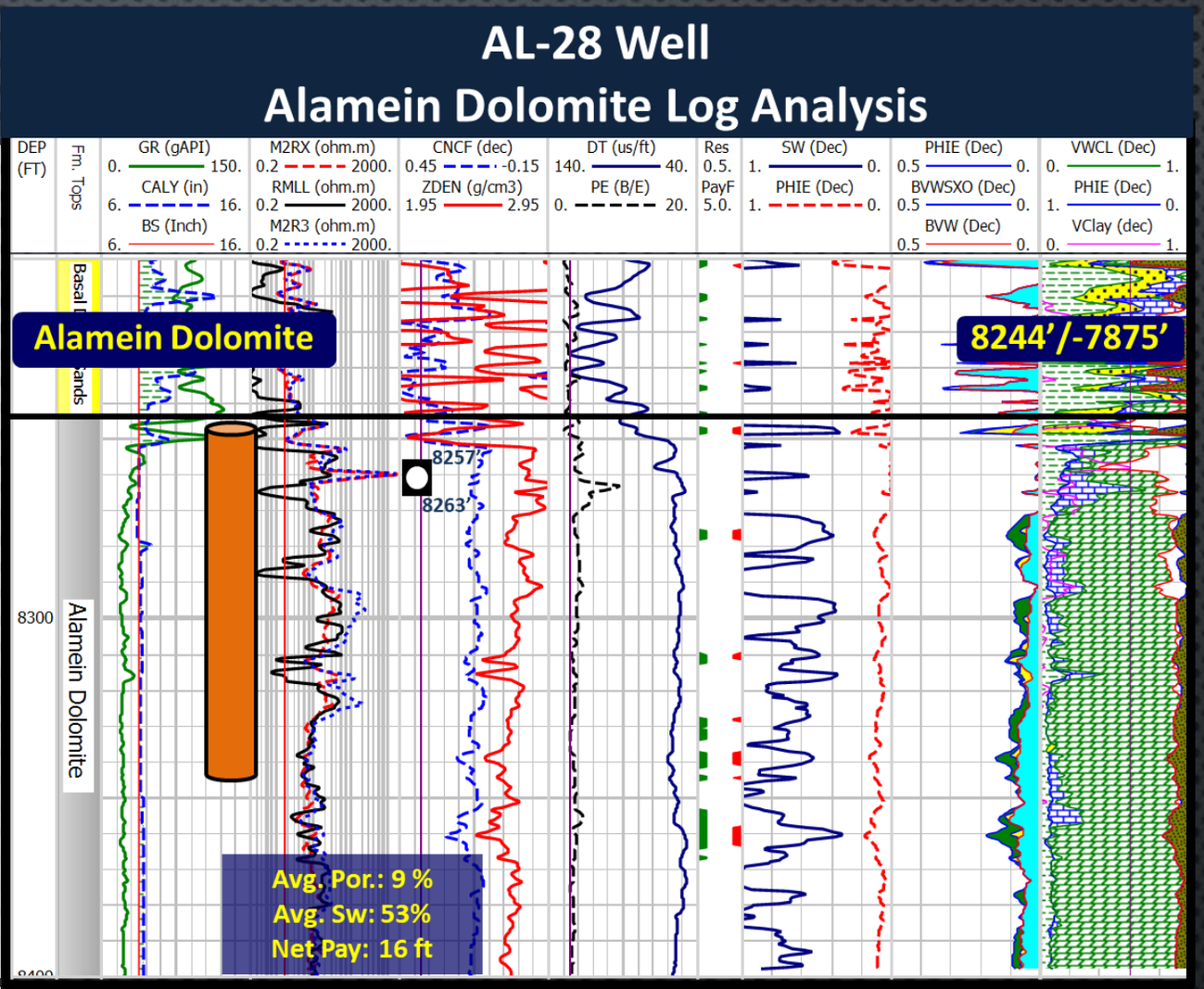


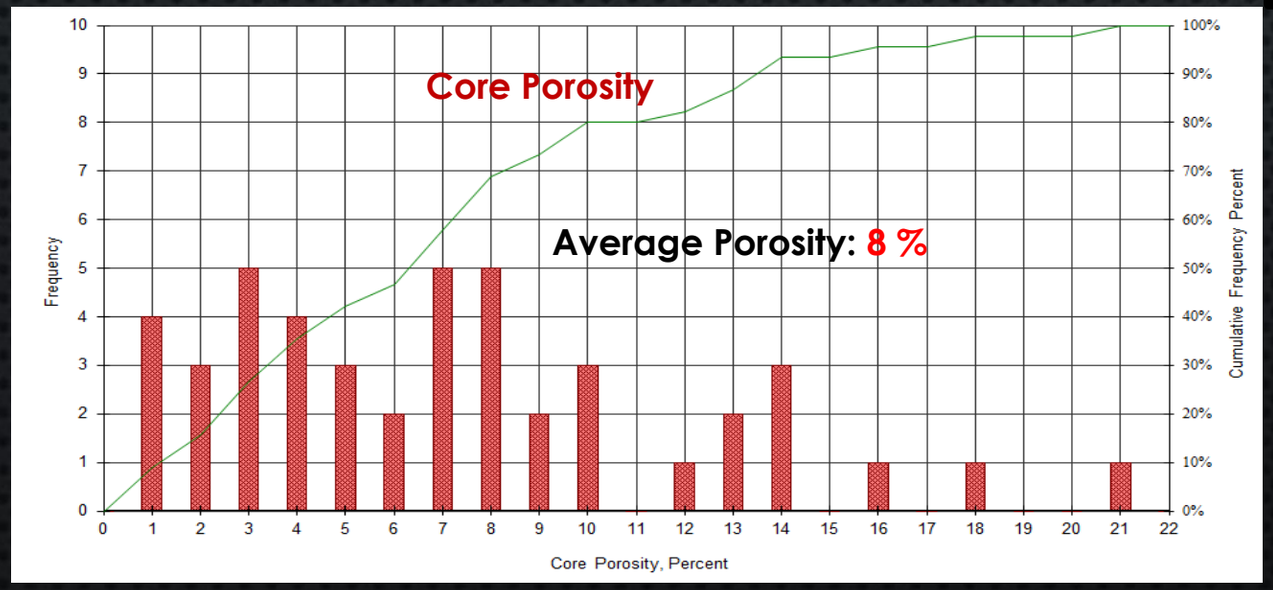


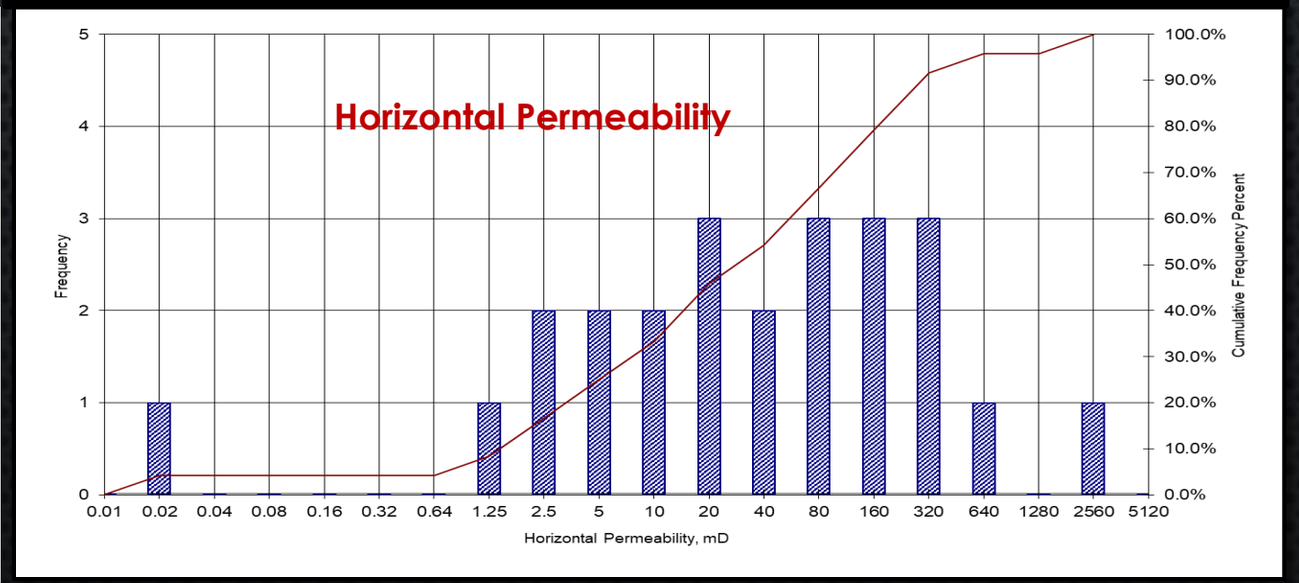
- The Alamein Field was discovered in August 1966 with the drilling of Alamein# 1x that started production with 8000 BOPD of 34.5° API.
- 31 wells penetrated the Reservoir
- 20 wells produced from Alamein Dolomite

Alamein Dolomite Conventional Core
Alamein 28 Well



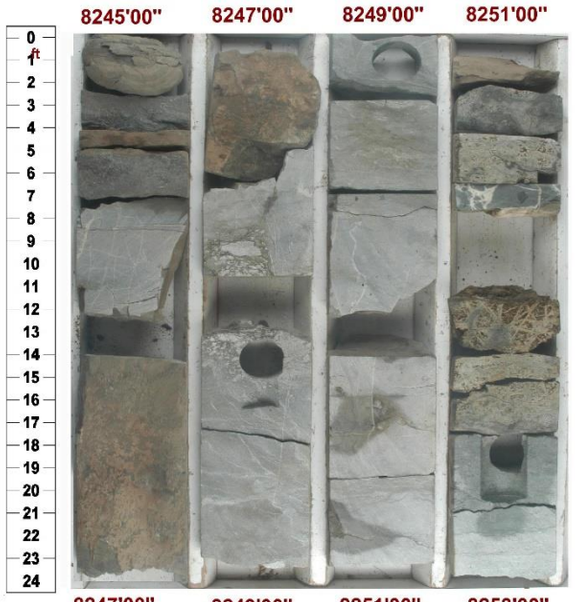






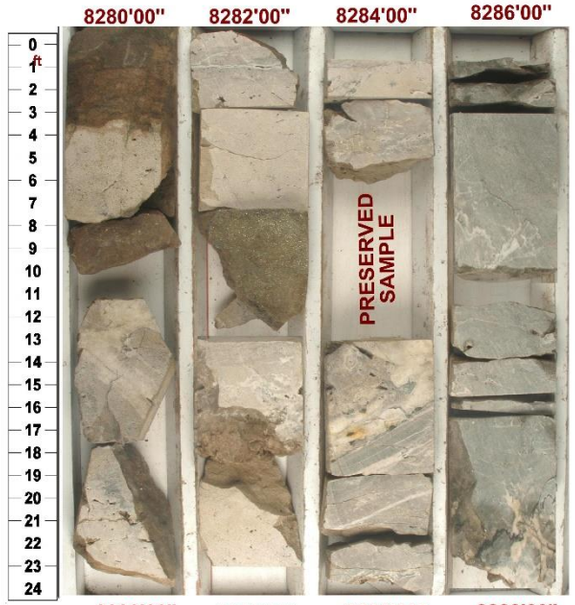
Alamein Dolomite Conventional Core
Alamein 28 Well_WL/UV Core Photo

EL HAMRA OIL PLATE 8
ALAMEIN -28
CORE 2



EL HAMRA OIL PLATE 11
ALAMEIN -28
CORE 2

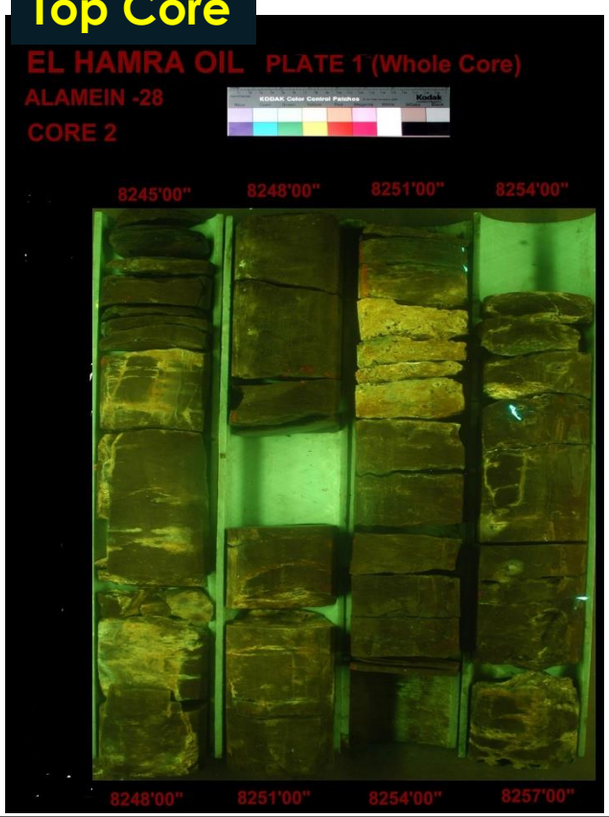
EL HAMRA OIL PLATE 13
ALAMEIN -28
CORE 3



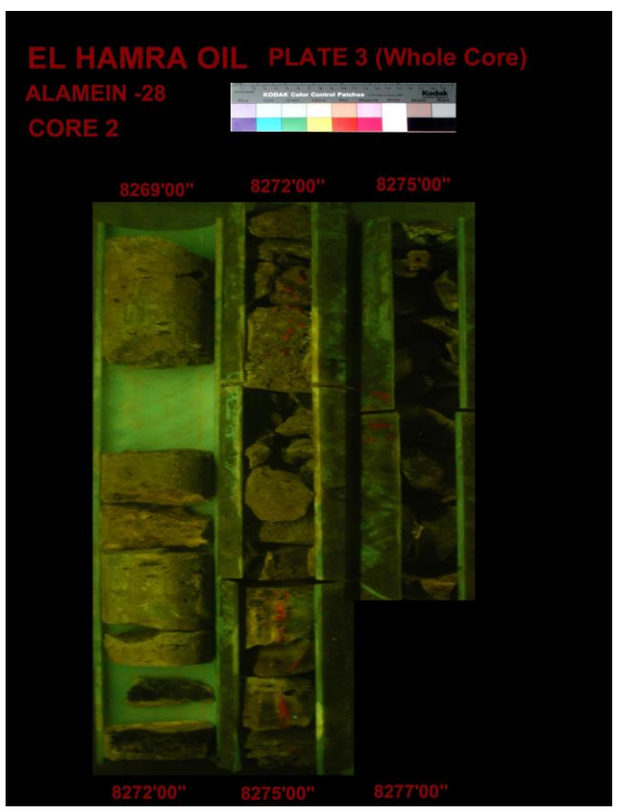
EL HAMRA OIL PLATE 19
ALAMEIN -28
CORE 4

Top Core

EL HAMRA OIL PLATE 1 (Whole Core)
ALAMEIN -28
CORE 2



EL HAMRA OIL PLATE 3 (Whole Core)
ALAMEIN -28
CORE 2

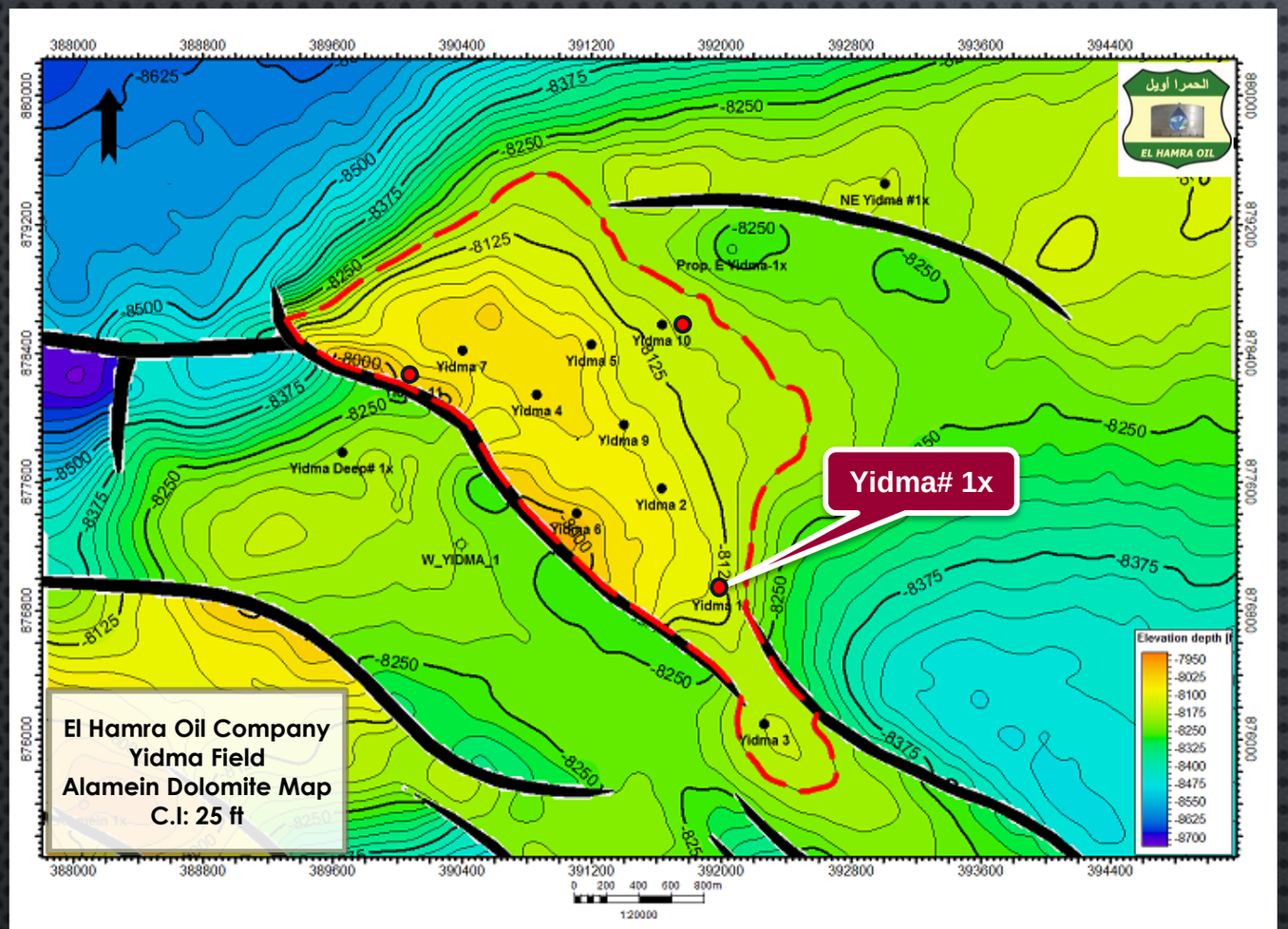


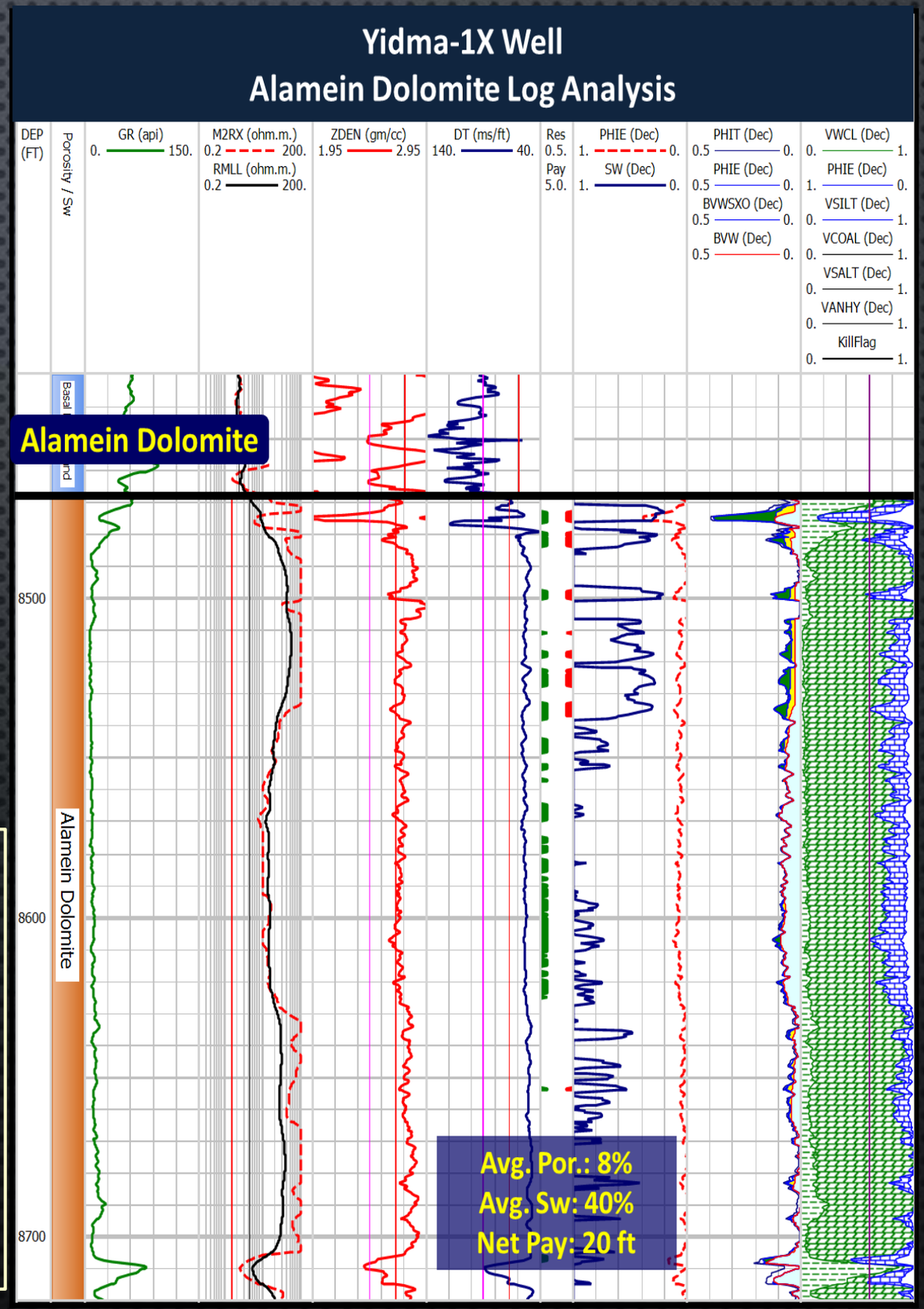
EL HAMRA OIL PLATE 4 (Whole Core)
ALAMEIN -28
CORE 3

EL HAMRA OIL PLATE 8 (Whole Core)
ALAMEIN -28
CORE 4

Bottom

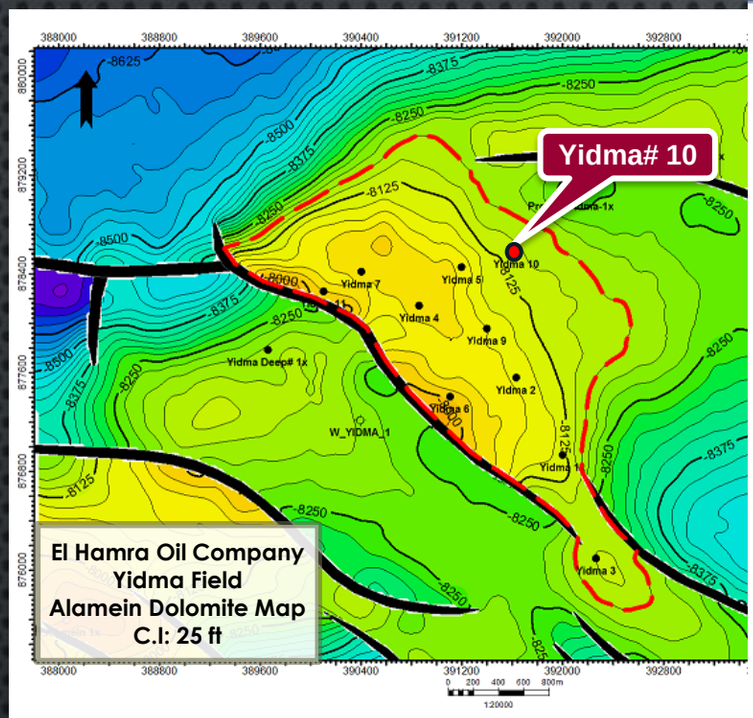
Alamein Dolomite Reservoir in Yidma Field

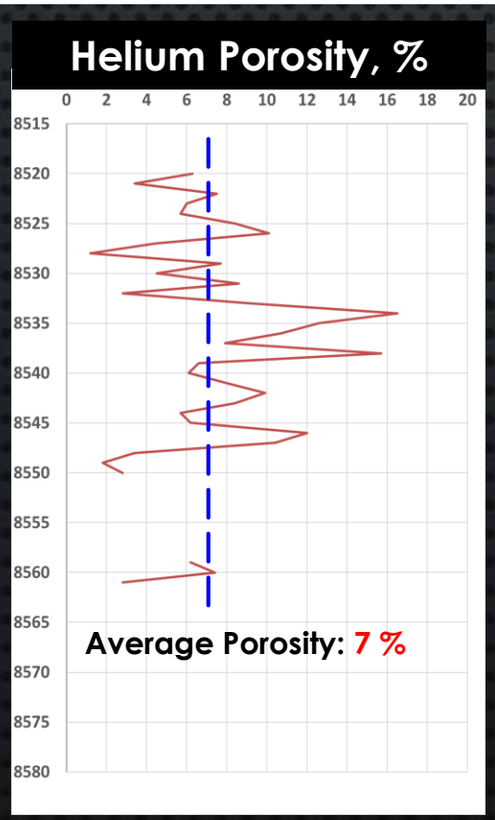




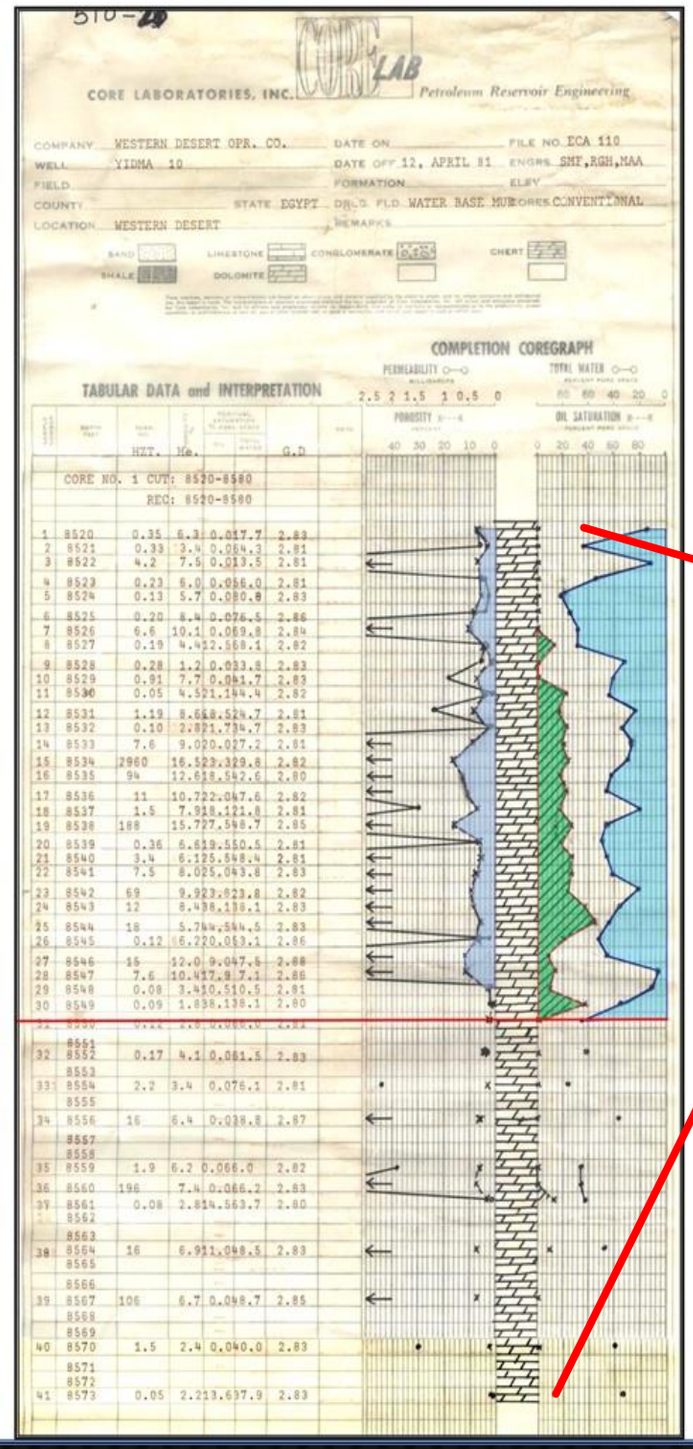
- The Yidma Field was discovered in June 1971 with the drilling of Yidma # 1x that started production with 1700 BOPD of 42° API, located 7 Km to SW from Alamein field.
- 11 wells penetrated the Reservoir
- 8 wells produced from Al. Dol. Reservoir

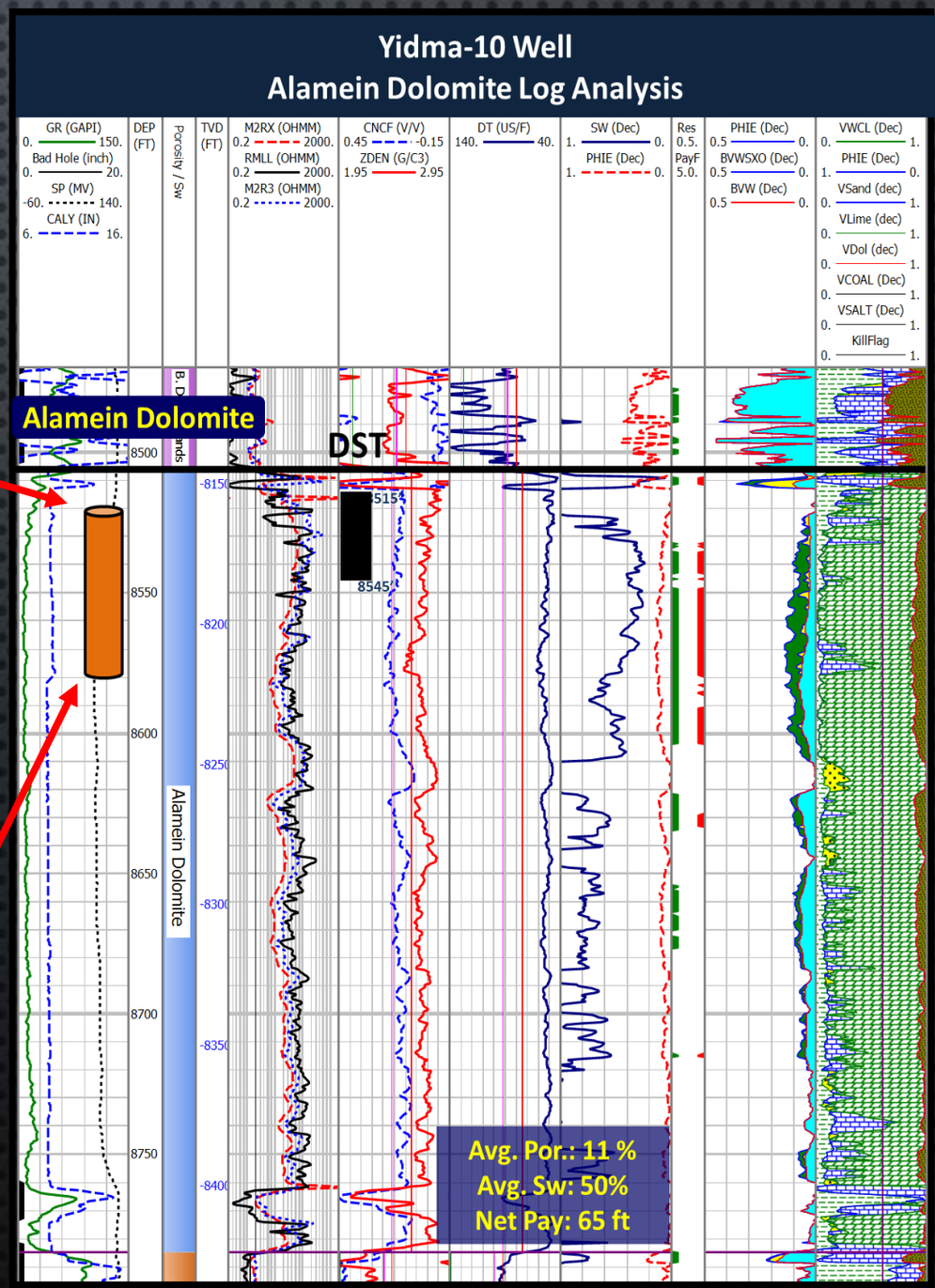
Alamein Dolomite Conventional Core
Yidma# 10 Well





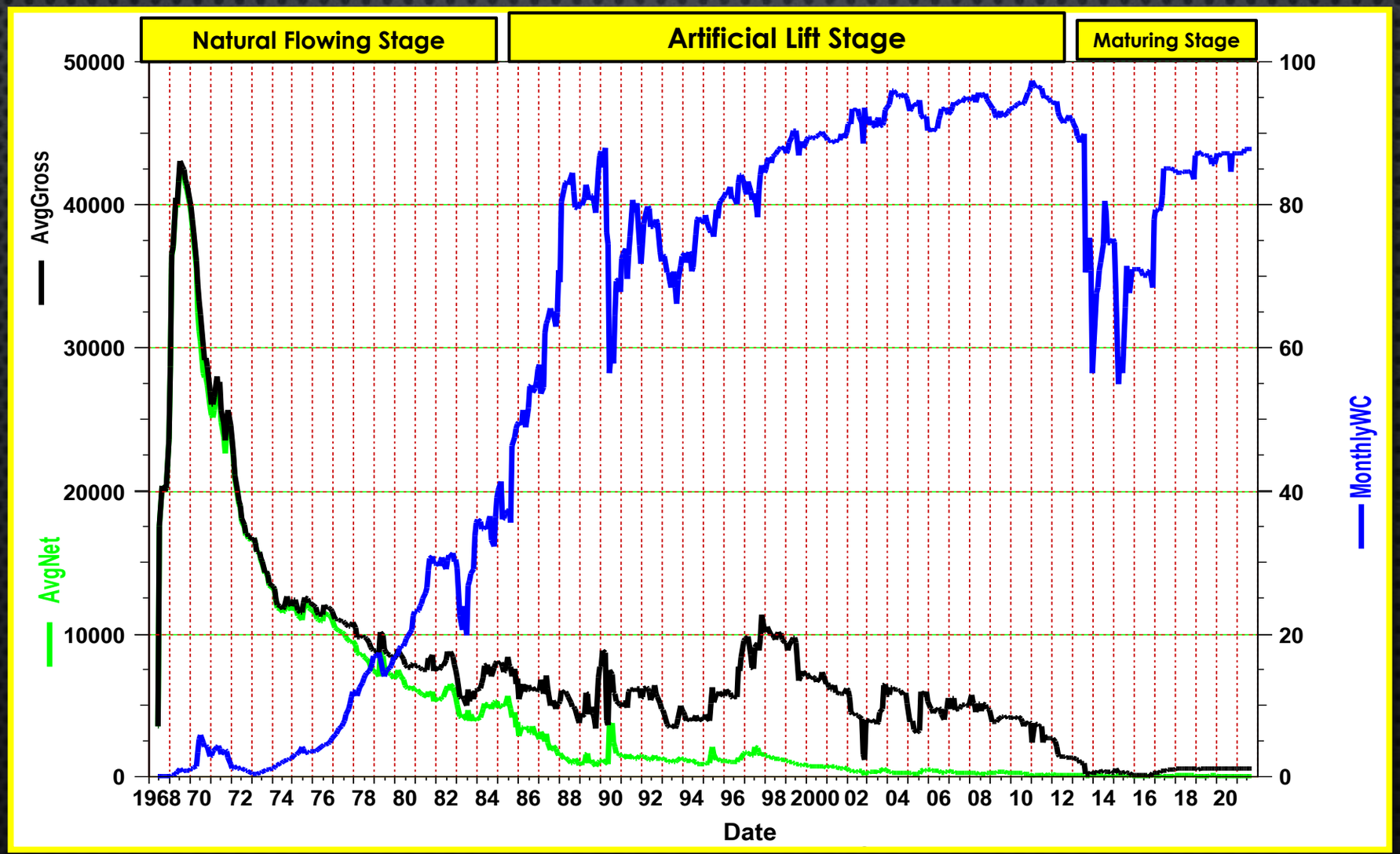
Yidma #10 well
Core Interpretation in Alamein Dolomite





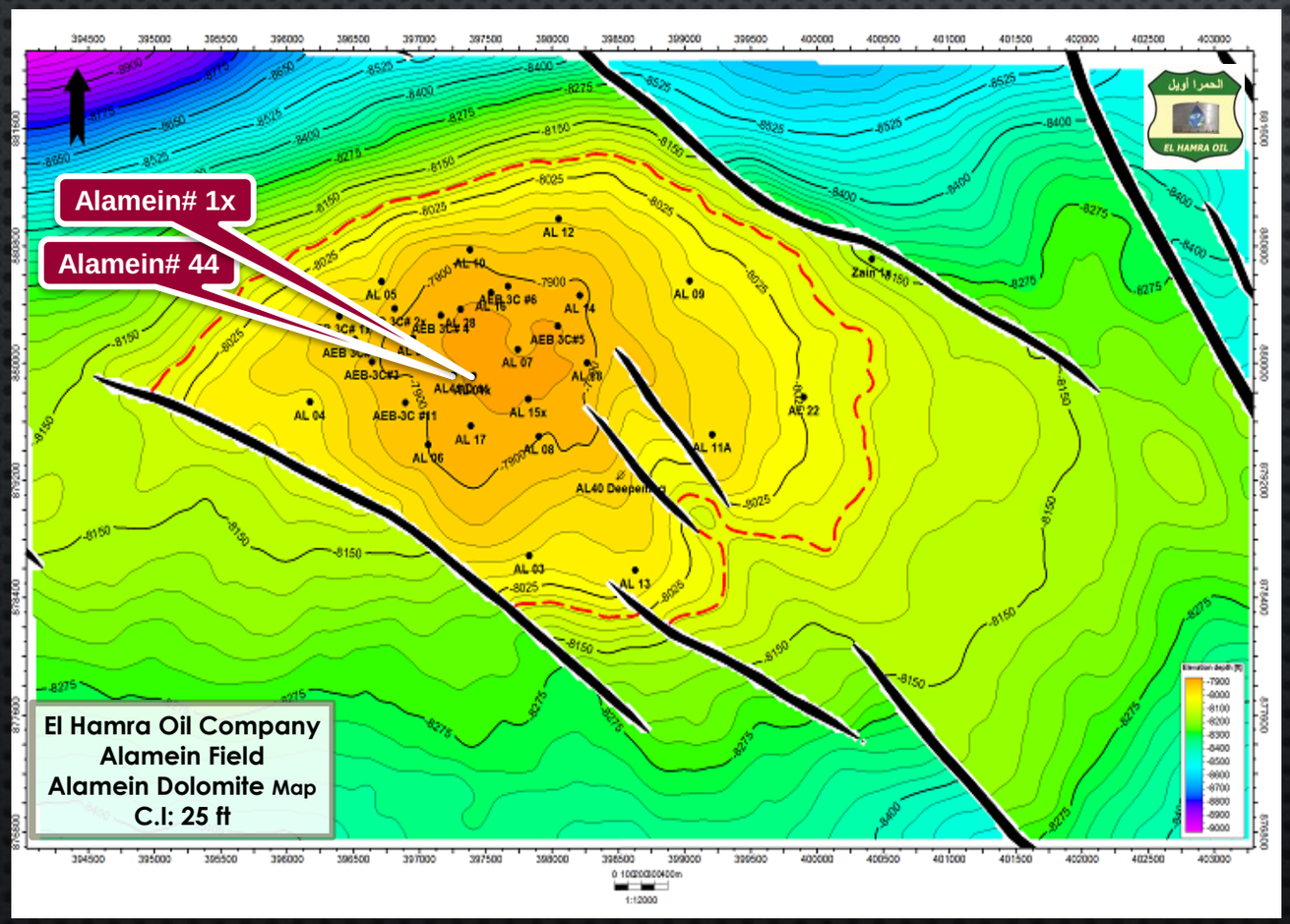
Alamein Dolomite reservoir Production Performance

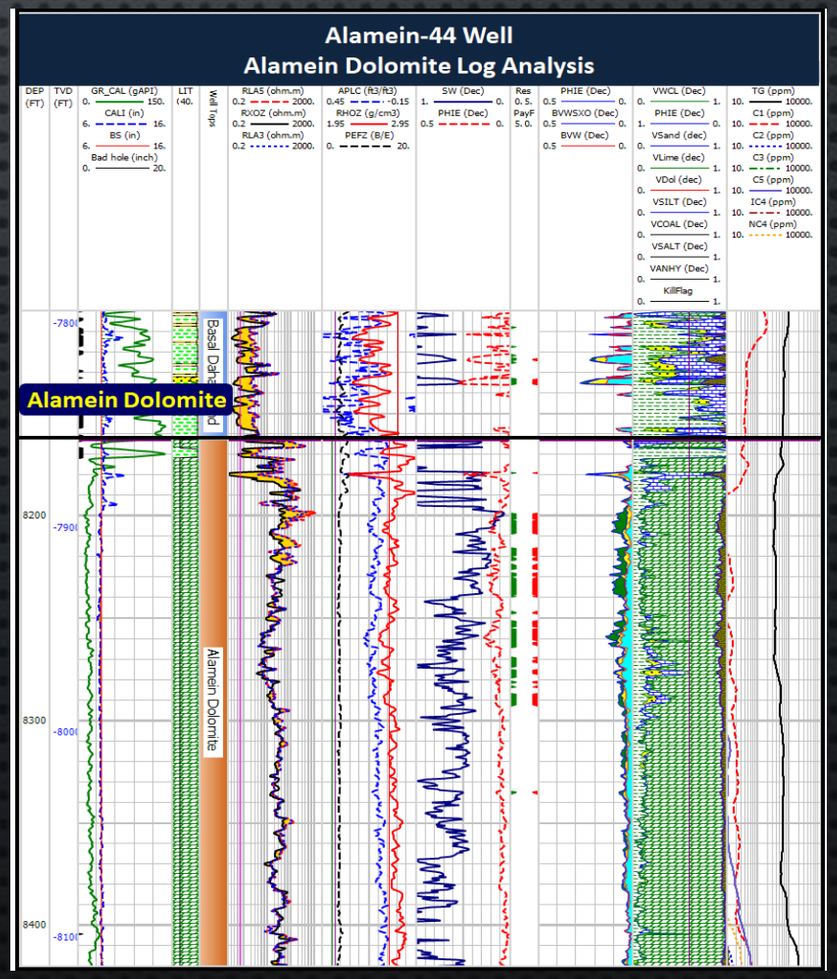
- The early period of production is characterized by high production rates by natural flow then after the wells cease to flow naturally & Artificial lift is implemented WC increase significantly.
- The challenge of Alamein dolomite is to maintain the life of the reservoir during 50 years of production by optimizing the production rates , Acid Stimulation 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.

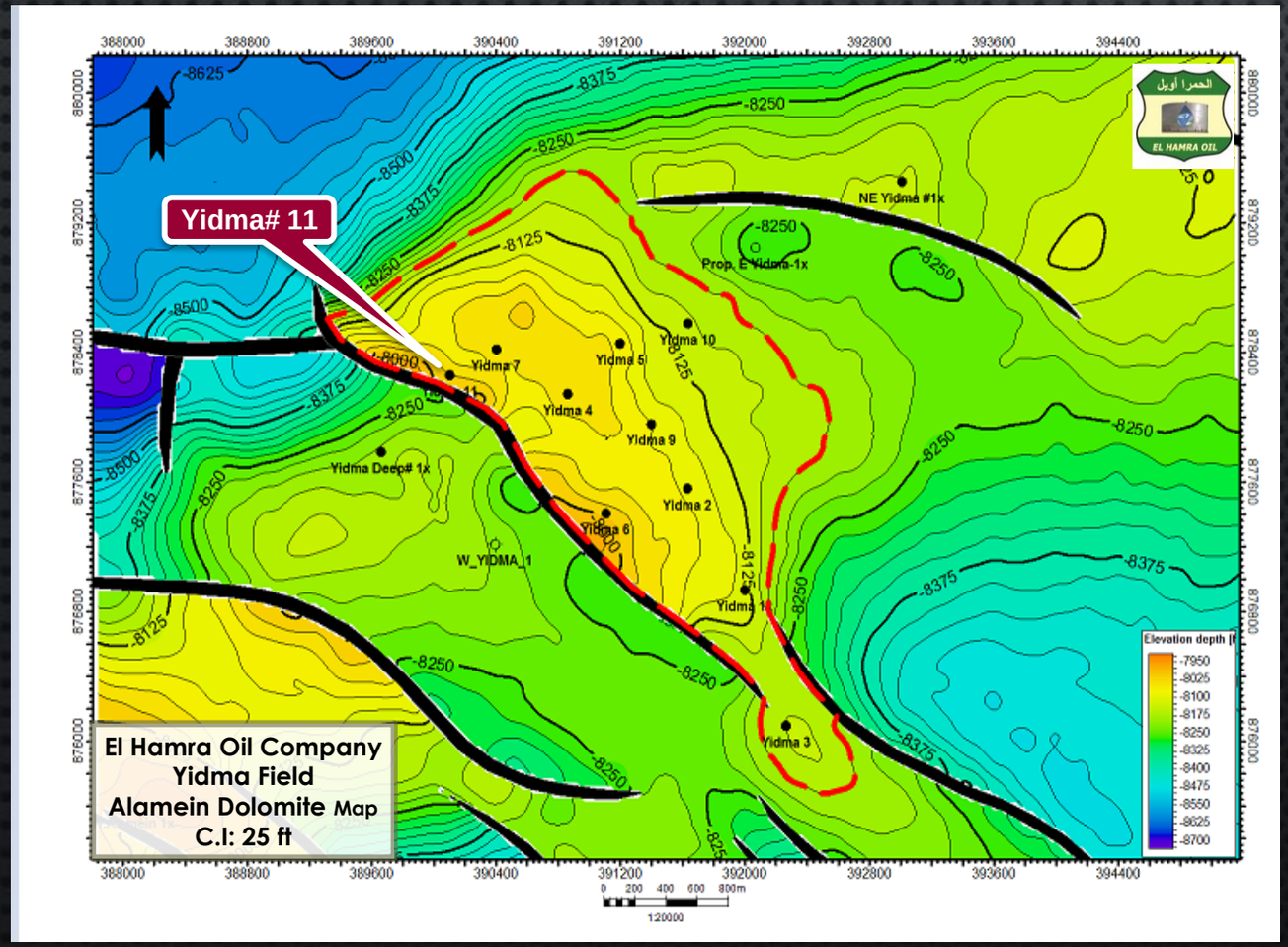


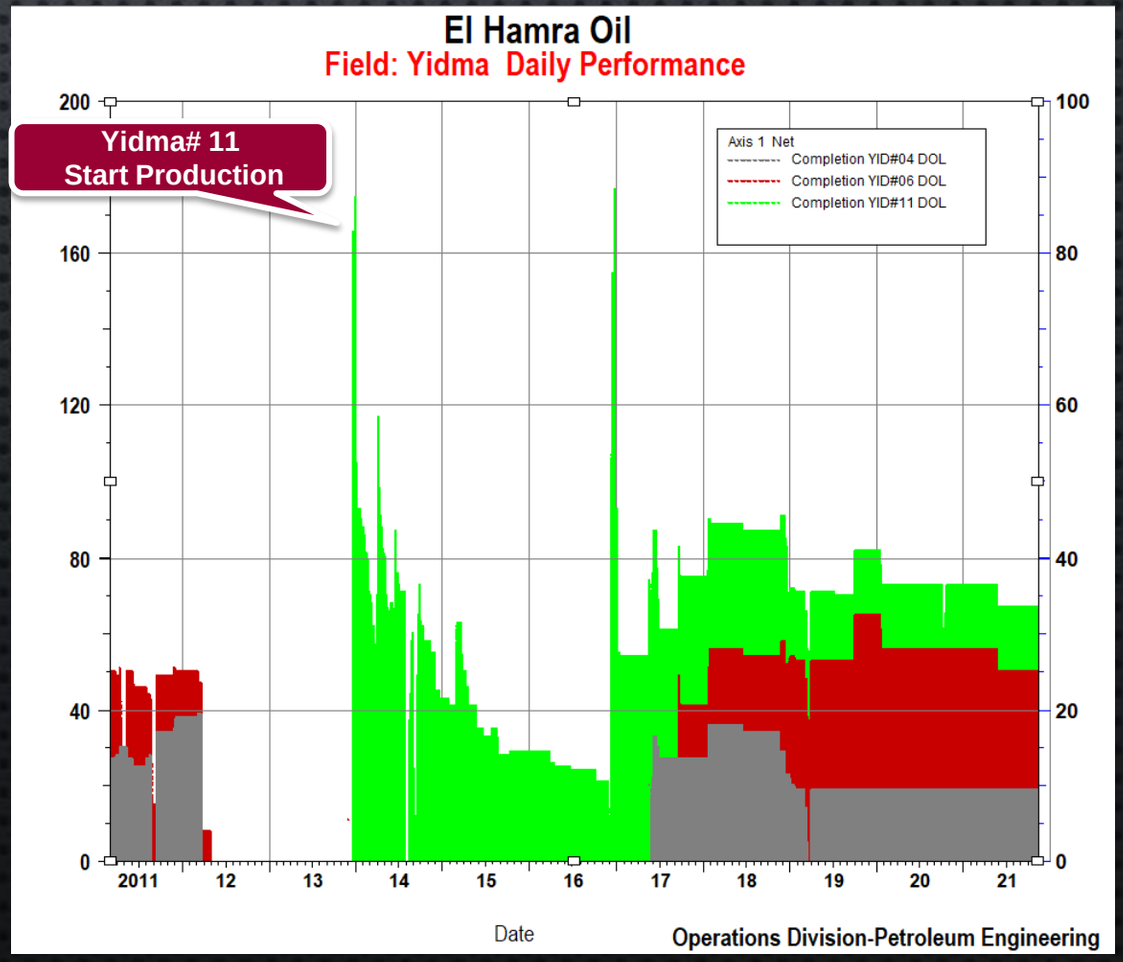


Alamein Dolomite Remaining Reserve (Yidma Field)

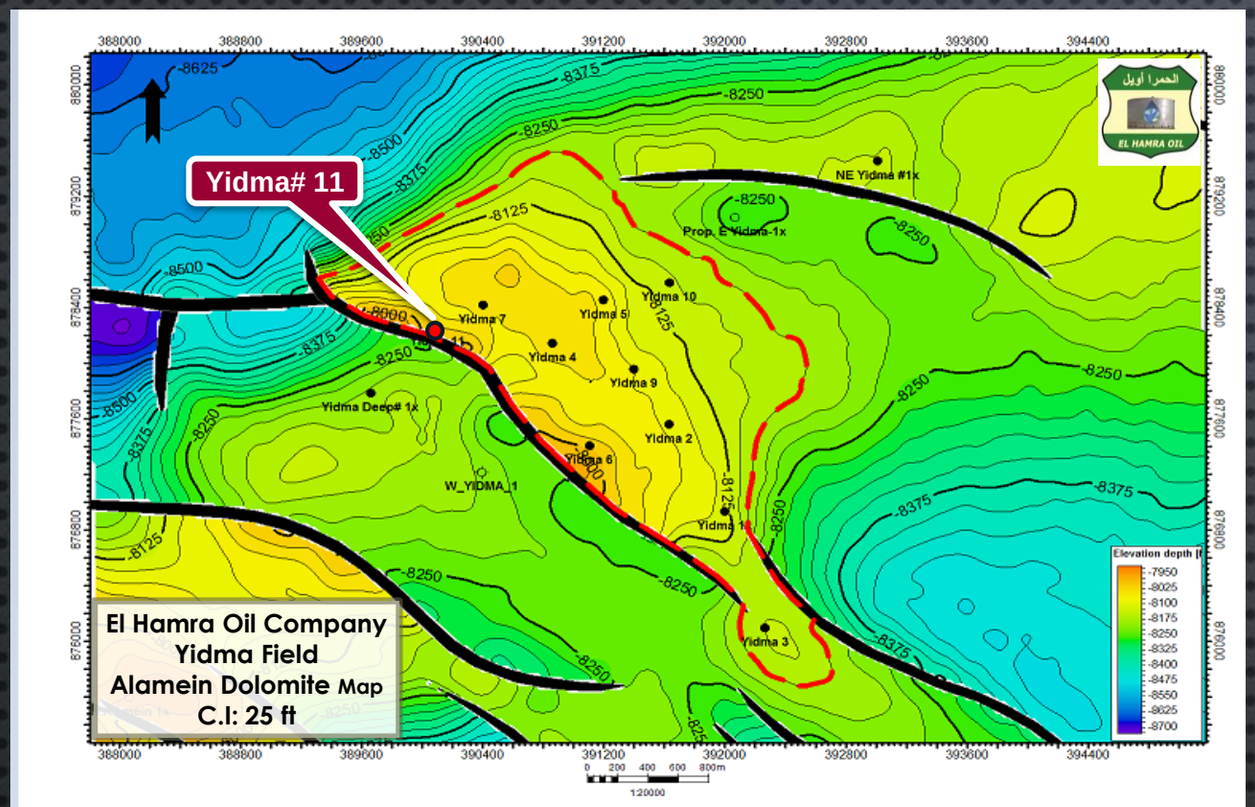
- The successful drilling on high structure areas of Alamein dolomite reservoir was done also in Yidma field by drilling of well Yidma#11 that started production with 140 BOPD & 10% WC therefore the field turned again into production after shut in for 2 years because of the uneconomic production rates of the other Alamein dolomite producers Yid#4 & Yid#6.

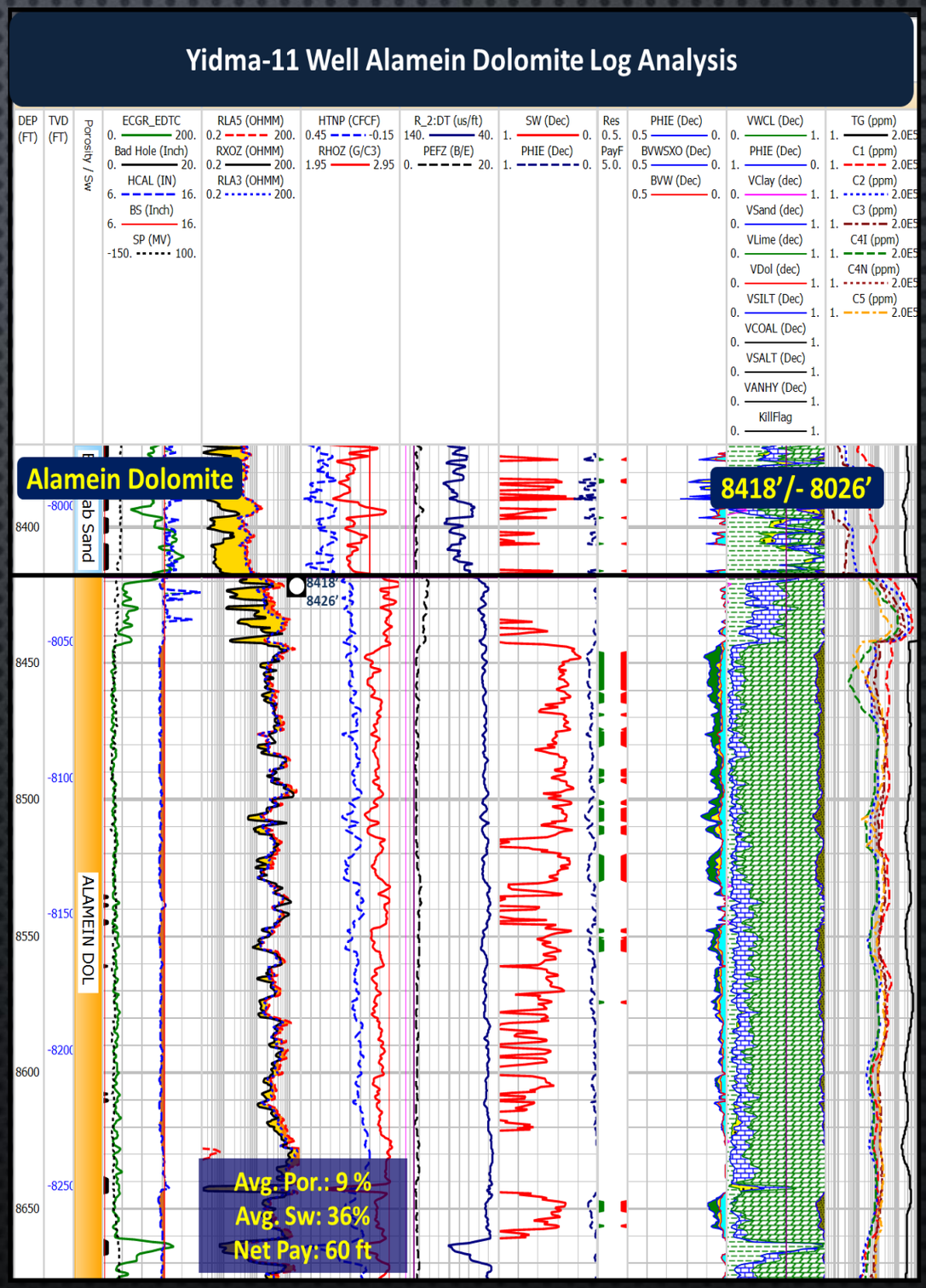
- The other challenge of Alamein dolomite in Yidma field was the high recovery factor that reached 53 % after cumulative production of 25 MMSTB that indicated more oil volume should be recalculated.





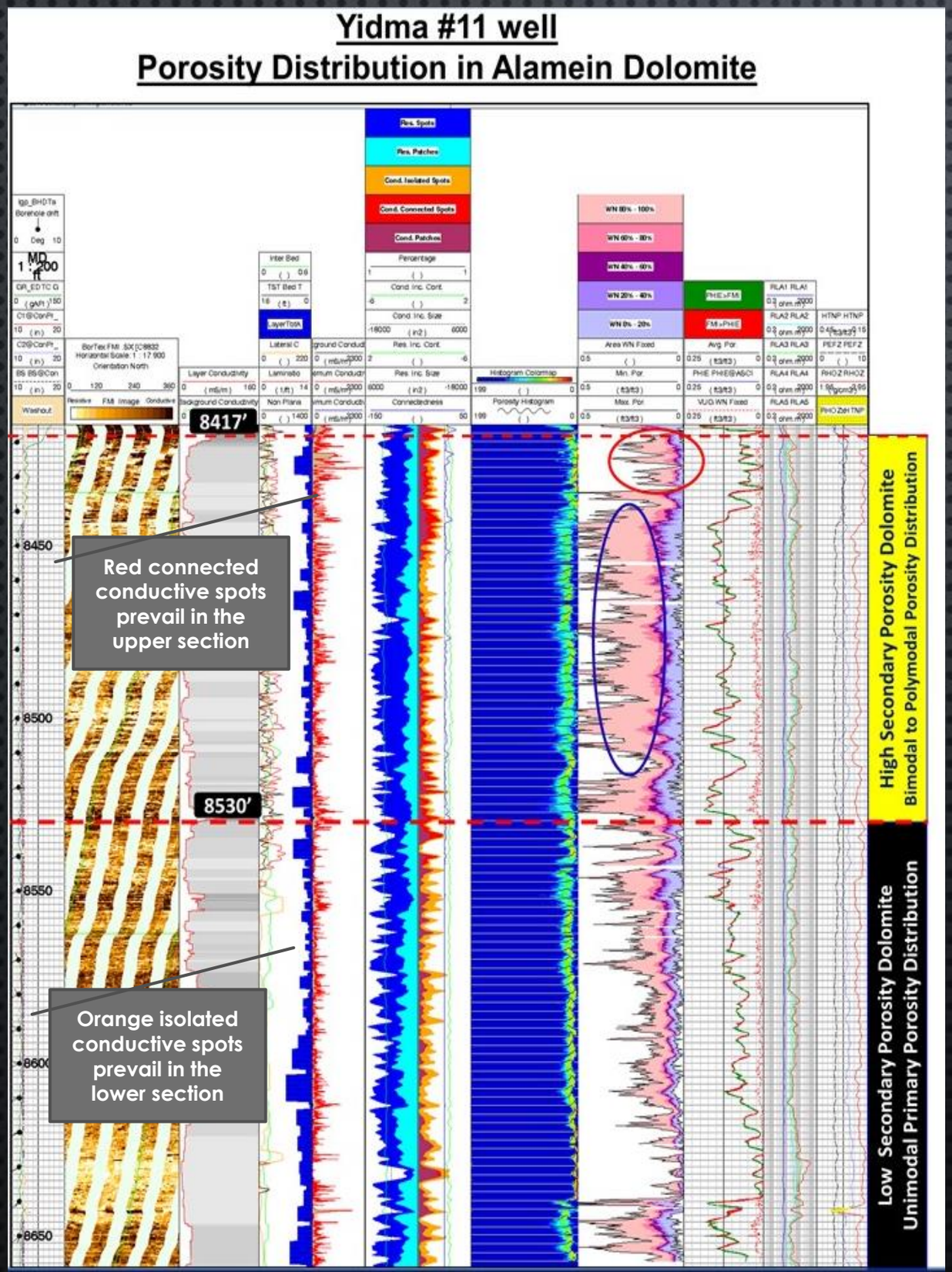
Alamein Dolomite Reservoir
Yidma# 11 Well_FMI Carbonate Study

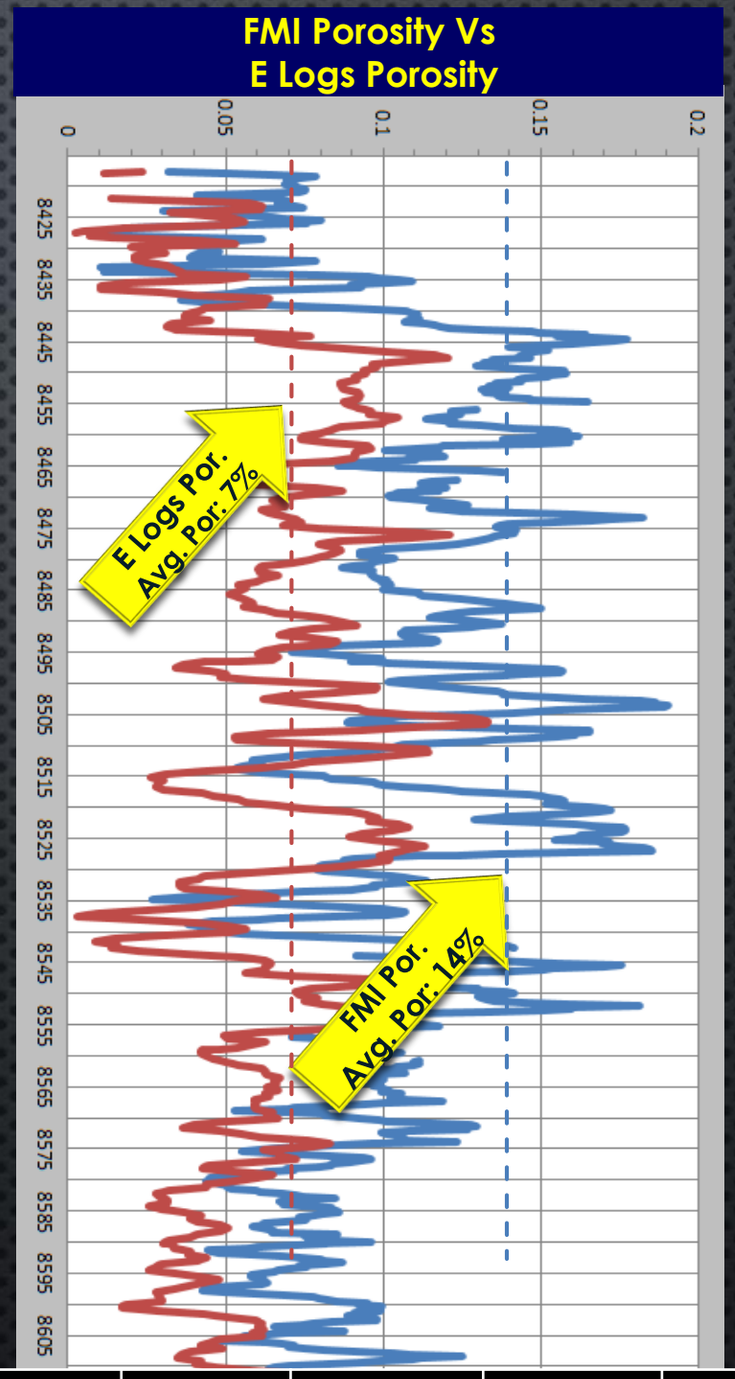




- Generally, petrophysical analysis for Alamein Dolomite conventional electric logs estimate only the primary matrix porosity.
- FMI acquired to enhance understanding of depositional processes and reservoir geometry through identifying the porosity distribution heterogeneities and quantify the secondary porosity.

Alamein Dolomite Reservoir_Yidma# 11 Well
FMI Carbonate Study





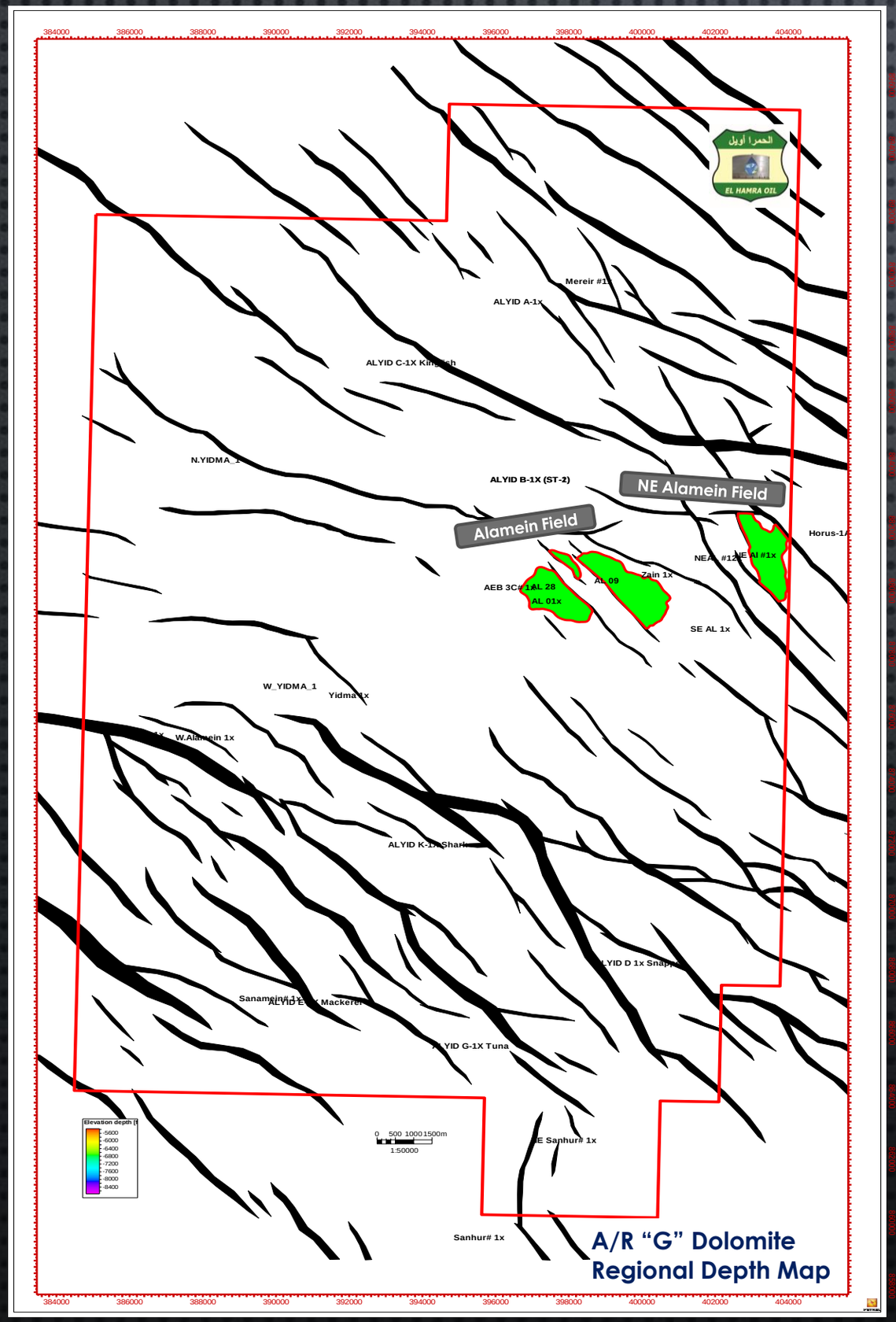
	Phi, %	OOIP, MMBO	Cum, MMBO	RF, %
Before FMI	7	48.5	25	53
After FMI	14	91	25	30

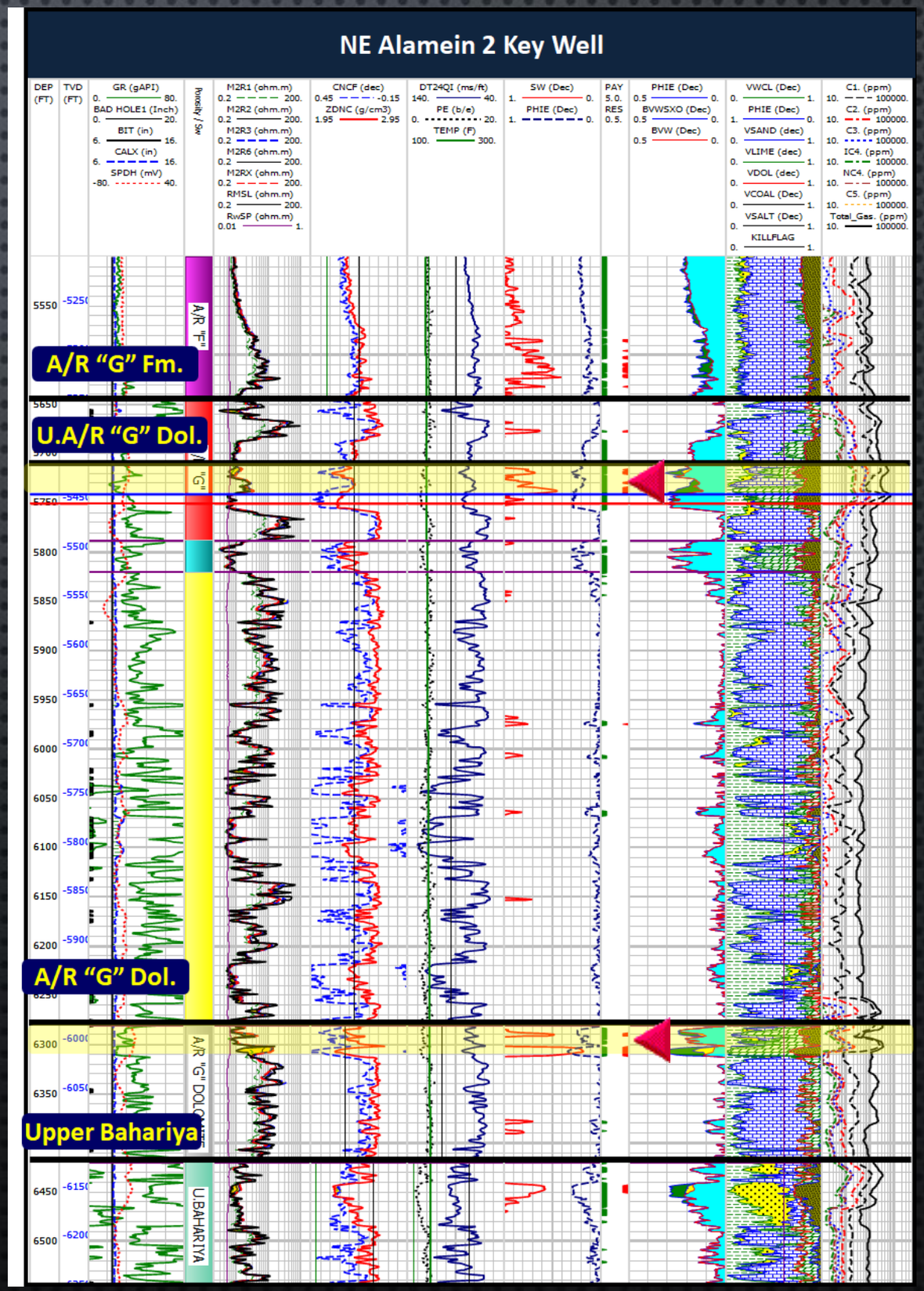
- A/R “G” MEMBER RESERVOIRS:-

1) A/R “G” DOLOMITE RESERVOIR

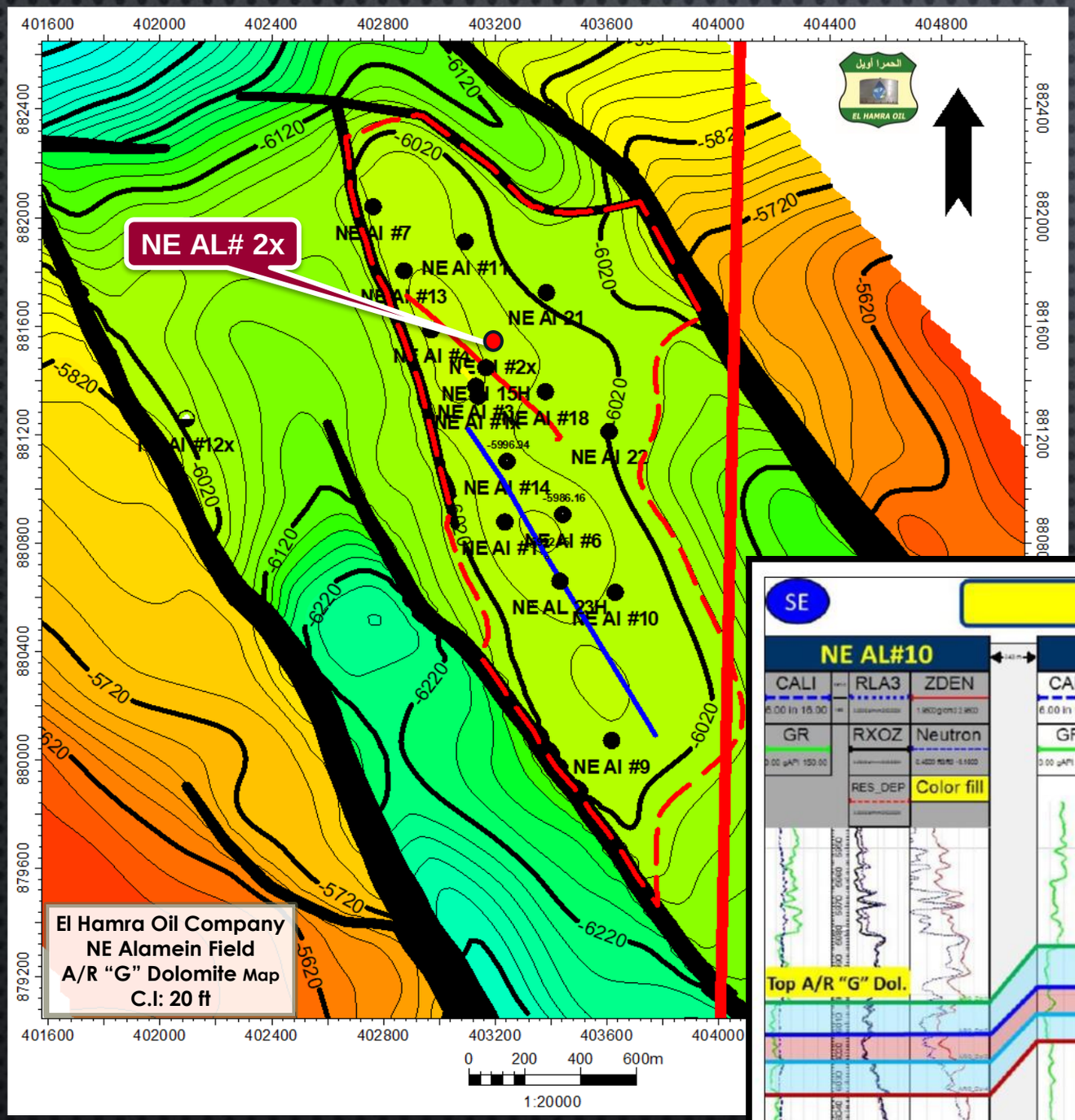
2) UPPER A/R “G” RESERVOIR

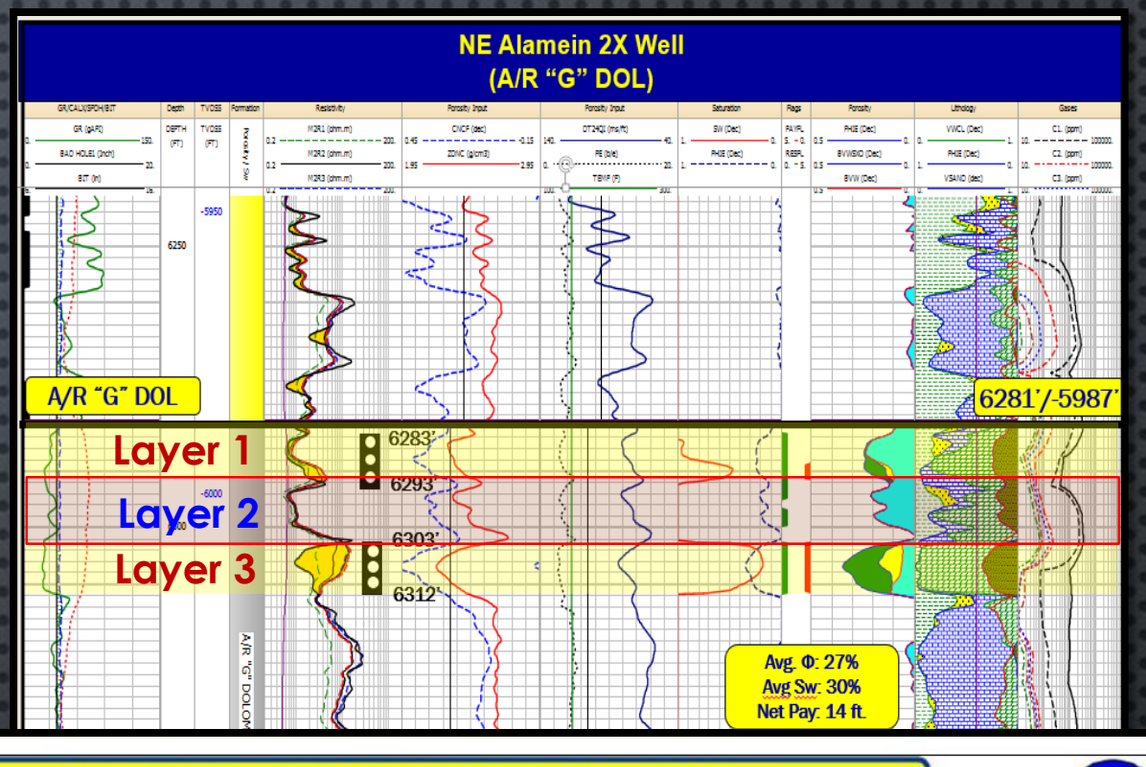
A/R “G” Dolomite reservoir in Yidma/ Alamein Area

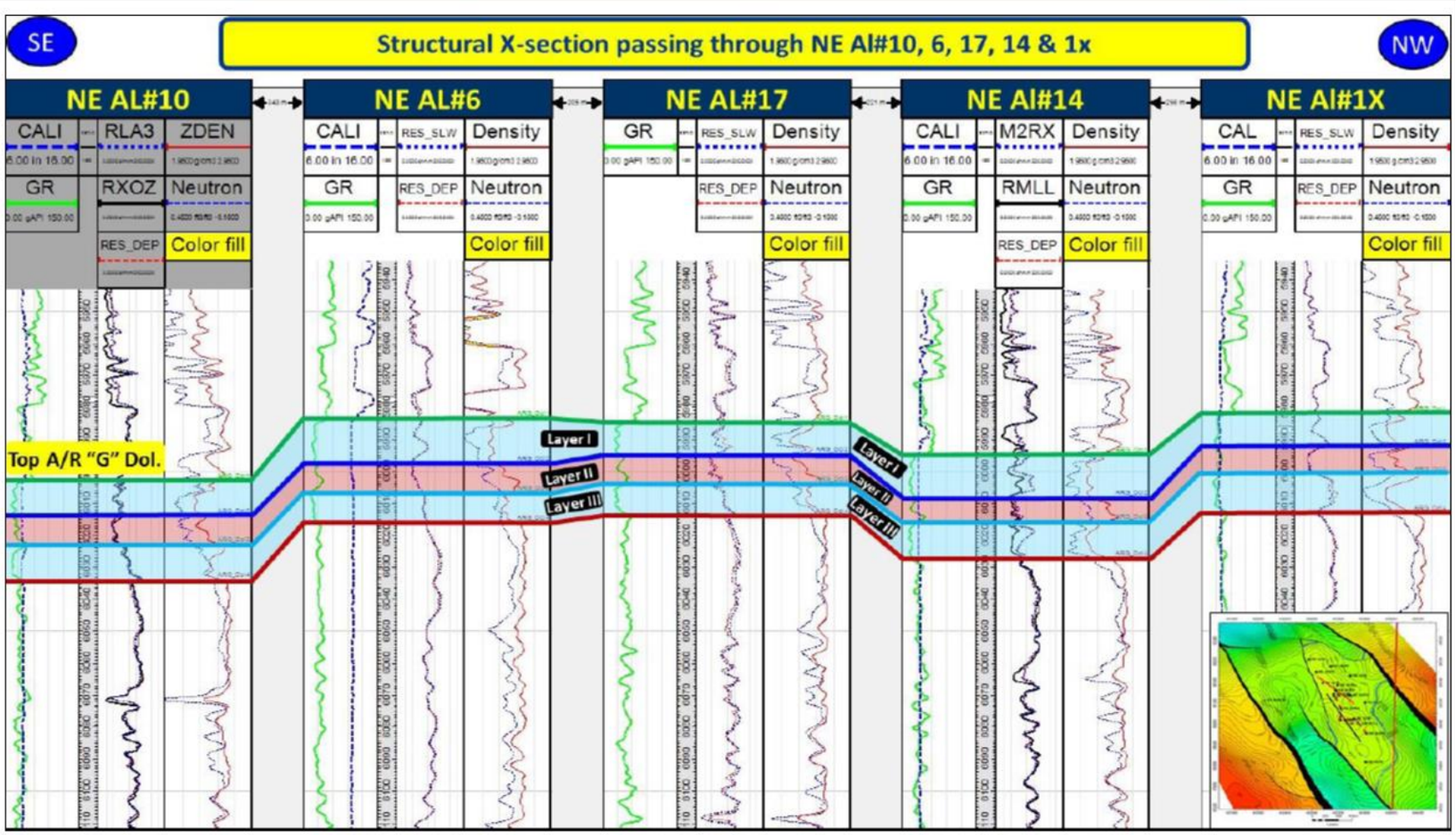




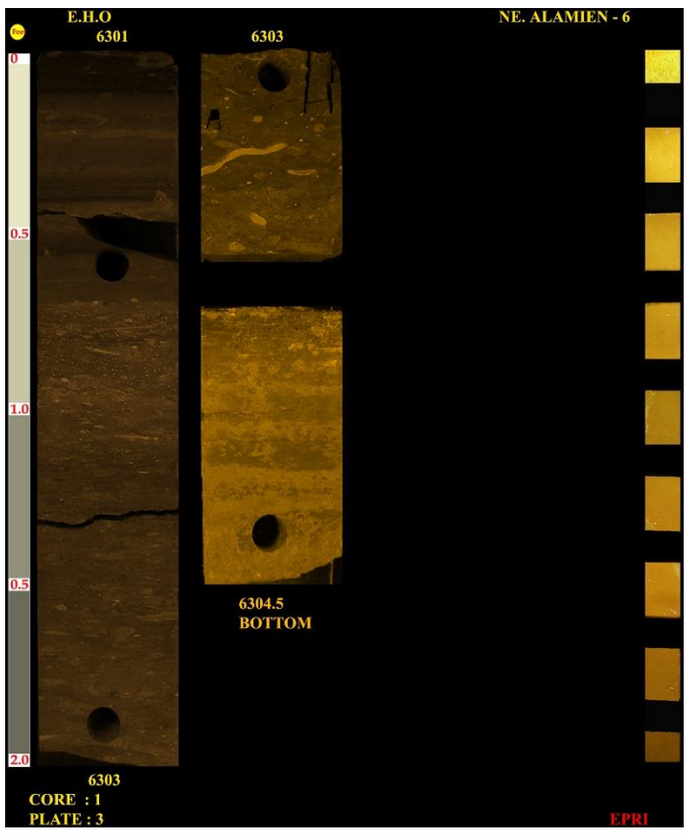
A/R "G" Dolomite Reservoir in NE Alamein Field



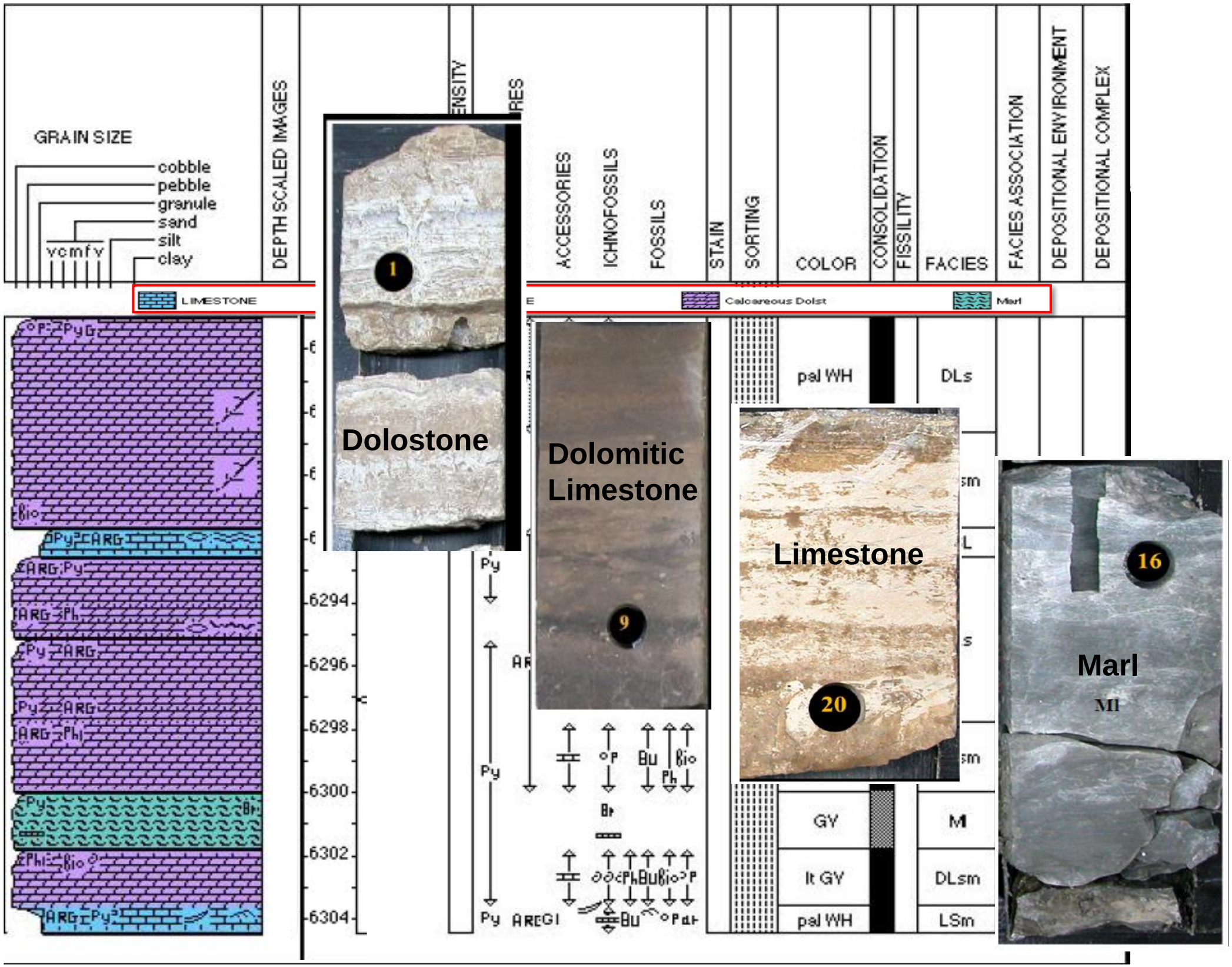




A/R" G" Dolomite Special Core
NE Alamein 6 Well_WL/UV Core Photos



A/R" G" Dolomite
NE Alamein 6 Well_Facies Log



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.

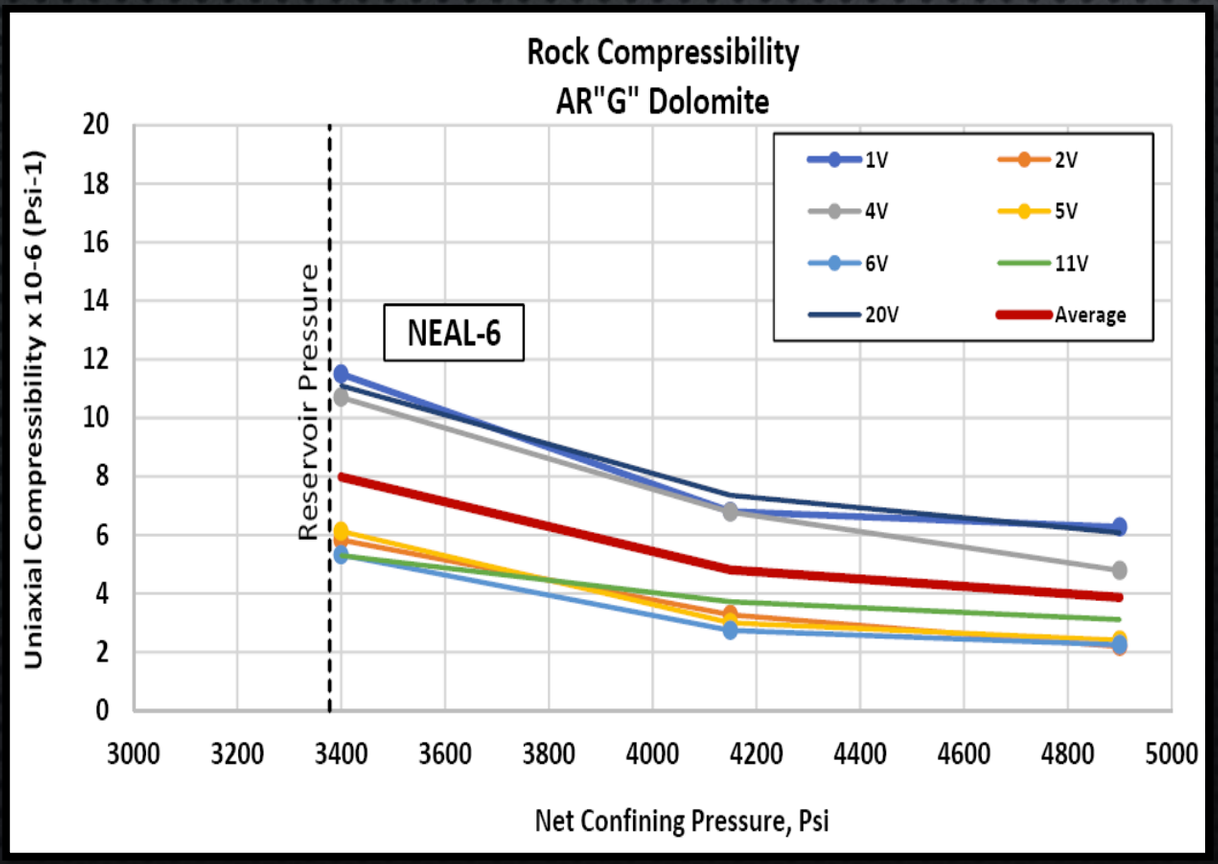


Table (4): Wettability by Amott method

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 **(60 Psi)** and very low solution gas-oil ratio **(9.378 Scf/Stb).**

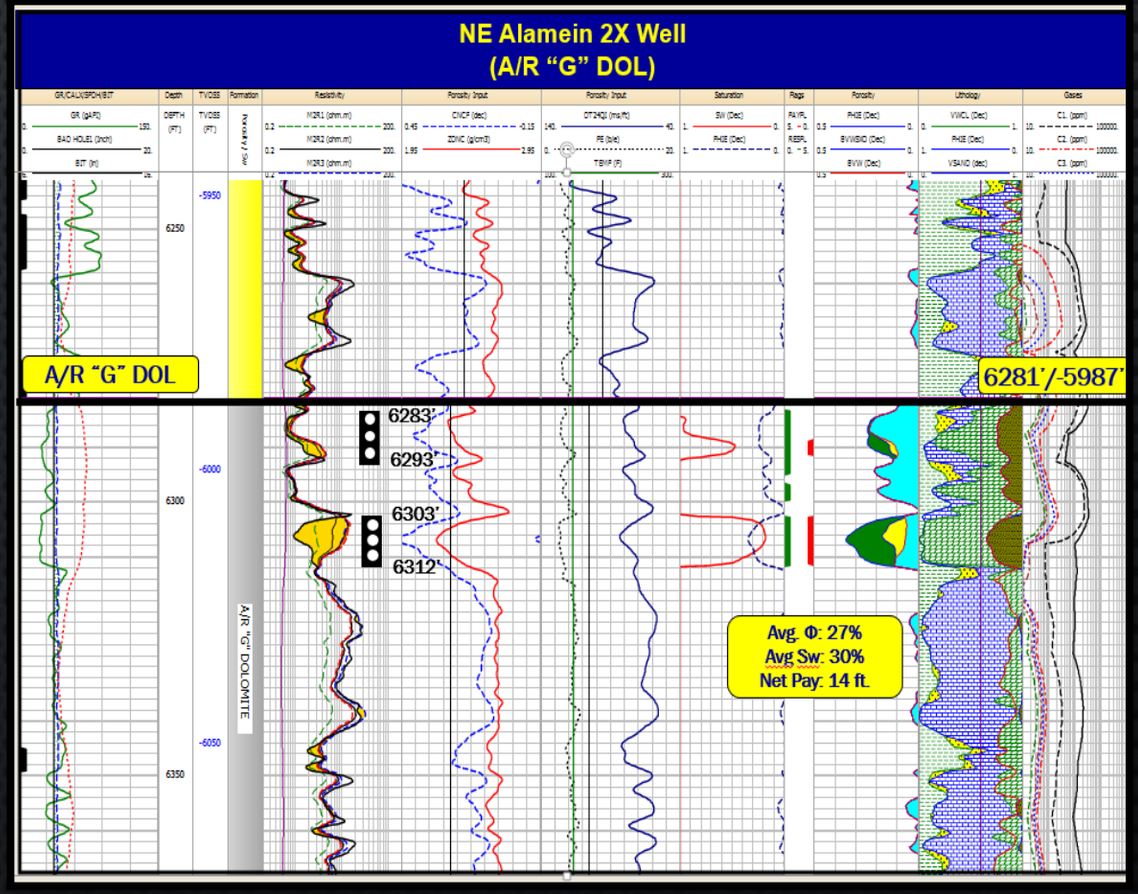
Pressure	Oil Density	Gas Gravity	Z-Factor	Oil F.V.F.	Adjusted Oil F.V.F.	Gas F.V.F.	Solution Gas/oil ratio	Adjusted Solution Gas/oil ratio	Oil Viscosity	Gas Viscosity	Compressibility
				βo	βo	βg	Rs	Rs			Co
psig	g/cc	Air=1.000		bbL/STB	bbL/STB	CF/SCF	SCF/STB	SCF/STB	cp	cp	$psi^{-1}x10^{-6}$
2575.0	0.87611			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	

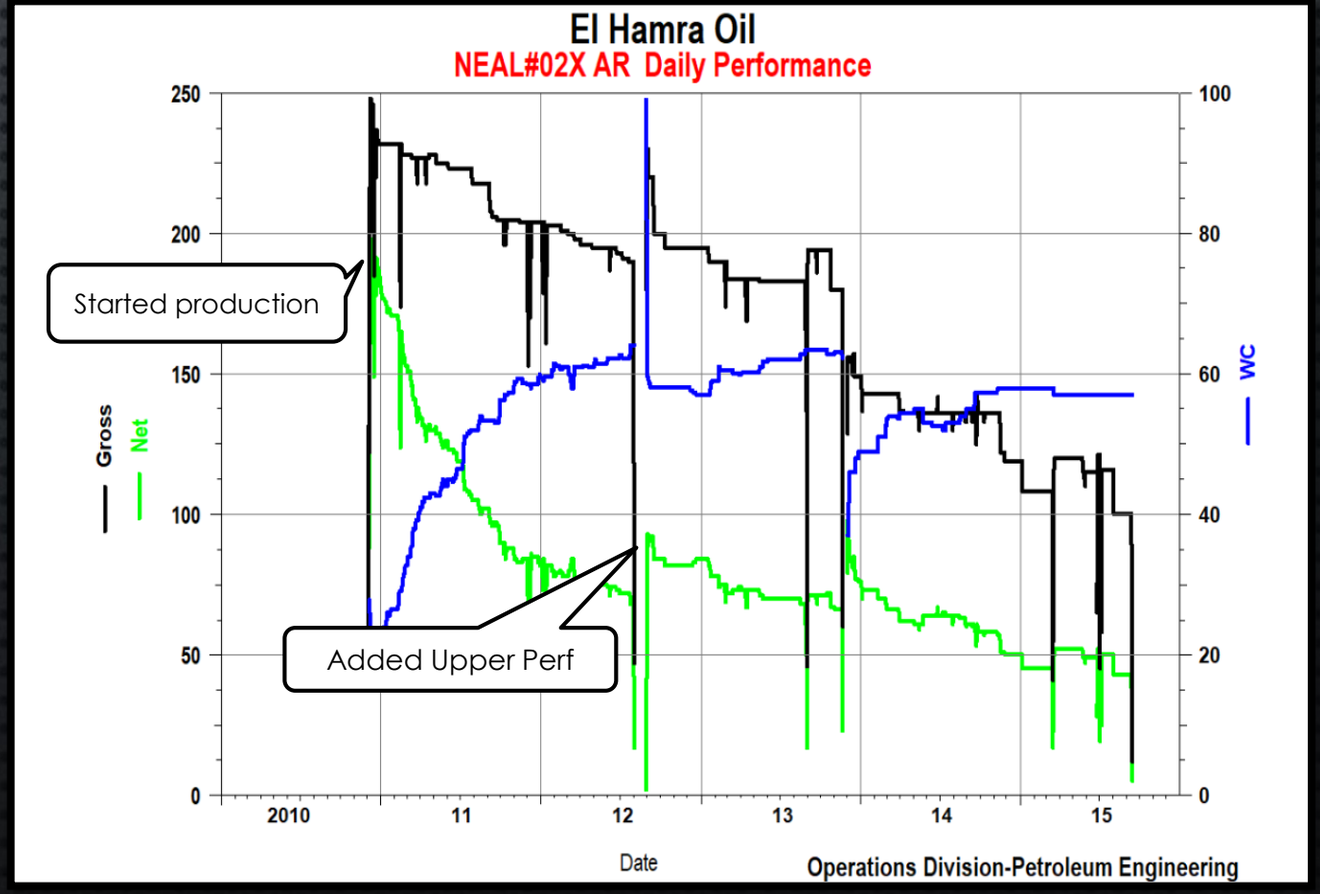
Saturation pressure

ARG Dolomite : Start Production

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

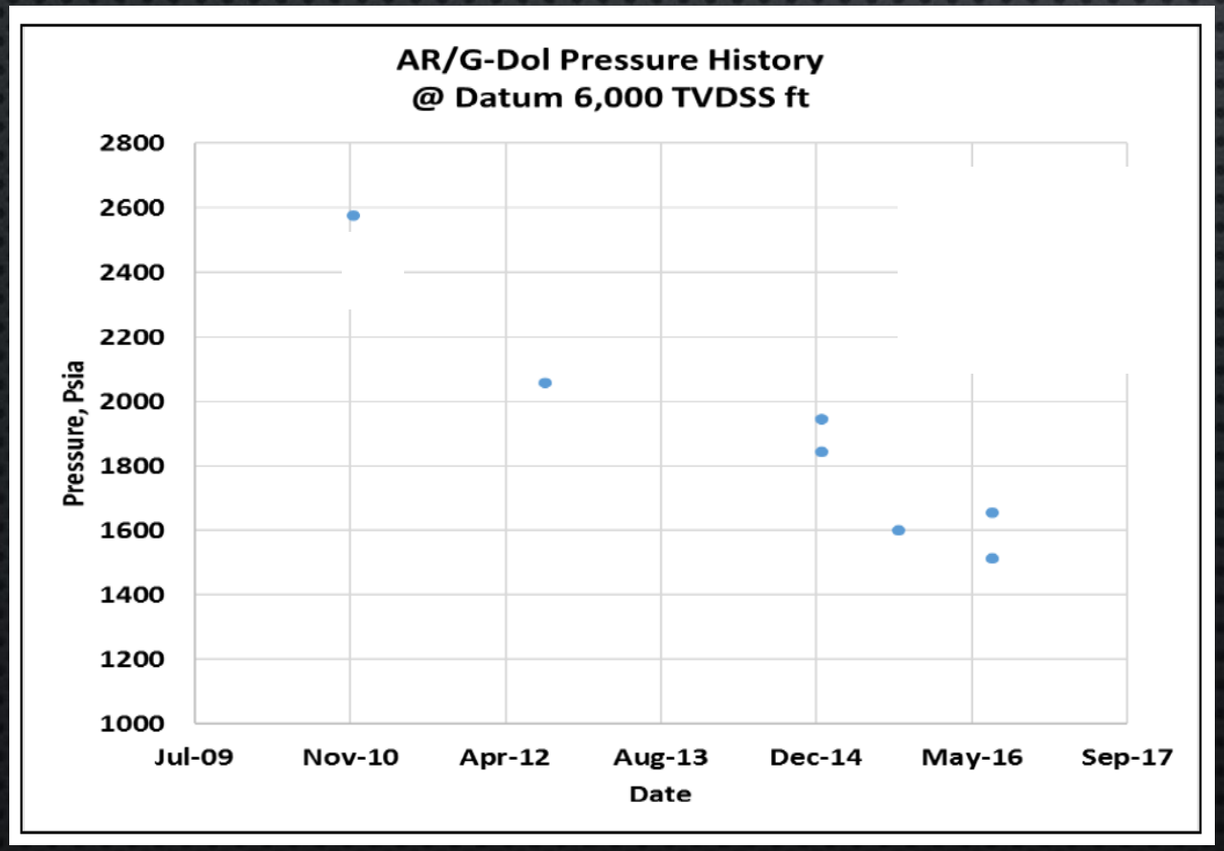
- The upper part of the reservoir was added in August 2012 to improve the productivity. The production rate increased by 25 BOPD and continue producing till shut in September 2015 after cumulative oil production of 135 MSTB .

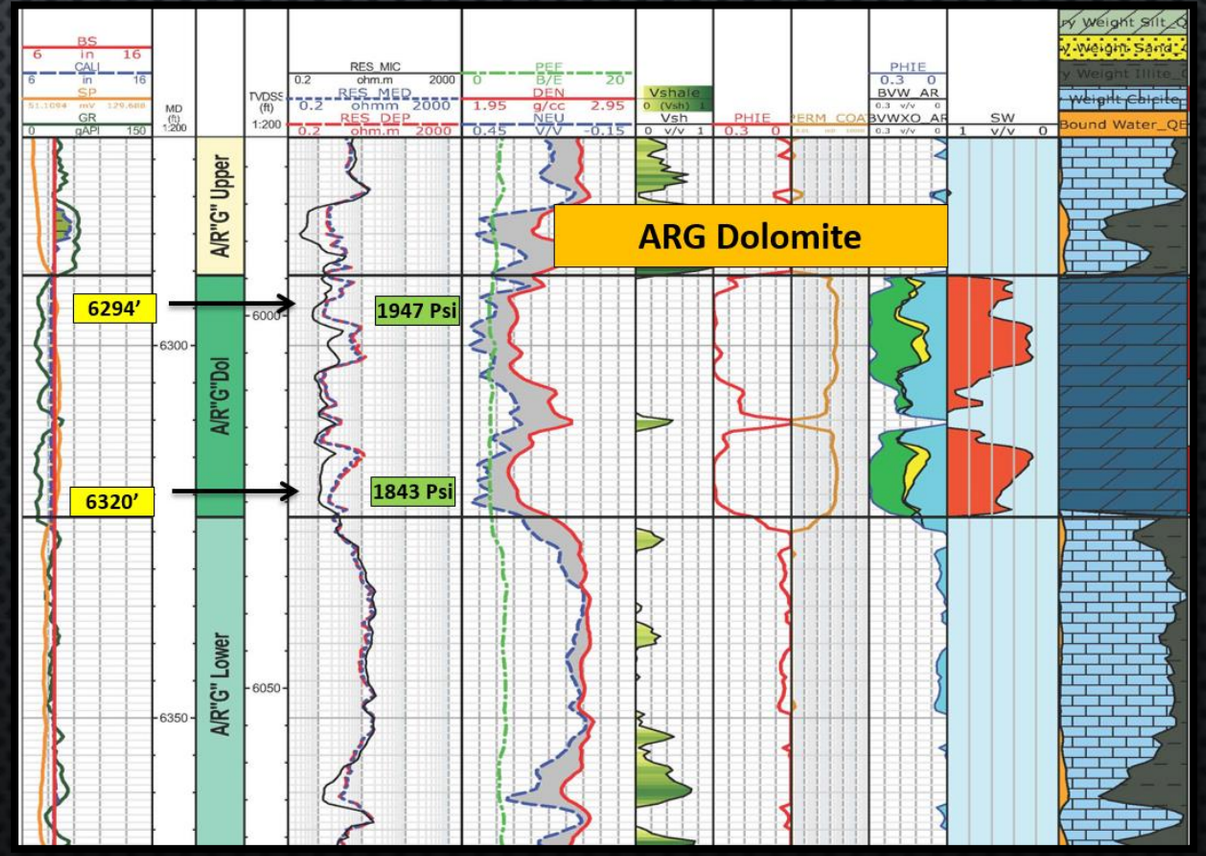




ARG DOLOMITE : Pressure History

- 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.

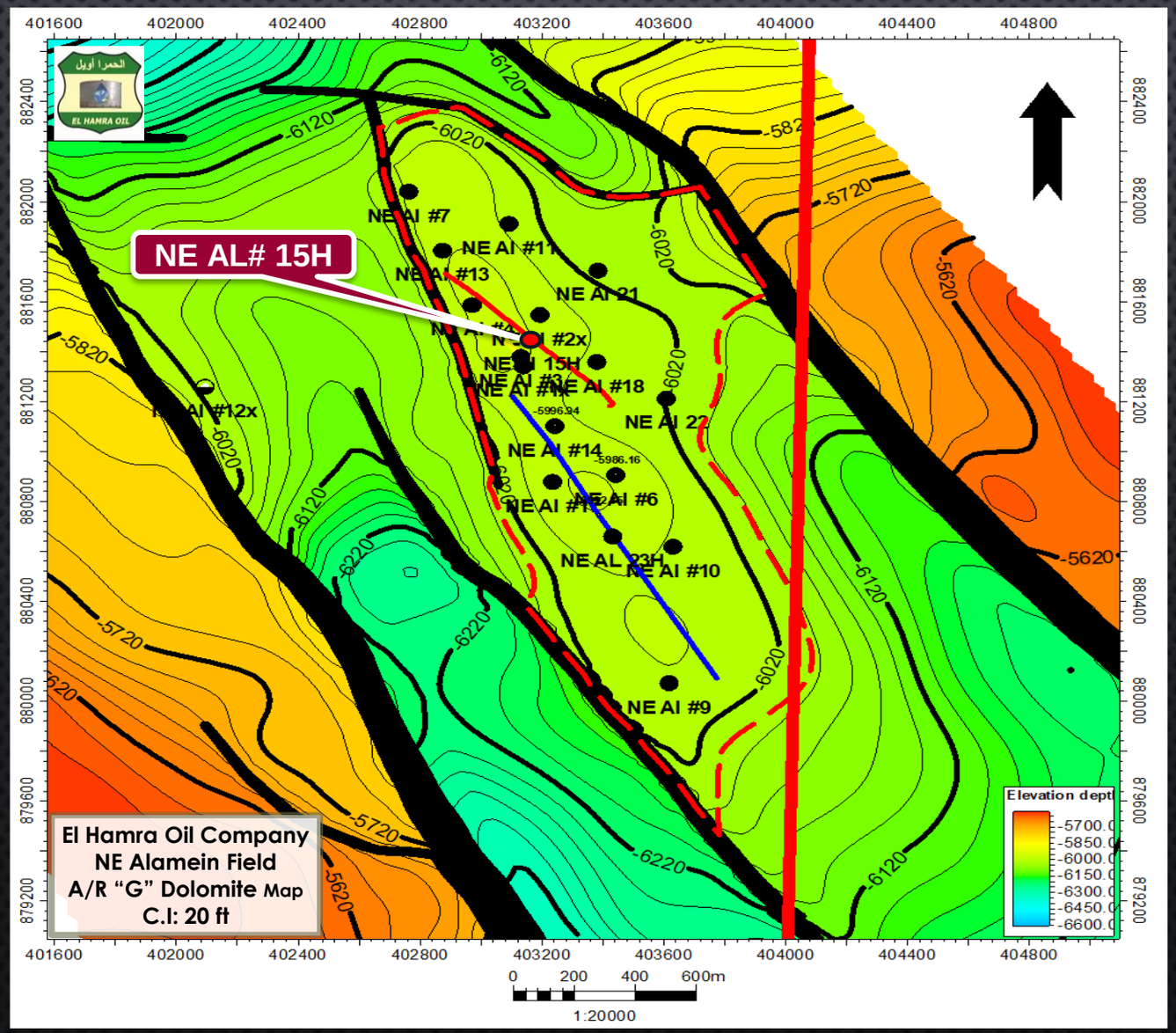




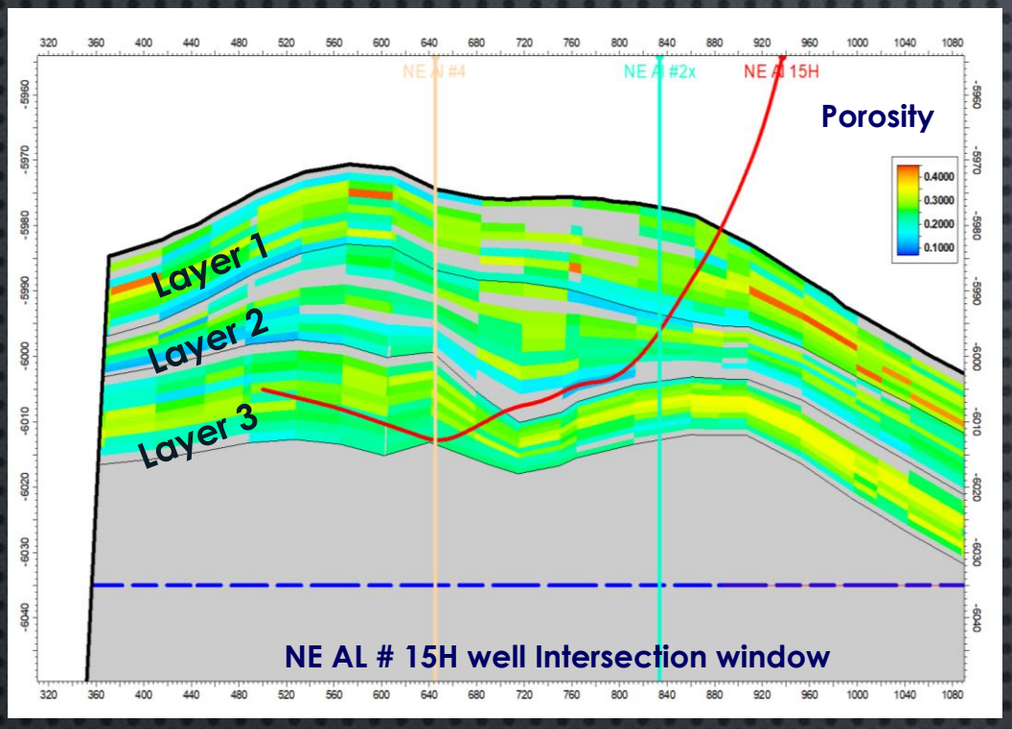
ARG DOLOMITE : Development Strategy

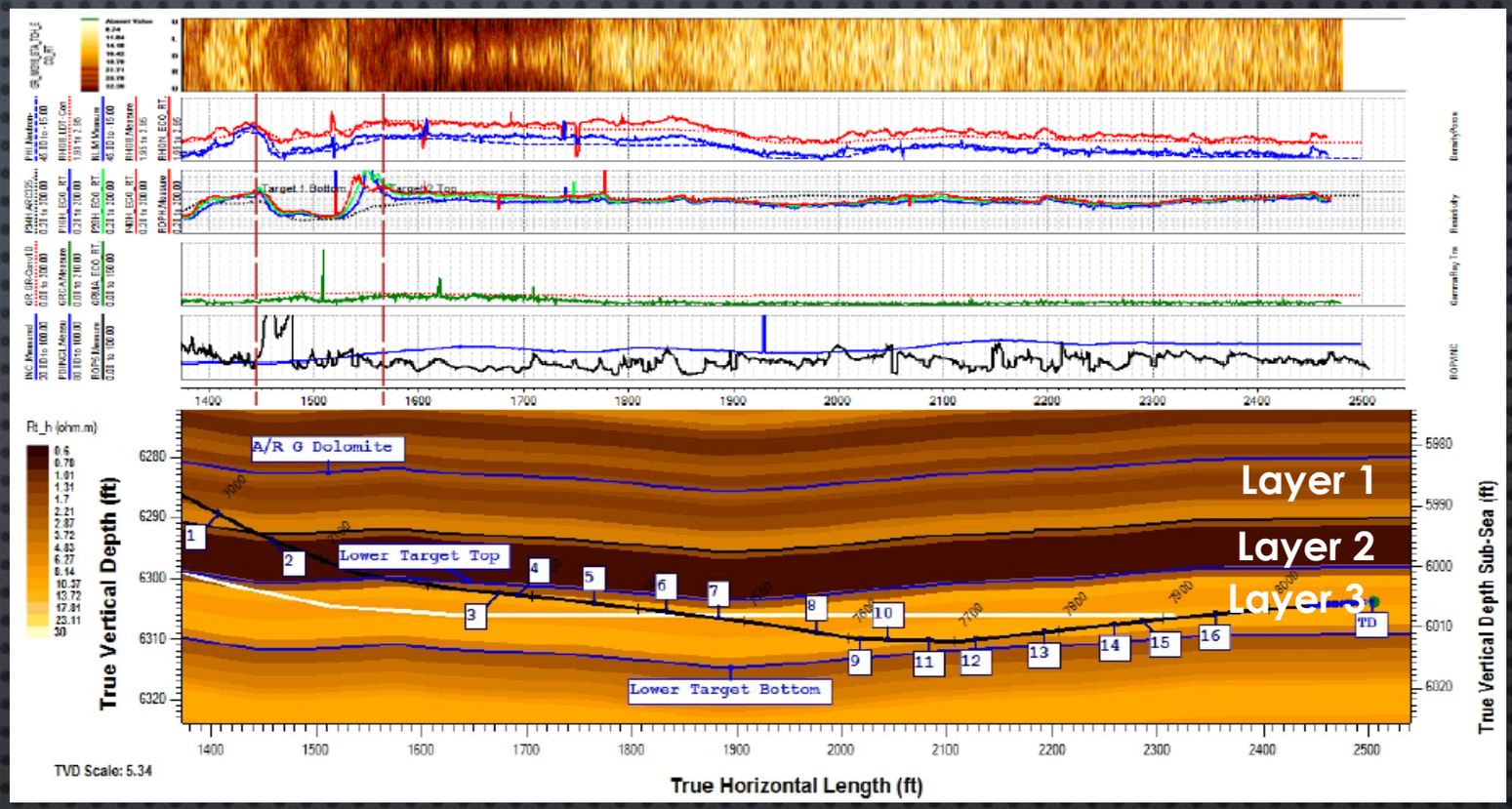
- Increasing the production rates from ARG dolomite reservoir was a big challenge because of the small thickness and tightness of the formation, facies quality variation and the high depletion rate of the reservoir that affected the production performance of the vertical well NEAL#2.

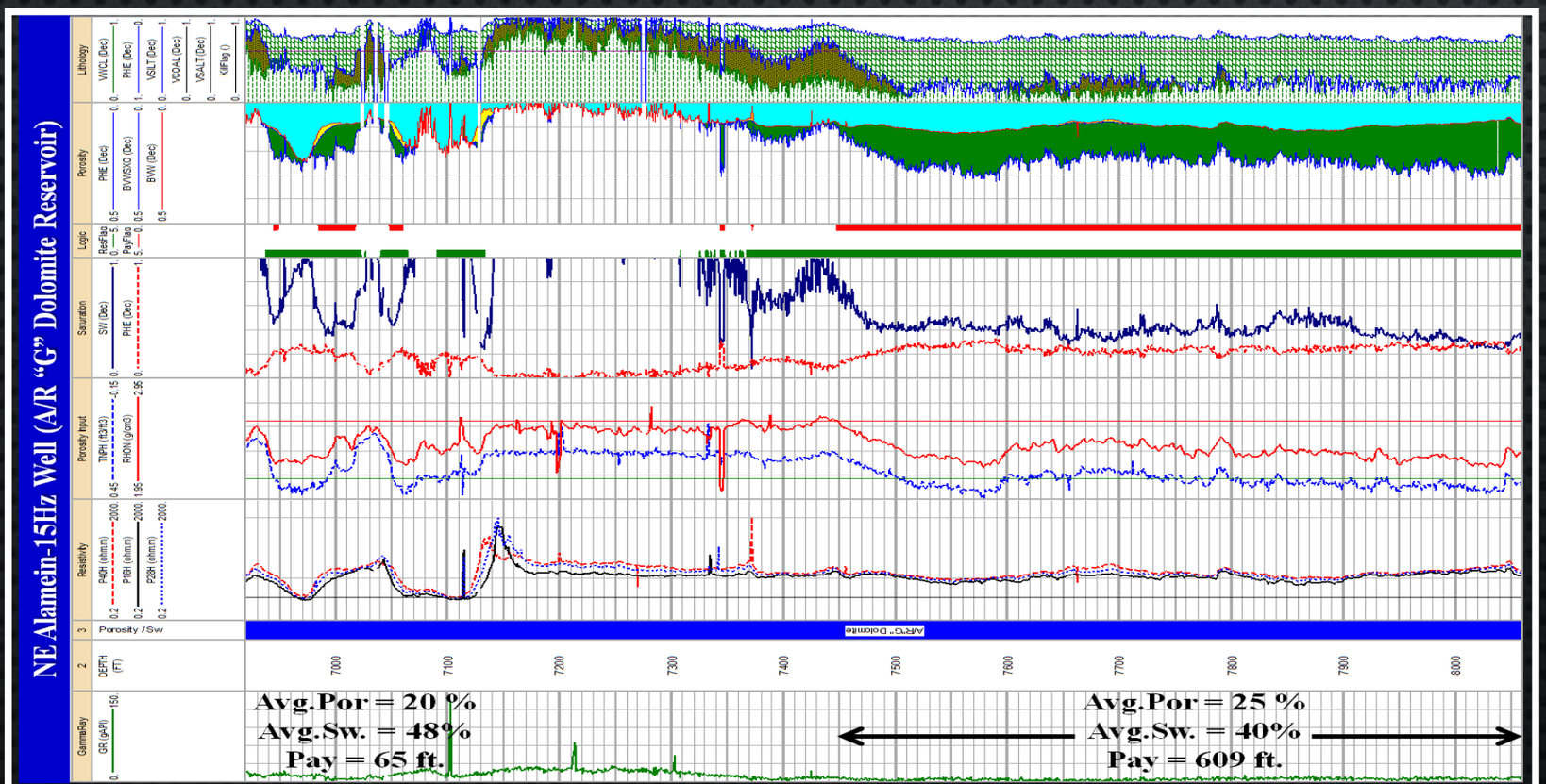
- EHO succeeded in drilling the first horizontal well NEAL#15 targeting ARG dolomite reservoir in July 2015 with a lateral section of 1200 FT. mainly in the lower part of the reservoir.



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





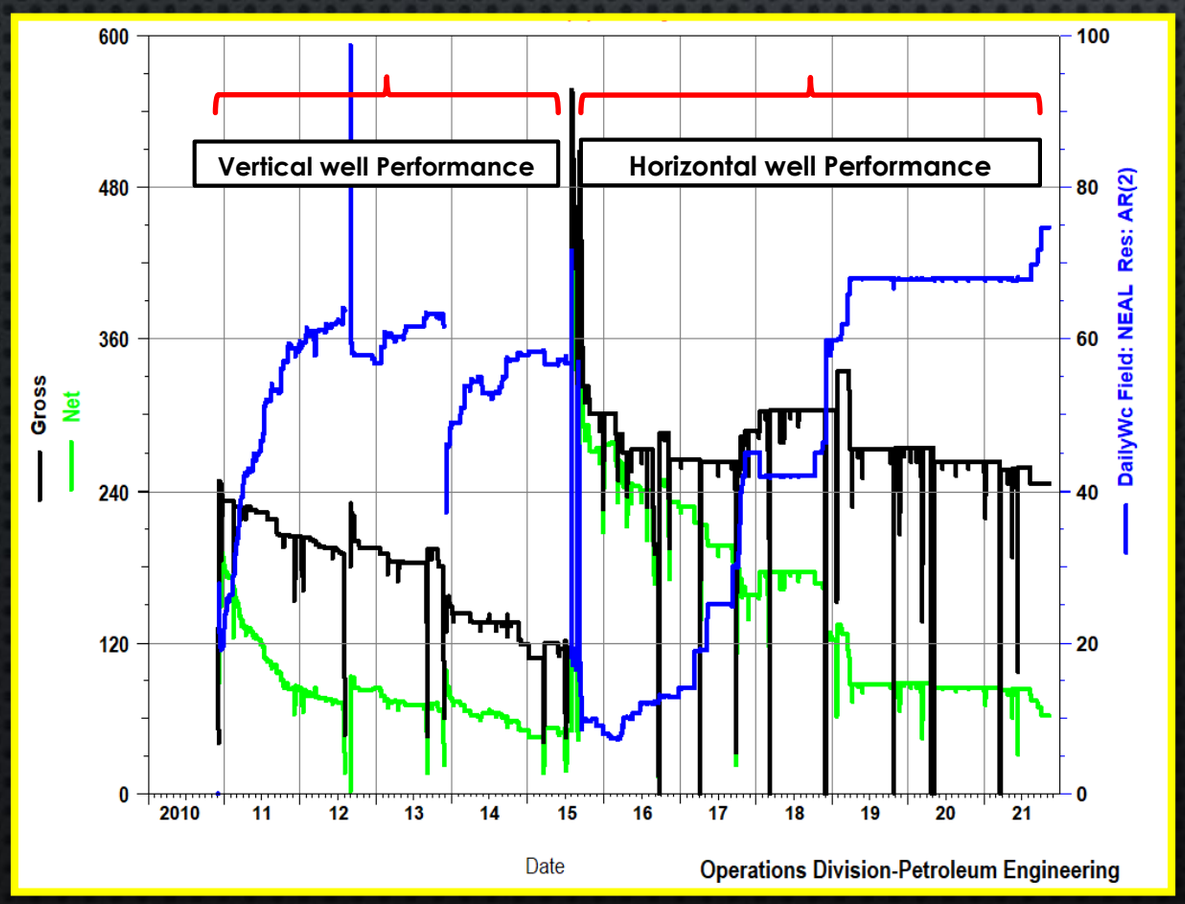


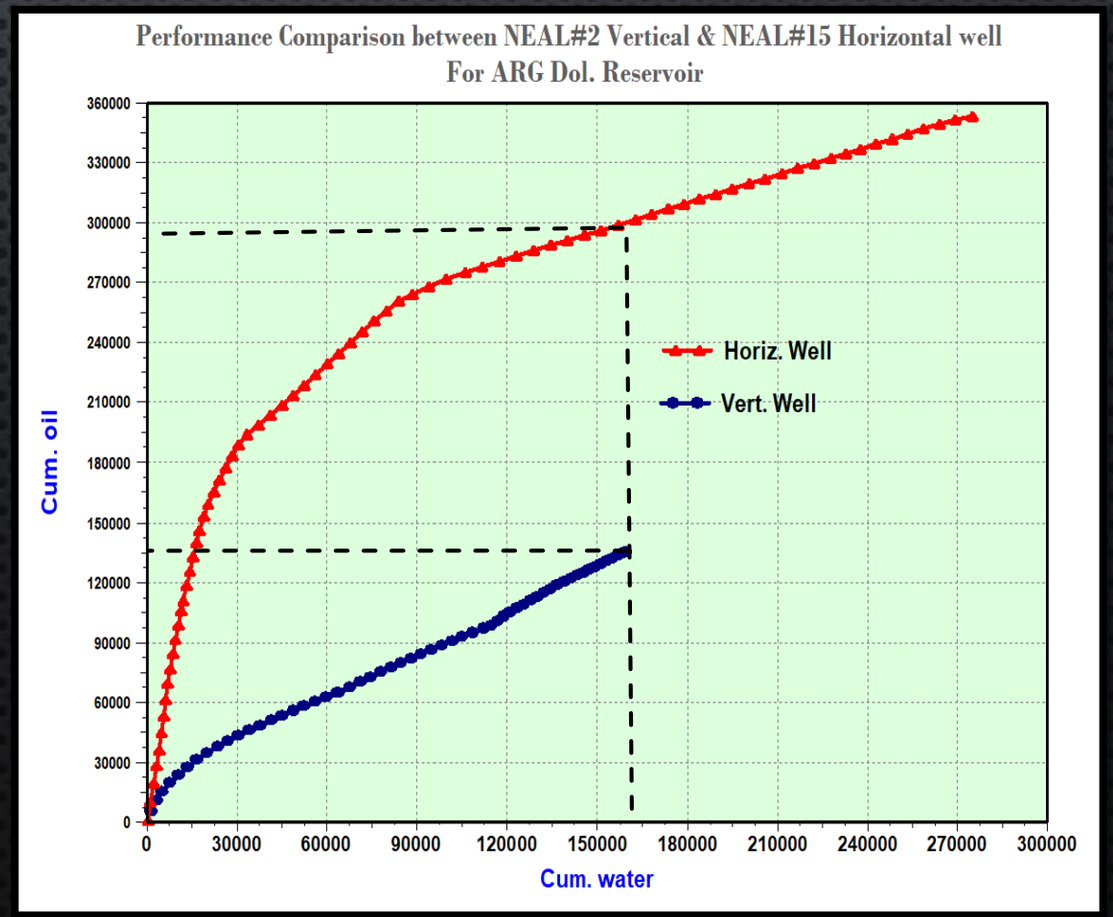
- The used geosteering method for well placement is Reactive Azimuthal Geosteering method.
- Technical teams managed to maximize the reservoir exposure while drilling the well that was confirmed from the petrophysical analysis.

Horizontal VS Vertical Well Performance

- The horizontal well started production with 400 BOPD and 5% water cut , this oil rate is eight times 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 reservpor production life.





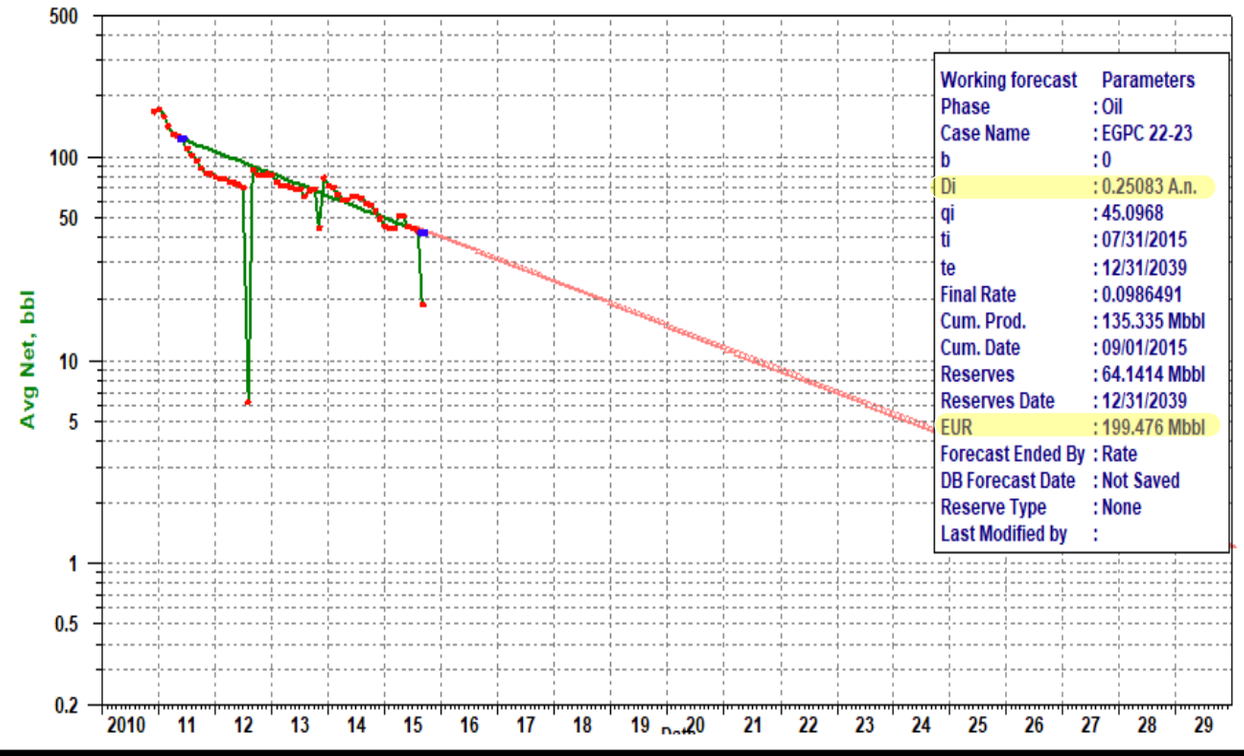
Improving Recovery

- 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)%.

Vertical Well

NEAL#02X AR

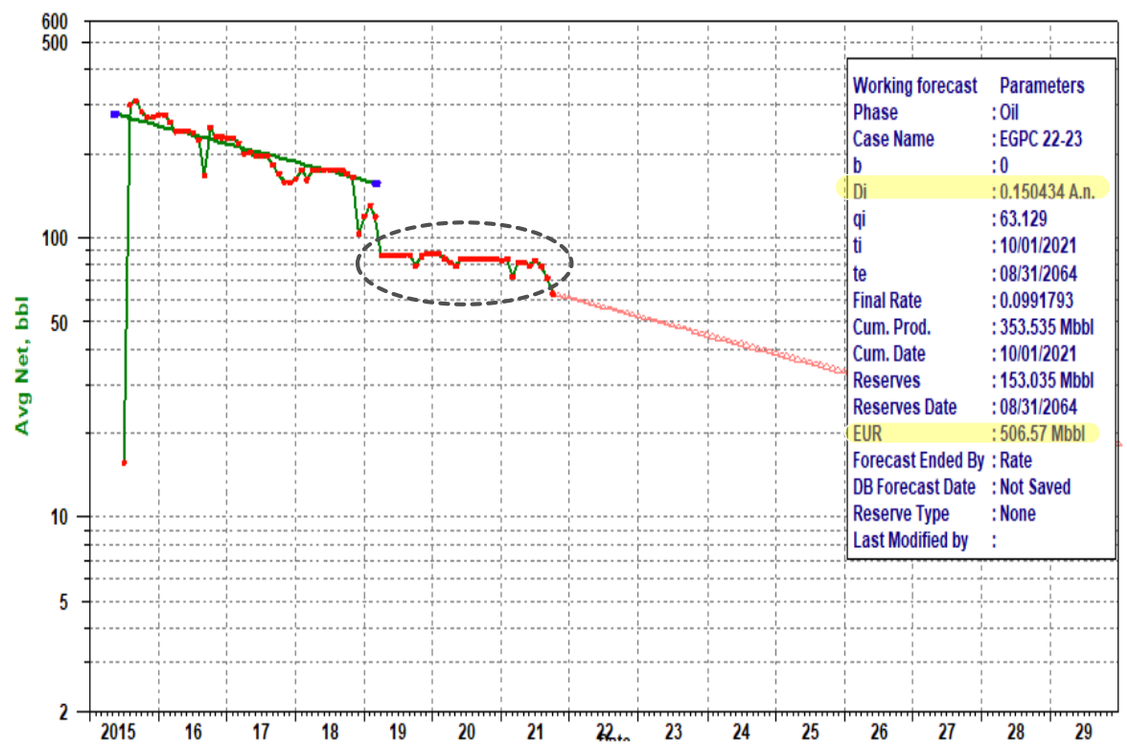
EHO Exponential Decline Curve Analysis



Horizontal Well

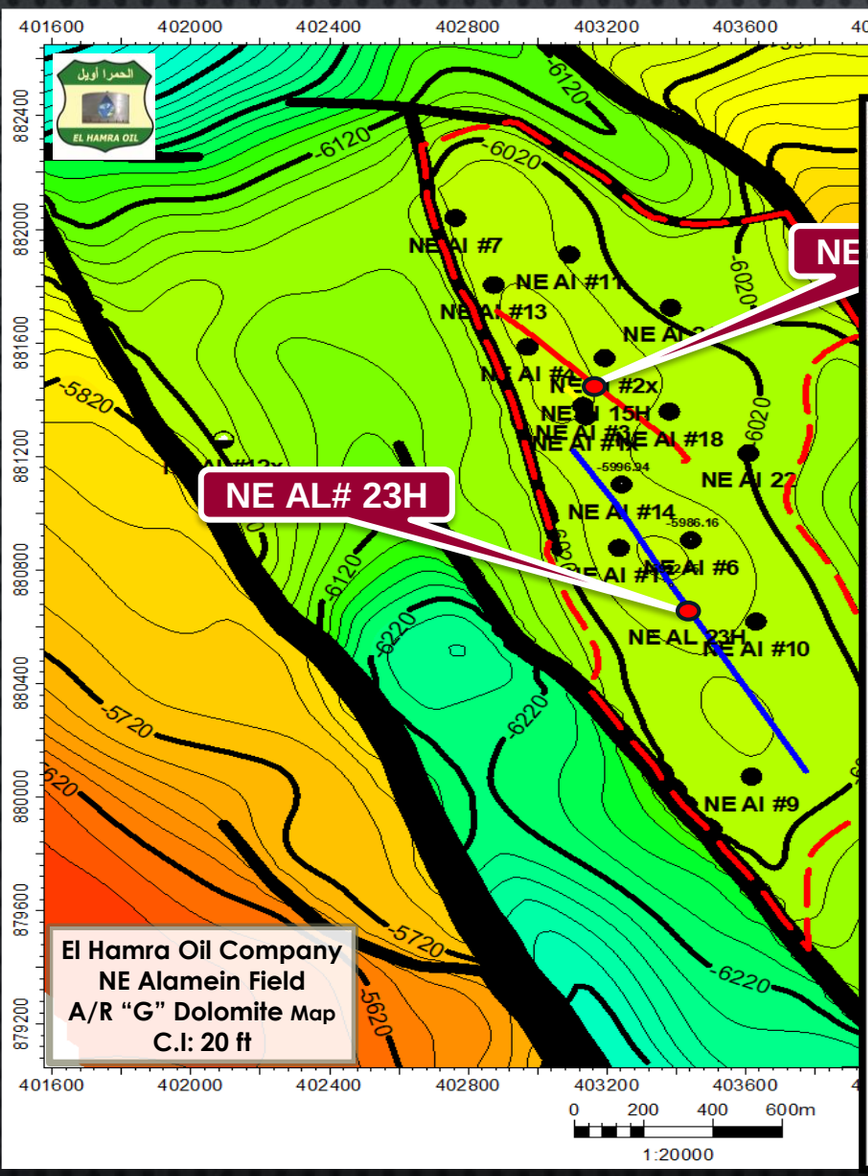
NEAL#15 AR

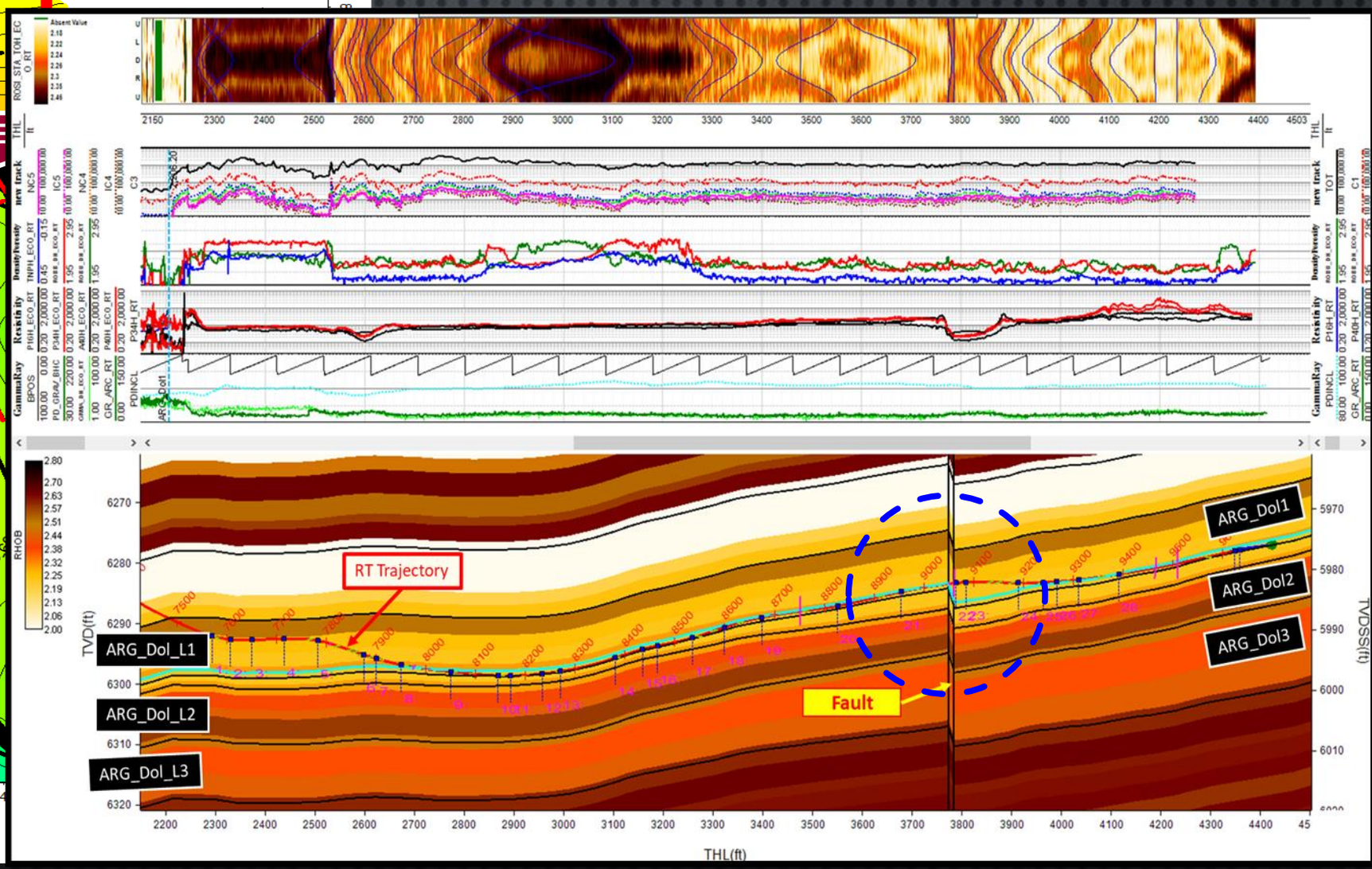
EHO Exponential Decline Curve Analysis



Continued Horizontal Drilling

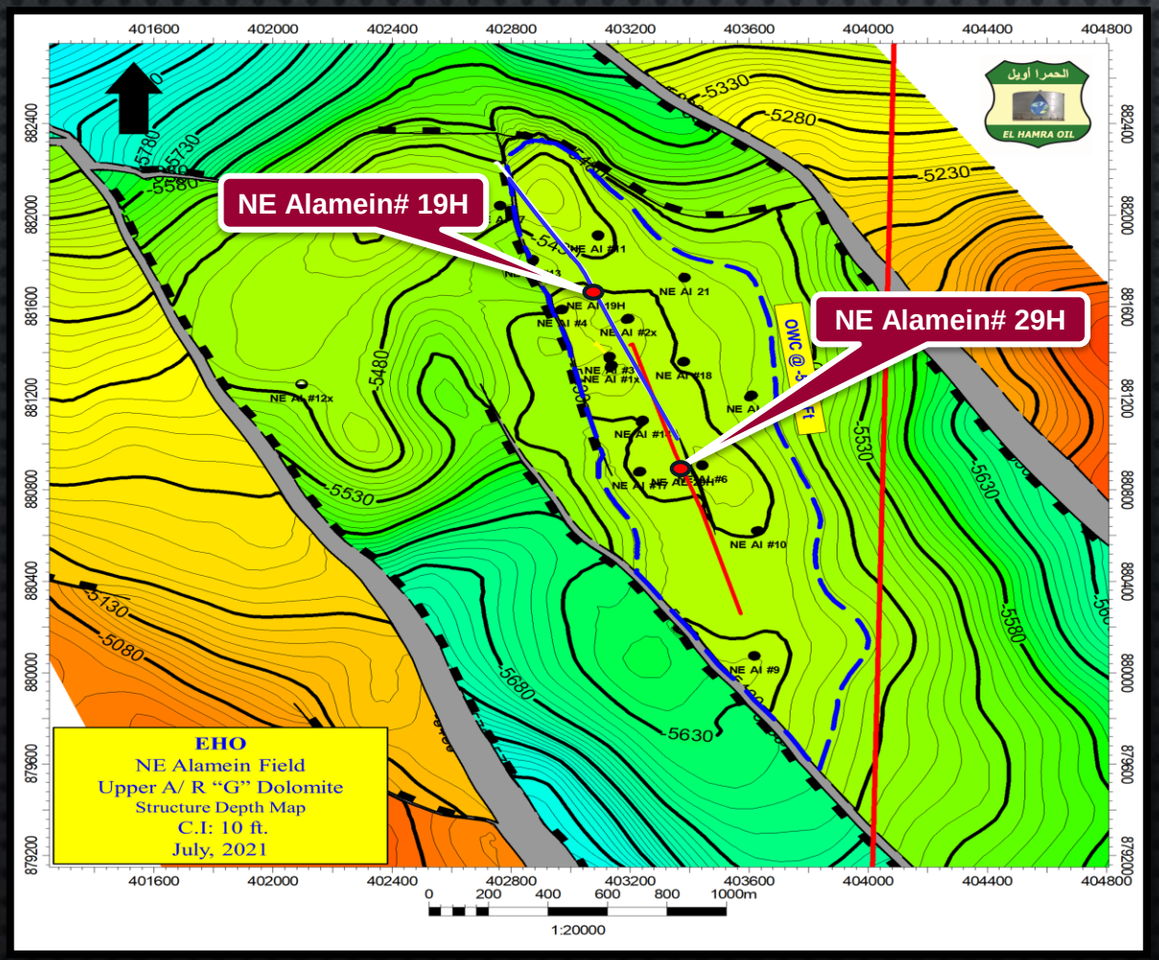
- Successful first horizontal well NEAL#15H encouraged EHO to develop the southern area of ARG Dol. reservoir by drilling the second horizontal well NEAL#23H with lateral section of 2200 FT.

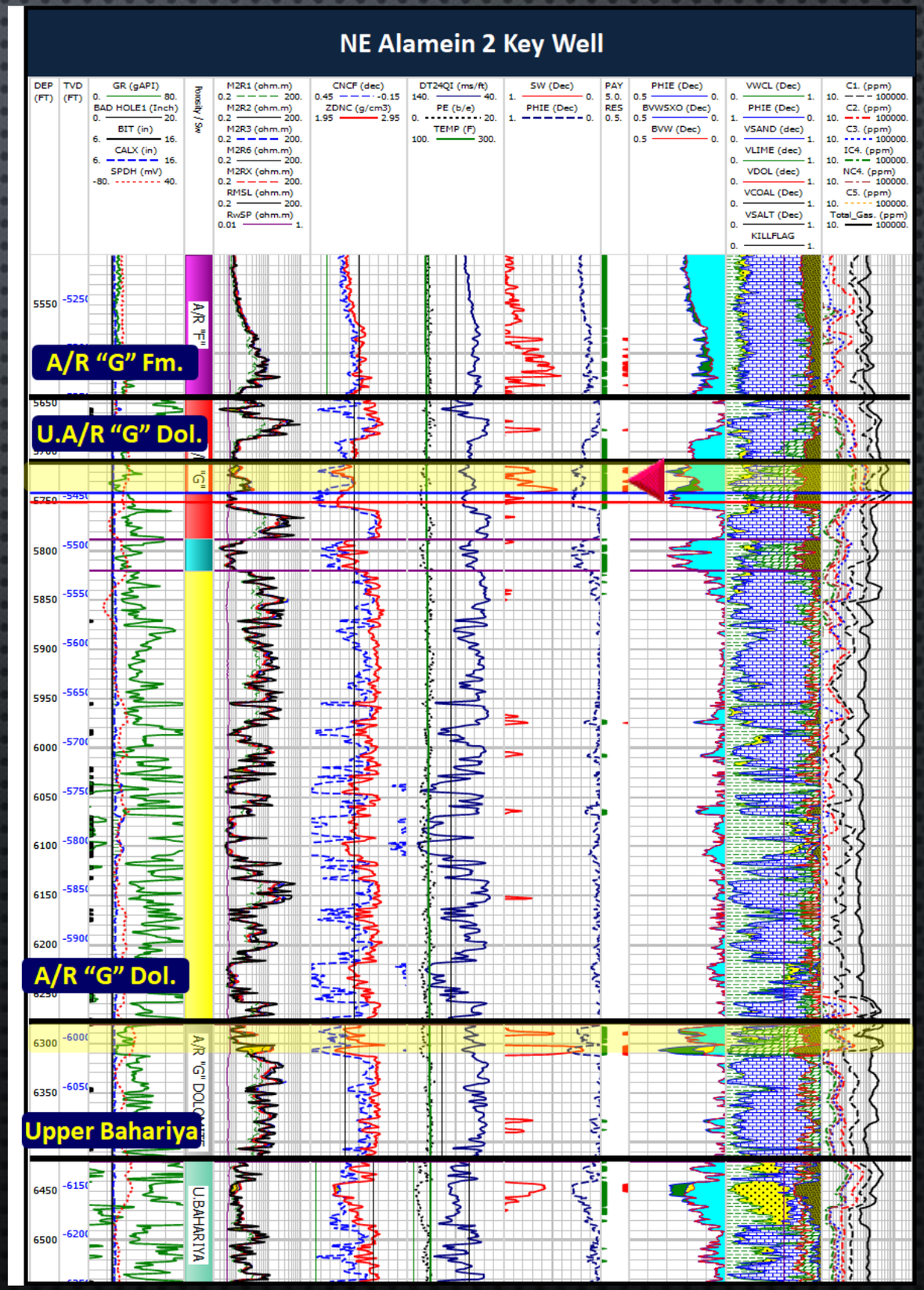




Upper A/R “G” Reservoir Horizontal Drilling

- 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.

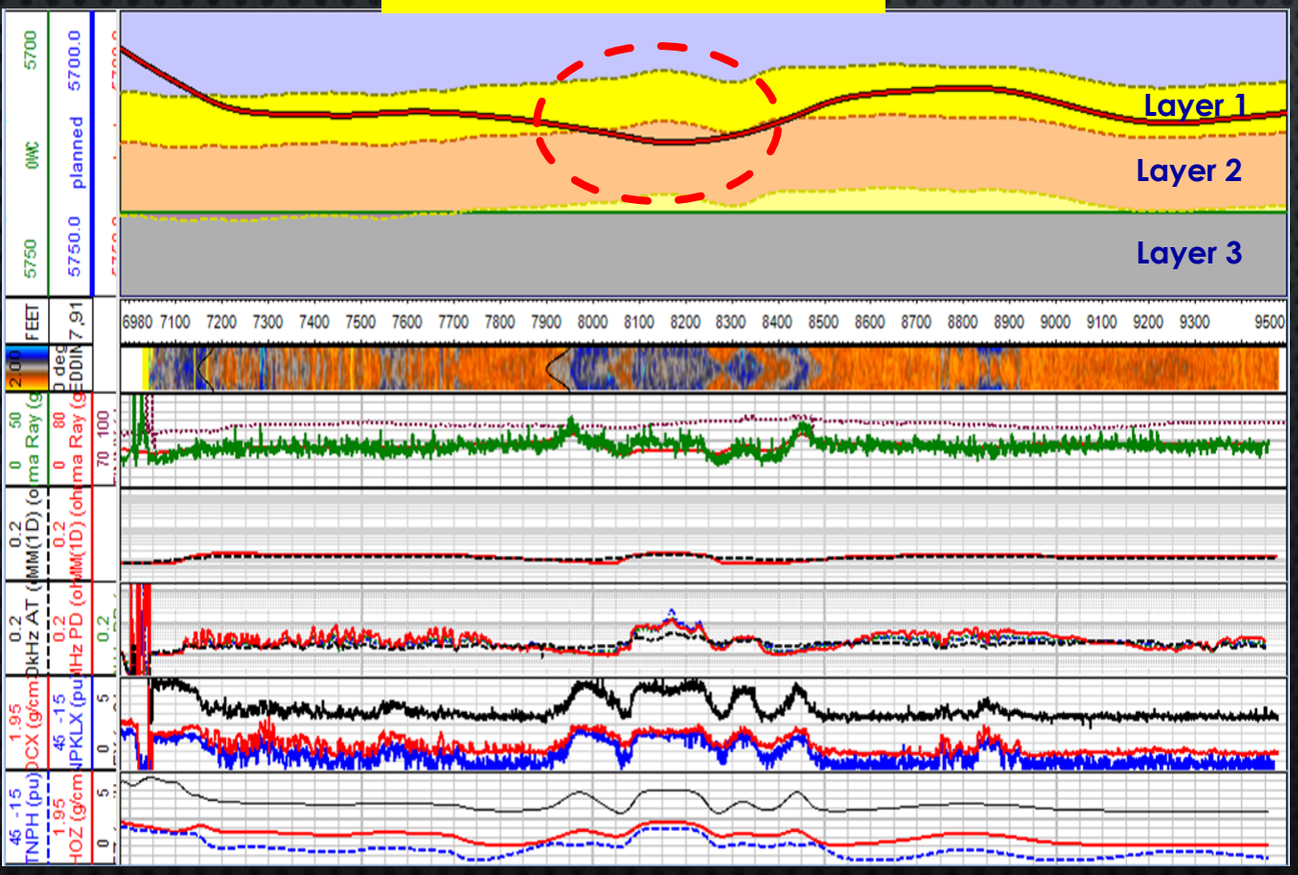




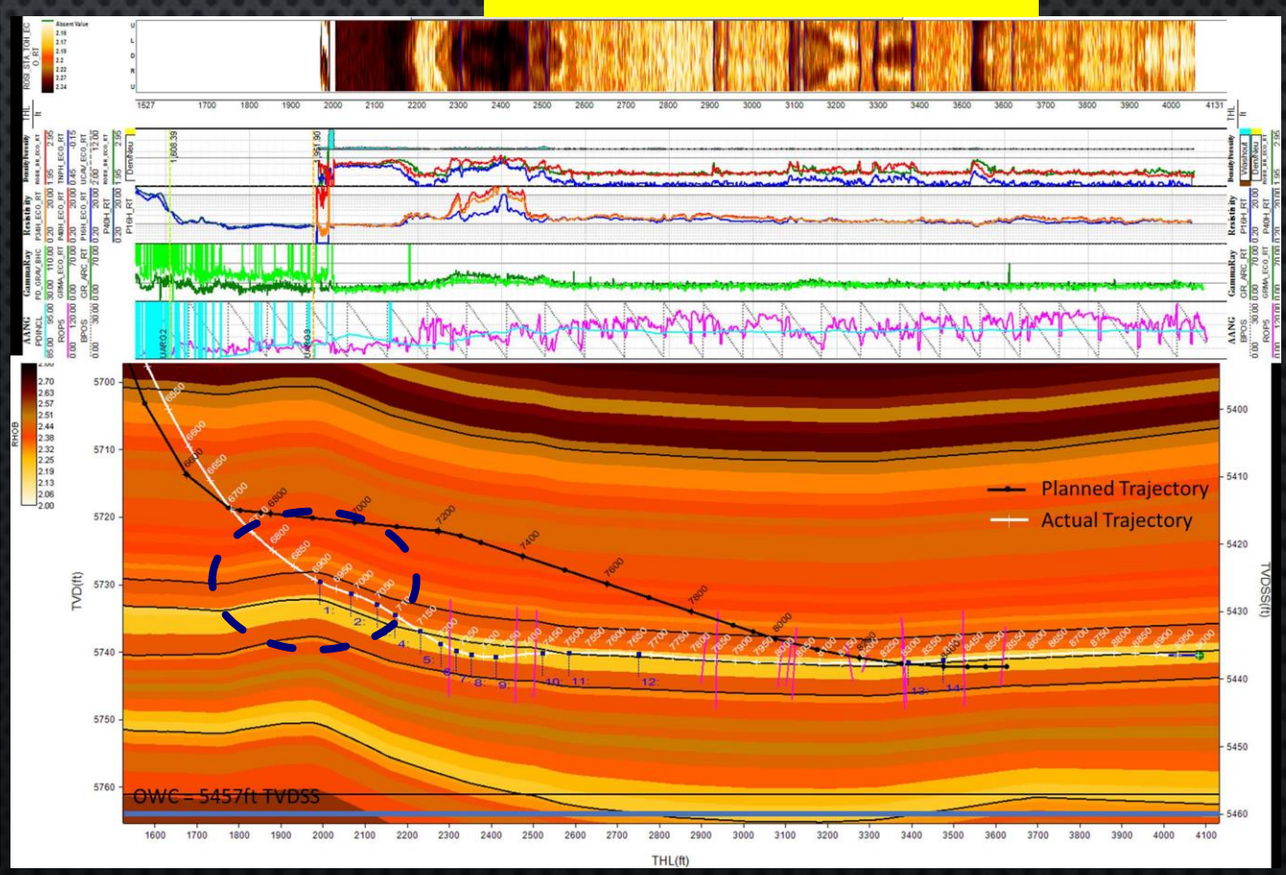
Upper A/R “G” Reservoir Horizontal Drilling

- Another Challenge we managed to overcome is to modify the planned trajectory while geosteering the well to maximize the reservoir exposure within the best quality facies in layer 1.
- The main Challenge was the landing point readjustment according to structure change as the reservoir entry was deeper than planned with 9 ft.

NE Alamein 19H Well

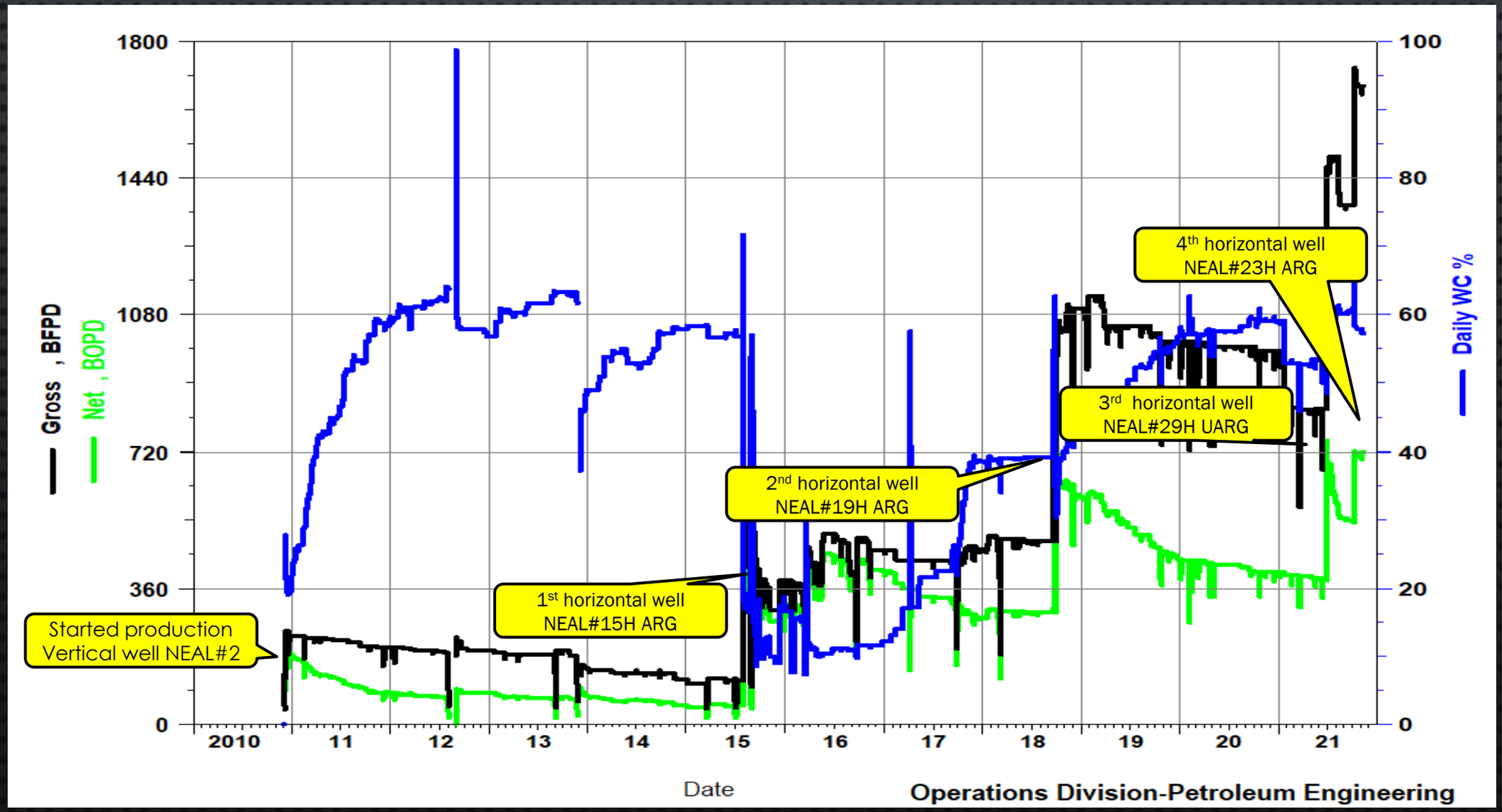


NE Alamein 29H Well



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 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.

Thank You