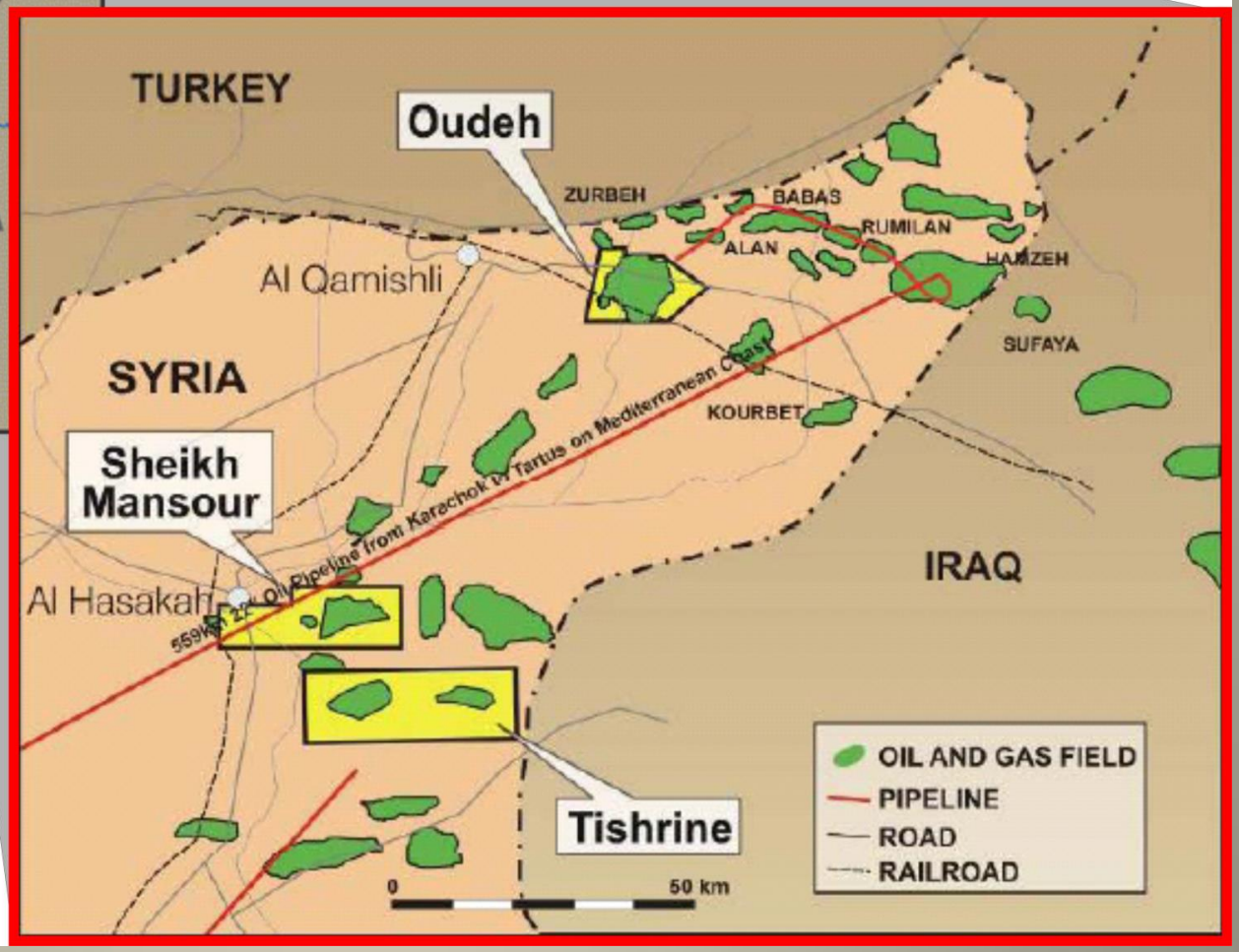
The Tishrine Oil Field, NE Syria

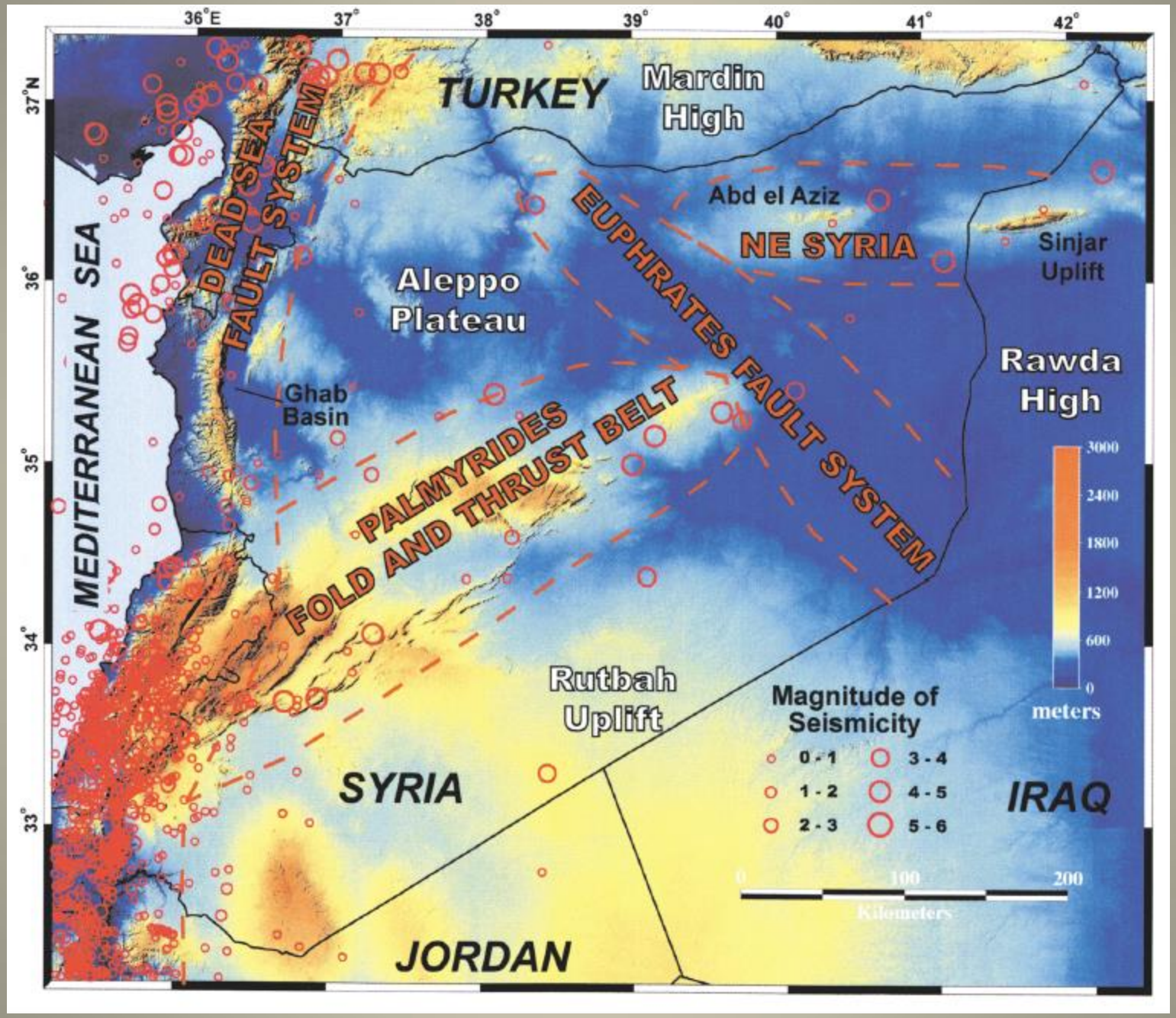
A case study of fractures and migration



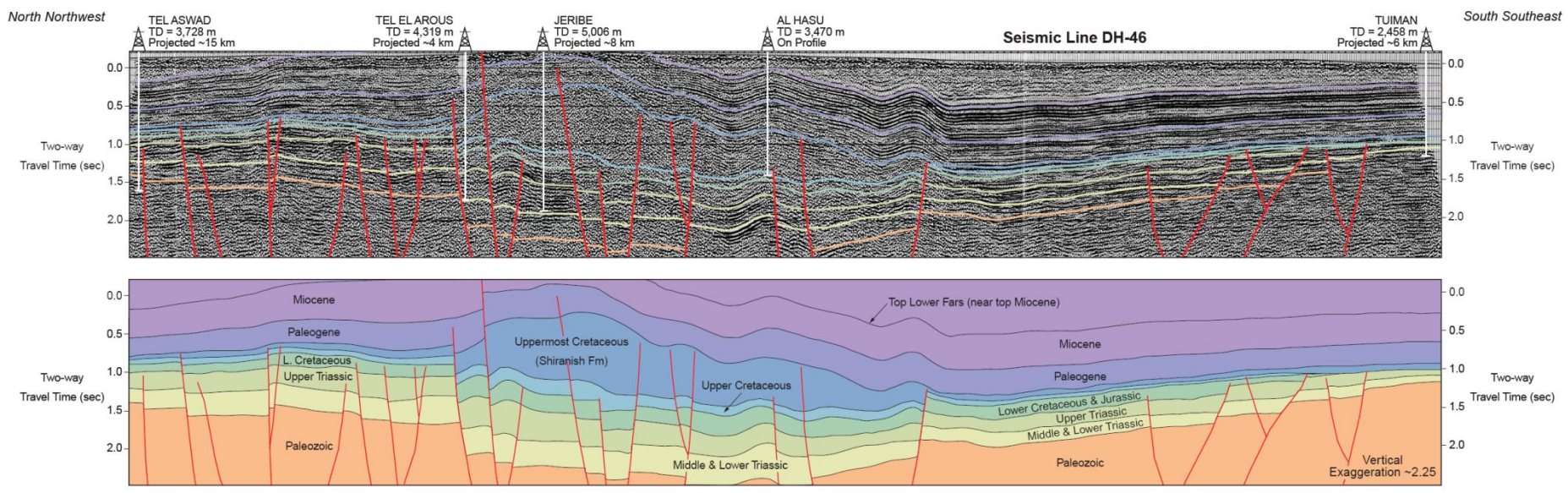
Syrian Oil Production:

- ~150,000 bbls/d (2012)
- Tishrine cold production ~750b/d

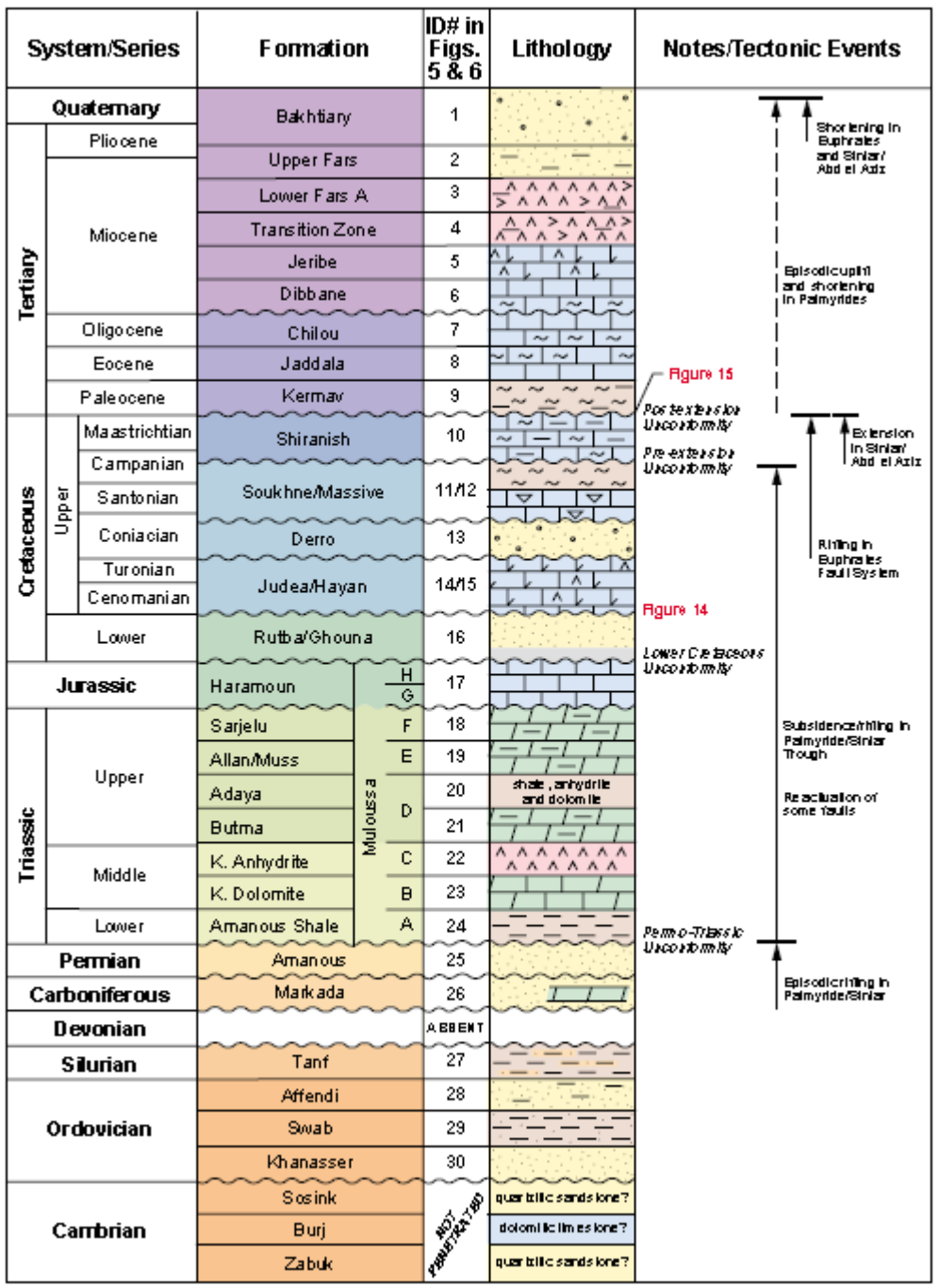
World Stress Map for the north flank of the Arabian Plate



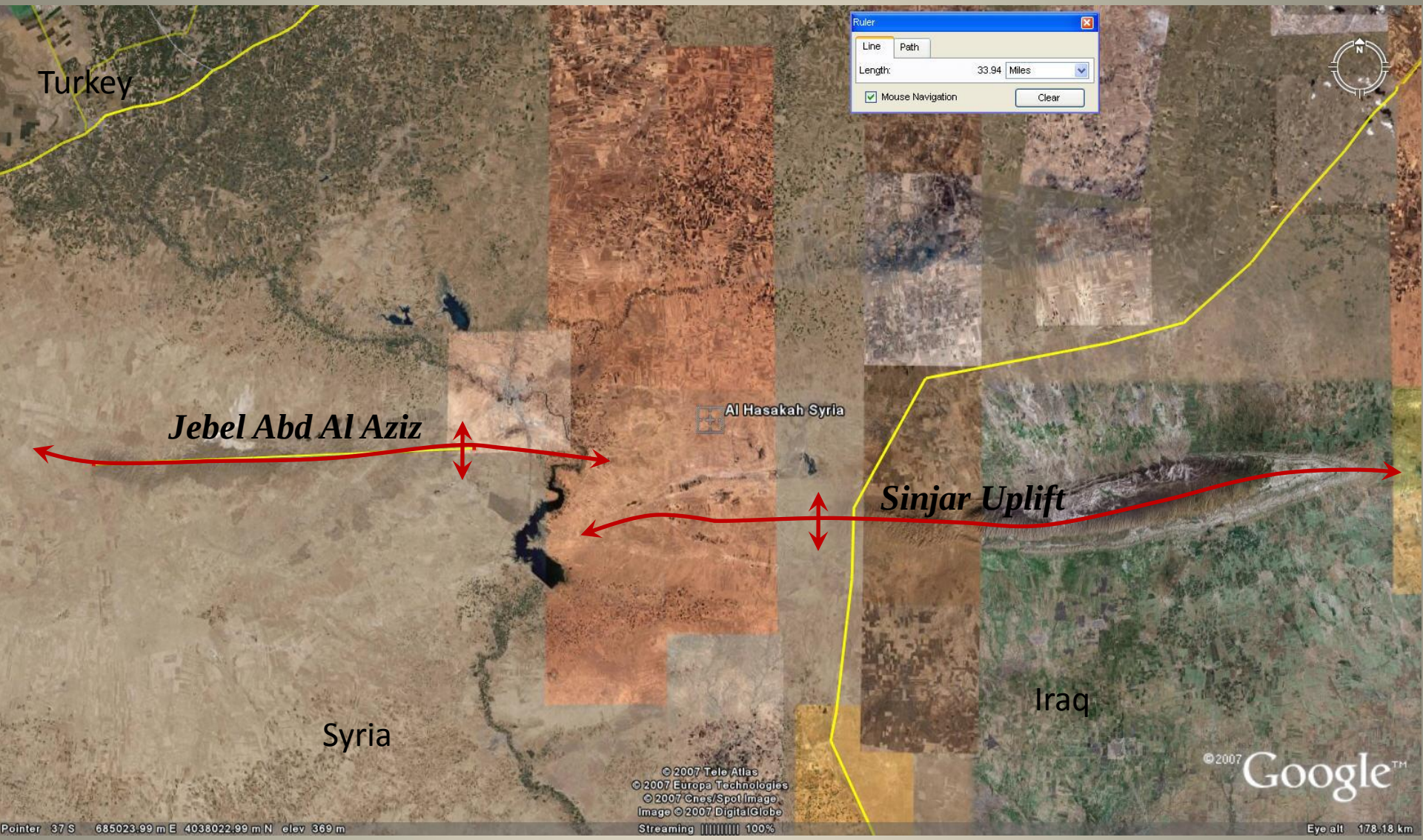
Major structural elements of Syria (Brew, 2000)



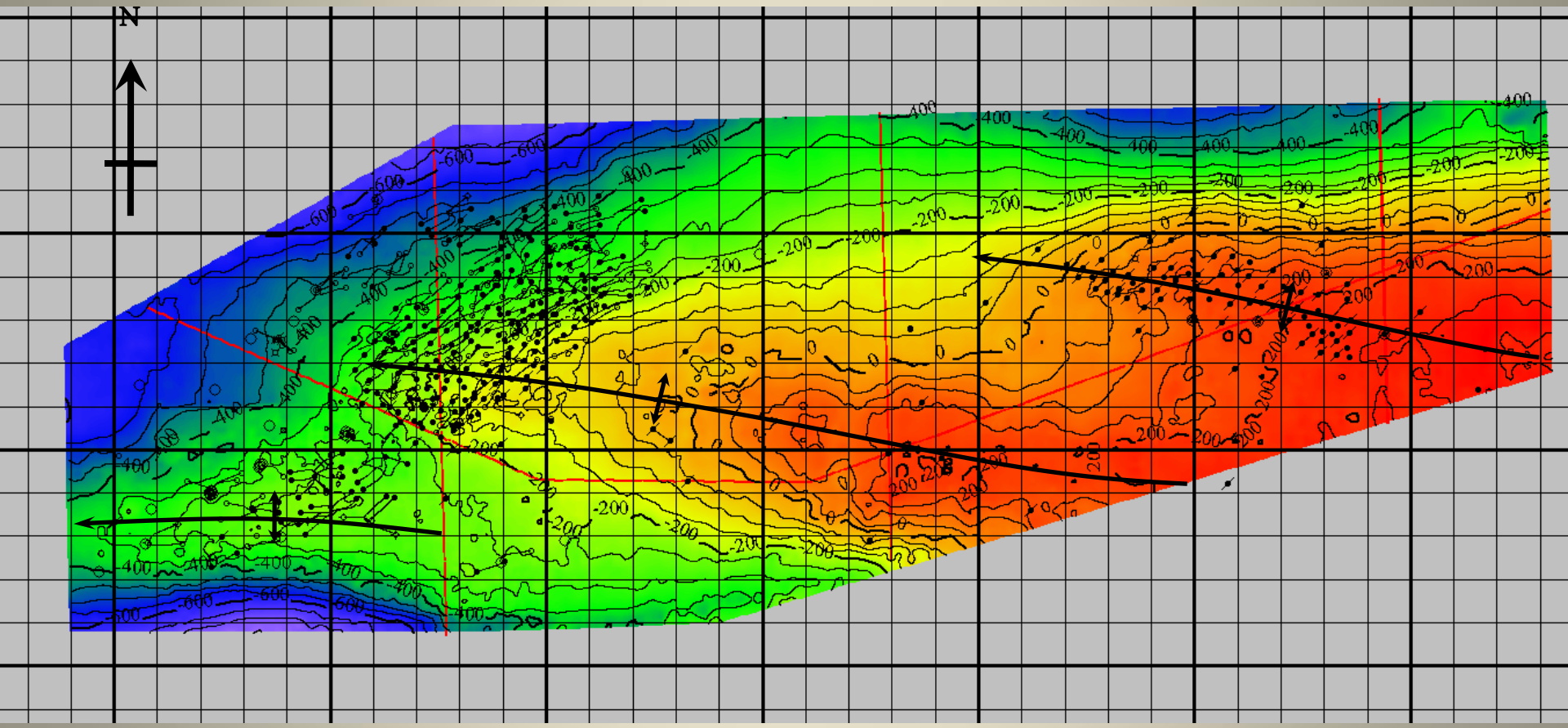
North – South 2D seismic line across the Sinjar Uplift with interpretation (Brew, 1999)



Stratigraphic Column - northeastern Syria (Brew, 1999)



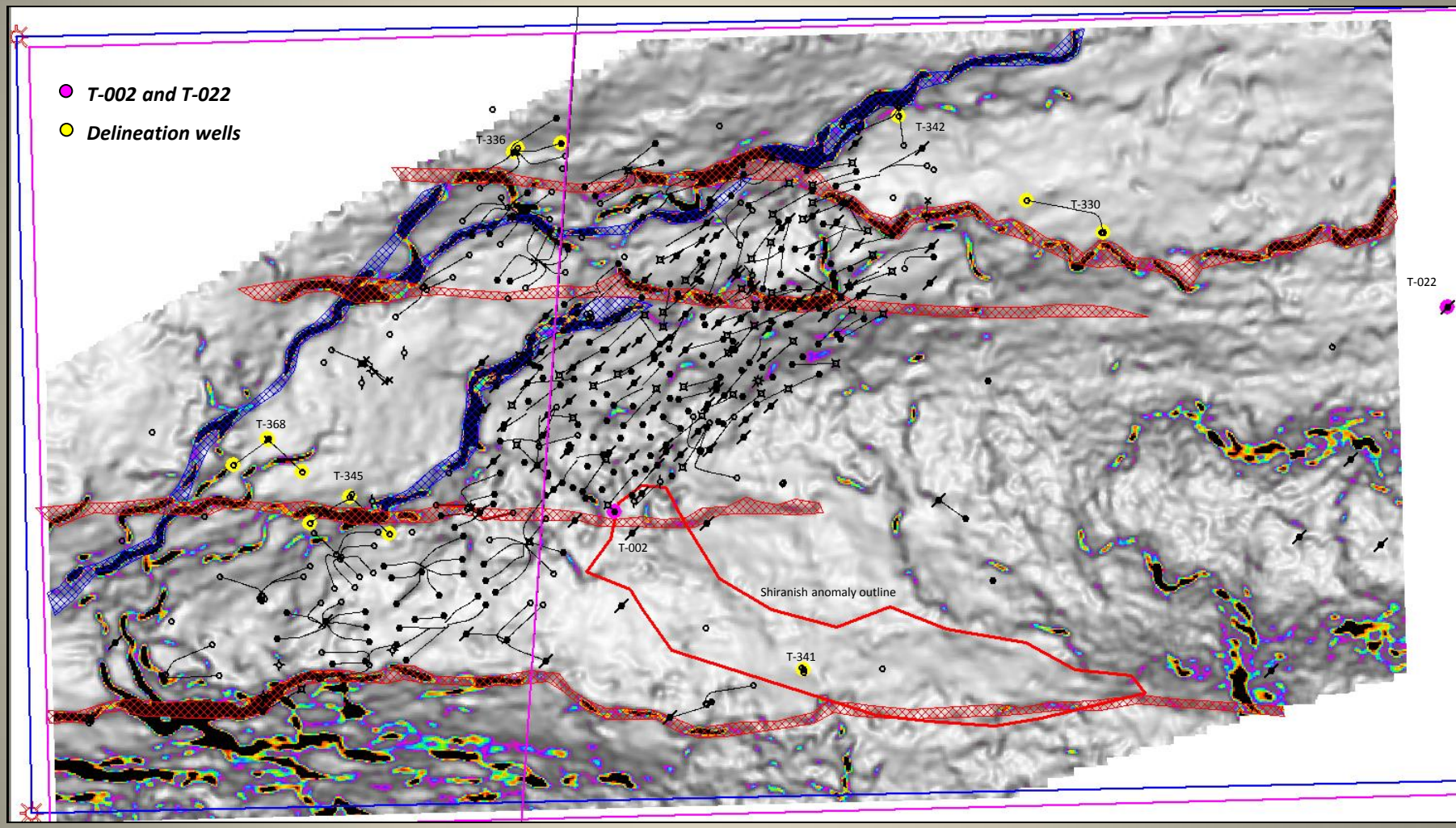
GoogleEarth image of the Sinjar and Jebel Abd Al Aziz Uplifts. Note the *en echelon* relationship possibly related to sinistral transpression from the north



Chilou Anhydrite
Time Structure

Time Structure of the Chilou Anhydrite showing the en echelon structural style from the East Tishrine Field to the West Tishrine Field to the southwestern extension of the West Tishrine Field

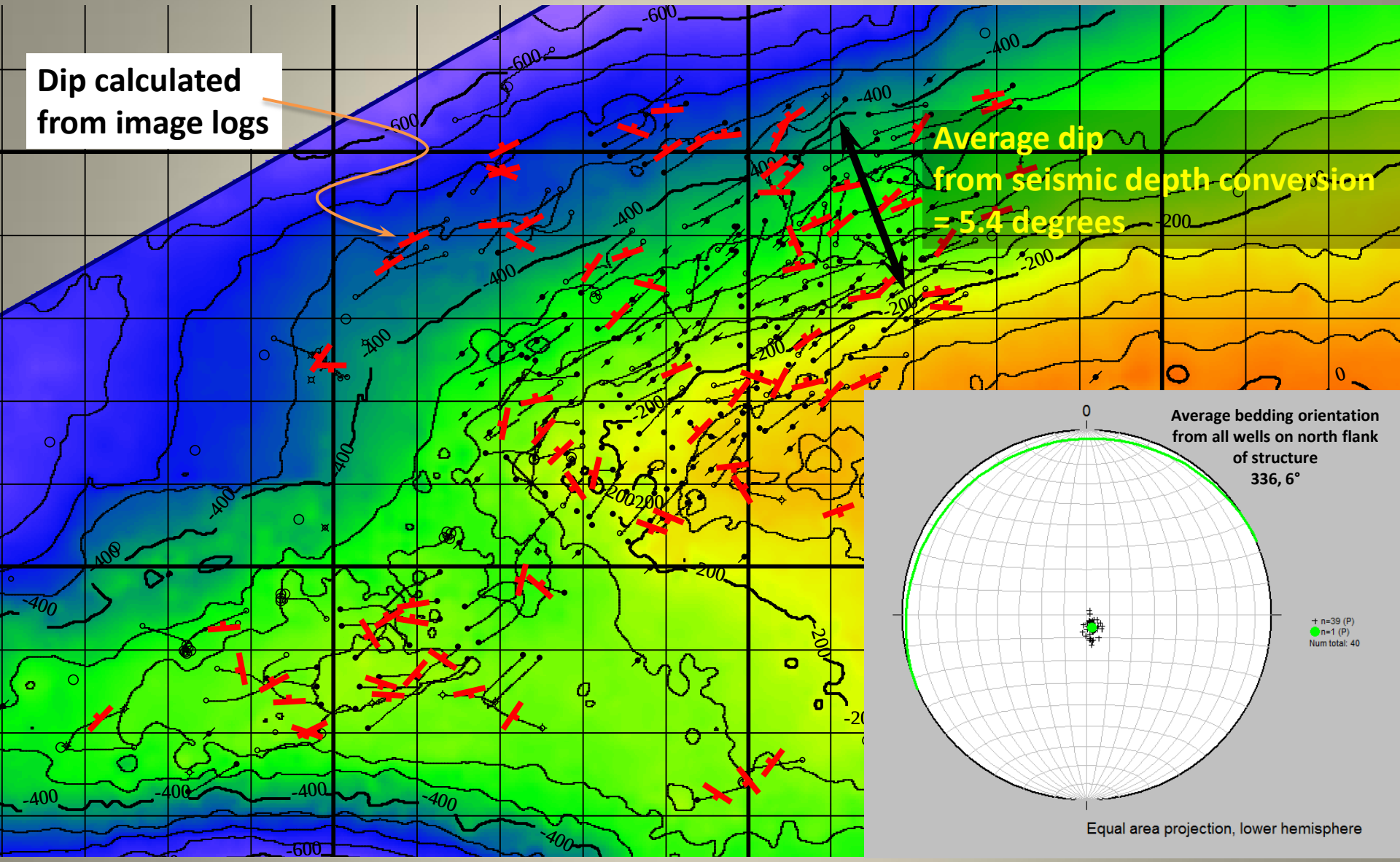
Delineation wells and Structural interpretation



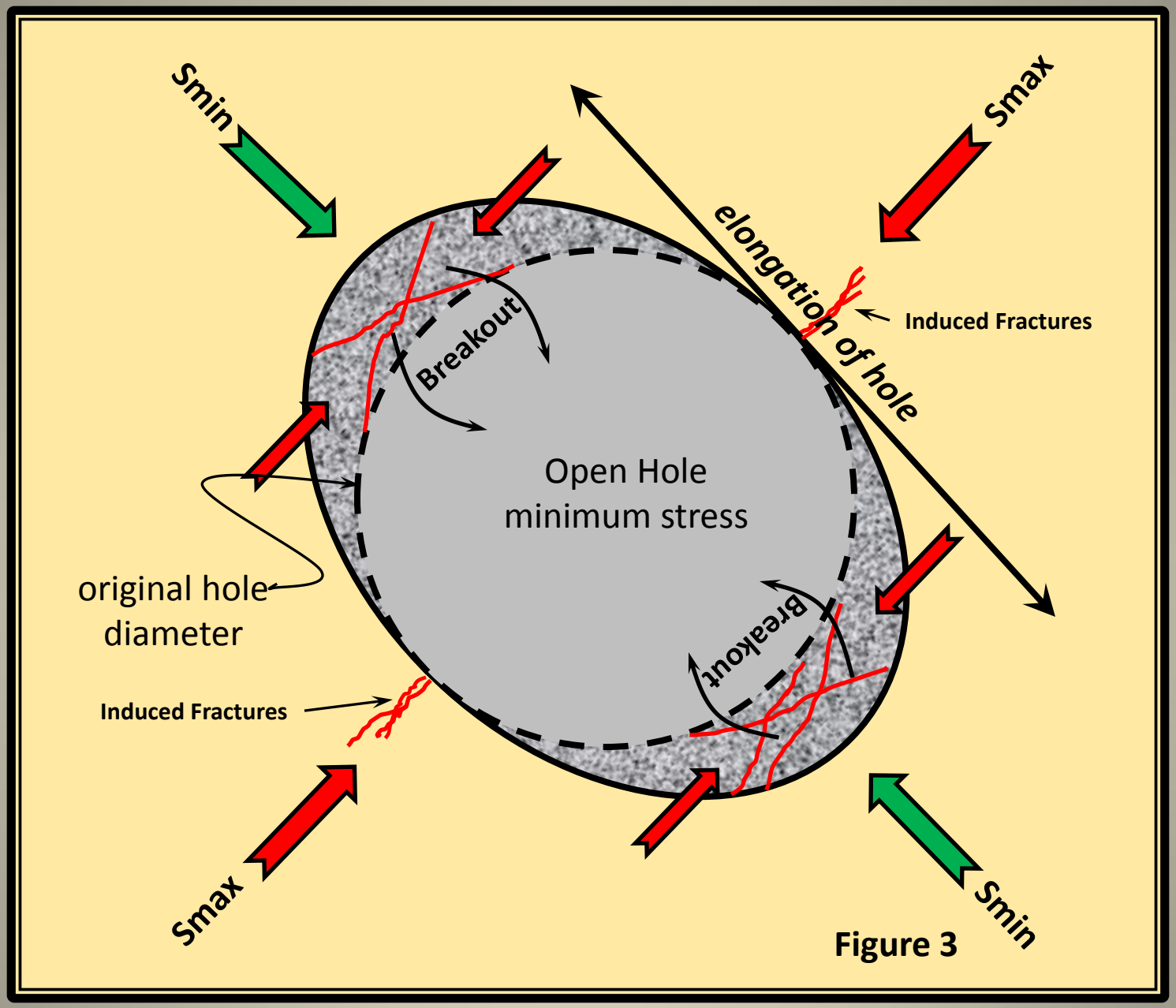
Seimic Line TB-3

Gradient mapping of the Tishrine Field showing inheritance of normal faults (Gill, 2009)

Structure for top of Chilou based on seismic time/depth conversion



Comparison of structural dip of north flank of the Tishrine Structure calculated from image logs and 3D seismic data.



Breakout patterns and collapse of a wellbore due to differential stress (Smax – Smin).

Stress Analysis - Tishrine

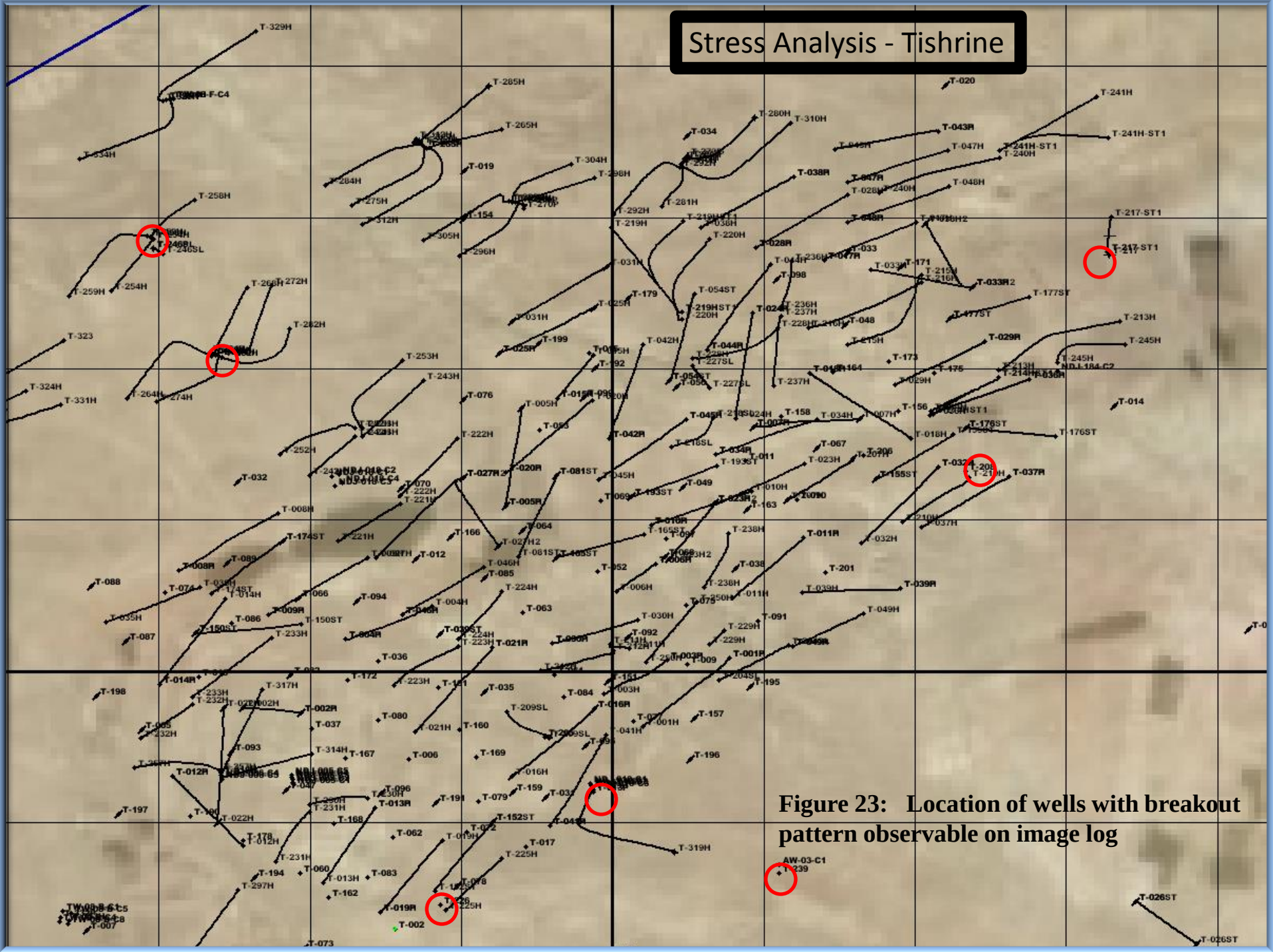


Figure 23: Location of wells with breakout pattern observable on image log

Stress Analysis - Tishrine

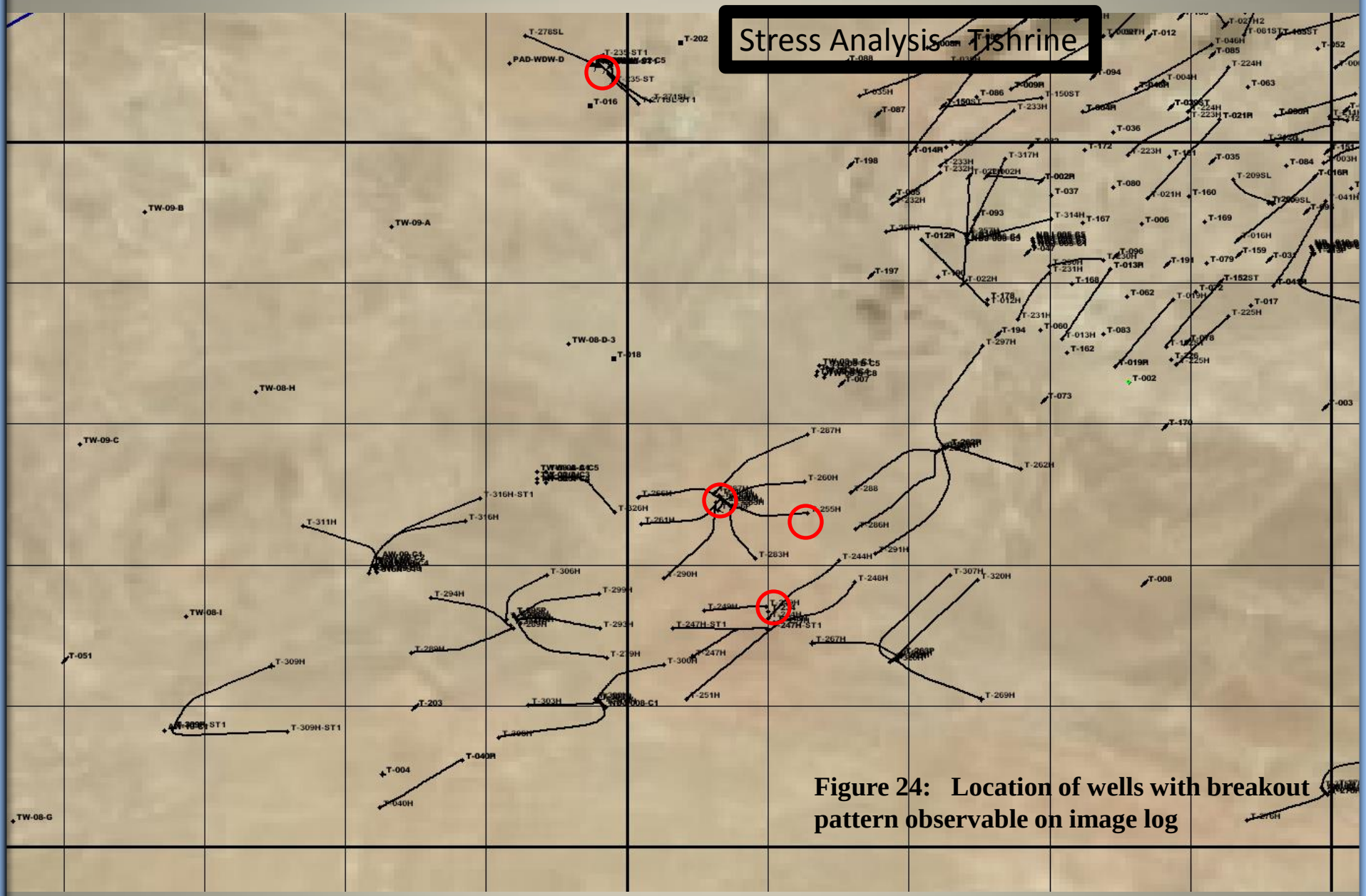
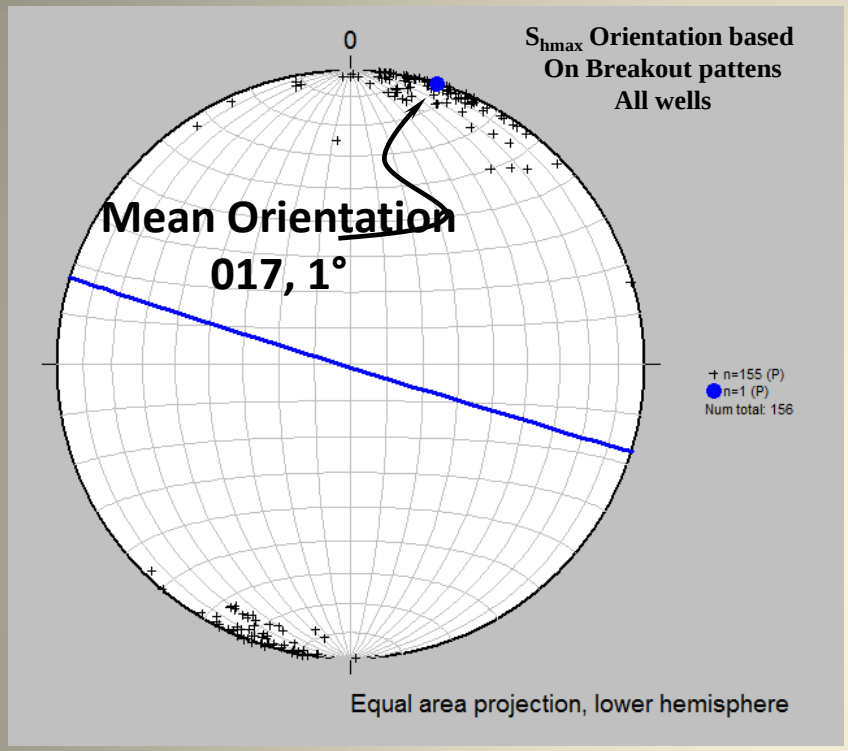
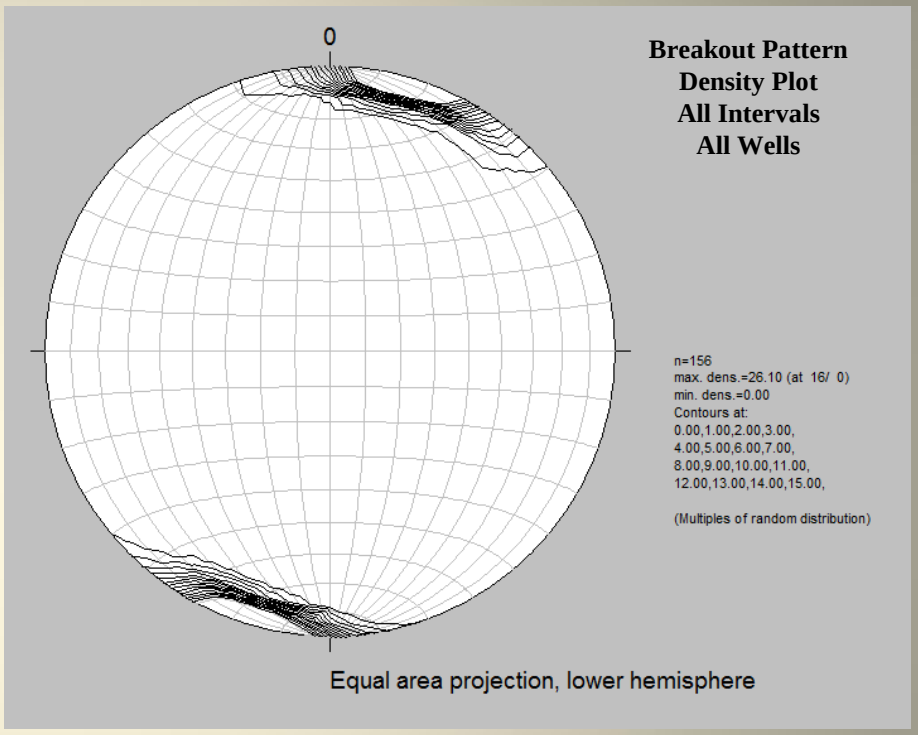


Figure 24: Location of wells with breakout pattern observable on image log


0
S_{hmax} Orientation based
On Breakout pattens
All wells
Mean Orientation
017, 1°
n=155 (P)
n=1 (P)
Num total: 156
Equal area projection, lower hemisphere


0
Breakout Pattern
Density Plot
All Intervals
All Wells
n=156
max. dens.=26.10 (at 16/ 0)
min. dens.=0.00
Contours at:
0.00,1.00,2.00,3.00,
4.00,5.00,6.00,7.00,
8.00,9.00,10.00,11.00,
12.00,13.00,14.00,15.00,
(Multiples of random distribution)
Equal area projection, lower hemisphere

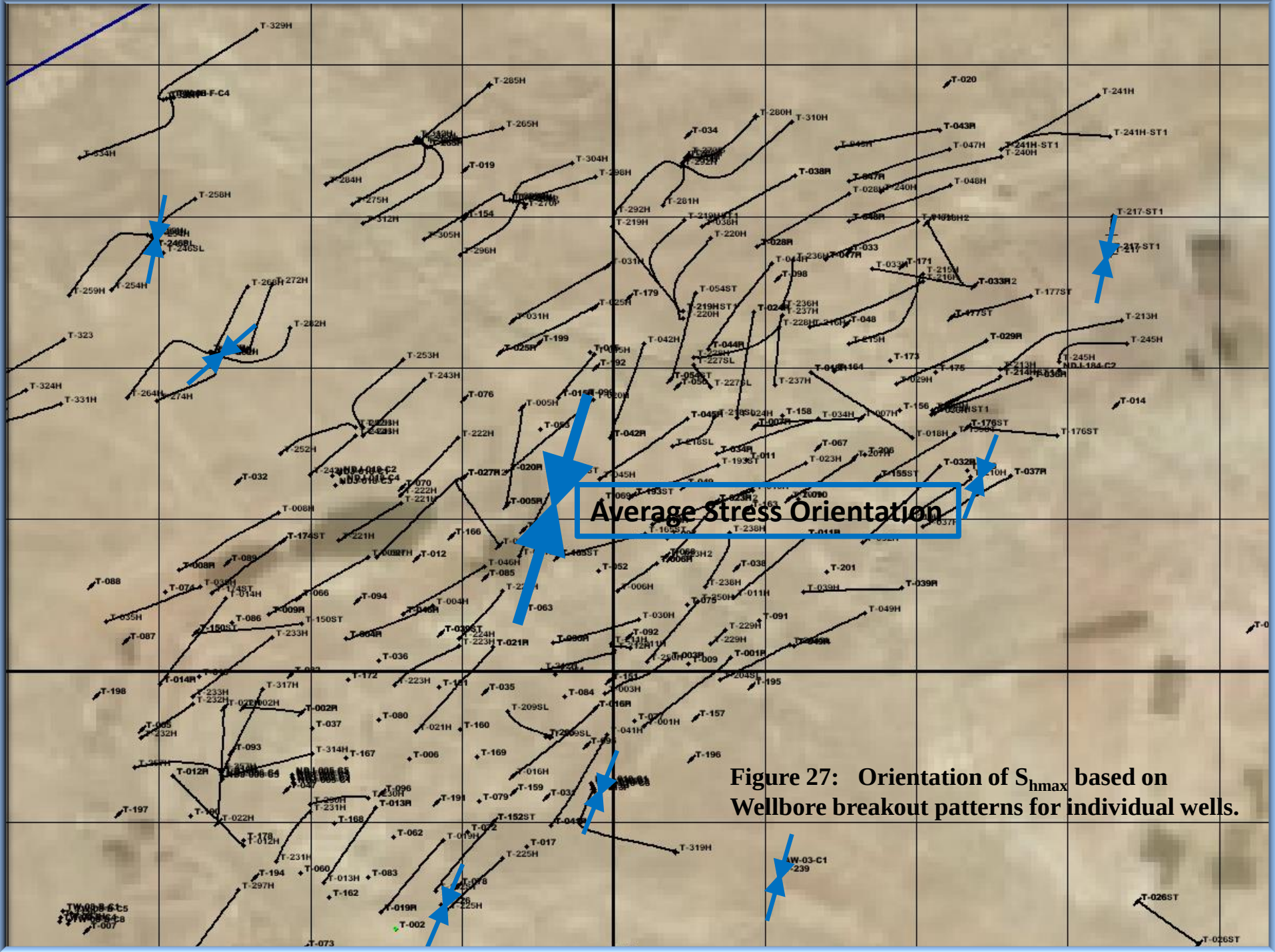


Figure 27: Orientation of S_{hmax} based on Wellbore breakout patterns for individual wells.

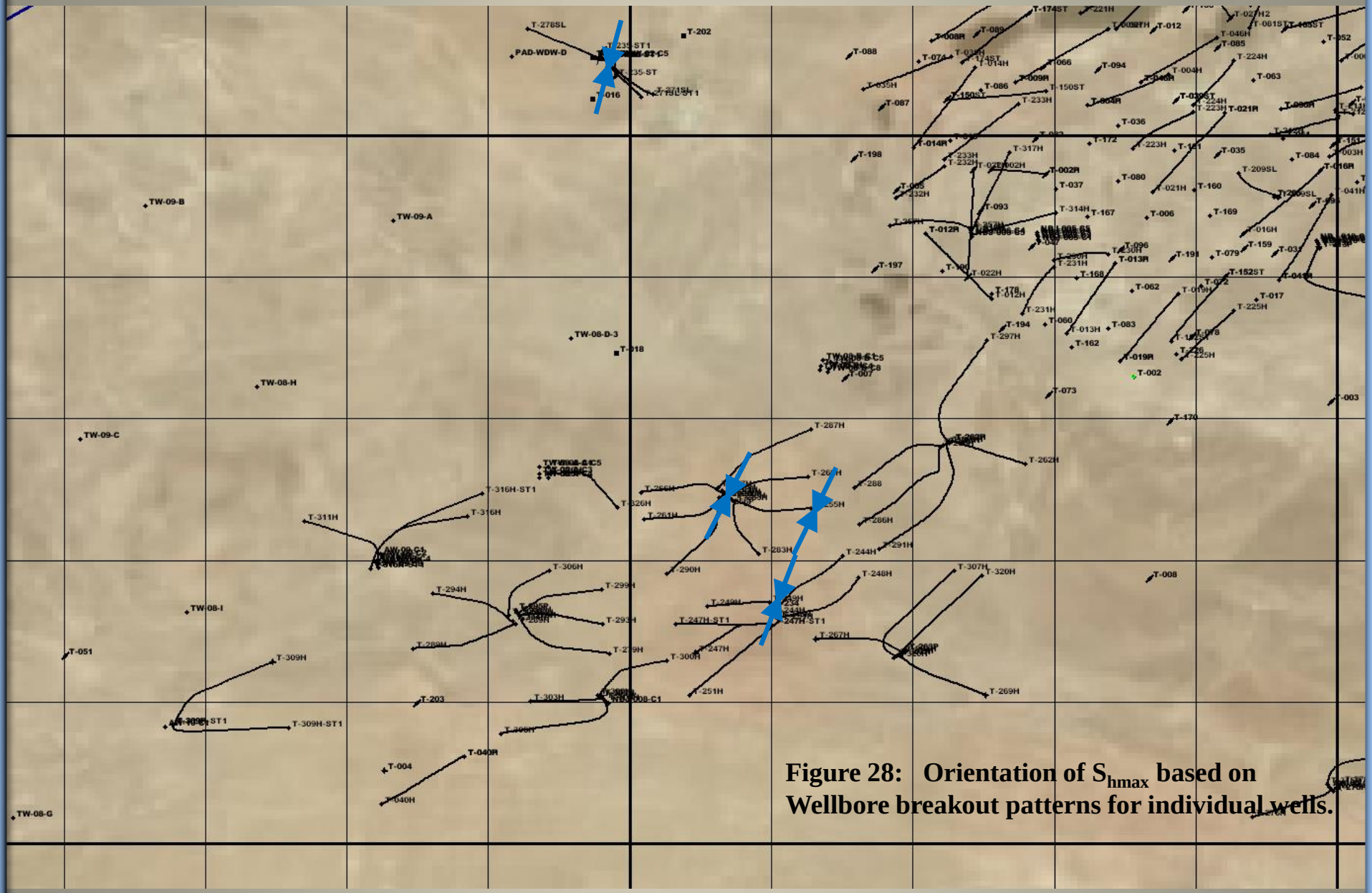
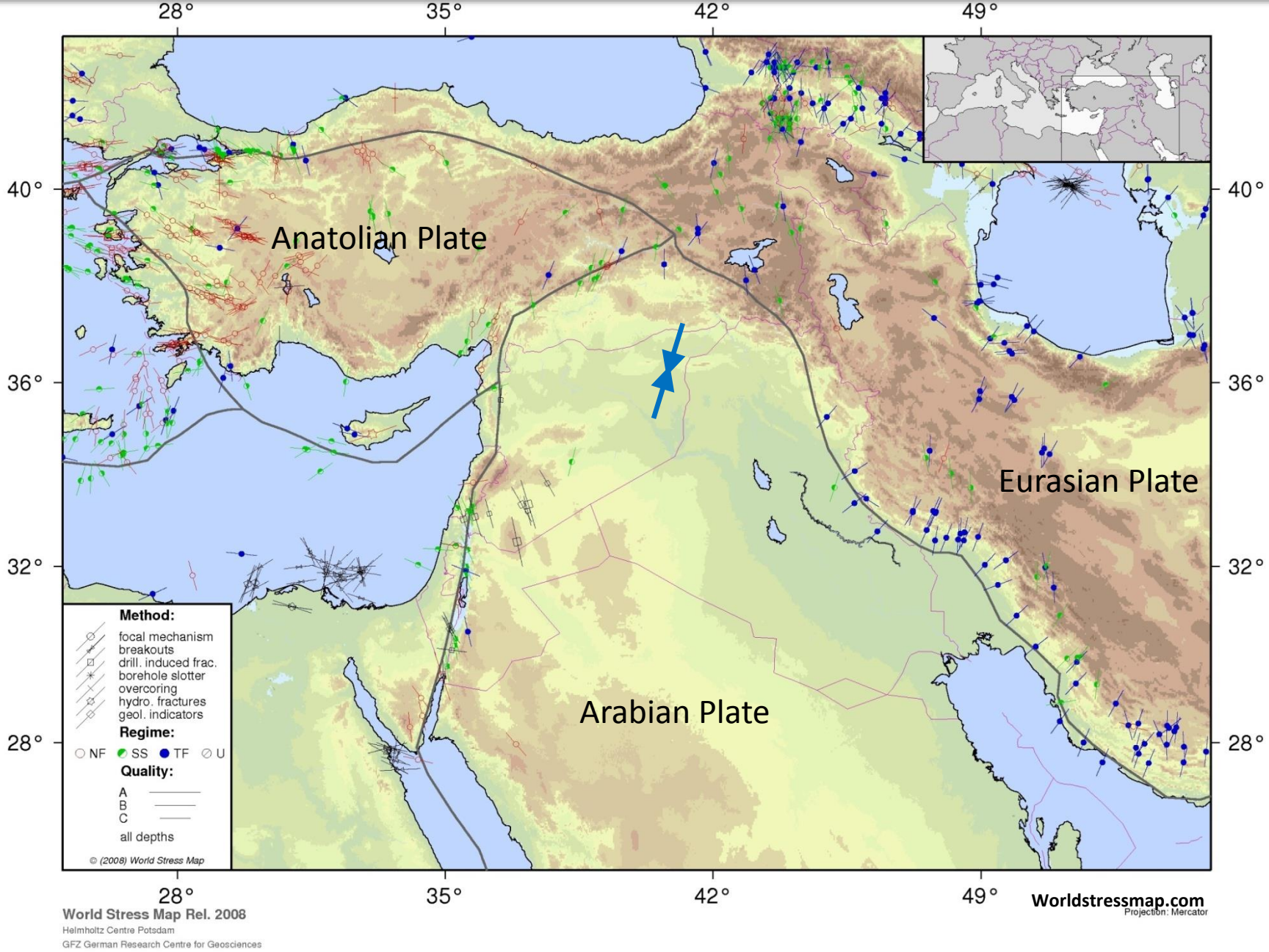


Figure 28: Orientation of S_{hmax} based on Wellbore breakout patterns for individual wells.



Average orientation of S_{hmax} based on wellbore breakout patterns and plotted on World Stress Map for the Arabian Plate and surrounding areas.

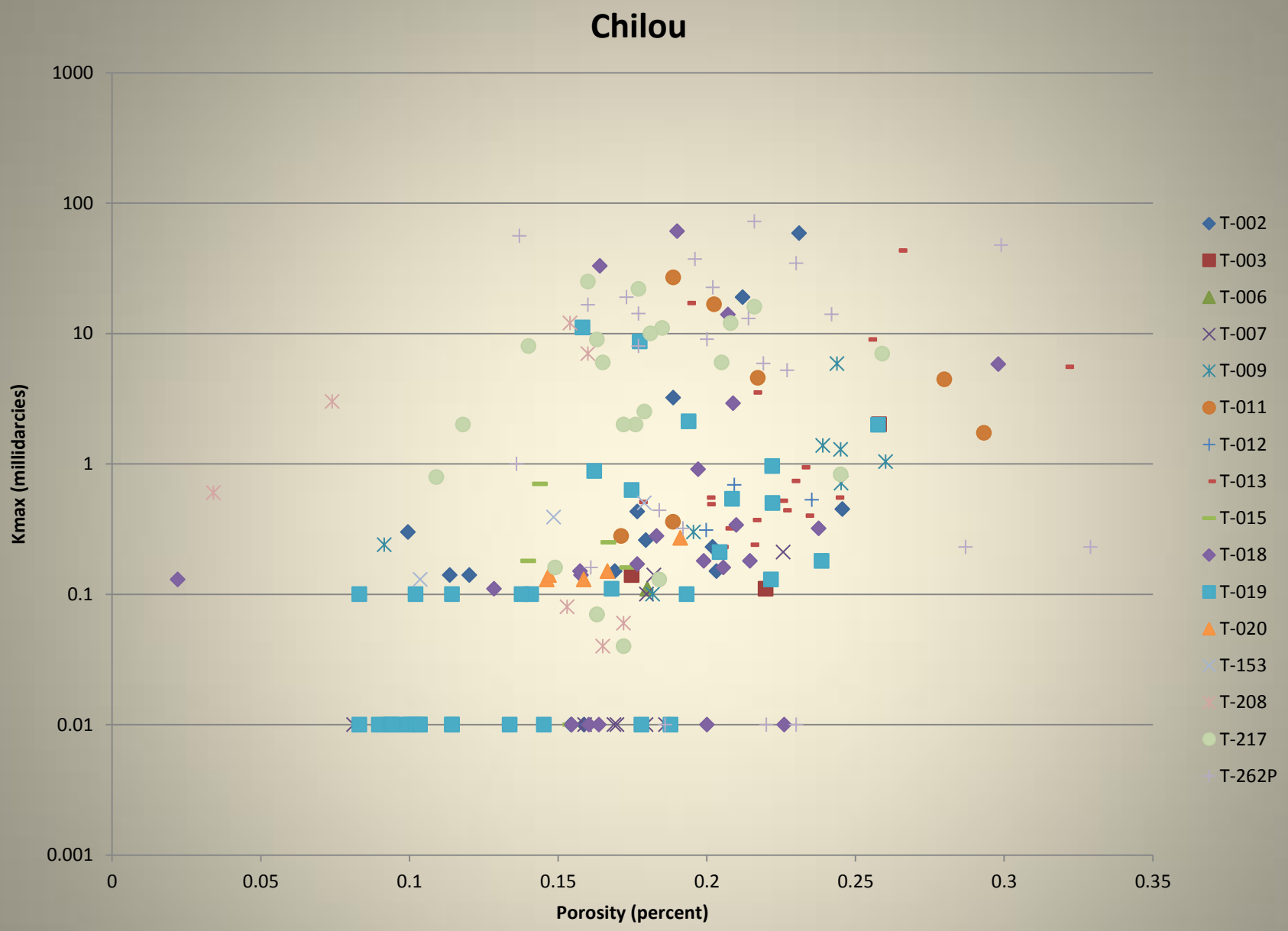


Figure 45: Porosity vs Permeability from core data – Chilou Fm.

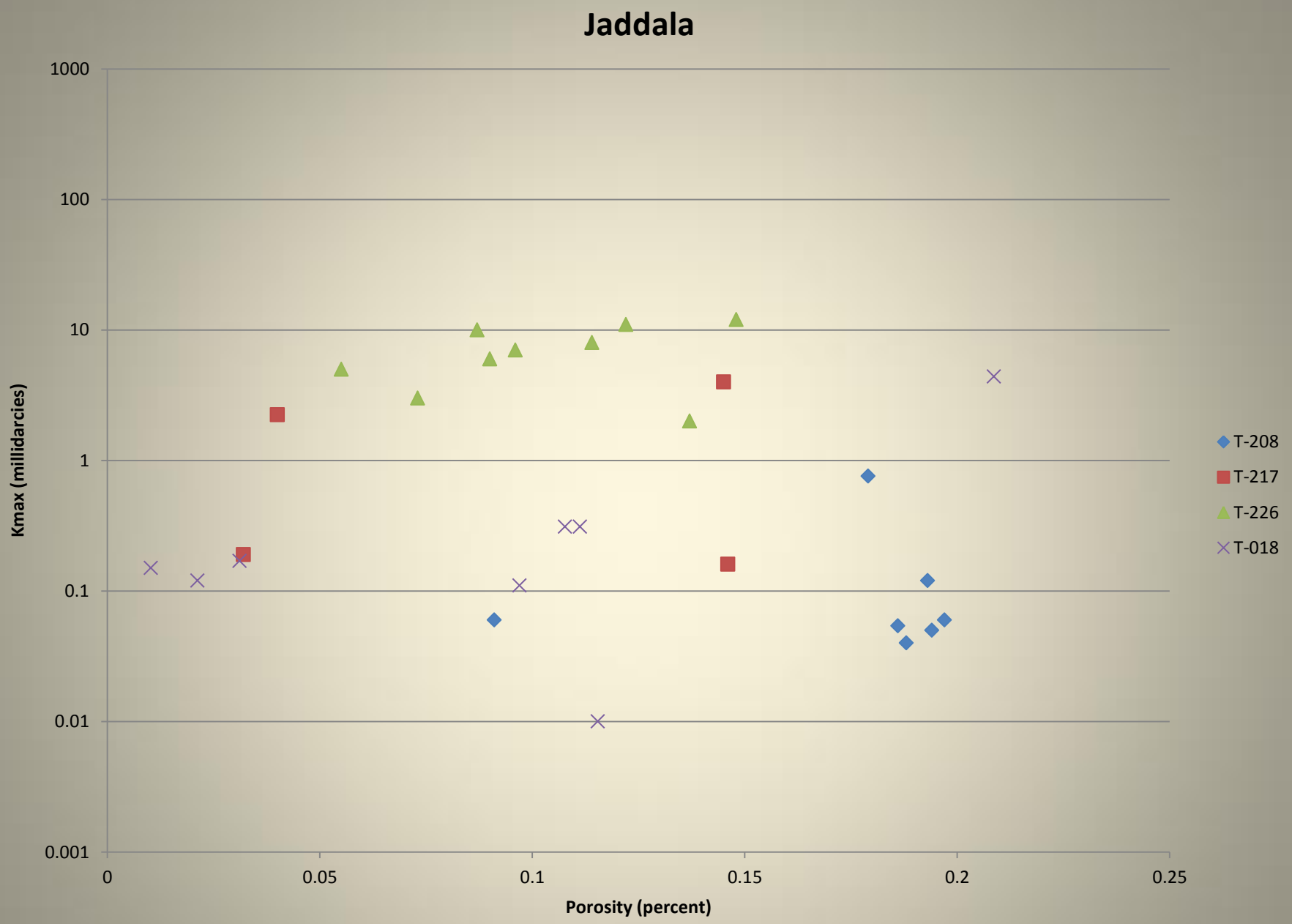
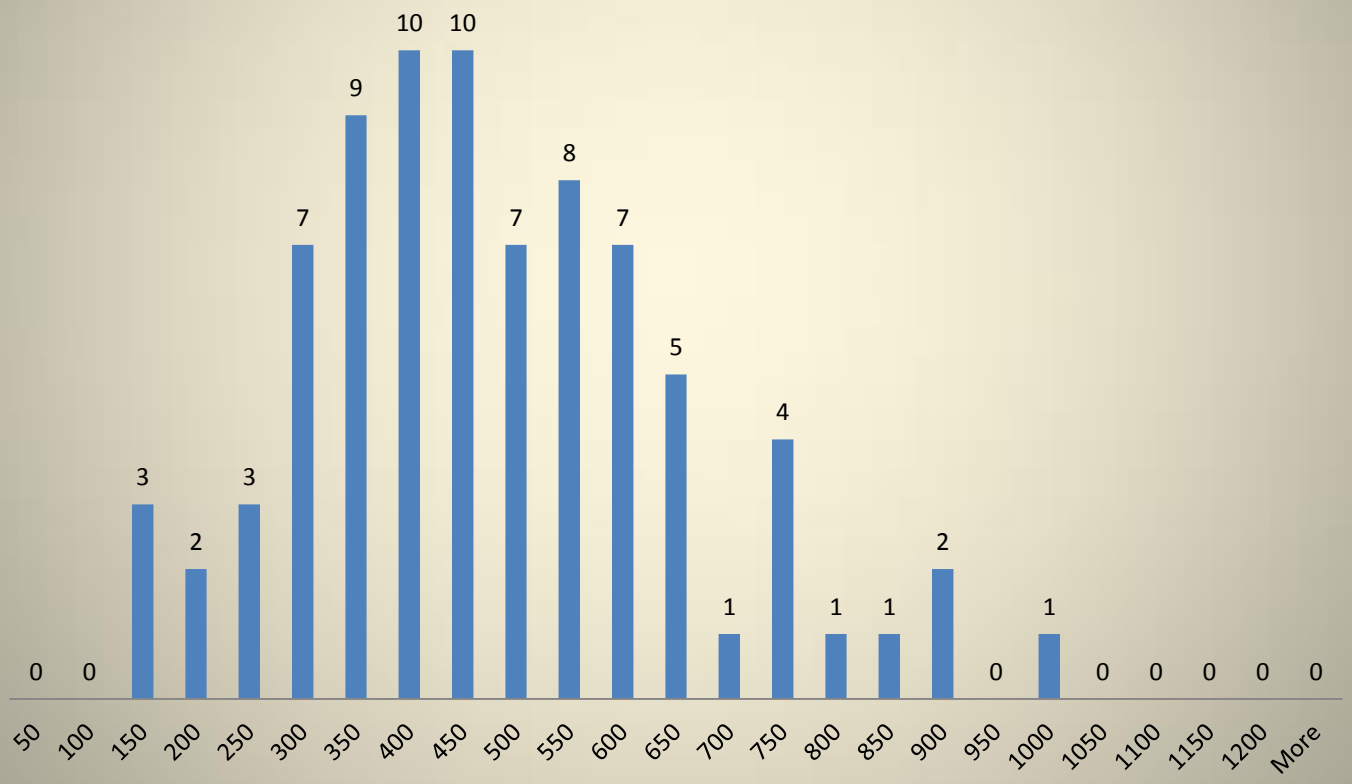


Figure 46: Porosity vs Permeability from core data – Jadalla Fm.

Length of lateral section for wells with image logs all formations



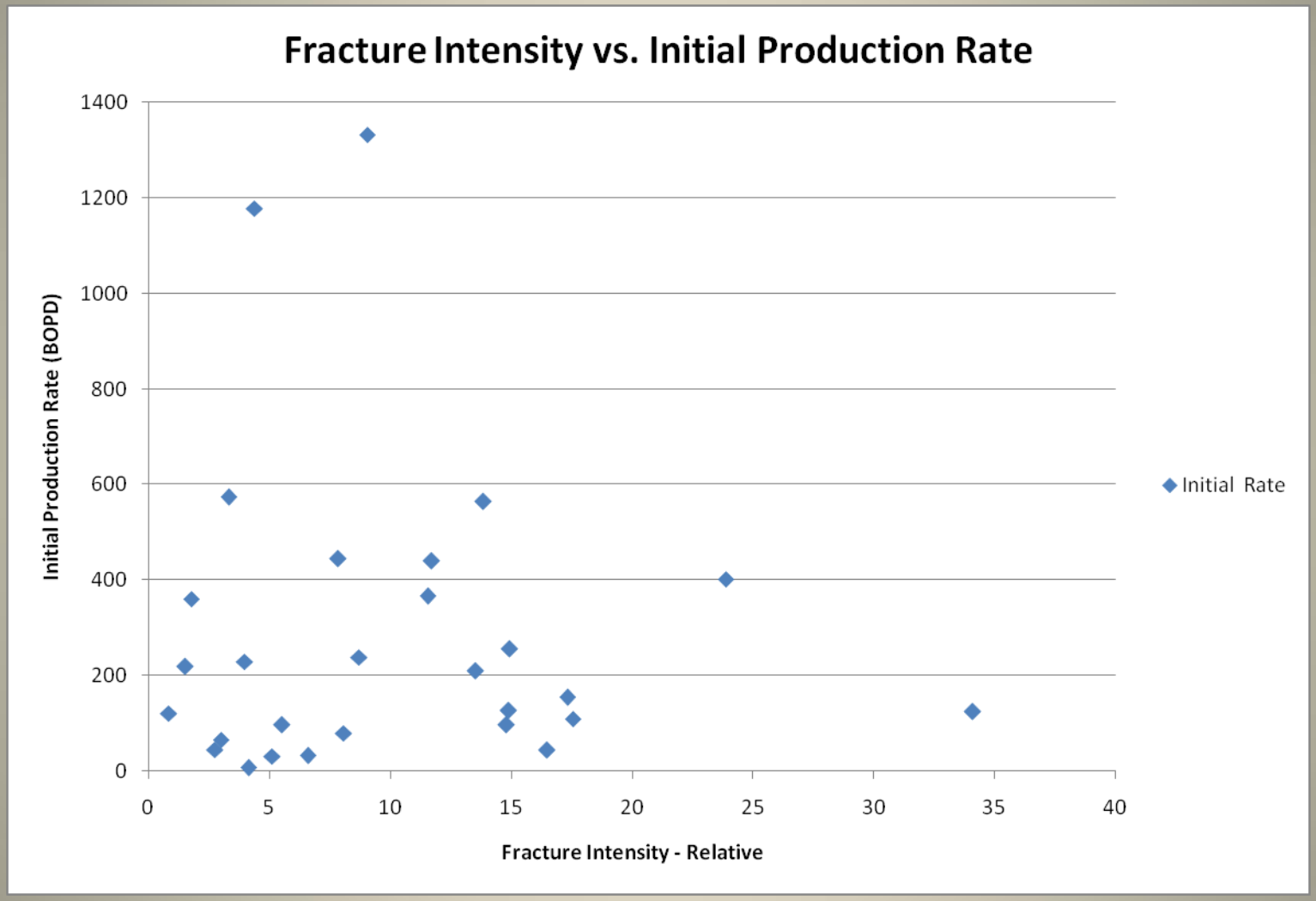
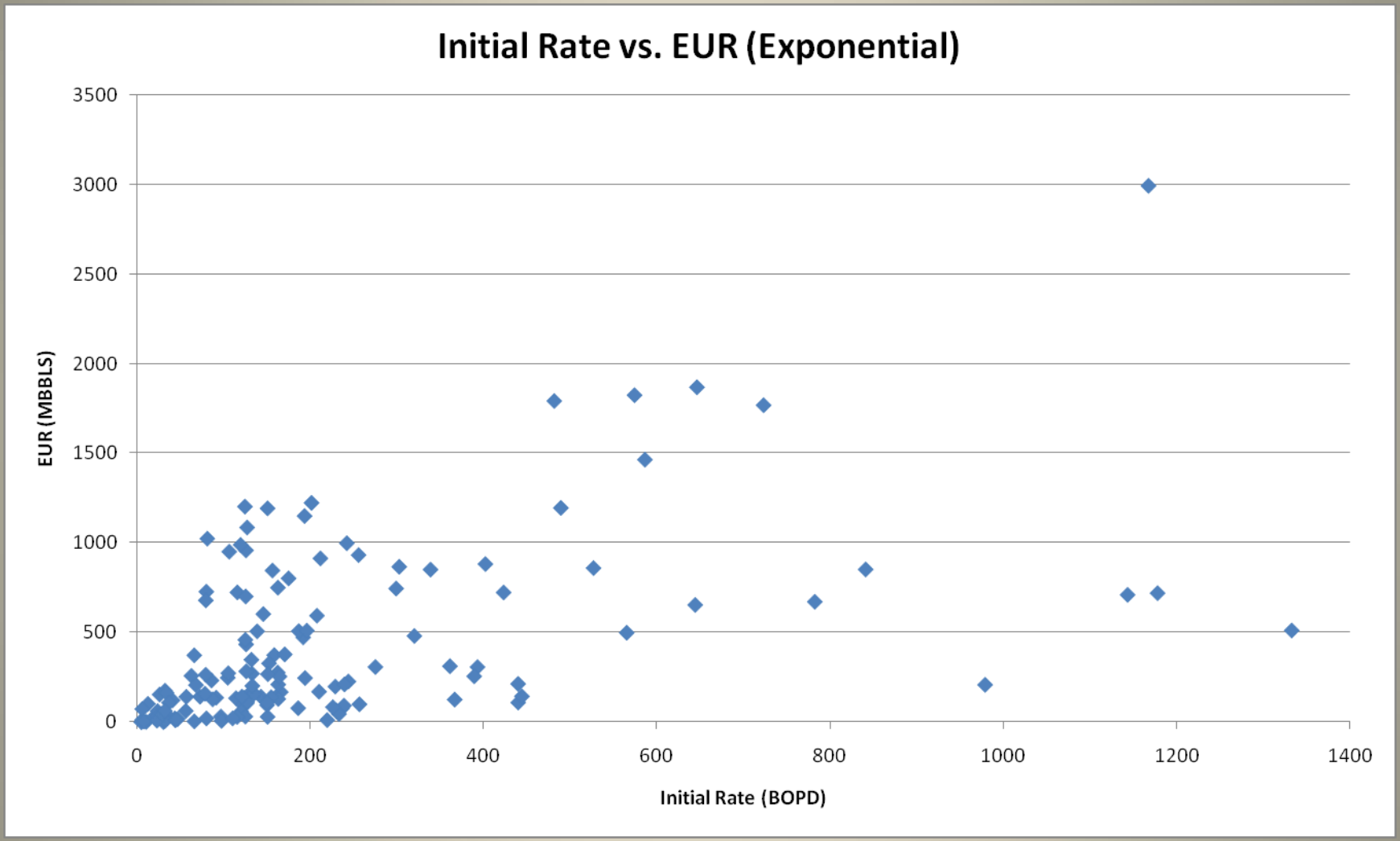


Figure 54: Initial production rate vs. fracture intensities (relative) – all zones


Initial Rate vs. EUR (Exponential)
EUR (MBBLS)
3500
3000
2500
2000
1500
1000
500
0
0
200
400
600
800
1000
1200
1400
Initial Rate (BOPD)

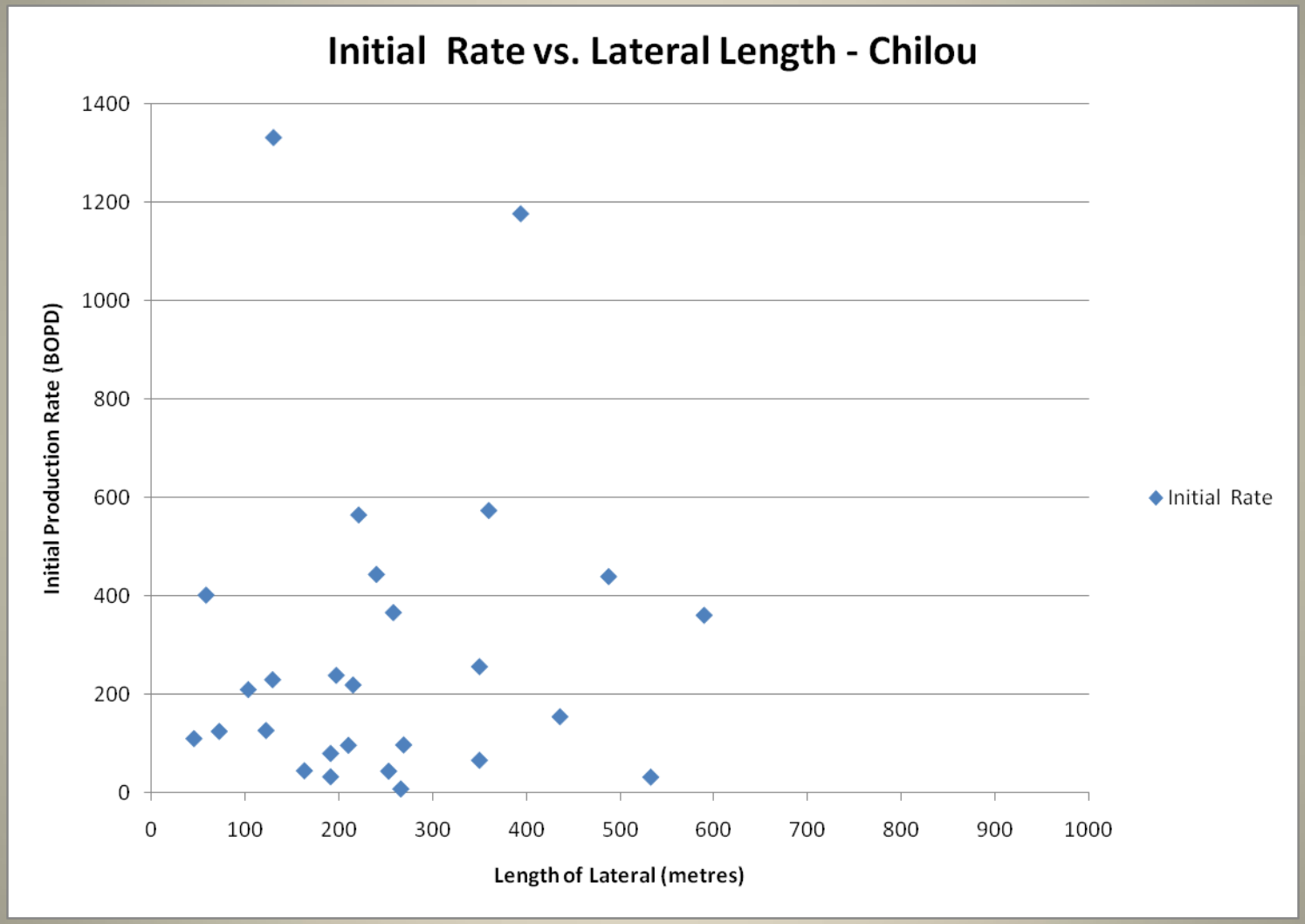


Figure 47: Relationship of length of lateral section and initial production rate – Chilou Fm.

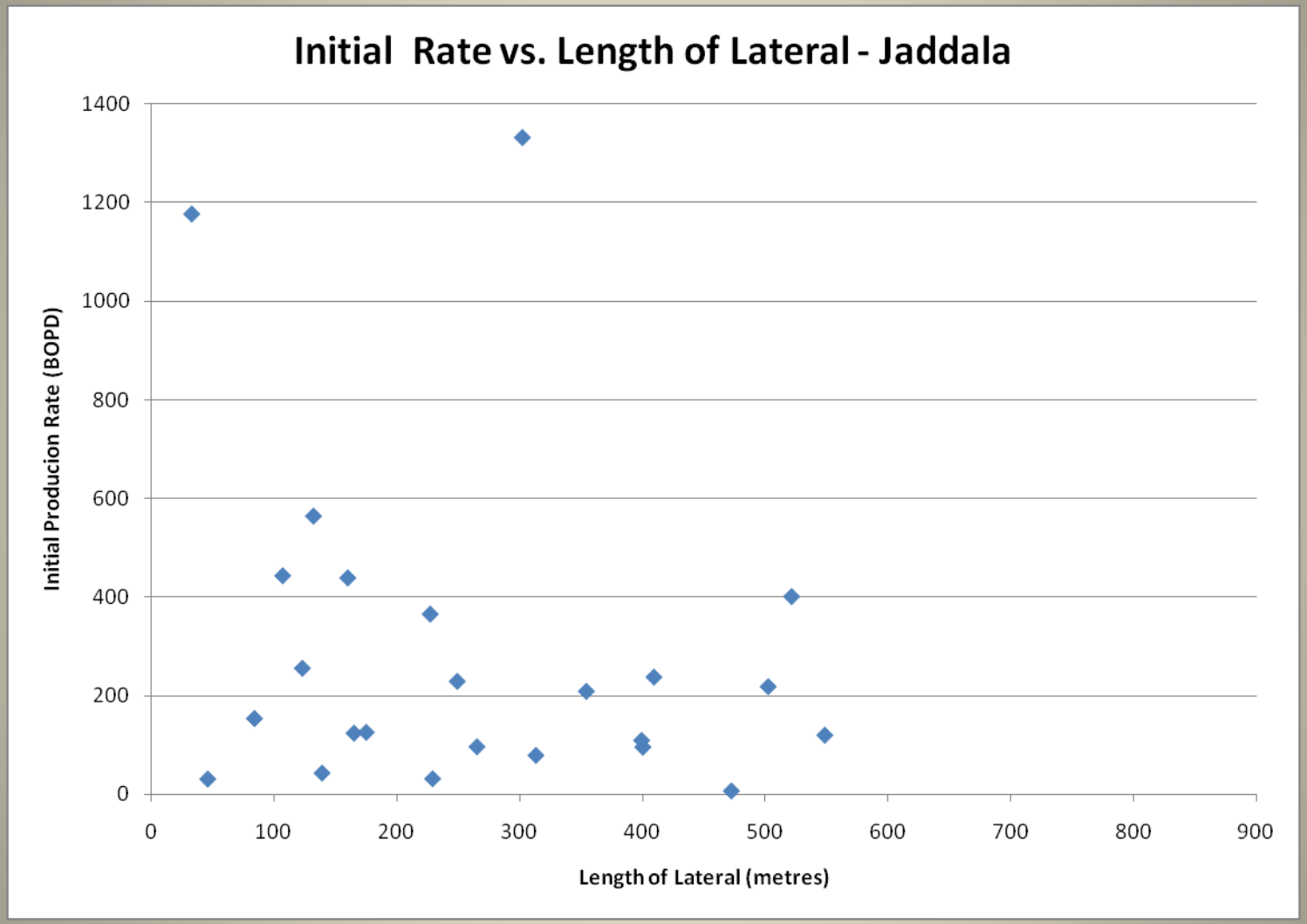


Figure 48: Relationship of length of lateral section and initial production rate – Jaddala Fm.

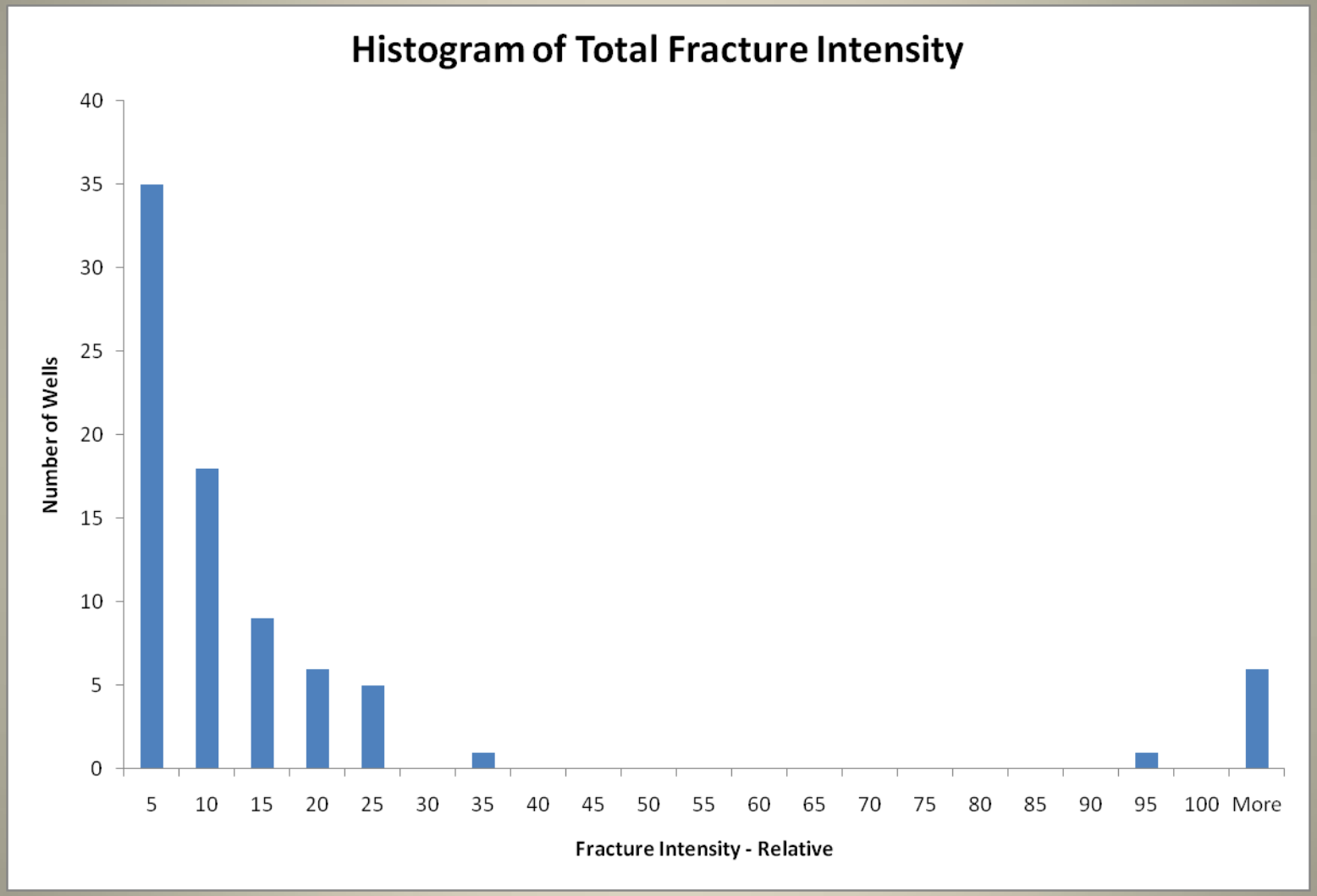


Figure 49: Distribution of wells with calculated fracture intensities (relative) – all zones

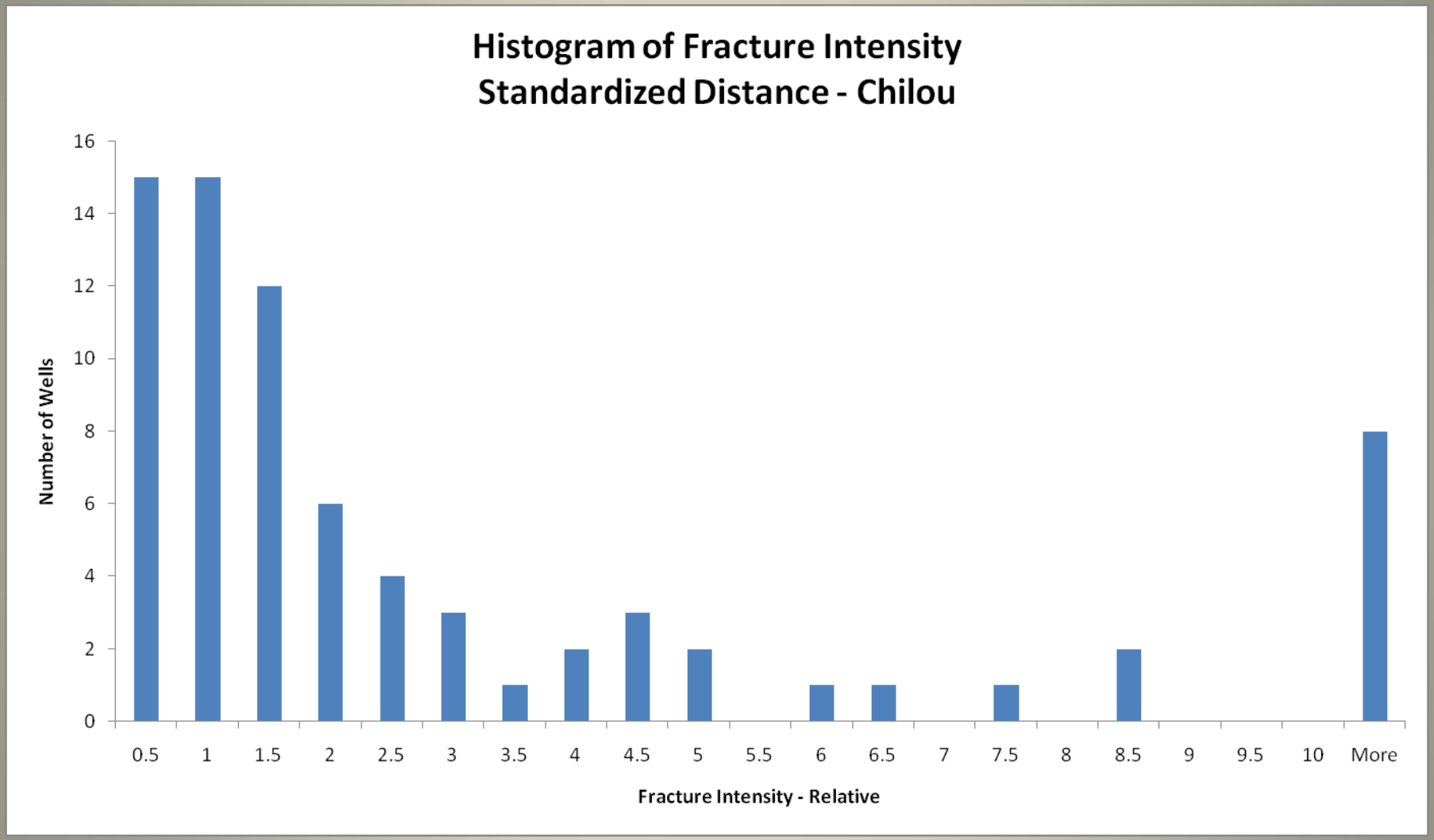


Figure 52: Distribution of wells with calculated fracture intensities (standardized) – Chilou Fm.

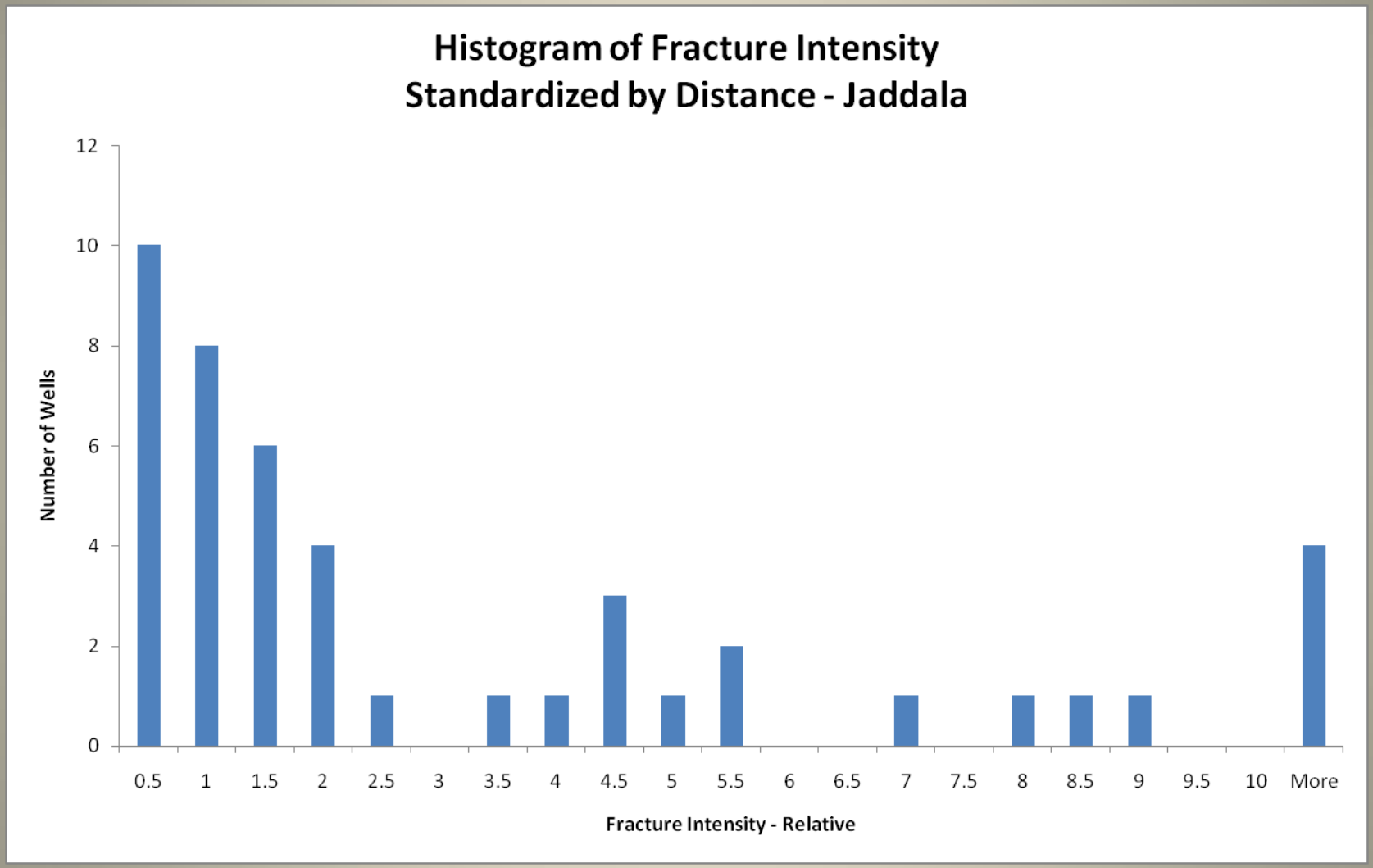


Figure 53: Distribution of wells with calculated fracture intensities (standardized) – Jaddala Fm.

Tishrine Field

Poles to open fractures

Lambert Equal Area Net

Dominant Fracture Orientations:

008/85 East

274/38 North

099/51 South

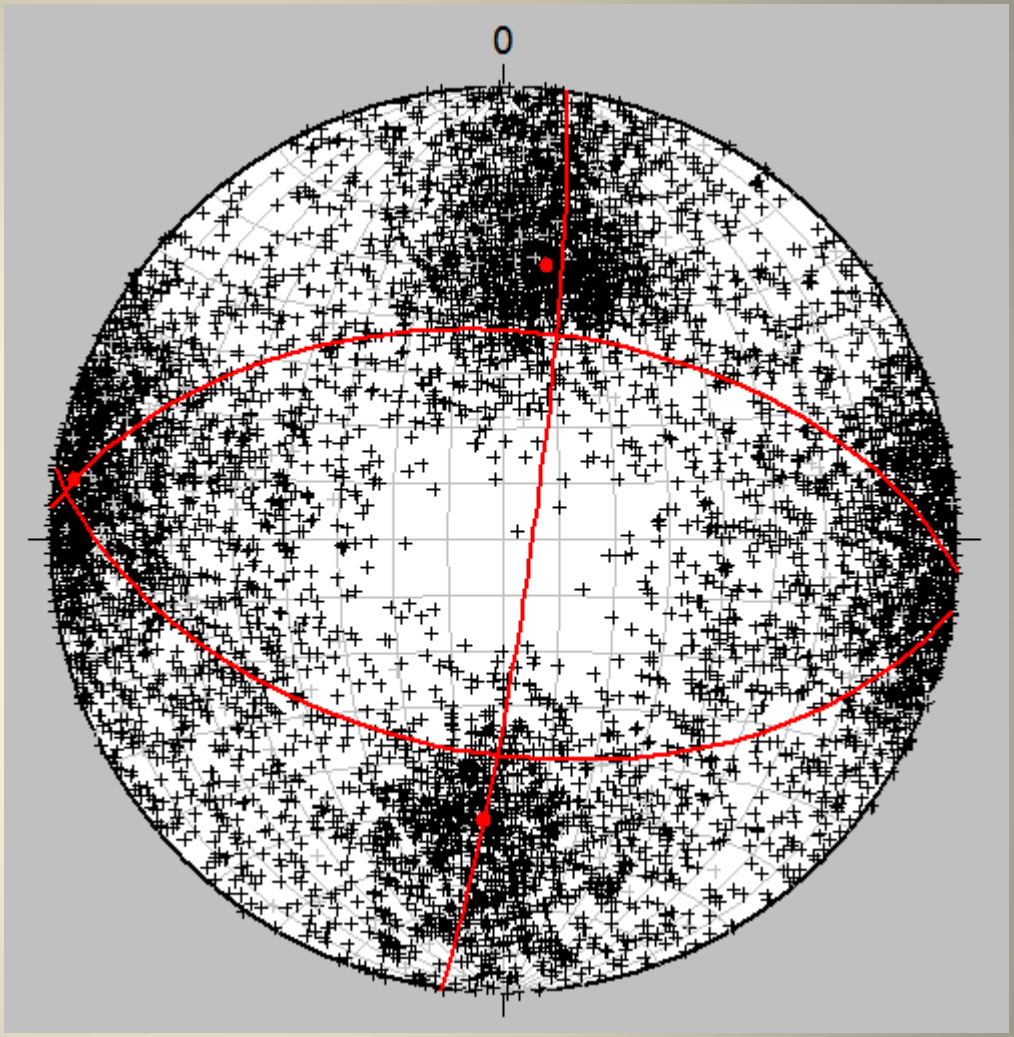


Figure 30: Poles to open fractures plotted on Lambert Equal Area Net.

Tishrine Field

Poles to open fractures

Lambert equal Area Net

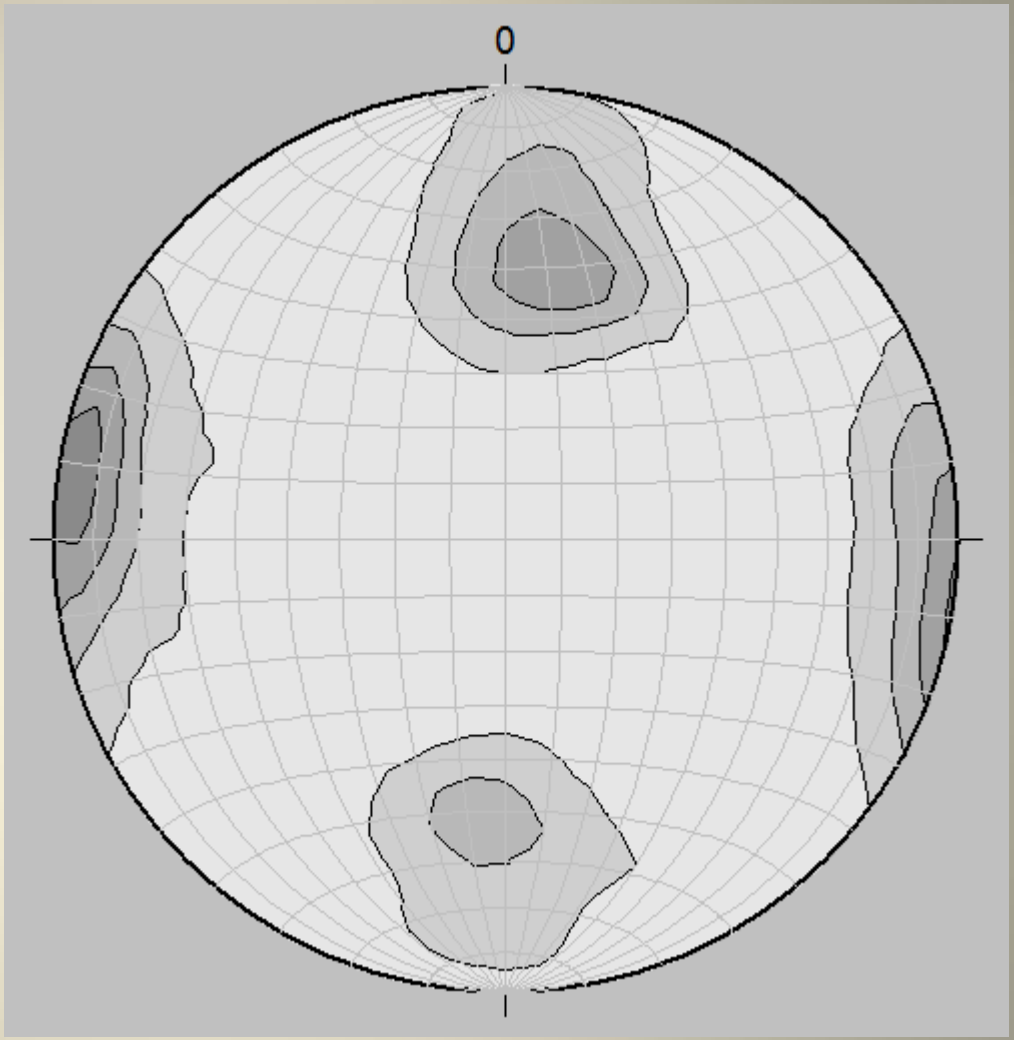
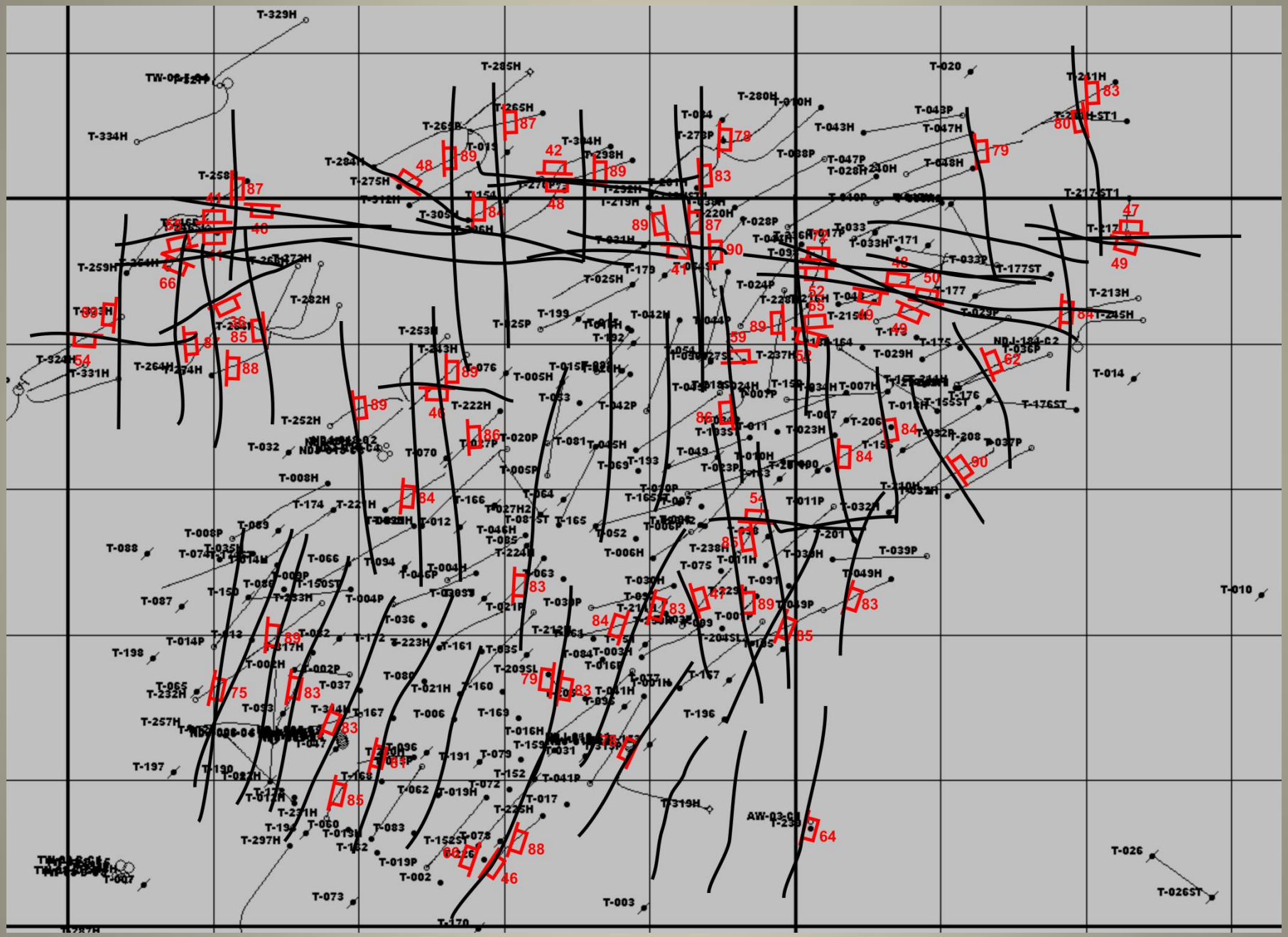


Figure 31: Density plot of poles to open fractures plotted on Lambert Equal Area Net.



Major trends of dominant fracture orientations – West Tishrine Field

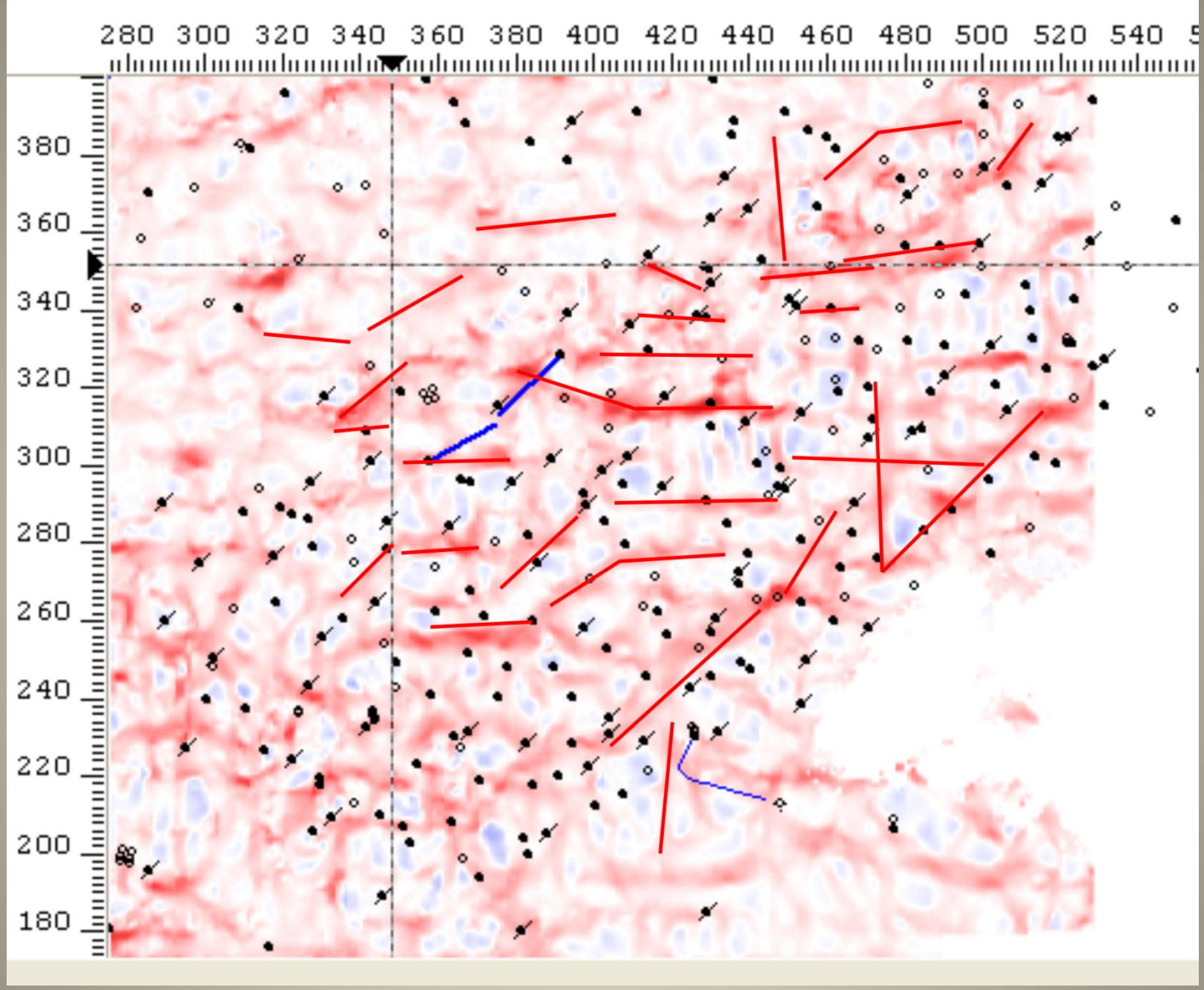


Figure 35: Most positive curvature with lineations highlighted (in red) – West Tishrine Field

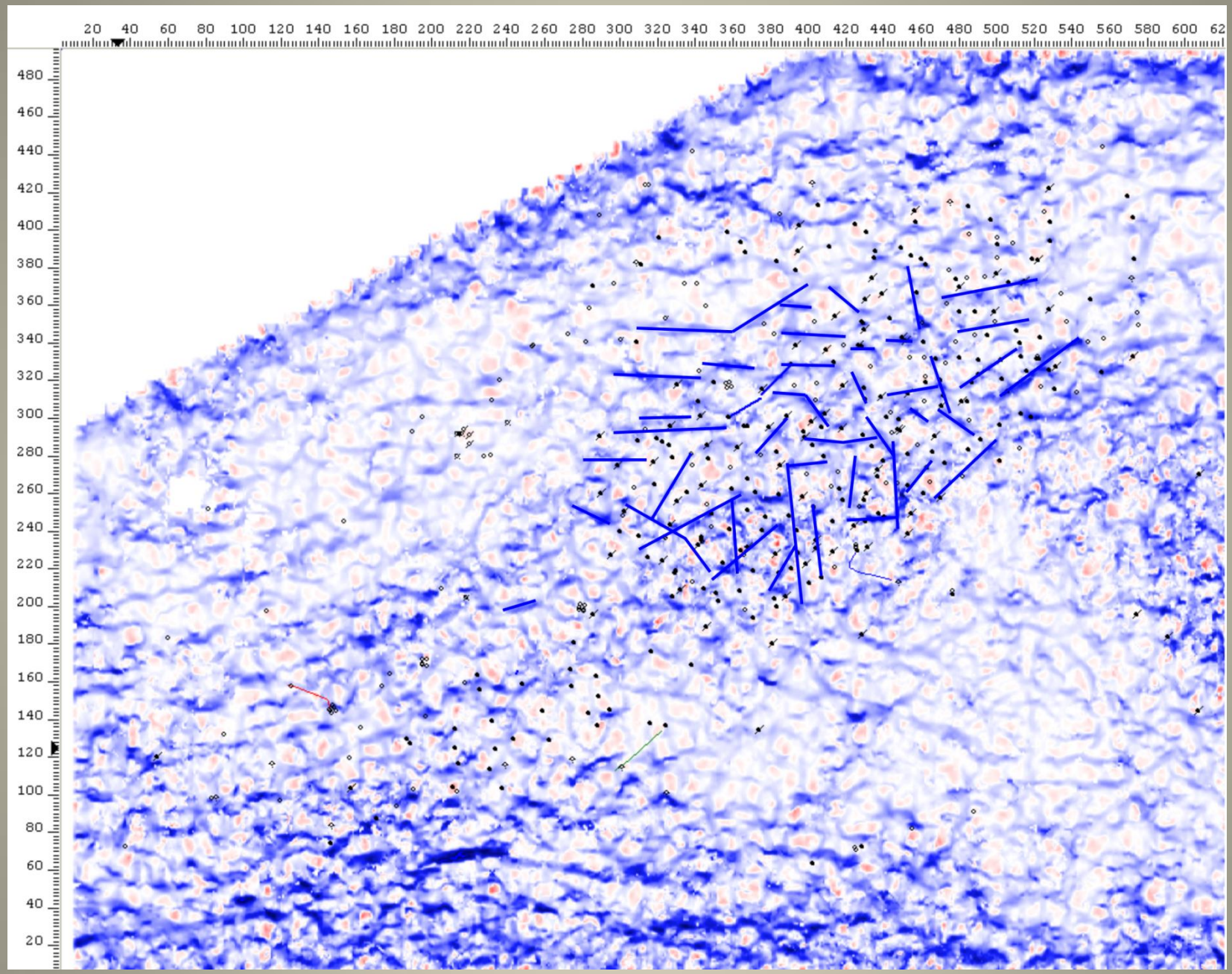
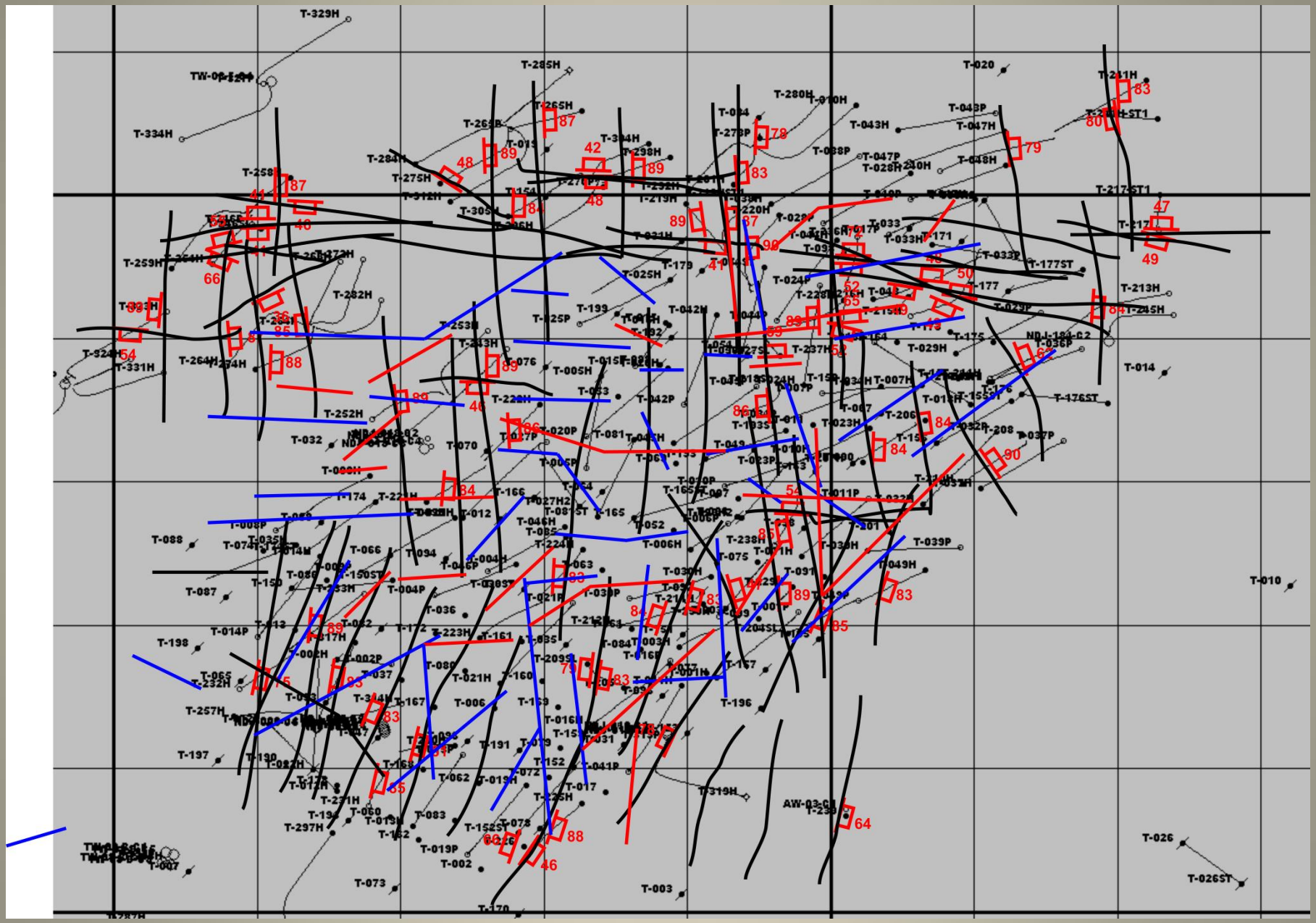


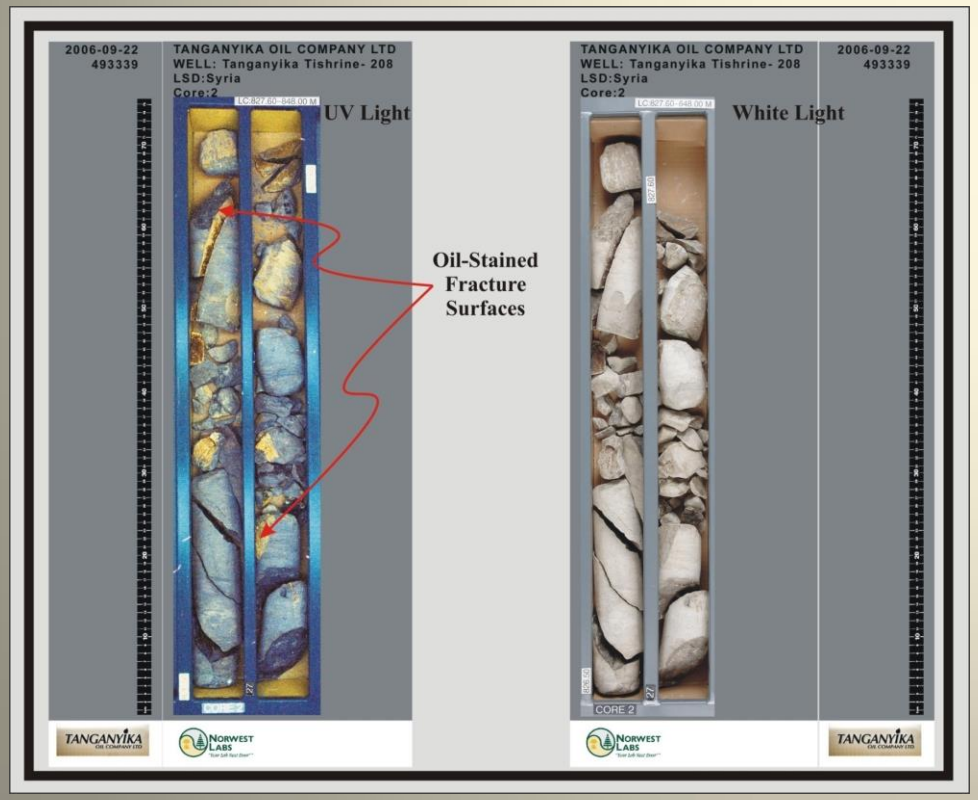
Figure 37: Most negative curvature with lineations highlighted (in blue) – West Tishrine Field

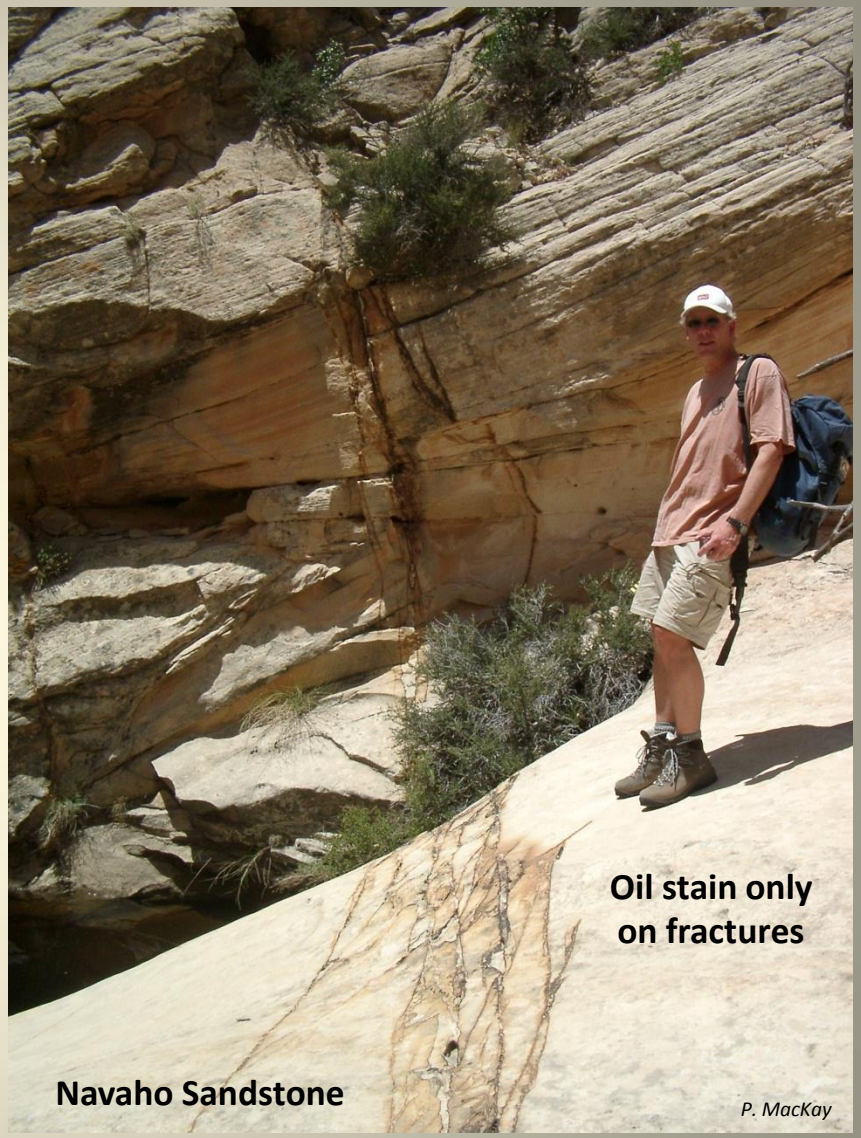


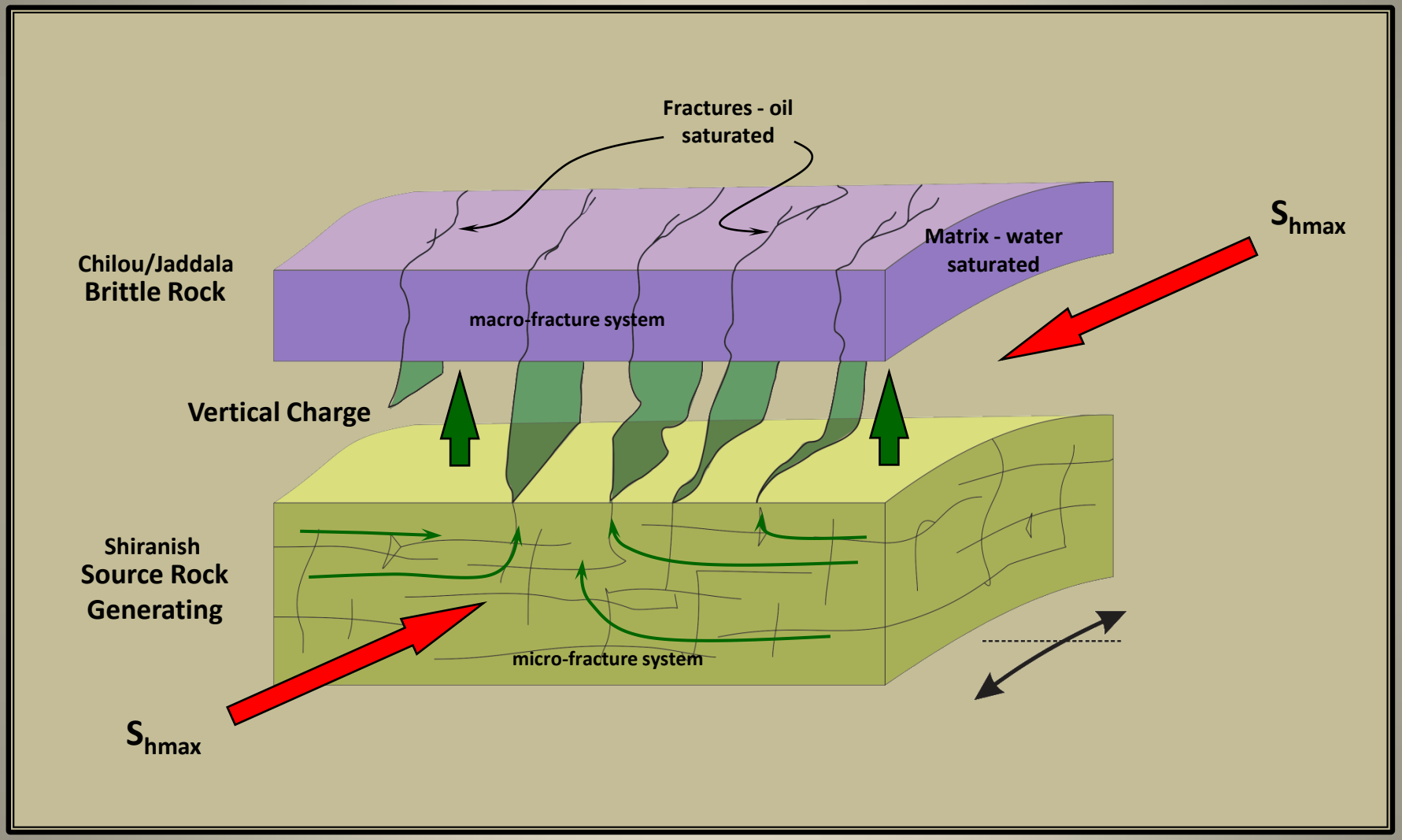
Lineations derived from curvature analysis (red and blue) overlaid with major fracture orientations derived from image logs (black) – West Tishrine Field.

Migration of Hydrocarbons

- Migration follows Darcy's Law
- Pressure differential created in organic pore space
- Fluid pressure also drives failure
- Fractures form in response to failure conditions and create fluid pathway for high pressure fluids (hydrocarbons) to escape
- This pathway will go through porous and tight rock. Migration into conventional reservoirs can only happen if the existing fluid within the matrix can move.






Fractures - oil saturated
Chilou/Jaddala
Brittle Rock
Matrix - water saturated
S_{hmax}
macro-fracture system
Vertical Charge
Shiranish
Source Rock
Generating
micro-fracture system
S_{hmax}

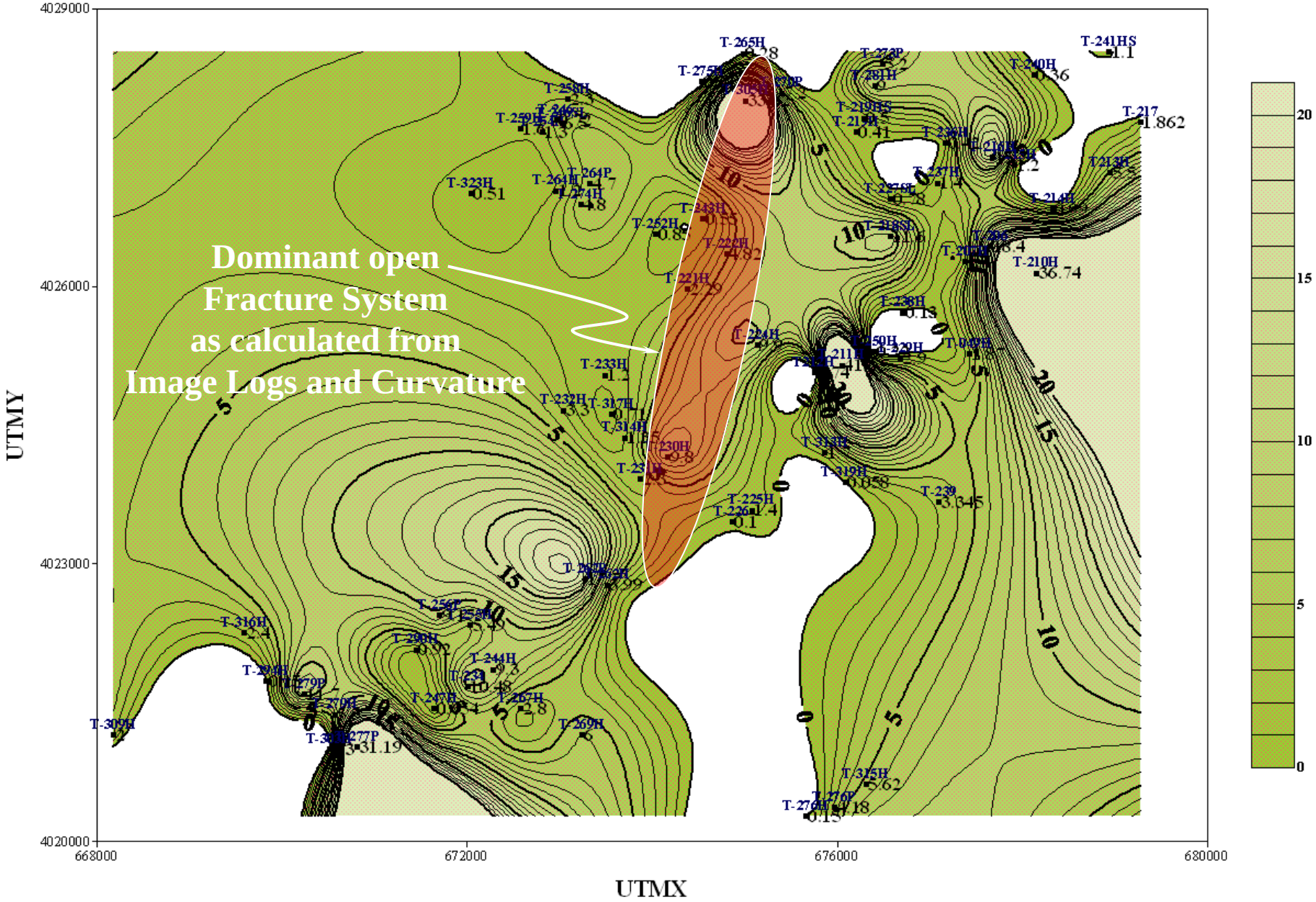


Figure 43: FFT – Standardized Fracture Intensity – posted at horizontal mid-point, min curve gridding