The Recognition and Exploitation of Fracture Systems in a Carbonate Reservoir

Issaran, a Heavy Oilfield Egypt

Paul A. MacKay
GeoConsultants Ltd.

Google Earth Image
Showing the western flank and normal fault distribution of the western edge of the sedimentary basin
Sinai
Gulf of Suez
Crystalline Basement
Issaran
Eastern Desert
20.0 mi
Image NASA
© 2008 Europa Technologies
Image © 2008 DigitalGlobe
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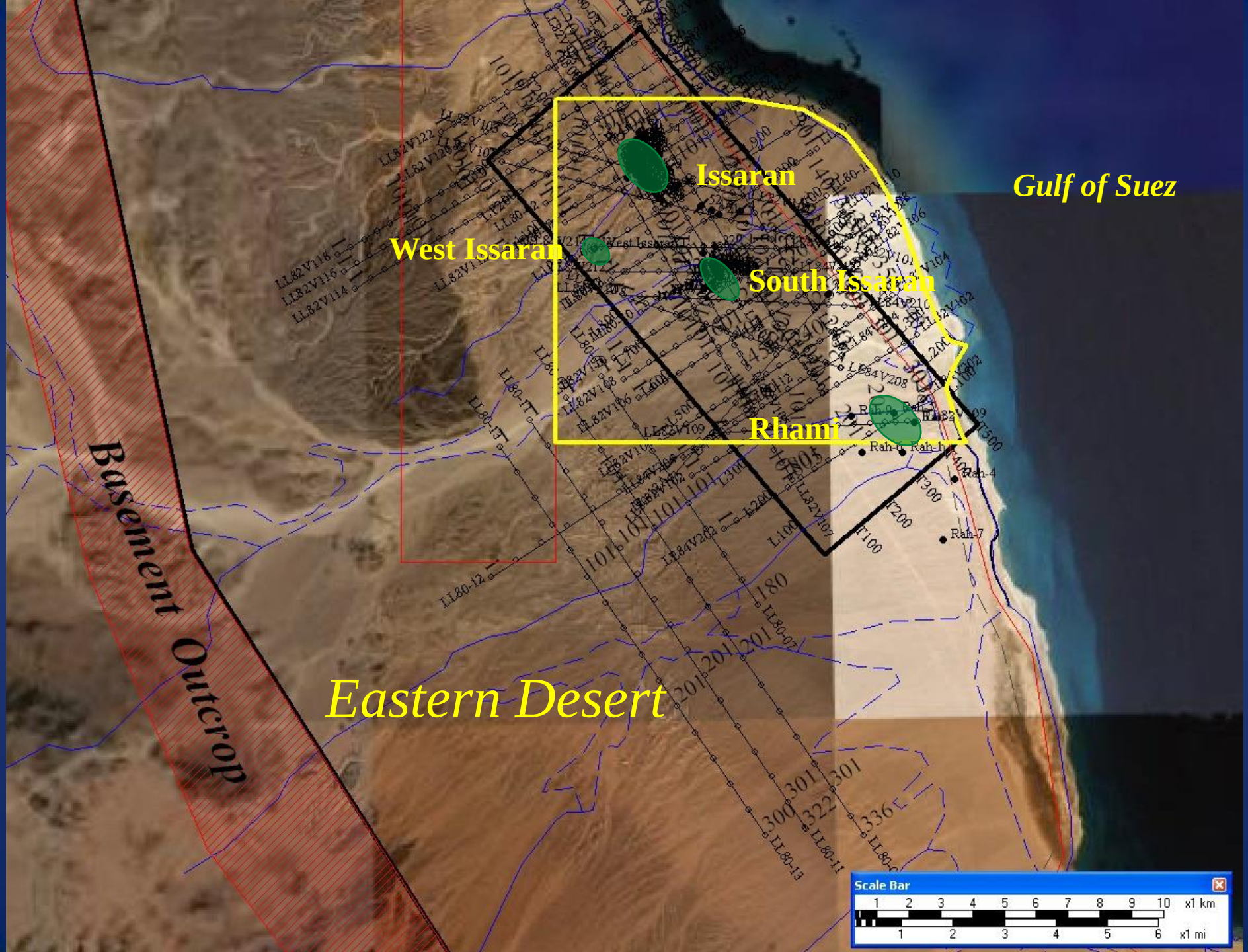
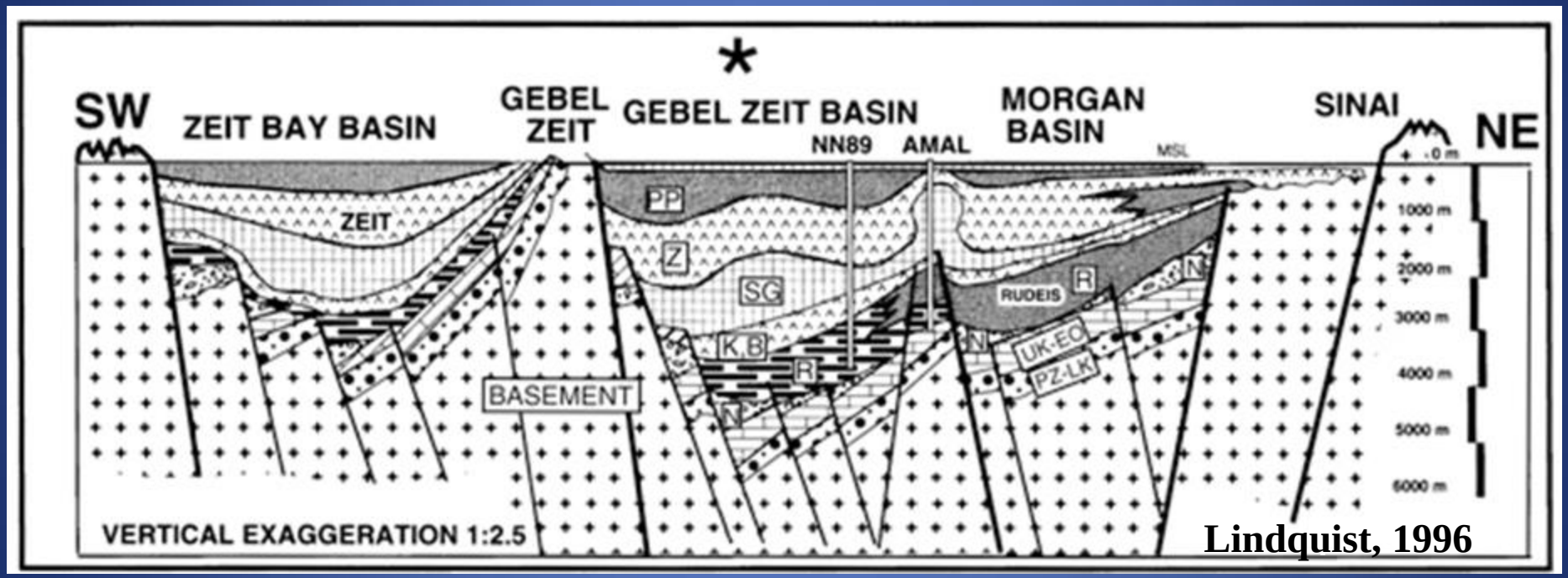
(Jerusalem)
Yerushalayim
lariyah
(Alexandria)
Israel
Jordan
(Cairo)
Issaran
Gulf of Aqaba
Gulf of Suez
Egypt

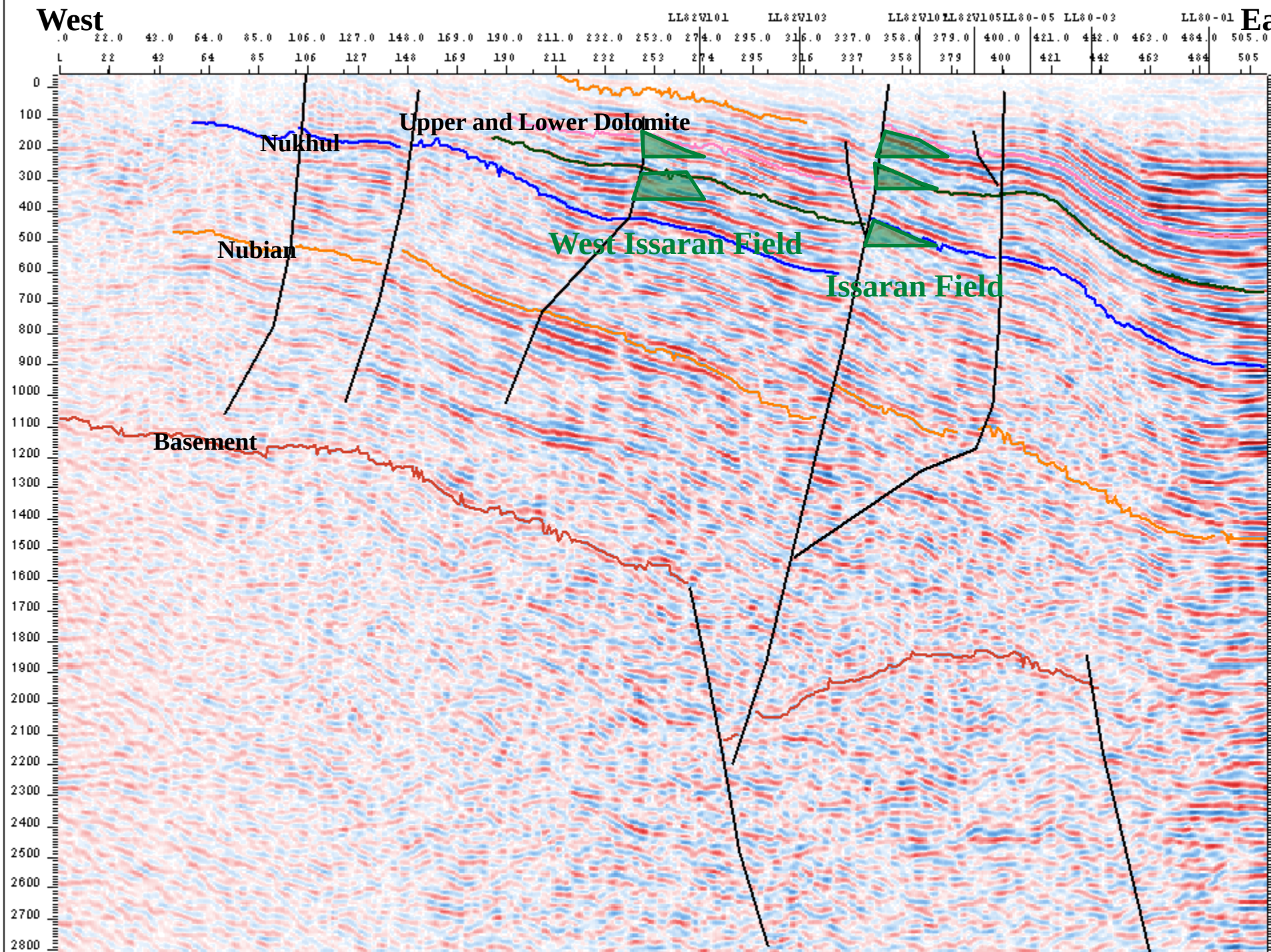

Issaran
West Issaran
South Issaran
Rhami
Gulf of Suez
Basement Outcrop
Eastern Desert
Scale Bar
1 2 3 4 5 6 7 8 9 10 x1 km
1 2 3 4 5 6 x1 mi

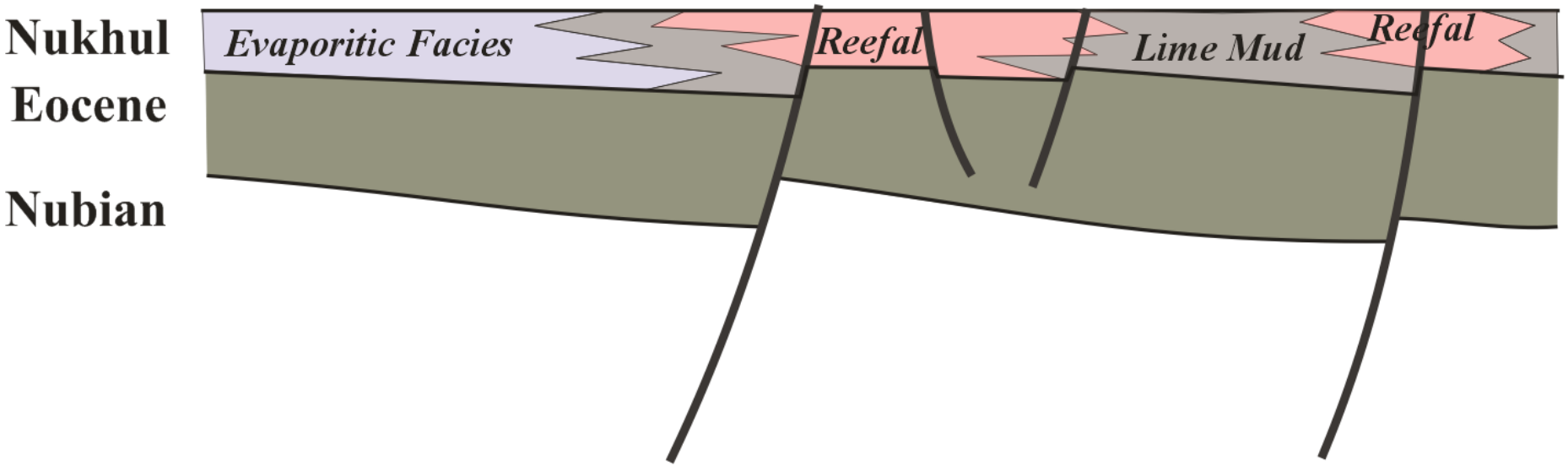
TW/2006

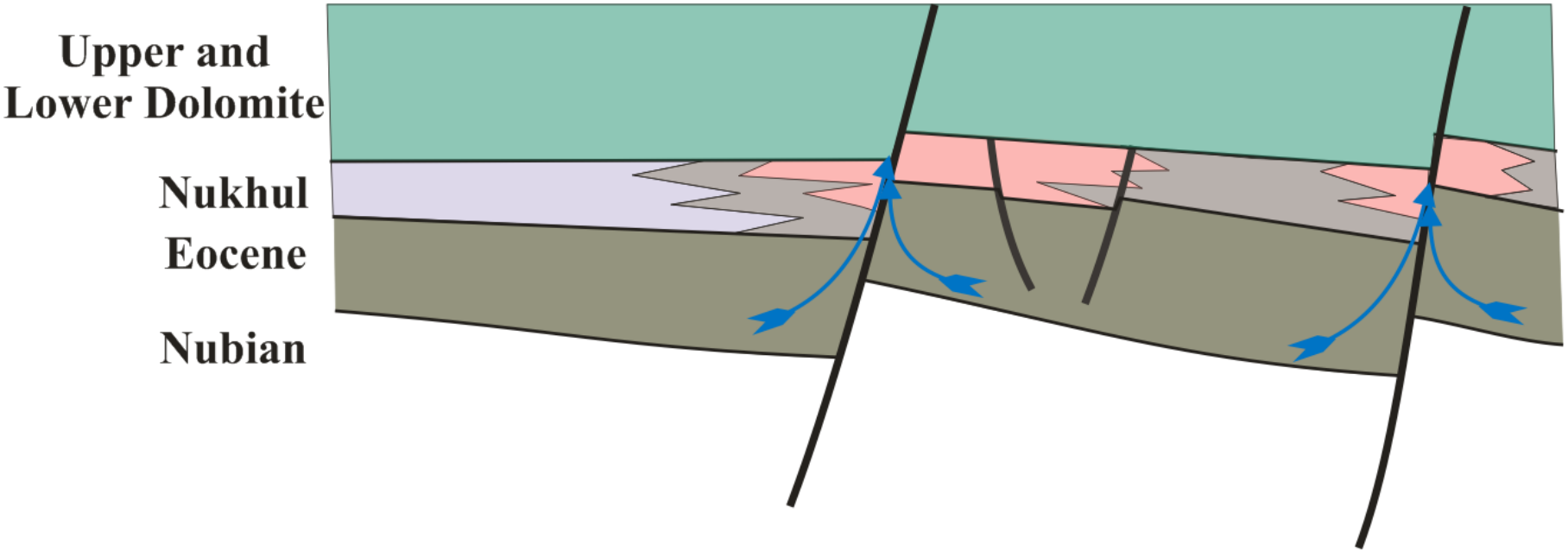
Cross-Section through Gulf of Suez

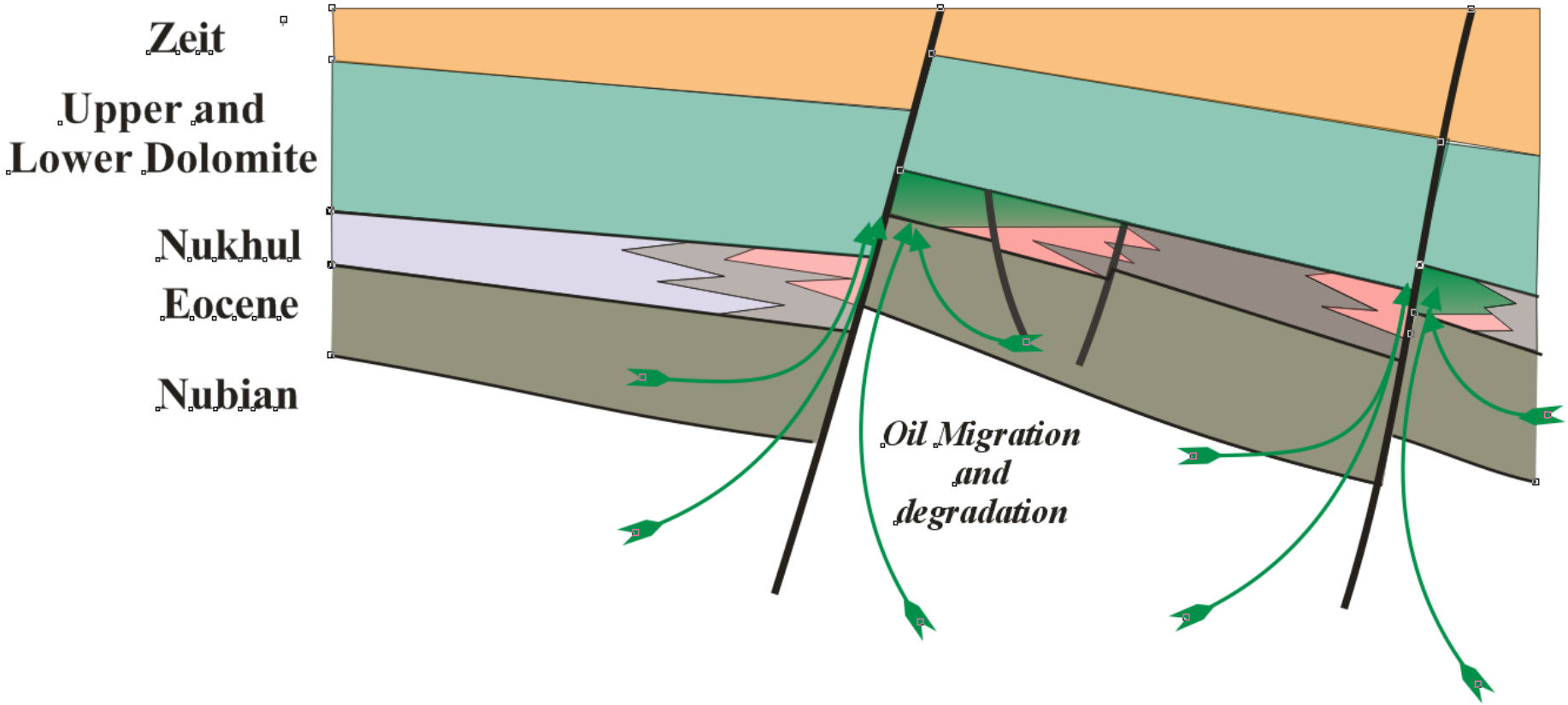


Lindquist, 1996

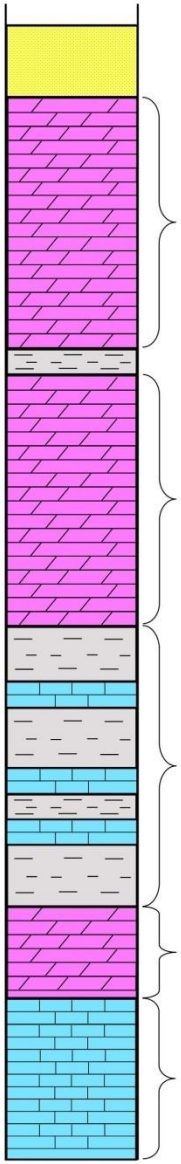

West
Ea
Upper and Lower Dolomite
Nukhul
Nubian
West Issaran Field
Issaran Field
Basement


Nukhul
Eocene
Nubian
Evaporitic Facies
Reefal
Lime Mud
Reefal


Upper and
Lower Dolomite
Nukhul
Eocene
Nubian


Zeit
Upper and
Lower Dolomite
Nukhul
Eocene
Nubian
Oil Migration
and
degradation

TYPE SECTION ISSARAN FIELD, EGYPT

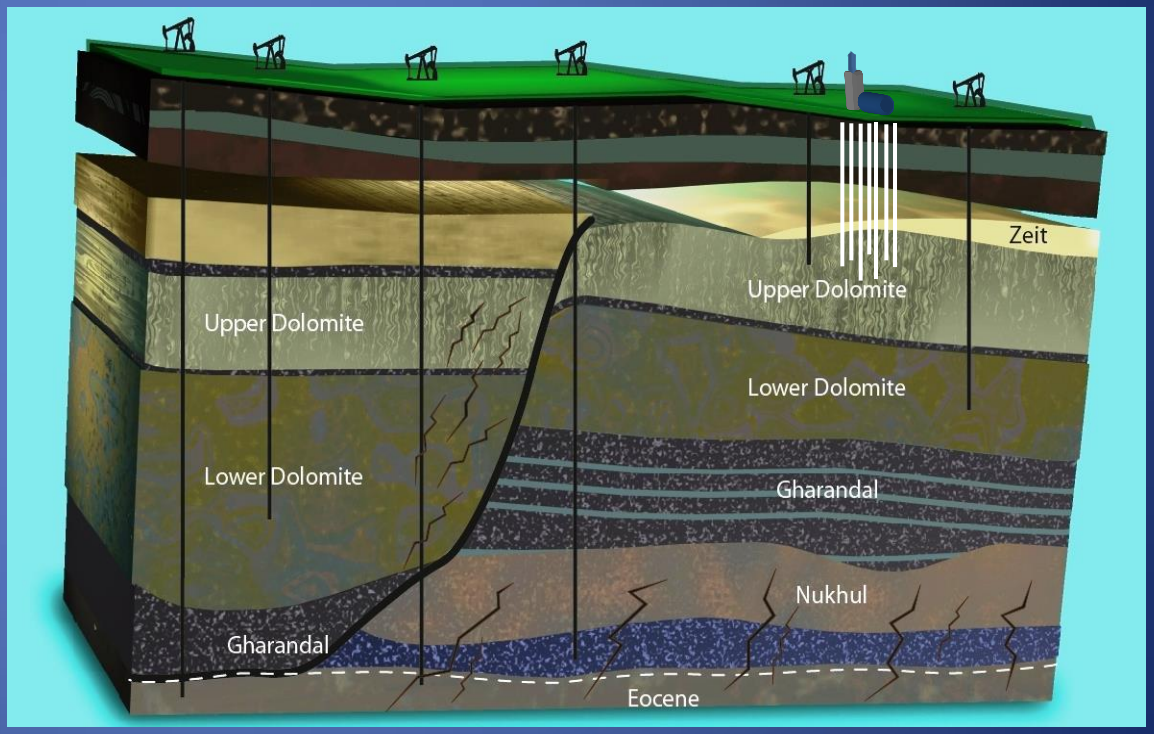


RALLY Energy Corp.

ISSARAN RESERVOIR SECTION

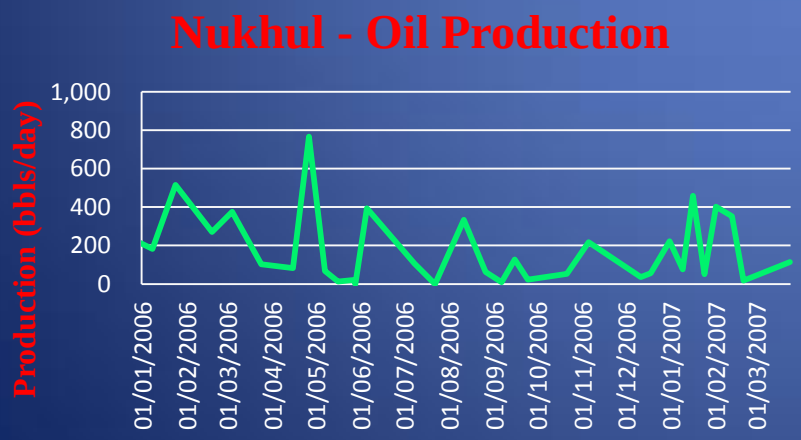
- 1,500 ft gross pay thickness
- 3 main pay zones each 150 to 250 ft net pay thickness
- Porosities upwards of 30%
- Matrix permeability 30 – 100 MD
- Heavy Oil/ Water emulsion
- Fractures enhance oil mobility
- Production statistics
  - Best wells IP 500 – 1,000 bopd
  - Average IP 200 + bopd
  - Cumulative production 100,000 to 500,000 barrels recoverable per well

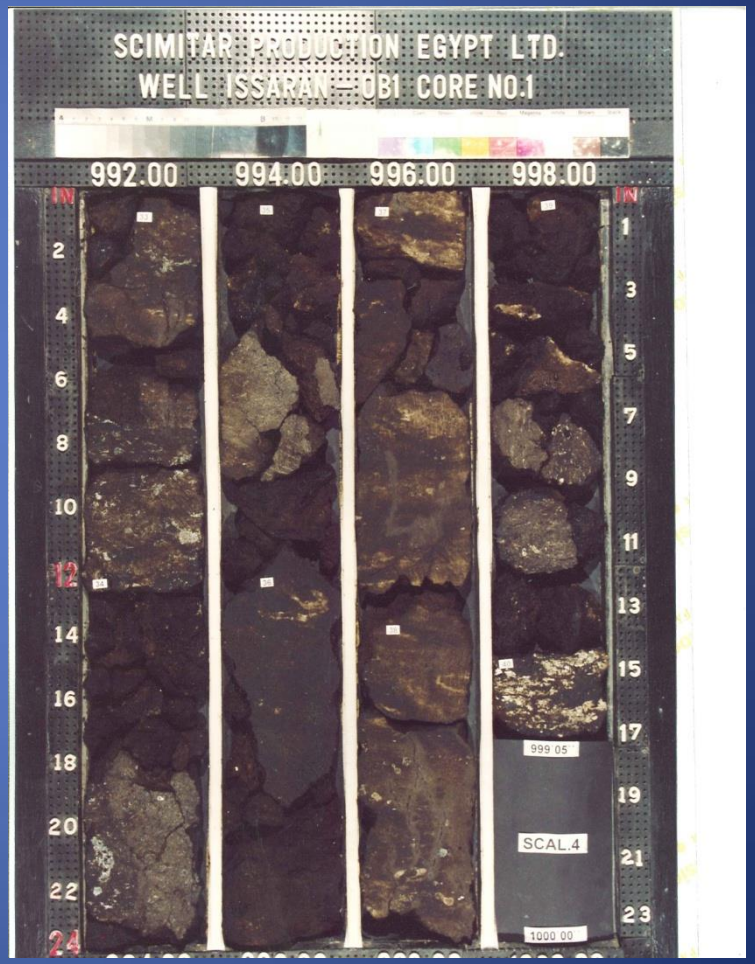
Northwest Southeast



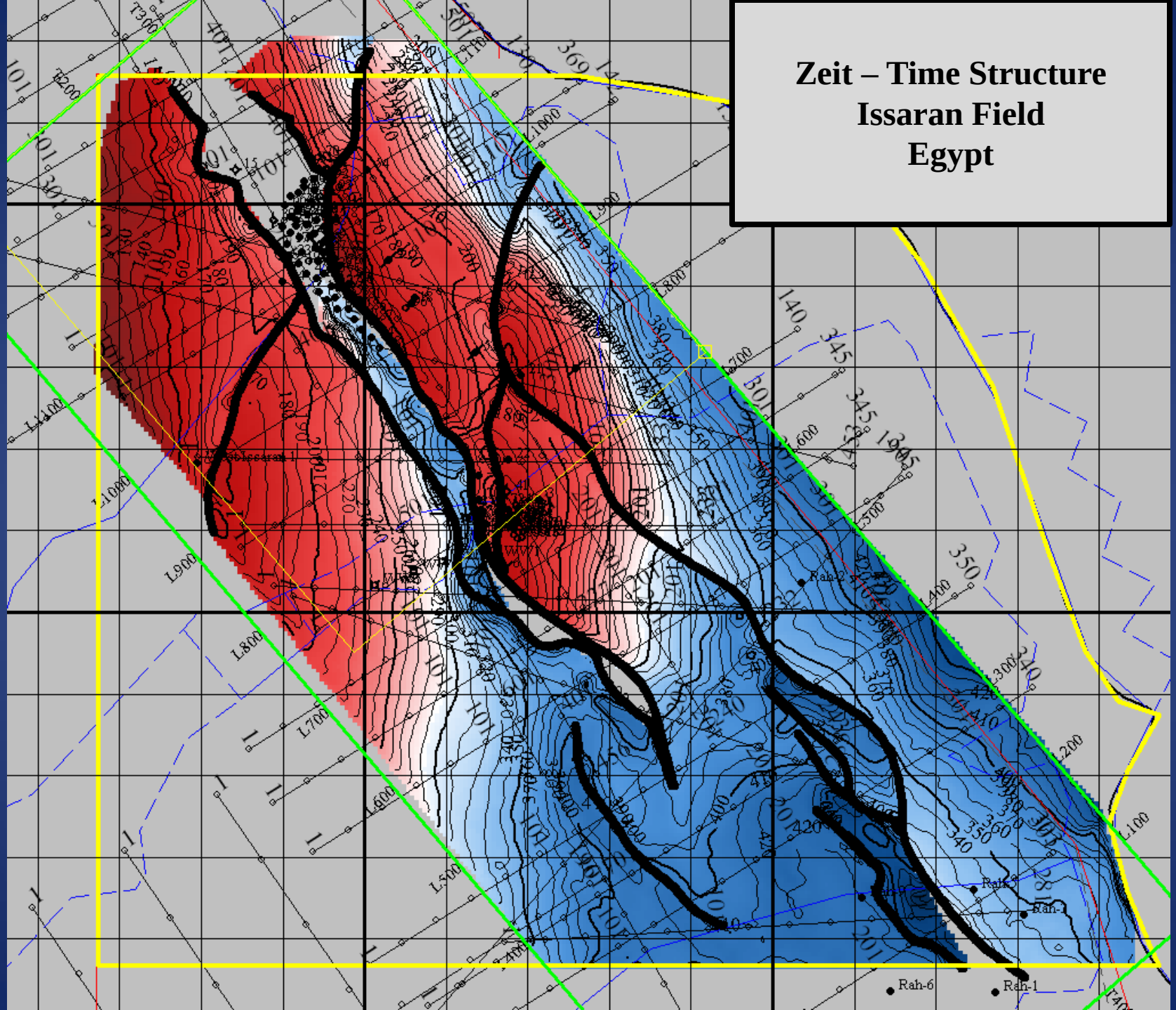
Evidence of a Fractured Reservoir

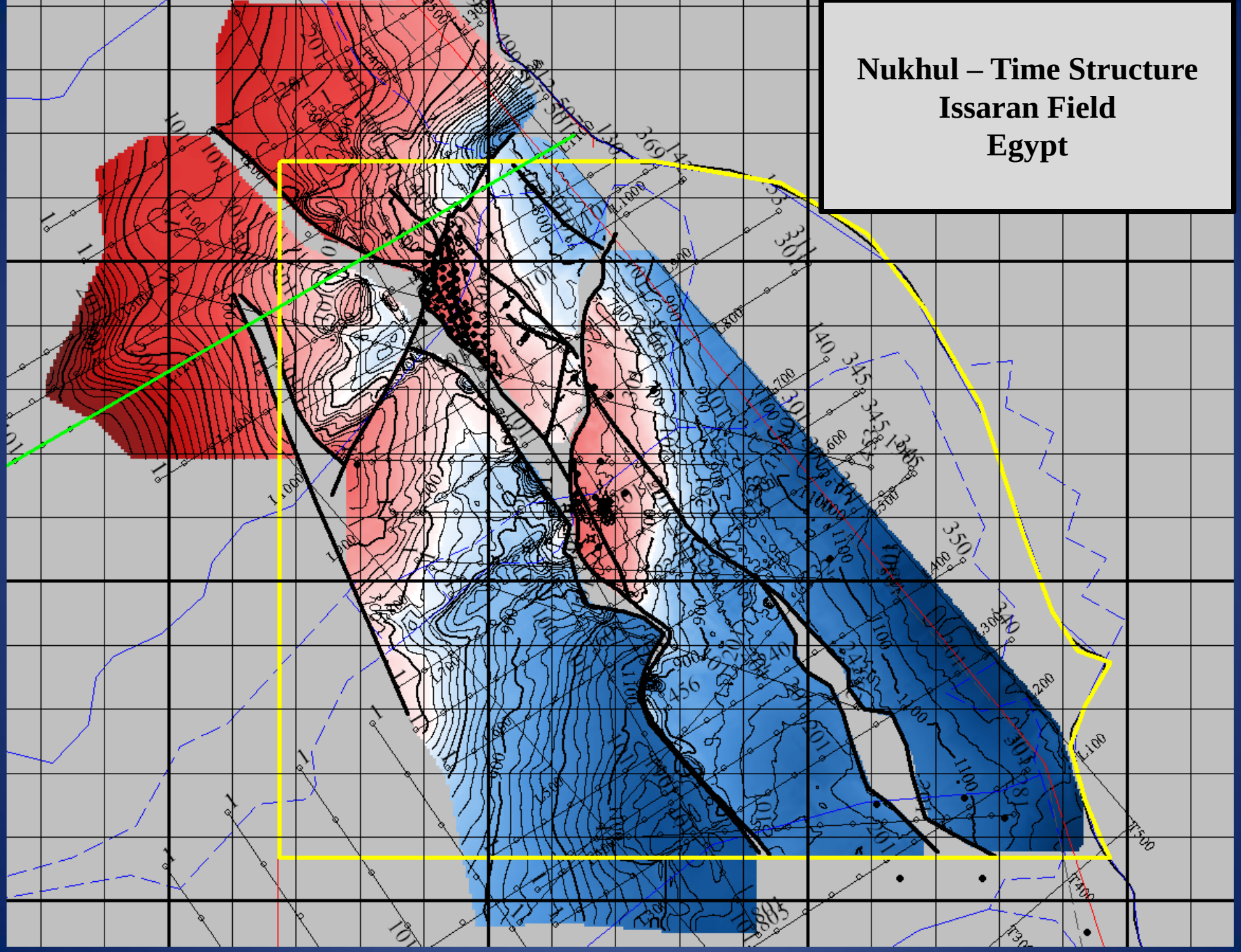
- Large variation in initial production rates
- Loss of circulation while drilling
- Core
- Image logs
- Variable water cuts
- Varying fluid recovery

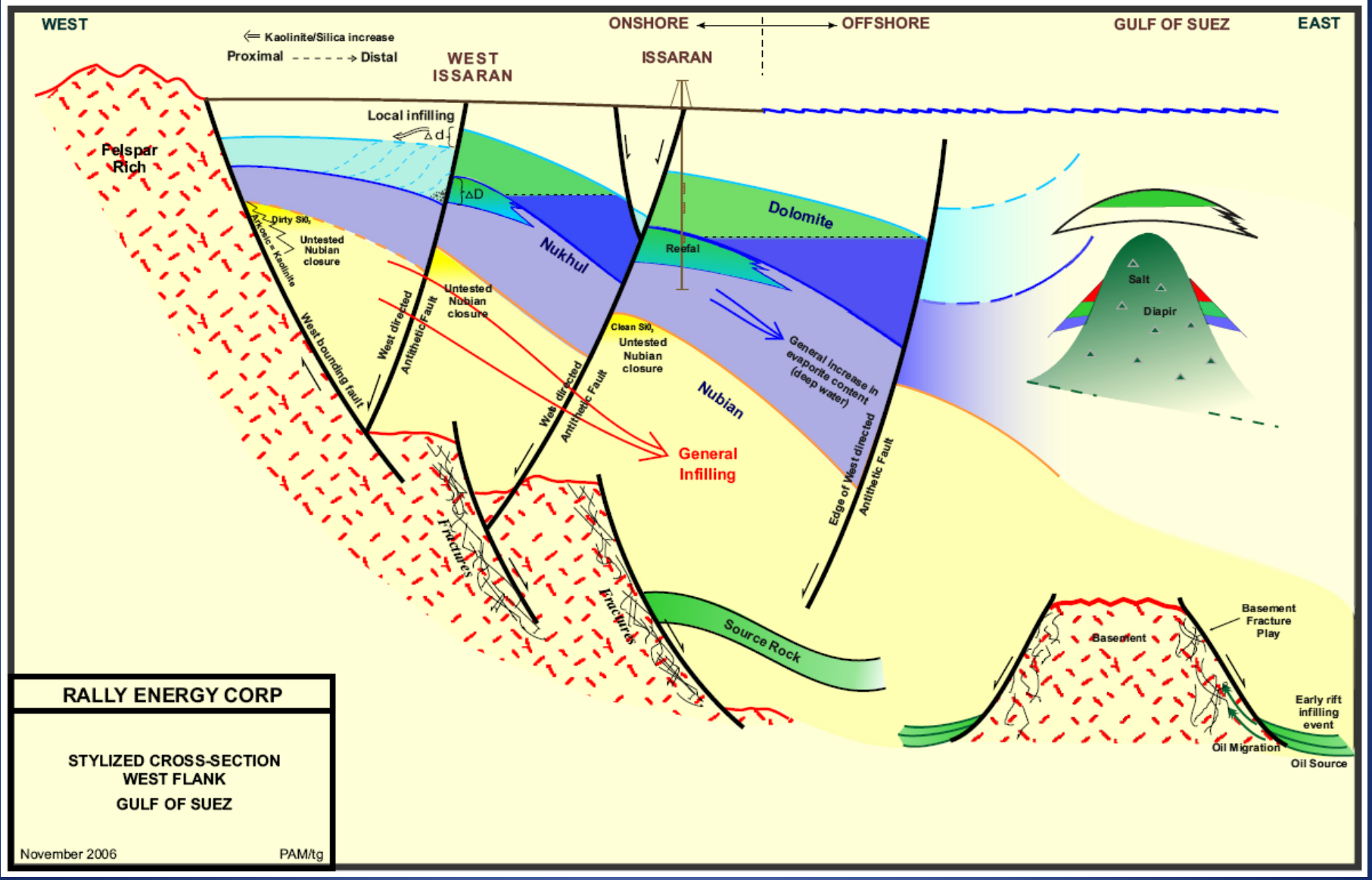


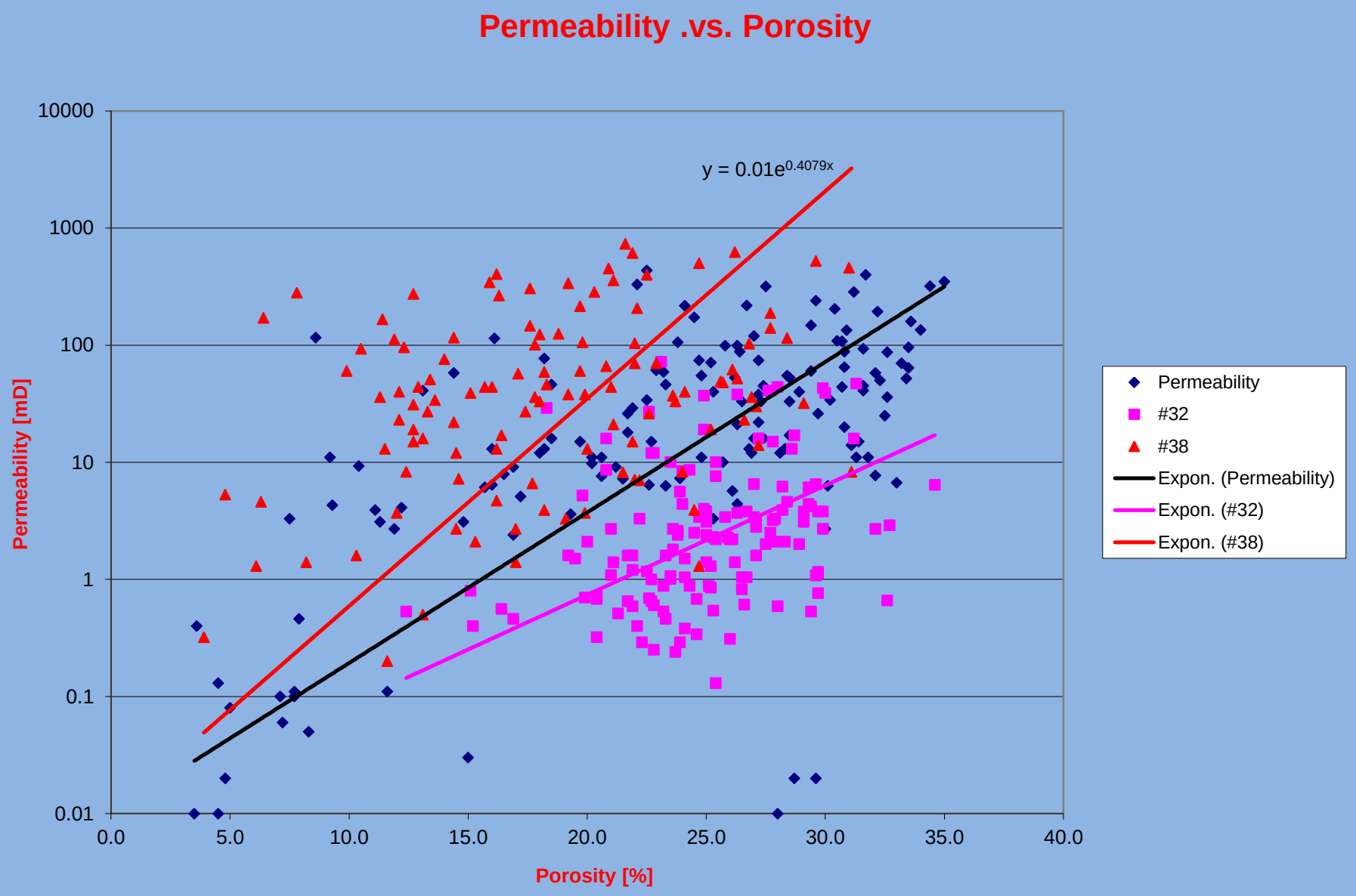


Zeit – Time Structure
Issaran Field
Egypt

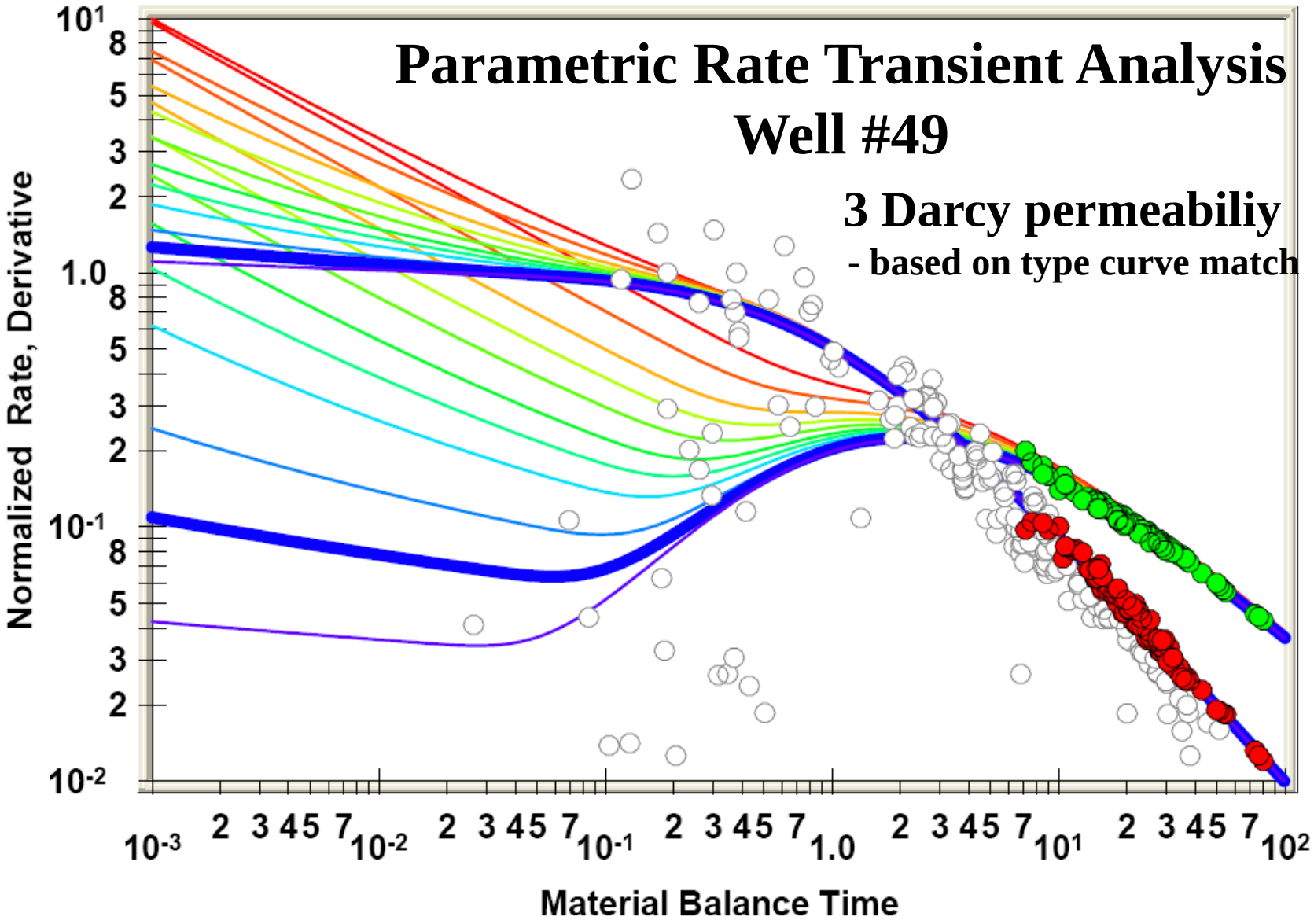



Nukhul – Time Structure
Issaran Field
Egypt


WEST
EAST
ONSHORE
OFFSHORE
GULF OF SUEZ
Kaolinite/Silica increase
Proximal
Distal
WEST ISSARAN
ISSARAN
Local infilling
Δd
ΔD
Pelspar Rich
Dirty SiO2
Arkosic = Kaolinite
Untested Nubian closure
West bounding fault
West directed Antithetic Fault
Untested Nubian closure
Nukhul
Reefal
Dolomite
Clean SiO2
Untested Nubian closure
West directed Antithetic Fault
Nubian
General Infilling
General increase in evaporite content (deep water)
Edge of West directed Antithetic Fault
Salt
Diapir
Fractures
Fractures
Source Rock
Basement
Basement Fracture Play
Early rift infilling event
Oil Migration
Oil Source
RALLY ENERGY CORP
STYLIZED CROSS-SECTION
WEST FLANK
GULF OF SUEZ
November 2006
PAM/tg


Permeability .vs. Porosity
y = 0.01e^0.4079x
10000
1000
100
10
1
0.1
0.01
Permeability [mD]
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
Porosity [%]
Permeability
#32
#38
Expon. (Permeability)
Expon. (#32)
Expon. (#38)

Blasingame Typecurve Analysis



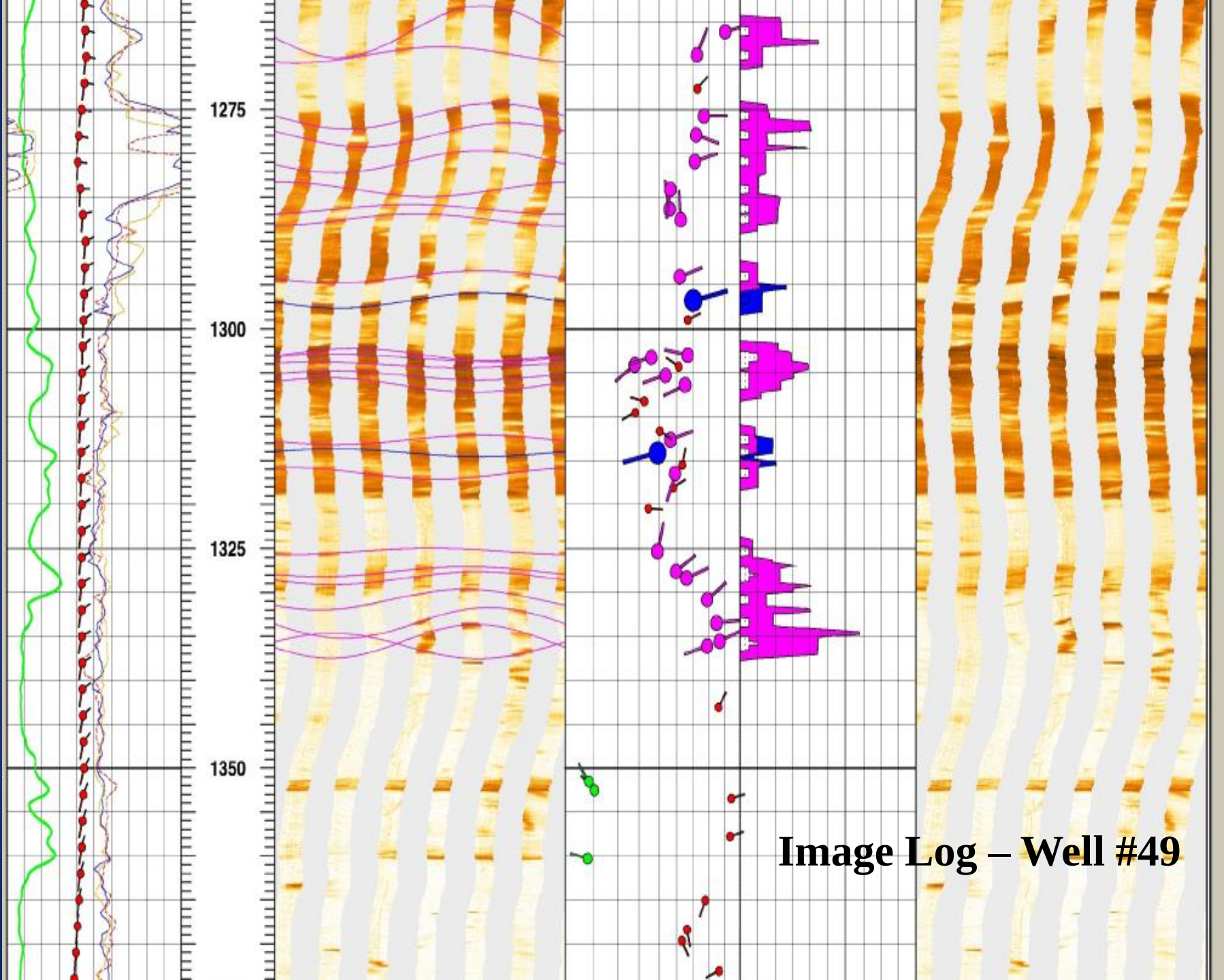


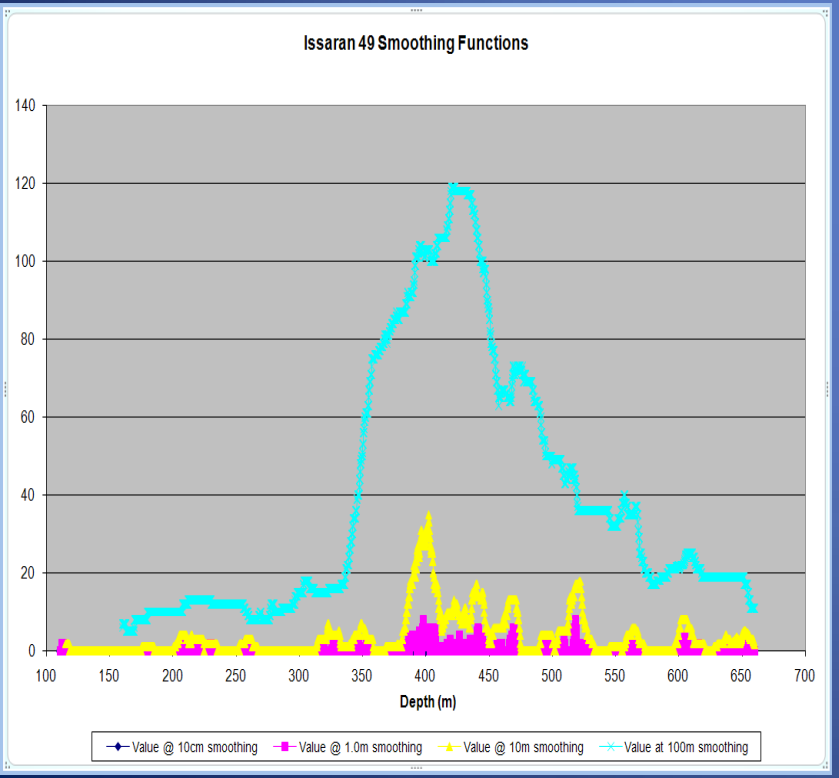
Image Log – Well #49

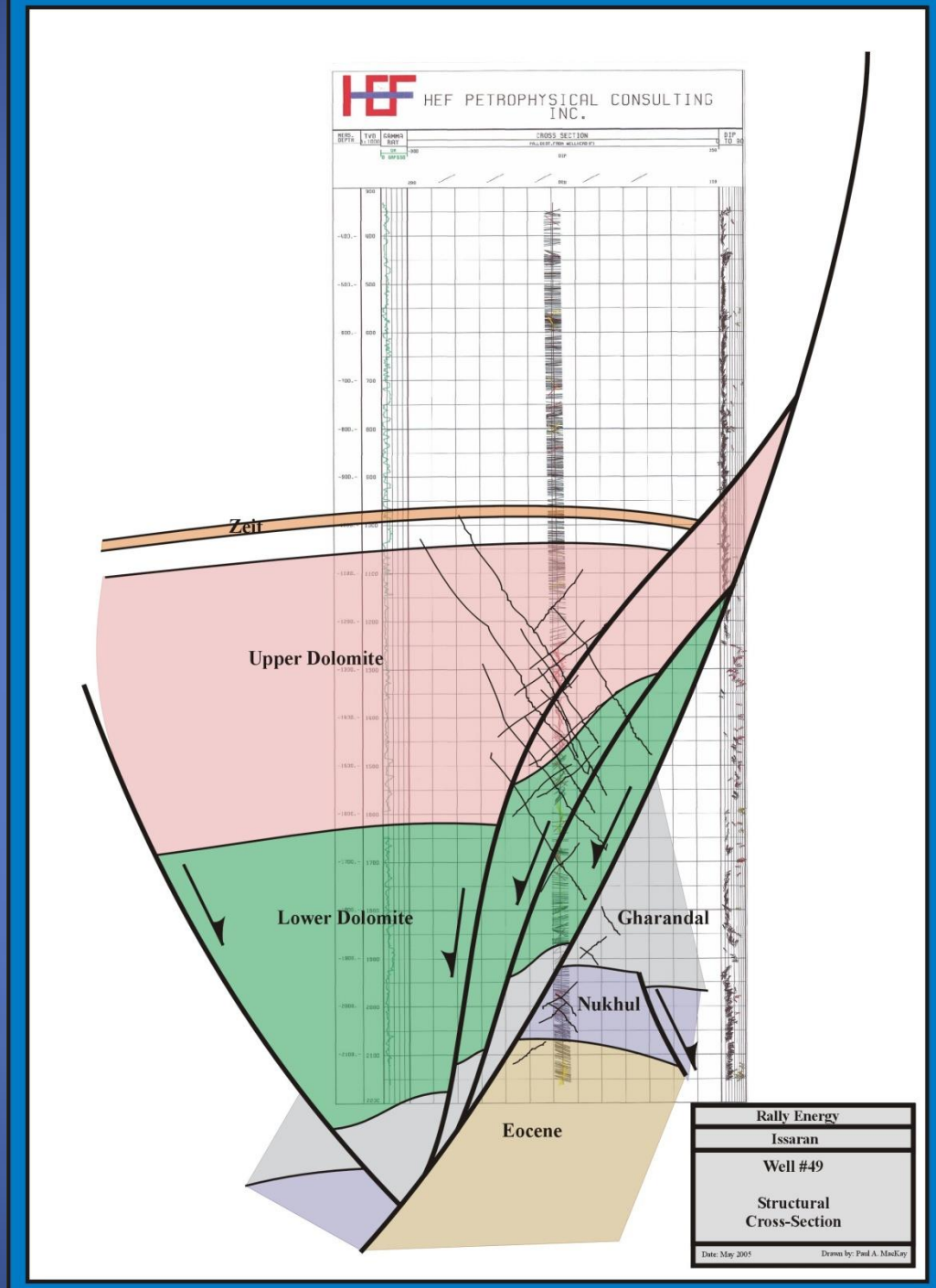
Well #49

410 BOPD

Cold Production

Fracture enhanced

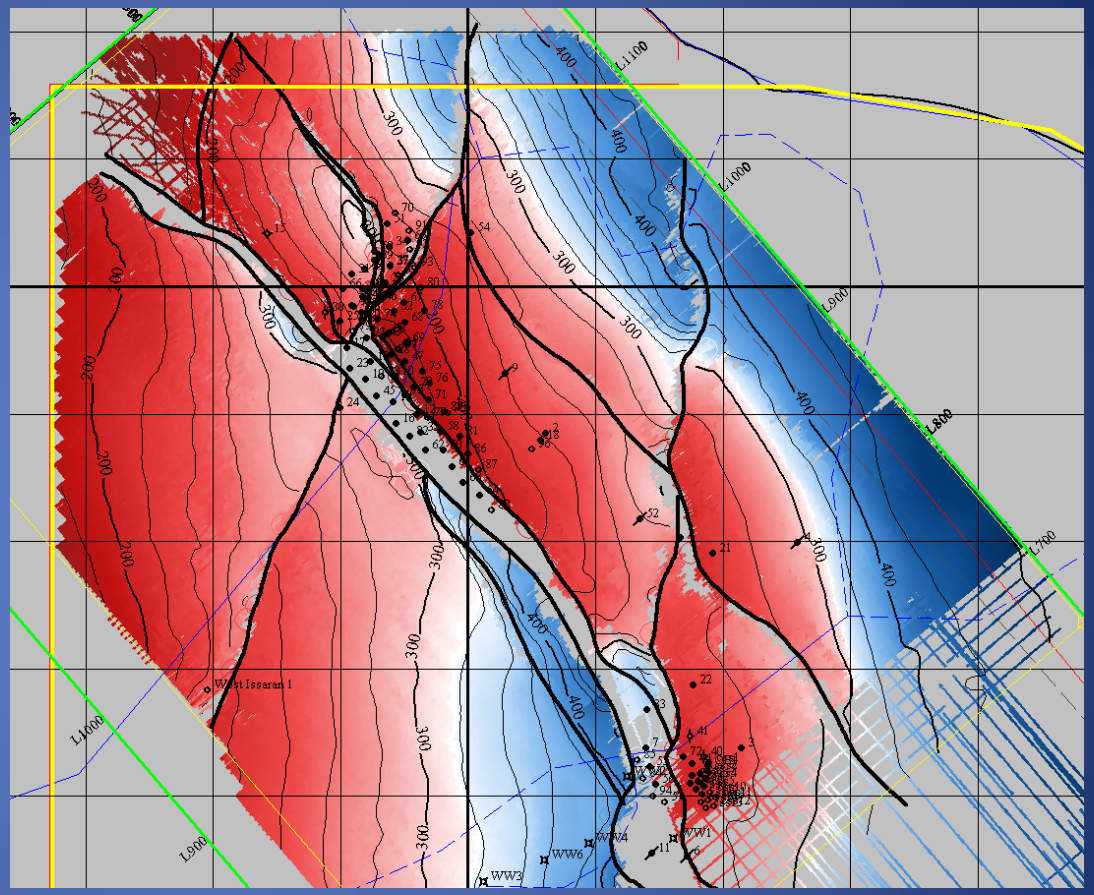




Issaran 3D

Time Structure – Upper Dolomite

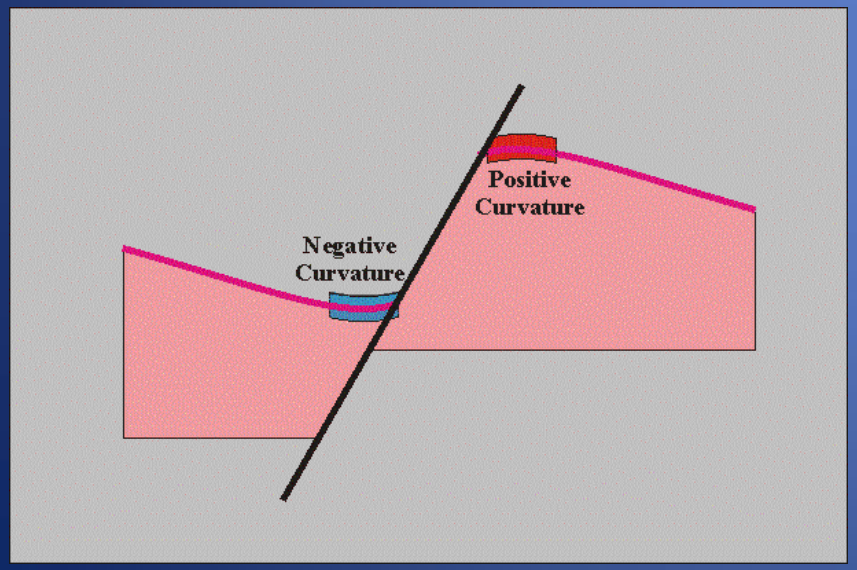
Horizon Pick

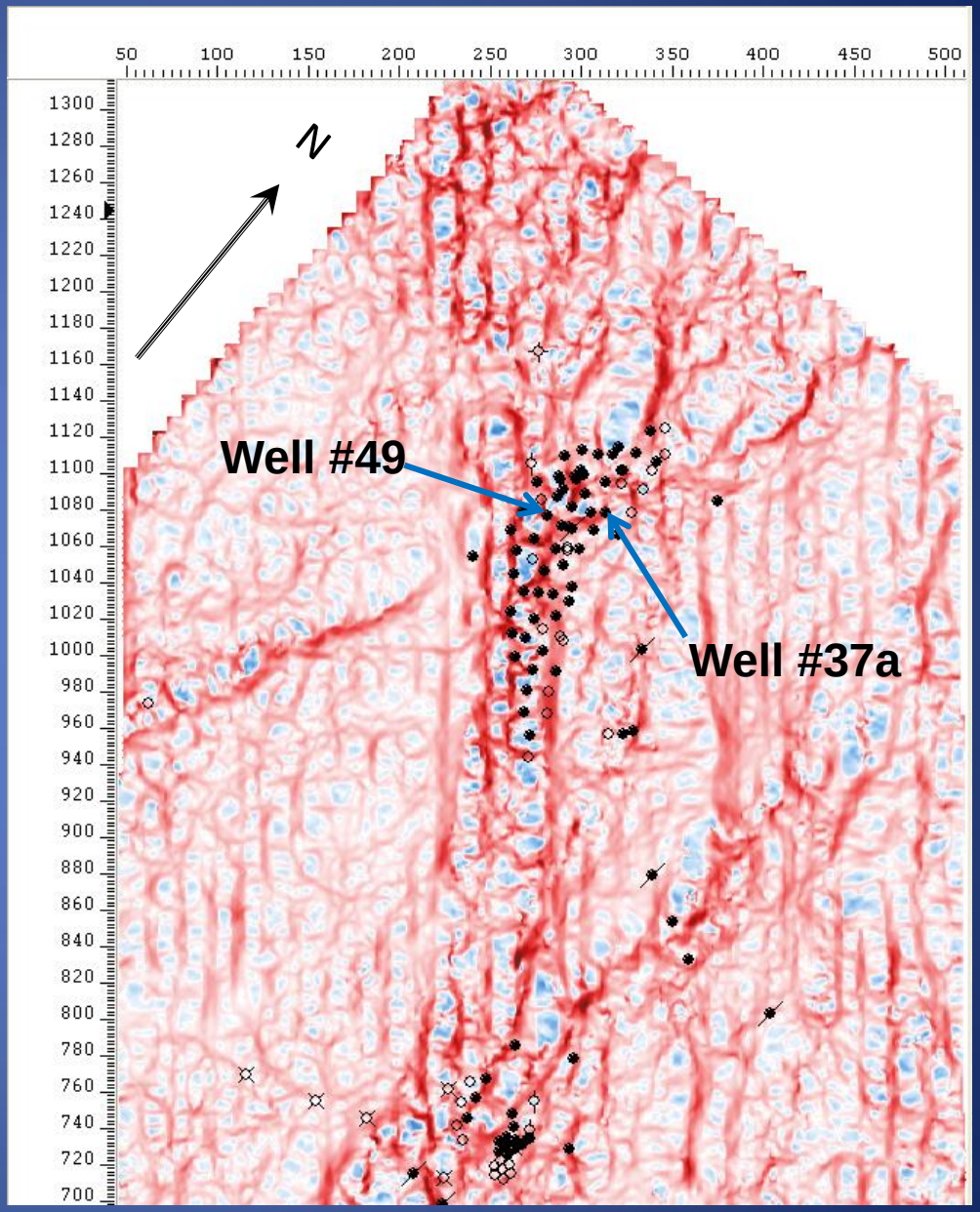


Issaran 3D

Positive Curvature

Note acquisition inheritance

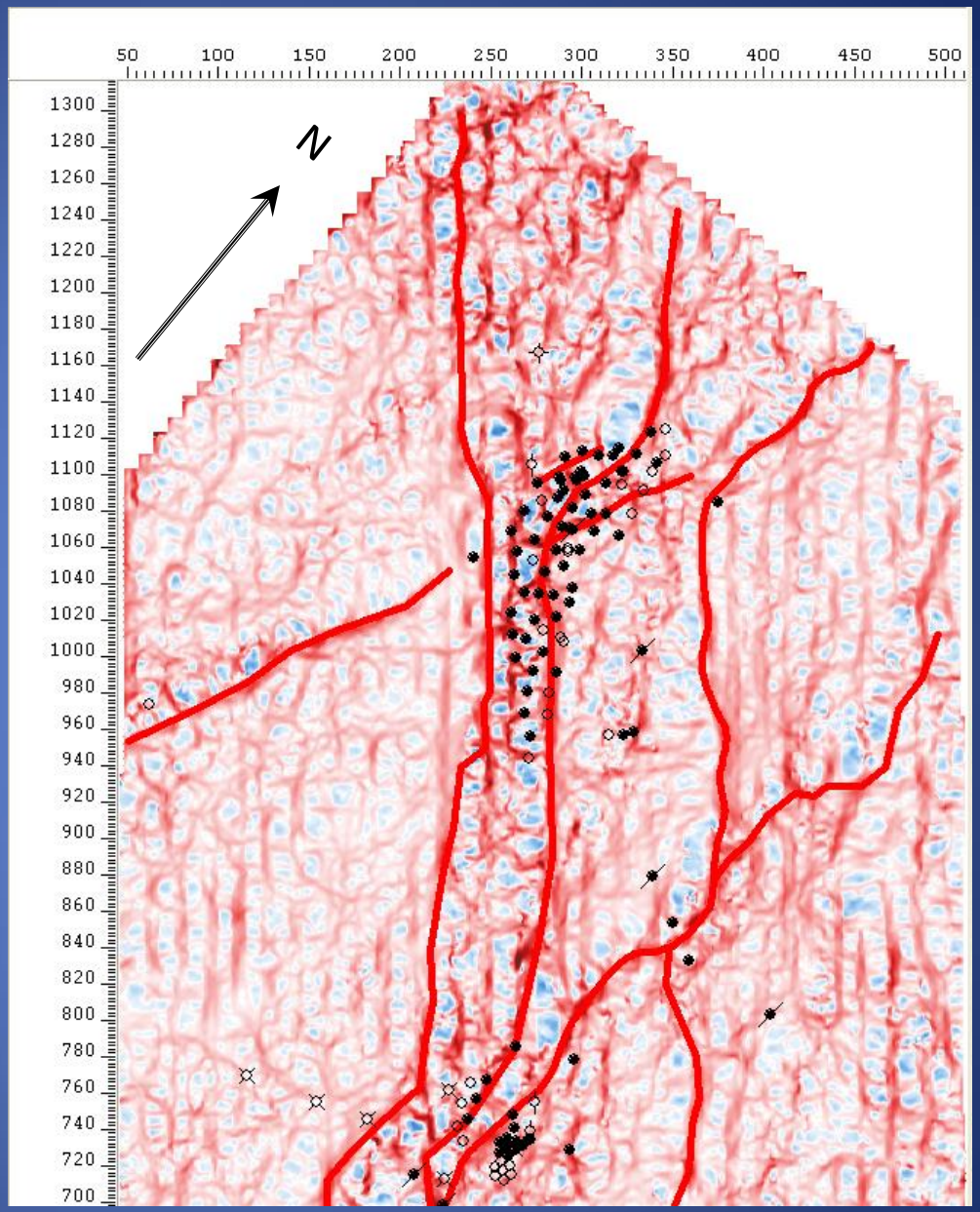




Issaran 3D

Positive Curvature

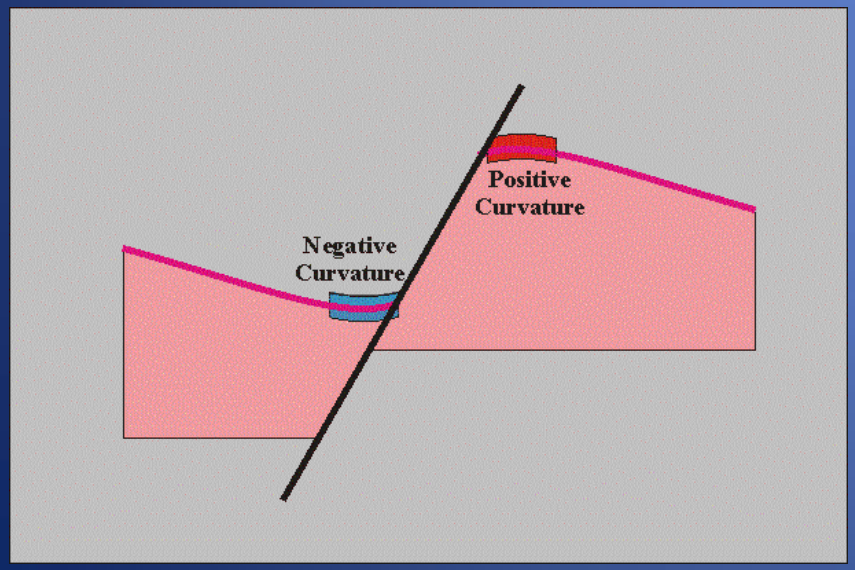
Red lines represent max. curvature

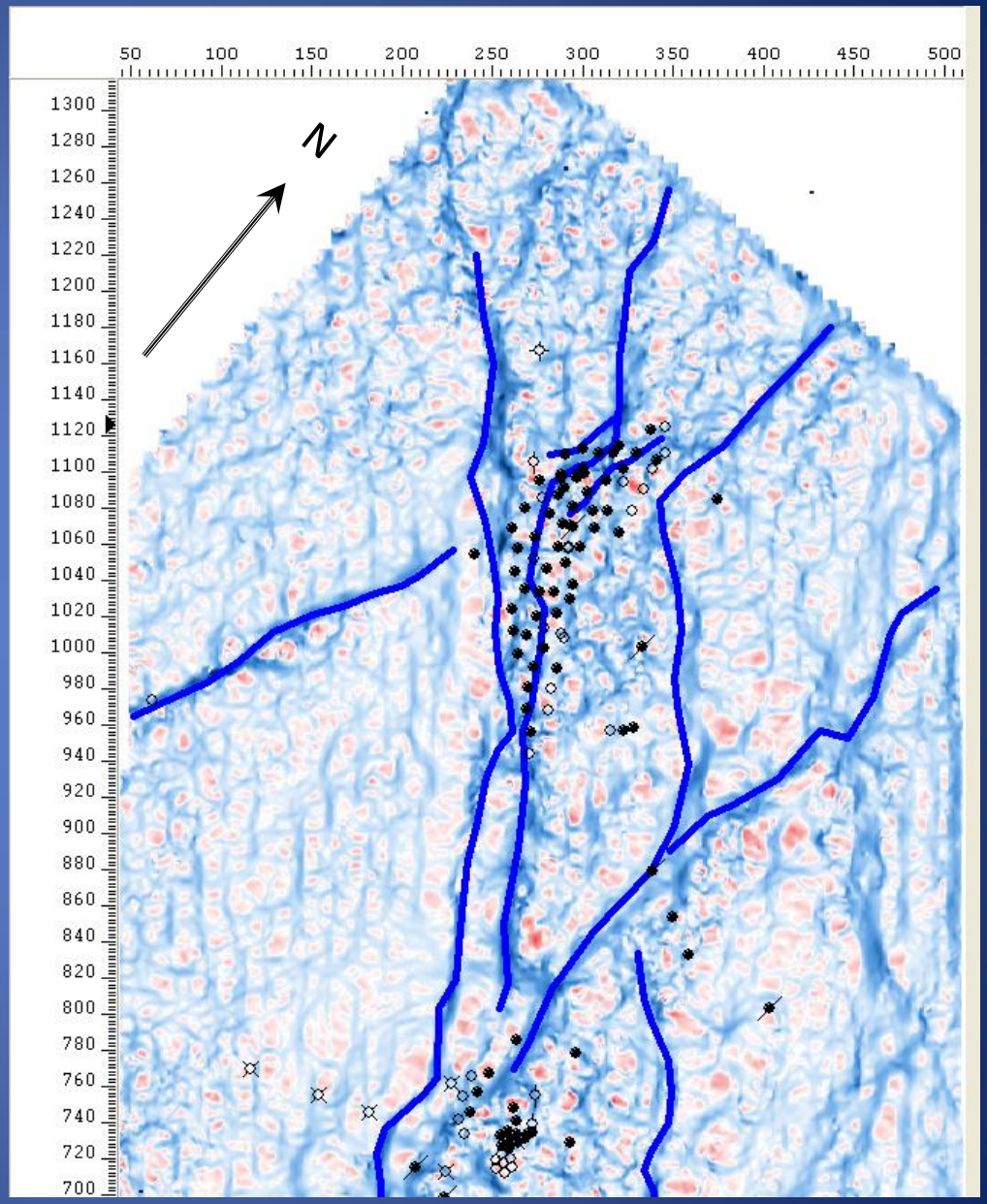


Issaran 3D

Negative Curvature

Blue lines represent max. negative curvature





Issaran 3D

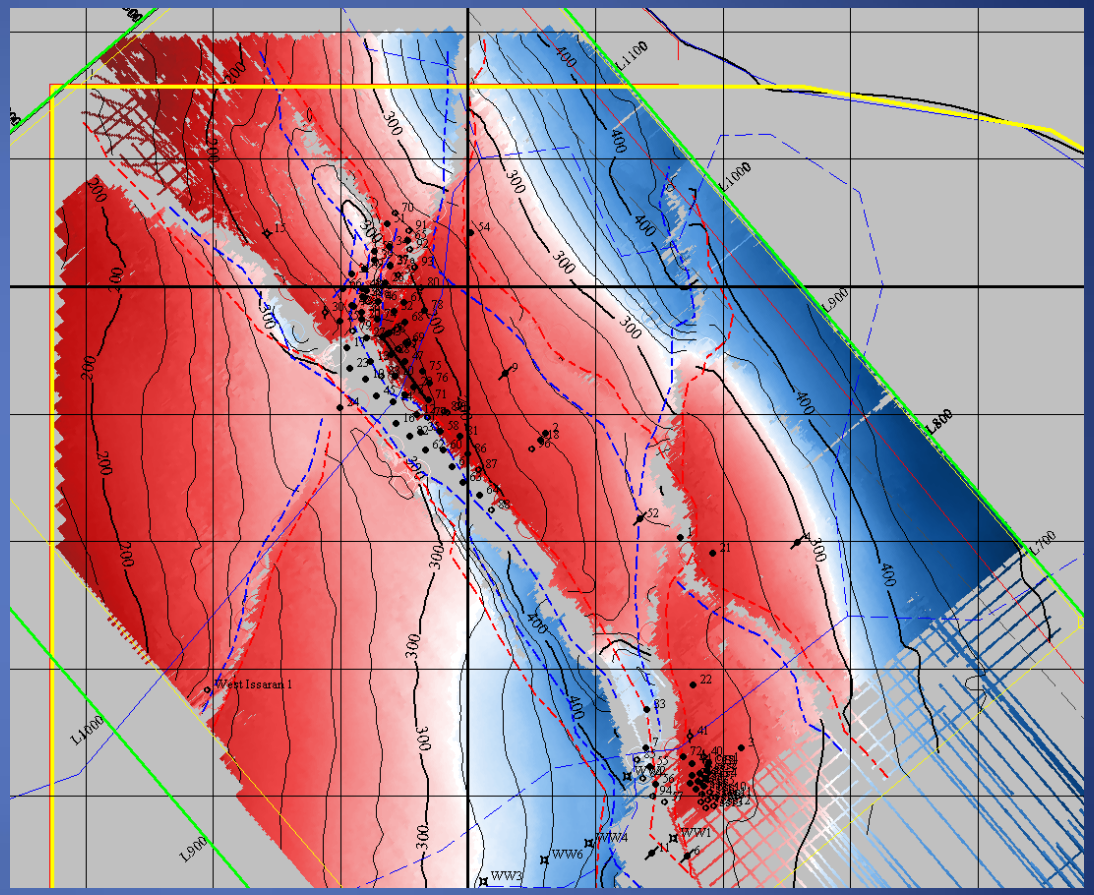
Time Structure – Upper Dolomite

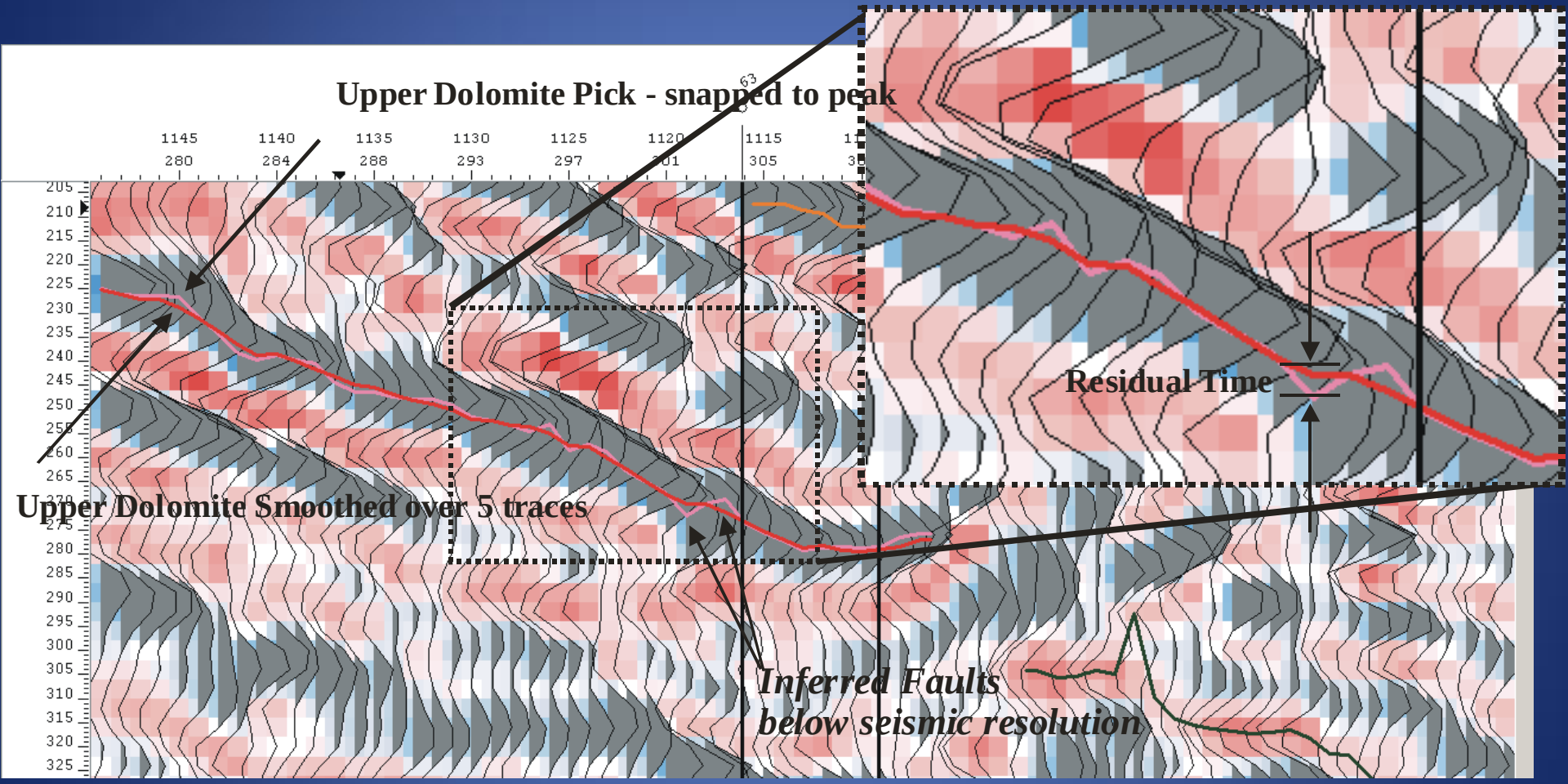
Horizon Pick

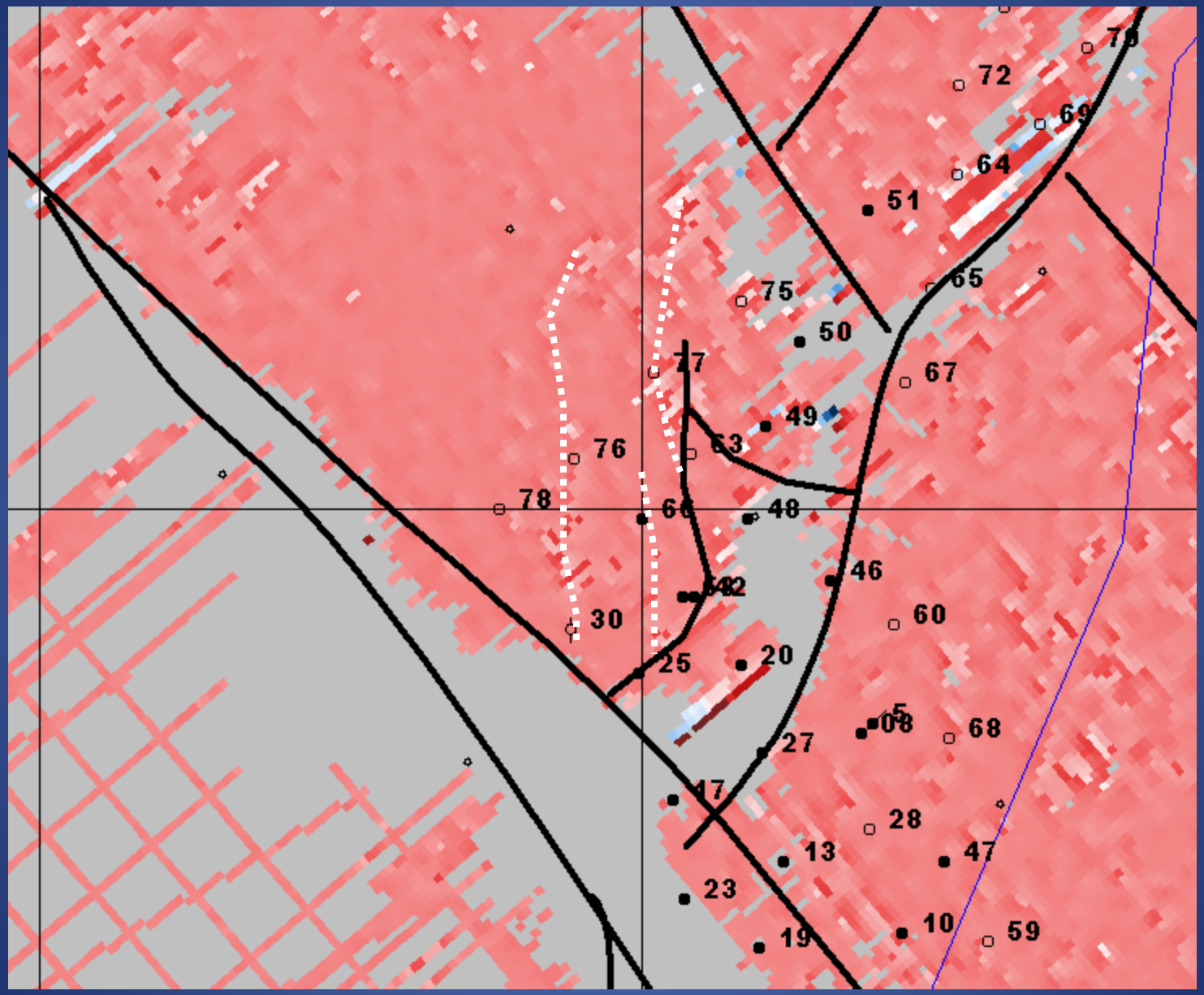
Fault cutoff interpretation from curvature analysis

Red footwall

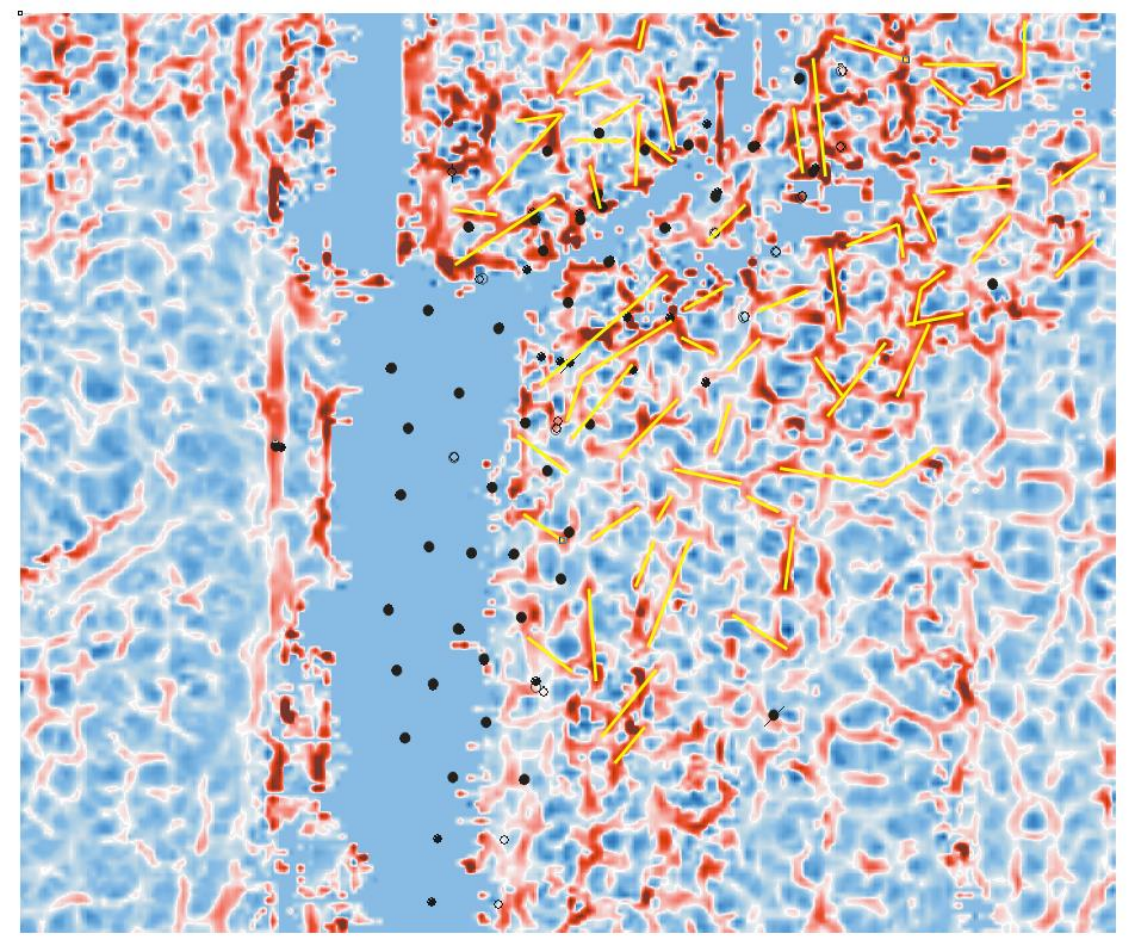
Blue hanging wall



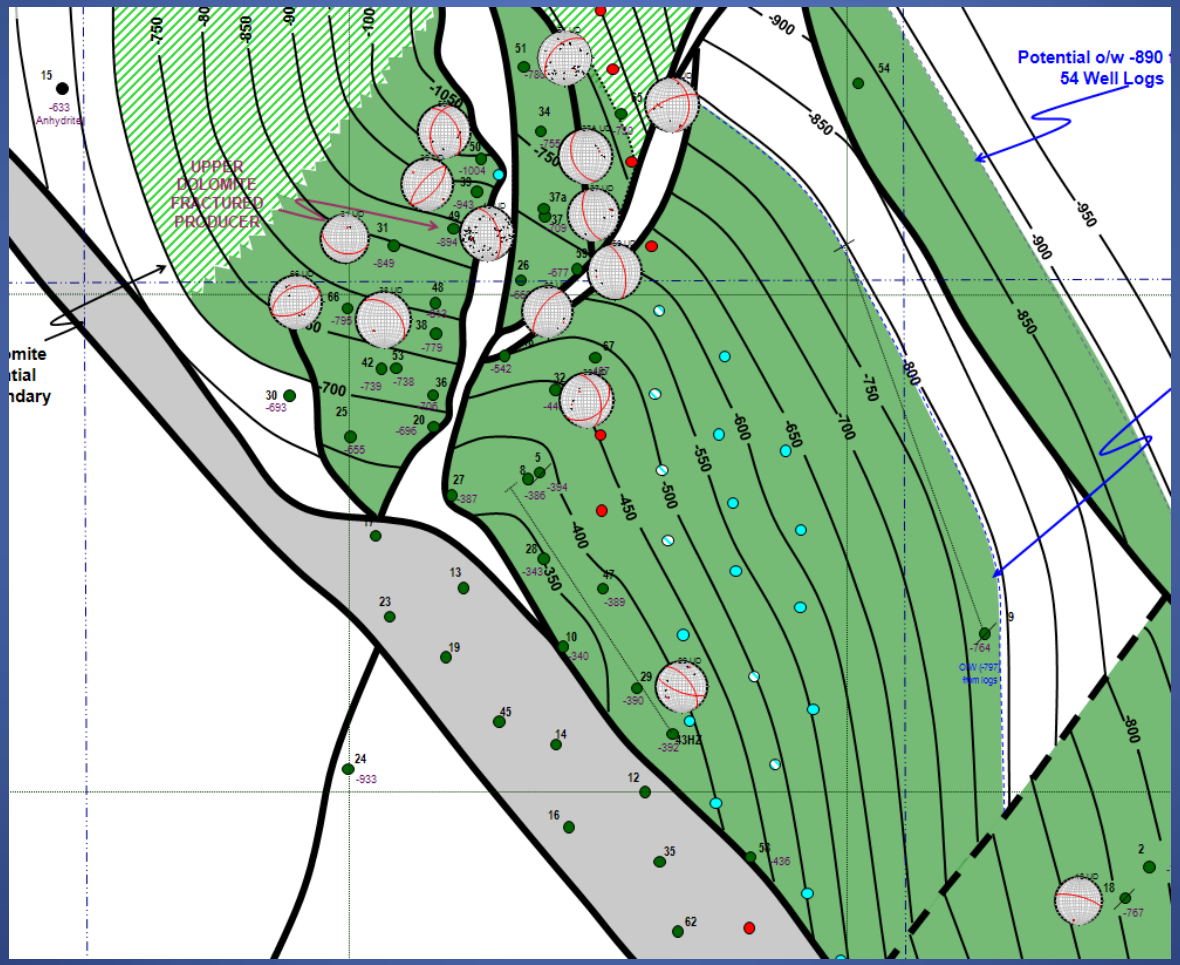

Upper Dolomite Pick - snapped to peak
Upper Dolomite Smoothed over 5 traces
Residual Time
Inferred Faults
below seismic resolution


72
69
64
51
65
75
50
67
49
76
63
78
48
46
60
30
20
68
27
28
47
13
23
10
59
19

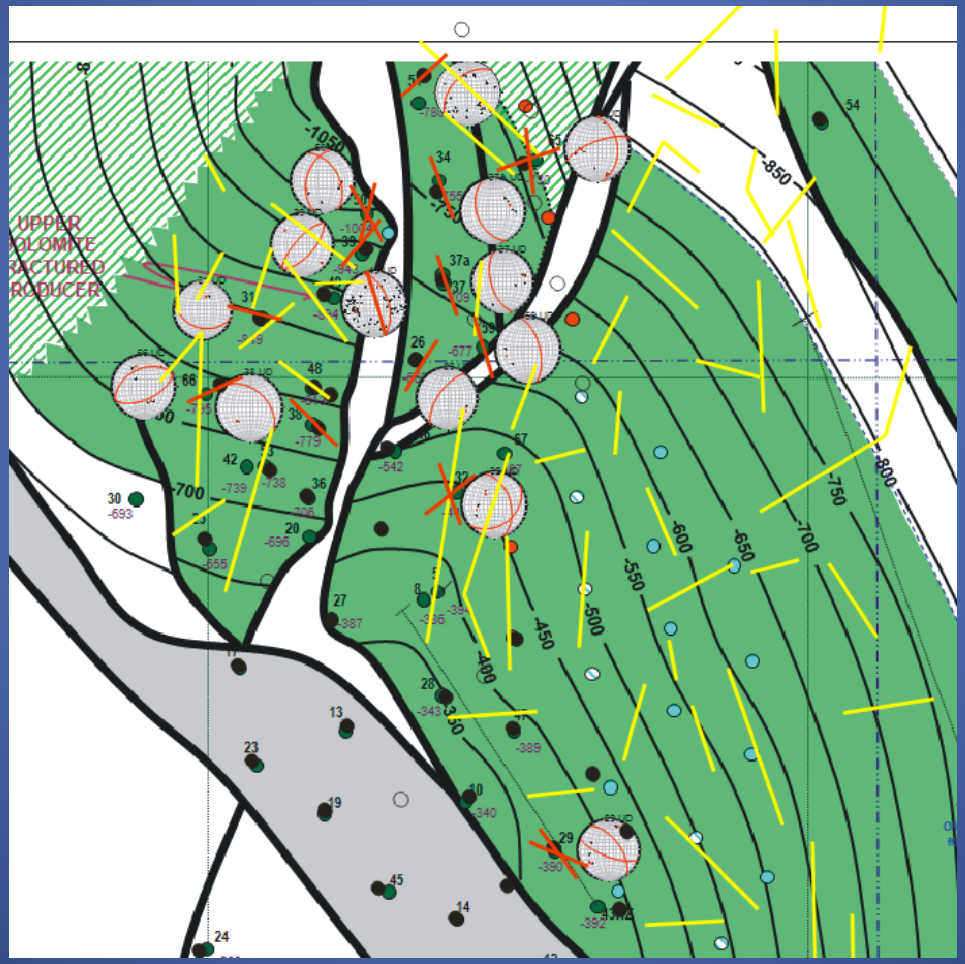
Picks from seismic time slice at UD Most Pos High Freq



UD – Image log results from fractures



UD level – compare seismic to image log
Most pos High Freq



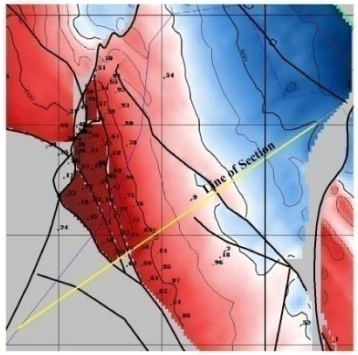
Rally Energy

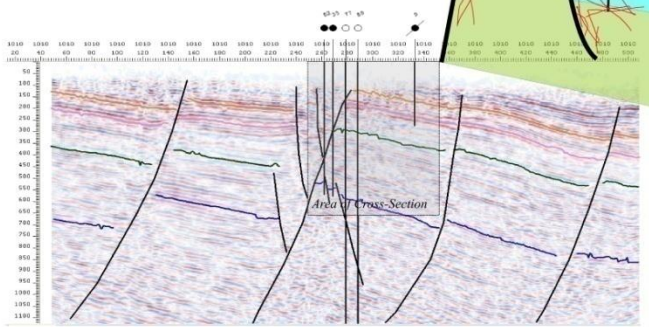
North Issaran Field - Egypt

Structural Cross-Section
A-A'

Date: January 2007 Drawn by: Paul A. MacKay

Nukhul: Time Structure





Well #82 Well #35 Well #58 Well #9

285 ft 430 ft 1410 ft

surface

Sea level

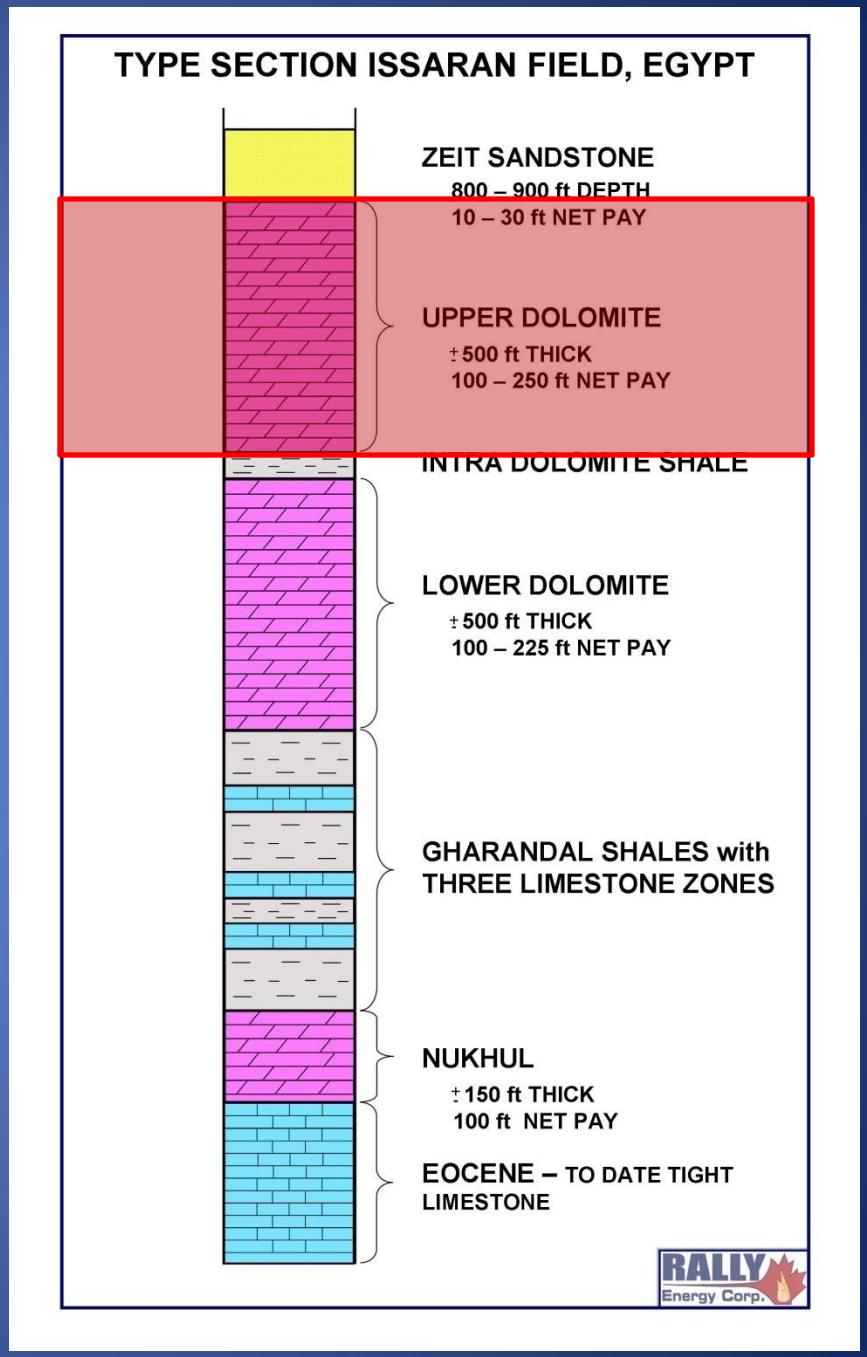
500 0 -500 -1000 -1500

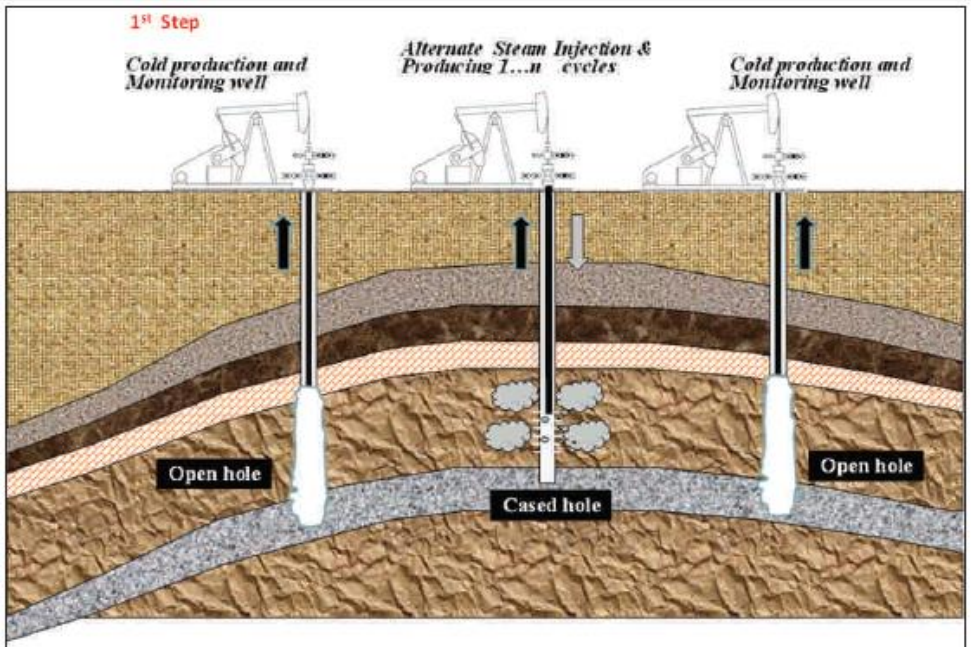
Zeit
(and younger)

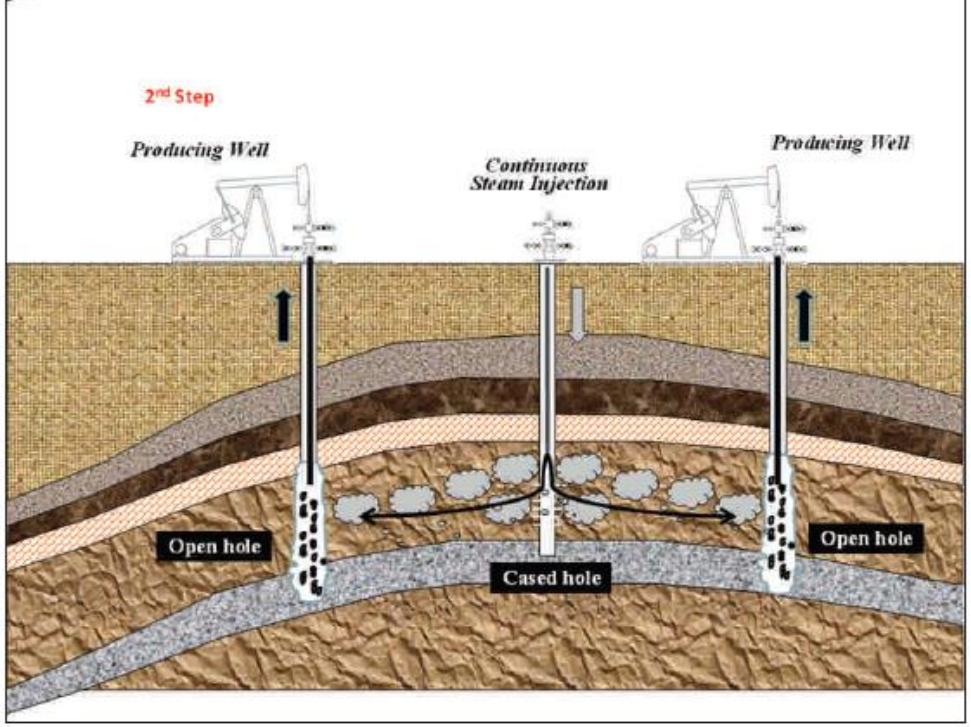
Upper Dolomite 'A'
Upper Dolomite 'B'
Upper Dolomite 'C'
Upper Dolomite 'D'
Inter-Dolomite Shale
Middle Dolomite Shale
Lower Dolomite 'A'
Lower Dolomite 'B'
Lower Dolomite 'C'
Lower Dolomite 'D'
Gharundal
Limestone 1
Limestone 2
Limestone 3
Limestone 4
Nukhul
Eocene

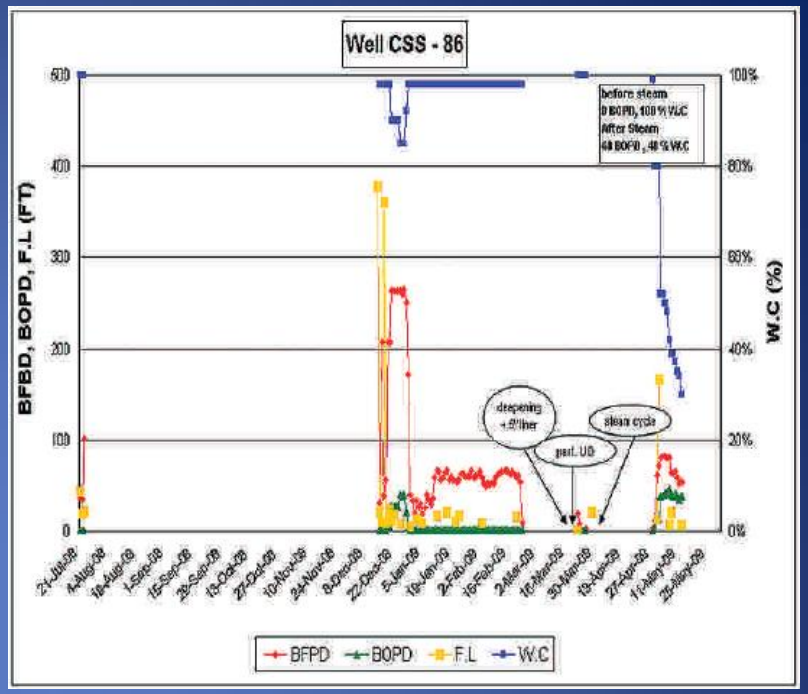
Upper Dolomite

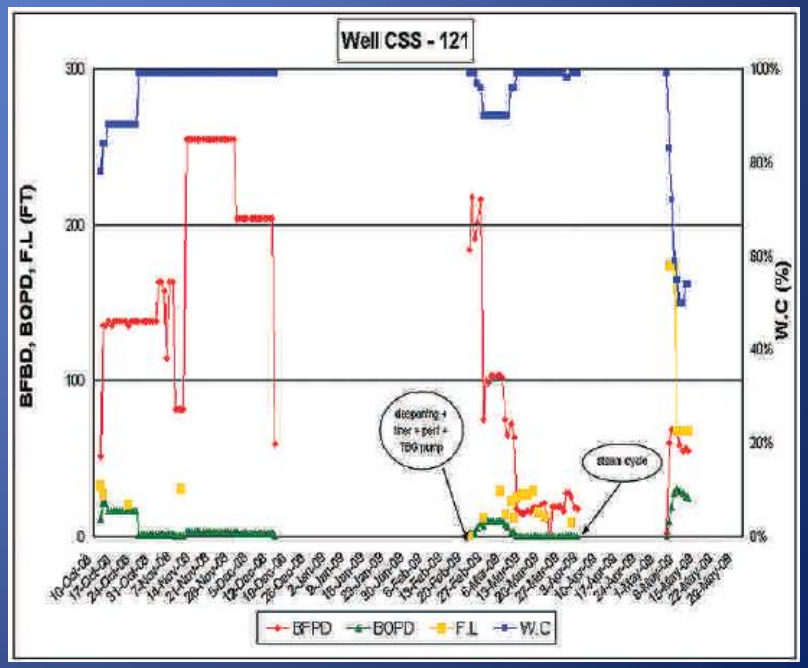
South Garib Fm.



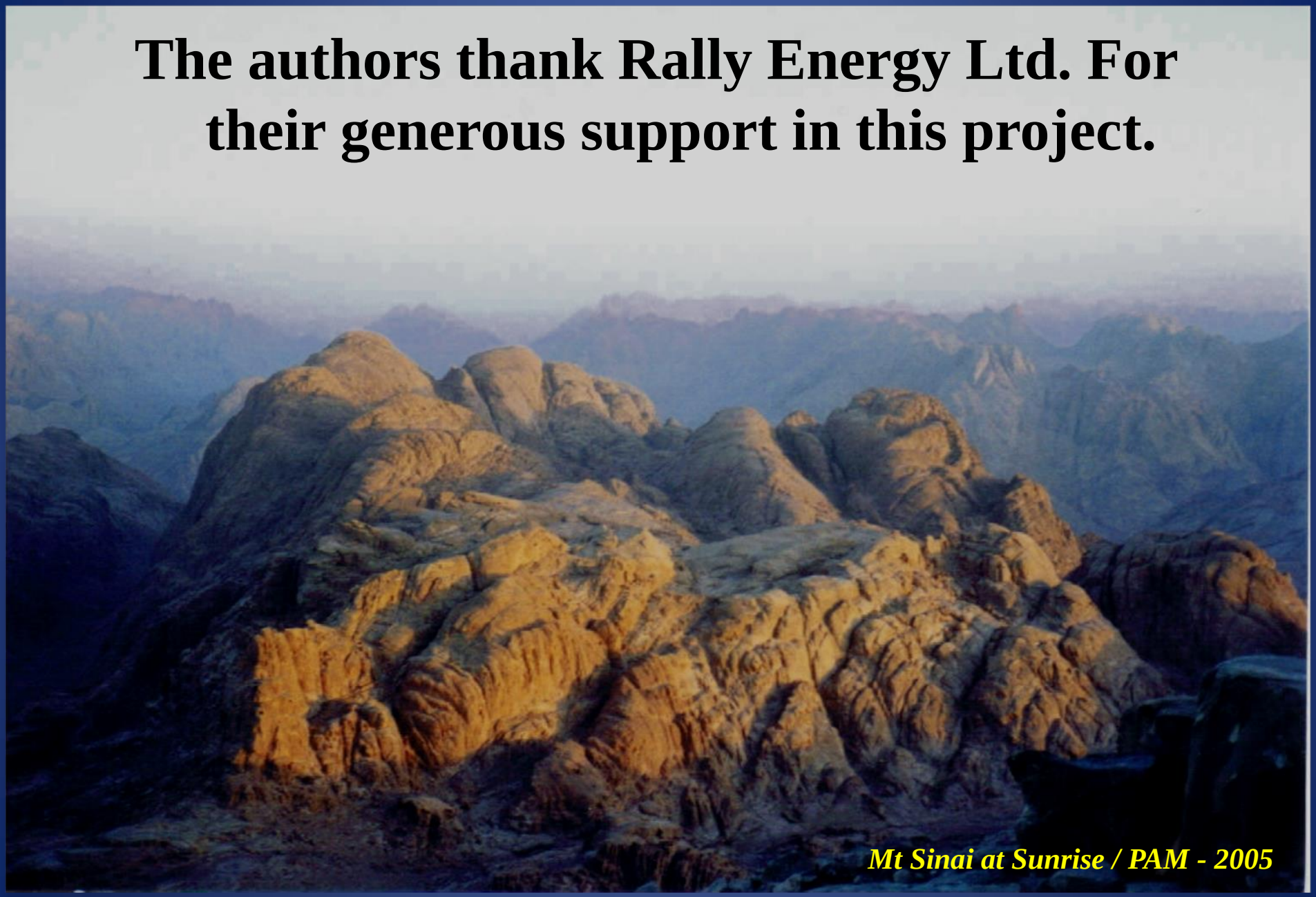

1st Step
Cold production and Monitoring well
Alternate Steam Injection & Producing 1…n cycles
Cold production and Monitoring well
Open hole
Cased hole
Open hole


2nd Step
Producing Well
Continuous Steam Injection
Producing Well
Open hole
Cased hole
Open hole


Well CSS - 86
BFBD, BOPD, F.L (FT)
W.C (%)
before steam
0 BOPD, 100 % W.C
After Steam
48 BOPD , 48 % W.C
deepening + 5" liner
perf. UB
steam cycle
BFPD
BOPD
F.L
W.C


Well CSS - 121
BFBD, BOPD, F.L (FT)
W.C (%)
deepening + liner + perf + TBG pump
steam cycle
BFPD
BOPD
F.L
W.C

The authors thank Rally Energy Ltd. For their generous support in this project.



Mt Sinai at Sunrise / PAM - 2005