Coring Through SRV Captures Complexities of Actual Hydraulic Fractures & Proppant Distribution

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Efficient Energy: Observations, Monitoring & Diagnostics

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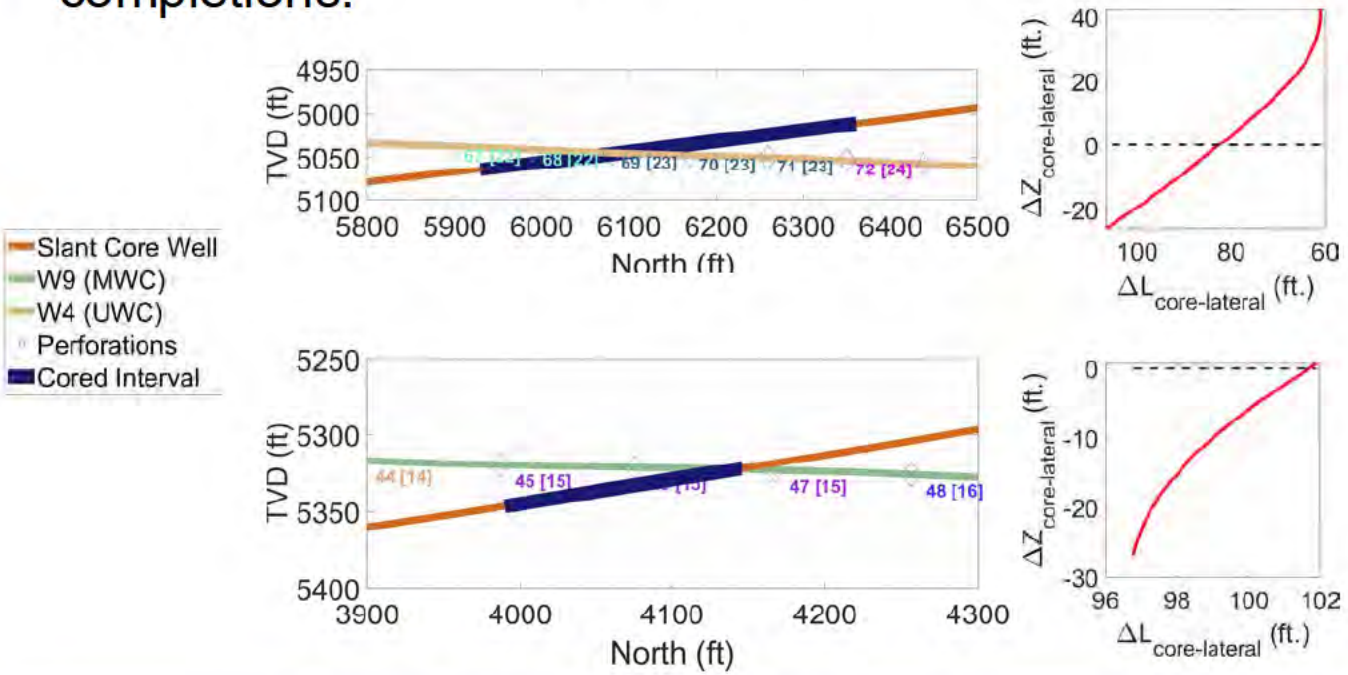
Agenda

- HFTS-1 coring program
- Proppant analysis workflow
- Proppant distribution in UWC/ MWC cores
- Possible proppant distribution drivers at varying scales
- Fracture complexities & quantification
- Future work

HFTS-1 coring program

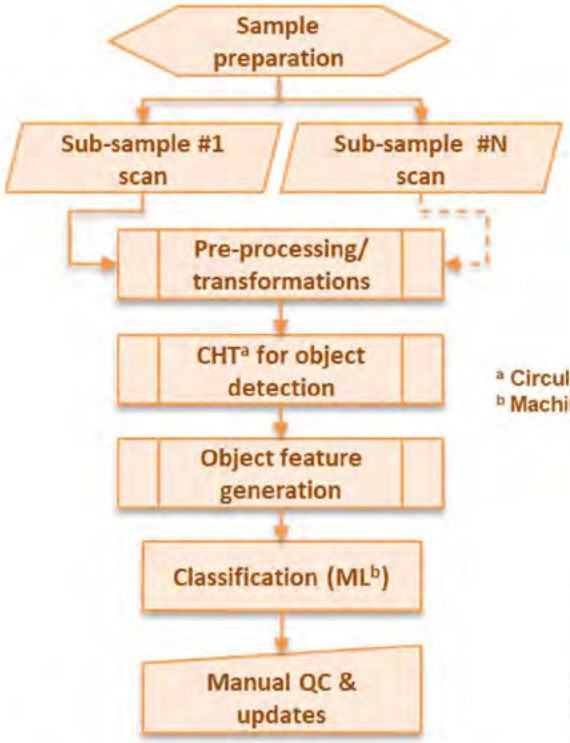
- Two reservoir units (upper & middle Wolfcamp) were cored post completions.



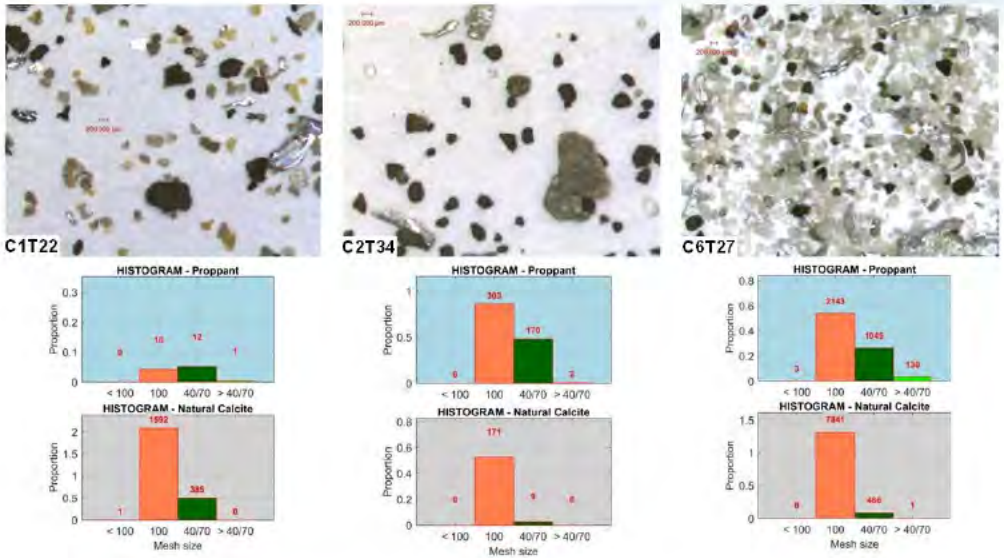
Various diagnostics include petrophysical & image logs, CT scans, detailed core fracture characterization, proppant analysis, geologic interpretation (core slabbing), compositional analysis (XRF/ FTIR), etc.

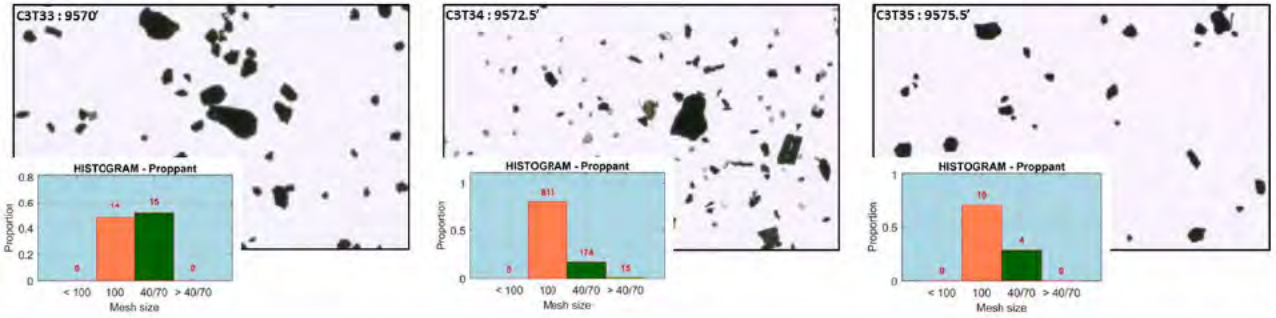
Proppant analysis

https://doi.org/10.1016/j.petrol.2018.09.062



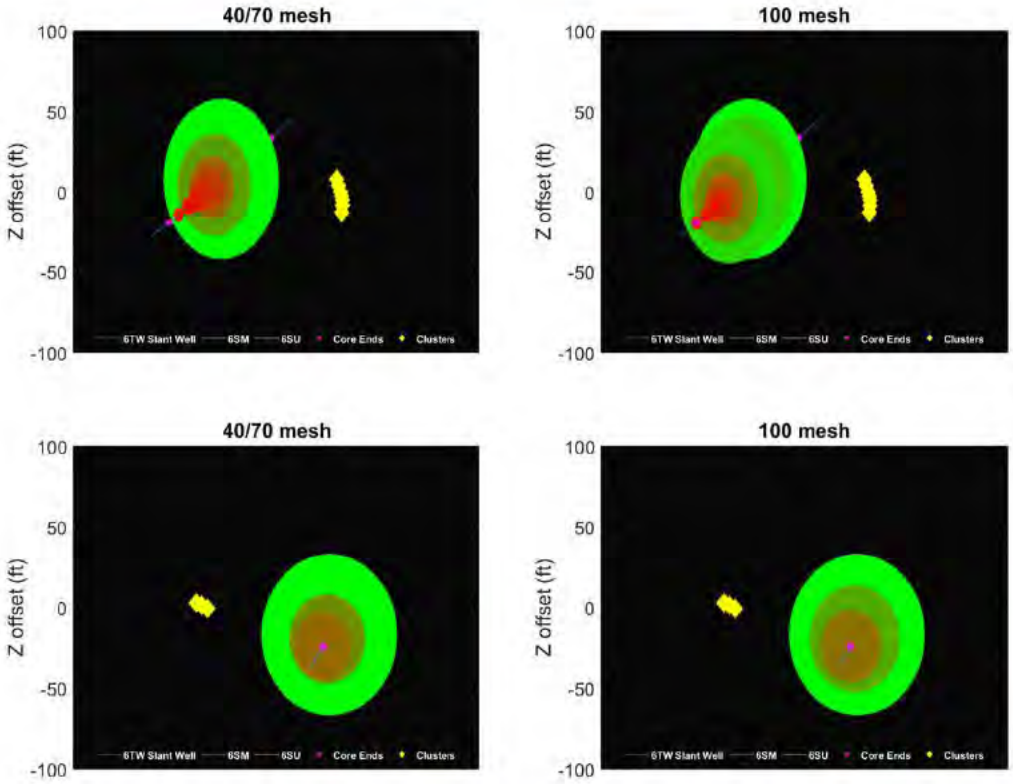
[a] Circular Hough Transform
[b] Machine Learning

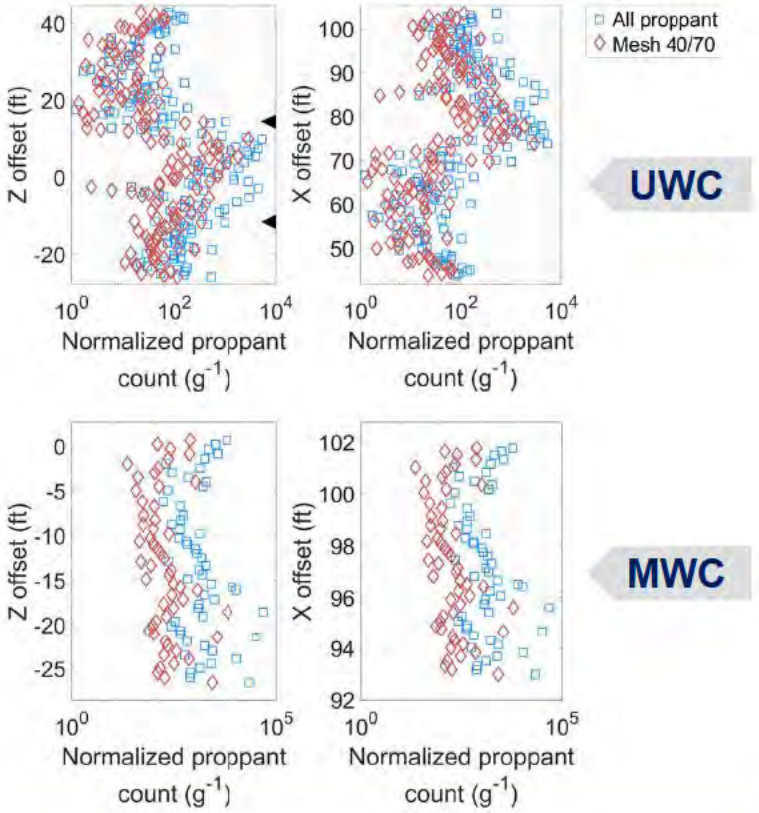




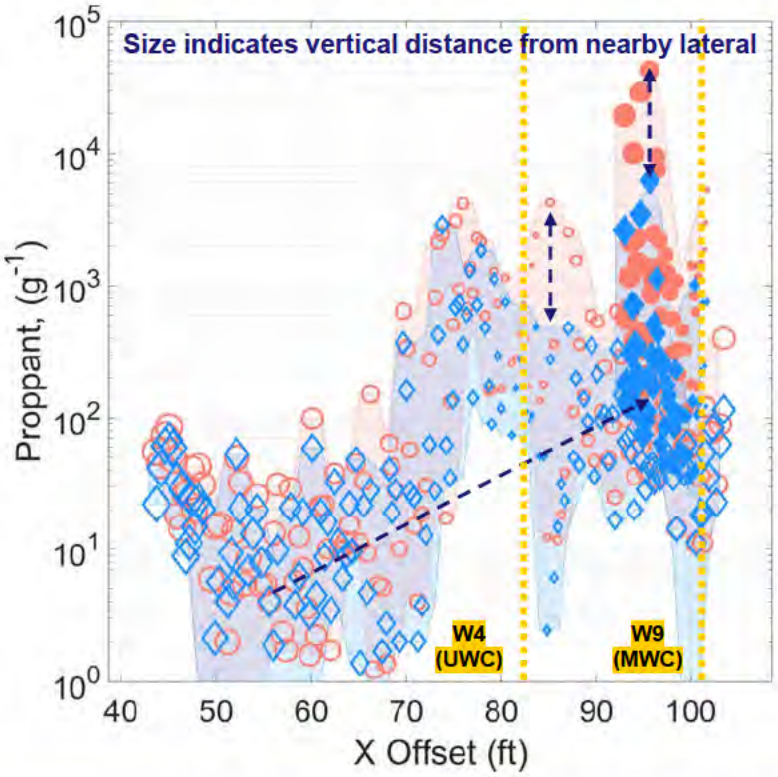
Proppant distribution

https://doi.org/10.2118/194496-PA





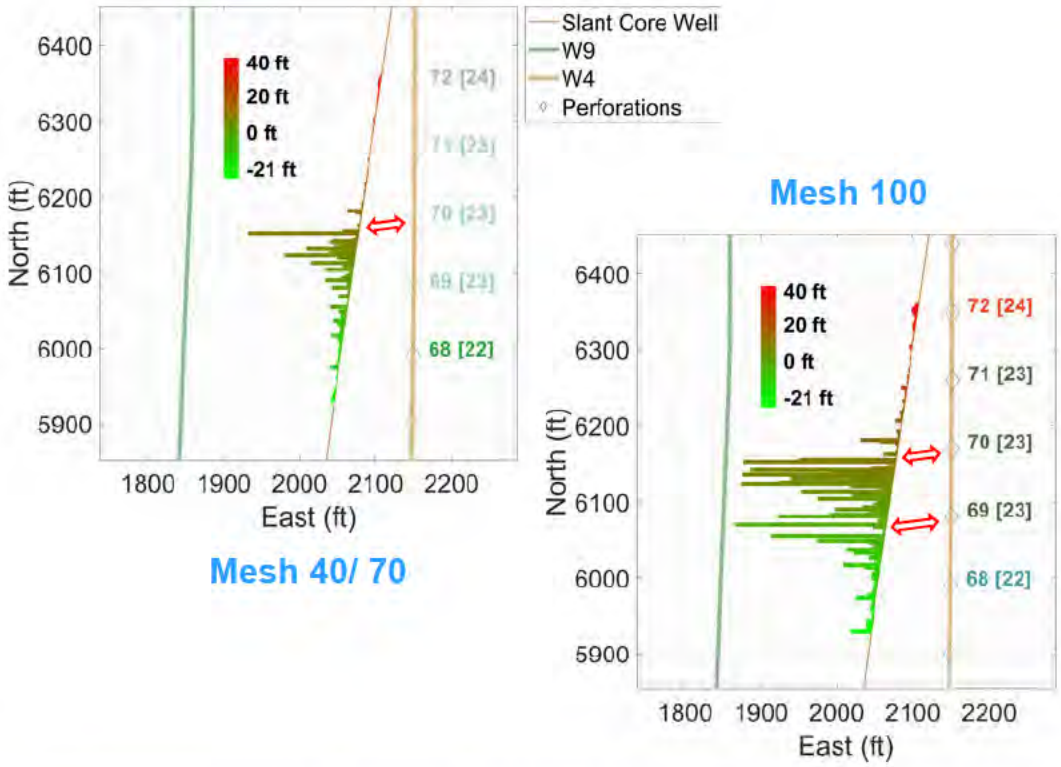
Distribution drivers – size vs. offset



○ 100 mesh proppant - UWC
◇ 40/70 mesh proppant - UWC
● 100 mesh proppant - MWC
◆ 40/70 mesh proppant - MWC

- Order of magnitude difference between UWC & MWC counts.
- Mesh 100 dominates at larger lateral offsets.
- Intuitively, we expect the lighter mesh 100 sand pumped first during treatment to travel farther out from the perforations compared with the heavier mesh 40/ 70 sand pumped later.

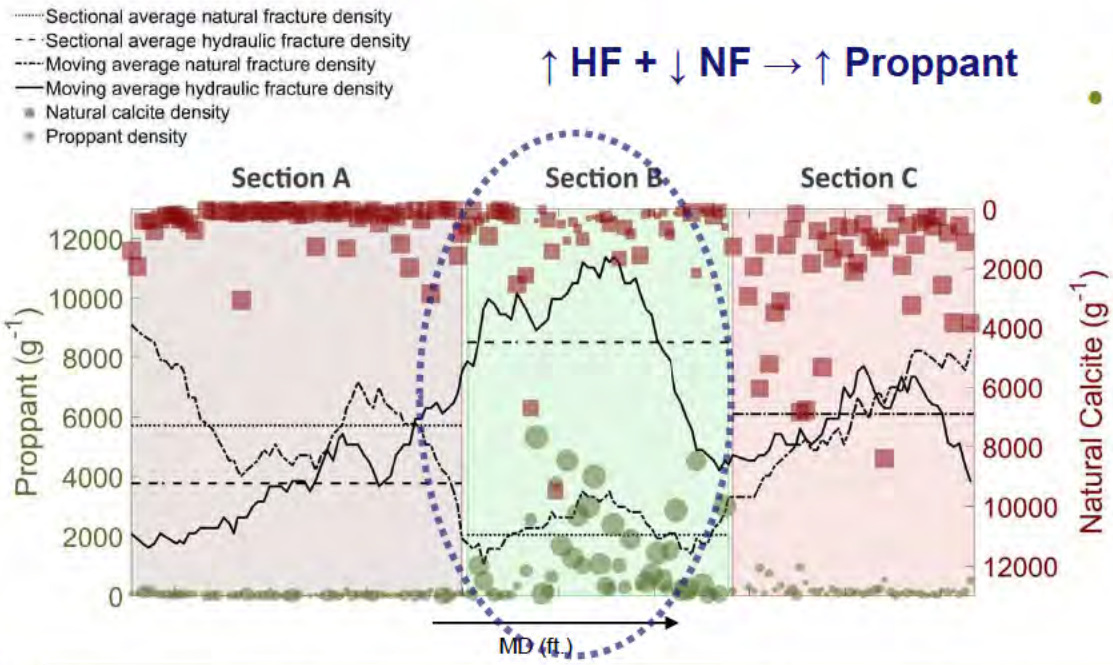
Distribution drivers – perforation clusters



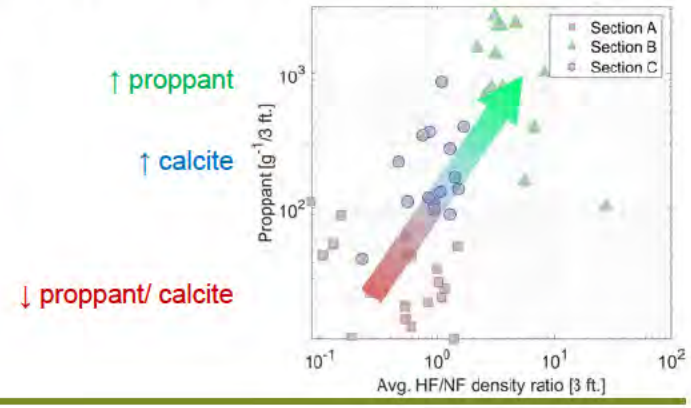
- Heel side distribution bias. For cluster 71, vertical offset is significant.
- Higher proppant count with smaller (mesh 100) fraction along cluster 69 likely a result of proppant transport behavior across clusters.
- Another reason could be decreasing lateral separation as we go from cluster 69 to 70.

Distribution drivers – hydraulic fractures

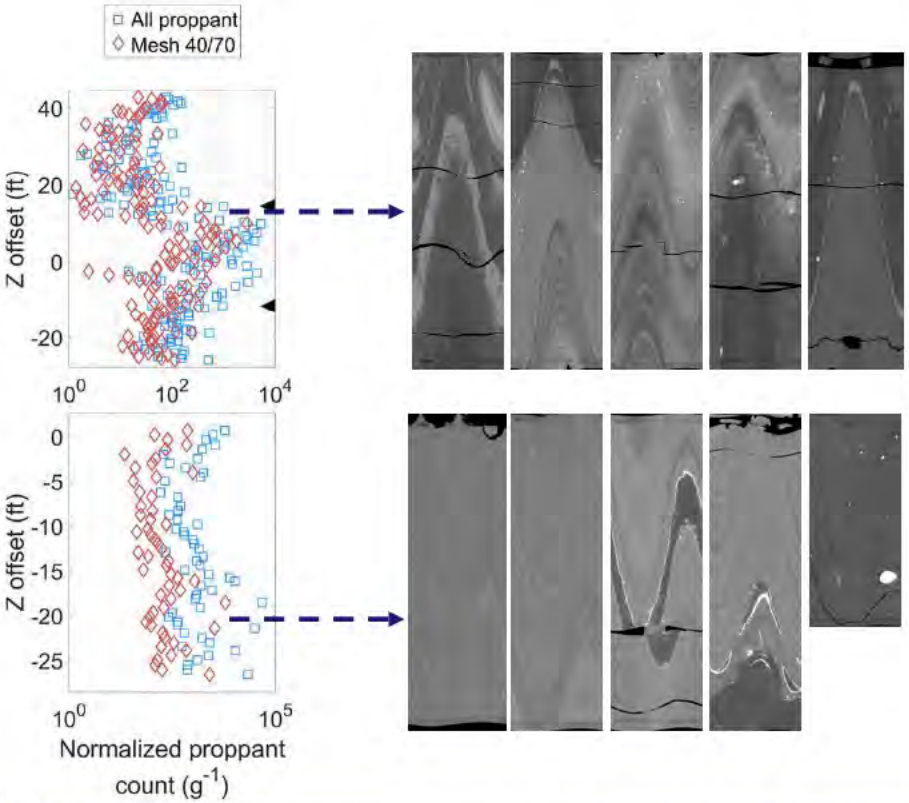
- Vertical offset of markers indicate the type count.
- Relative size of the markers indicate prevalence of particle type in that sample compared to all classified particles.



- Variations in proppant/ calcite could be due to fracture interaction/ reactivations.
- Calcite distribution in sections B & C is broadly correlated with natural fractures.



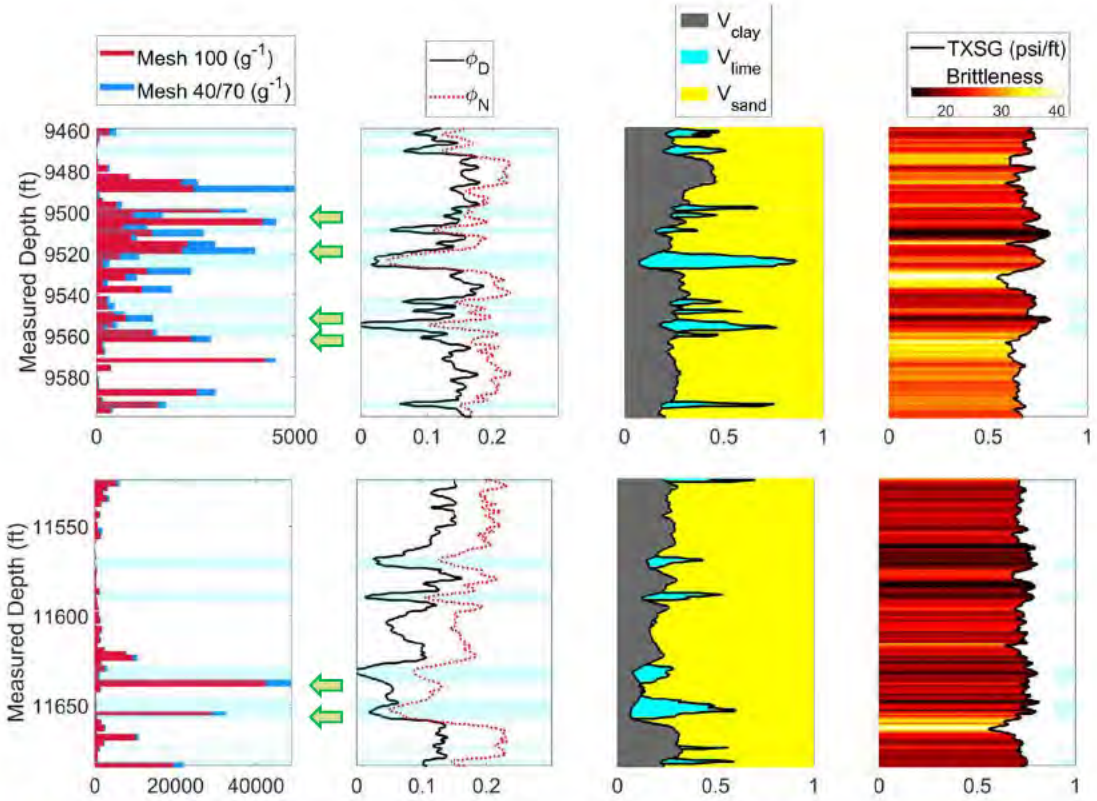
Distribution drivers – fracture complexities



- Abrupt changes in proppant concentrations are observed in some locations from core CT scans – particularly where shales are separated by carbonate intervals.
- A possible explanation could be stress contrasts/ boundary effects causing complex fracturing & local screen out.
- How do these variations & selective screen-out impact fracture productivity.

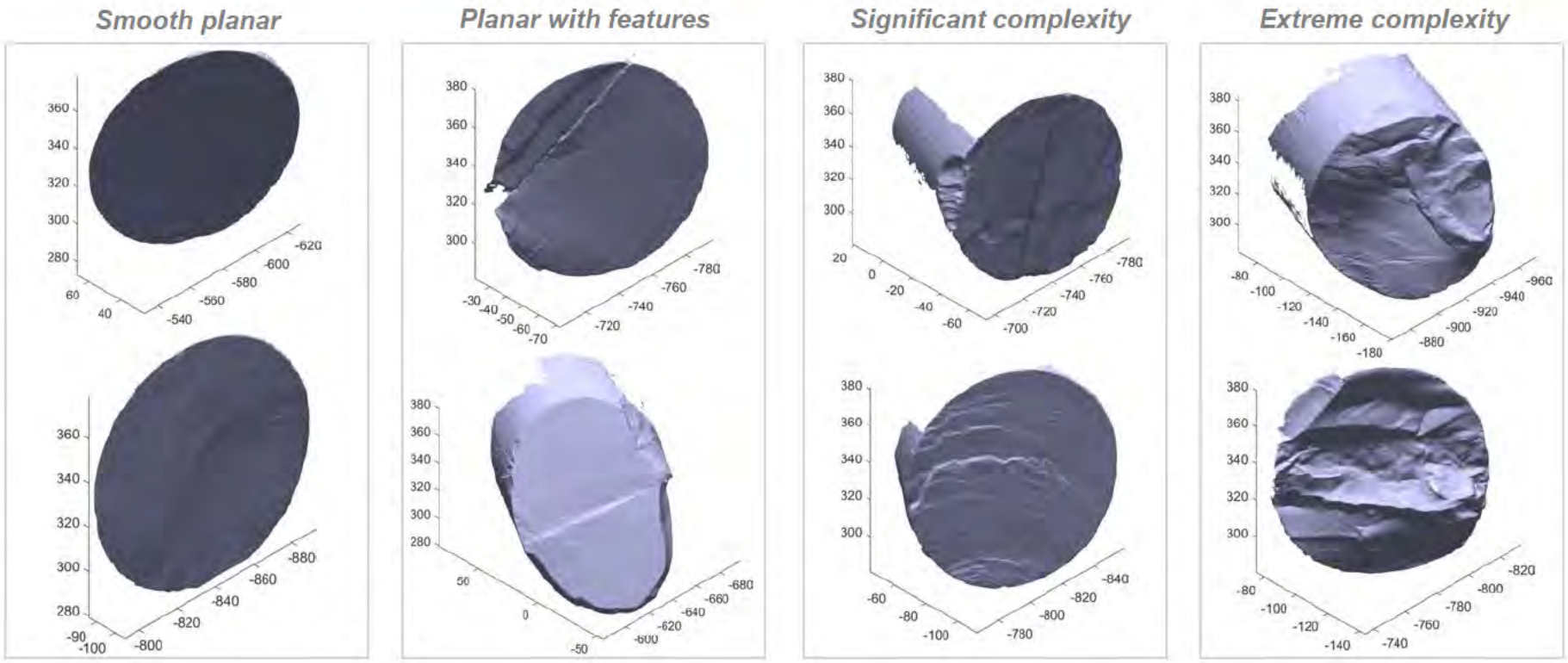
Distribution drivers – bedding margins

https://doi.org/10.2118/194496-PA

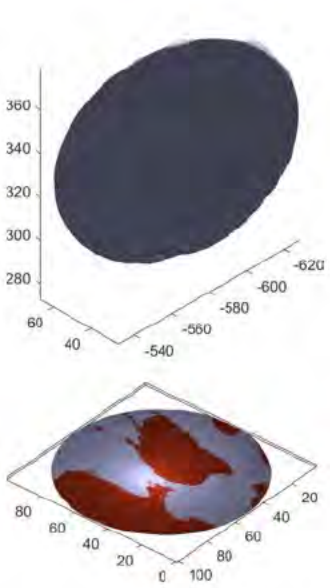


- Proppant peaks proximal to bed boundaries or sections with significant stress changes.
- Could be a function of fracture complexity in areas with high stress contrasts.
- Proppant entrapment in localized zones likely has impact on connectivity within stimulated rock.

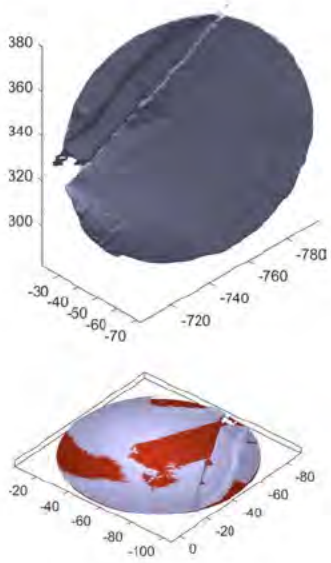
Fracture mapping (3D laser scans)



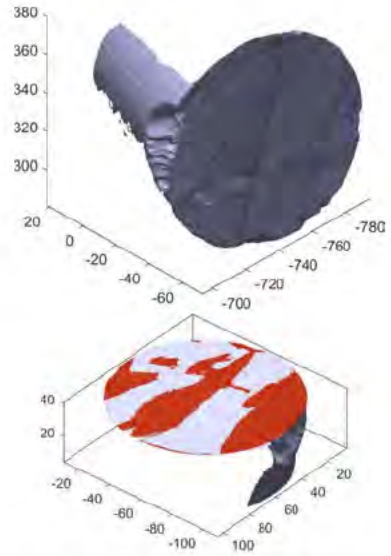
Fracture complexities - quantification



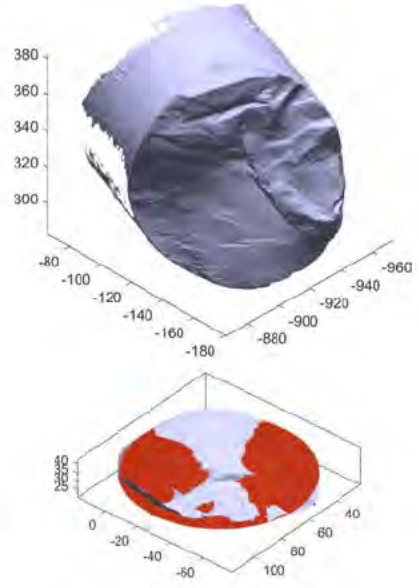
Roughness: 0.23 ± 0.17 mm
Fit: 2.21



Roughness: 0.38 ± 0.42 mm
Fit: 1.86



Roughness: 0.37 ± 0.61 mm
Fit: 0.86



Roughness: 2.21 ± 1.73 mm
Fit: 0.56

INCREASING QUANTIFIED ROUGHNESS

Future Work

- Fracture surface “feature” quantification for automated analysis – roughness, propagation features, complexity, etc. *How do fractures differ?*
- Understanding the relationship between fracture properties & proppant distribution identified within the core. *Is localized proppant distribution guided by fracture features?*
- Comparing complexity against known lithology distribution within the cored interval. *Are fracture features governed by lithology/ stresses?*
- Analysis of proppant distribution & fractures from additional cores from HFTS-1 EOR pilot as well as HFTS-2 slant core wells.
- Potential future applications such as automated fracture/ stimulated reservoir characterization.