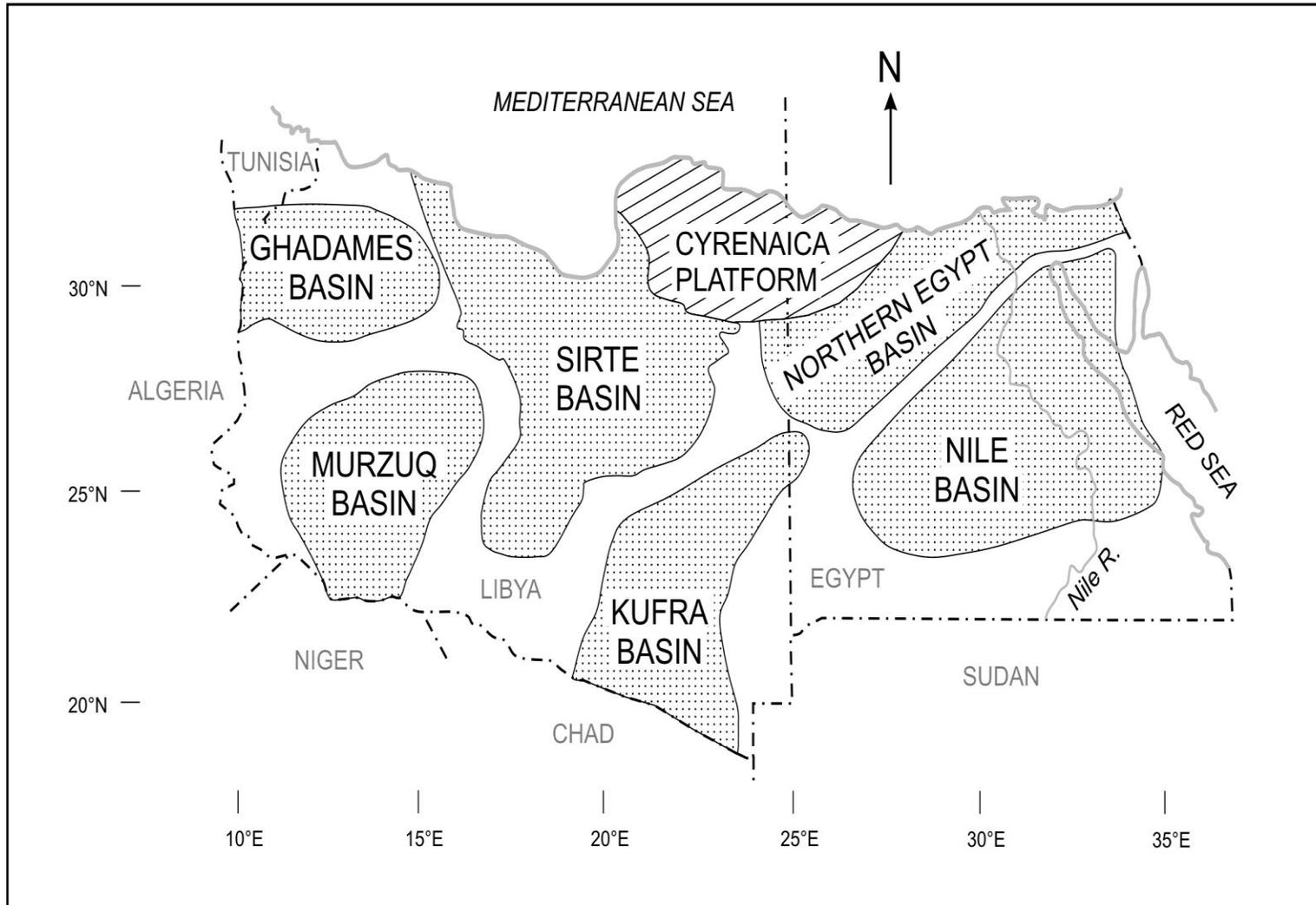


**THE DESTRUCTION OF THE LIBYAN
SANDSTONE AQUIFER SYSTEM (NSAS)
2011.....**

Fridtjov Ruden
ruden@rudenas.com



NUBIAN SANDSTONE AQUIFER SYSTEM NSAS



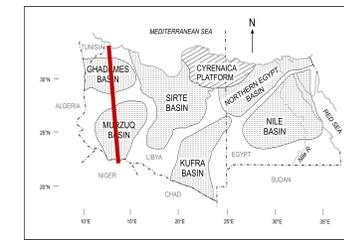
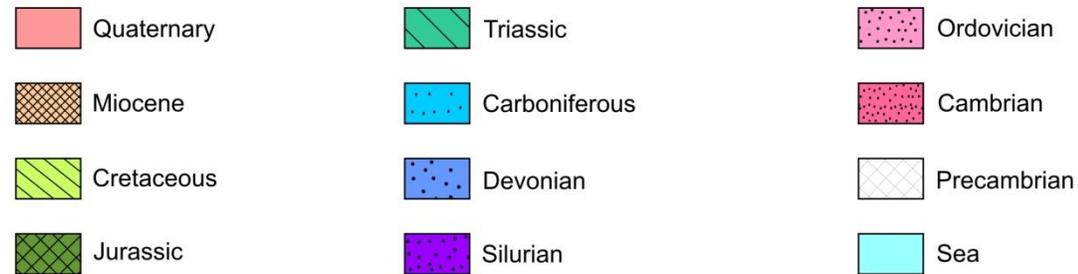
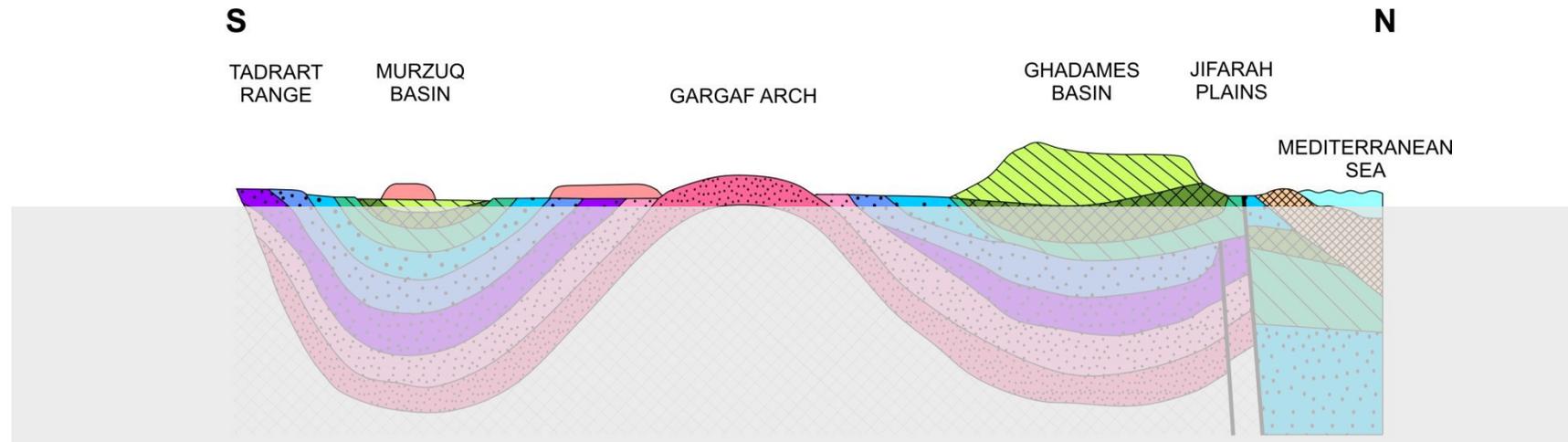
ANTROPOCENE HISTORY OF THE NUBIAN SANDSTONE AQUIFER SYSTEM

1. 5900 BP, Sahara dries up, climate refugees move out.
2. 146 BC, the 3rd Punic War ends.
3. 147, LIBYA (aka CARTHAGE) destroyed.
4. 147, SALT is poured in the wells...
5. 2011, history repeats itself...

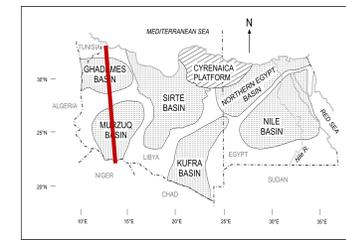
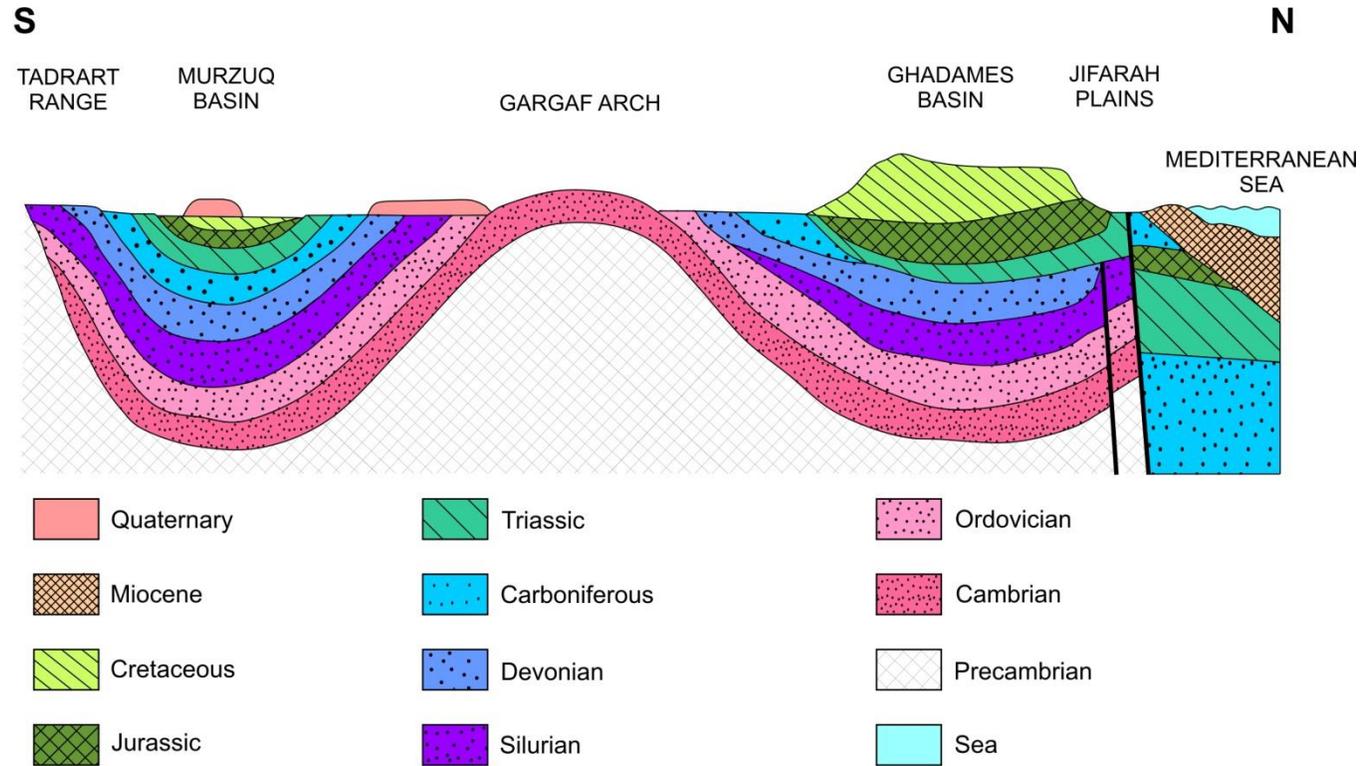
Welcome to the Nubian Sandstone Aquifer System (NSAS) Anno 2022...



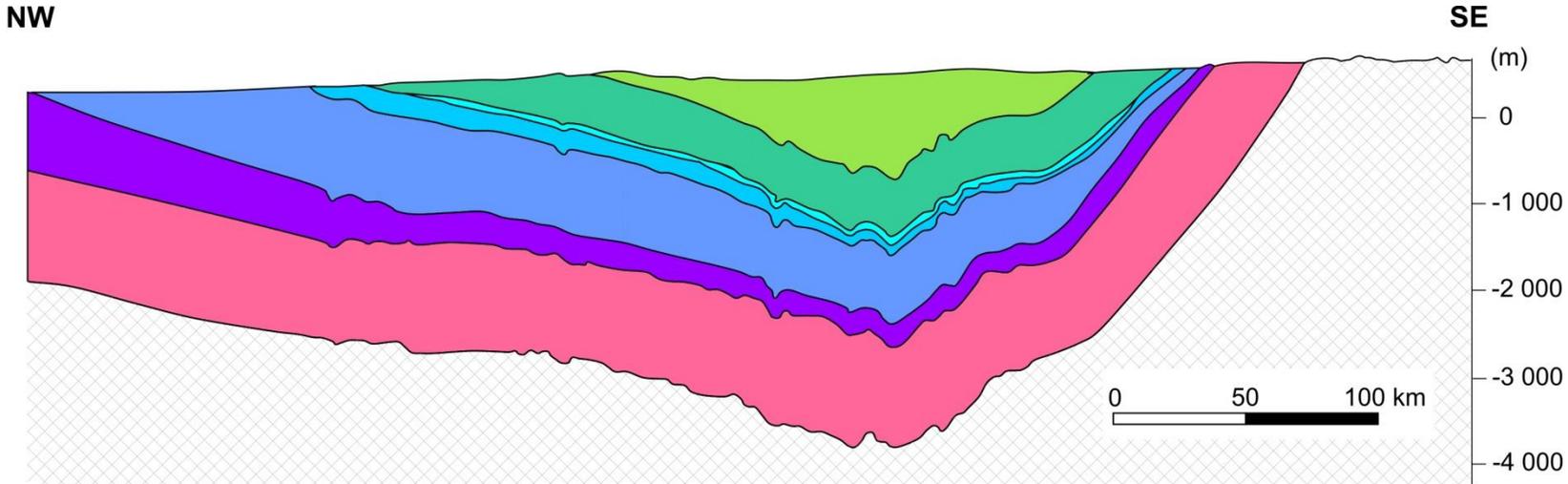
TRADITIONAL WATER PERSPECTIVE - NSAS (LIBYA)



OUR PERSPECTIVE – NSAS (LIBYA)

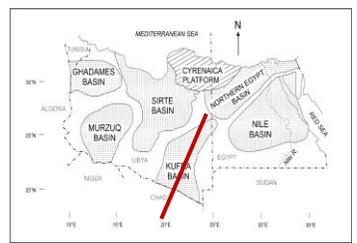


AL KUFRAH BASIN



- Lower Cretaceous
- Permian
- Devonian
- Cambro-Ordovician
- Triassic
- Carboniferous
- Sylurian
- Precambrian

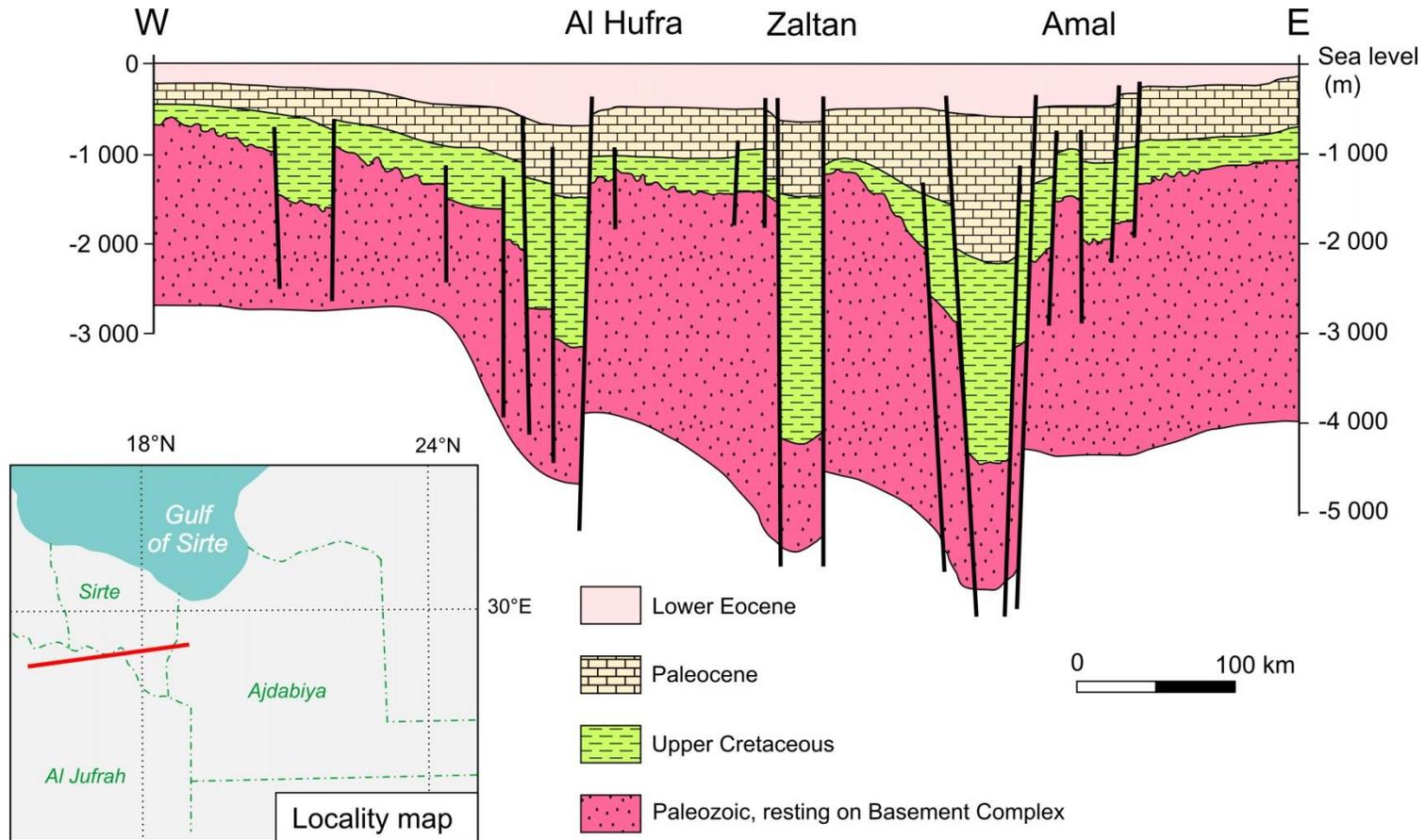
Modified after Wright, 1982



Volume H₂O: 225 000 km³



SIRTE BASIN

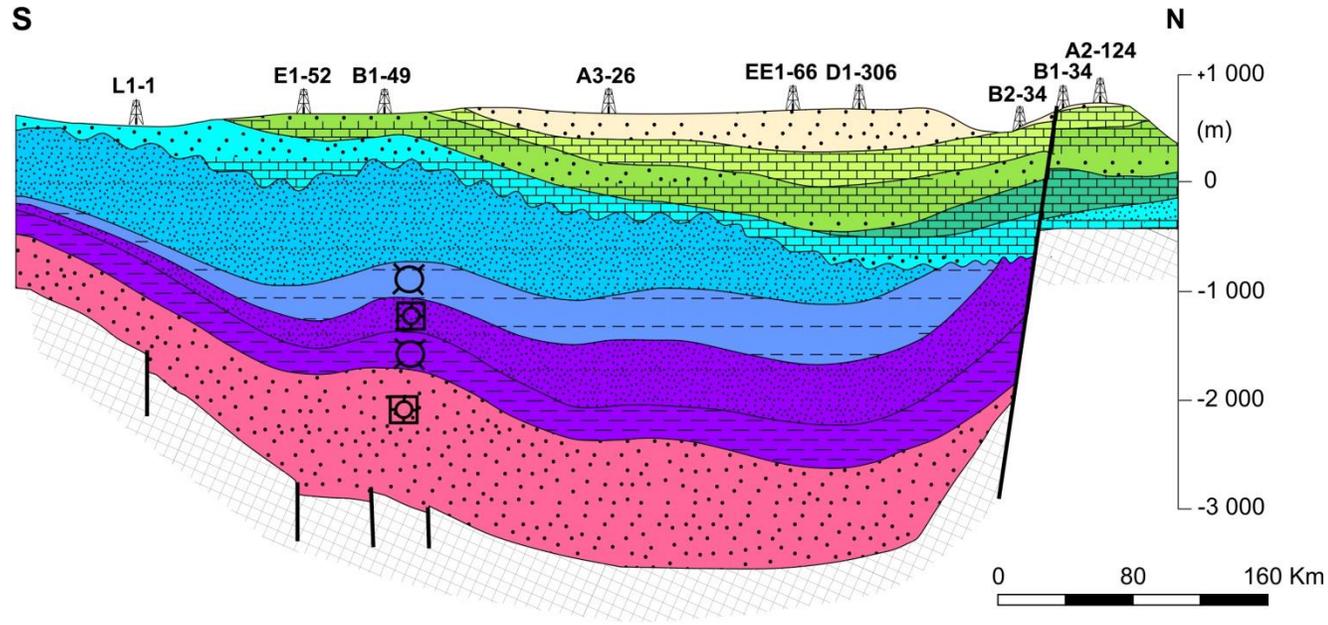


Volume H₂O: 280 000 km³

West-East cross section of Sirte Basin (Based on Roohi, 1996)

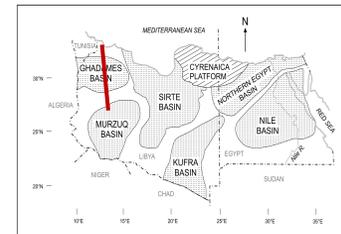


GHADAMIS BASIN



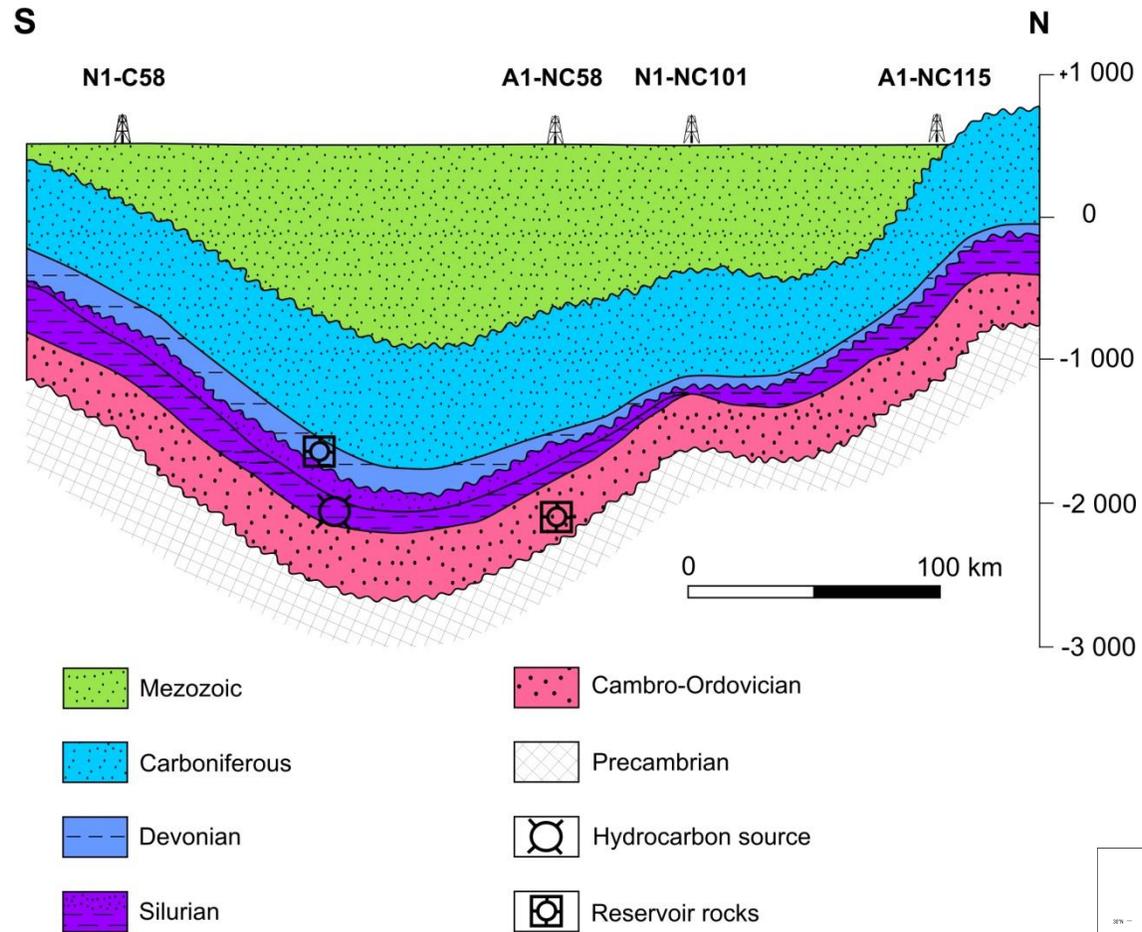
- | | | |
|------------------|---------------|--------------------|
| Tertiary | Permian | Cambro-Ordovician |
| Upper Cretaceous | Carboniferous | Precambrian |
| Lower Cretaceous | Devonian | Hydrocarbon source |
| Triassic | Silurian | Reservoir rocks |

North-south cross section of Ghadamis Basin. (Modified after Pallas, 1980)

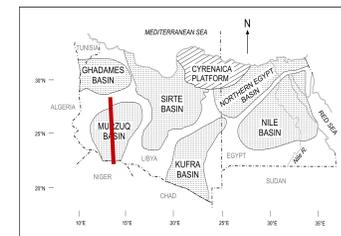


Volume H₂O: 144 000 km³

MURZUQ BASIN

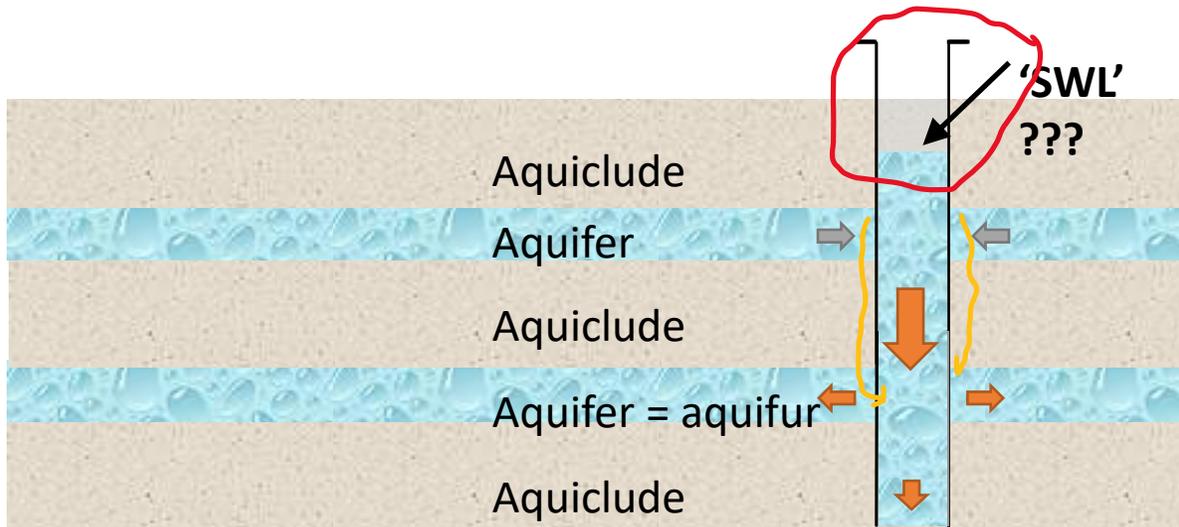


North-south cross section of Murzuq Basin. (Modified after Pallas, 1980)



Volume H₂O: 75 000 km³

THE 4 CURSES OF NSAS:



1. CORROSION
2. CROSSFLOW
3. DISSOLUTION
4. CROSS CONTAMINATION

Aquiclude = *water barrier*
Aquifer = *water bearing*
Aquifur = *water thief (sic!)*

TWO DISASTERS WHICH WILL SET A TREND...



DISASTER 1: THE OKN-32 BERKAOUI

Haoud Berkaoui Oil Field, the northern part of the Algerian Sahara, 26 October 1986

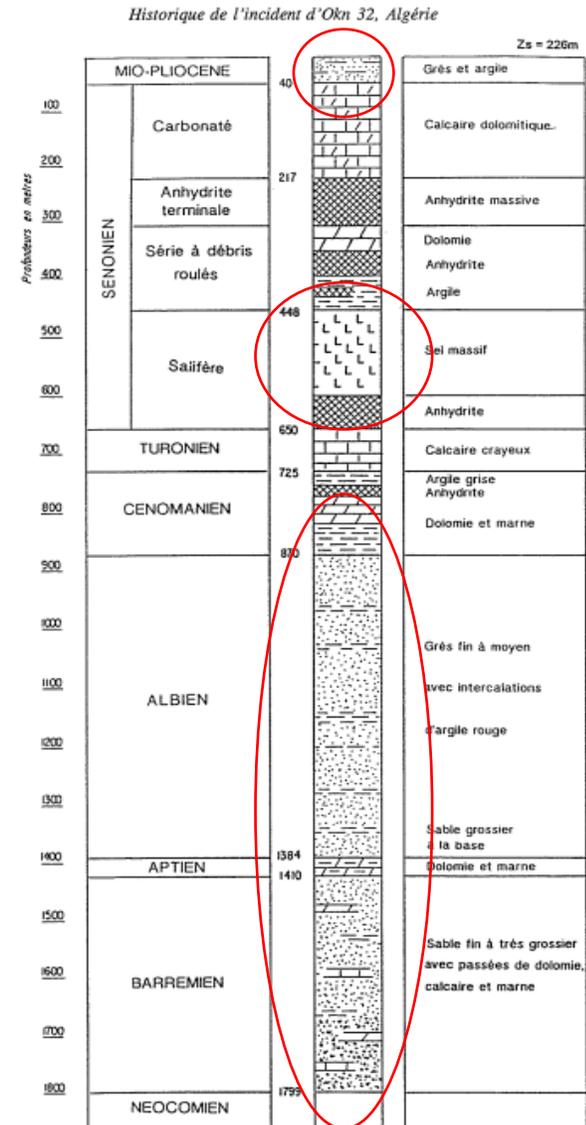
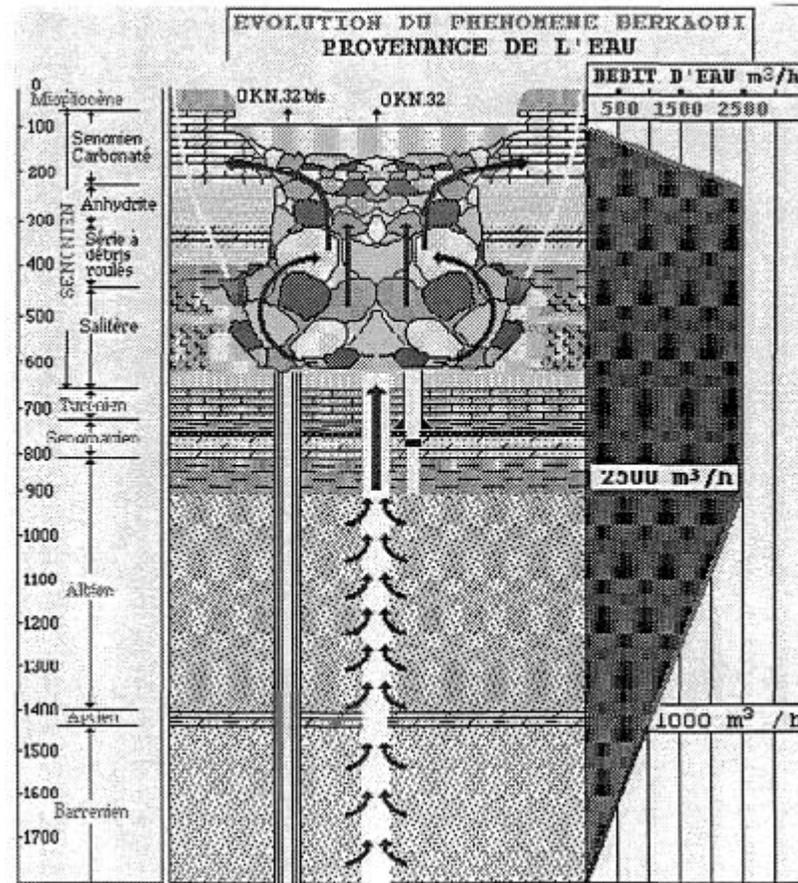
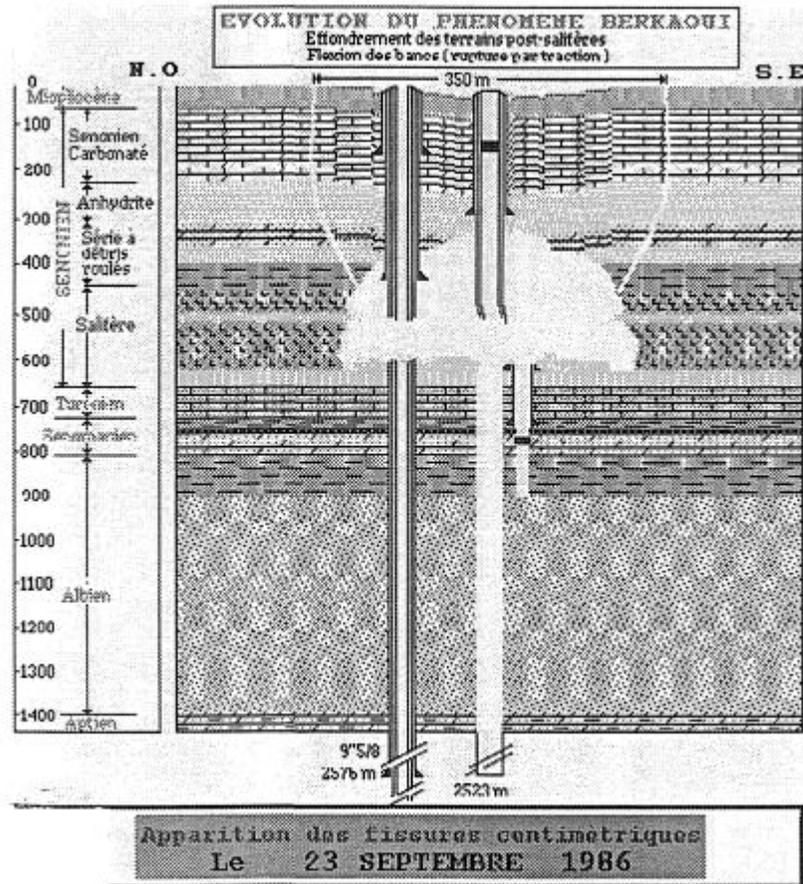


Fig. 2 Log lithostratigraphique du forage Okn 32.



THE OKN-32: ONGOING DESTRUCTION OF AN ENTIRE REGIONAL AQUIFER



OKN-32: DESTRUCTION OF AN ENTIRE REGIONAL AQUIFER



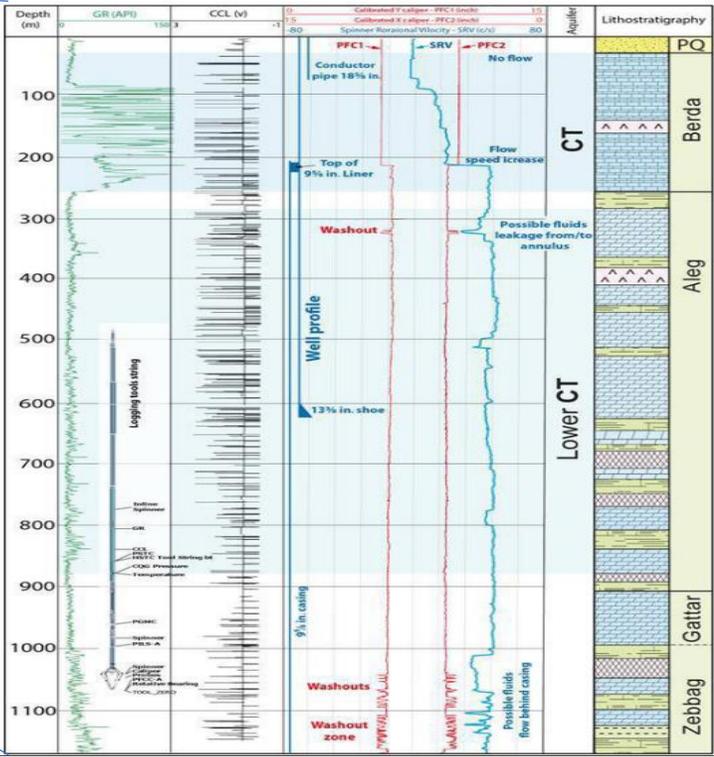
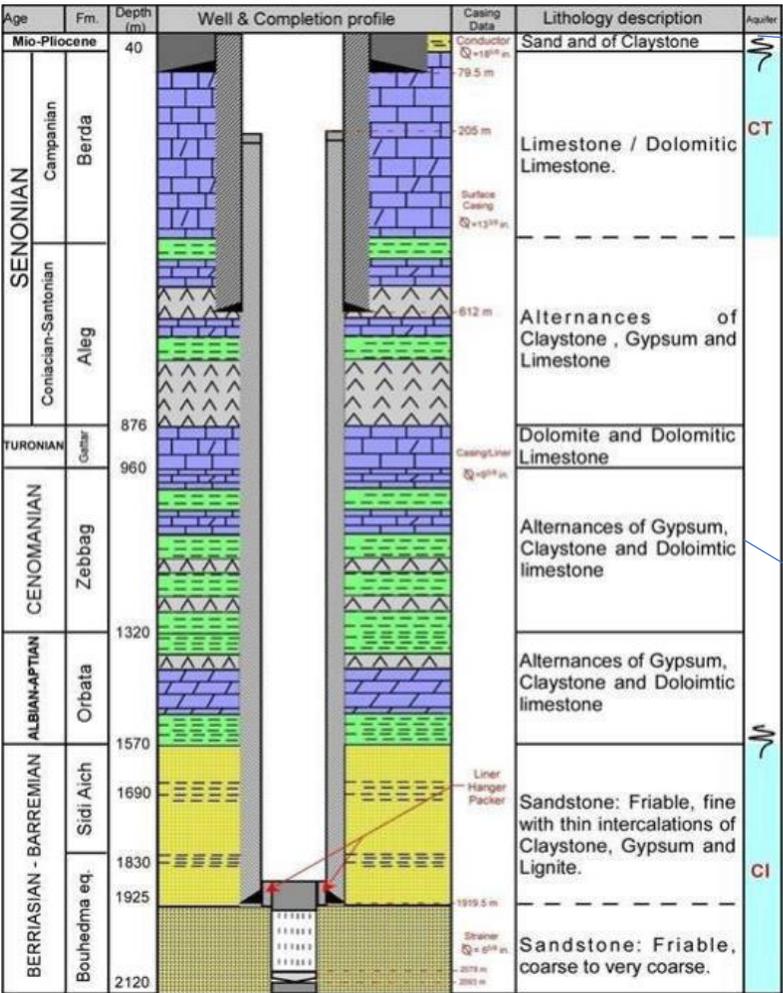
Discharge: 2500 m³/h (700 L/s)

Salinity: 275 g/L

Salt mined over 40 years: 140.000.000 tons

-all from a single corroded casing.....

CASE OF CI-11 WELL (NSAS, Jemna Oasis, 2014, Southern Tunisia)



The main cause of this accident is a single cement failure.

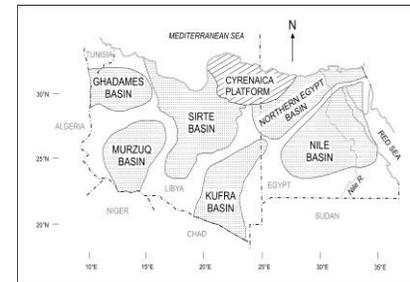


AT STAKE: LIBYAN AQUIFERS

PRINCIPAL BASINS OF LIBYA

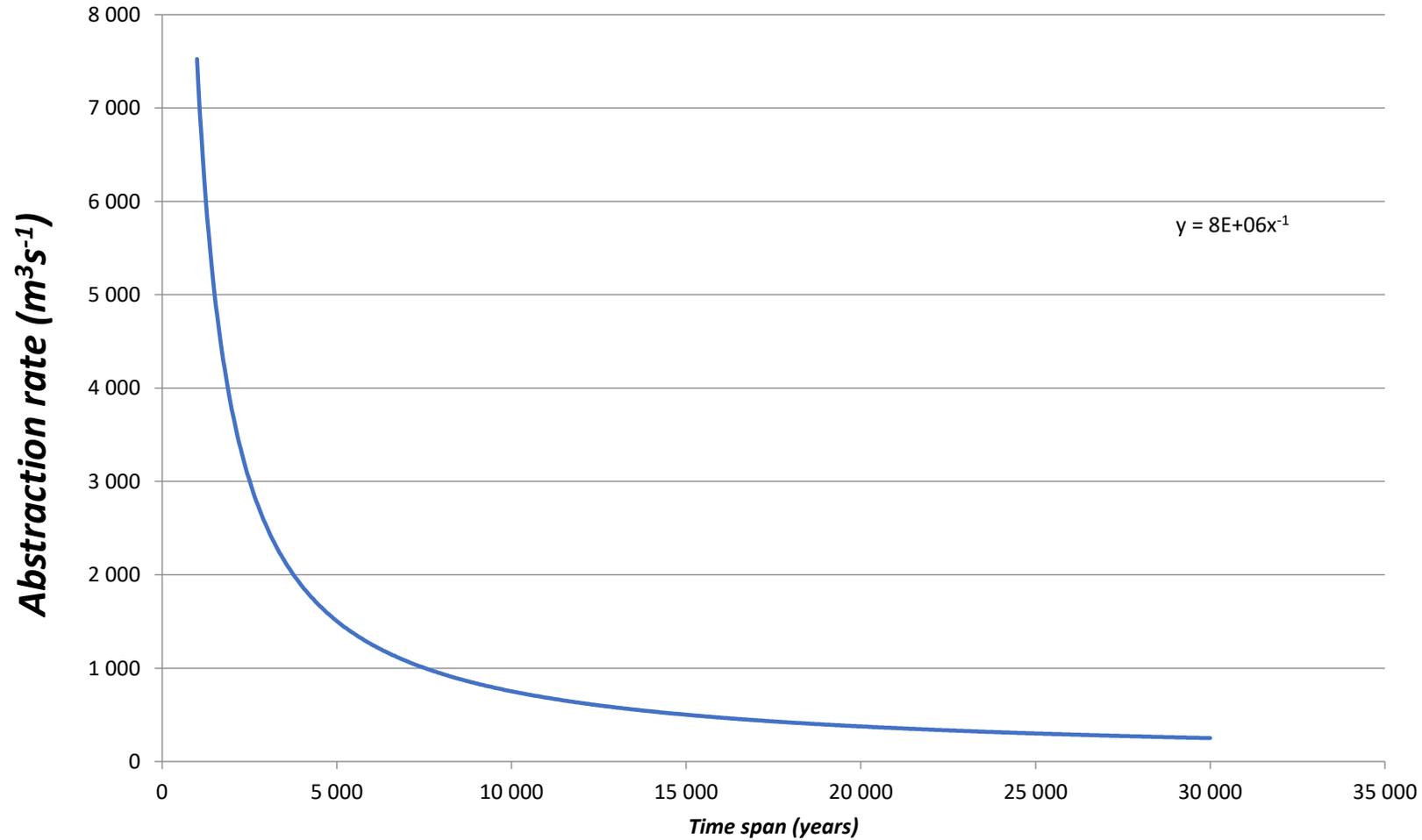
<i>Basin</i>	<i>H₂O (km³) apprx.</i>
Cyrenaica Platform*	25 000
Murzuq Basin	75 000
Ghadamis Basin	144 000
Sirte Basin	280 000
Kufrah Basin	225 000
Tripolitanian Offshore Basins*	100 000
H₂O km³	Apprx. 800 000

**Cyrenaica Platform and Tripolitanian Offshore Basins are inferred*

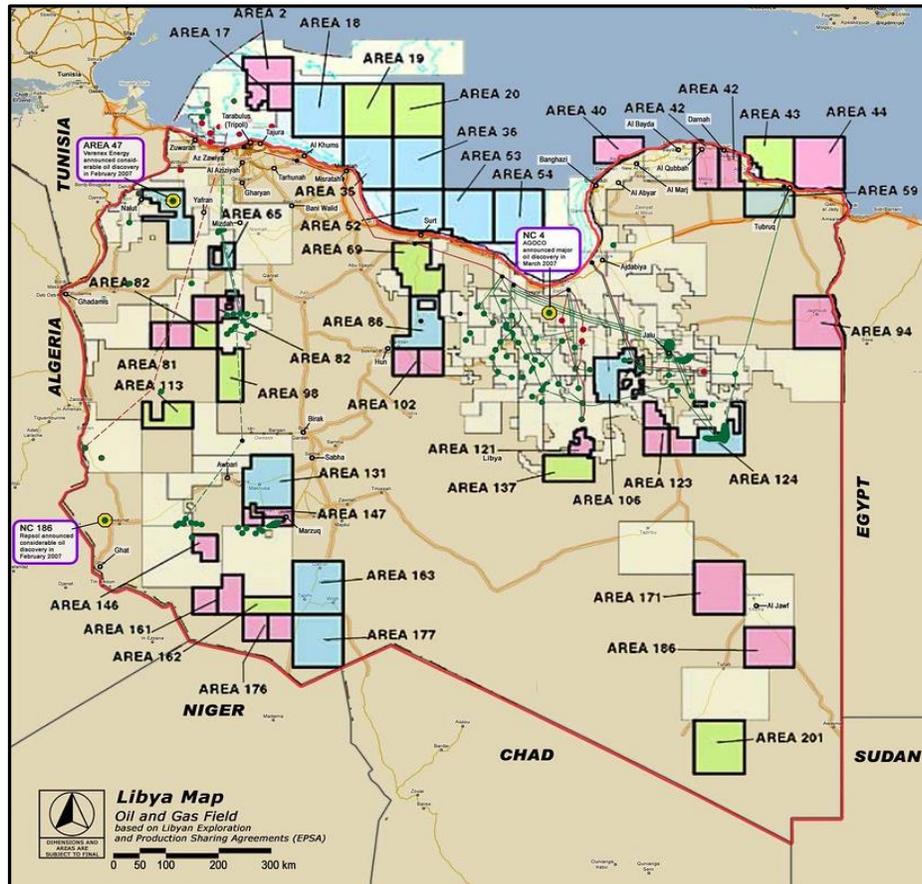


SUSTAINABLE ABSTRACTION – NSAS (LIBYA)

25% depletion of NSAS (Libyan) aquifers



NSAS: AN UNEASY RELATIONSHIP BETWEEN OIL & WATER



WATER QUALITY OF DEEP GROUNDWATER

Issued by Libyan Petroleum Institute

Date of Issue

Test Report No.

Sample1

NO.	PARAMETER		RESULTS	UNITS	METHOD
1	Color.	*	0.00	PCO	---
2	pH – value @ 21.0 °C		6.55	-	ASTM D-1293
3	Conductivity	*	352	µs/cm @ 25°C	ASTM D-1125
4	Phosphate	*	0.00	mg/L	ASTM D-4327
5	Turbidity	*	16.77	FTU	ASTMD889
6	Total Hardness	*	70	mg/L	ASTM D-4327
7	Bicarbonate	*	120	mg/L	ASTM D-1067
8	Calcium Hardness	*	25	mg/L	ASTM D-4327
9	Sulphate	*	15	mg/L	ASTM D-4327
10	Chloride	*	35	mg/L	ASTM D-512
11	Calcium	*	10	mg/L	ASTMD4327
12	Magnesium	*	11	mg/L	ASTMD4327
13	Sodium	*	21	mg/L	ASTM D-2791
14	Potassium	*	28	mg/L	ASTM D2791
15	Nitrate	*	8.81	mg/L	ASTM D-4327
16	Nitrite	*	0.00	mg/L	ASTM D-4327
17	Magnesium Hardness	*	45	mg/L	ASTM D-4327


 Approved Signatory

.....End of report.....

A PERSPECTIVE: VALUE OF AQUIFERS VS. OIL

AQUIFER SYSTEM	WATER STORAGE (Km ³)	PRESENT VALUE (USD)*
Guarani (South America)	37 000	3.7E+13
Ogallalla (Central US)	4 000	4E+12
Great Artesian Basin (Aus)	65 000	6.5E+13
Libyan basins	849 000	1.0E+15

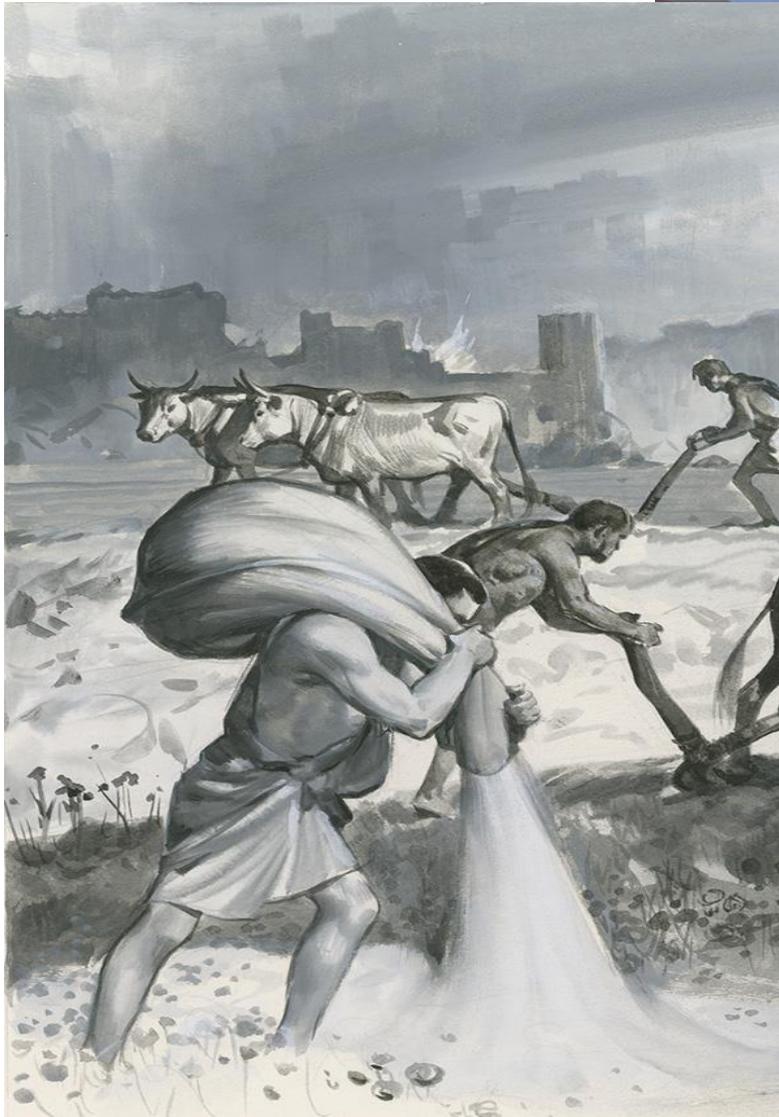
OIL RESERVOIR	OIL VOLUME (Km ³)	PRESENT VALUE (USD)**
Ekofisk	2.0	1.284E+12
Statfjord N	2.0	1.284E+12
Statfjord E	1.6	1.0272E+12

Based on market value of 1 USD/m³ for water, and 100 USD/bbl oil***

NSAS STATUS 2022: SUMMARY OF AN ENTIRELY AVOIDABLE PROBLEM

- INFRASTRUCTURE DESTROYED BY RANDOM **BOMBING** (SCAR)
- NO **REGULATORY REGIME** FOR OIL WELL COMPLETION, OPERATIONS & ABANDONMENT
- STACKED AQUIFER SYSTEMS STRONGLY PRONE TO **CROSSFLOW**
- **REMEDIAL ACTION NOT FEASIBLE** DUE TO SECURITY CONCERNS & LACK OF INFRASTRUCTURE
- **ROGUE OIL FIELD OPERATIONS** FLOURISH
- **ONGOING 24/7** CROSSFLOW CONTAMINATION OF WORLD CLASS PRISTINE AQUIFERS
- **NO ONE WILL EVER BE HELD ACCOUNTABLE**
- **NO PLANS NOR FUNDS AVAILABLE FOR RESTITUTION**





What next?

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