# Can a Fractured Reservoir be Characterised without BHI Data? A Carbonate Field Example from the Sicily Channel, Italy

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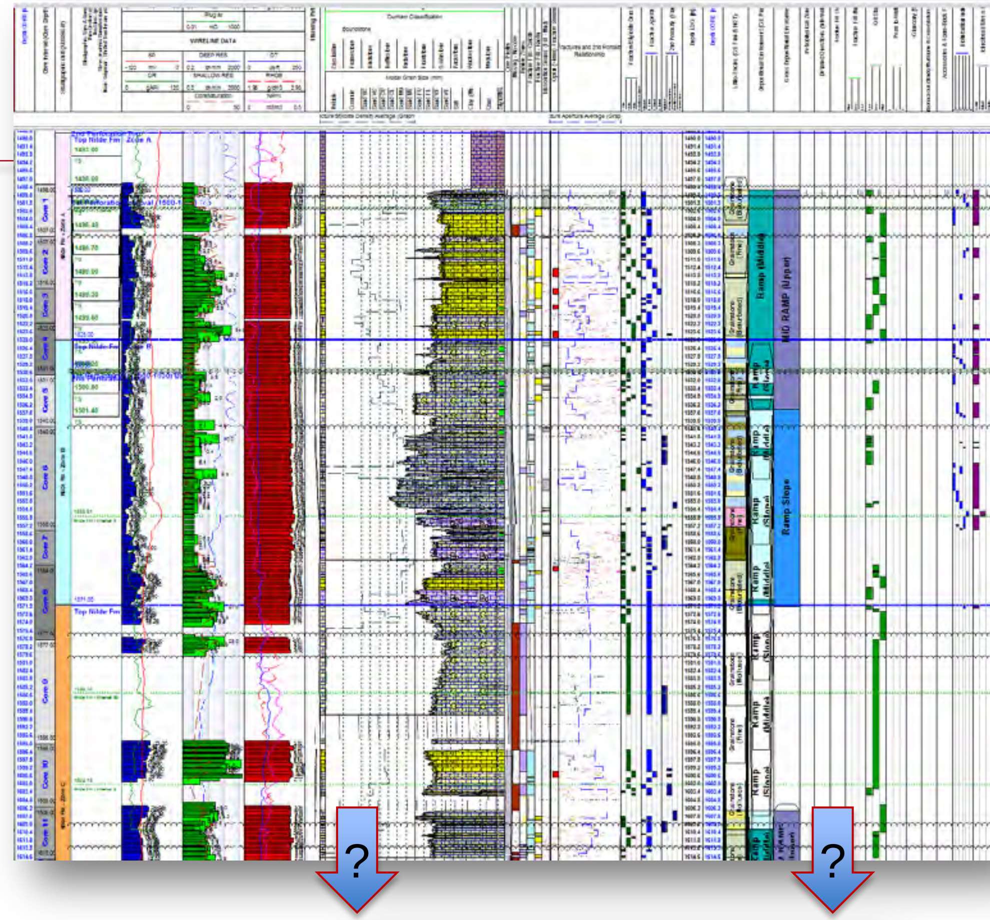
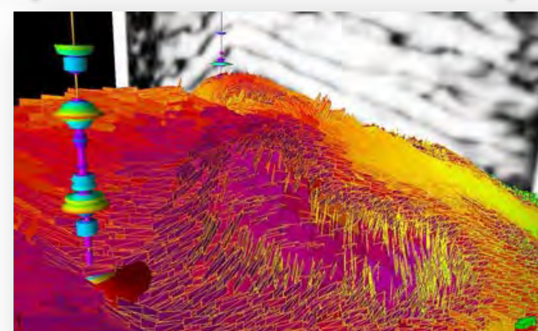
**Presented By: Dr. C. Cubitt, Jan 18th 2017, Larnaca, Cyprus**

# Agenda

- **The premise of the project**
- **Characterisation**
- **Analysis**
- **Discussion**
- **Conclusions**
- **Acknowledgements**



Note: Generic Petrel fracture model illustrated (from Schlumberger, 2017)

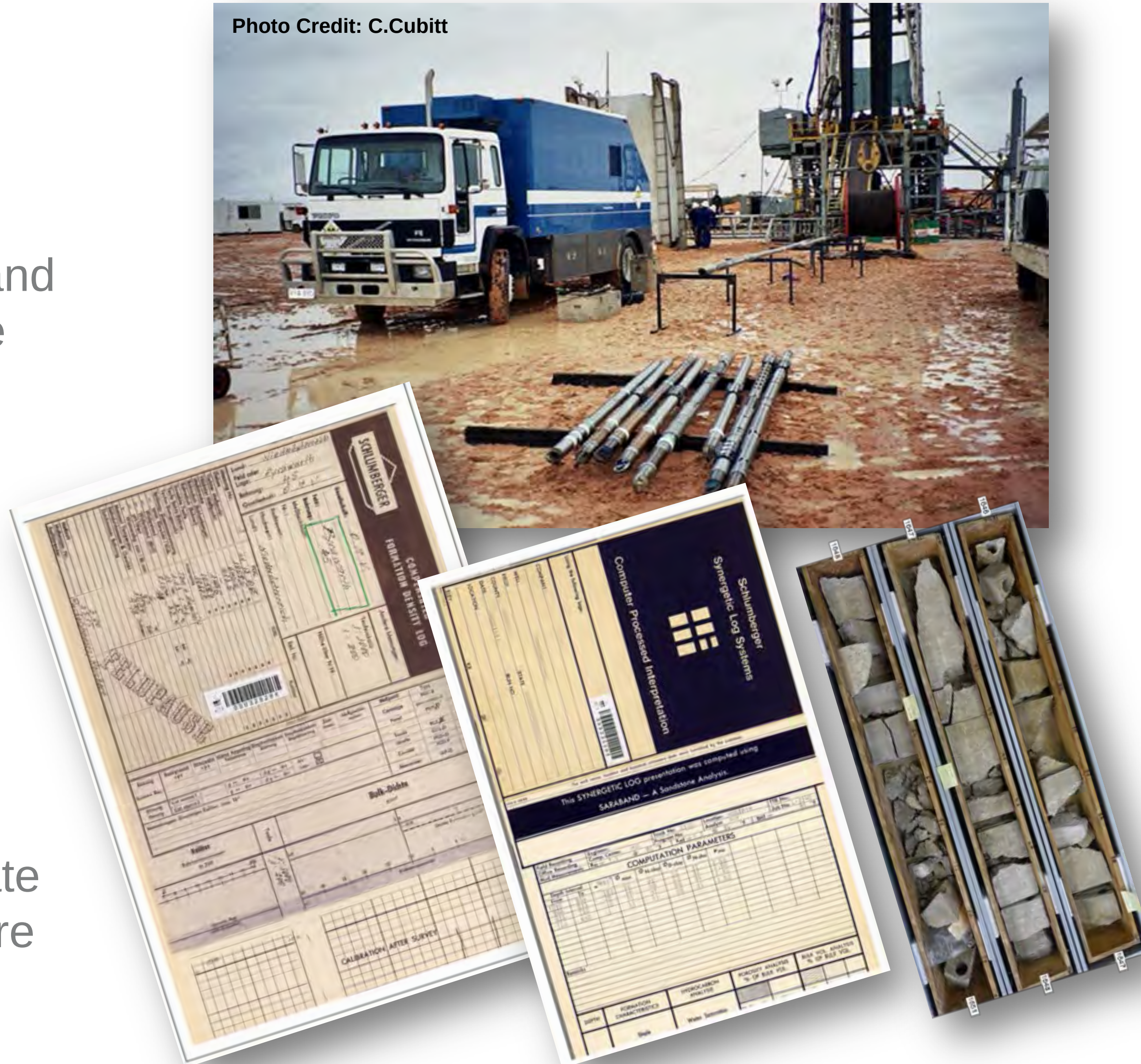
# But First, An Introduction

**The Problem………**

- More and more the global E&P industry is having to make critical economic decisions using old (early and pre-1990's) and incomplete data sets. Can we still use these data to make these decisions?....

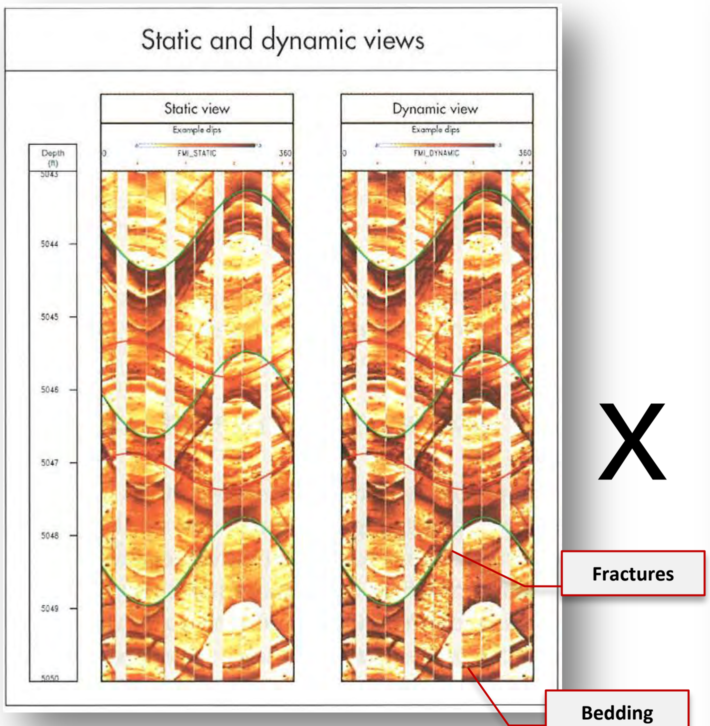
*We have to! We no choice.*

- But can we, for instance, characterise (and maybe model) a fractured carbonate reservoir without critical bore hole image (BHI) fracture data?



# ….. Yes We Can……to a Degree!

The following presentation and associated abstract outlines just how this can be achieved!




From: Poeppelreiter, M., Garcia-Carballido, C., Kraaijveld, M.A. (eds) (2010): Dipmeter and Borehole Image Log Technology. AAPG Memoir 92. AAPG, Tulsa, Oklahoma.

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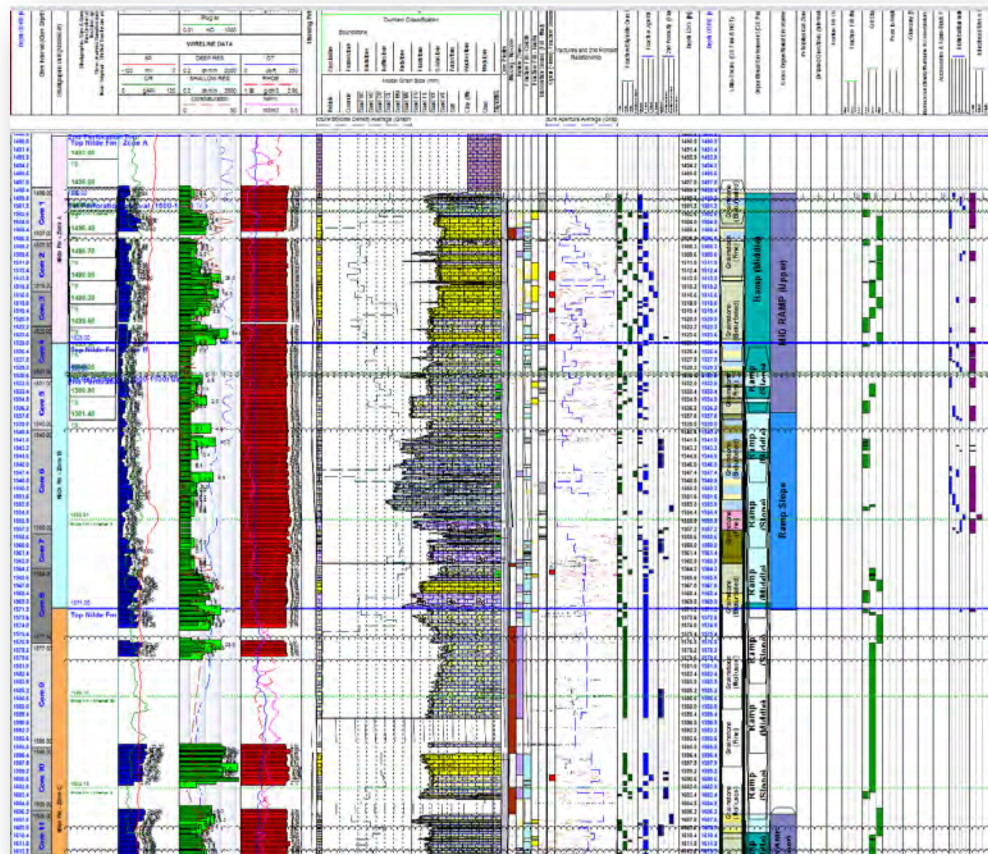
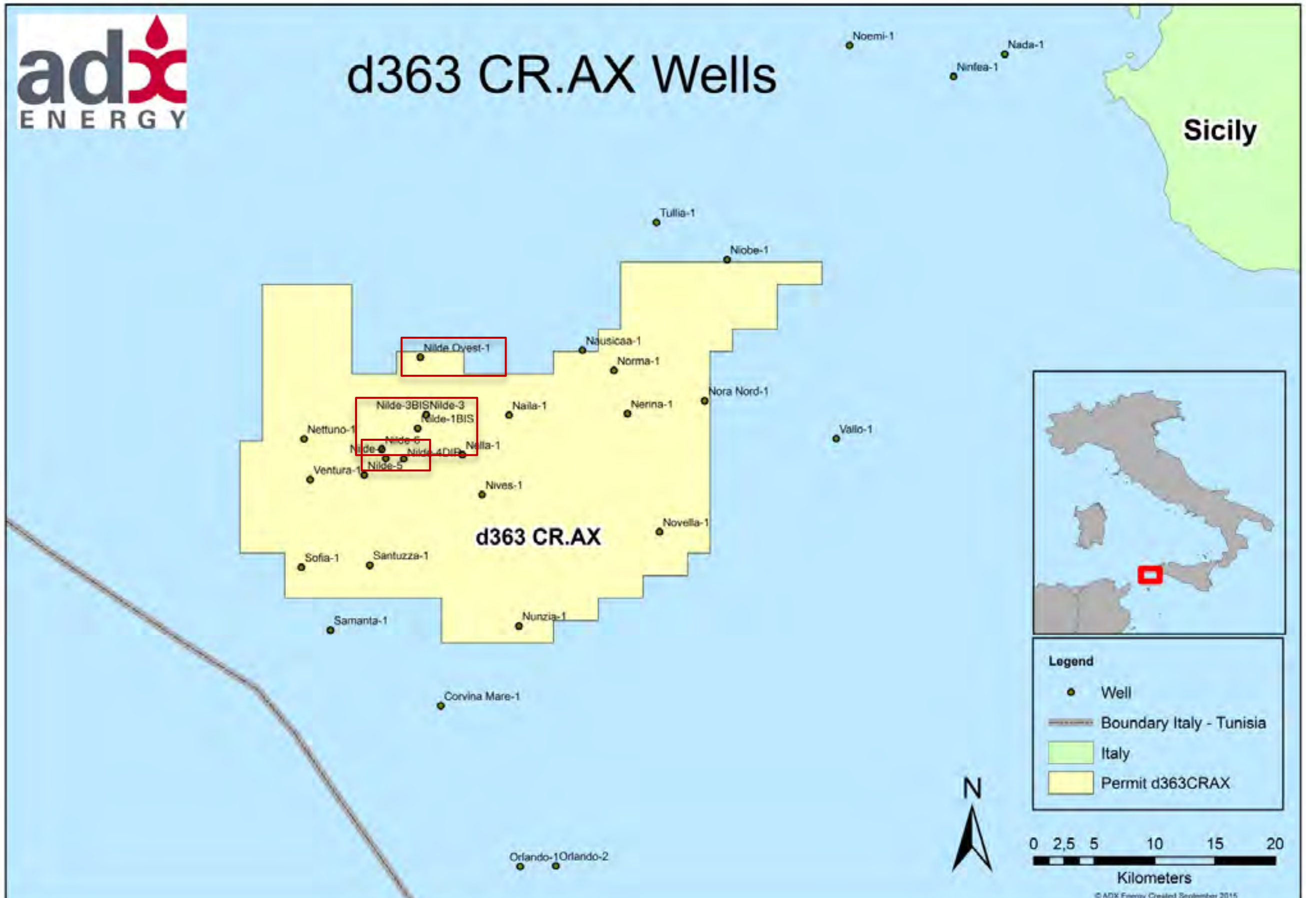
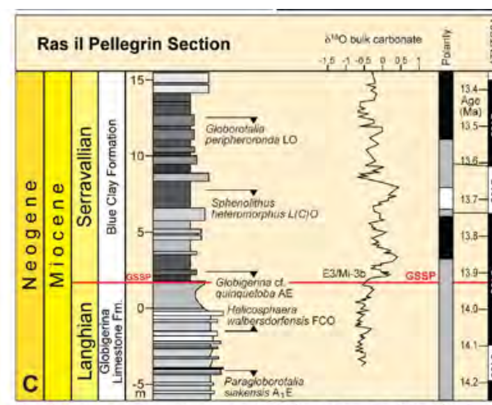


✓

# The Case Study Region & Basic Facts




XXX Field reservoirs are mid-Miocene (Langhian-Serravallian) in age located in the Sicily Channel (Italian waters). The field produced for a total of 8 years (early-1980's to 1989).




Global boundary stratotype section and point (GSSP) for the Serravallian Stage at Ras il Pellegrin on Malta, showing section (A), location (B) and log and magnetobiostratigraphic and oxygen isotope data (C)

from: The Geologic Time Scale 2012, Elsevier

For more information on **GSSPs** go to ***Geologic TimeScale Foundation:*** *http://engineering.purdue.edu/Stratigraphy/gssp/index.php*

# The Case Study Field: Reservoir Stratigraphy

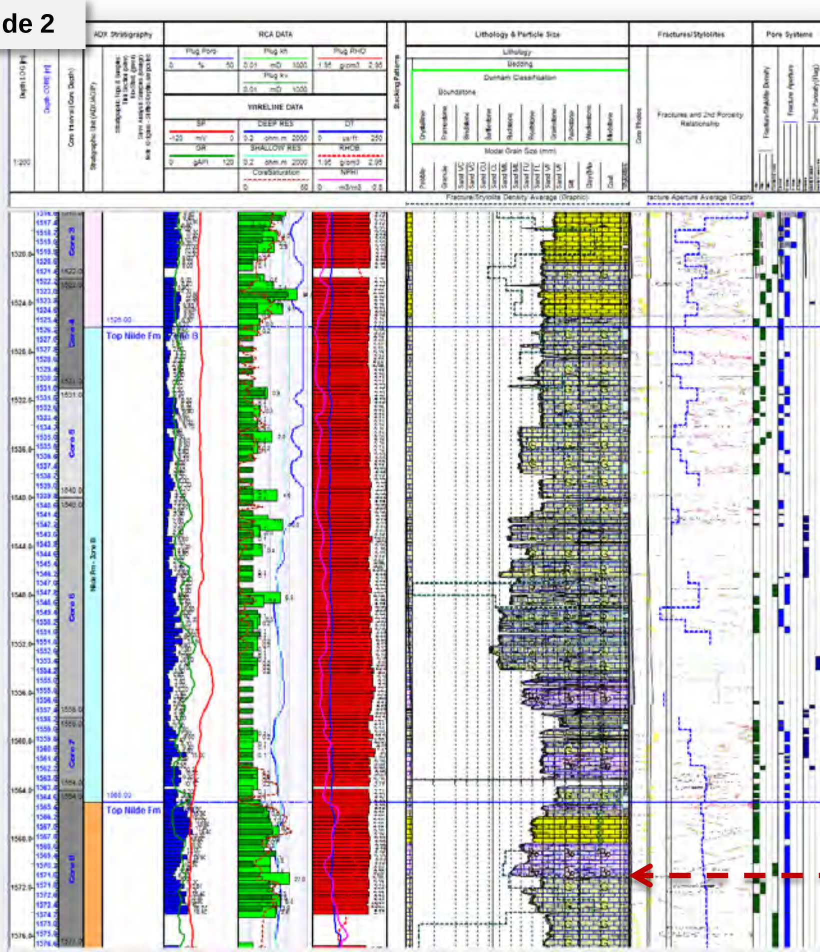
- Core and wireline defined within the regional context

Nilde 2

Zone A

Zone B

Zone C



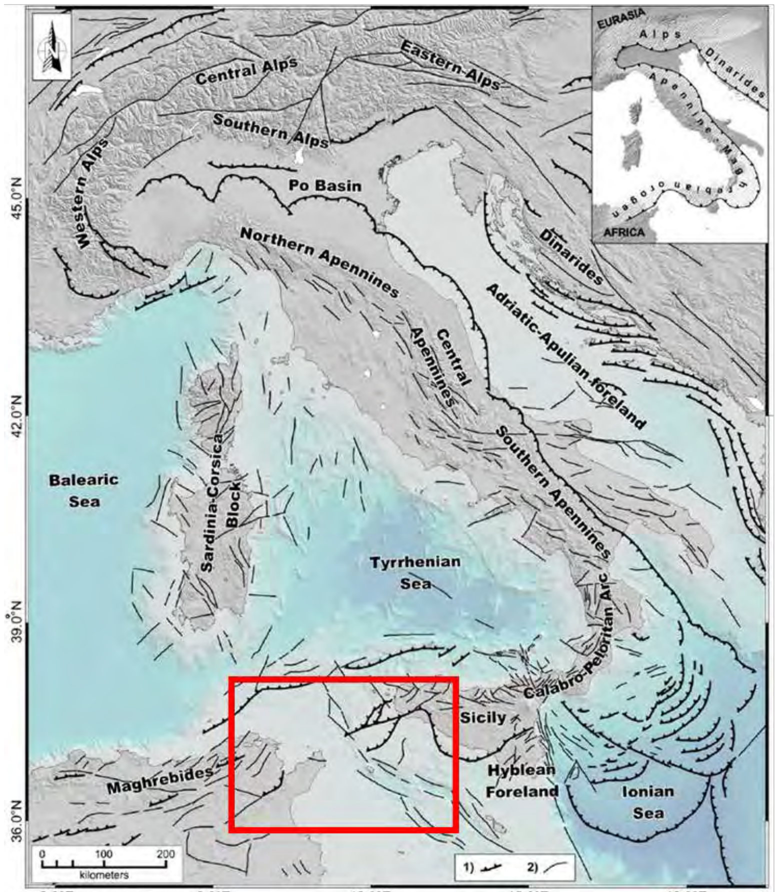


?

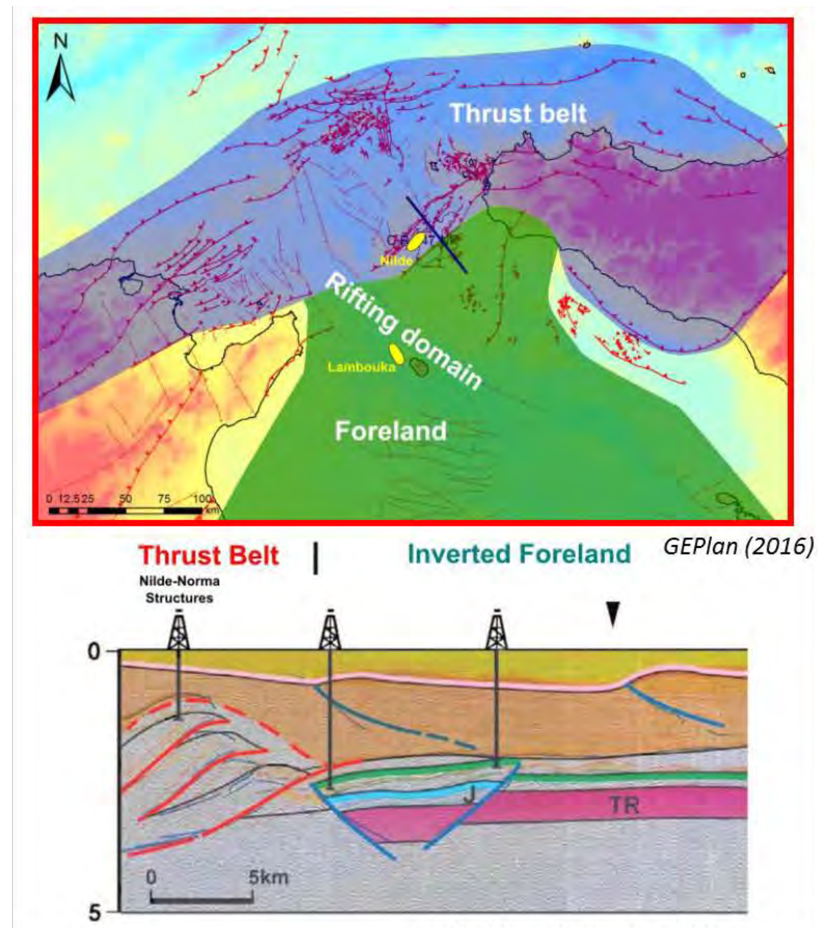
Surfaces were then ”pushed out” to non-cored intervals

# Regional Tectonics

- The northwestern side of the Sicily Channel in the central Mediterranean has been shaped by the occurrence of two independent tectonic processes that overlap each other, the Maghrebides-Apennines accretionary prism and the Sicily Channel rift




*Palano (2015)*

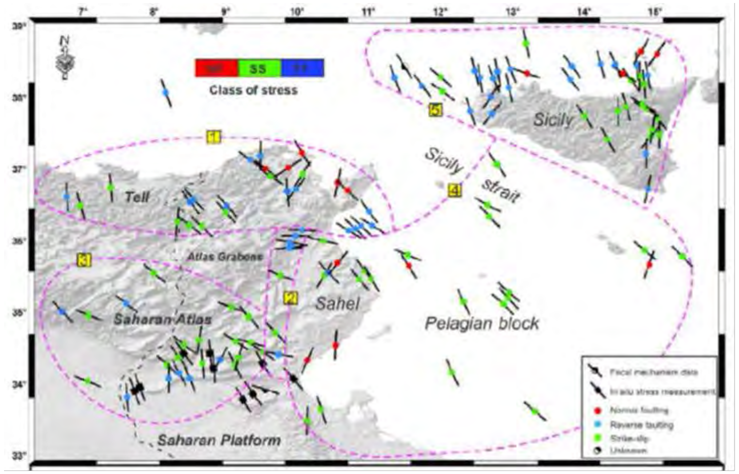



*GEPlan (2016)*

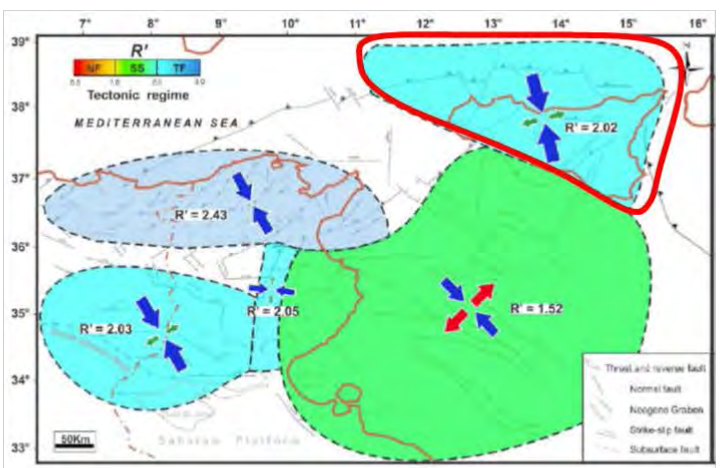
*Modified from Roure et al. (2012)*

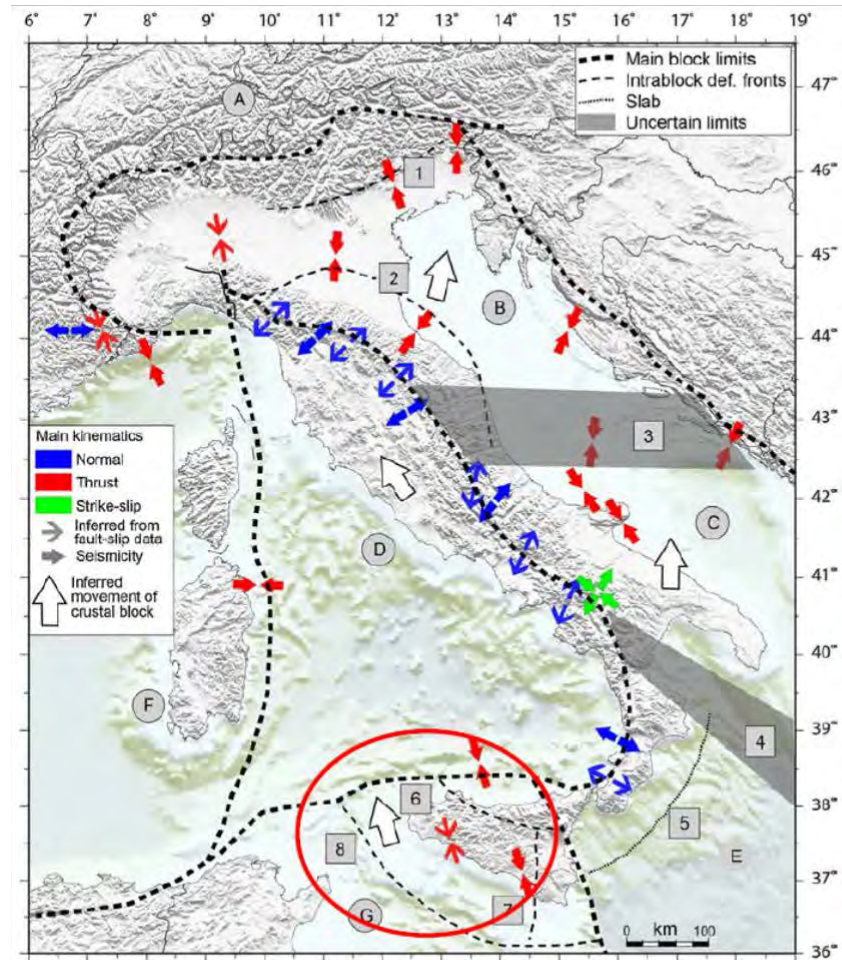
# Regional Stress

- The stress orientation (NNW-SSE) can be applied to the case study area




*Soumaya et al. (2015)*



# Case Study: Aims

**The primary aims**

- To ascertain which pore systems dominate the xxx Field reservoir
  - Fractures or vugs (secondary porosity)

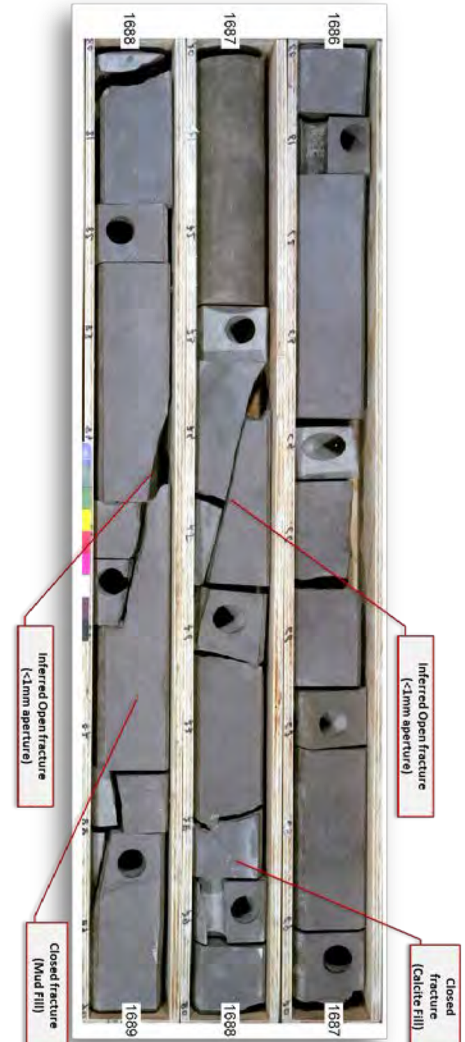
- To ascertain the contribution, if any, of the reservoir matrix porosity

- To independently assess key petrophysical assumptions and predictions

**The secondary aims:**

- To produce a continuous log of fracture density/aperture

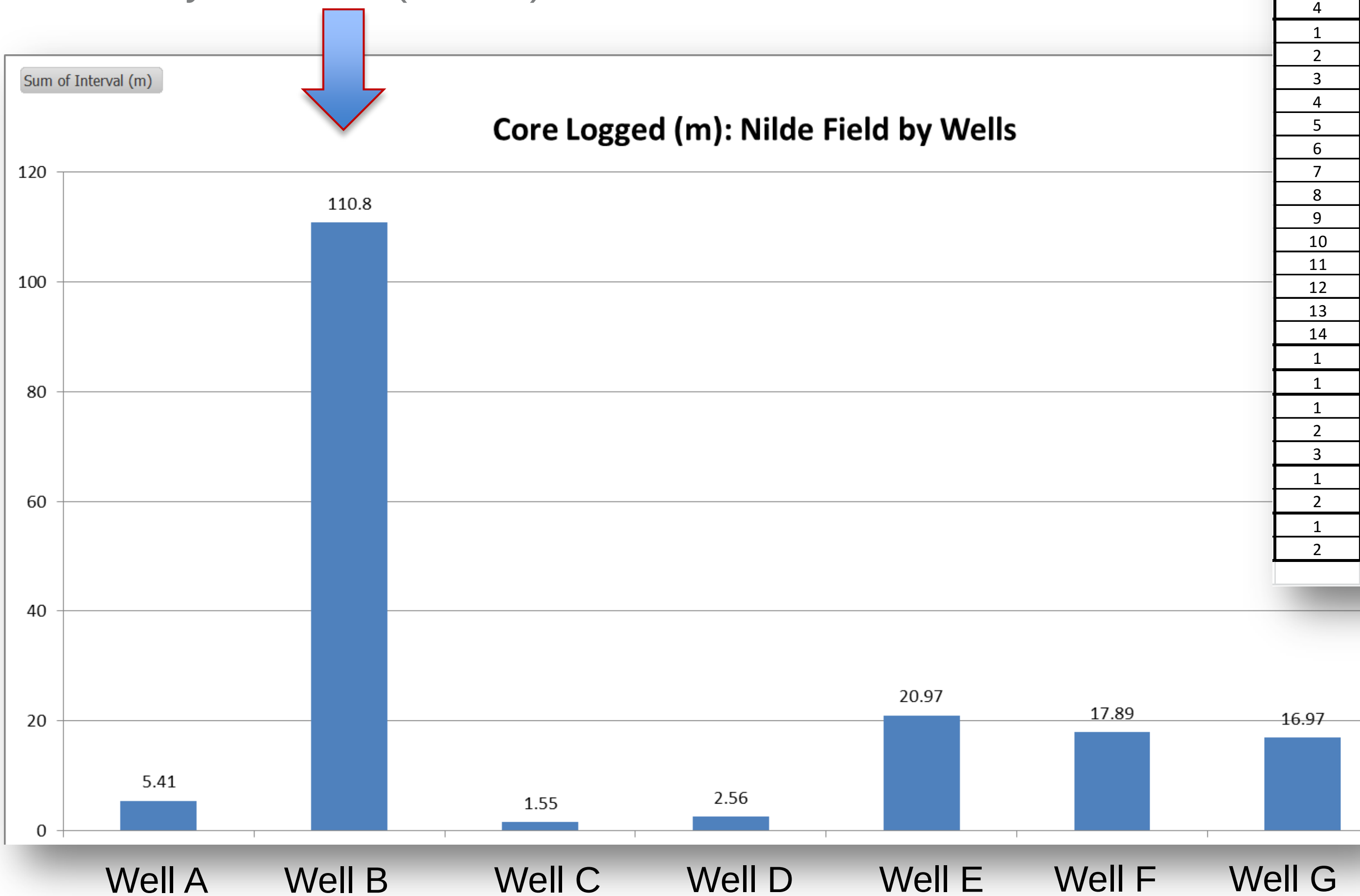
- To produce a continuous lithology/oil stain log over the coincident fracture log intervals



# Methods

# Methods: Core Logging Metrics

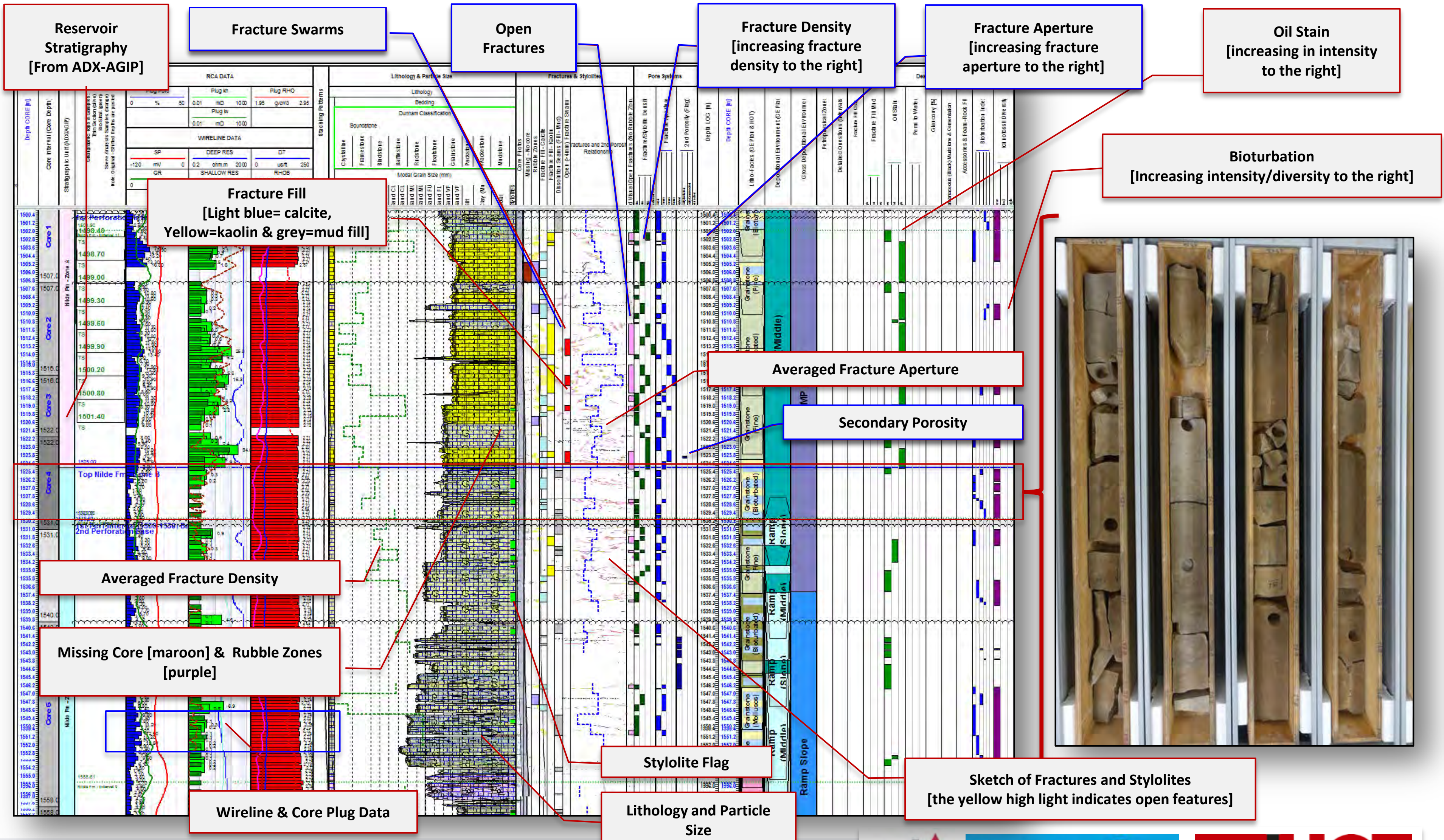
- Approximately 176m of core described
  - Mostly in Well B (~111m)



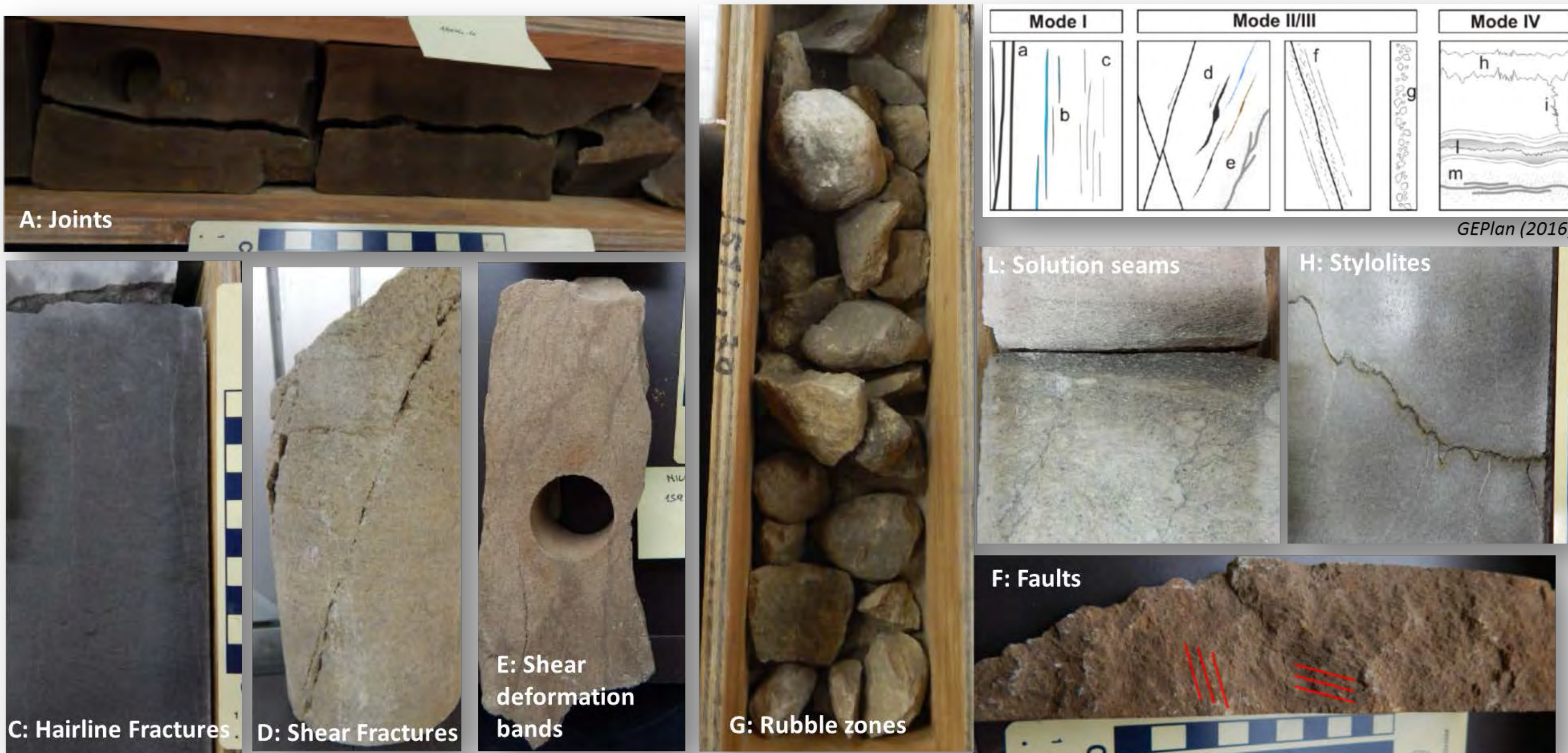

| Core No. | Top [m] | Bottom [m] | Thickness [m] | |
|---|---|---|---|---|
| 4 | 1643.00 | 1651.00 | 8.00 | Well A |
| 1 | 1498.00 | 1507.00 | 9.00 | Well B |
| 2 | 1507.00 | 1516.00 | 9.00 | |
| 3 | 1516.00 | 1522.00 | 6.00 | |
| 4 | 1522.00 | 1531.00 | 9.00 | |
| 5 | 1531.00 | 1540.00 | 9.00 | |
| 6 | 1540.00 | 1558.00 | 18.00 | |
| 7 | 1558.00 | 1564.00 | 6.00 | |
| 8 | 1564.00 | 1577.00 | 13.00 | |
| 9 | 1577.00 | 1595.00 | 18.00 | |
| 10 | 1595.00 | 1606.00 | 11.00 | |
| 11 | 1606.00 | 1615.00 | 9.00 | |
| 12 | 1615.00 | 1615.40 | 0.40 | |
| 13 | 1615.40 | 1620.00 | 4.60 | |
| 14 | 1958.00 | 1967.00 | 9.00 | |
| 1 | 1593.00 | 1602.00 | 9.00 | Well C |
| 1 | 1605.00 | 1608.00 | 3.00 | Well D |
| 1 | 1603.00 | 1612.00 | 9.00 | Well E |
| 2 | 1612.00 | 1621.00 | 9.00 | |
| 3 | 1621.00 | 1630.00 | 9.00 | |
| 1 | 1680.00 | 1689.00 | 9.00 | Well F |
| 2 | 1691.00 | 1700.00 | 9.00 | |
| 1 | 1708.00 | 1717.00 | 9.00 | Well G |
| 2 | 1717.00 | 1726.00 | 9.00 | |
| | | Total | 214.00 | |

Total available core of which 176m was described in detail

# Methods: Fracture Core Logs - A Users Guide



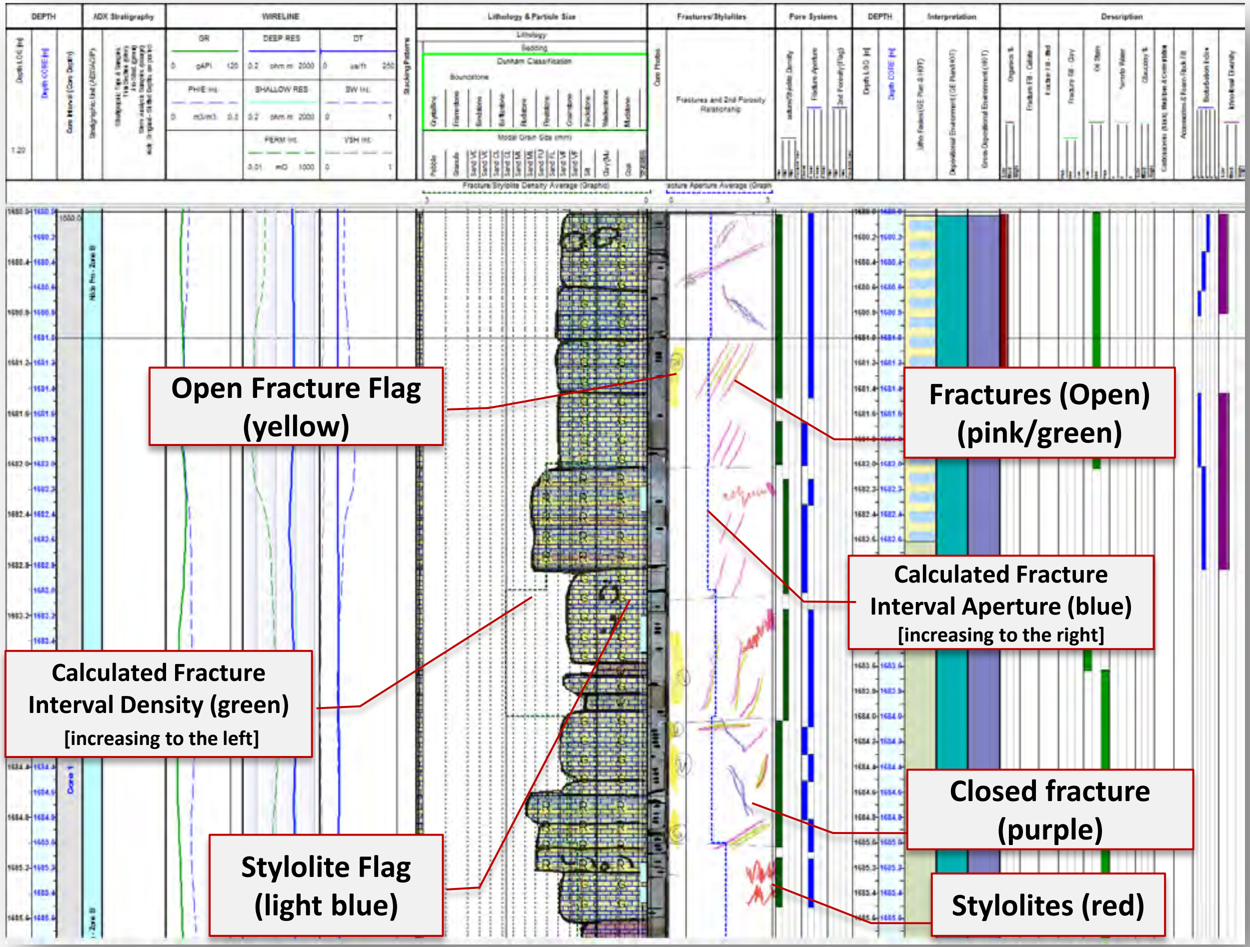
# Structural Features Observed in the Core

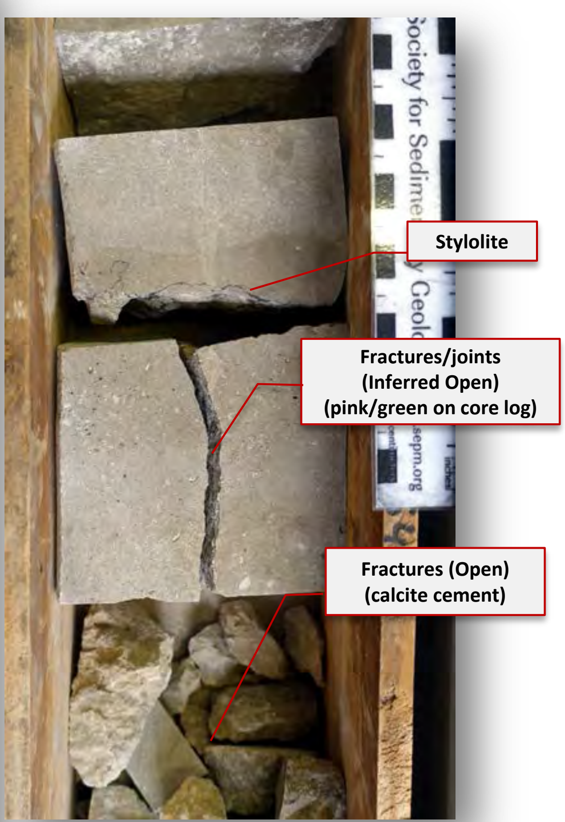



*GEPlan (2016)*

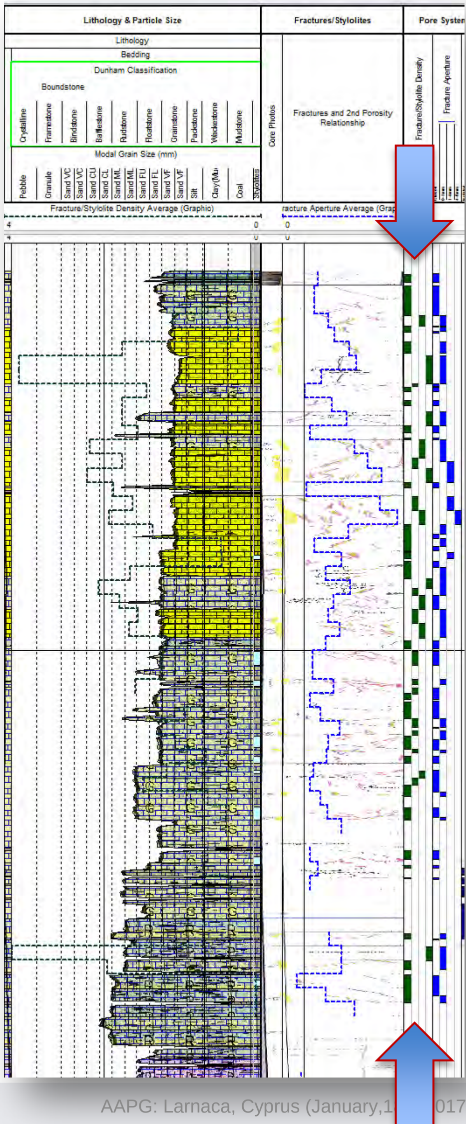
# Methods: Core Log Fractures and Stylolites

- Sketches show relative location of fractures/stylolites, orientation (core only) and if they are **open or closed**

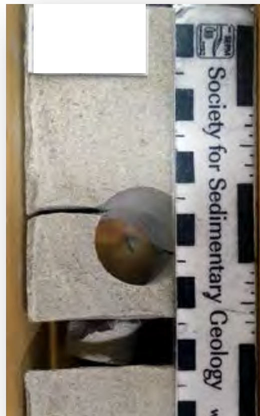


# Methods: Core Log Fracture Density

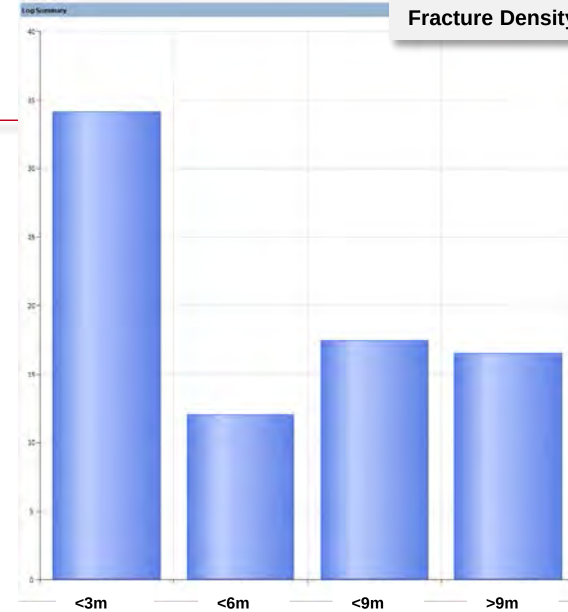



No Fractures

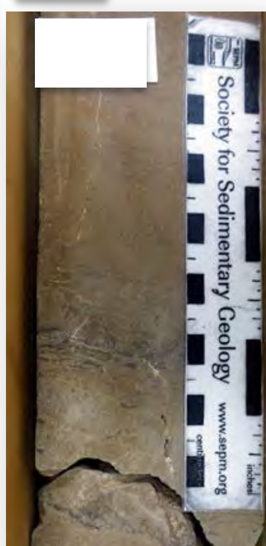



<3/m


Fracture Density




<6/m

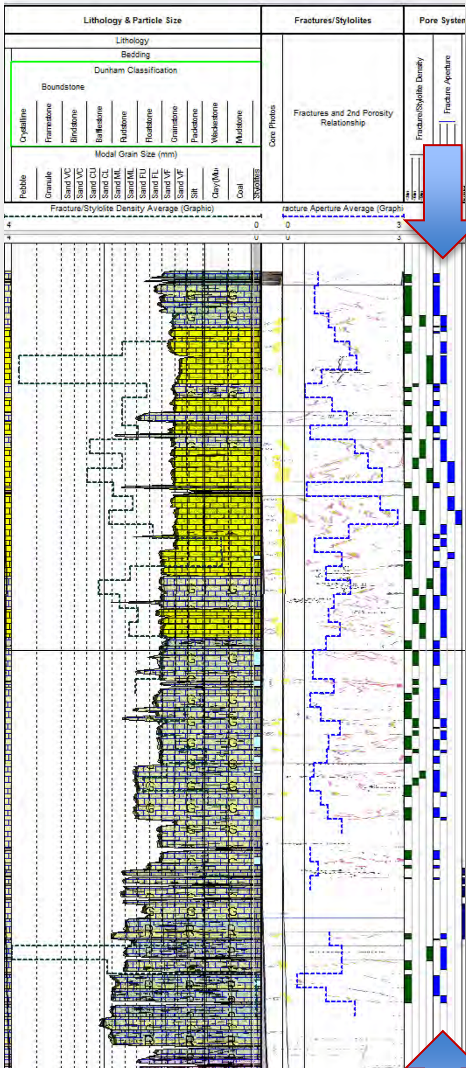



<9/m

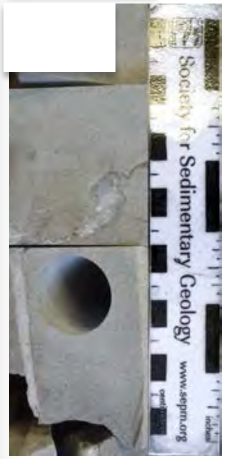

>9/m


Stylolites

# Methods Core Log Fracture Aperture



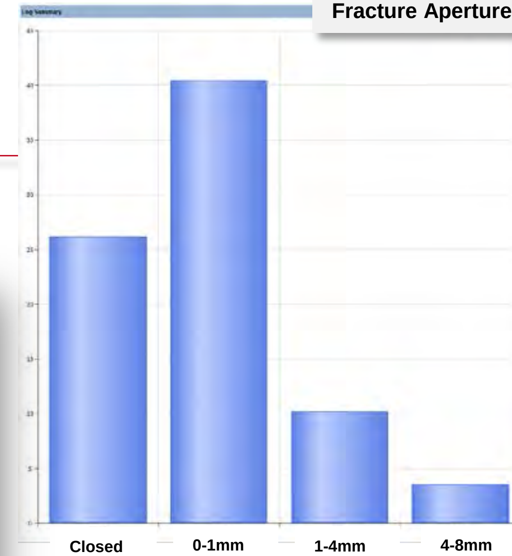

Closed




Open: 0 – 1mm



Fracture Aperture




Open: 1 – 4mm

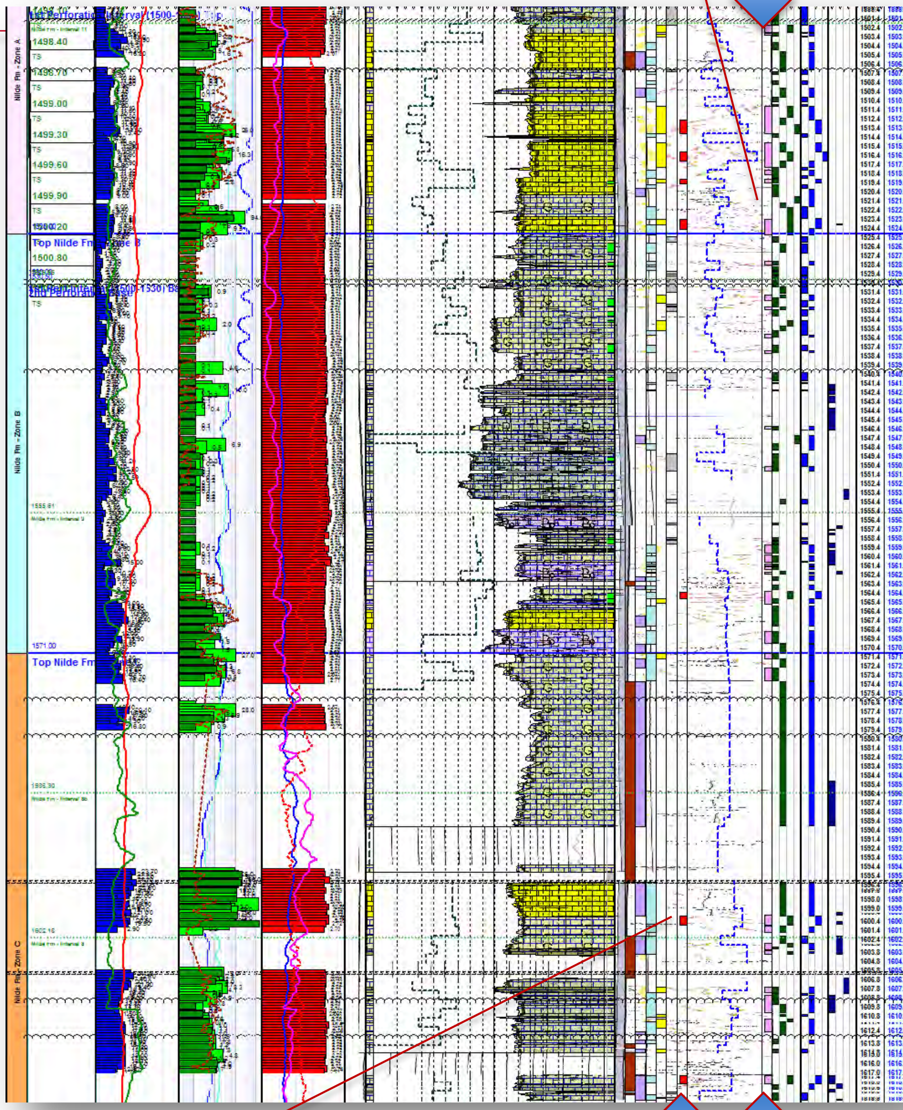


Open: 4 – 8mm

# “Rolled Up” Open Fracture Flag: The Key

- **All inferred & visible open fractures are flagged (pink). However open fractures in the rubble zones are not counted**

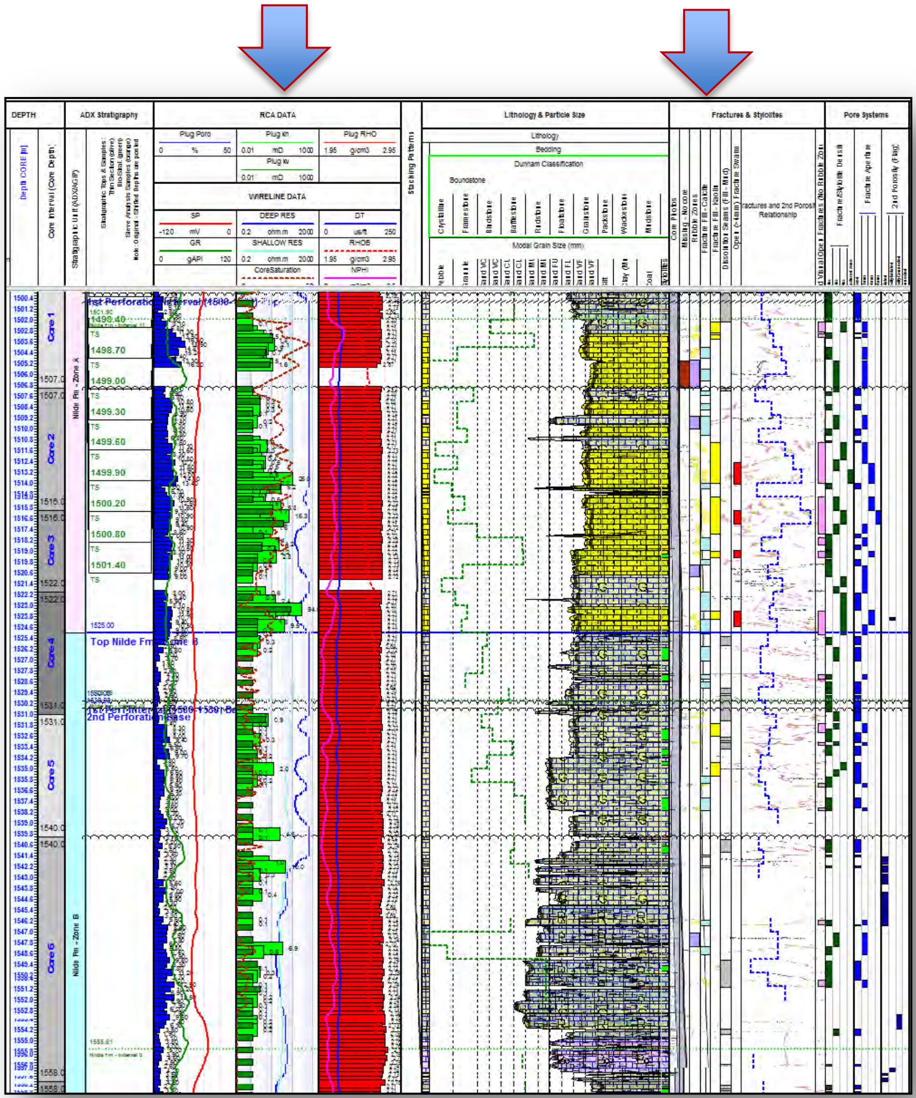
- The fractures swarms (shear zones) are counted as open fractures (of course) and can be broken out by looking at the red flag on all core logs



# Results & Discussion

# The Premise….

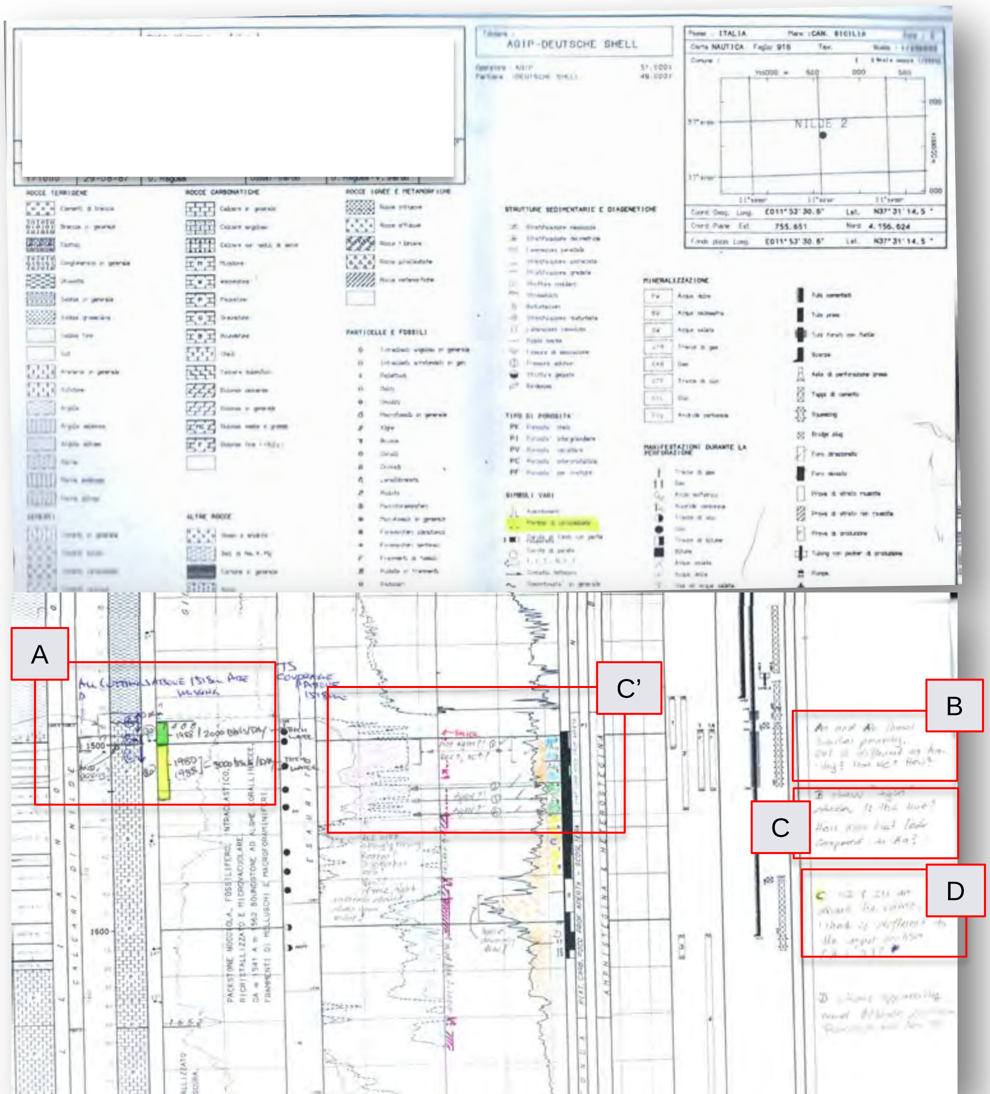
- Can core-based data be used to help define a perceived unconformity at the top of the reservoir?
- Does the wireline (petrophysics) match the core? Can we use the core as an independent check?



# Petrophysical vs Core Observations: Summary

Questions

- ✓ **A.** Is there a barrier between perforation intervals? *Yes 2-3m of calcite cement was observed in thin section across the upper zone*
- ✓ **B.** Reservoir zones Aa and Ab show similar porosity BUT the resistivity is different in Aa. Why? Lithology change with heavier HC stain in the Aa zone (more shells and less algal material)
- ✓ **C.** Reservoir zone B shows tight streaks (C'). Is this true? Yes.
- ✓ **D.** ILD and SN have a similar response. What is different to the upper section? (Zones A& B). The difference corresponds with a lithology change
- ✓ In general the core plug and wireline porosities match well



# Stratigraphy: Is there a Physical Expression of Top Reservoir?

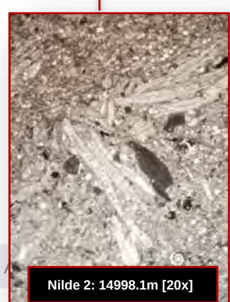
## Question

A. Is there a barrier between perforation intervals?

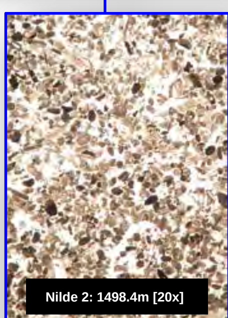
*Answer (A): Yes (in Well B at least) where 2-3m of calcite cement was observed in thin section across the upper zone*

| Depth (m) | TS From? | Top Seal or Reservoir | Dominant Framework Component | Dominant Matrix Component | Interpretation | Plug No | Porosity (RCA) | Permeability (RCA) |
|---|---|---|---|---|---|---|---|---|
| 1485 | Drill Cuttings | Top Seal | Pellets | Micrite | | N/A | N/A | N/A |
| 1493 | Drill Cuttings | Reservoir | Pellets | Micrite | | N/A | N/A | N/A |
| 1498 | Drill Cuttings | Reservoir | Pellets | Micrite | | N/A | N/A | N/A |
| 1498.1 | Core Plug | Reservoir | Pellets, forams, shells | Micrite | | 1 | 9.5 | 0.1 |
| 1498.4 | Core Plug | Reservoir | Pellets, forams | Crystaline | UC | 4 | 0 | 4.6 |
| 1498.7 | Core Plug | Reservoir | Forams, algae, shells (min) | Crystaline | UC | 7 | 0.1 | 9.1 |
| 1499 | Core Plug | Reservoir | Forams, algae, shells | Crystaline | UC | 10 | 0.1 | 10.2 |
| 1499.3 | Core Plug | Reservoir | Forams, shells, bitumen | Crystaline | UC | 13 | 0.1 | 8.2 |
| 1499.6 | Core Plug | Reservoir | Red algae, forams | Crystaline | UC | 16 | 0.1 | 6.7 |
| 1499.9 | Core Plug | Reservoir | Foram, pellets | Crystaline | UC | 19 | 0.1 | 3.3 |
| 1500.2 | Core Plug | U/C Reservoir | Micrite/foram (sparry) | Crystalline/Micrite | UC | 22 | 0 | 3.3 |
| 1500.8 | Core Plug | Reservoir | Forams (Heterostegne) | Micrite | | 28 | 0.1 | 5.4 |
| 1501.4 | Core Plug | Reservoir | Forams, bitumen | Micrite | | 34 | 0 | 2.6 |

Some calcite cement, low porosity



Nilde 2: 14998.1m [20x]

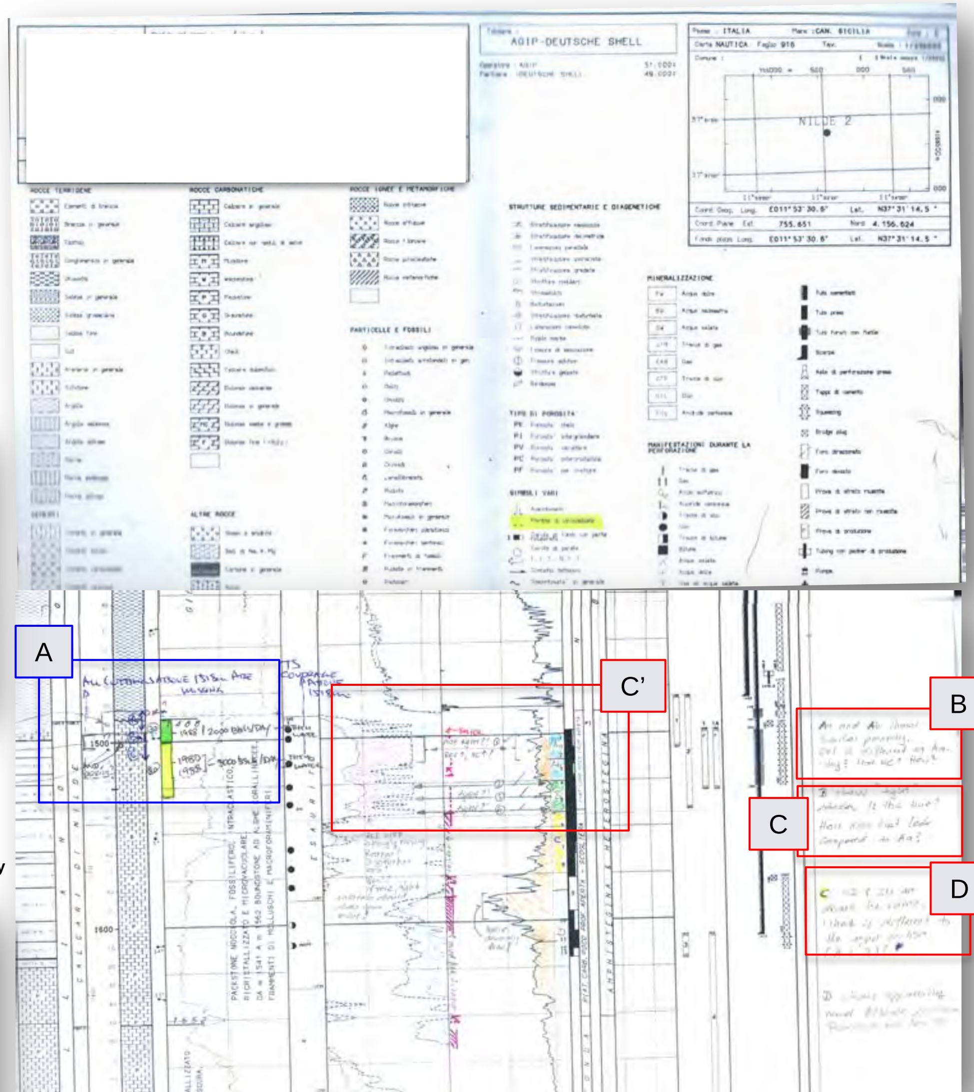


Nilde 2: 1498.4m [20x]

Calcite cement, no porosity

Some calcite cement, low porosity

Nilde 2: 1500.8m [20x]

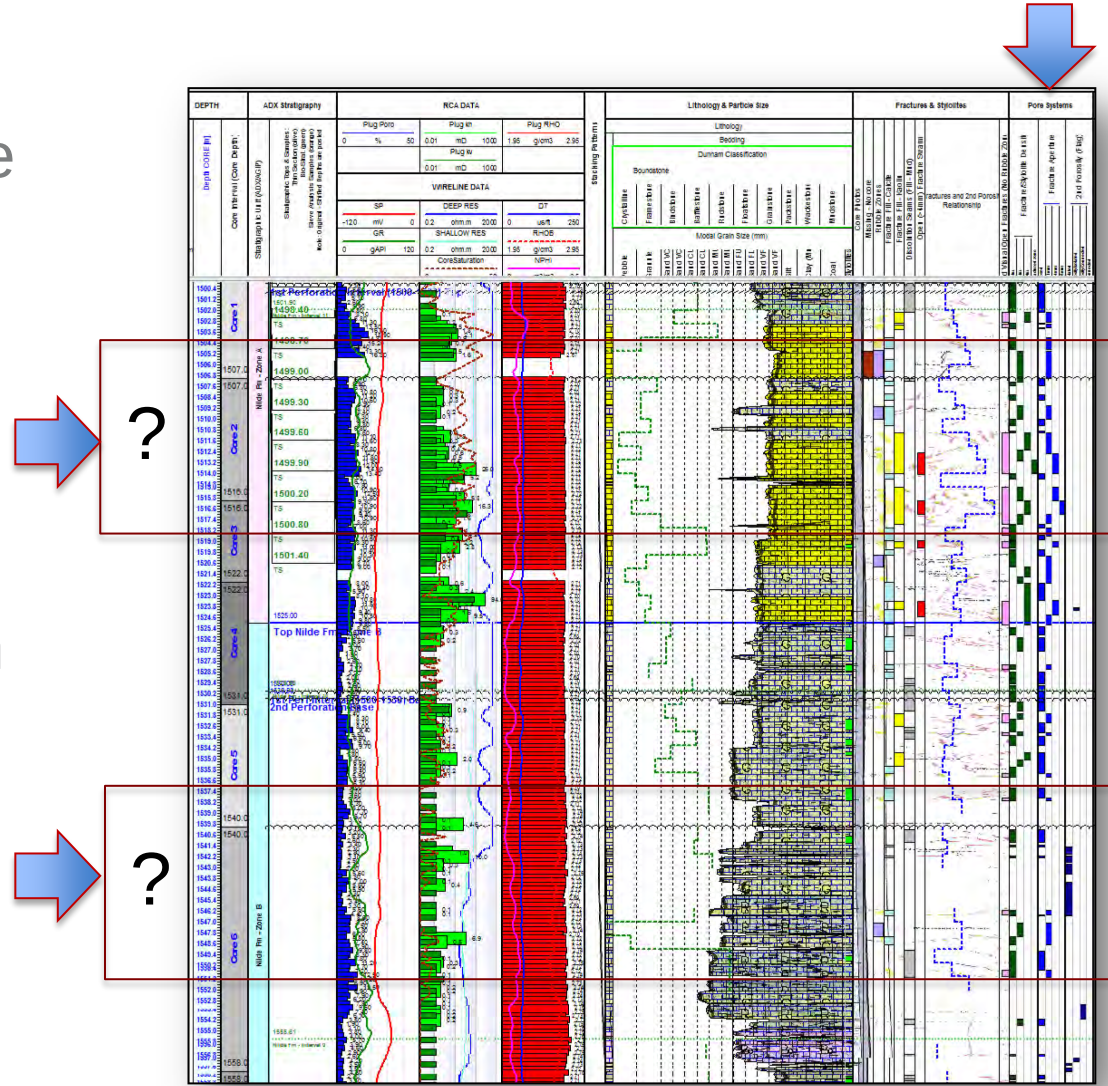


# Summary of Results

- **Stratigraphy:** Quick look thin section analysis did reveal a 2-3m thick spar calcite zone that is interpreted to be associated with the top reservoir unconformity
- **Petrophysics:** The wireline dataset was deemed to be accurately reflecting the nature of the reservoir with core and wireline independently verified.
- **Pore Systems:** Matrix porosity was observed throughout with oil stain intensity varying with the matrix porosity. However matrix porosity does not equate with productivity. Productivity is coincident with fracture swarms.
- **Fracture Characterisation:** It was ascertained that fractures, not vugs (secondary porosity) are the dominant porosity type. Fracture density is related to lithology. Fracture swarms were identified and correlate with the most productive DST/production zones
- **Core/BHI-Based Fracture Data:** Core-based data used instead of BHI data. However long continuous cored intervals must be used and a detailed, continuous and standardised recording of fractures needs to be made

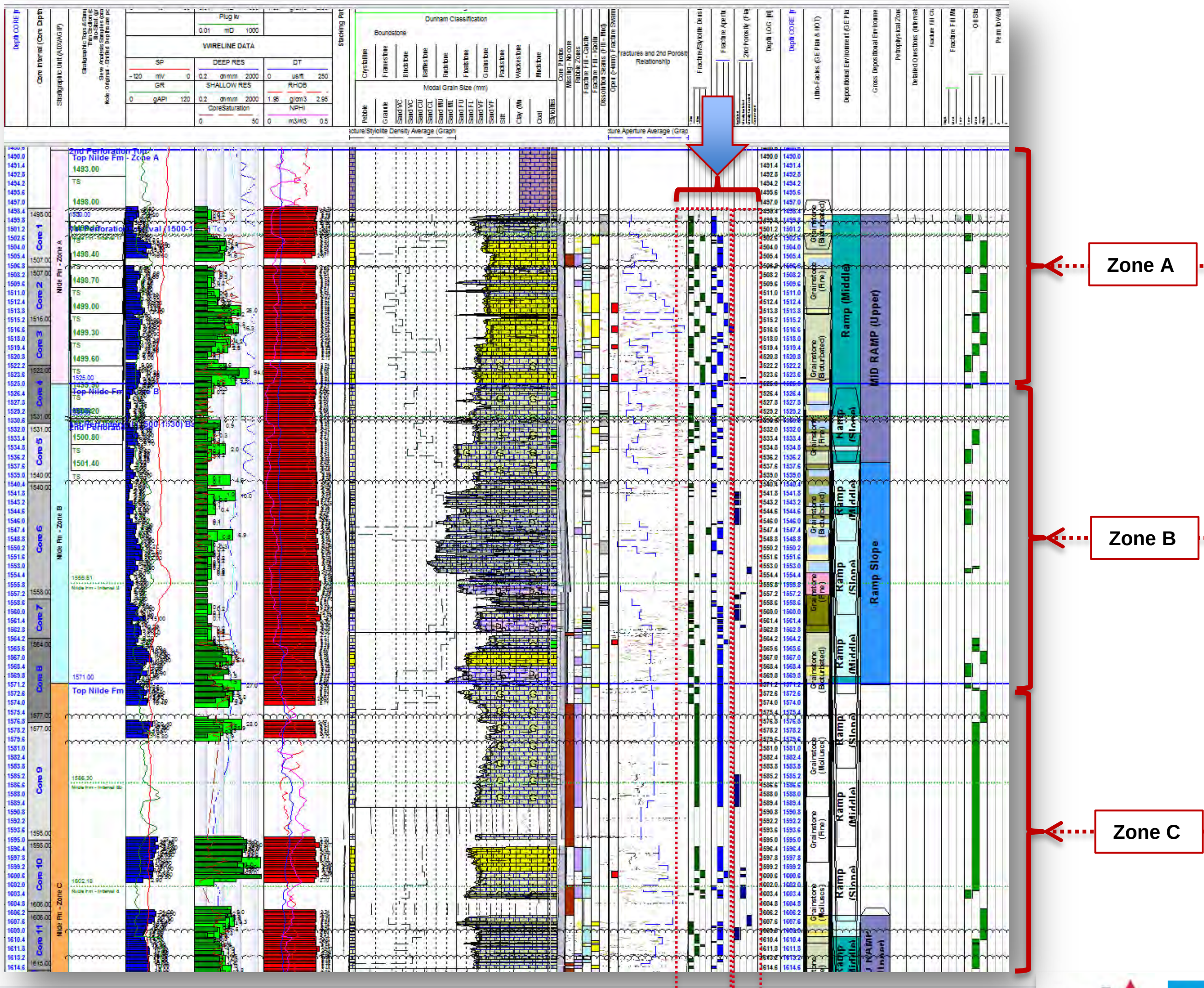
# The Premise….

- Can core-based data be used to  discriminate between pore systems (in the absence of BHI data)?
- Can we ascertain which pore system(s) is contributing most to production?

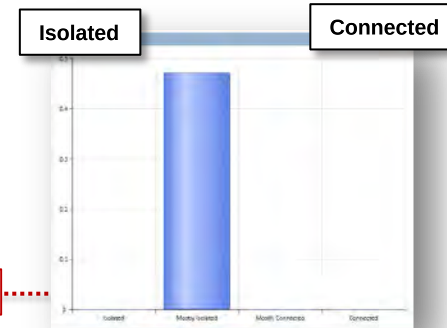


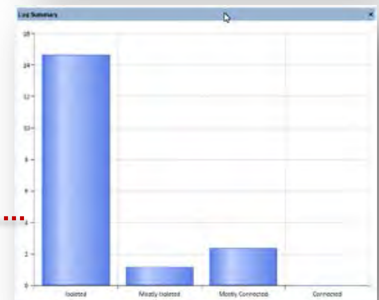
# Summary - Fracture vs Vugs (Zones A, B & C)

- **Fracture dominate, secondary ø is not a significant pore type**



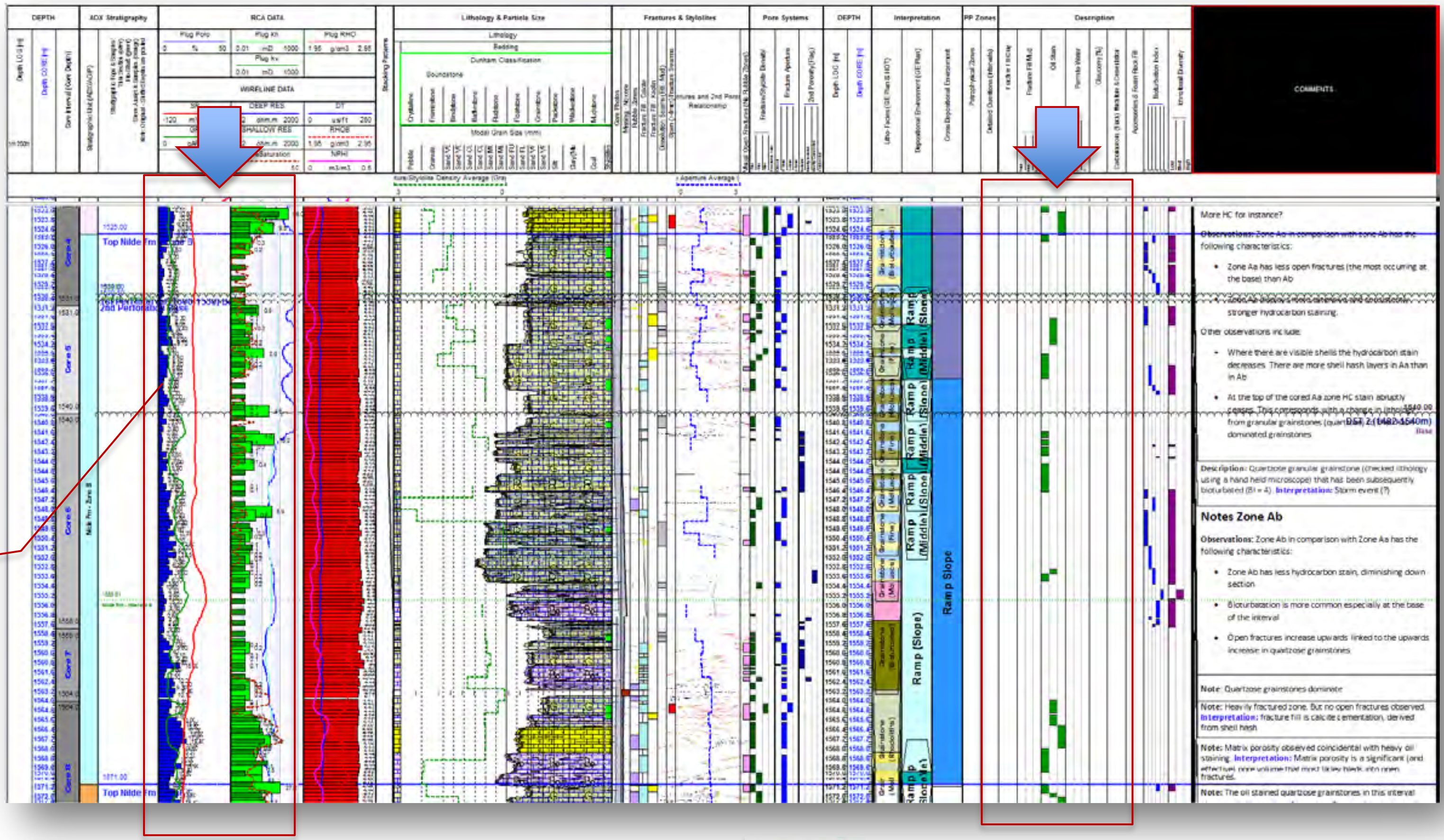

**Secondary Porosity**



# Discussion: Pore Systems - Matrix

- Matrix is not the main productive pore system (from RE observations). However this notion is also reflected in core plug data where the best producing zones correspond with fracture swarms not elevated matrix permeability



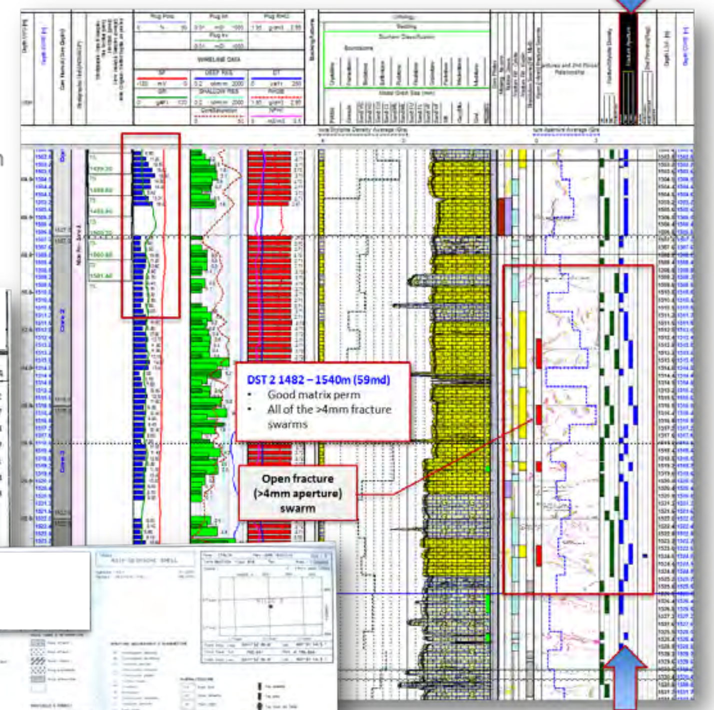
Core plug poro-perm trends somewhat match oil staining trends (especially in the middle but this does not equate with most productive intervals)

# Discussion - Reservoir Productivity and Fracture Swarms

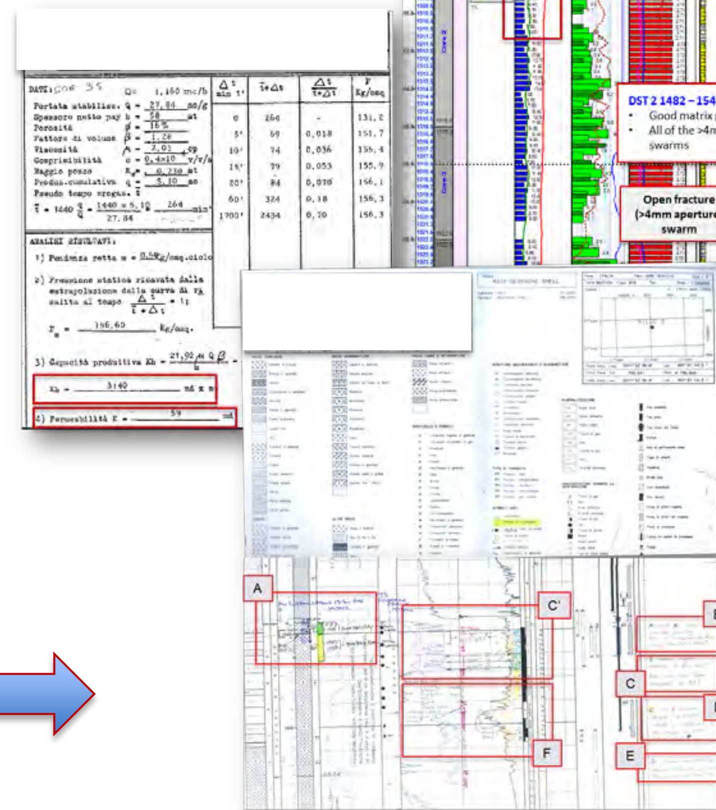
- The reservoir engineering investigations focused on the outcomes of key DST's, production history matching and future production scenarios.

- Four fracture swarms sustaining very high permeability

Covers most of Zone A – Less than 3140md (Official ENI Results) pre-acidising. Up to 26md matrix. Contains all of the >4mm fracture swarm zones (red)



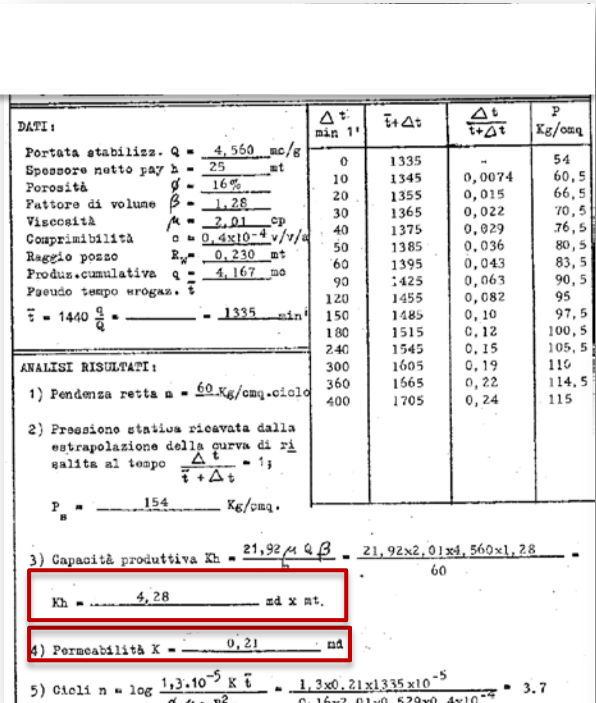

- Petrophysical reviews were undertaken to determine if the early 1980's vintage wireline log data was up to the task of deriving permeability and saturation height modelling.




- Confidence in the wireline data was achieved by investigating log response versus core observations.

# Fracture Pore Systems: DST 1 (1482 – 1507m) - Zone A

- **Covers most of Zone A – Less than 1md (official results). Pre-acidising. *No fracture swarms* and thus no significant permeability (matrix only).**



DATI:

Portata stabilizz. Q = 4,560 mc/g
Spessore netto pay h = 25 mt
Porosità $\phi$ = 16%
Fattore di volume $\beta$ = 1,28
Viscosità $\mu$ = 2,01 cp
Comprimibilità c = $0,4\times10^{-4}$ v/v/a
Raggio pozzo $R_w$ = 0,230 mt
Produz.cumulativa q = 4,167 mc
Pseudo tempo erogaz. $\bar{t}$

$\bar{t} = 1440 \frac{q}{Q}$ = ______ = 1335 min'

| $\Delta t$ min 1' | $\bar{t}+\Delta t$ | $\frac{\Delta t}{\bar{t}+\Delta t}$ | P Kg/cmq |
|---|---|---|---|
| 0 | 1335 | - | 54 |
| 10 | 1345 | 0,0074 | 60,5 |
| 20 | 1355 | 0,015 | 66,5 |
| 30 | 1365 | 0,022 | 70,5 |
| 40 | 1375 | 0,029 | 76,5 |
| 50 | 1385 | 0,036 | 80,5 |
| 60 | 1395 | 0,043 | 83,5 |
| 90 | 1425 | 0,063 | 90,5 |
| 120 | 1455 | 0,082 | 95 |
| 150 | 1485 | 0,10 | 97,5 |
| 180 | 1515 | 0,12 | 100,5 |
| 240 | 1545 | 0,15 | 105,5 |
| 300 | 1605 | 0,19 | 110 |
| 360 | 1665 | 0,22 | 114,5 |
| 400 | 1705 | 0,24 | 115 |

ANALISI RISULTATI:

1) Pendenza retta m = 60 Kg/cmq.ciclo

2) Pressione statica ricavata dalla estrapolazione della curva di risalita al tempo $\frac{\Delta t}{\bar{t}+\Delta t} = 1$;

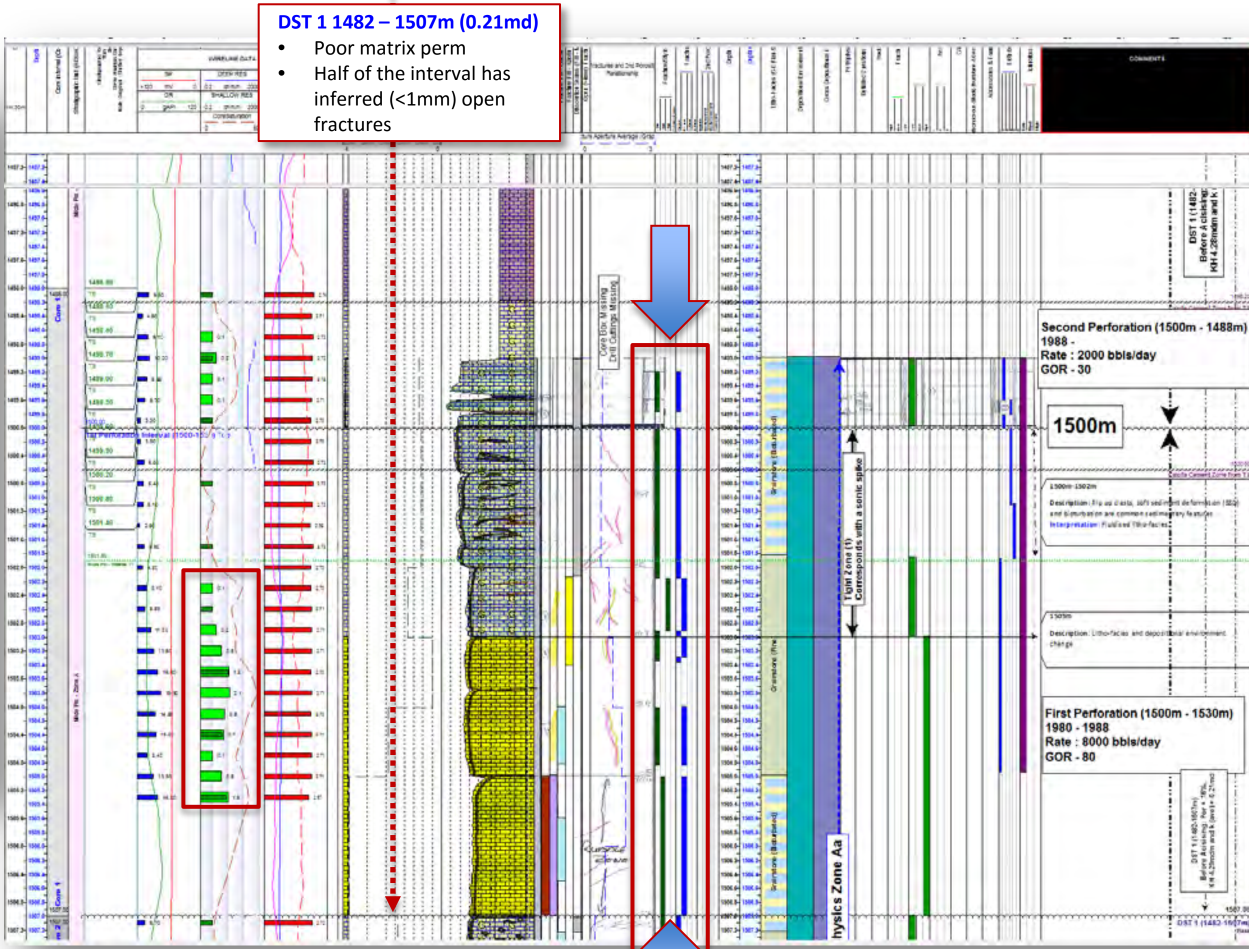
$P_s$ = 154 Kg/cmq.

3) Capacità produttiva Kh = $\frac{21,92\,\mu\,Q\,\beta}{m} = \frac{21,92\times2,01\times4,560\times1,28}{60}$ =

Kh = 4,28 md x mt.

4) Permeabilità K = 0,21 md

5) Cicli n = log $\frac{1,3\cdot10^{-5}\,K\,\bar{t}}{\phi\,\mu\,c\,R_w^2} = \frac{1,3\times0,21\times1335\times10^{-5}}{0,16\times2,01\times0,529\times0,4\times10^{-4}}$ = 3.7






adx ENERGY  GEPlan Consulting Petroleum GeoSciences  HOT

# Fracture Pore Systems: DST 2 (1482 – 1540m) - Zones A & B

- **HOWEVER *Four fracture swarms* sustaining very high permeability**

- Covers most of Zone A – 3140md (Kave) (official results) pre-acidising. Up to 26md matrix. Contains all of the >4mm fracture swarm zones (red)

DATI: COP 35 $Q =$ 1,160 mc/h

Portata stabilizz. $q$ = 27,84 mc/g
Spessore netto pay $h$ = 58 mt
Porosità $\phi$ = 16 %
Fattore di volume $\beta$ = 1,28
Viscosità $\mu$ = 2,01 cp
Comprimibilità $c$ = 0,4x10 v/v/a
Raggio pozzo $R_w$ = 0,230 mt
Produz.cumulativa $q$ = 5,10 mc
Pseudo tempo erogaz. $\bar{t}$

$$\bar{t} = 1440 \frac{q}{Q} = \frac{1440 \times 5,10}{27,84} = 264 \text{ min'}$$

| $\Delta t$ min 1' | $\bar{t}+\Delta t$ | $\frac{\Delta t}{\bar{t}+\Delta t}$ | P Kg/cmq |
|---|---|---|---|
| 0 | 264 | - | 131,2 |
| 5' | 69 | 0,018 | 151,7 |
| 10' | 74 | 0,036 | 155,4 |
| 15' | 79 | 0,053 | 155,9 |
| 20' | 84 | 0,070 | 156,1 |
| 60' | 324 | 0,18 | 156,3 |
| 1700' | 2434 | 0,70 | 156,3 |

ANALISI RISULTATI:

1) Pendenza retta m = 0,50 Kg/cmq.ciclo

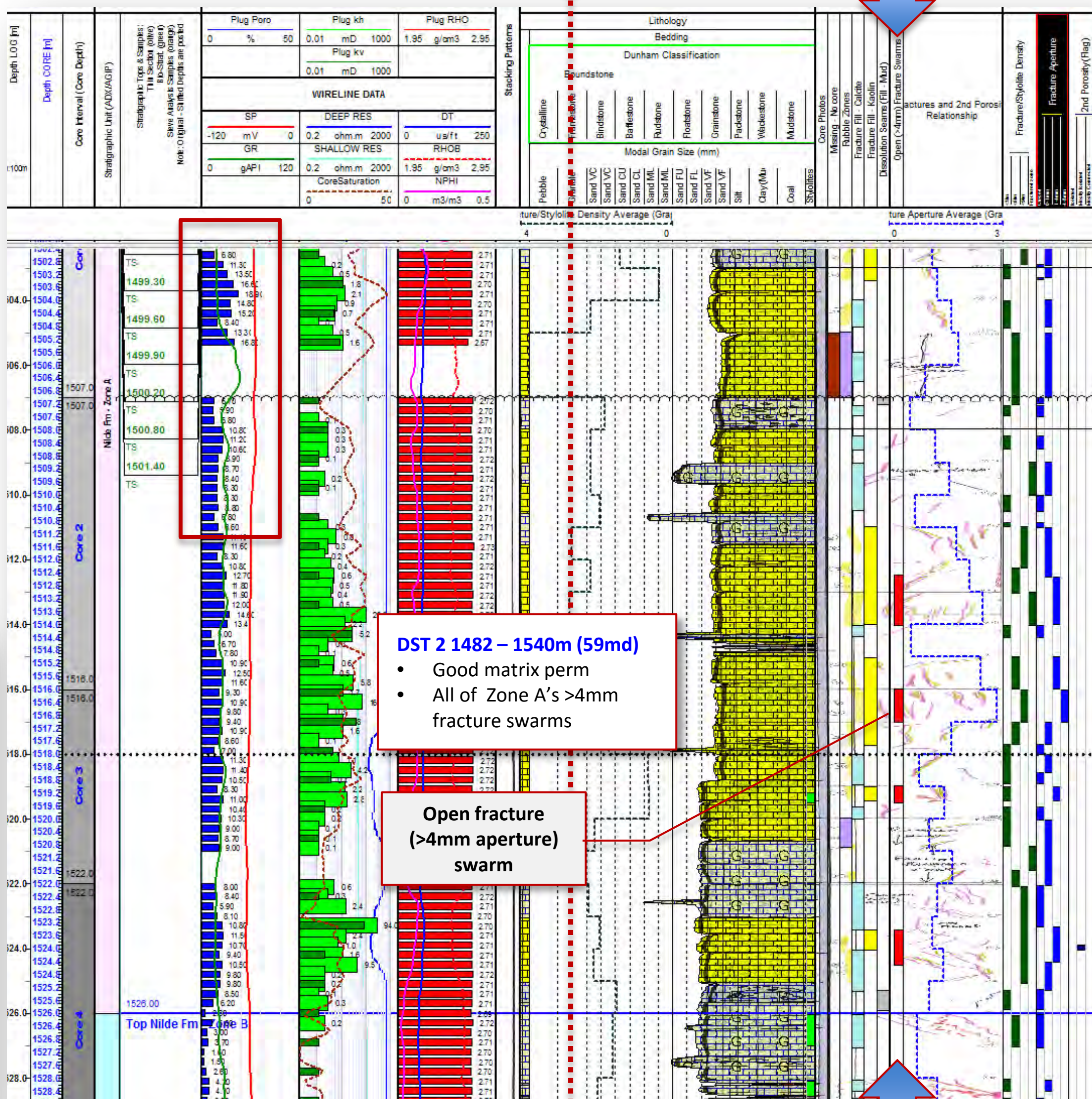
2) Pressione statica ricavata dalla estrapolazione della curva di risalita al tempo $\frac{\Delta t}{\bar{t} + \Delta t} = 1$;

$P_s$ = 156,60 Kg/cmq.

3) Capacità produttiva $Kh = \frac{21,92\, \mu\, Q\, \beta}{m} = \frac{21,92 \times 2,01 \times 27,84 \times 1,28}{0,50} =$

Kh = 3140 md x mt

4) Permeabilità K = 59 md




On production this interval produced at 9000bbls/d

# Summary of Results

- **Stratigraphy:** Quick look thin section analysis did reveal a 2-3m thick spar calcite zone that is interpreted to be associated with the top reservoir unconformity

- **Petrophysics:** The wireline dataset was deemed to be accurately reflecting the nature of the reservoir with core and wireline independently verified.

- **Pore Systems:** Matrix porosity was observed throughout with oil stain intensity varying with the matrix porosity. However matrix porosity does not equate with productivity where by historic production intervals are coincident with fractures (swarms).

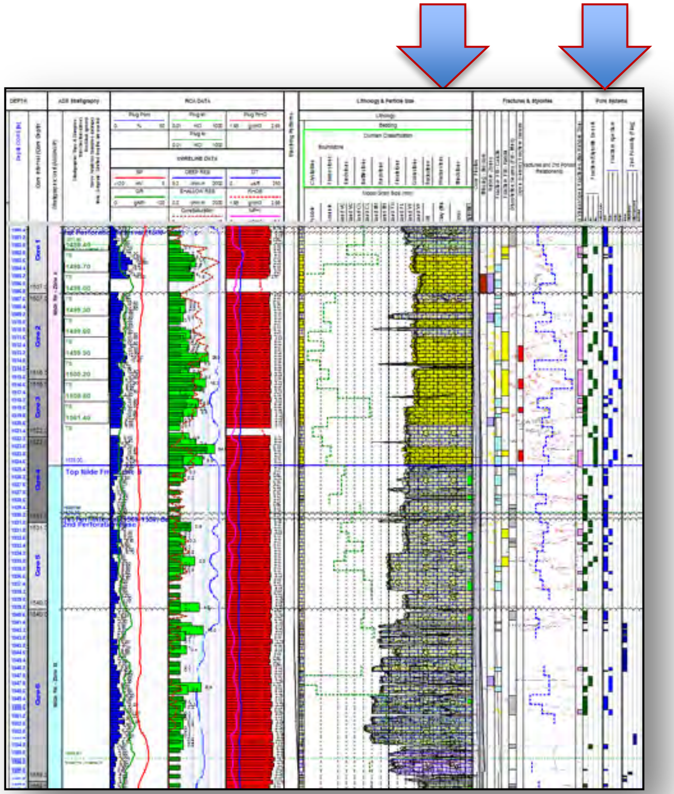
- **Fracture Characterisation:** It was ascertained that fractures, not vugs (secondary porosity) nor matrix are the dominant porosity type. Fracture density is related to lithology. Fracture swarms were identified and correlate with the most productive DST/production zones

- **Core/BHI-Based Fracture Data:** Core-based data used instead of BHI data. However long continuous cored intervals must be used and a detailed, continuous and standardised recording of fractures needs to be made

# The Premise….

- Can core-based data be used to characterise fracture pore systems in the absence of BHI data?

✓

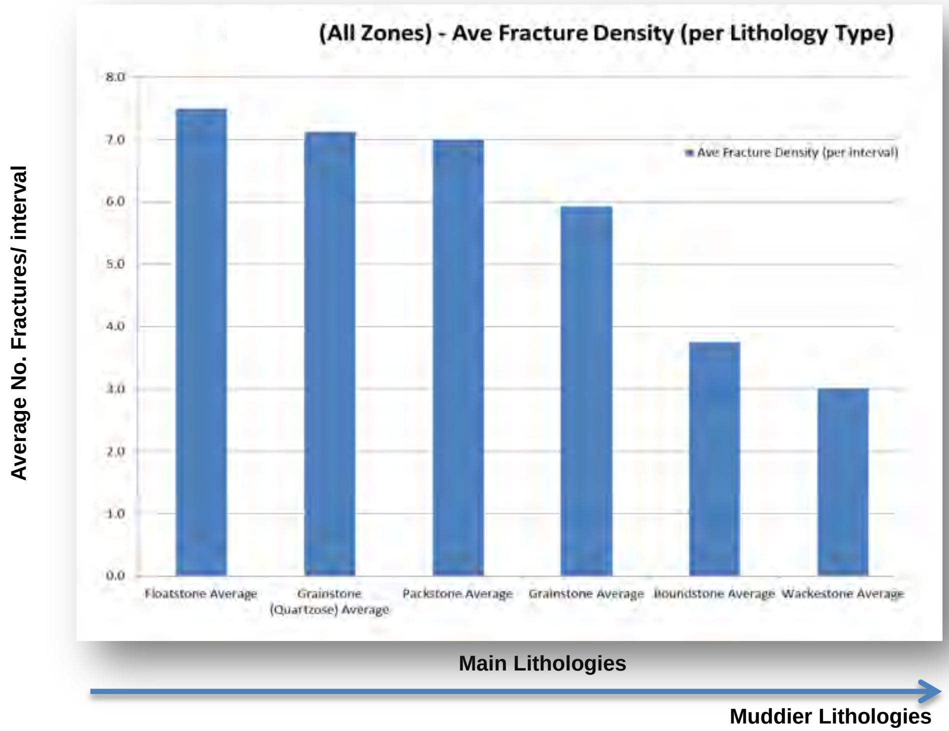


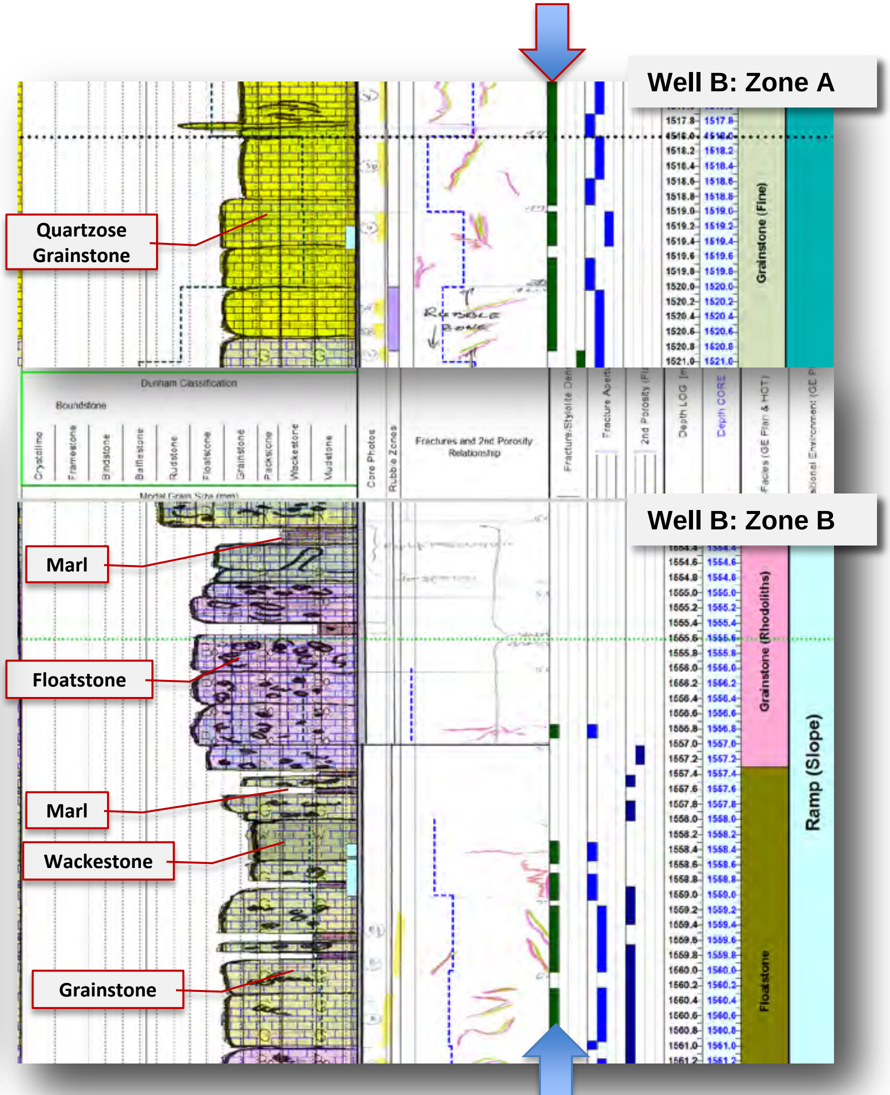
- If so can we use this data then to analyse fracture relationships:
  - Controls on fracturing

- Can we use the core-based fracture data in our modelling?

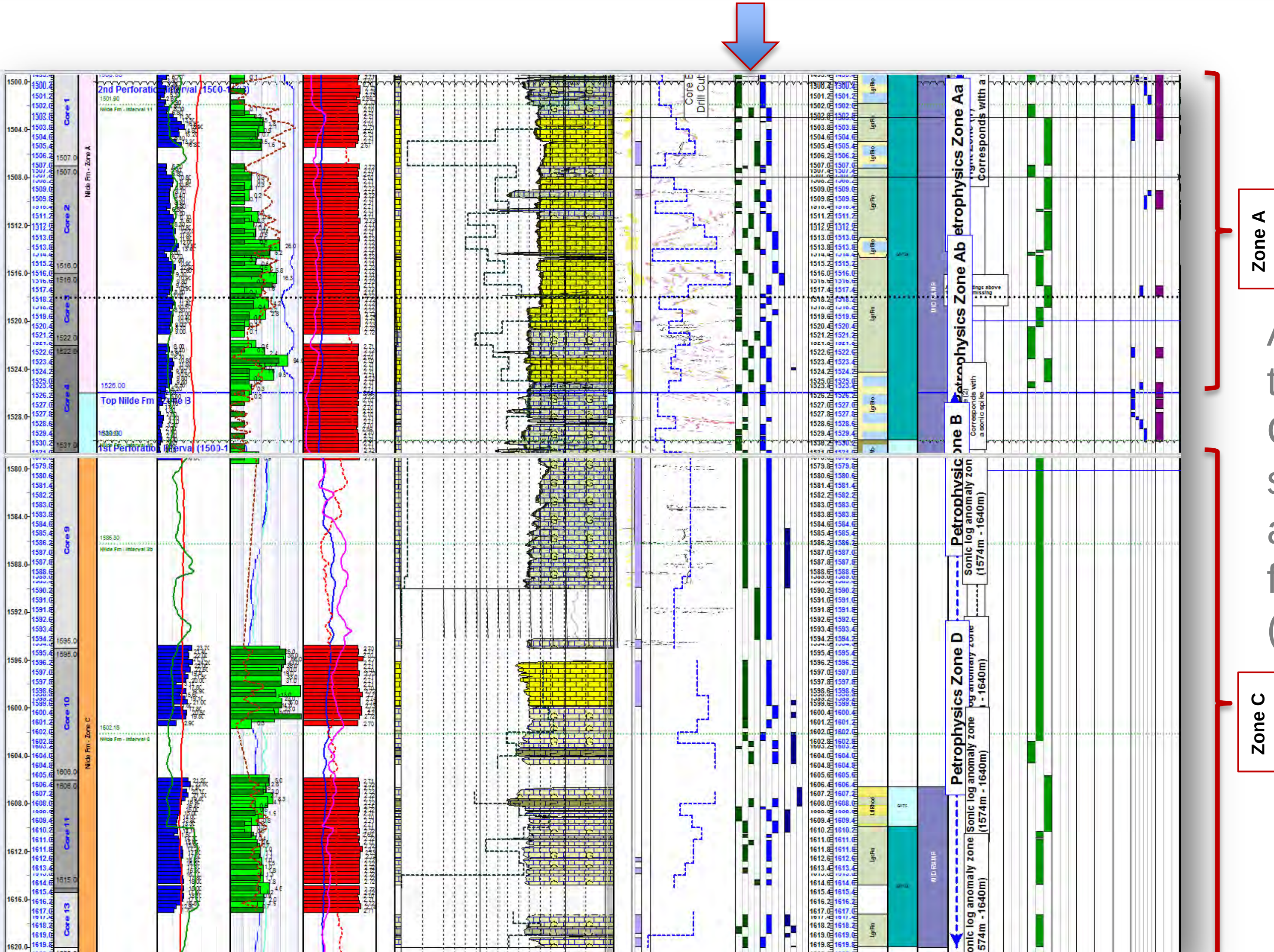
# Discussion: Controls on Fractures (All Zones)

- Fracture density (arrowed) appears to be controlled by lithology, whereby the more quartzose and cemented the lithology the more brittle (and fractured) is the rock



# Fracture Characterisation: Zone A vs Zone C – Comparison




Analysis reveals that Zones A and C have very similar lithologies and subsequently fracture gradients (apertures).

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# The Premise….

- Can core-based data be used to characterise fracture pore systems in the absence of BHI data? ✓

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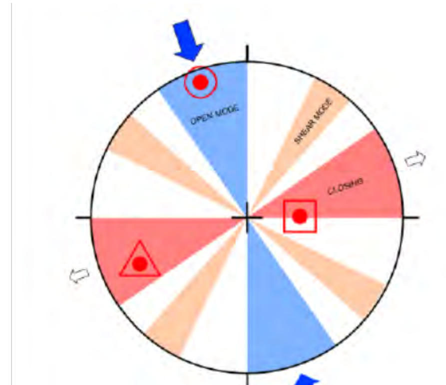
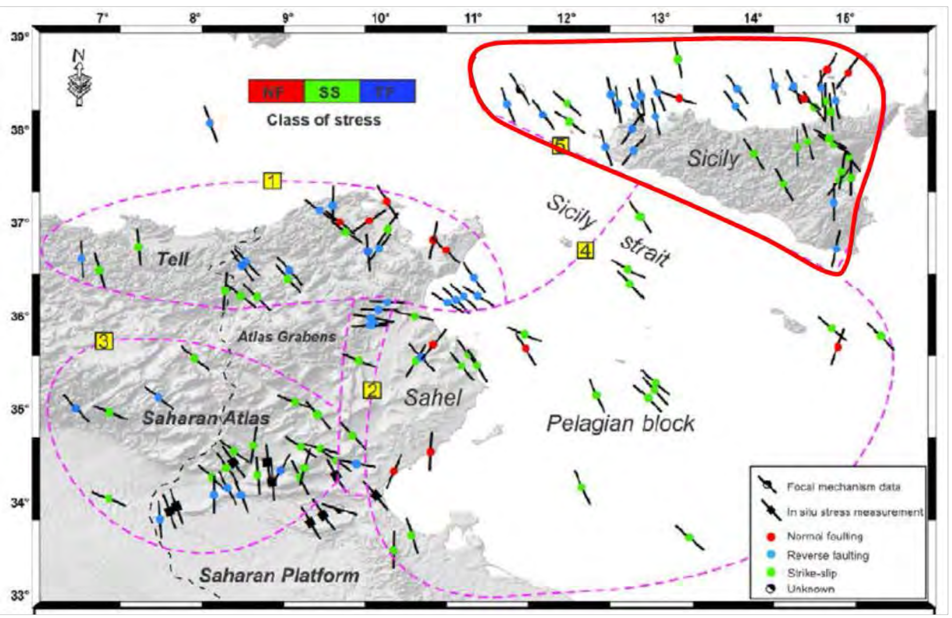


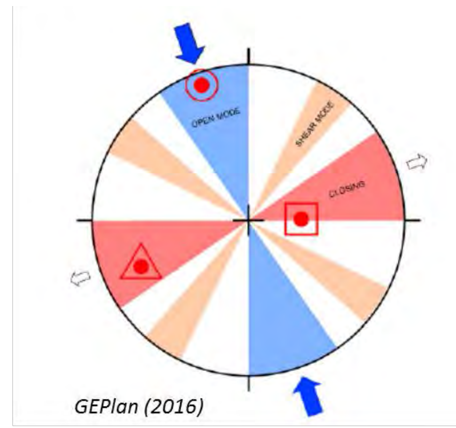
GEPlan (2016)

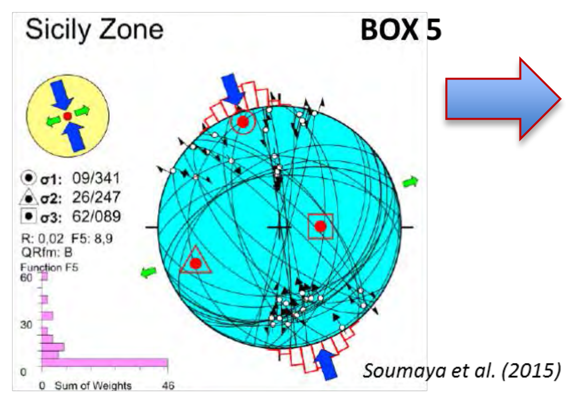
- Can we use the core-based fracture data in our modelling?

# Orientating Core-Based Fracture Data Using Regional Trends

- Stress orientation (NNW-SSE) can be applied to the case study field area of the western offshore Sicily. This maximum horizontal stress orientation is also consistent with the general kinematic of the entire central-western Sicily block




Can we now use this knowledge to orientate core based fracture data and use it in modeling?

# Orientated Core-Based Fractures as a Model Input?

- The discrete fracture model is currently being built!

Regional fracture orientation data

?

| Stratigraphy ( | Top Depth (m) | Bottom Depth ( | Interval (m) | Fracture Density | fracture |
|---|---|---|---|---|---|
| Zone C | 1588.69 | 1588.98 | 0.29 | 0.392157 | 3 |
| Zone C | 1644.09 | 1644.28 | 0.19 | 0.705882 | 3 |
| Zone C | 1644.84 | 1645.03 | 0.19 | 0.588235 | 3 |
| Zone C | 1645.44 | 1645.68 | 0.24 | 0.16 | 3 |
| Zone C | 1645.84 | 1646.03 | 0.19 | 0.16 | 3 |
| Zone C | 1646.16 | 1646.52 | 0.36 | 0.156863 | 3 |
| Zone C | 1647.04 | 1647.22 | 0.18 | 1.68627 | 6 |
| Zone C | 1647.22 | 1647.95 | 0.73 | 0.588235 | 3 |
| Zone C | 1648.27 | 1648.44 | 0.17 | 0.54902 | 3 |
| Zone A | 1499.19 | 1499.76 | 0.57 | 0.901961 | 3 |
| Zone A | 1500.02 | 1502.15 | 2.13 | 0.823529 | 3 |
| Zone A | 1502.15 | 1502.9 | 0.75 | 2.94118 | 9 |
| Zone A | 1502.9 | 1503.33 | 0.43 | 0.352941 | 3 |
| Zone A | 1504 | 1504.84 | 0.84 | 0.54902 | 3 |
| Zone A | 1504.99 | 1507 | 2.01 | 1.64706 | 6 |
| Zone A | 1507 | 1507.24 | 0.24 | 1.29412 | 6 |
| Zone A | 1507.25 | 1507.55 | 0.3 | 0.27451 | 3 |
| Zone A | 1508.19 | 1508.59 | 0.4 | 0.823529 | 3 |
| Zone A | 1508.99 | 1510 | 1.01 | 1.30693 | 6 |
| Zone A | 1510 | 1510.5 | 0.5 | 0.823529 | 3 |
| Zone A | 1510.85 | 1510.99 | 0.14 | 0.705882 | 3 |
| Zone A | 1510.99 | 1512.26 | 1.27 | 2.66667 | 9 |
| Zone A | 1512.26 | 1513.03 | 0.77 | 1.64706 | 6 |
| Zone A | 1513 | 1514.01 | 1.01 | 3.76471 | 12 |
| Zone A | 1514.01 | 1514.4 | 0.39 | 0.823529 | 3 |
| Zone A | 1515 | 1516 | 1 | 2 | 9 |
| Zone A | 1516 | 1517 | 1 | 2.7451 | 9 |
| Zone A | 1517.02 | 1517.71 | 0.69 | 1.52941 | 6 |
| Zone A | 1517.71 | 1518.92 | 1.21 | 0.54902 | 3 |
| Zone A | 1519 | 1519.45 | 0.45 | 0.27451 | 3 |
| Zone A | 1519.62 | 1520.85 | 1.23 | 0.941176 | 3 |
| Zone A | 1520.85 | 1521.59 | 0.74 | 2.49057 | 9 |
| Zone A | 1521.59 | 1522.08 | 0.49 | 1.92157 | 6 |
| Zone A | 1522.08 | 1525.11 | 3.03 | 2.7451 | 9 |
| Zone B | 1525.3 | 1525.88 | 0.58 | 0.196078 | 3 |
| Zone B | 1526.05 | 1527.04 | 0.99 | 1.56863 | 6 |
| Zone B | 1528.03 | 1528.39 | 0.36 | 0.0784314 | 3 |
| Zone B | 1528.62 | 1529.06 | 0.44 | 0.0784314 | 3 |
| Zone B | 1529.05 | 1529.46 | 0.41 | 0 | 3 |
| Zone B | 1529.61 | 1530.8 | 1.19 | 0.941176 | 3 |
| Zone B | 1530.79 | 1531.48 | 0.69 | 1.45098 | 6 |
| Zone B | 1531.68 | 1532.03 | 0.35 | 1.72549 | 6 |
| Zone B | 1532.03 | 1533.02 | 0.99 | 0.941176 | 3 |
| Zone B | 1533.01 | 1533.27 | 0.26 | 1.64706 | 6 |
| Zone B | 1533.28 | 1534.01 | 0.73 | 0 | 3 |
| Zone B | 1534.53 | 1535.07 | 0.54 | 2.94118 | 9 |
| Zone B | 1535.07 | 1535.56 | 0.49 | 1.72549 | 6 |
| Zone B | 1535.58 | 1536.35 | 0.77 | 0.823529 | 3 |
| Zone B | 1537.16 | 1538.05 | 0.89 | 0.54902 | 3 |
| Zone B | 1540.22 | 1541.14 | 0.92 | 0.823529 | 3 |
| Zone B | 1541.3 | 1541.44 | 0.14 | 0.901961 | 3 |
| Zone B | 1542.12 | 1542.24 | 0.12 | 0.470588 | 3 |
| Zone B | 1546.13 | 1546.52 | 0.39 | 0.901961 | 3 |
| Zone B | 1547.05 | 1548.04 | 0.99 | 2 | 9 |

?

Note:

- A predictive dynamic model was built incorporating this core-based fracture data (and other data) whereby history matching was achieved (for the first time in the field's history).
- The production performance was able to be explained.

Note: Generic Petrel fracture model illustrated (from Schlumberger 2017)

# Core Based Fracture Data – A Proxy for BHI Data?

- We have been able to characterised fracture, matrix, and secondary pore systems using core-data (standardised continuous core logging)
- We have demonstrated that fractures are the most important production contributor equating this with DST and historical production
- The next step is then to use the fracture data for modelling. We have shown that we can use this core derived data set as if it were a BHI dataset:
  - Yes, core can (and was) used to determine the varying structural features
  - Yes, core can (and was) used for the determination of fracture density and aperture
  - Yes, core can (and was) used to determine cross cutting relationships….
  - Yes, controls on fracturing were able to be discerned from the core-based dataset
- And yes (maybe) as we can try to approximately orient the core-based fracture data according to the regional stress trends
- Can we now use this data for reservoir modelling? Yes we can……….as a guide

# Conclusions

- **Stratigraphy:** Quick look thin section analysis did reveal a 2-3m thick spar calcite zone that is interpreted to be associated with the top of the reservoir interval.
- **Petrophysics:** The wireline dataset was deemed to be accurately reflecting the nature of the reservoir with core and wireline independently verified.
- **Pore Systems:** Matrix porosity was observed throughout with oil stain intensity varying with the matrix porosity. However matrix porosity does not equate with productivity. Productivity is coincident with fracture swarms.
- **Fracture Characterisation:** It was ascertained that fractures, not vugs (secondary porosity) are the dominant porosity type. Fracture density is related to lithology. Fracture swarms were identified and correlate with the most productive DST/production zones
- **Core/BHI-Based Fracture Data:** Core-based data can be used to gain BHI styled fracture data. Orientation can be guided be regional stress trends. Long continuous cored intervals must be used and then rendered into the digital world to enable analysis and modelling

Maybe old dogs can learn new tricks!


# Acknowledgements

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