The Unconventional Gas Play in Tunisia Ghadames Basin

Require a Certain Edge

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Why is it Called "Unconventional"?

- Conventional Methods DON'T WORK;
- Resource Type, Reservoir & Trap Poorly Understood;
- Difficult to Produce Using Conventional Drilling and Completion Techniques;
- DST's Often Yield Nothing.

IT'S NOT CONVENTIONAL

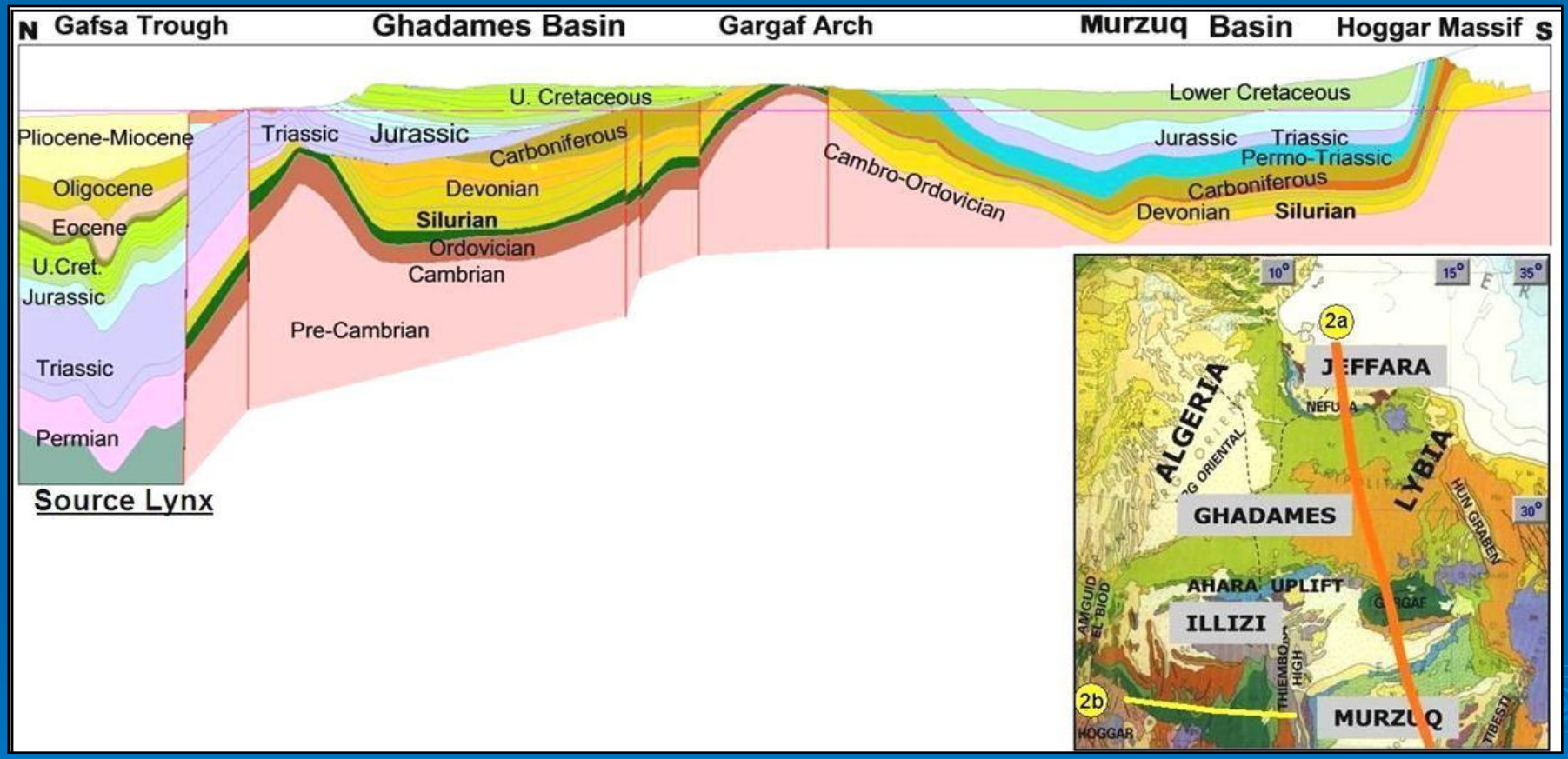
Factors Governing GIP in Shale

Total Gas = Free Gas + Adsorbed Gas + Solution Gas

Free Gas in Pores and Fracture	*Adsorbed Gas*	*Solution Gas*
• Area	• Area	• Area
• Thickness	• Thickness	• Thickness
• Pressure	• Pressure	• Pressure
• Temperature	• TOC	• Temperature
• Porosity	• Content	• Total Bitunmen Liptinite content
• Gas Saturation	• Maturity	• Maturity

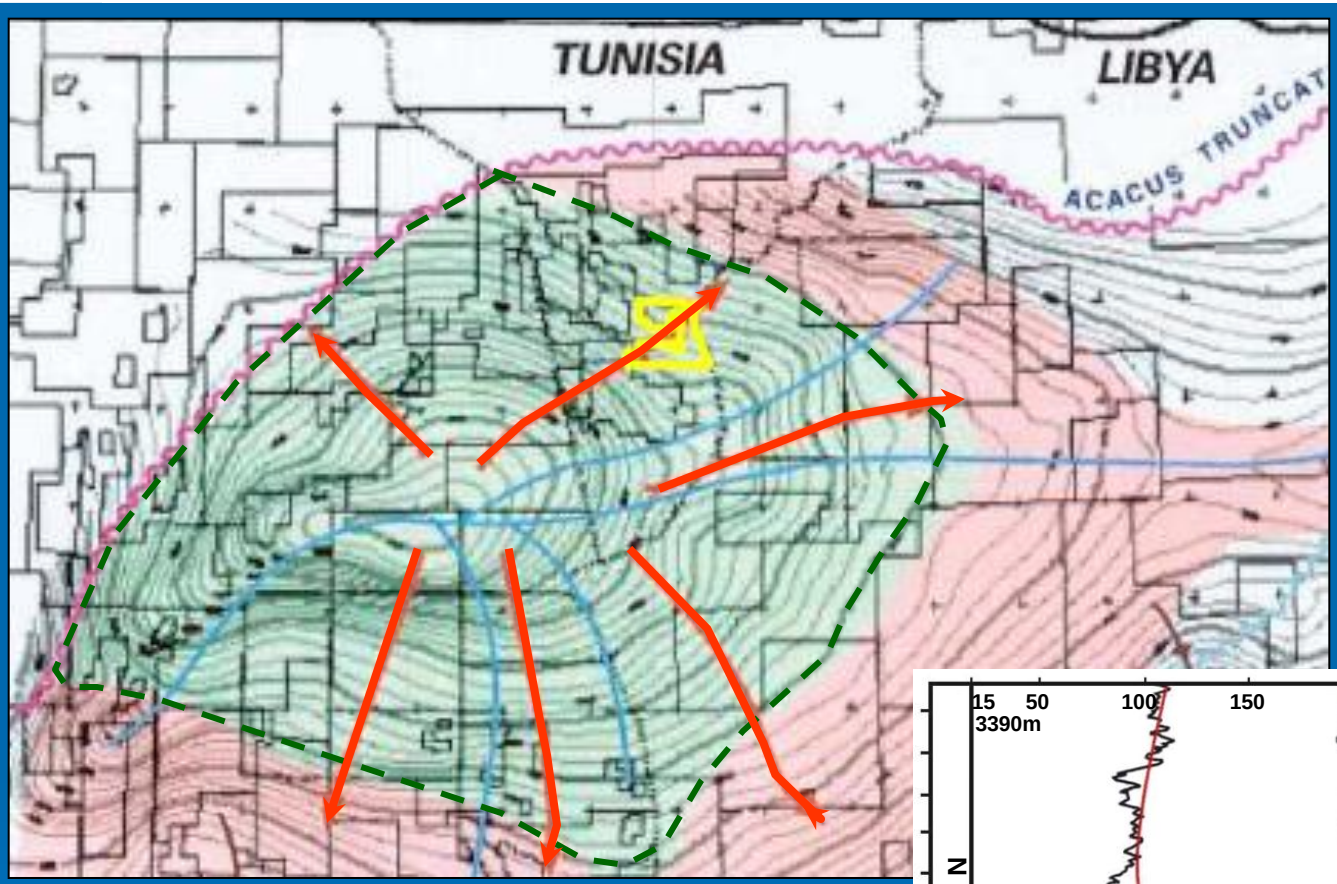
The Opportunity to Assess the Silurian Shale Unconventional Play in Ghadames Basin

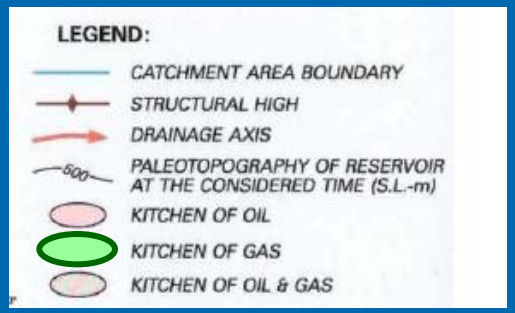
Unconventional Play in Ghadames Basin



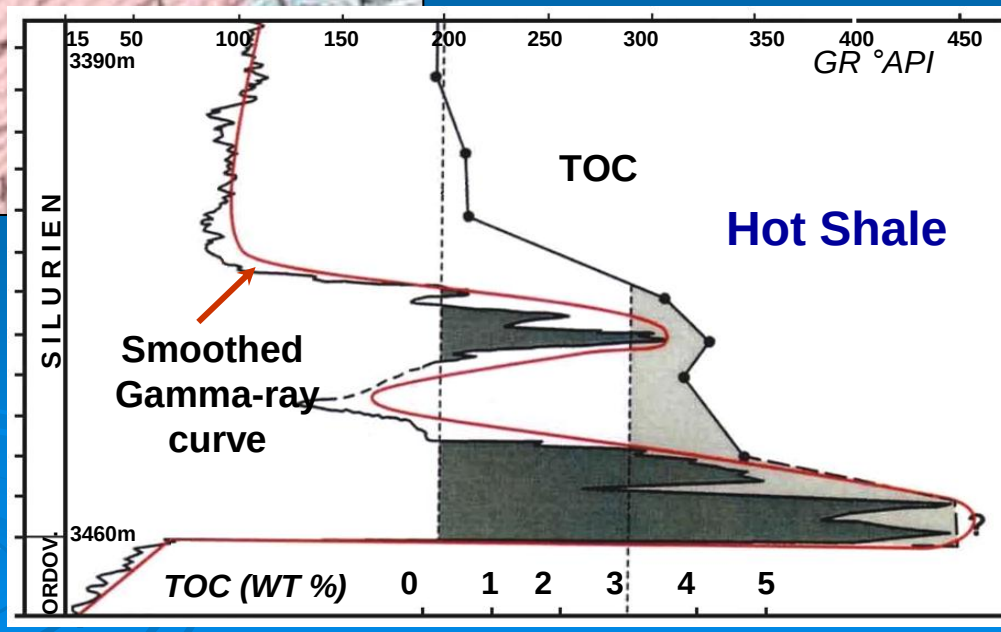
ARCHITECTURE OF GHADAMES BASIN

Tannezuft SR & Maturity Migration Path



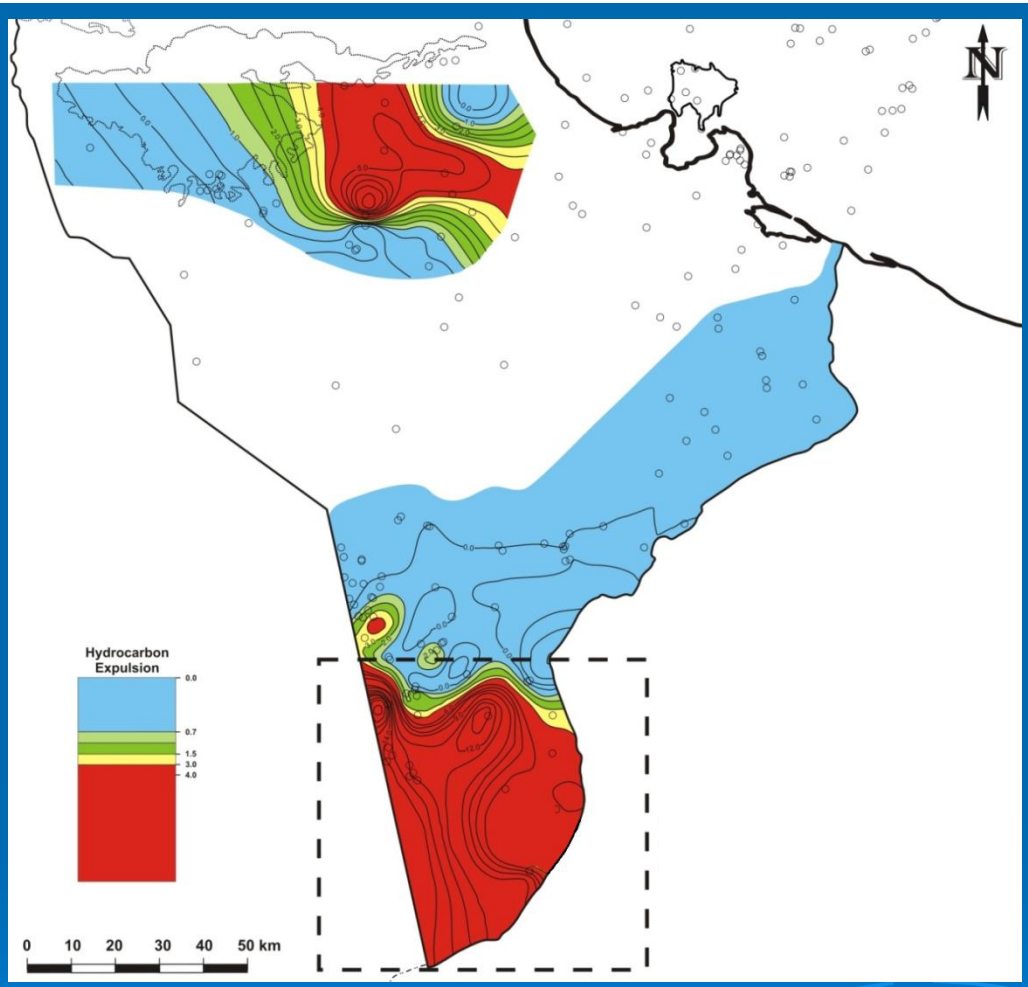


- The Tannezuft SR shales are very mature beneath a thick Paleozoic and Mesozoic cover.
- Oil generation during the Paleozoic was affected, and in some cases halted by the Hercynian uplift.
- The peak oil generation occurred probably during Mid-Cretaceous.



Tannezuft Shale Gas Play Chance ?

Segment n°2



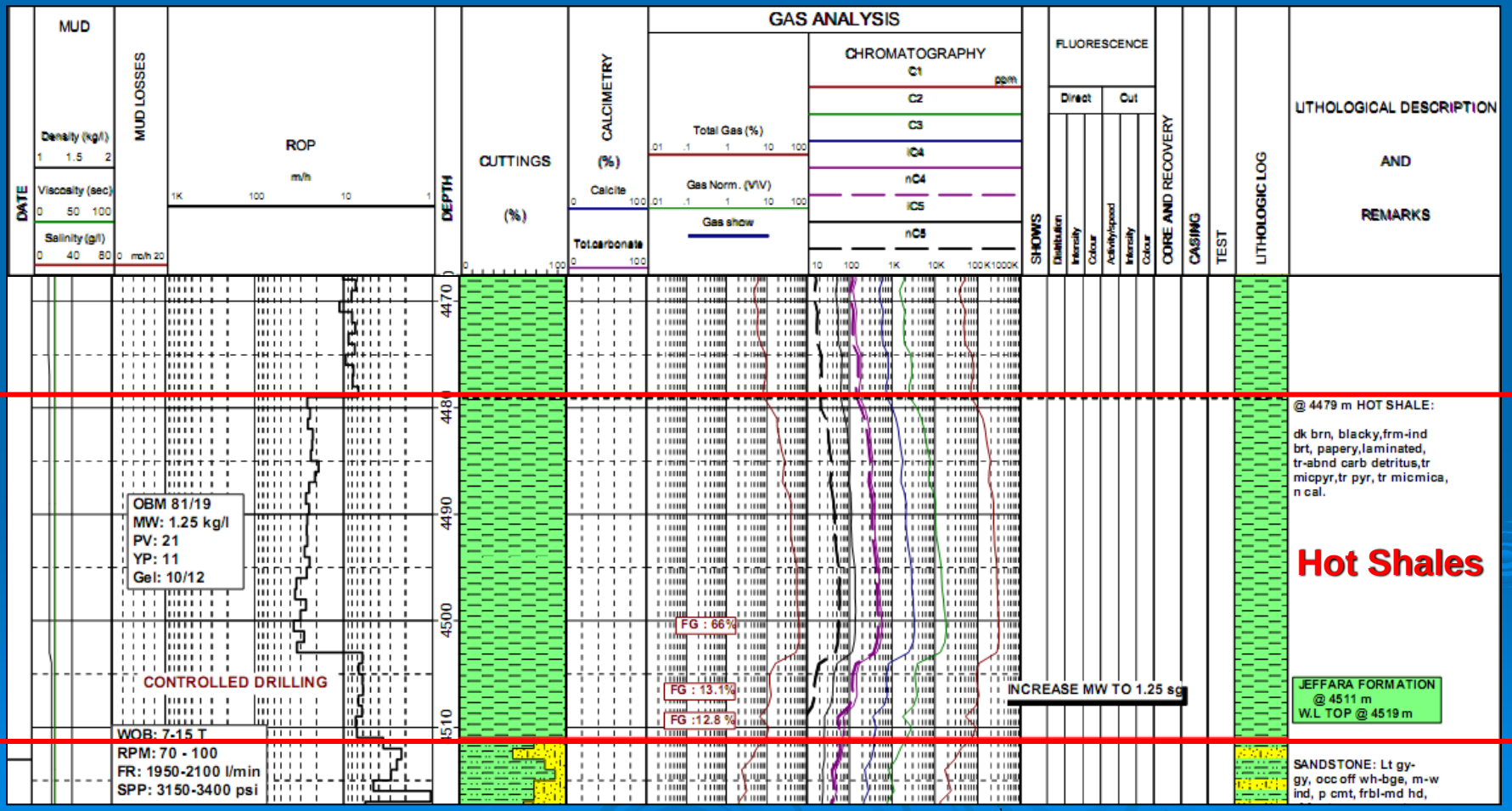
Segment n°1 Possible High Success Rate

- High TOC
- High Thermal maturity: Po~2.2
- Area within Gas Kitchen
- High Qz Content (Proximity to uplifted zones)

SET-1

Presence of high gas background in the Hot shales unit:

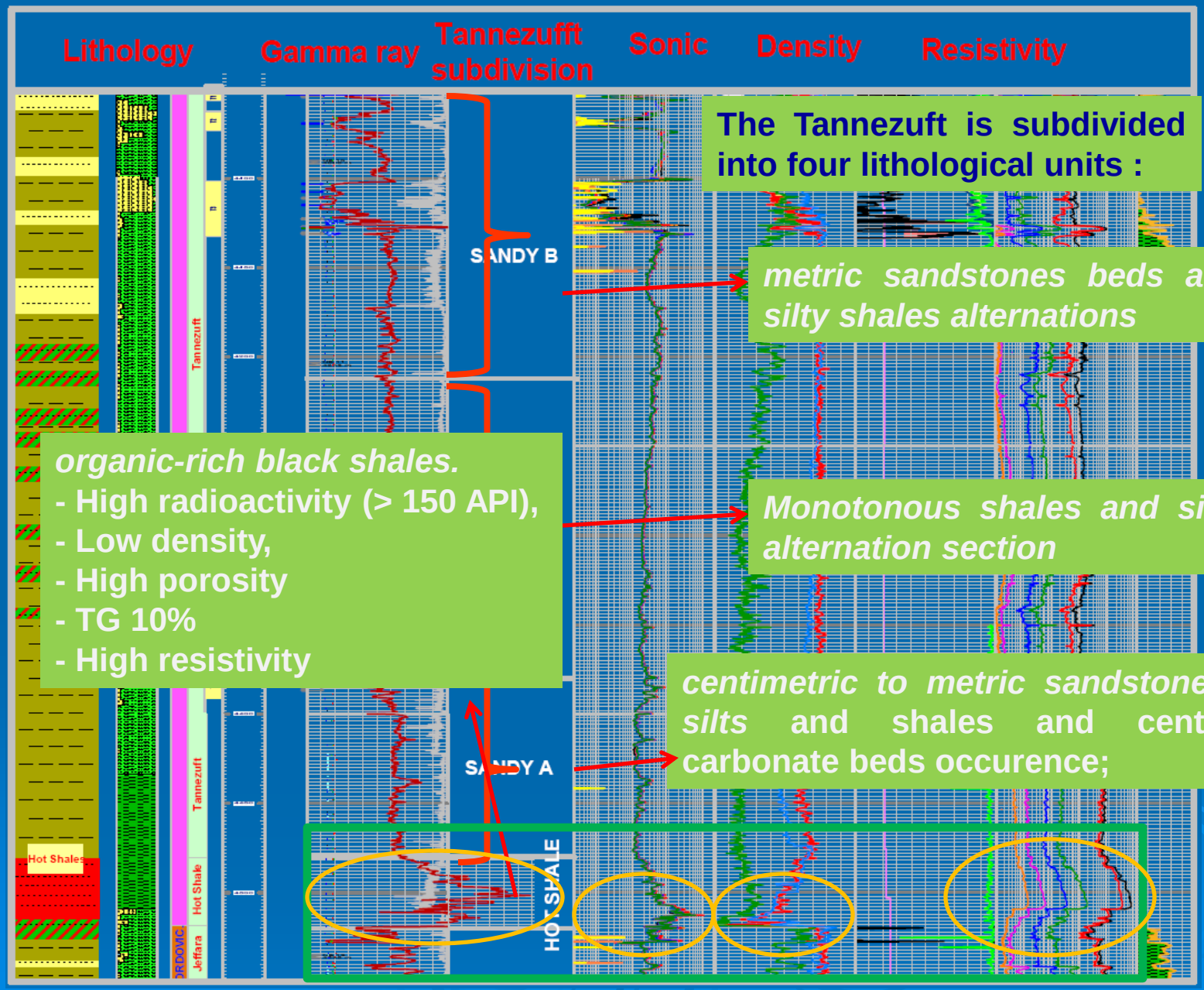
Total Gas till 66%



LITHOSTRATIGRAPHY OF THE TANNEZUFT

SHALE FORMATION

Unconventional Play/ Gas from Lower Silurian Shale - Ghadames basin



The Tannezuft is subdivided into four lithological units :

metric sandstones beds and silty shales alternations

organic-rich black shales.
- **High radioactivity (> 150 API),**
- **Low density,**
- **High porosity**
- **TG 10%**
- **High resistivity**

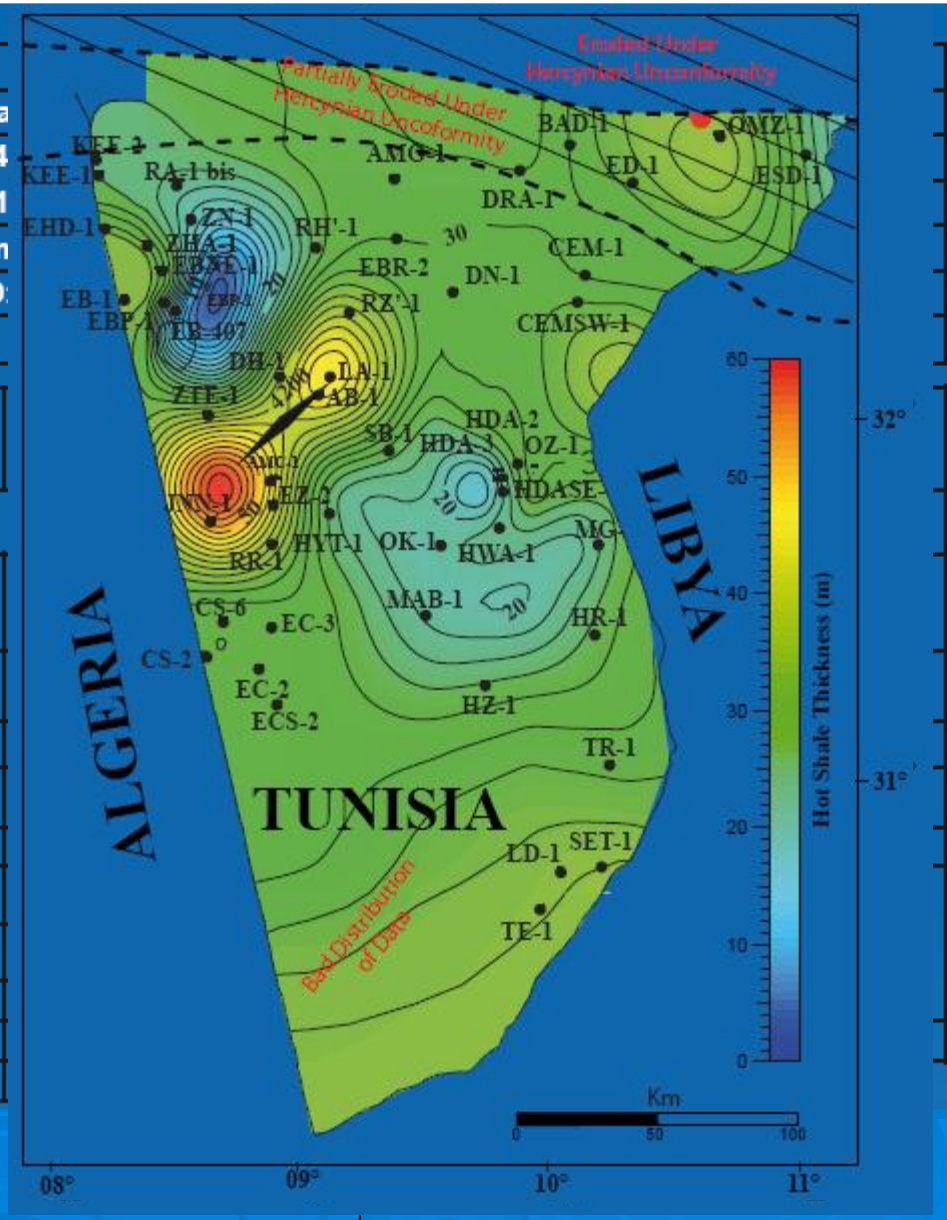
Monotonous shales and silts alternation section

centimetric to metric sandstone beds, silts **and shales and centimetric carbonate beds occurence;**

Unconventional Play/ Gas from Lower Silurian Shale - Ghadames basin

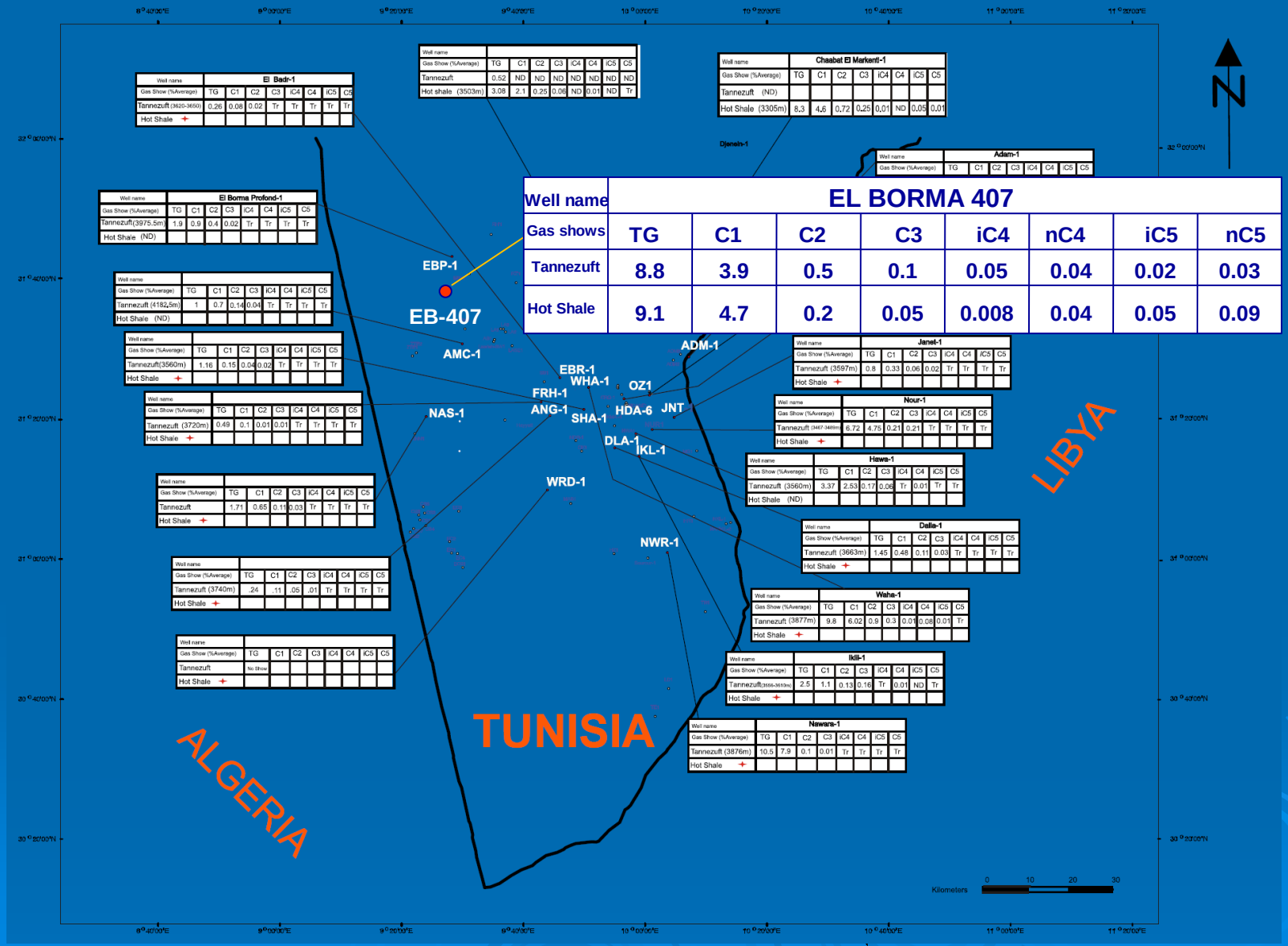
Permit / Concession: Cherouq B		Well:
Company:	PIONEER	Spud Da
Coordinates:	X = 559948.27 m	Y = 3464
	Long = 9° 37' 47.930" E	Lat = 31
Objectives:	Acacus A, Tannezuft & Ordovician Fm	
TD = 4436m	TVD = m	Fm@TD
Casing:18"5/8@m, 13"3/8@m, 9"5/8@2005m		

AGE		Grp	Formation	Top/KB (m)
SILURIAN	Pridolian		Acacus	3101
	Ludlovian			
	Wenlockian	TANNEZUFFT	Tannezuft sandy b	3784
			Tannezuft shaly	
			Tannezuft sandy a	
	Llandoverian		Hot Shales	4165
ORDOVICIAN	Ashgillian		Jeffara	4191
	Caradocian			
	Llandeilian		Bir Ben Tartar	4271
	Llanvirnian			
	Arenigian		Kasbah Leguine	4336
	Tremadocian		Sanrhar	4355
			TD	4436



Thickness map of the Tannezufft Hot Shale

Unconventional Play/ Gas from Lower Silurian Shale - Ghadames basin

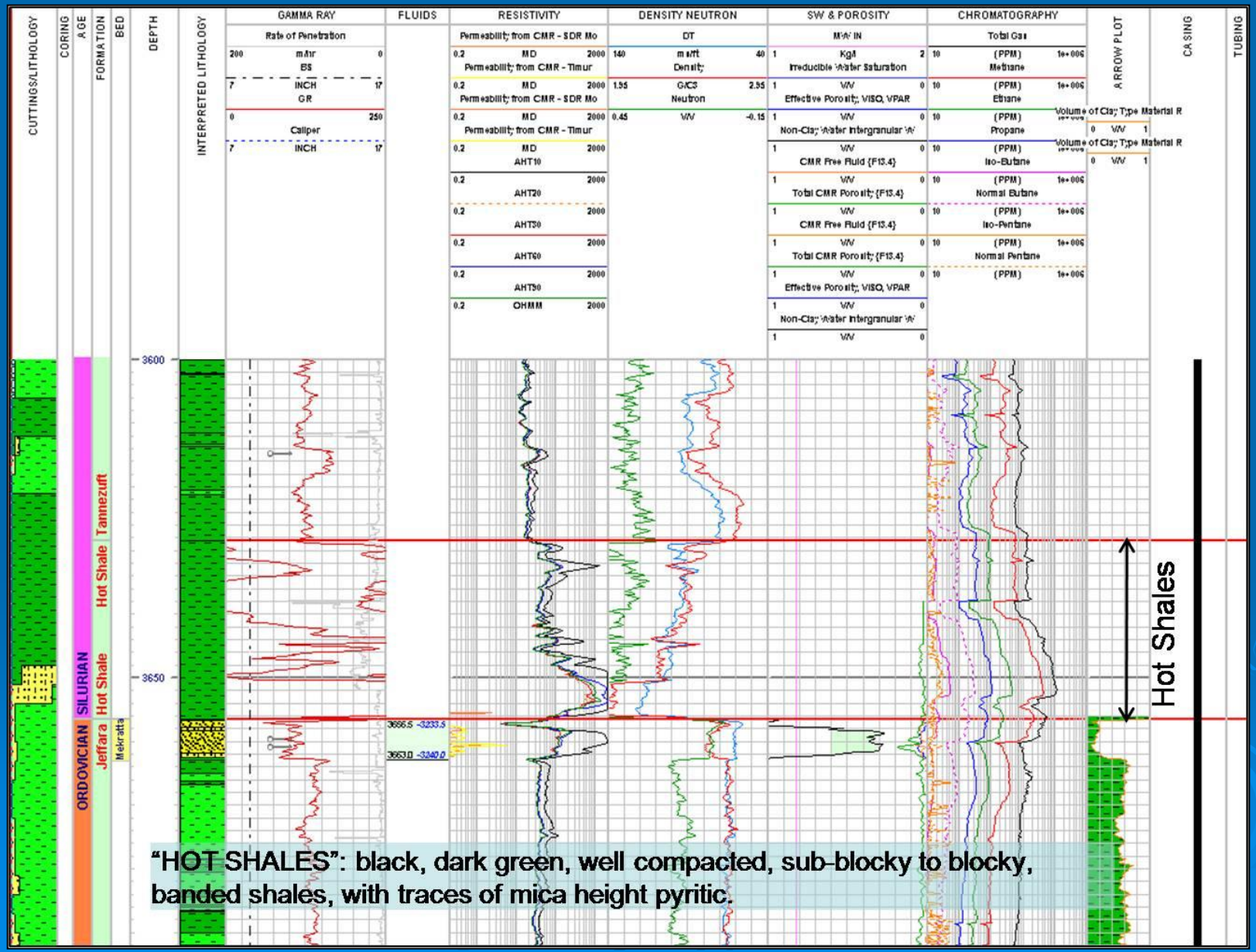


Main Gas Shows within the Tannezuft Fm.

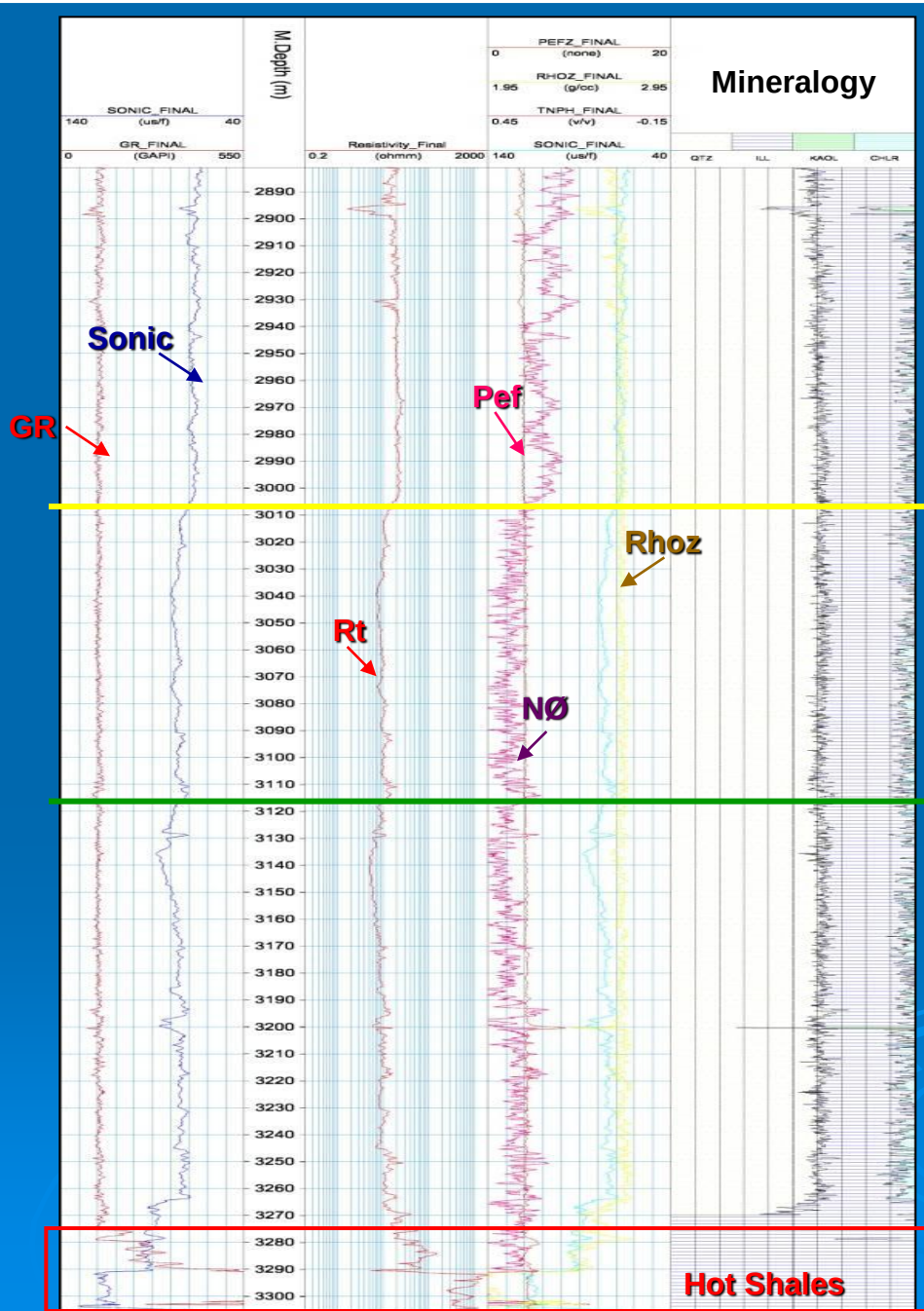
RESERVOIR CHARACTERIZATION

MINERALOGICAL & PETROPHYSICAL STUDY

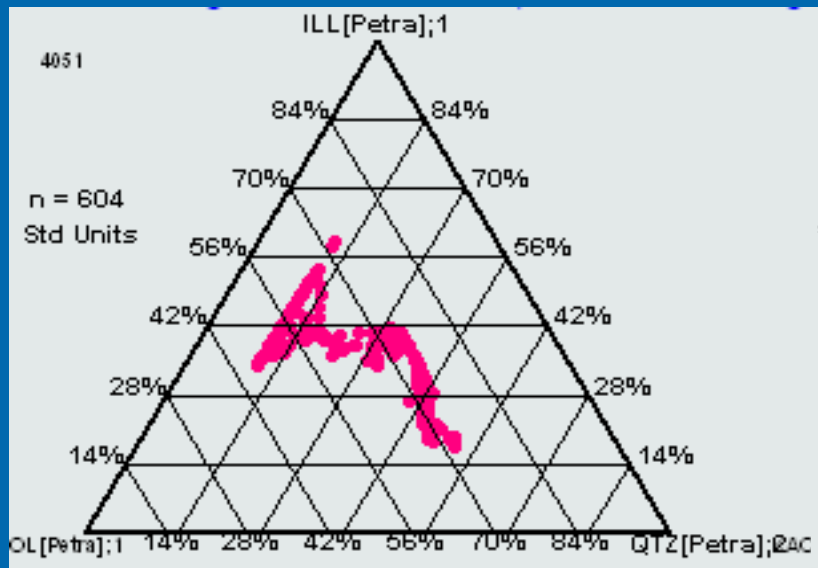
Detail of wireline logs shift registered in the Hot Shales unit



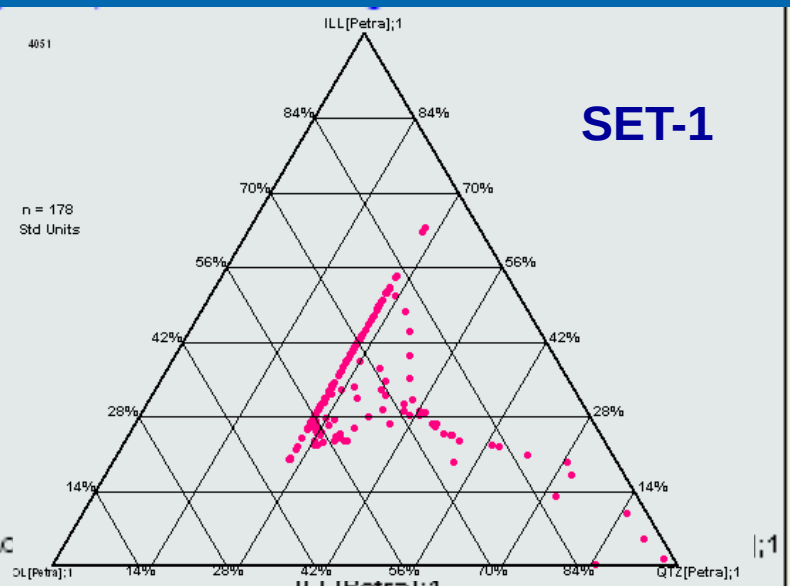
Tannezuft Fm log type section (CEM-1)



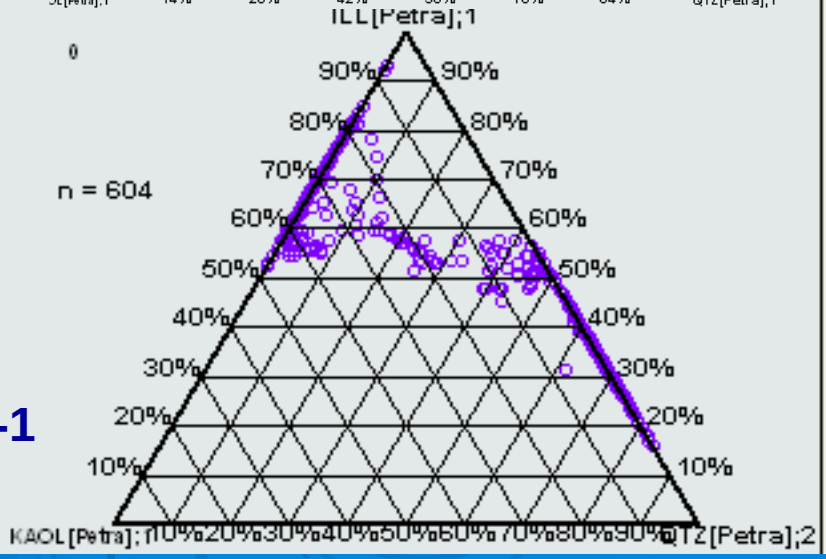
Quantitative Mineralogy of the Hot Shales



LASE-1



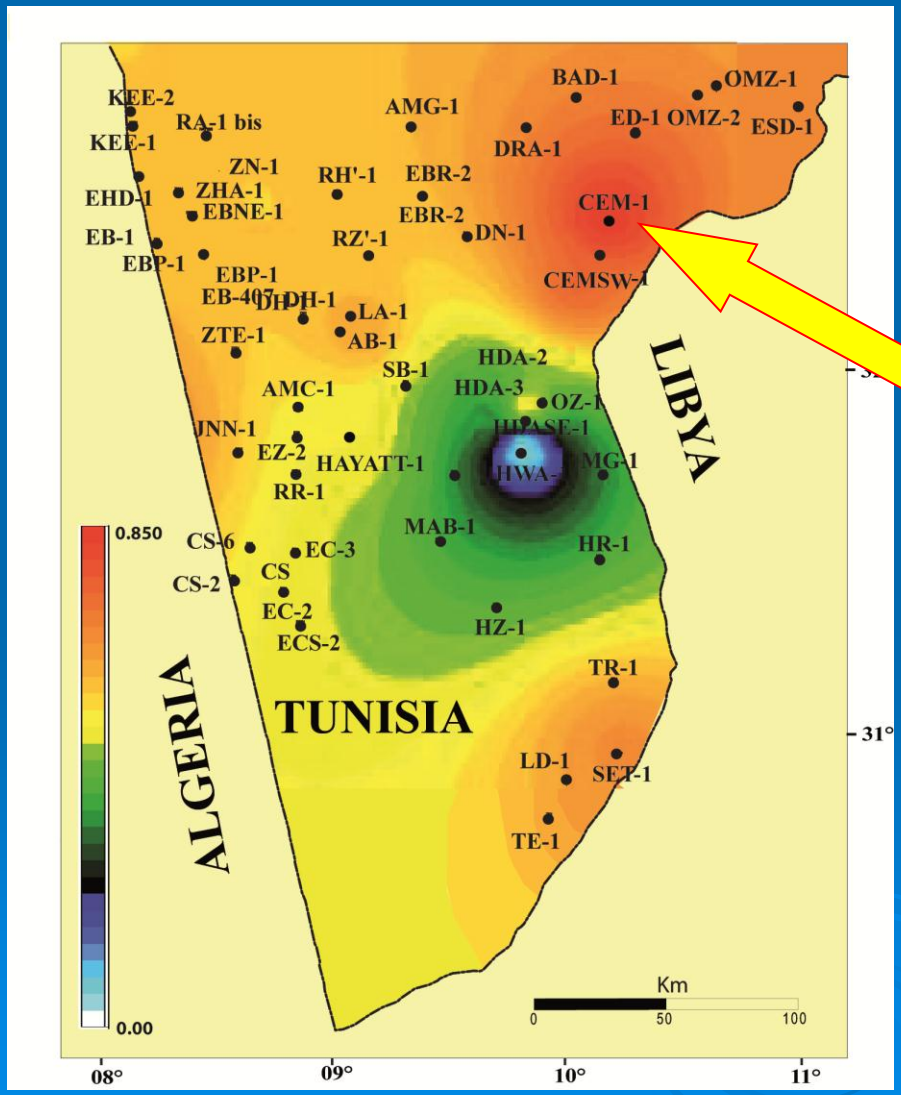
SET-1



HWA-1

MINERALS' DISTRIBUTION MAPS

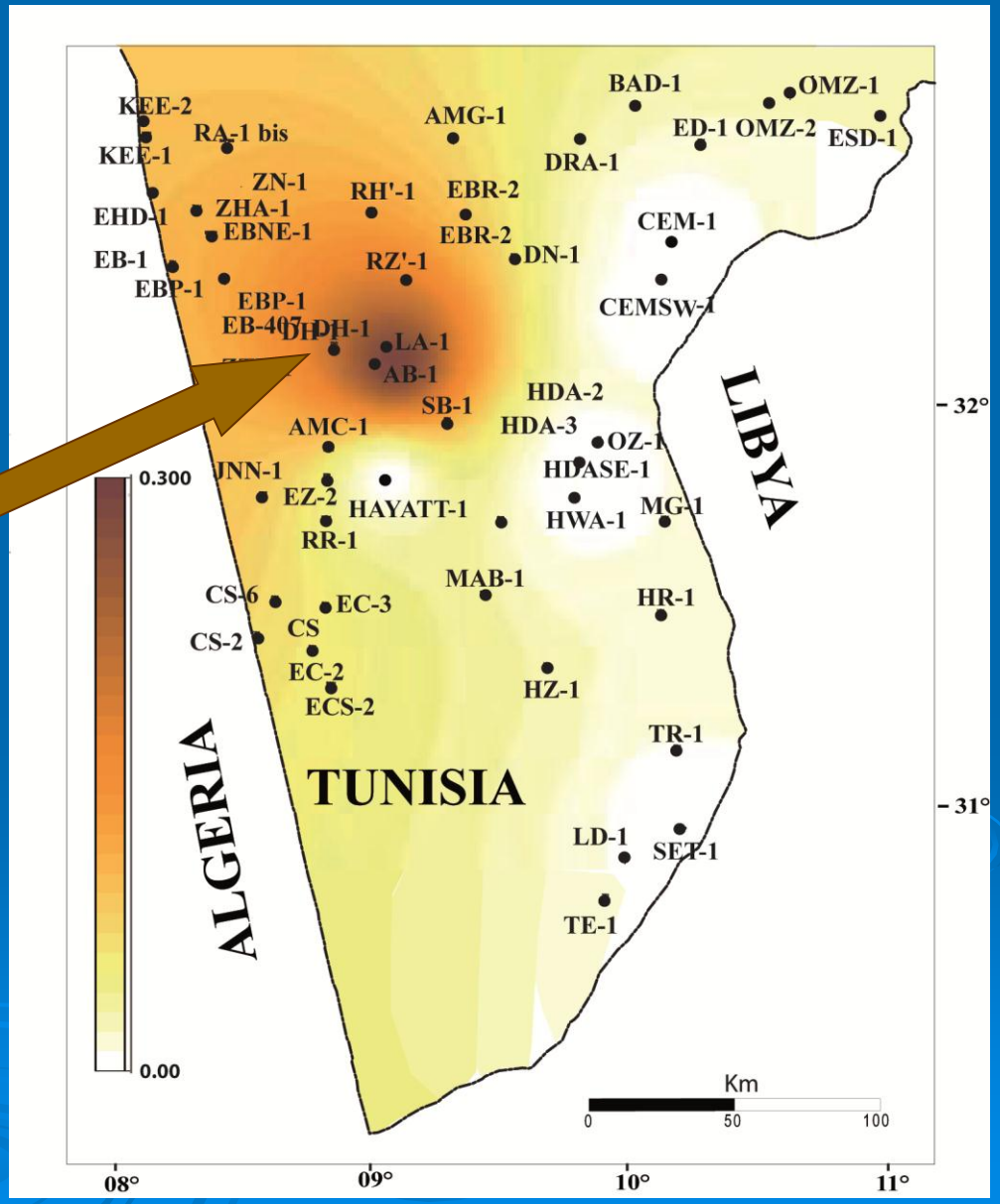
Illite Modelled Distribution Map



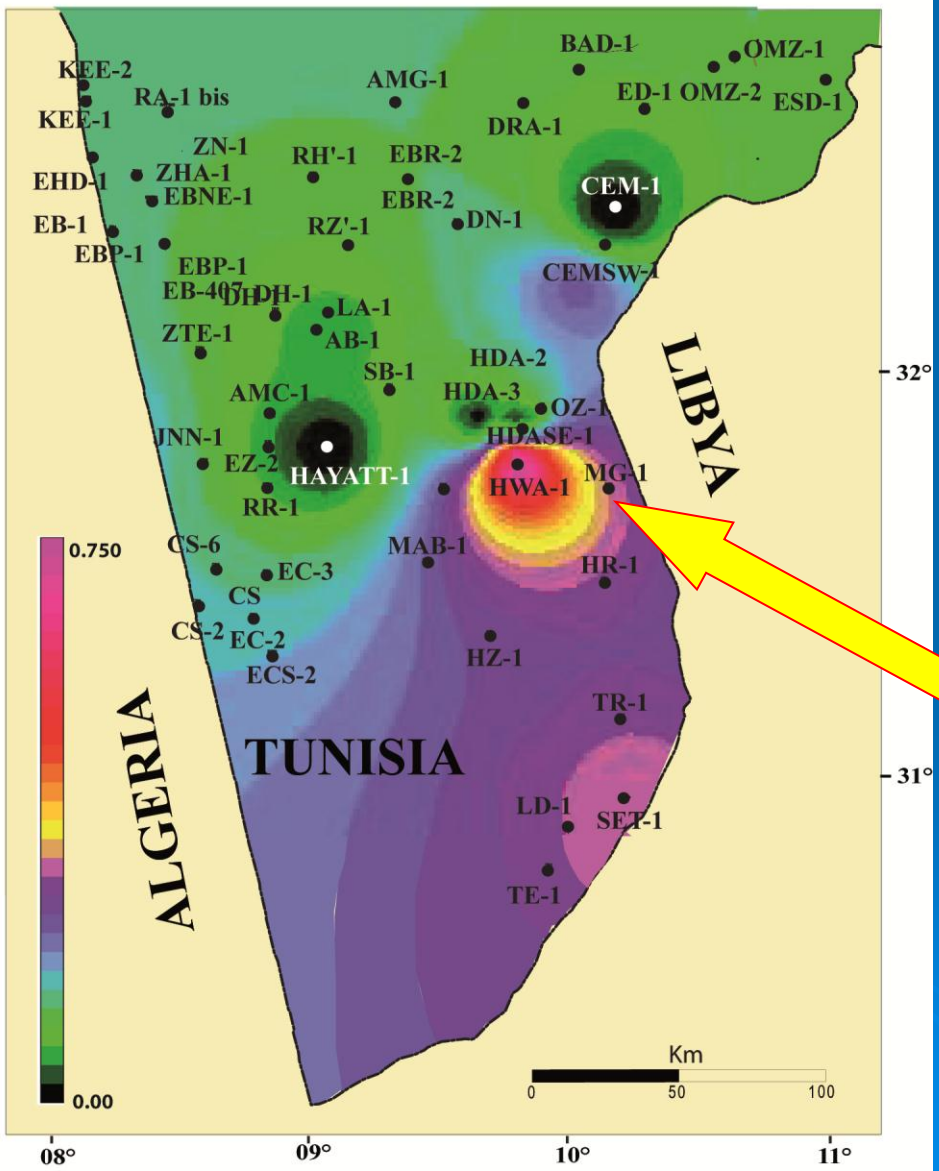
Area with higher illite content

Kaolinite Modelled Distribution Map

Area with higher kaolinite content

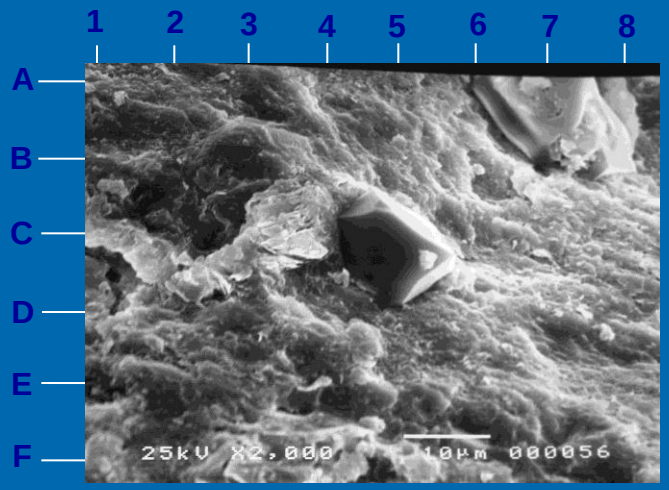


Quartz Modelled Distribution Map

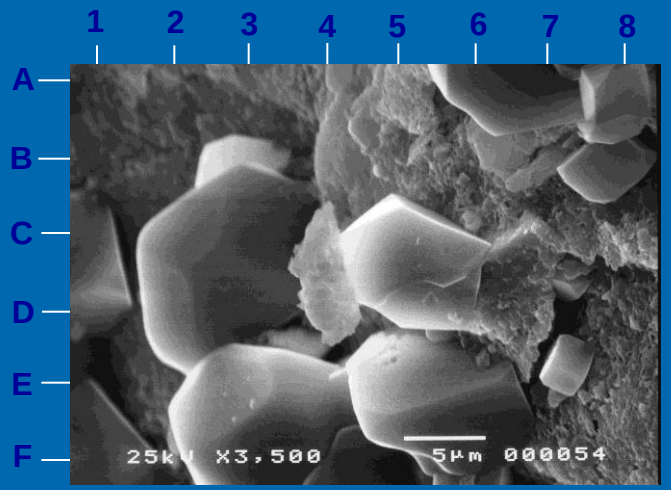


Area with higher quartz content

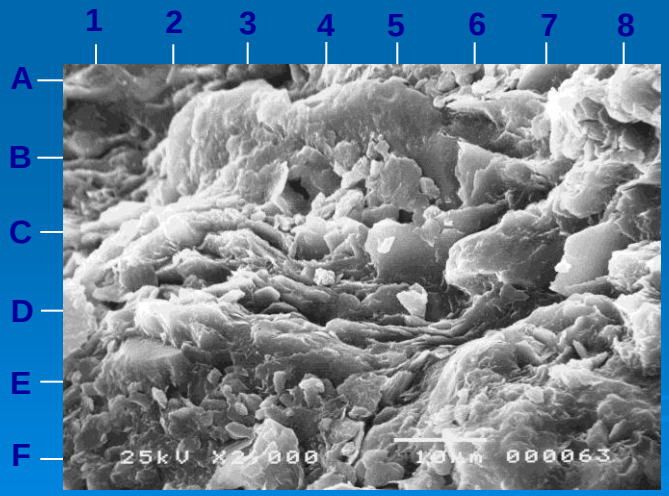
Unconventional Play / Gas from Lower Silurian Shale - Ghadames basin



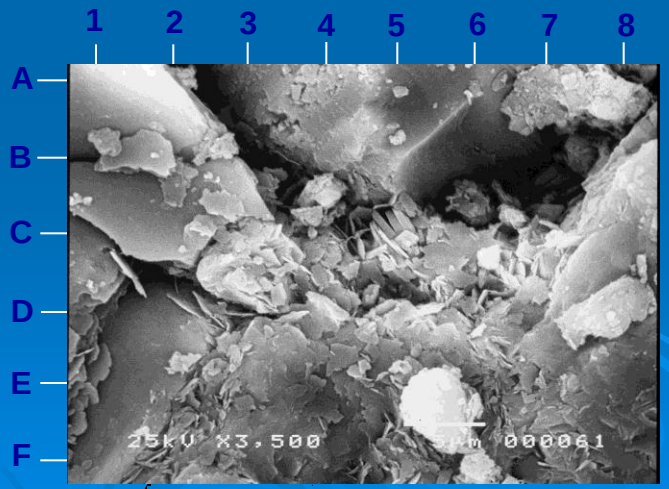
CEM# 1: 3111 m Shales (x 2000)



CEM #1: 3111 m Quartz (x 3500)



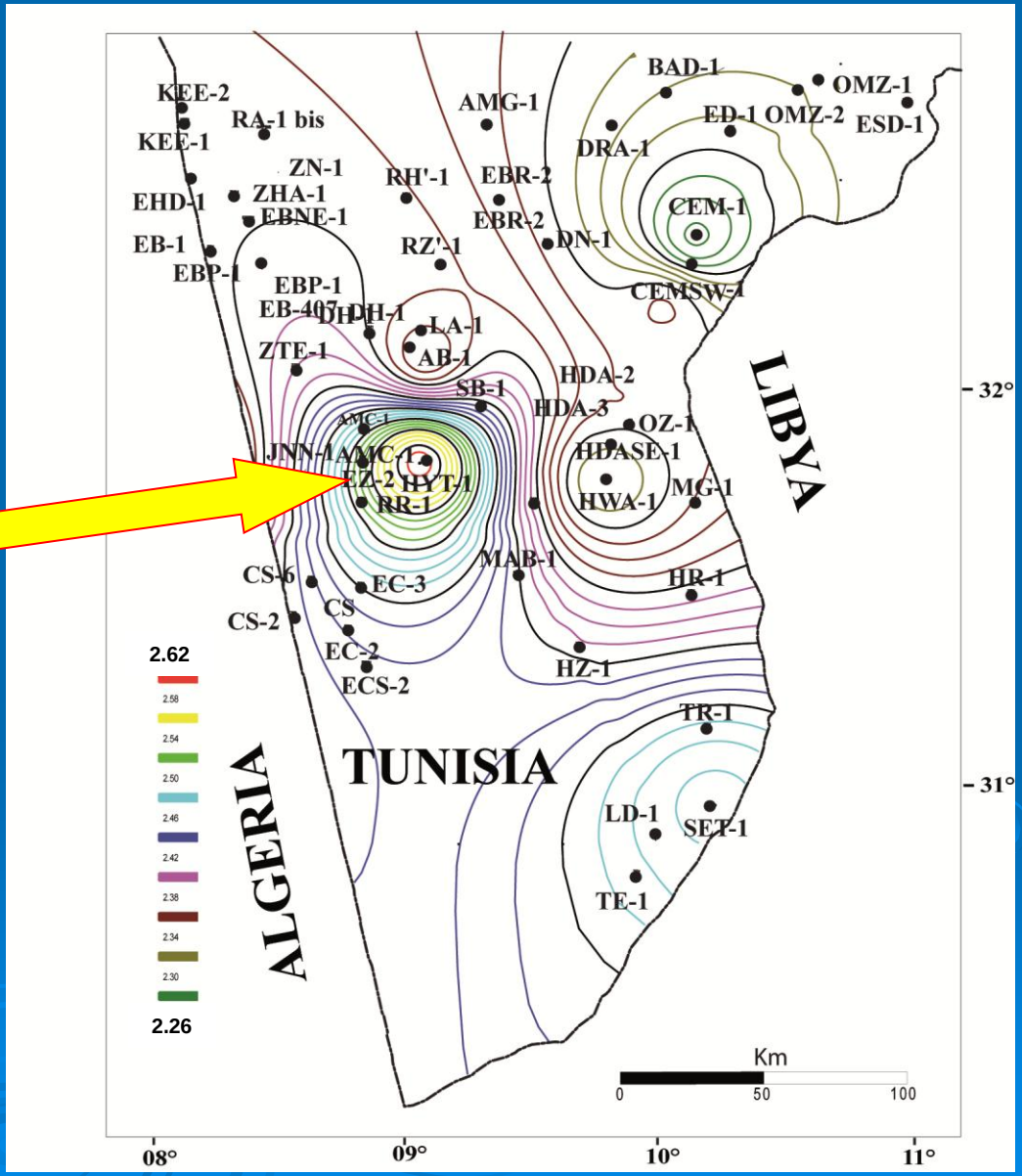
OZ #1: 3629 m Shales (x 2000)



OZ# 1: 3505 m Sandstone (x 3500)

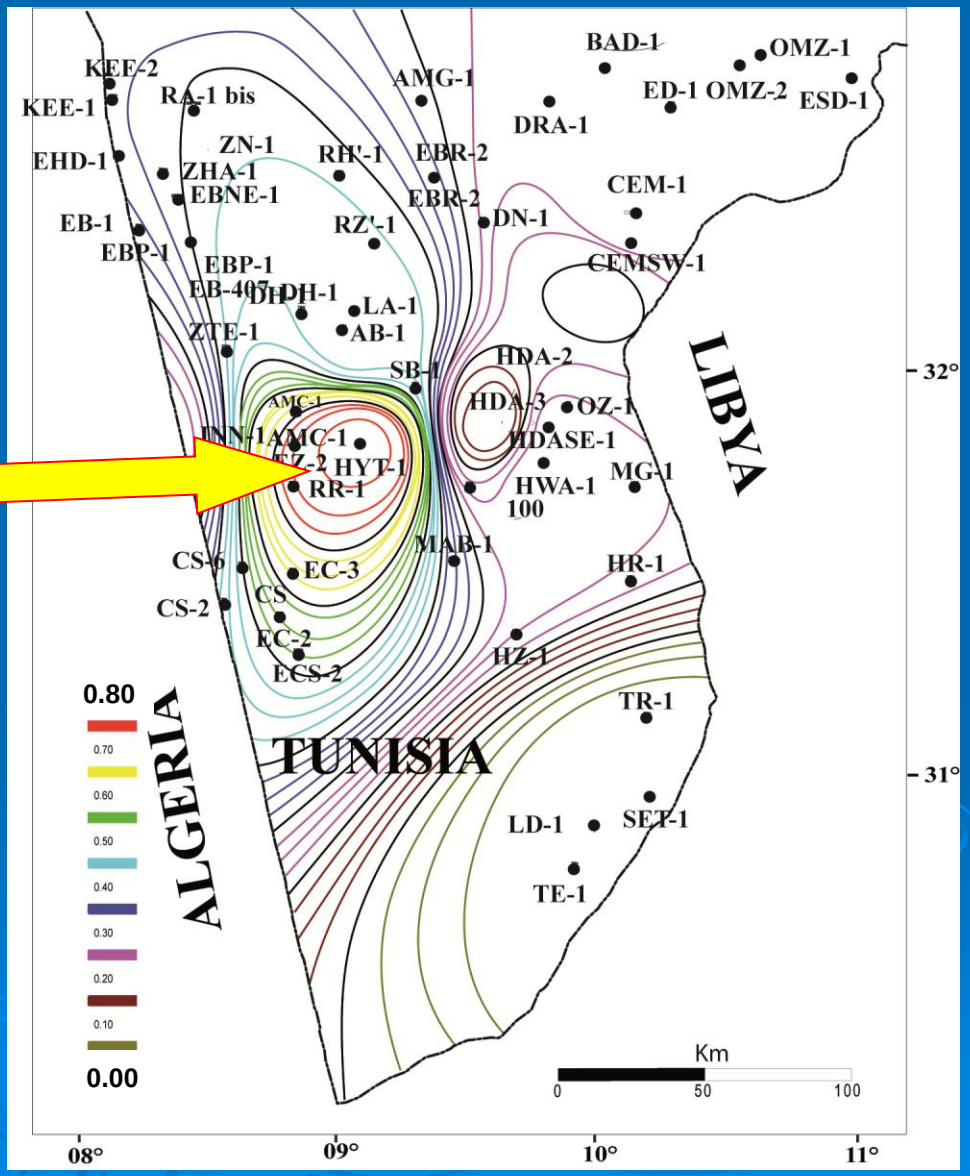
Hot Shales Density Variation Map

Area of higher density



Hot Shales Porosity Variation Map

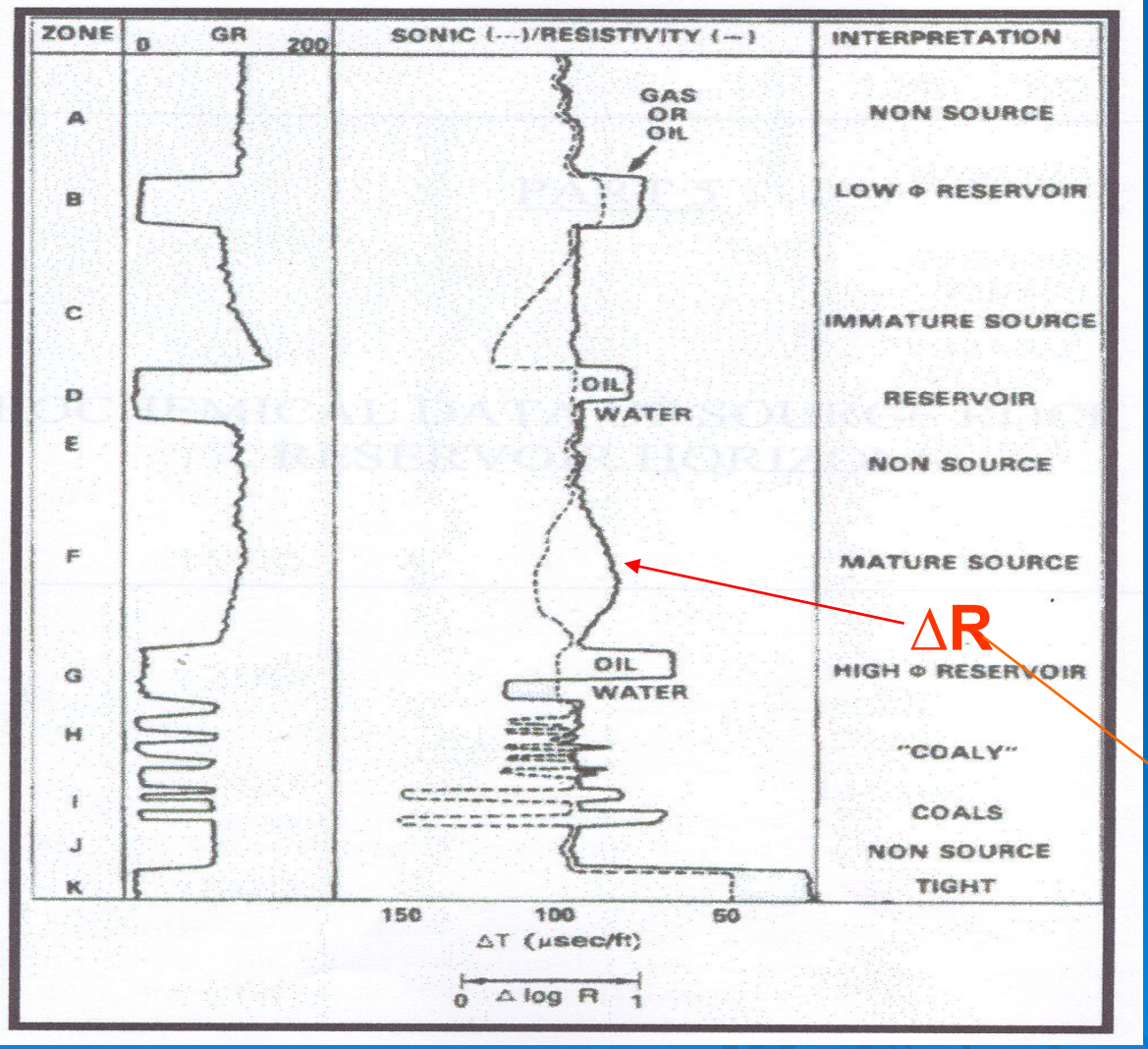
Area of higher porosity



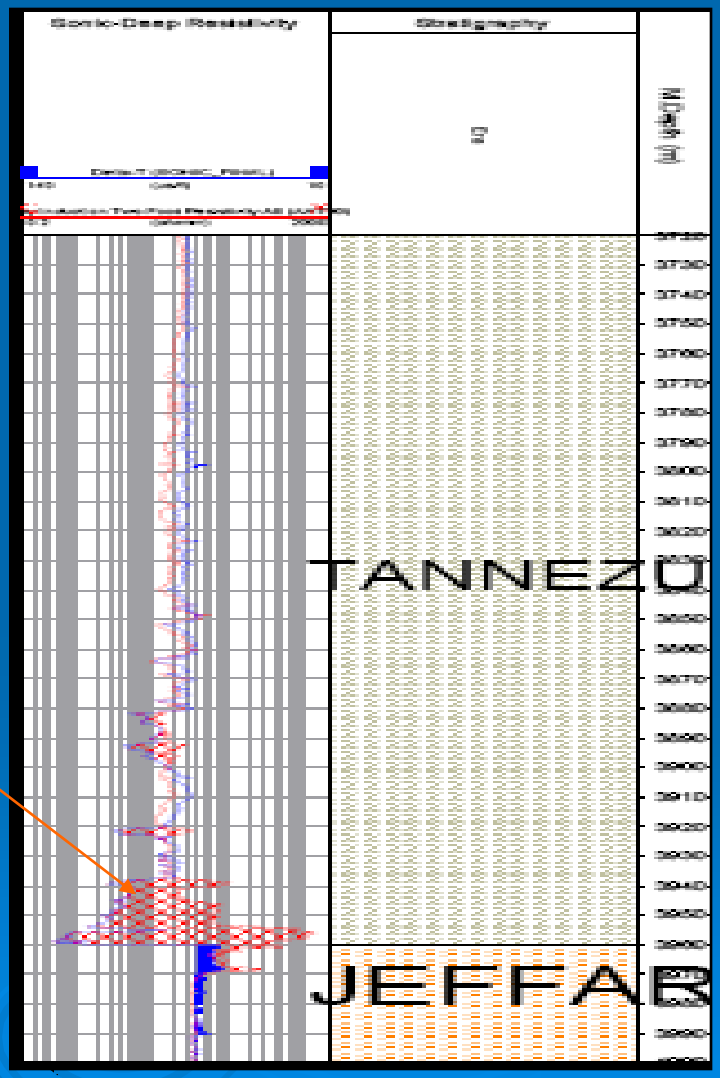
GEOCHEMICAL ASSESSMENT OF TANNEZUFT HOT SHALE

TOTAL ORGANIC CARBON CONTENT ASSESSMENT

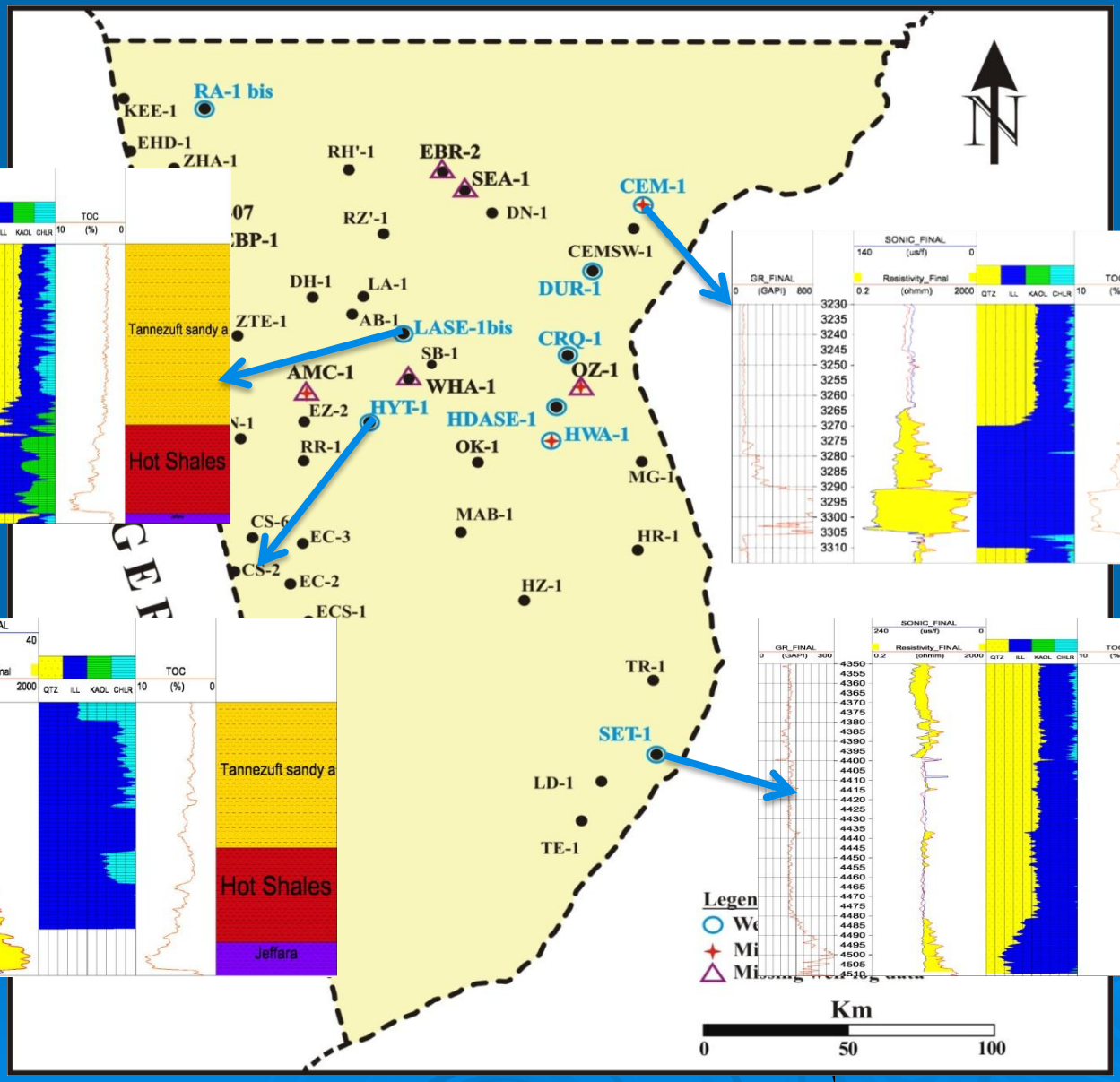
EXXON and ESSO Technique

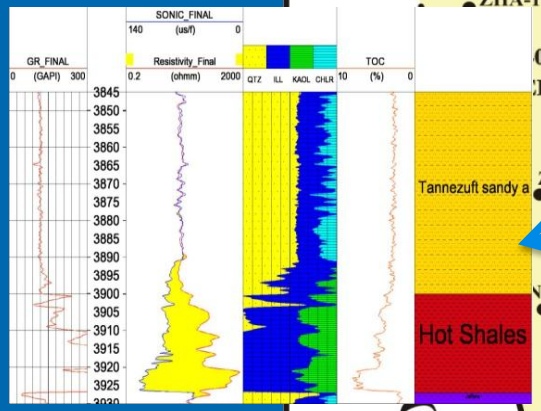


ΔR



TOTAL ORGANIC CARBON CONTENT ASSESSMENT





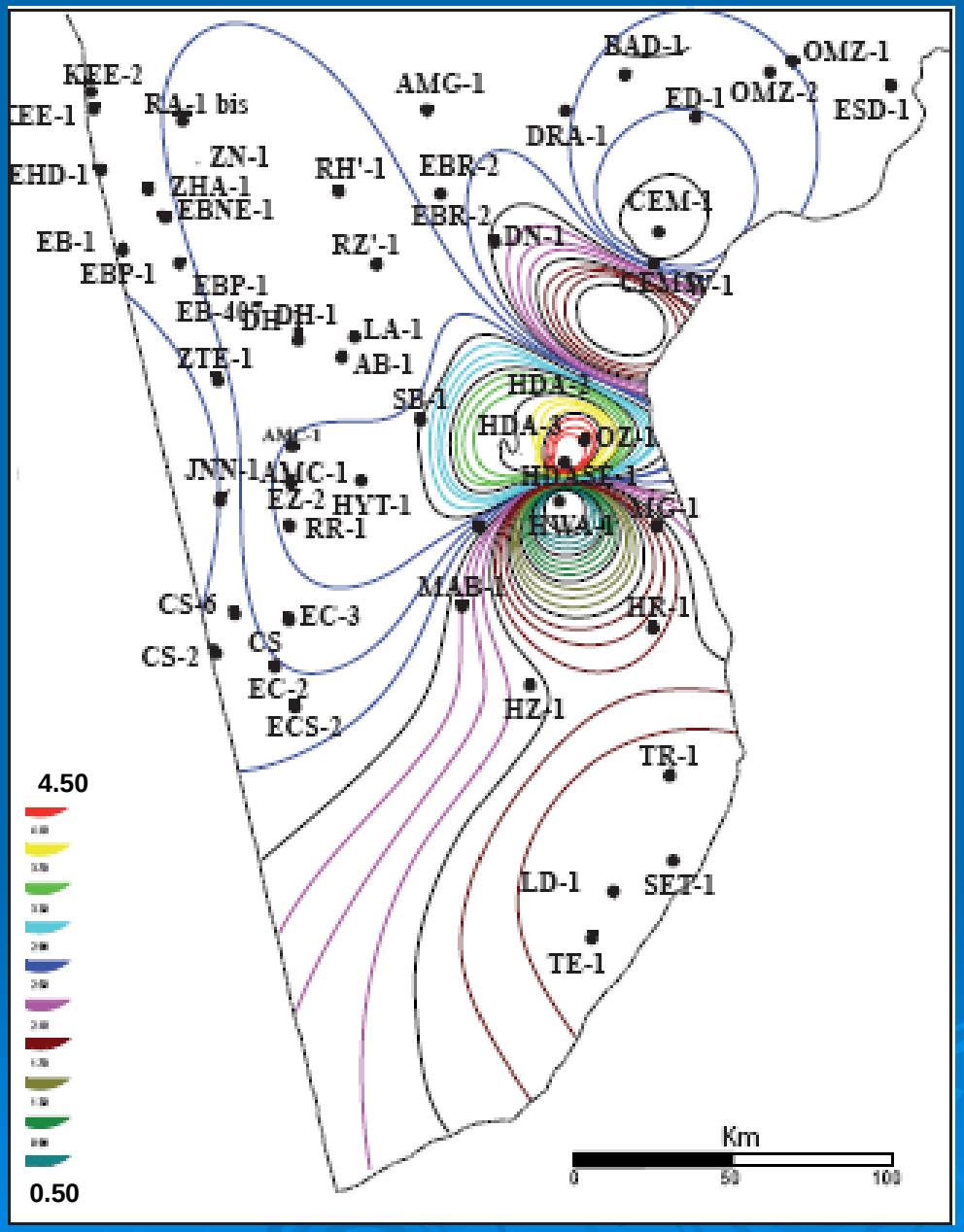
3.70%

6.87%

4%

2.81%

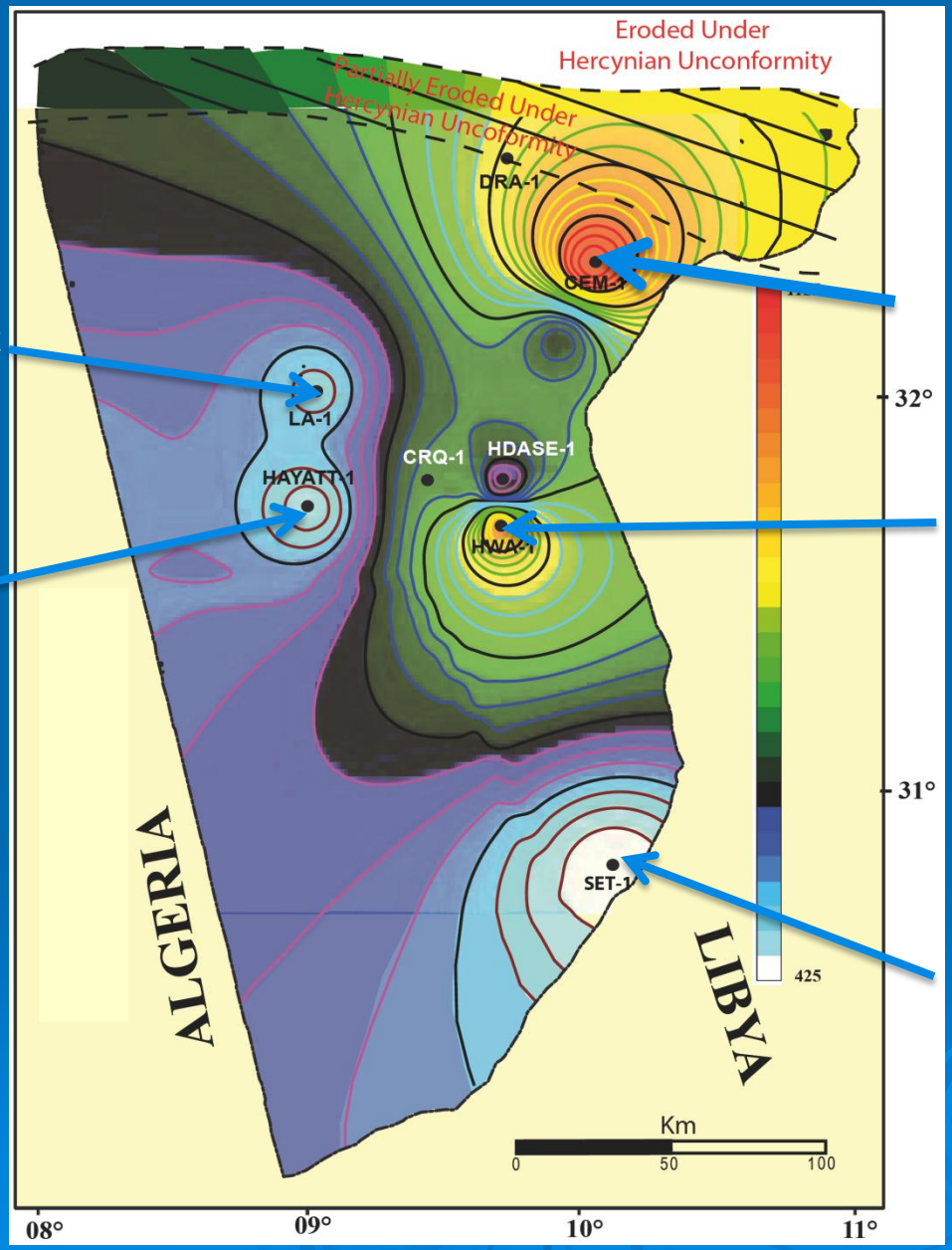
TOTAL ORGANIC CARBON CONTENT ASSESSMENT



TOC DISTRIBUTION MAP

Unconventional Play/ Gas from Lower Silurian Shale - Ghadames basin

GEOCHEMICAL ASSESSMENT-KEROGEN TYPE



484mg Hc/g TOC

637 mg Hc/g TOC

490mg Hc/g TOC

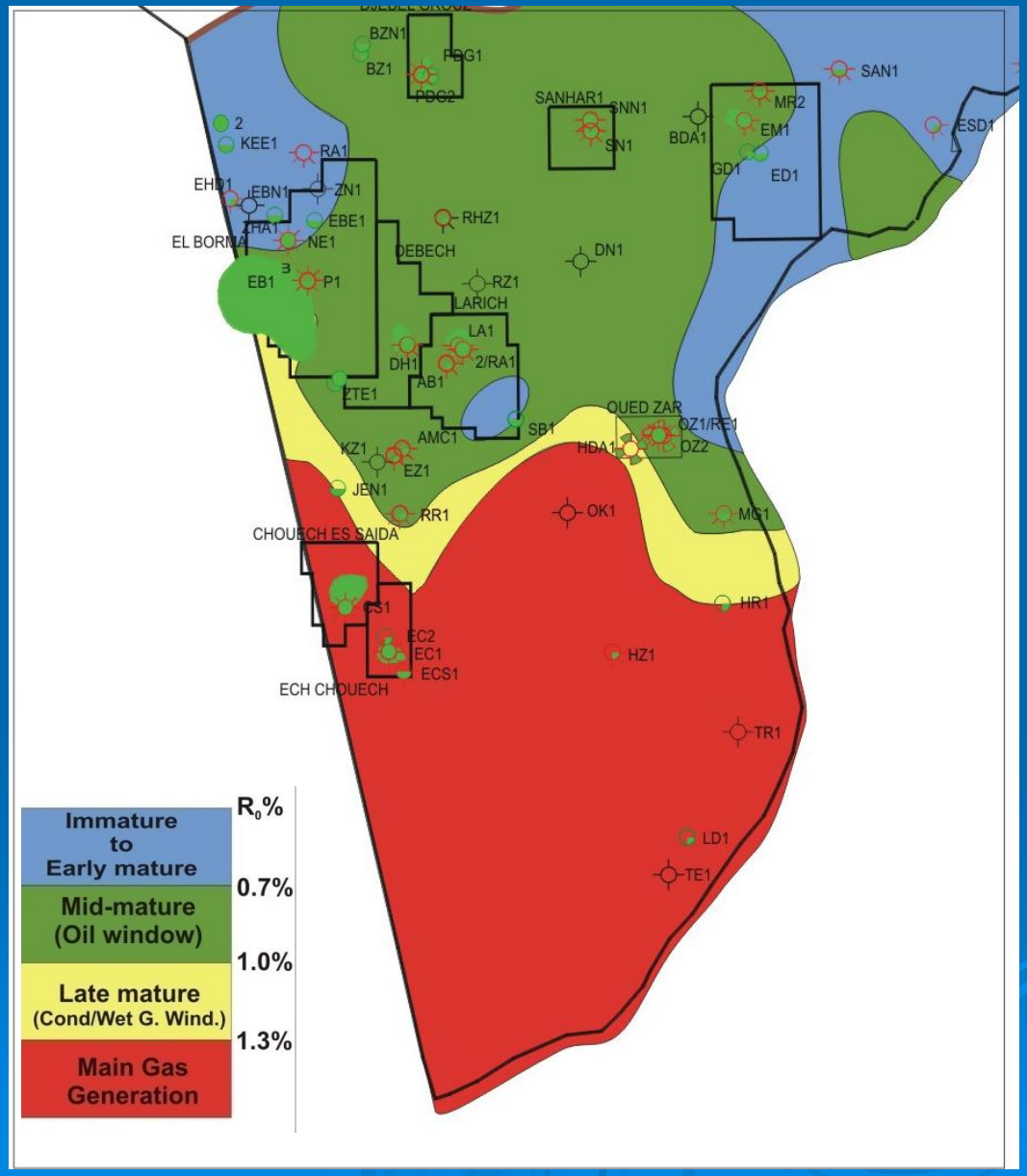
458mg Hc/g TOC

448mg Hc/g TOC

INITIAL HYDROGEN INDEX DISTRIBUTION MAP

Unconventional Play/ Gas from Lower Silurian Shale - Ghadames basin

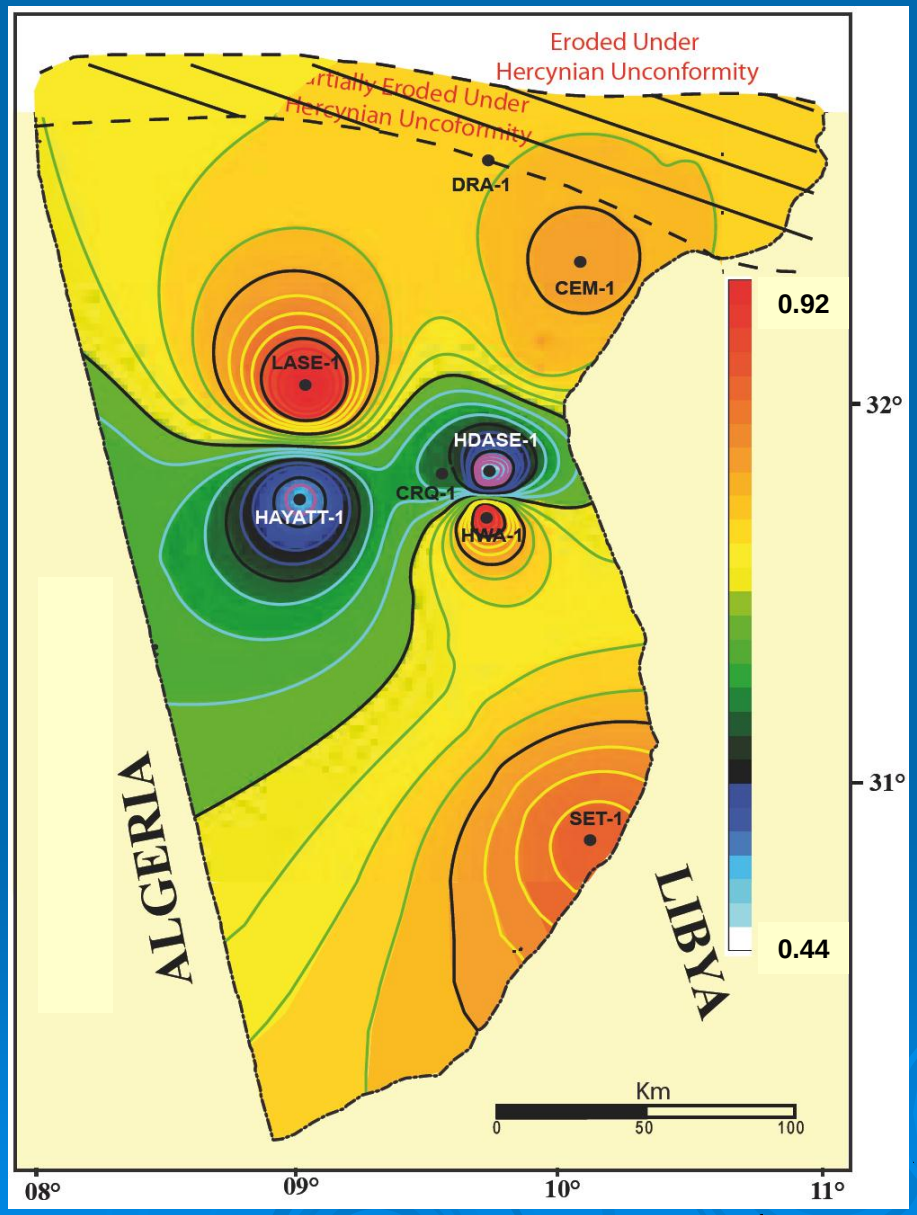
GEOCHEMICAL ASSESSMENT- THERMAL MATURITY



MATURITY MAP

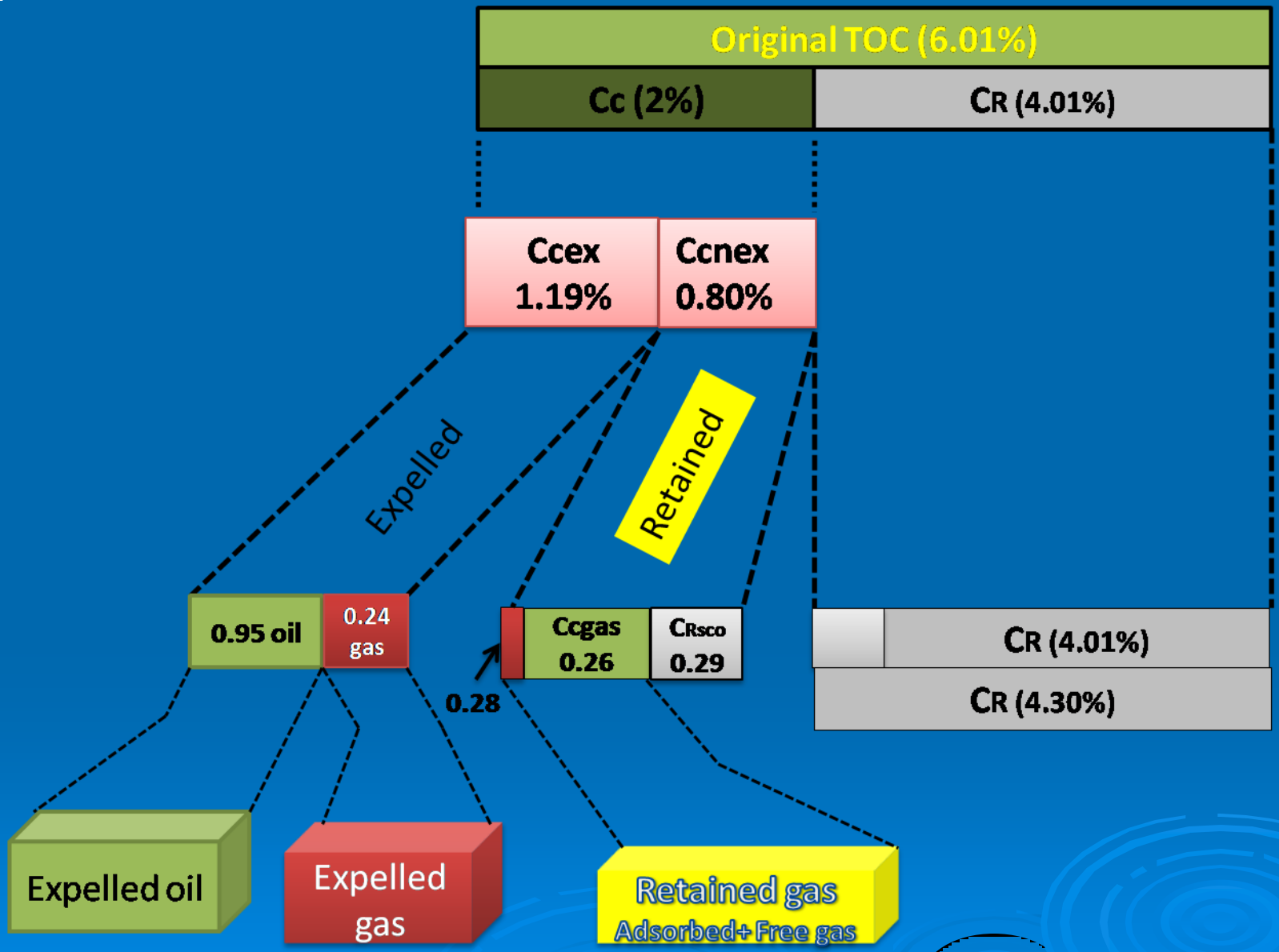
Unconventional Play/ Gas from Lower Silurian Shale - Ghadames basin

GEOCHEMICAL ASSESSMENT- THERMAL MATURITY



KEROGEN TRANSFORMATION RATIO MAP

Unconventional Play/ Gas from Lower Silurian Shale - Ghadames basin

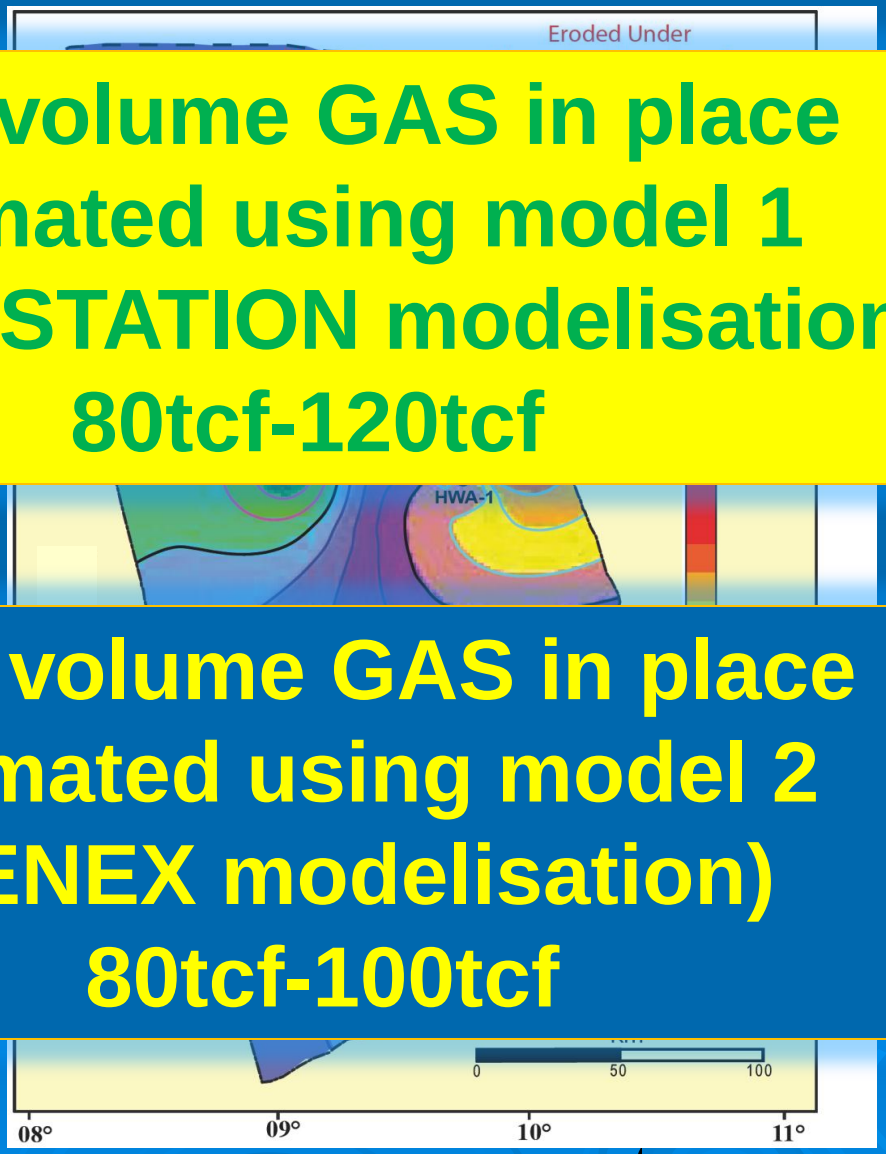


Description of TOC components and values that result from thermal maturation of organic matter in Tannezuft Hot shale

Unconventional Play/ Gas from Lower Silurian Shale - Ghadames basin

Quantitative Gas volumetric models

Total volume GAS in place estimated using model 1 (TERRASTATION modelisation) 80tcf-120tcf



Total volume GAS in place estimated using model 2 (GENEX modelisation) 80tcf-100tcf

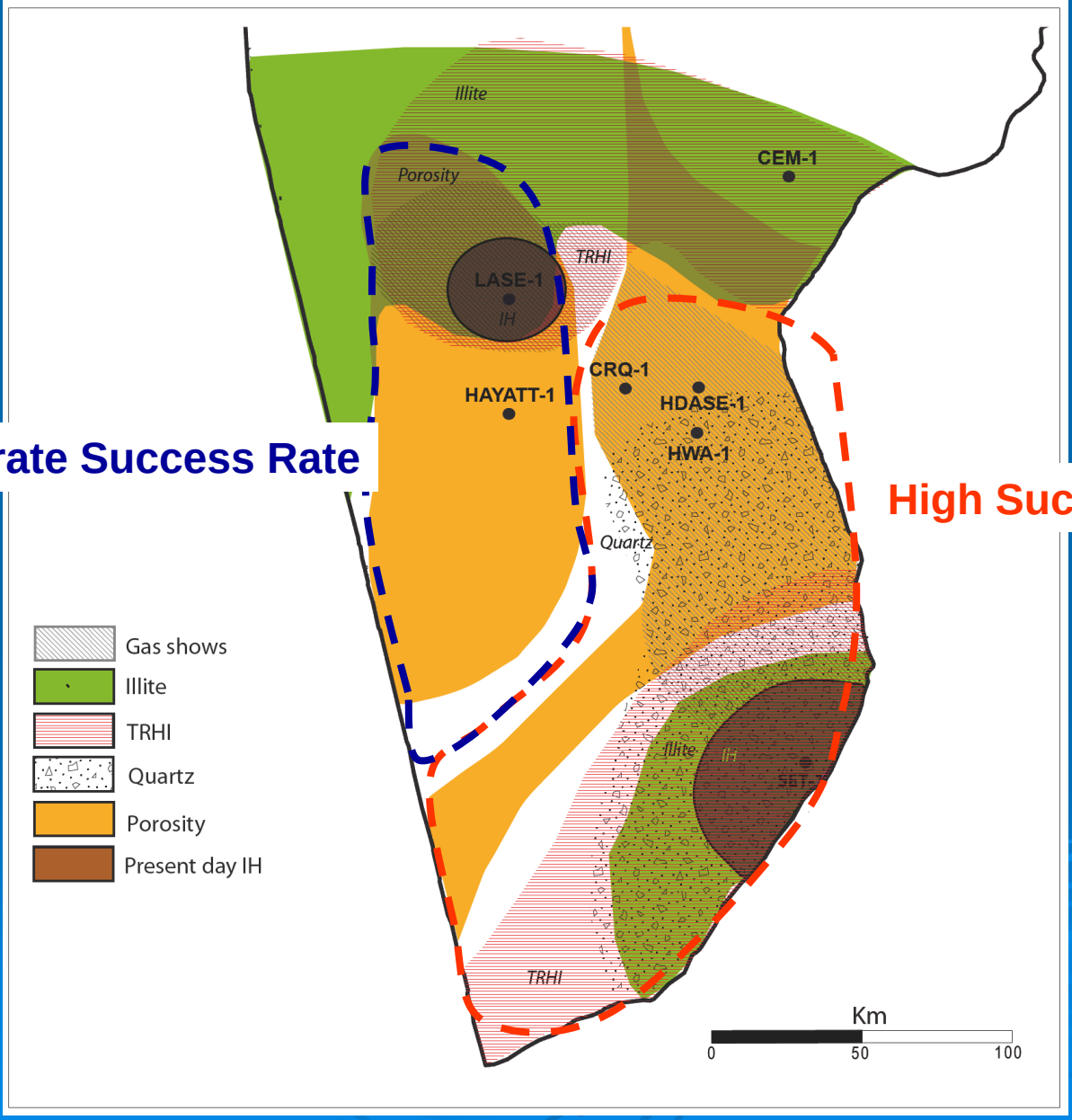
GAS IN PLACE DISTRIBUTION MAP (free+adsorbed gas)

Gas composition

	C1	C2	C3	iC4	nC4	iC5	nC5
CEM-1	81,45	12,74	4,40	Tr	Tr	Tr	Tr
RA-1bis	63,77	23,19	13,04	Tr	Tr	Tr	Tr
Durra-1	88,06	9,26	2,48	Tr	Tr	Tr	Tr
AMC-1	79,55	15,91	4,55	Tr	Tr	Tr	Tr
SET-1	94,29	4,65	1,06	Tr	Tr	Tr	Tr

DRY GAS

DEFINITIVE PLAY MAP SUMMARY OF LOWER SILURIAN SHALE-GHADAMES BASIN



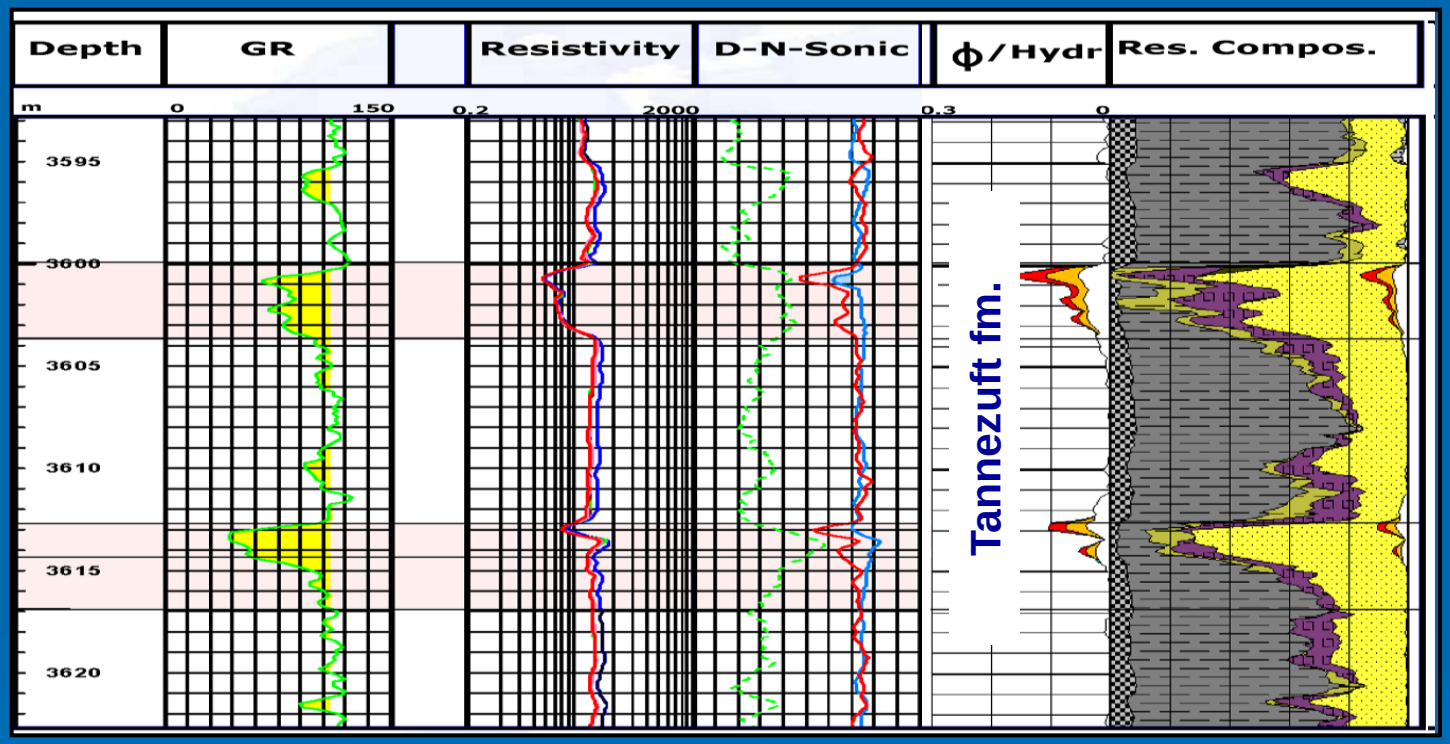
Shale Gas Characteristics & Comparaison with Tannezuft SR in Tunisia

PARAMETER	TARGET RANGE	WOOD FORD	BARNETT	FAYETTE VILLE	HOT SHALE Tunisia
TOC, %	2 – 10%	3 – 10	3 – 8	3 – 8	3 - 15 (Av.6)
Thermal Maturity % Ro	1.1 – 3.0%	1.1 – 3.0	1.2 – 2.0	1.2 – 4.0	0.7 - 2.2
Qz Content, %	30 – 80%	60 – 80	40 – 60	40 – 60	Up to 35
Gas Filled Ø, %	2 – 8%	3 – 6.5	3 – 5.5	3 – 5.5	1 to 6
Thickness, m	>30	30 – 65	60 – 150	15 – 100	20 - 50
YM, MMpsi	>3		4 - 6		----
PR	<0.22		.15 - .22		----
Depth, m	1000-3000	1800 - 3600	1800 - 2700	450 - 2000	2500 - 4000
Pressure Grad, psi/ft	Over Pressured	.52	.52	.43	----
BCF/Section		40 – 120	50 – 200	55 - 65	----
Frac Barriers	Yes	Yes	Yes/No	Yes	Yes

EXPLOITATION ISSUES

- Difficult to Produce Using Conventional Drilling and Completion Techniques;
- DST's Often Yield Nothing.

Tannezuft SR log Response, Ghadames basin



High Resistivity
High Gas Background

Siliceous & Brittle shales

Hydraulic Fracturing of Shales

Thick Zone
Low Permeability
Low Porosity
Immense Surface Area
Filled Natural Fractures
Huge Gas (Locked) In Place

Massive Hydraulic

"Creating Permeability" With Fracs

Rheology explain the reservoir Behavior

Trican Frac Spread, NE BC

Source: Trican Well Services

Developing Shale Gas Play in Tunisia ?

Developing the Tannezuft Gas Shale play in Ghadames basin, Need to understand the follwing questions:

- How much gas is there (OGIP)? **80 - 120 TCF**
- How much can be produced and at what rate (Deliverability)?

RF = 10-12% → **10 - 15 TCF**

In this new Play there is Huge Potential, Developing them is a Business Decision

Thanks For your Attention