Application of Pyrenean Fractured Carbonate Outcrops for Reservoir Characterisation*

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Abstract

Fractured reservoirs such as tight carbonates, clastics and basements, are often highly heterogeneous in terms of open fracture distributions and connectivity, as well as hydrocarbon or fluid distributions. Working on sub-surface data without the benefits of relevant analog exposure and the application of geological principles based on field knowledge, can lead to mis-interpretation of well or seismic data as well as the results derived from techniques such as curvature analysis or seismic attribute analysis. This poster picks on some good-quality analog exposures in the Spanish Pyrenees to examine the following issues:

- The often major influence of mechanical stratigraphy on fracture distribution, connectivity and style.
- The problem of how to include sub-seismic scale fractures in reservoir models and meaningful simulations.
- The common assumption that faults and their damage zones are a good drilling target in fractured reservoirs.

References Cited


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This is an edited version of the slideset used in the talk, for download from the AAPG Conference site. Please contact Jon at gutmanis@geoscience.co.uk for more information

AAPG European Regional Conference and Exhibition
Barcelona May 13 to 15 2014
Fractured Reservoirs are Challenging!
Finding ‘Sweetspots’ and Connected Volume

Fractures in Devonian mudstones with Fe-rich alteration haloes - Cornwall
 Typical Data Inputs for FRC

The 'seismic gap'

Seismic Conditioning

Edge Detection (e.g., coherency attributes)

Edge Enhancement (Ant Tracking)

Fault Volume (Ants)
Modelling the Fracture Component
Geology for the RE’s!

- Vein
- Fracture corridor
- Fault
- Stylolite
- Tension Fracture
- Solution cleavage
- Lime mudstone
- Oolite
- Clay mudstone
- Solution cleavage

Conceptual

CFN

Facies map

Fracture permeability map

Wennberg et al. 2007
Objectives and Overview

- To illustrate how outcrop can help us
  - with seismic and well data interpretation
  - understanding outputs from ‘back box’ softwares and techniques

- Look at some (related) issues:
  1. How litho-mechanical units influence fracturing
  2. How the outcrop can help model the sub-seismic volume

- Using some outcrops in the Tremp region of the south-central Pyrenees
  - Integration of outcrop and sub-surface data
Regional Geology for the Outcrop Locations
South-central Thrust Unit
Regional Geology for the Outcrop Locations

EBRE BASIN | SOUTH-CENTRAL THRUST UNIT | AXIAL ZONE | NORTH-PYRENEAN THRUST UNIT | AQUITAINÉ BASIN

Serres Marginals | Montsec | Bóixols | L'Orri | Llavorsí | Pallaresa | Moredo | North-Pyrenean Fault | Arize

ALPINE COVER

- Tertiary
- Upper Cretaceous
- Lower Cretaceous

HERCYNIAN BASEMENT

- Granites
- Silurian, Devonian and Lower Carboniferous
- Cambro-Ordovician
- Upper Carboniferous, Permian and Triassic
- Undifferentiated

Symbols:
- Fault
- Thrust
- Oil exploration well
Regional Geology for the Outcrop Locations
South Central Thrust Sheets

Pre-foreland

Upper Cretaceous foredeep

Eocene piggy-back
1. Mechanical Control on Fracturing

Location A
1. Mechanical Control on Fracturing

Southern block
1. Mechanical Control on Fracturing

Southern block - UPPER
1. Mechanical Control on Fracturing

Southern block - UPPER
1. Mechanical Control on Fracturing

Southern block - LOWER
Applying the Outcrop Knowledge: A Project Example

- *In-situ* stress profile built from density logs (Sv), log-based strength estimates calibrated with LOT’s and rock testing (Shmin), and drilling records (Shmax).

- Formation boundaries in blue: Cretaceous carbonates to Triassic mixed carbonate/evaporites sequence.

- Fracture count from borehole image log analysis in the vertical blue column.

- Close correlation between rock strength variations, stress, fracture count and fracture orientation.

The picture of in situ stress variation with depth in a Zagros exploration well that was shown here in the talk is confidential and not included in this pdf.

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2. Investigating the Sub-Seismic Domain
Location B

Interfingering Coniacian reefal carbonates and calc-arenites

Pseudo-seismic profile
2. Investigating the Sub-Seismic Domain
2. Investigating the Sub-Seismic Domain

Spacing Data and Grid Cell Size

Seismic scale faults: ~500 to 1000m  May be clustered
Sub-seismic faults:  ~100 to 250m  Clustered
Fracture corridors:  10 to 100m  Clustered
Stratabound joints:  .5 to 10m  Systematic

Lengths and heights can also be defined
2. Investigating the Sub-Seismic Domain
2. Applying the Outcrop Knowledge
   A Project Example

- GoCad ➤ Petrel ➤ Eclipse

- Stochastic fracture realisations were generated to predict fracture-network permeabilities for reservoir simulation

Courteousy of Steve Gross (Chevron)
2. Applying the Outcrop Knowledge

Select Appropriate Modelling Strategy

K multipliers for the bigger features and leave background out?

Or what grid cell size to capture heterogeneity range but not make the model slow?
2. Applying the Outcrop Knowledge

K modifiers at faults

F2 (88.5 m)

F3 (32.5 m)
2. Applying the Outcrop Knowledge

Appropriate grid cell size

What grid cell size to capture heterogeneity but not make the model slow........2 m x 50m....2m x 100m?
In Conclusion
Derive Fracture Parameters, Concepts, Templates

Reservoir Characterisation Data: Scales of Observation

Fracture Corridors Live in the 'Seismic Gap'
In Conclusion
Test Software-Generated Results

Flexural slip & flow folding:
highest strains are in fold limbs

Tangential longitudinal folding:
highest strains on fold hinges

Plus lithomechanical properties affect deformation

Ramsay 1967
Thanks

Have fun fieldwork (and safe) but expect the unexpected......

A chopping board made from 400 Ma volcanic tuffs, NW England

Lluis at work