Using Advanced Workflows to Support Development of Unconventional Plays

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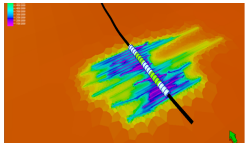
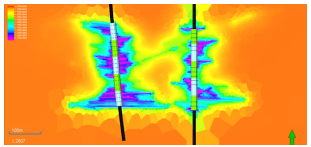
SIS Global Forum

PRESENTATION OUTLINE

- **Introduction**
  - Observations from an Unconventional development
  - Objective
- **Methodology**
  - Reservoir Geomechanics Coupling for Parent-Child development
  - Stress Shadowing Effect using a Finite Element Solution Method
- **Results & Analysis**
  - Analytical Solution Method (ASM) versus Finite Element Solution Method (FESM) on Stress Shadowing Effect
    - Base Case Stage Spacing versus Half Base Case Stage Spacing
    - Single Well and Multi Well
- **Summary**



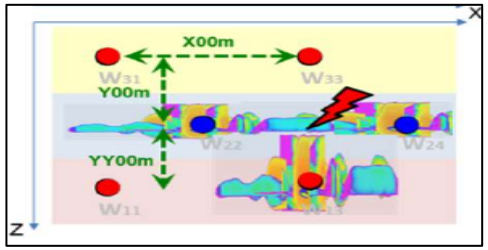


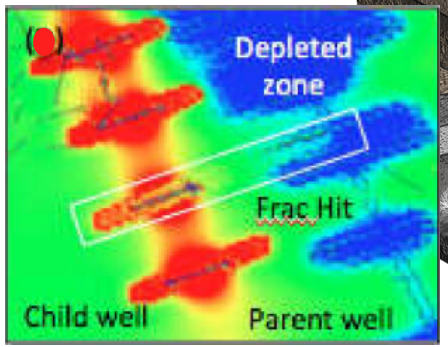
INTRODUCTION – Unconventional plays context

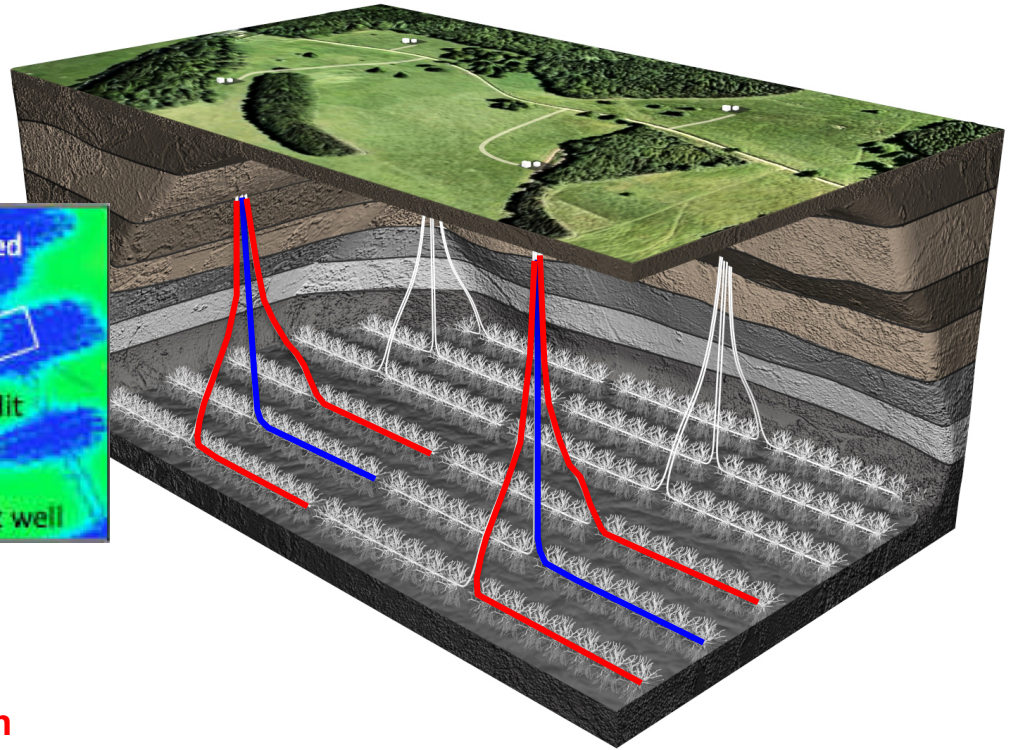
SPACE:

- Vertical and Horizontal well spacing
- Pad design/array

Well Interference, Frac Hit, etc







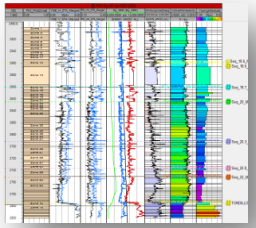
TIME:

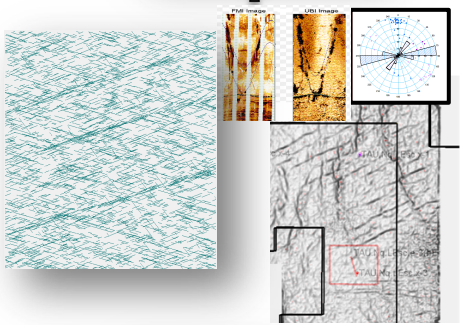
- Completion Sequence
- Parent-Child Development

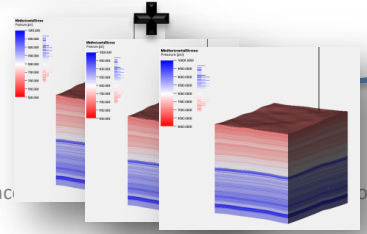
Due to stress changes during frac & production
Child wells have lower recovery than Parent wells

METHODOLOGY (AS YOU MAY KNOW)

1 1DMEM, DFN, Grids

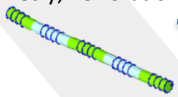




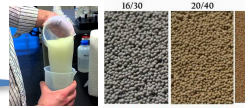


2 Frac Design

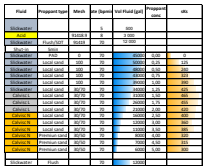
Geometry, Perforations



Fluid and Proppants properties

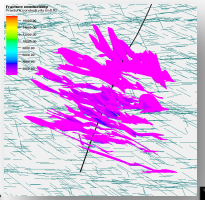


Pumping Schedule

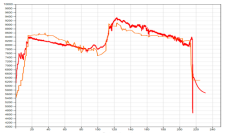


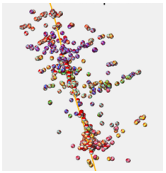
3 Frac simulation and pressure matching process

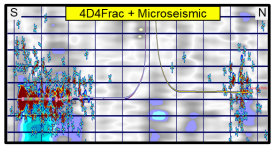
Frac Simulation



Pressure Match

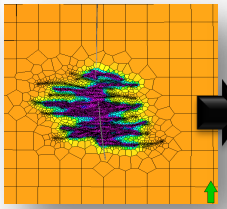






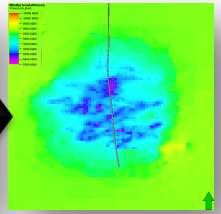
4 Production Grid

Unstructured Grid

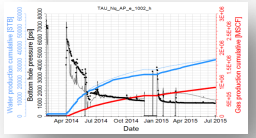


5 HM and Forecast

Pressure/Production Matching GRID

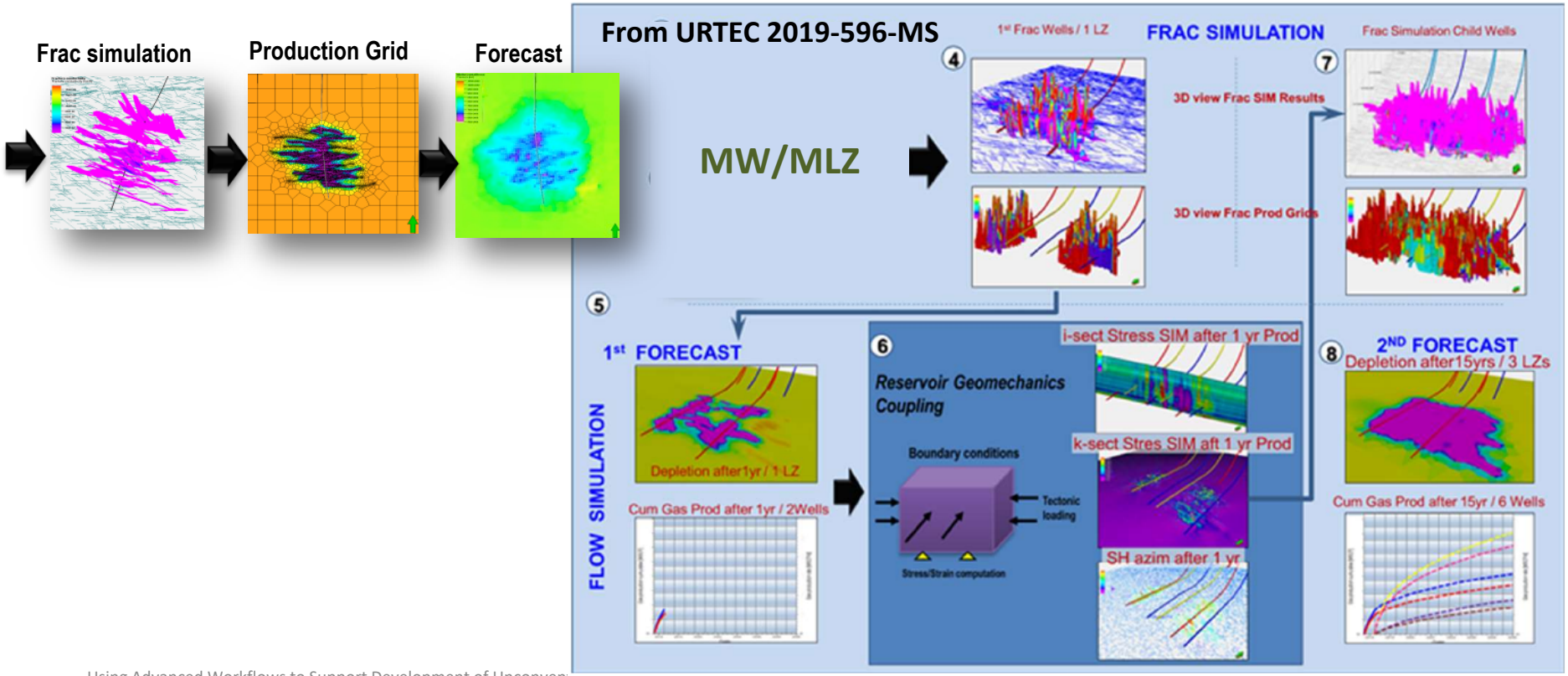


History Match



METHODOLOGY (ADRESSING « TIME » IN MULTI-WELL)

Reservoir Geomechanics Coupling



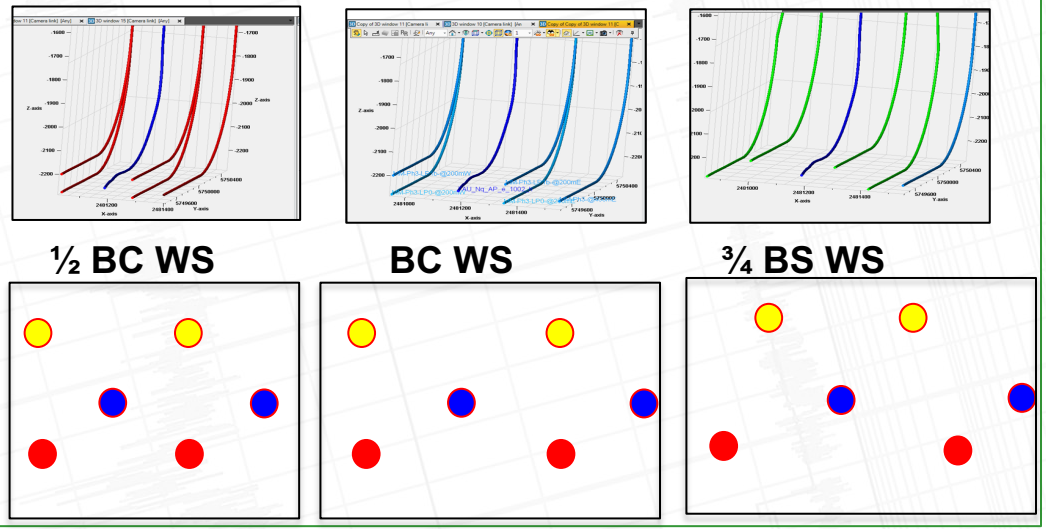
OBSERVATIONS: FIELD CASE Multi-LZ Sensitivity

From URTEC 2019-596-MS

SPACE:

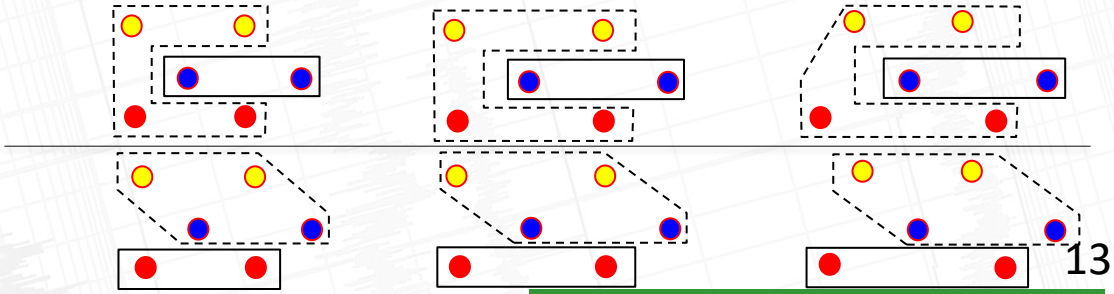
- Vertical and Horizontal well spacing
- Pad design/array

LZ1, LZ2 and LZ3 together



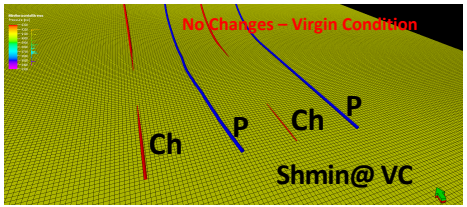
TIME:

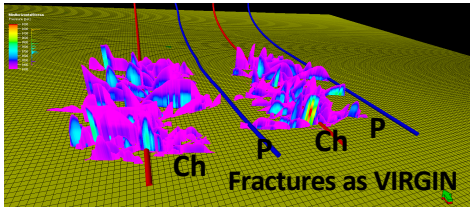
- Completion Sequence
- Parent-Child Development



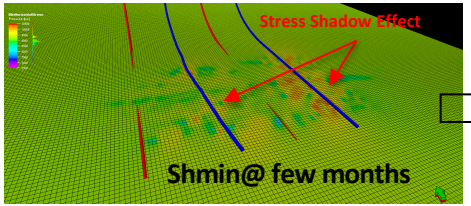
OBSERVATION FROM A MLZ FIELD CASE

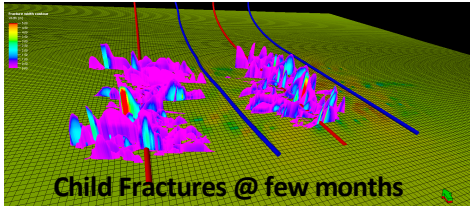
INTER WELL : WHEN complete the Child matters !



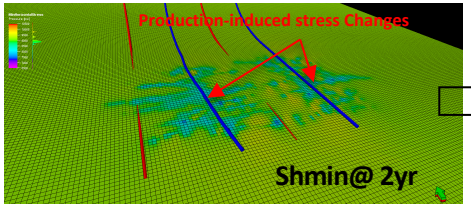


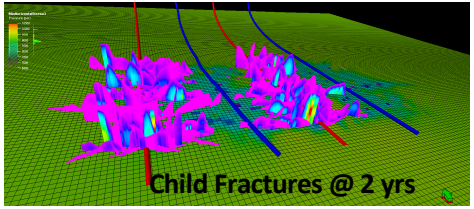
Longer Lf



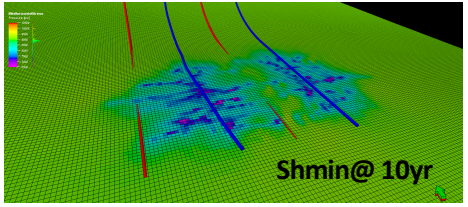


Shorter Lf

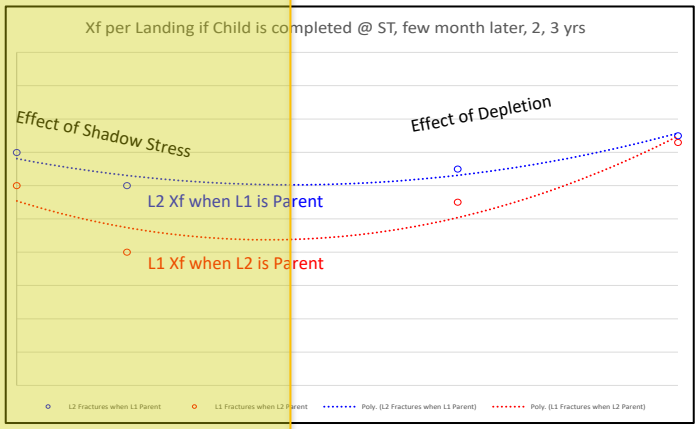


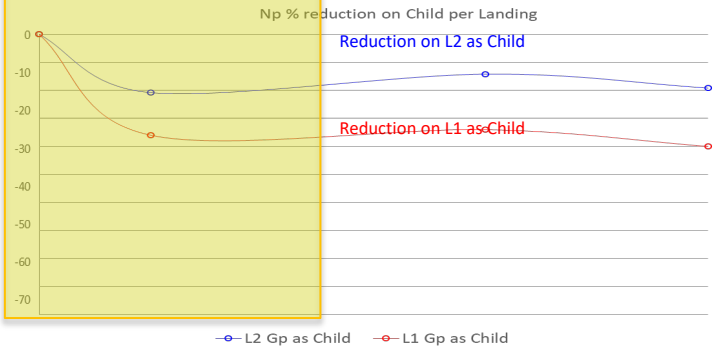


Longer Lf



THIS EFFECT IS MORE INTENSE IN HIGHER ANISOTROPIC FACIES INTERVAL



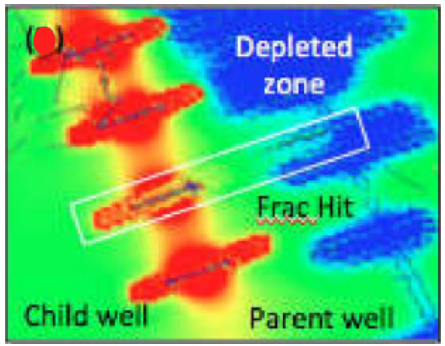


Also observed in Pichon, S., et al, 2018

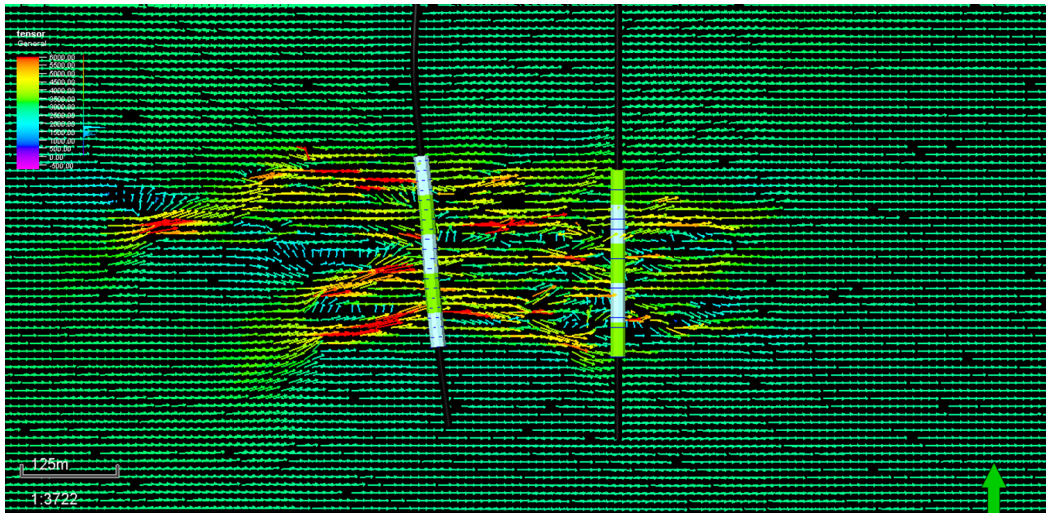
OBJECTIVE

Show a workflow that solve the 3D change (frac-to-frac) of the full Stress Tensor using a Finite Element Solution Method (FESM).

Before this happens

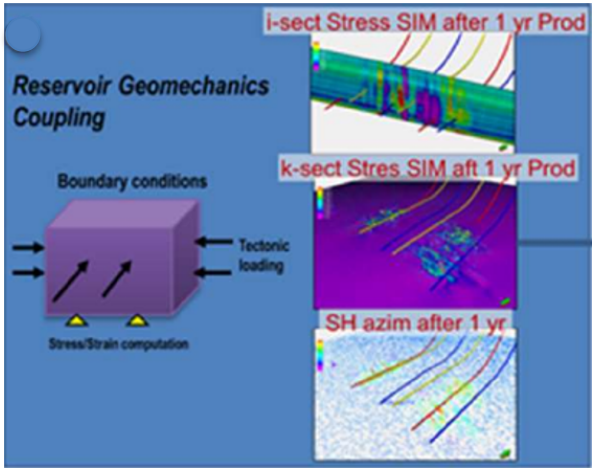


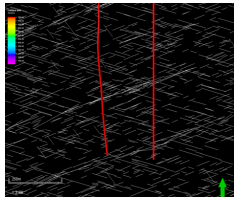
How this happens / How We simulate What happens



FES METHODOLOGY FOR SSE

For each stage





Hydraulic Fracture Network for Visage

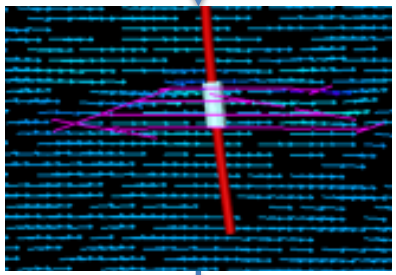
Stimulation Stresses

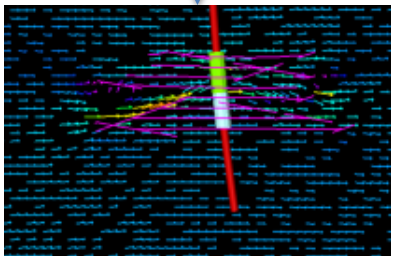
- Analysis
  - Stresses, Pressure and Rock Data
  - Unstructured Grid
  - Hydraulic fracture
- Natural Fractures (DFN)
  - Fracture Compliance

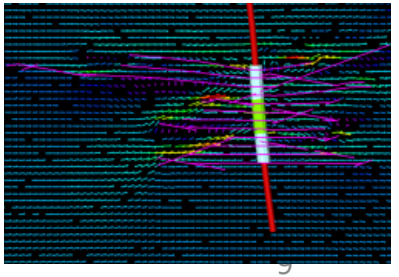
VISAGE Simulation, Then Frac Stage 1

VISAGE Simulation after Stage 1, **THEN FRAC Stag 2**

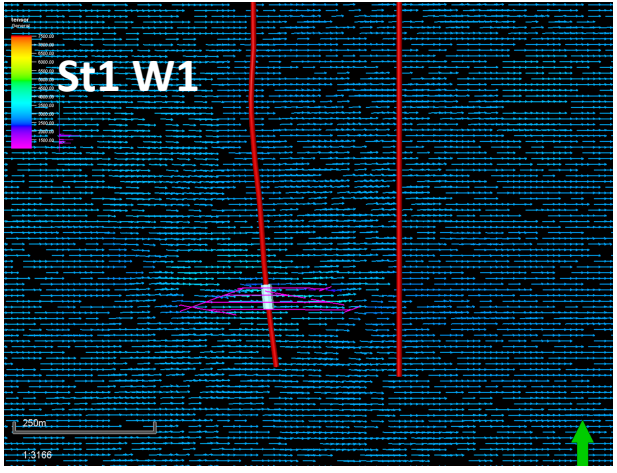
VISAGE Simulation aft Stage 2, **THEN FRAC Stage 3**

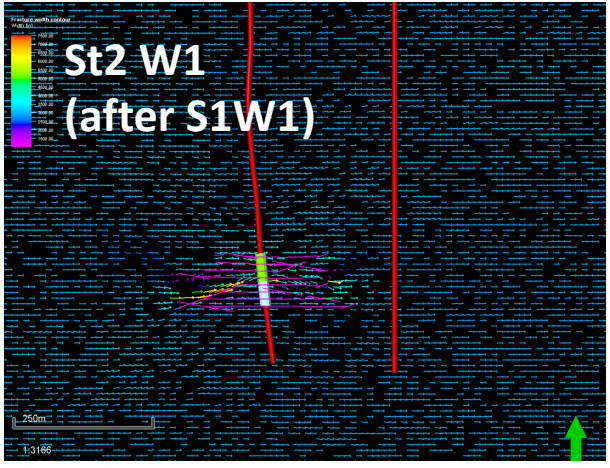


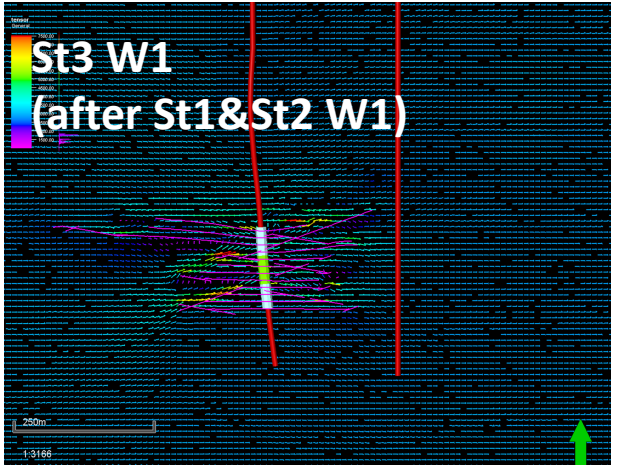


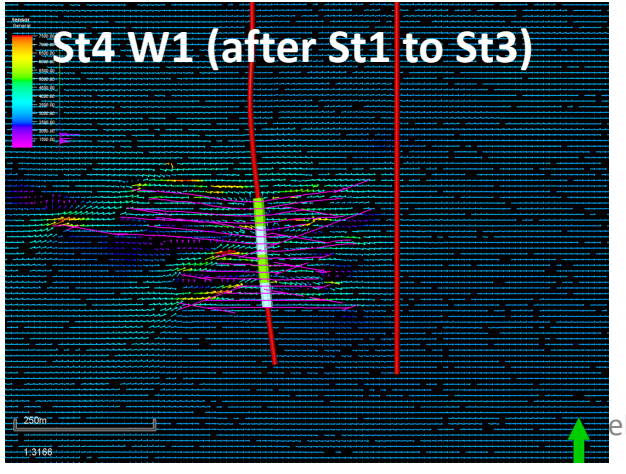


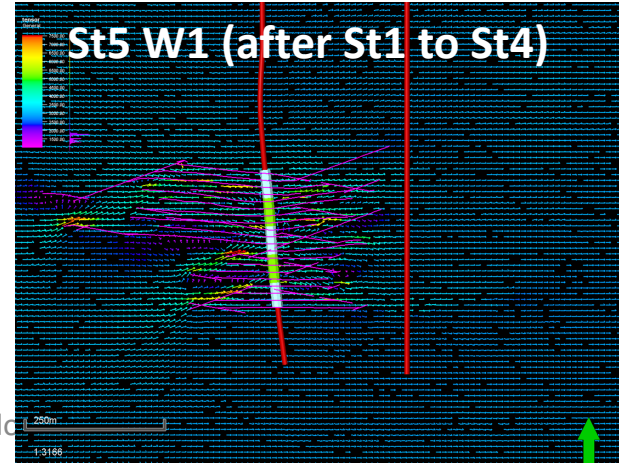
FES METHODOLOGY FOR SSE - Single to Multi Well

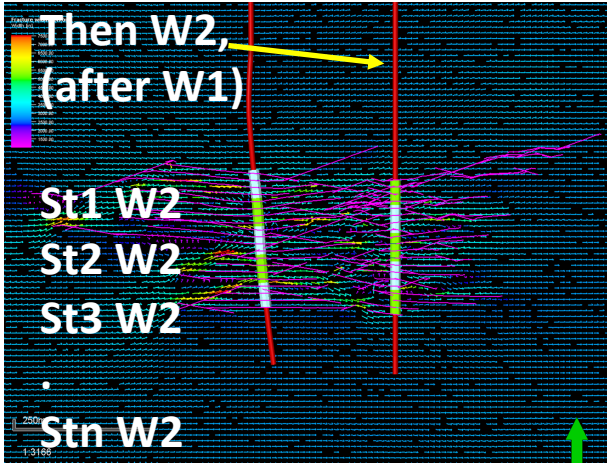






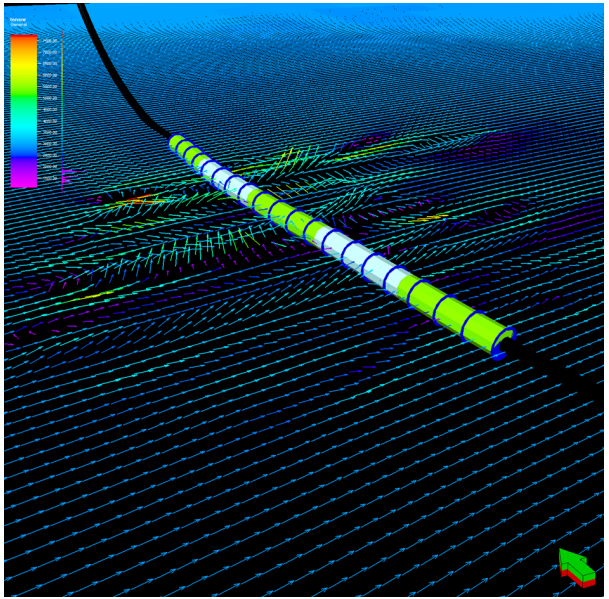




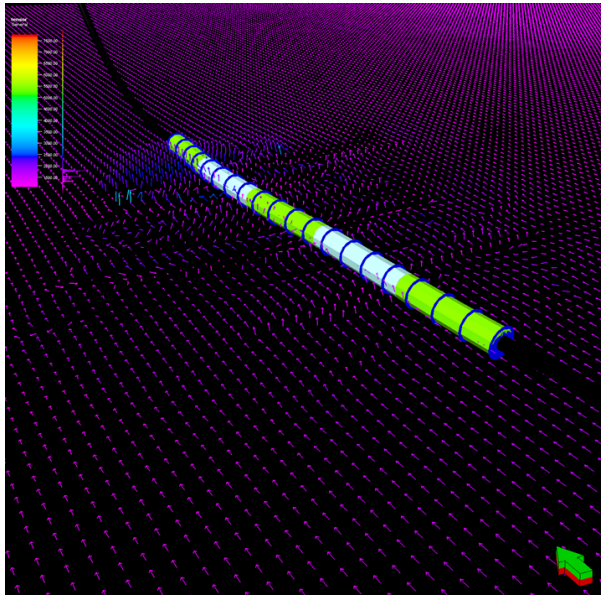


Stress Tensor w/shadowing effect simulated using FESM

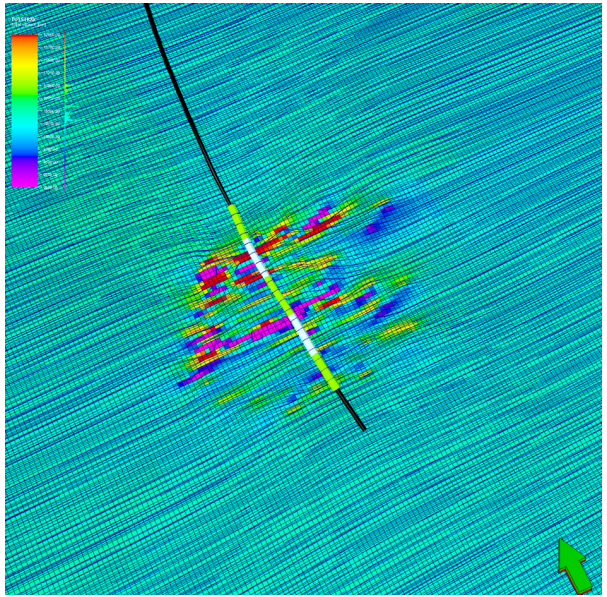
S1



S3



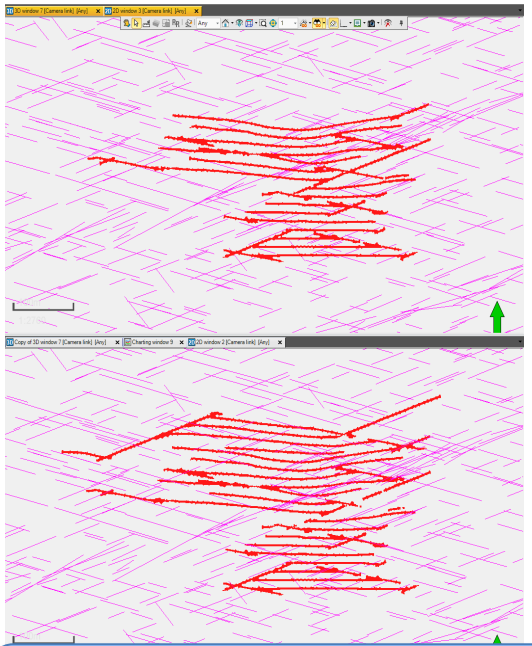
TOTSTRXX

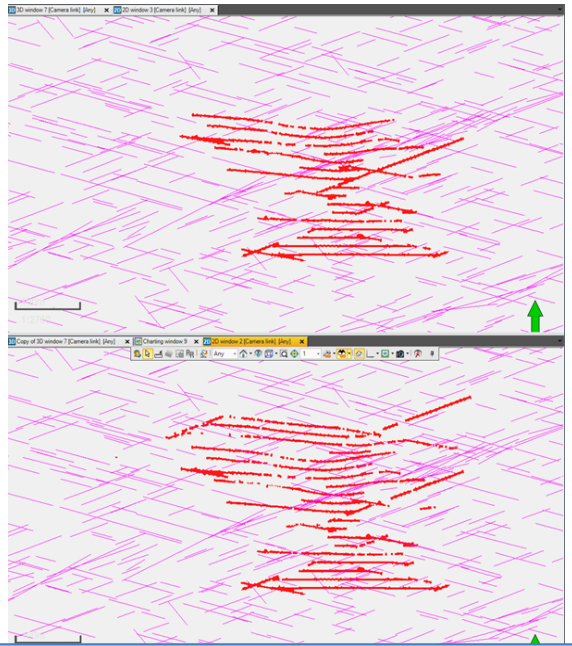


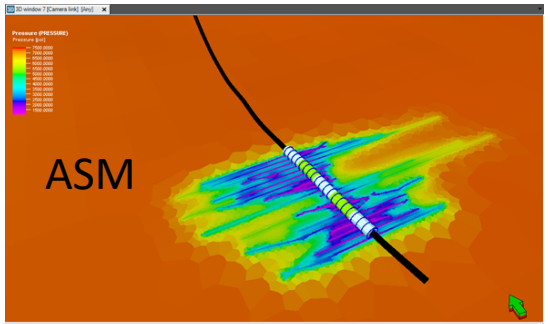
½ BCSS – Proppant Region Distribution – AS vs FES

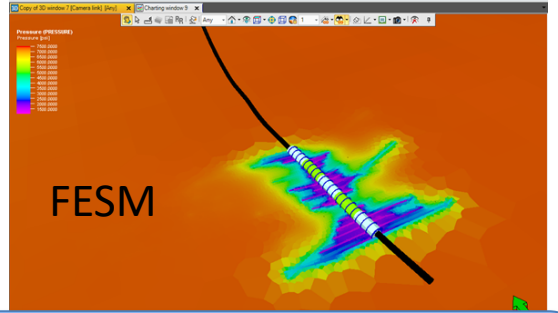
All Regions

Propped Regions



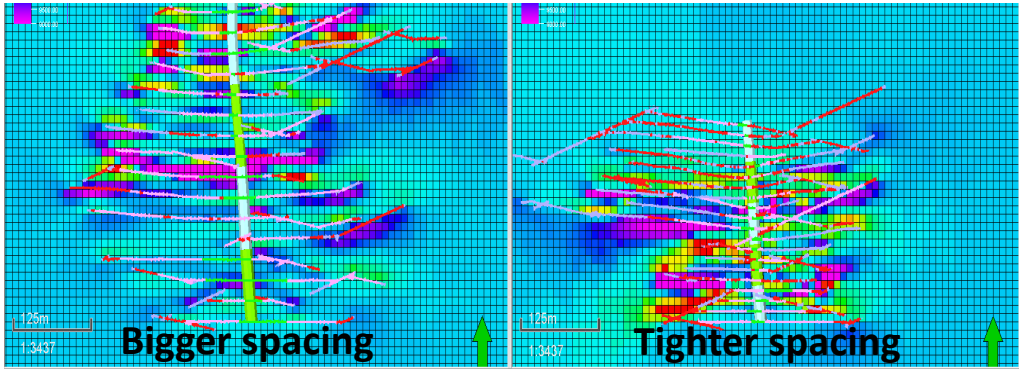


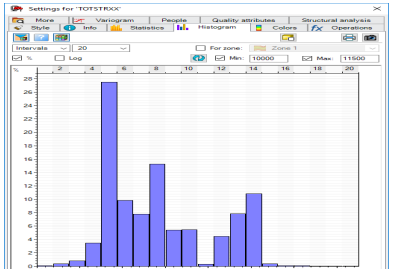


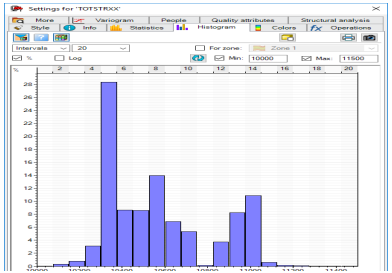


1) *Apparent longer fractures that end being less propped ➔ impact on drainage volume*
2) *What other impact of those longer unpropped fractures ? CsngDef*

TOTSTRXX – BC vs ½ BC SS

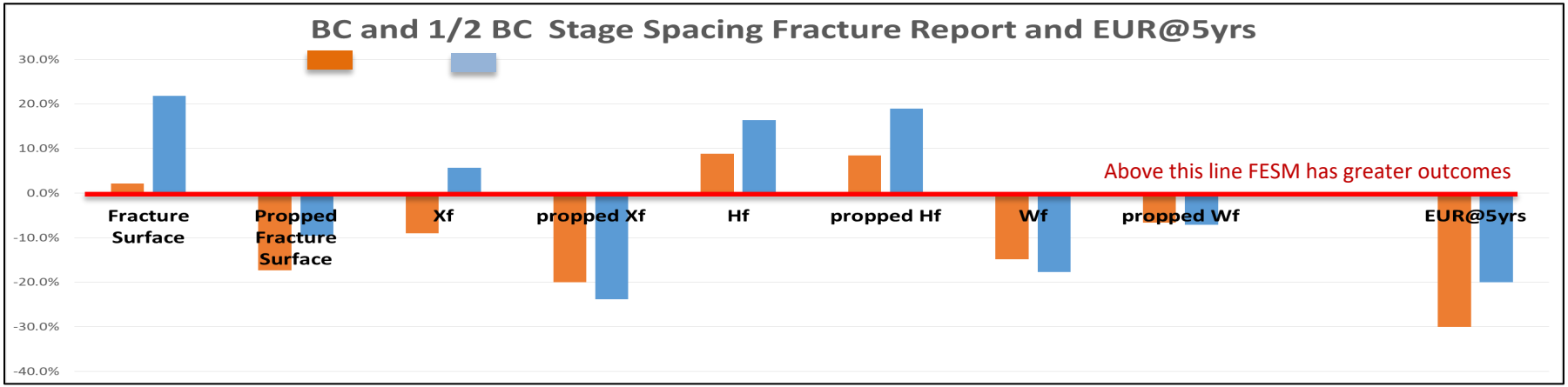


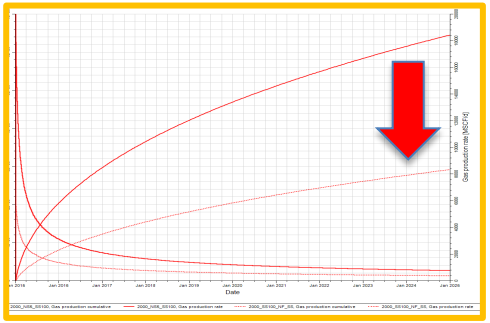


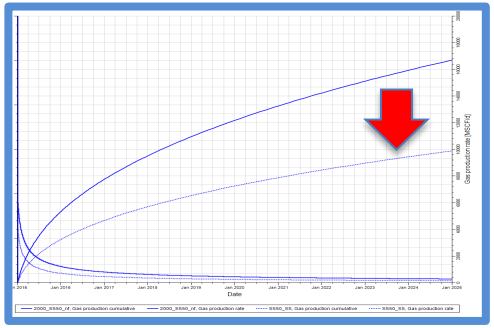


Similar outcome values distribution but different spatial distribution ➔ SRV impact ?

Results and Analysis – Single Well (BC and ½ BC SS)
Impact of SSE on SRV.G SRV.P – ASM vs. FESM

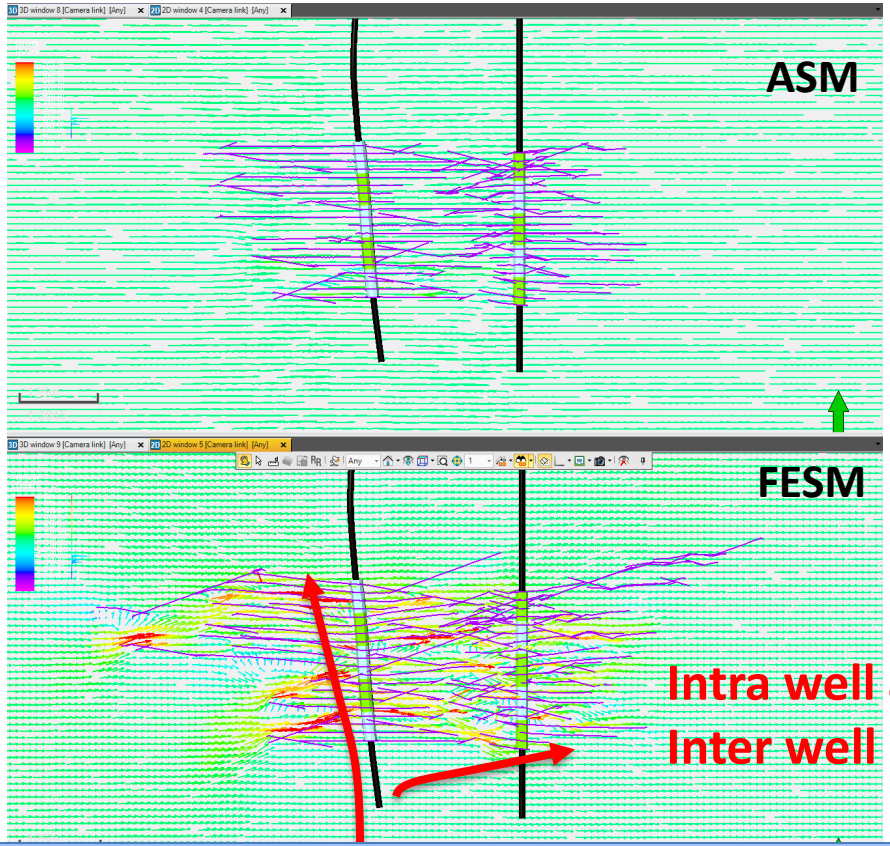






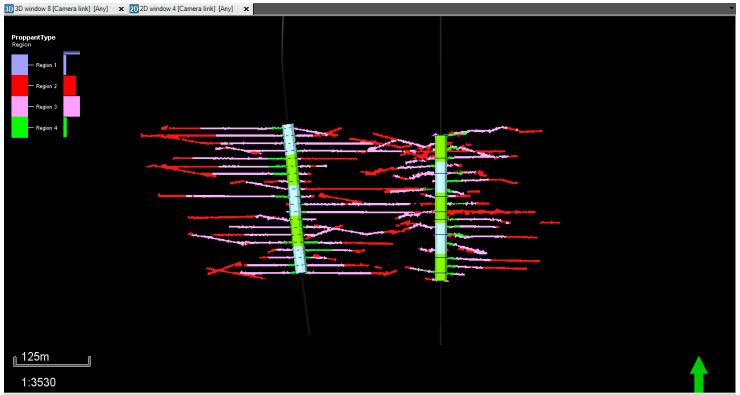
Smaller Propped Surface Fracture and Width F using FESM. And ~20% less EUR

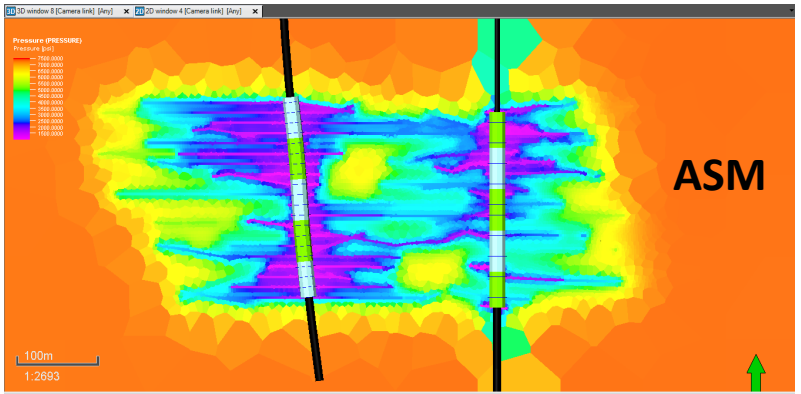
Results and Analysis – Multi-Well

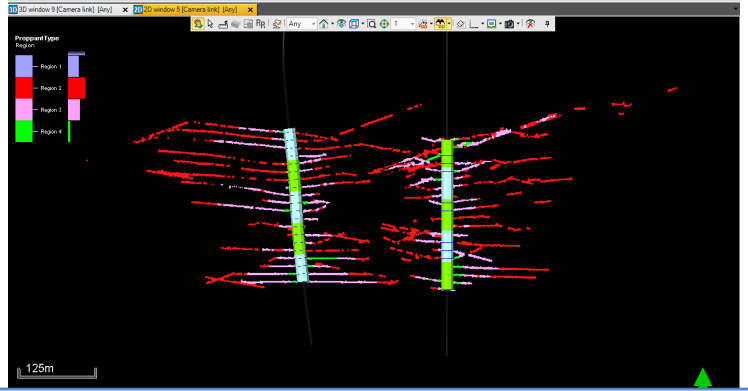


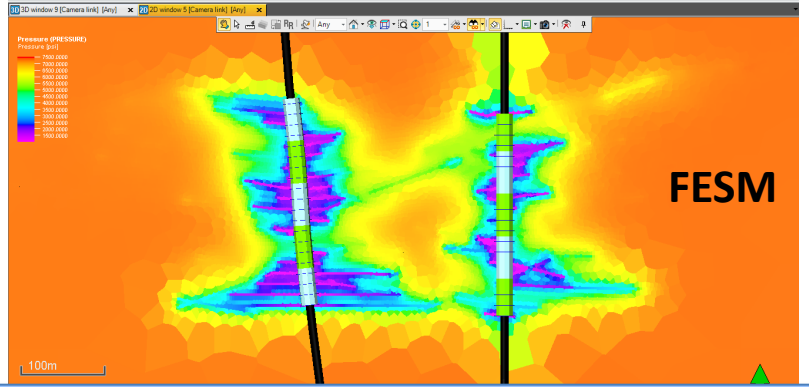
Higher variation of the SRV.G / Stage on FESM. Longer Fractures ?

Results and Analysis



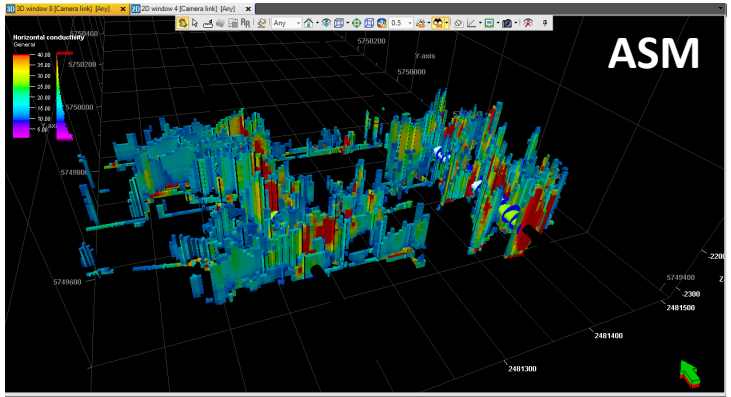


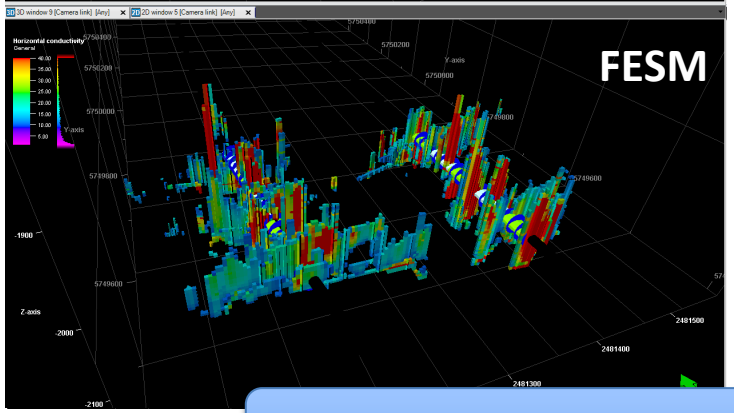


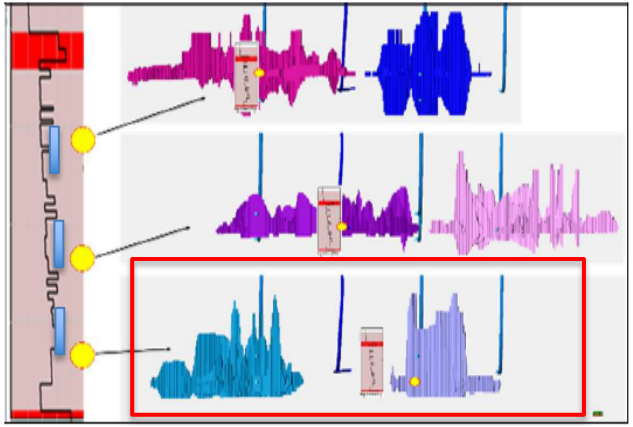


Although longer Total fracture length with FESM, less connected, hence, less drained area

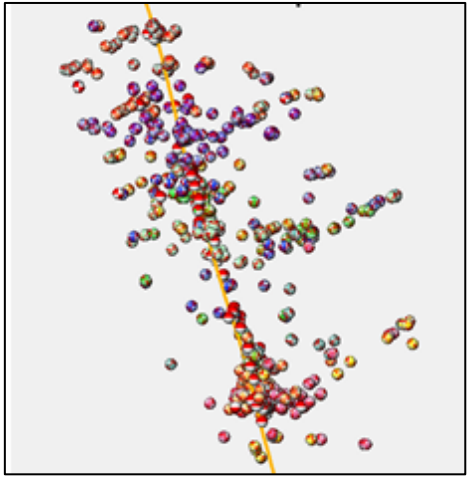
Results and Analysis
- Less than what We thought !



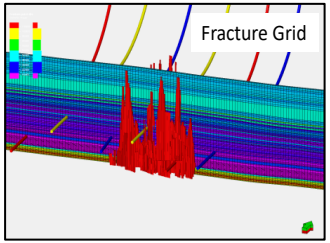


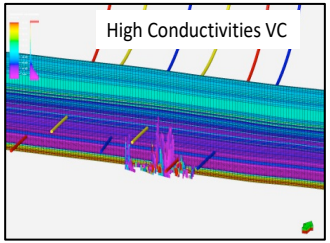


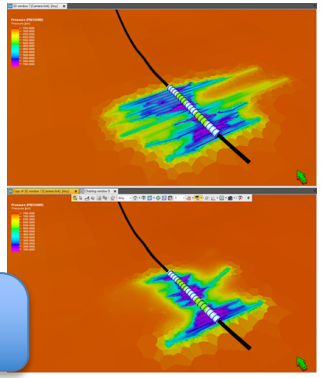
L3 Simulation Fcd



Courtesy M. Vinchon

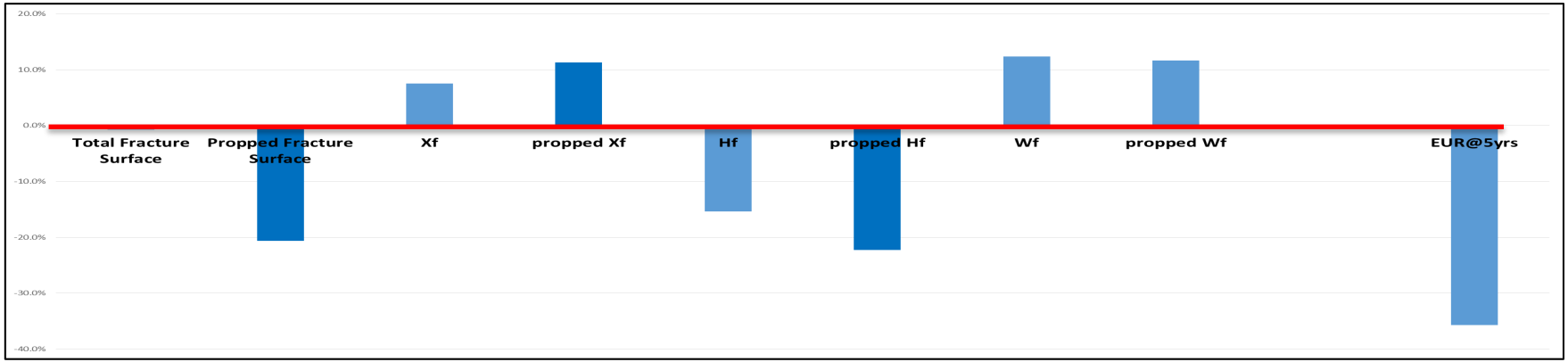


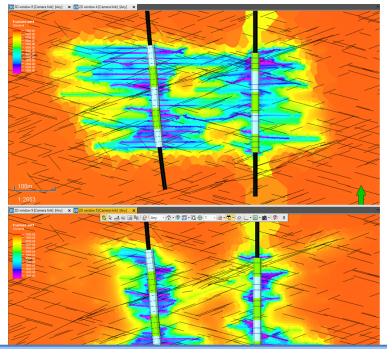


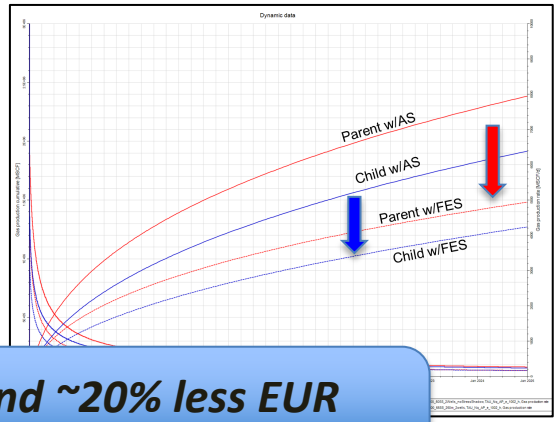


Better correlation was found btw SRV.G, S. events and SRV.P

SRV.G and SRV.P Results – Multi-Well Case







Smaller Propped Surface Fracture using FESM. And ~20% less EUR

SUMMARY

- Integrating VISAGE into the frac-to-frac simulation, allows to get a rigorous 3D change of the full stress tensor.

  The 3D option in the Analytical Solution method (ASM), is a pseudo 3D – the fracture model used in Kinetix (or any other frac software) it is a 2D ASM called P3D

  Kinetix enhances the solution with Natural Fractures (that are still strictly vertical – reason why the theory behind can only treats a 2D solution, not a real 3D).

- By using FESM, a Kinetix Fracture Model with the best input in term of true 3D stress tensor is provided.

- FESM offers an INTRA and INTER-well solution, which is required in any unconventional play assessment.

Acknowledgment

Total Austral and partners to allow the publication of this work

Vincenzo De Genaro, Schlumberger, Technical support.

Thanks