International Gas Union Research Conference
IGRC COPENHAGEN 2014
September 17-19

APPLYING FRACTALS THEORY TO PROPAGATE AND MODELISE NATURAL FRACTURES IN TIGHT GAS RESERVOIRS

HAMRA QUARTZITES FORMATION/RHOURDE NOUSS FIELD/ALGERIA

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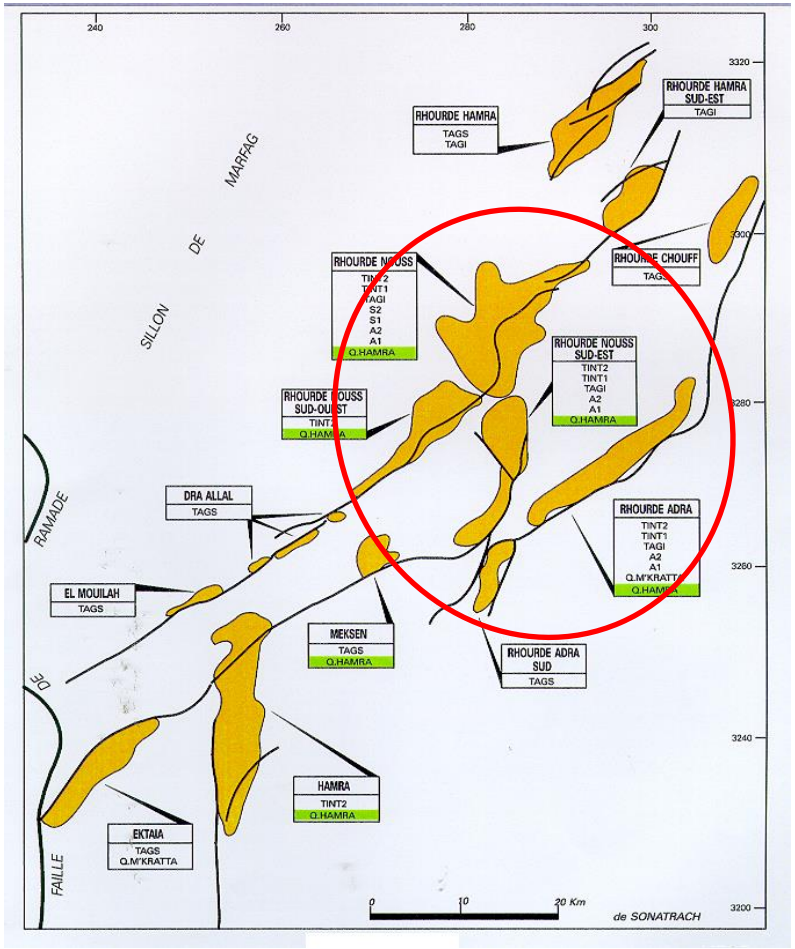
Summary

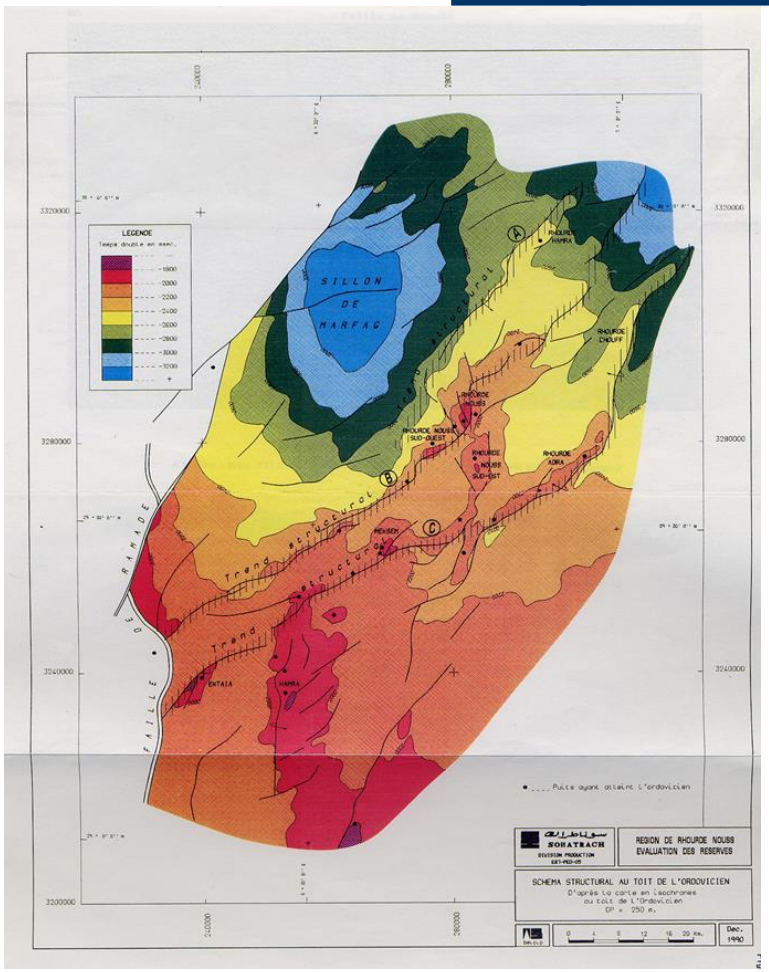
- Overview about the studied area
- Classical of natural fractures (Cores, Images)
- Applying the tectonic model of Riedel de 1928
- Special Core Analysis SCAL (RMN sections, CT scans)
- Observations and proofs of the fractal event
- Fractal Propagations of the fractures corridors
- Applying the méthodology on 1 development well
- Applying same method for 13 others wells
- Conclusions



STUDIED STRUCTURES

- Rhourde Nouss Central
- Rhourde Nouss South East
- Rhourde Nouss South West
- Rhourde Adra
- Rhourde Adra South

Major StructuralTrends



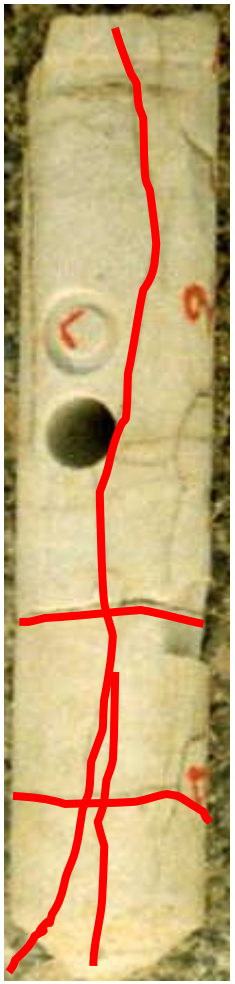
- **Trend A : Rhourde Hamra**
- **Trend B : - RNNE**
  - **RN Centre**
  - **RN Sud Ouest**
- **Inter-Trend: B-C ; RNSE**
- **Trend C : - Rhourde Adra**
  - **Rhourde Adra Sud**
  - **Lobe RN-3**
  - **Nord de Hamra**

Petrography of Hamra Quartzites

- **Quartzites and quartzified sandstones tight and hard**
- **Clean constitution about 98 % of Silicium**
- **Invisible sedimentary patterns**
- **Strongly affected by multiple diagenetic phases**
- **Strongly fractured naturally in specific areas of the field**
- **Strongly affected by micro-fracturation**

Classical Analysis of natural fractures

Natural fractures observed in a routine core description



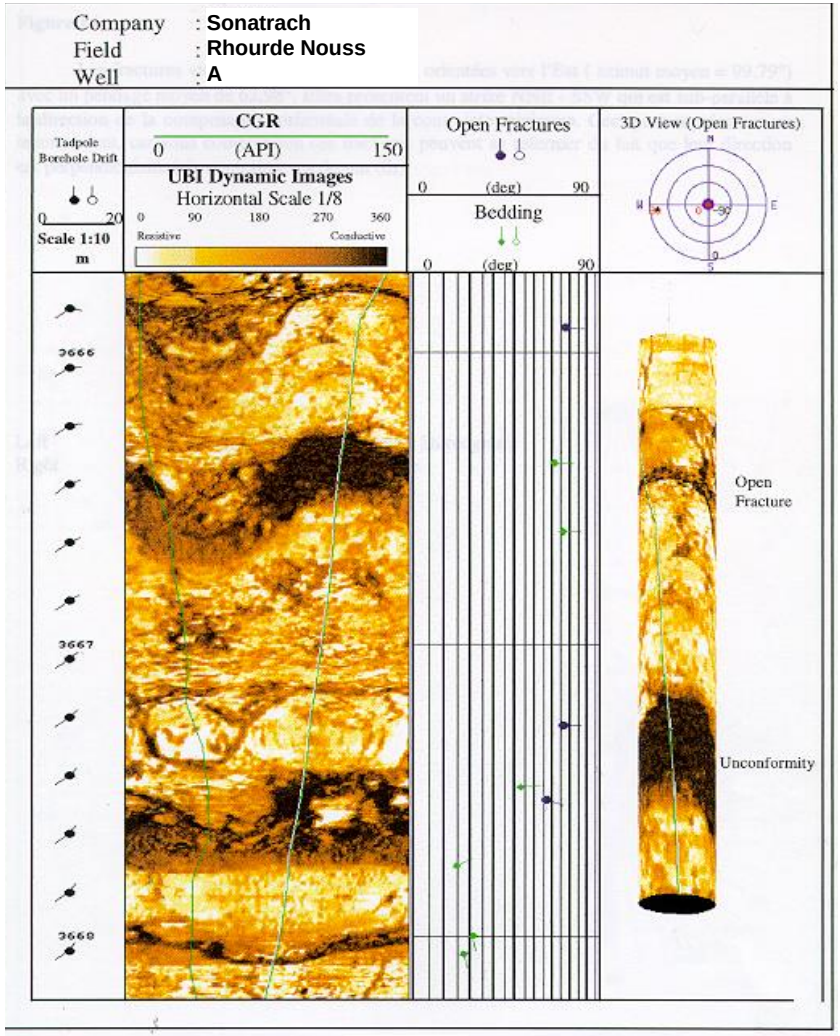


Image analysis of the Hamra Quartzites formation

Well A

StructuralDips : Undetermined

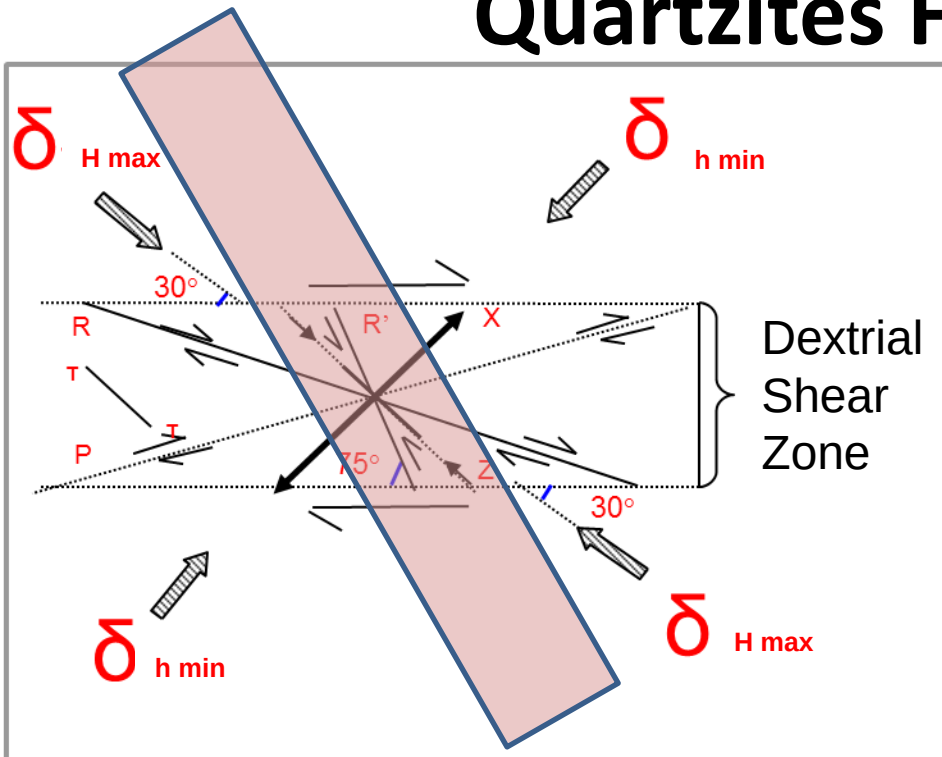
Direction of natural fractures : WNW – ESE

Direction of In-Situ Stress :

NW – SE (δ_1)

APPLYING THE TECTONIC MODEL OF RIEDEL (1928)

Applying Riedel Model for Hamra Quartzites Formation



R R' : Conjugated Riedel fractures

Z : Maximum shortening axis

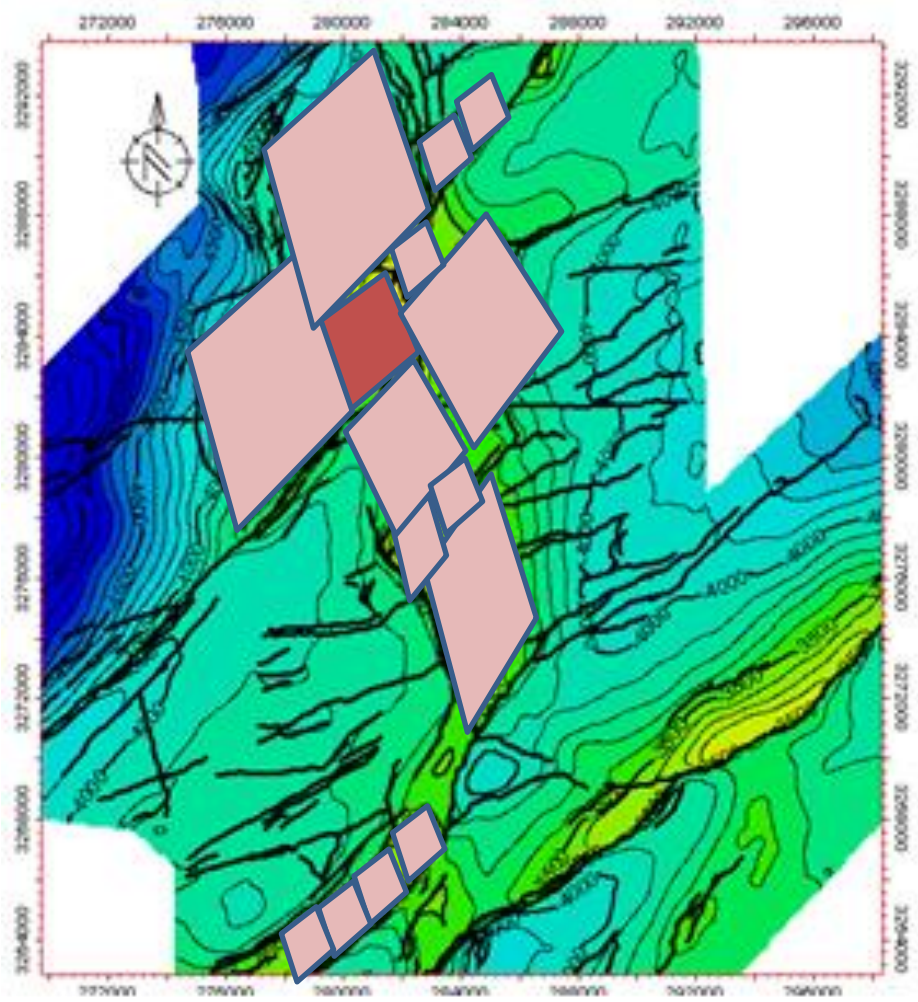
X : Maximum elongation axis

T : Extension fractures

P : Symetrical system of R

Remarque : angles are function of δ, in this case δ=30°

Riedel, 1928

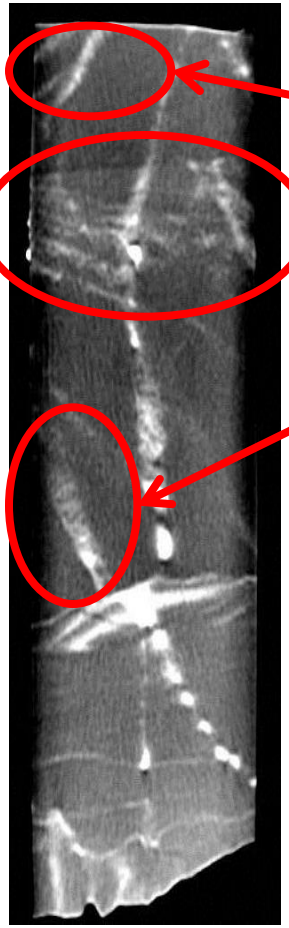


Segmentation of the structural model

Special Core Analysis
RMN Sections
CT Scans

CT Scan

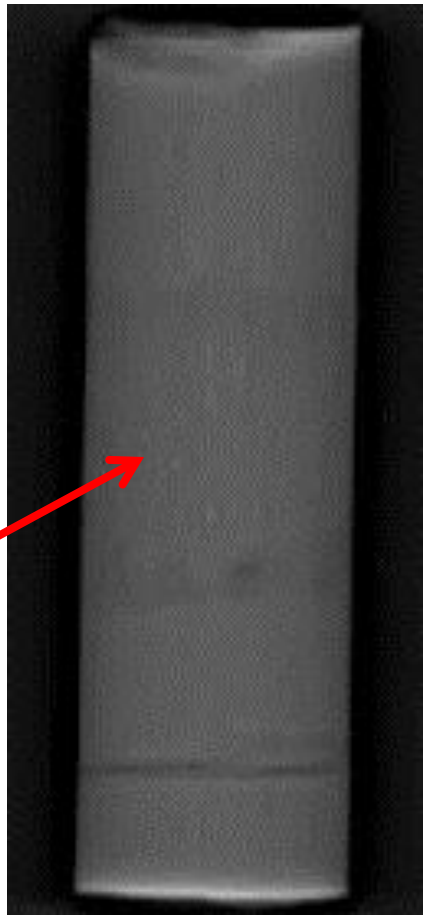
WELL A
3416,0-3416,2



Natural open fractures observed in CT scan and not by eye

No natural fractures observed in CT Scan (Tight Rock)

WELL B
3351,0-3351,2



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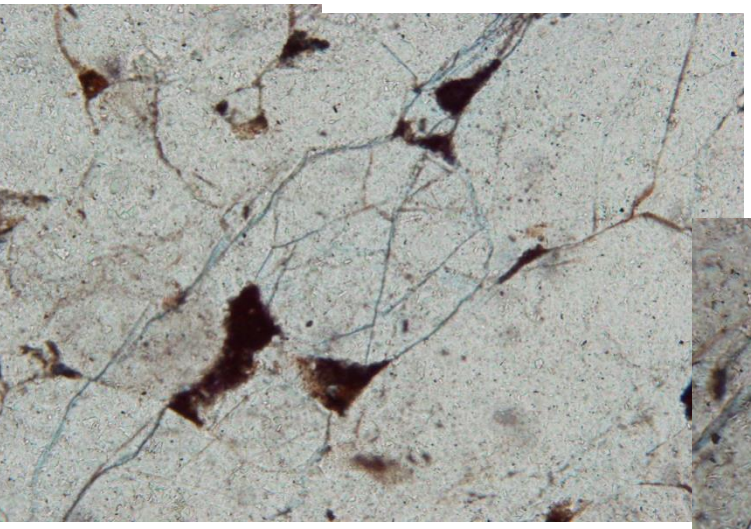
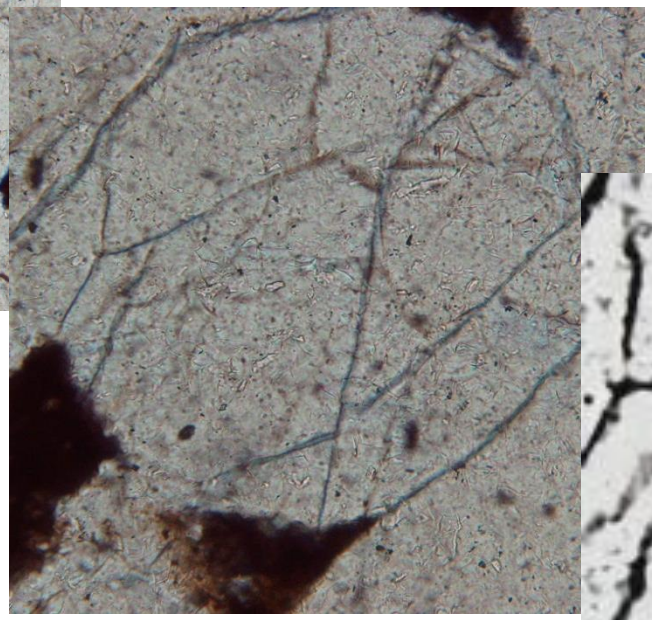
Gas Innovations Inspiring Clean Energy

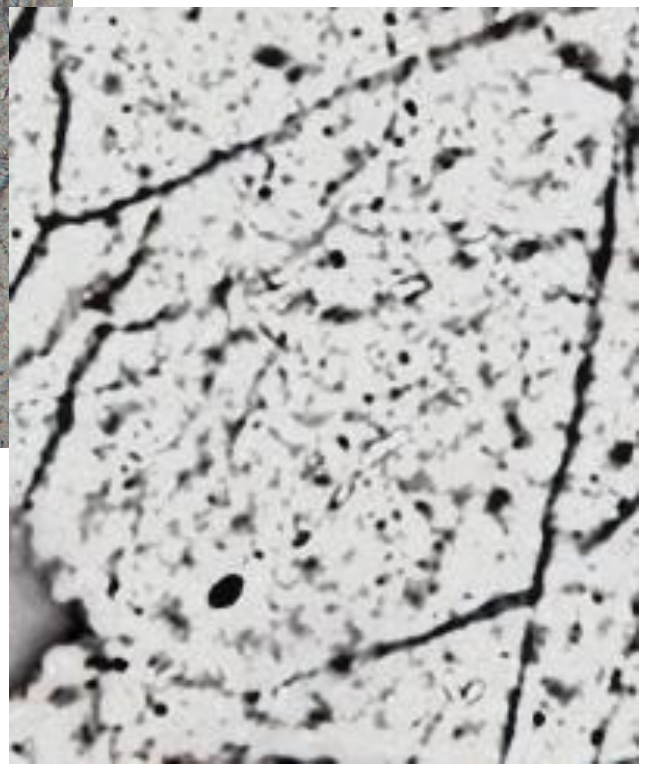
Micro-fractures





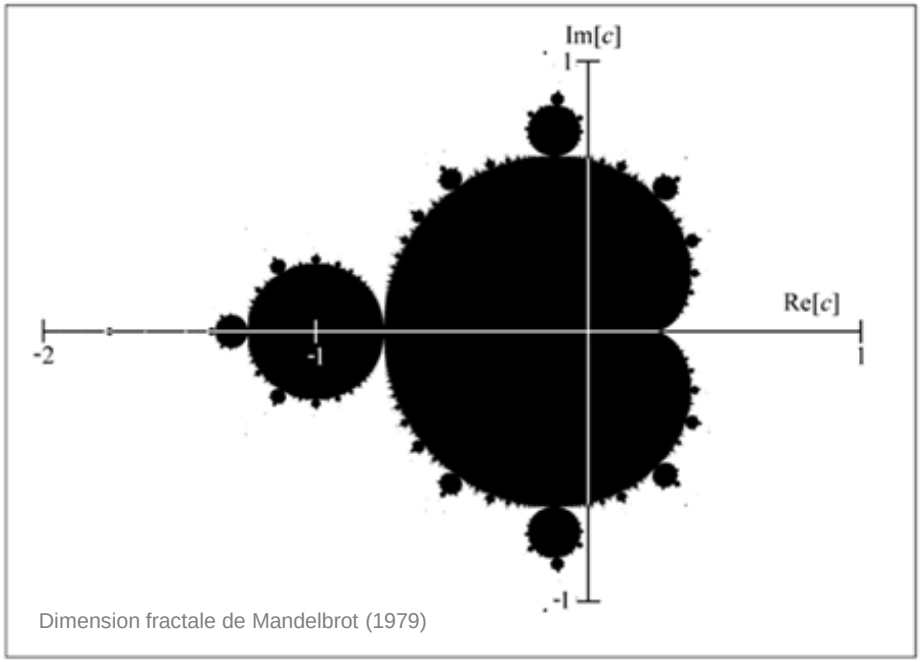
N

RMN Section b/w



WELL A
Thin Section 3416,0 m
(Oriented Core)

THEORY OF FRACTALS



Dimension fractale de Mandelbrot (1979)

A fractal is a natural phenomenon or a mathematical set that exhibits a repeating pattern that displays at every scale. If the replication is exactly the same at every scale, it is called self-similar pattern. Fractals can also be nearly the same at different levels.

The term "fractal" is a neologism proposed by Benoît Mandelbrot in 1975

FRACTAL CORRESPONDANCES

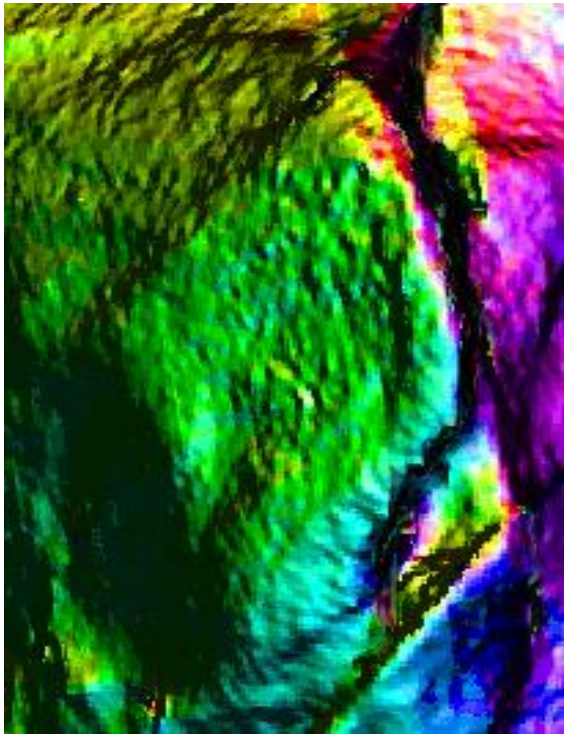
OBSERVATIONS AND PROOFS

FRACTAL CORRESPONDANCE ON AXIS X AND AXIS Y

RMN SECTION

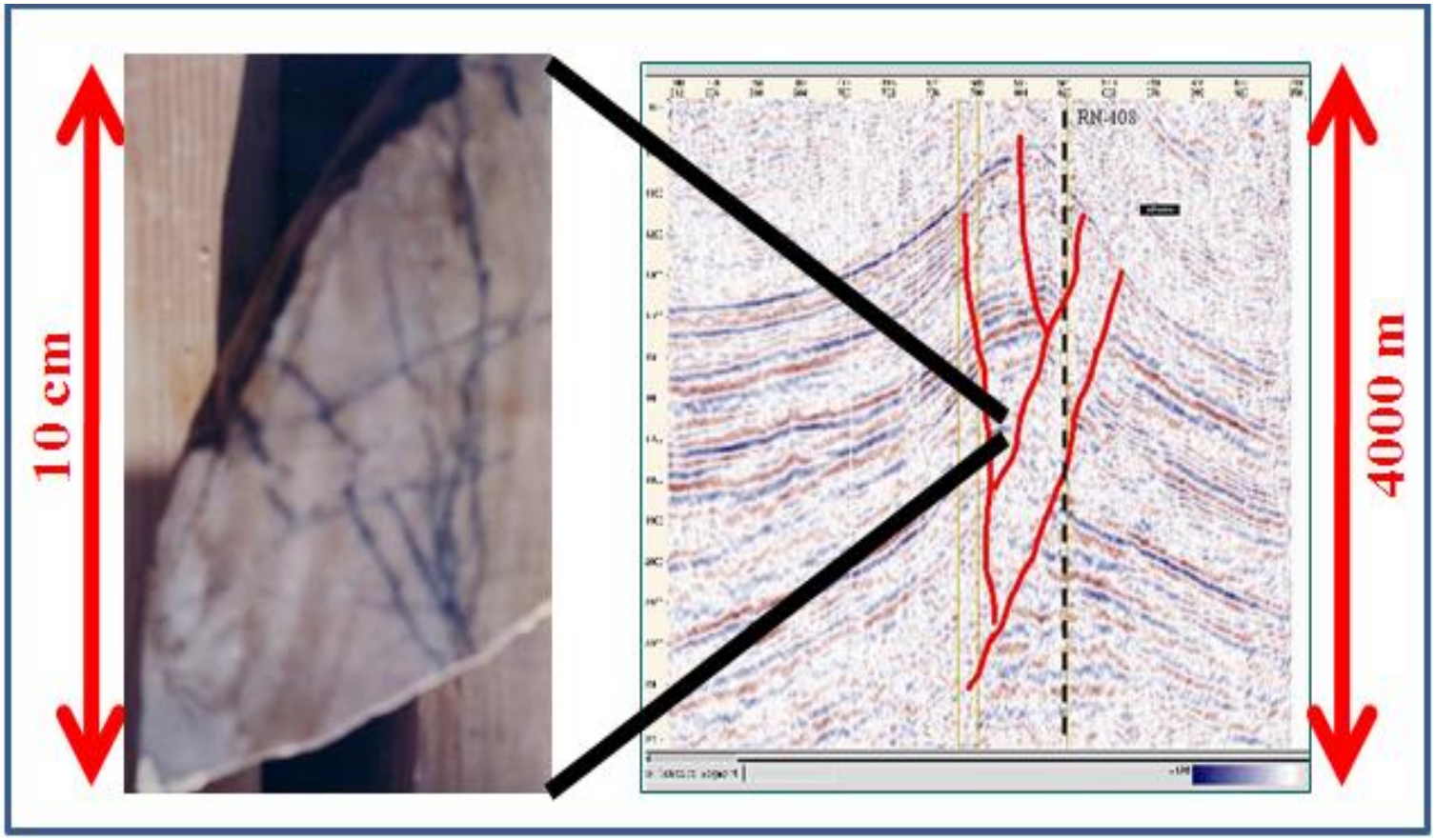
10 MICRONS

VARIANCE CUBE

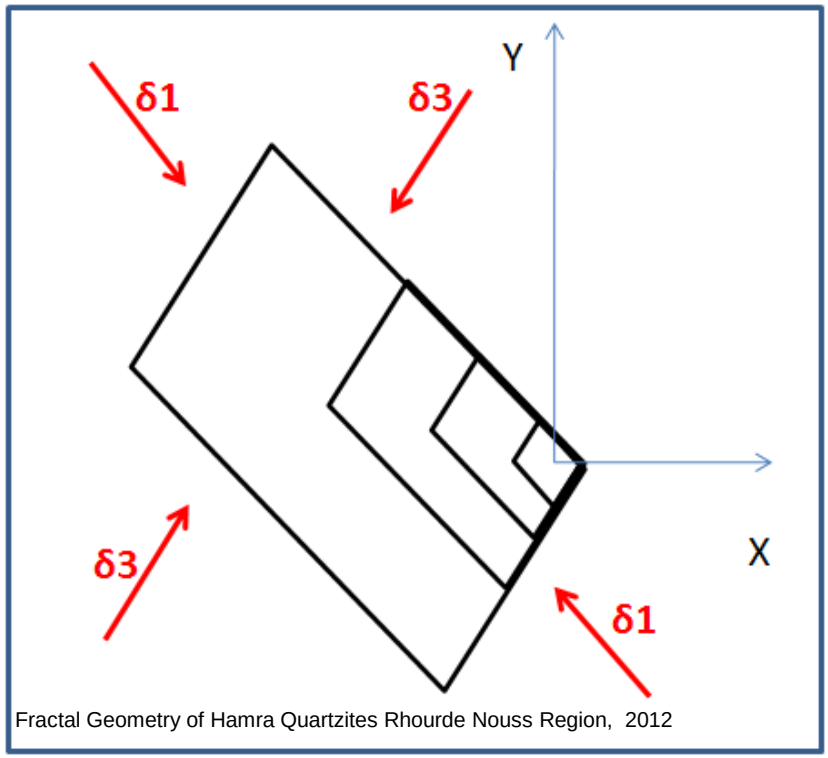


1 Km

FRACTAL CORRESPONDANCE ON AXIS Z



THE FRACTAL DIMENSION OF RHOURDE NOUSS-QH



Fractal Geometry of Hamra Quartzites Rhourde Nouss Region, 2012

When the fractal consists of replicas of itself smaller, its fractal dimension can be calculated as follows:

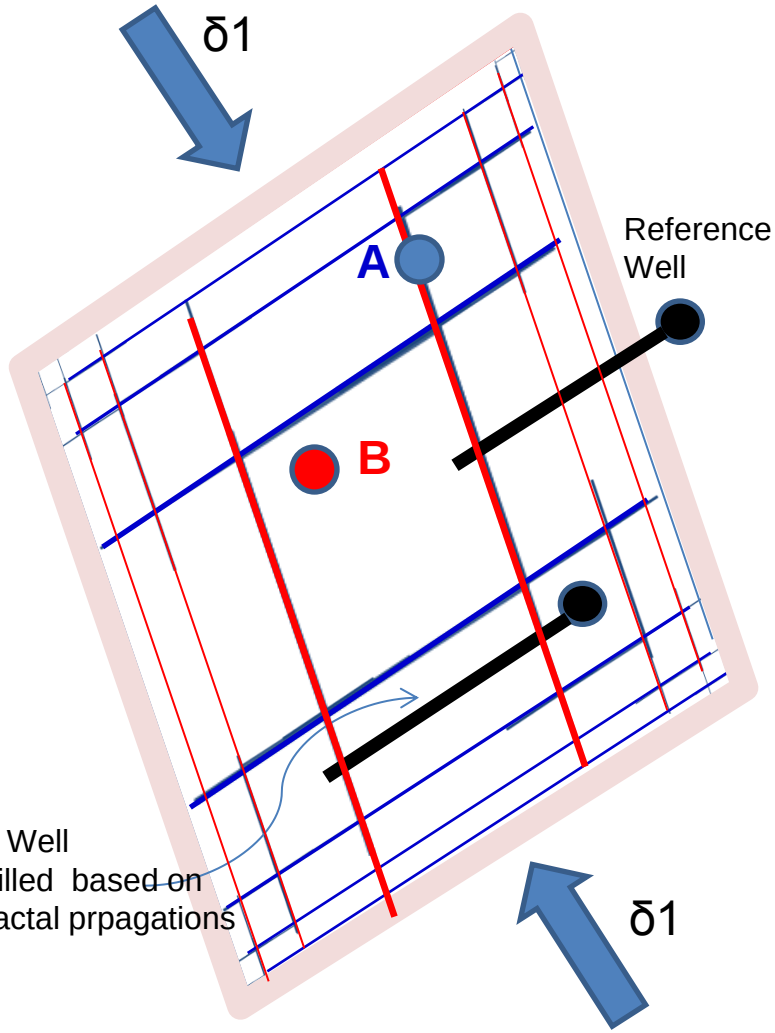
$$d = \frac{ln(N)}{ln\,(H)}$$

Where the fractal starting consists of N copies whose size has been reduced by a factor H (for scaling).

FRACTAL PROPAGATION OF NATURAL FRACTURES CORRIDORS

Hamra Quartzites formation

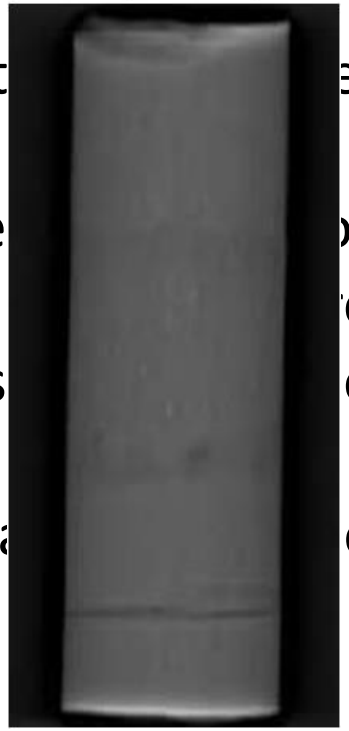
RHOURDE NOUSS FIELD



- Fract ion t el Mod
- Appl n we or the well e real nalys e simu lors
- 75 % ponda e realit

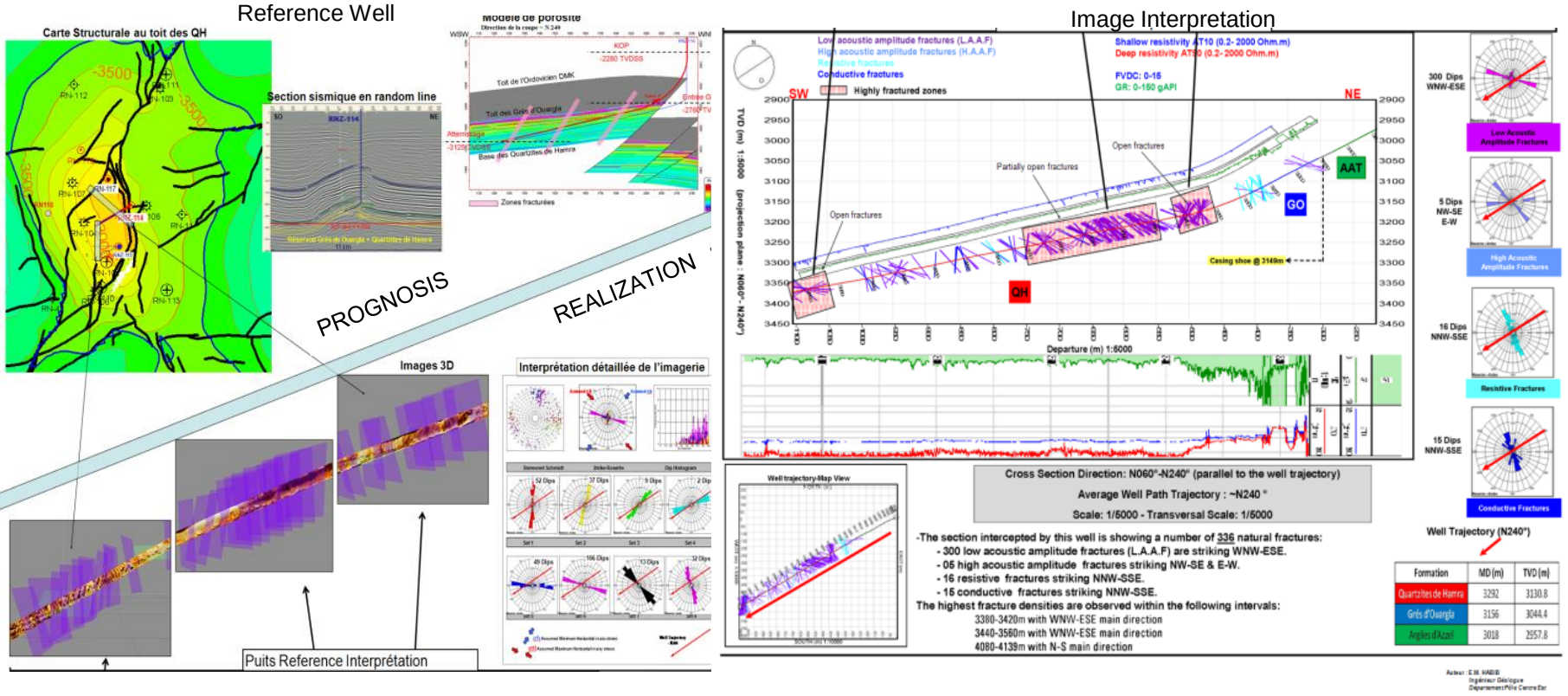
WELL A

WELL B

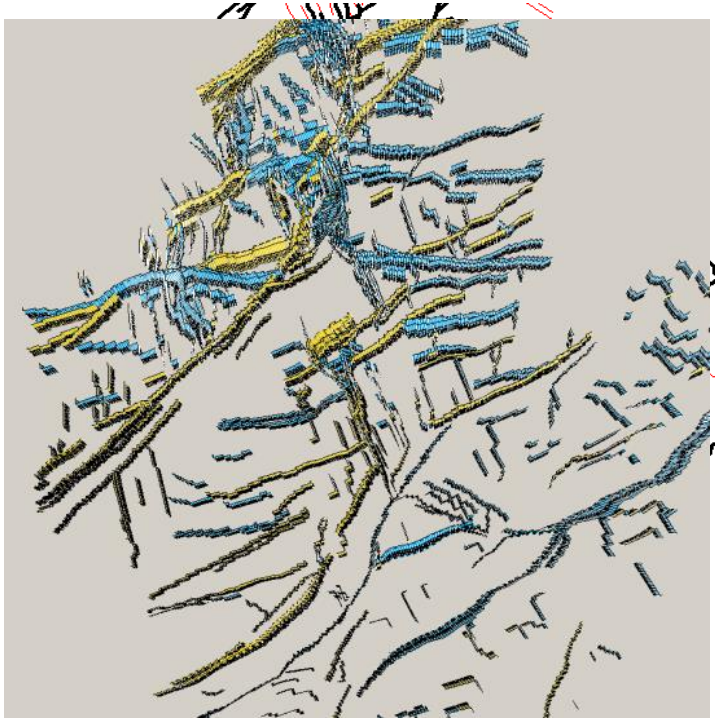


Open Fractures in majority
Fractures partially or completely closed

RESULTATS DE L'ANALYSE DE L'IMAGERIE RELLE PAR RAPPORT AUX PROPAGATIONS FRACTALES



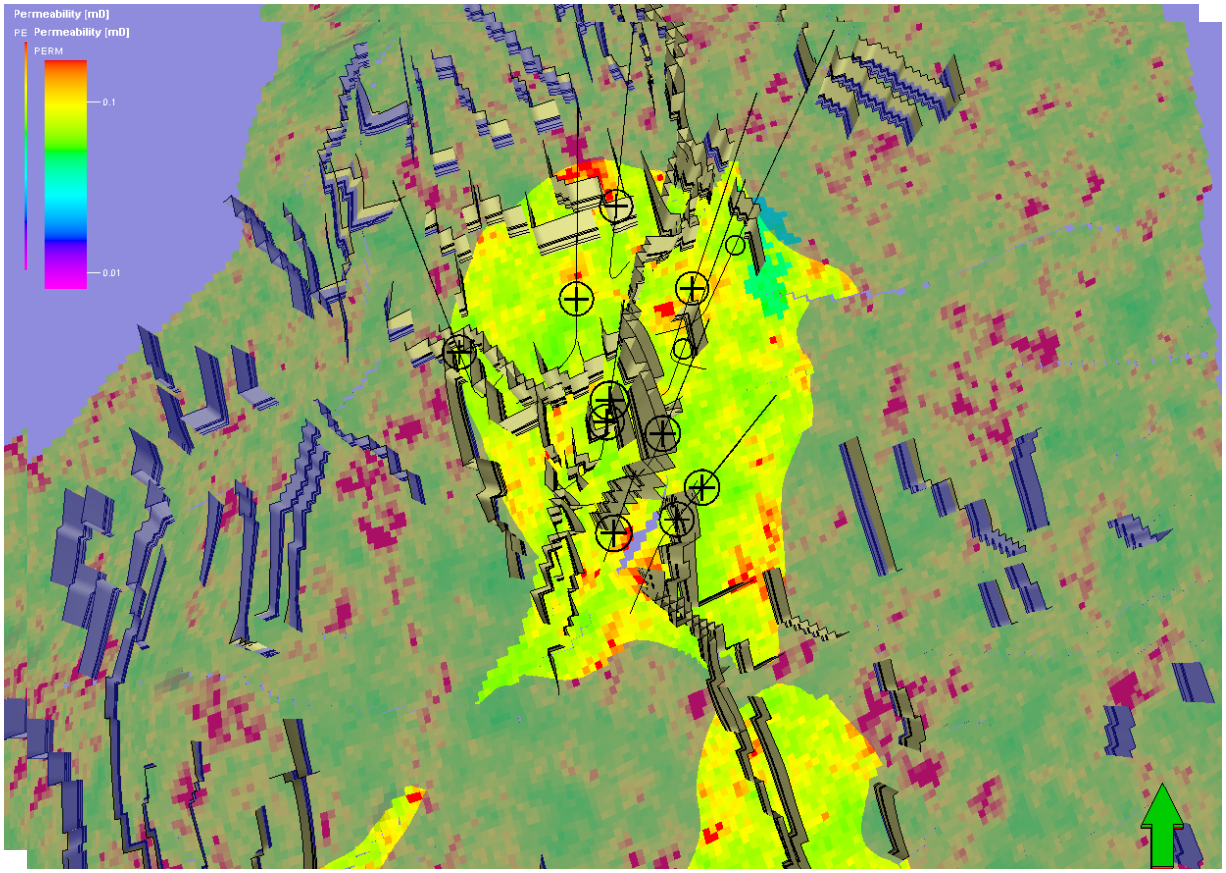
DISCRETE FRACTURE MODEL OBTAINED FROM FRACTAL PROPAGATION

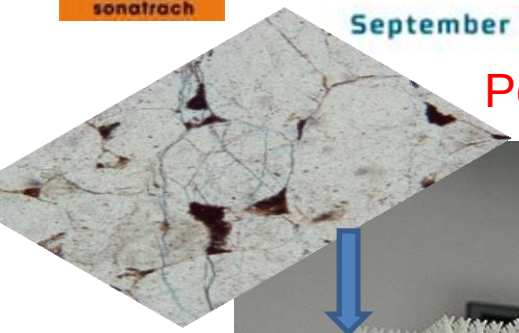


After fractal propagation

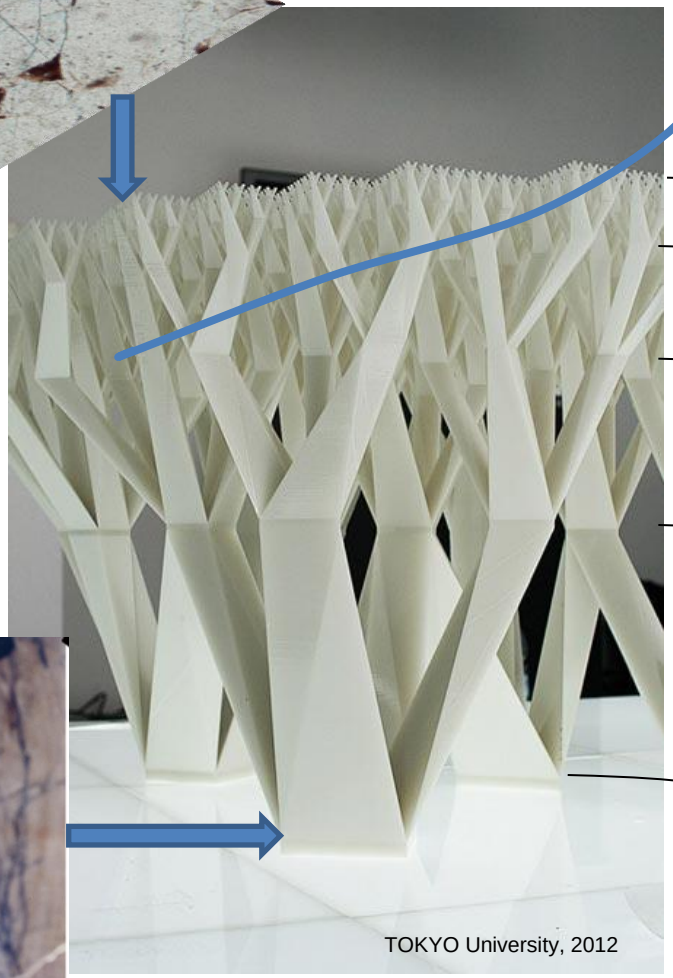
Before fractal propagation

FINAL DISCRETE FRACTURE MODEL

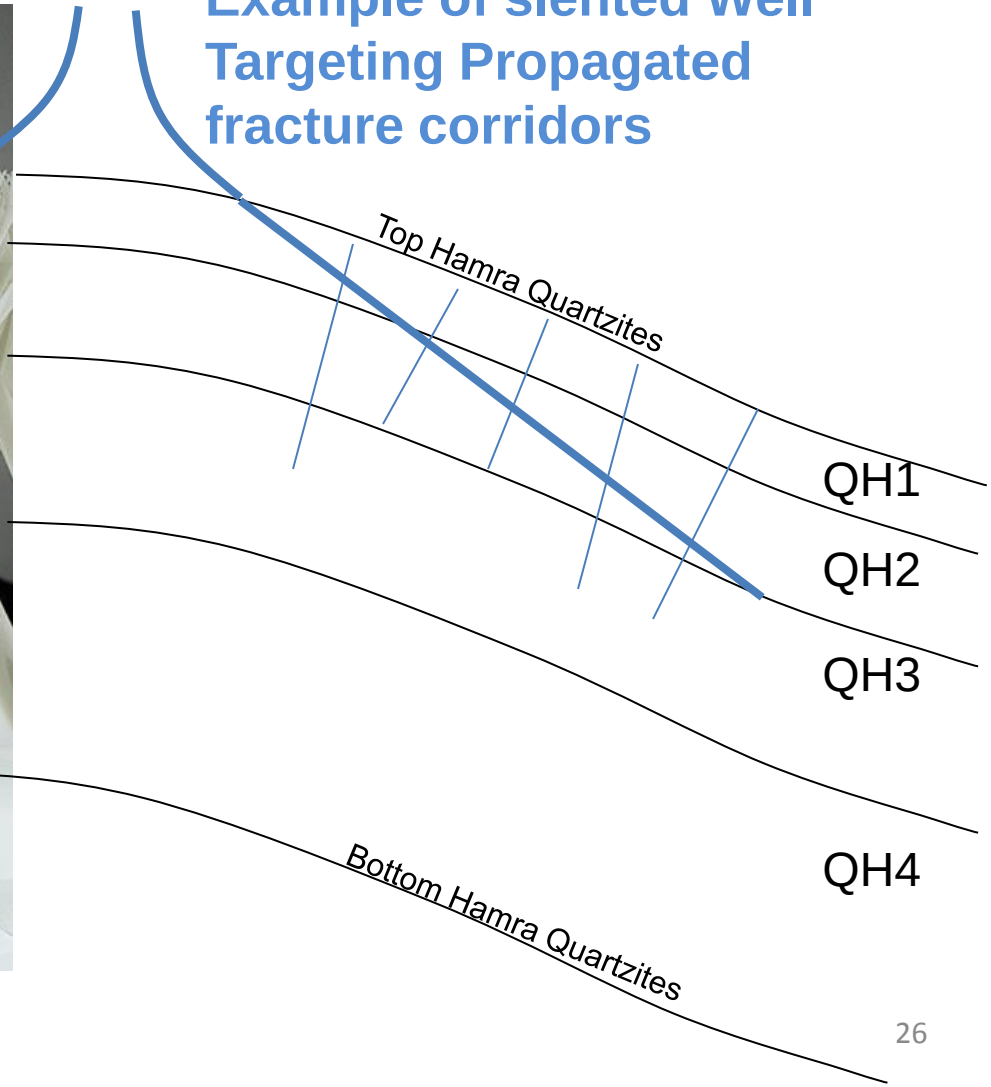




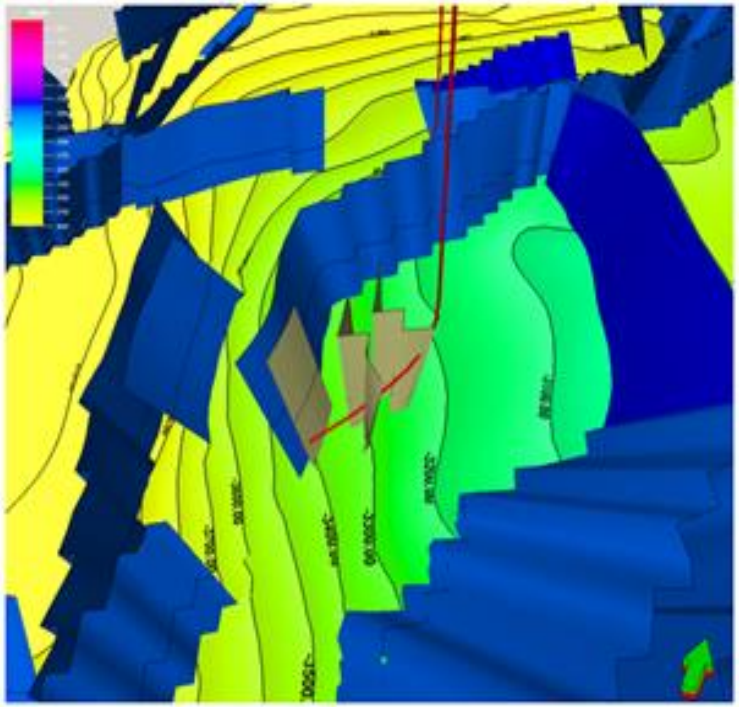
Perfect Tree Model



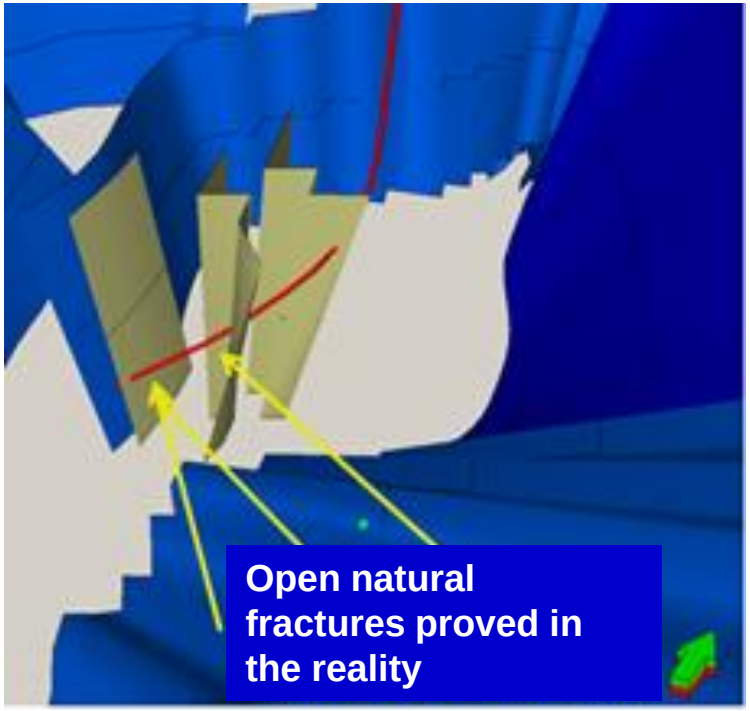
Example of slented Well Targeting Propagated fracture corridors



1 OF THE 12 EXAMPLES OF FRACTAL PROPAGATION FOR A GOOD DEVELOPPEMENT WELL

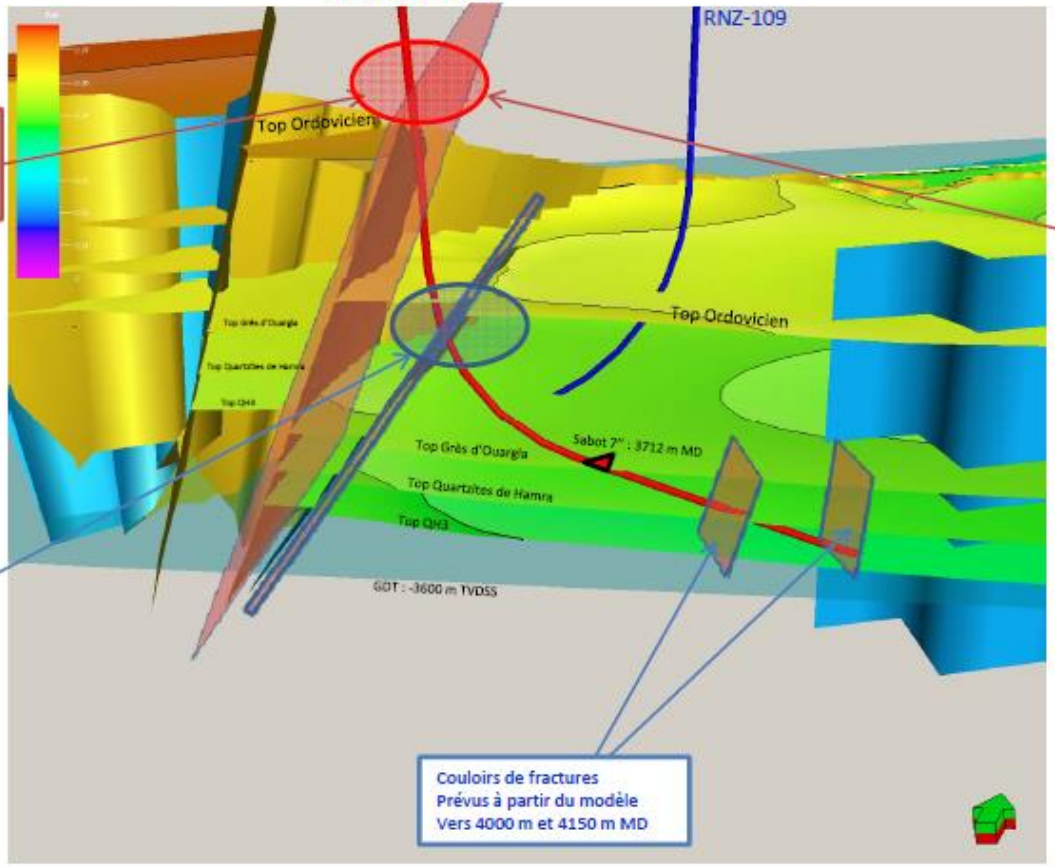


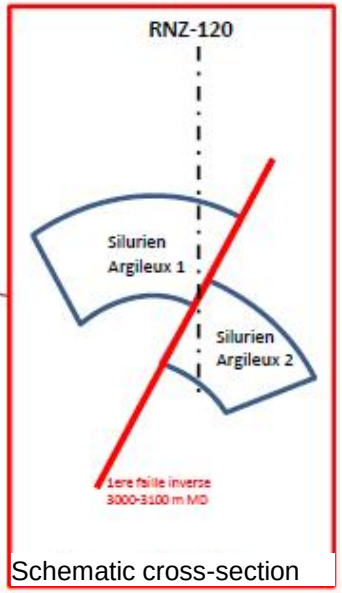
3D STRUCTURAL MODEL



3 CORRIDORS OF PROPAGATED FRACTURES

3D well section from fracture model





Schematic cross-section

CONCLUSIOINS

The fractal event was indeed proven to natural fractures Hamra Quartzite Rhourde Nouss.

- A fractal geometry of natural fractures was created for the first time in a Tight Gas Reservoir in Algeria.

-A method of fractal propagation for natural fractures was created in PED Division / Sonatrach marking a new aspect of modeling.

-The Only wells that have not had the desired results are the exceptions that proves the rule and define its limits.

-A modelling method has been optimized to produce the Tight Gas reservoirs **without using hydraulic fracturing.**

THANKS

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