Passive Acoustic Metamaterial Proppants for Advanced Fracture Diagnostics

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Oceanit

U.S. Department of Energy

National Energy Technology Laboratory

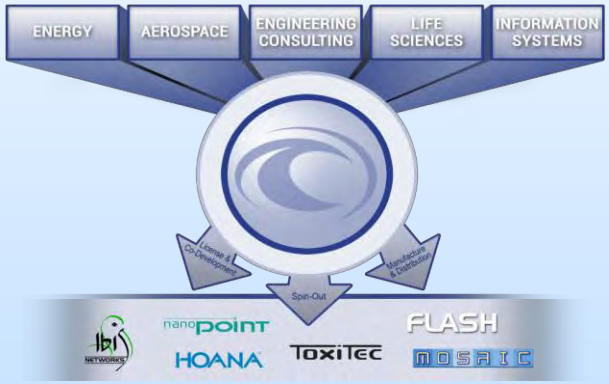
Mastering the Subsurface Through Technology Innovation, Partnerships and Collaboration:
Carbon Storage and Oil and Natural Gas Technologies Review Meeting

August 13-16, 2018

Oceanit Background

- **Founded 1985**
- **Diversified Technology Company**
- **160+ Employees**
- **HQ: Honolulu, Hawaii**

U.S. DEPARTMENT OF ENERGY



Oceanit Business Model

Oceanit Innovation Process

NATIONAL ENERGY TECHNOLOGY LABORATORY

Oceanit Collaboration

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VuFrac Presentation Outline

- Background and project objective
- Smart proppant technologies
- VuFrac Oceanit Fracture Mapping Technology
- VuFrac smart proppant production
- VuFrac laboratory acoustic testing
- VuFrac mechanical loading effects
- Pilot field study with VuFrac smart proppant

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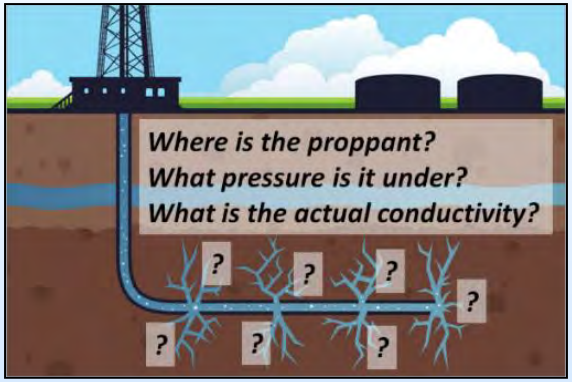
VuFrac Background and Objective

- To evaluate and improve fracture design method, it is useful to know the geometry and behavior of the propped fracture, such as:
  - Proppant bed height
  - Fracture coverage and flow directions
  - Perforation efficiency
  - Details of wellbore connectivity



- The objective of this project was to conduct a pilot field demonstration of an acoustically responsive proppant in shallow buried environment.
- The desired outcome was identification of the location and size of proppant deposits.

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Smart Proppant Technologies

- PROBLEM: Existing and proposed smart proppant technologies have major limitations and do not give a clear or comprehensive readings.
  - Radioactive tracers
    - » Limited isotope half-life
    - » Environmental concerns and restrictions
  - High thermal neutron capture cross section compounds
    - » Detected with neutron logging tools
    - » Penetration depth limited to less than a foot
    - » No indication of closure stress
  - Magnetic nanoparticles
    - » Detected with magnetic susceptibility measurements
    - » Range for these tools is limited to less than an inch
    - » Can only be used in open boreholes or with PVC casing

- SOLUTION: Acoustic interrogation using Oceanit's unique smart proppant.

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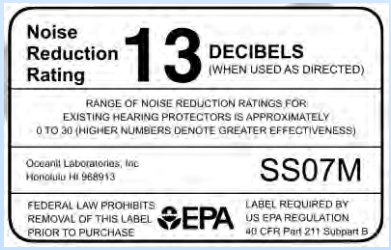
Oceanit Acoustic Products



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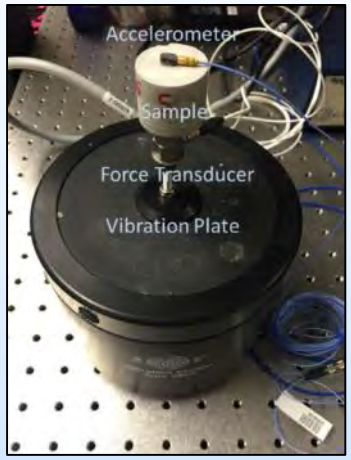
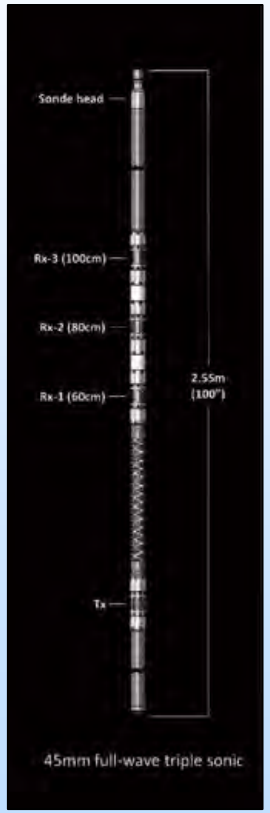
VuFrac (Oceanit Fracture Mapping Technology)

- Oceanit technology allows detection of proppant location and environmental conditions away from the wellbore using industry standard acoustic logging tools.

- The smart proppant is engineered with specific acoustic band gap properties.
- The background well and formation properties can be measured at a frequency at which the smart proppant is acoustically transparent.
- Smart proppant location can be detected at an adjacent frequency at which it is acoustically opaque.

Investigational Acoustic Interrogation Tools





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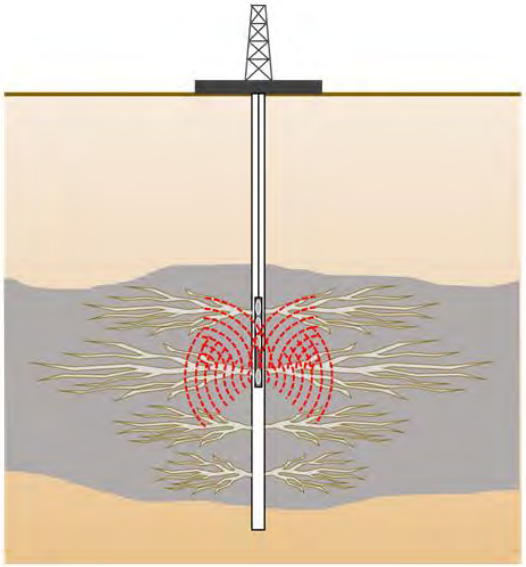
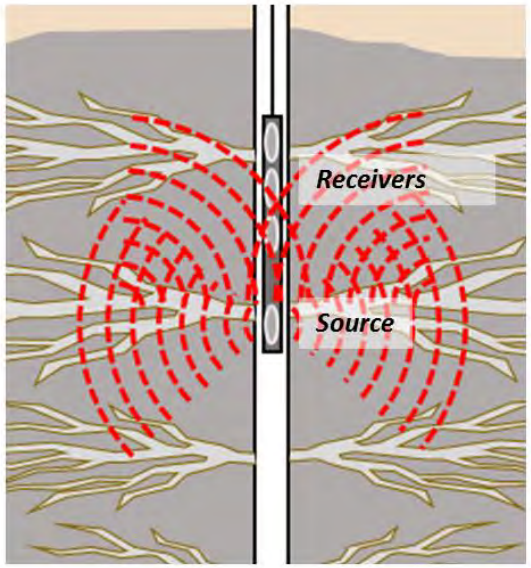
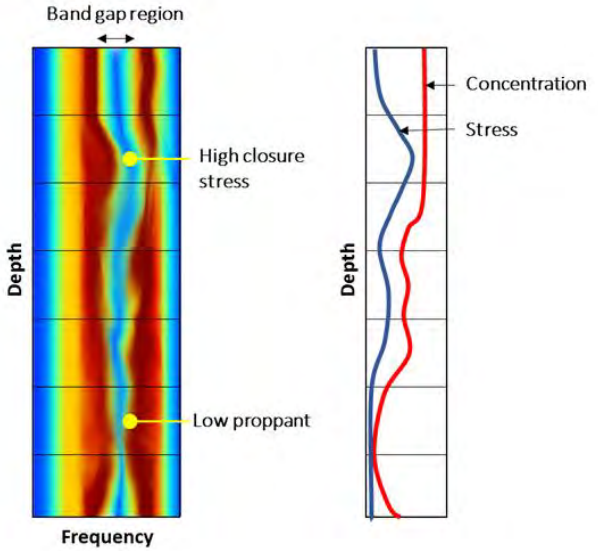
VuFrac (Oceanit Fracture Mapping Technology)

- Proppant mapping using a standard sonic logging tool.



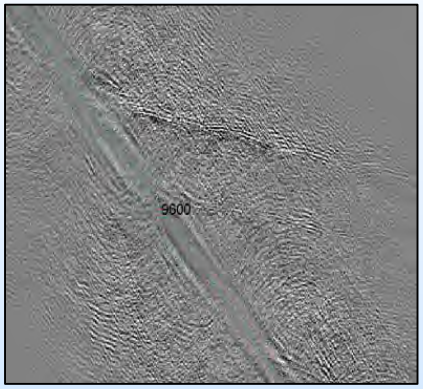




  - Logging of proppant distribution of multiple stages using currently available logging tools
  - Multi-parameter mapping of accessed formation geometry and geophysical features
  - Logs can be run as often as desired during the life of the well with no pretreatment log

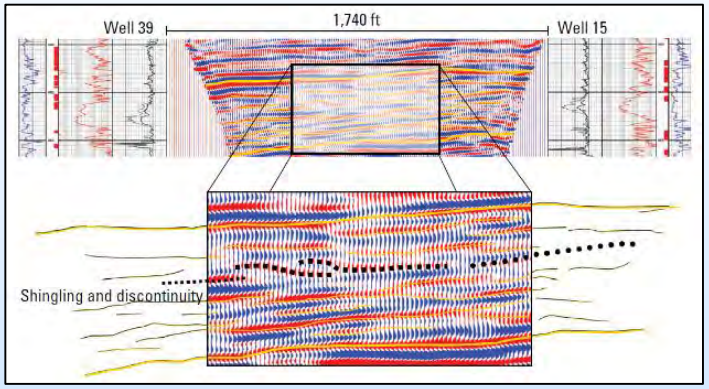
VuFrac (Oceanit Fracture Mapping Technology)

- The technology is amenable to other acoustic interrogation techniques as well.

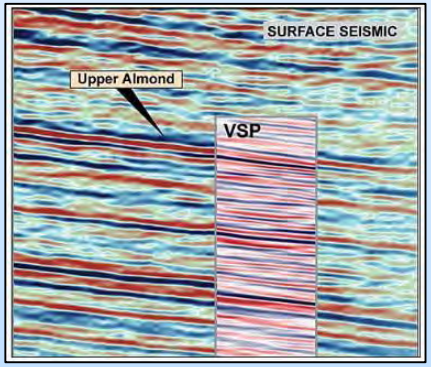


Borehole Acoustic Reflection Survey

Cross-well Sonic Logging



Seismic Imaging



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VuFrac Smart Proppant Production

VuFrac Smart Proppant Production

Example Batch	Density (g/cc)	Diameter (mm)
A	1.47	2.13
B	2.61	1.44
C	3.91	0.92

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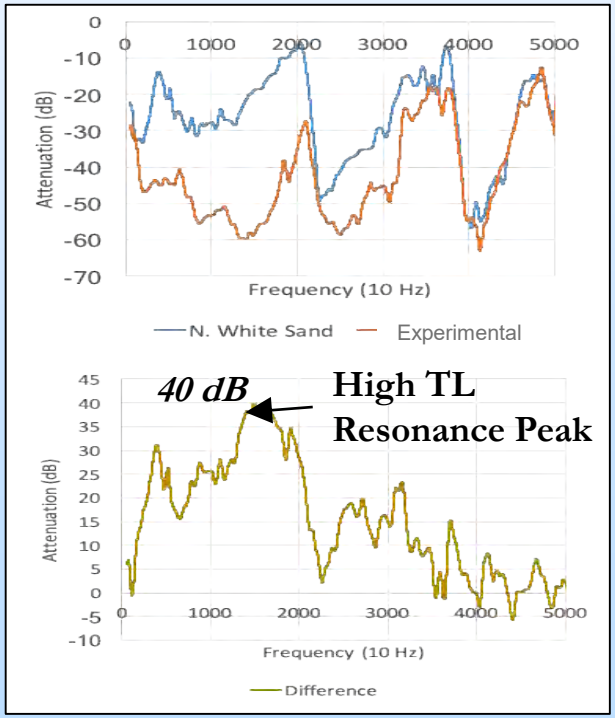
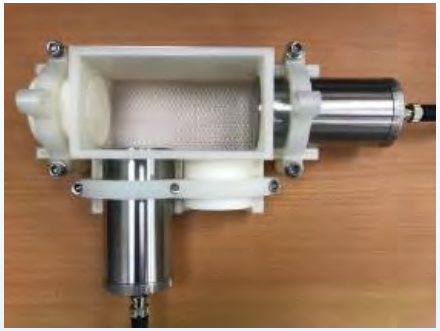
VuFrac Laboratory Acoustic Testing

Transmission Loss





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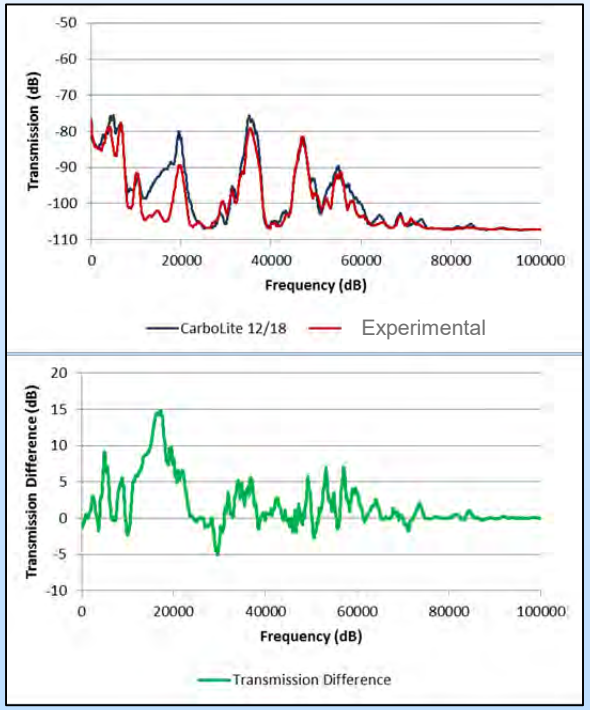
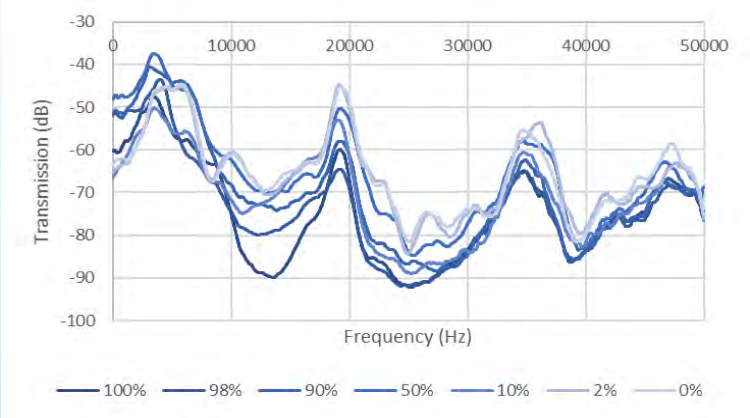
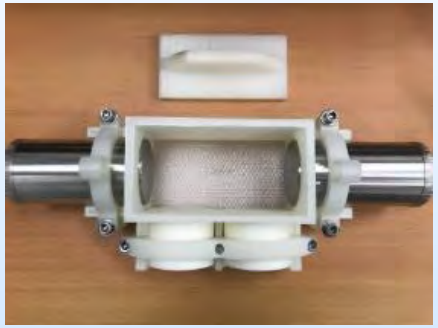
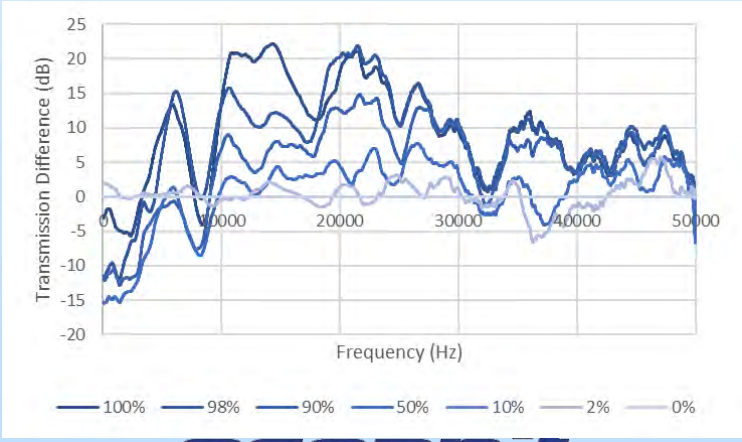


VuFrac Laboratory Acoustic Testing

- Mixtures of Oceanit smart proppant with traditional proppant were used to assess the concentration dependent effect of the metamaterial particles.



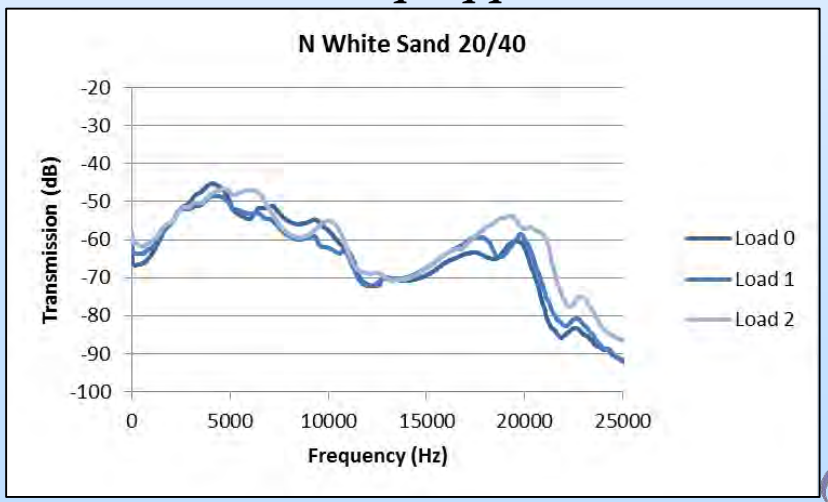




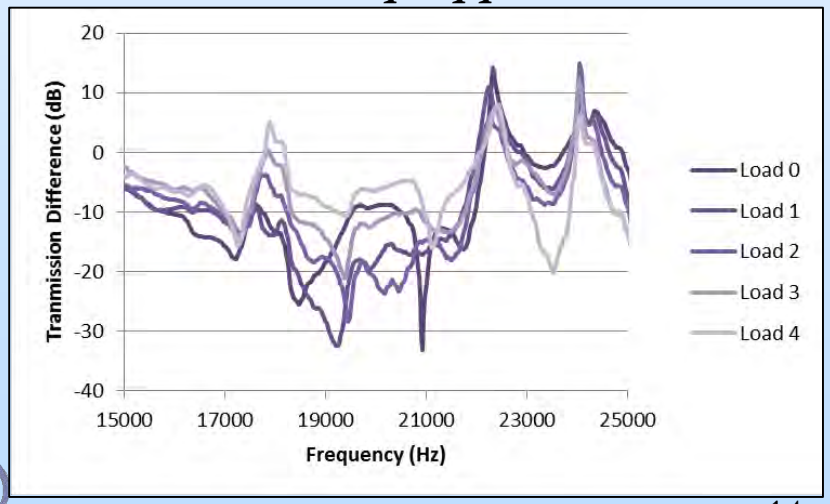
VuFrac Laboratory Acoustic Testing

- Clamps were used to apply different levels of mechanical load to sample in 3D printed holder.

control proppant



smart proppant



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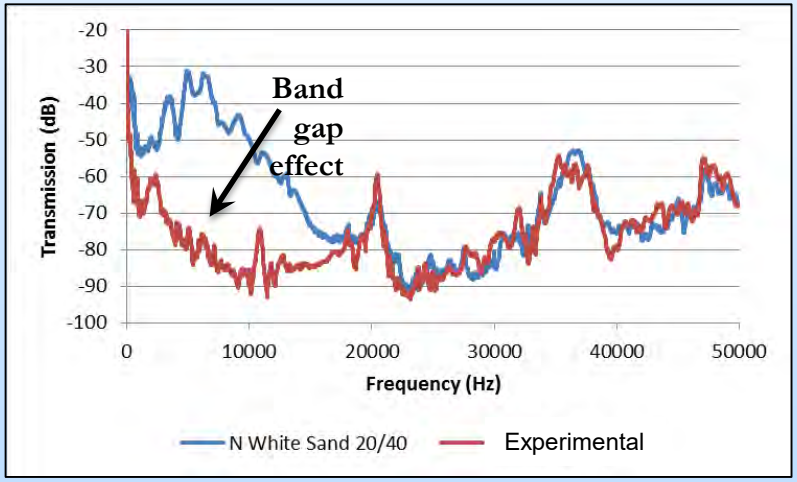
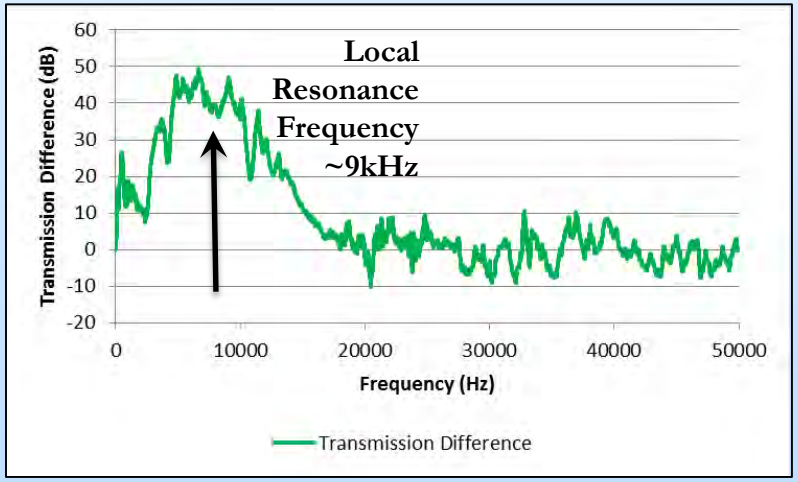
VuFrac Laboratory Acoustic Testing

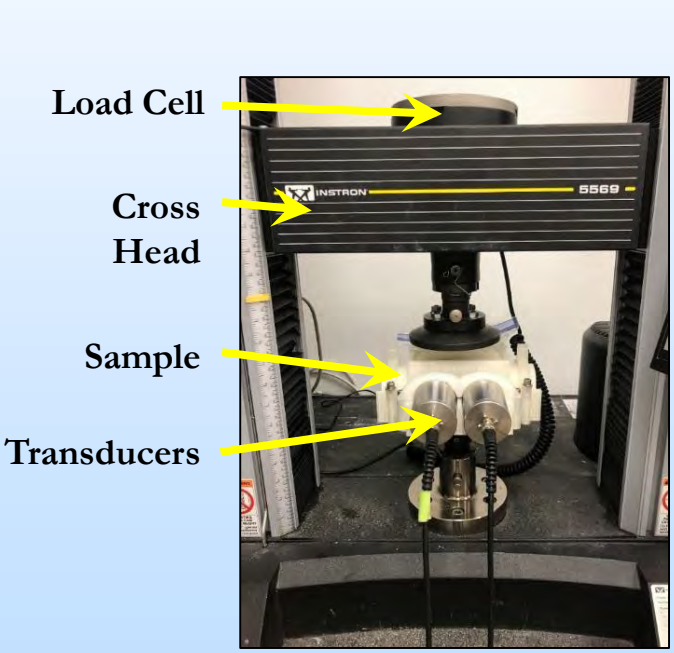
- Ultrasonic transducers were placed directly into a tub of proppant.

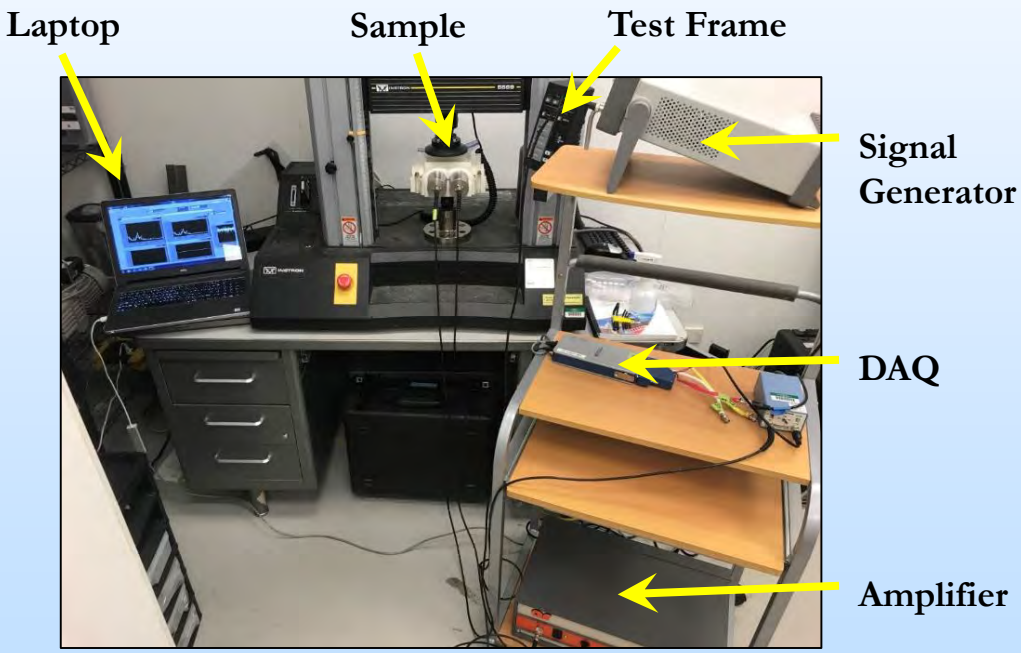




VuFrac Mechanical Loading Effects

- Acoustic measurements were taken during mechanical loading and unloading.





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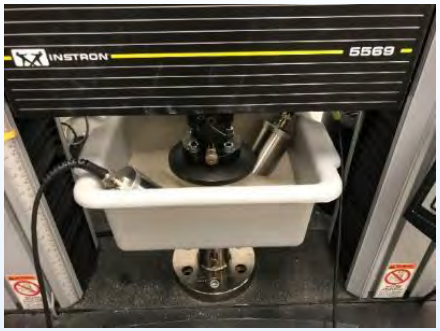
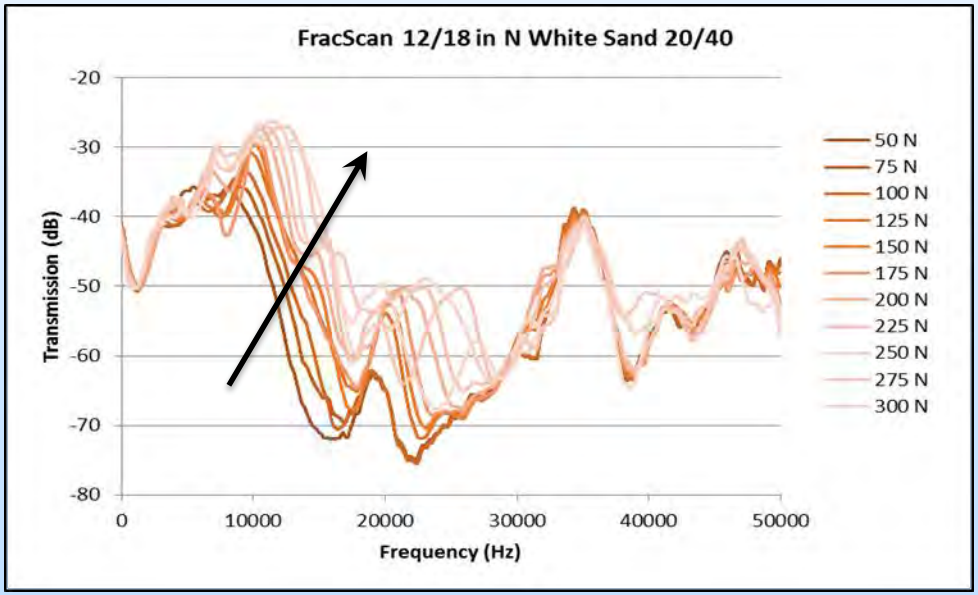
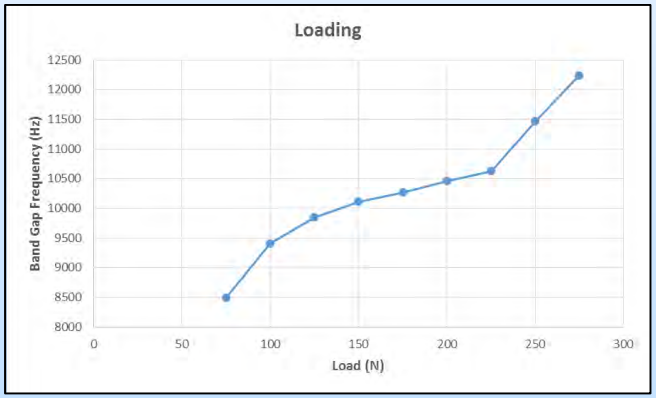
VuFrac Mechanical Loading Effects

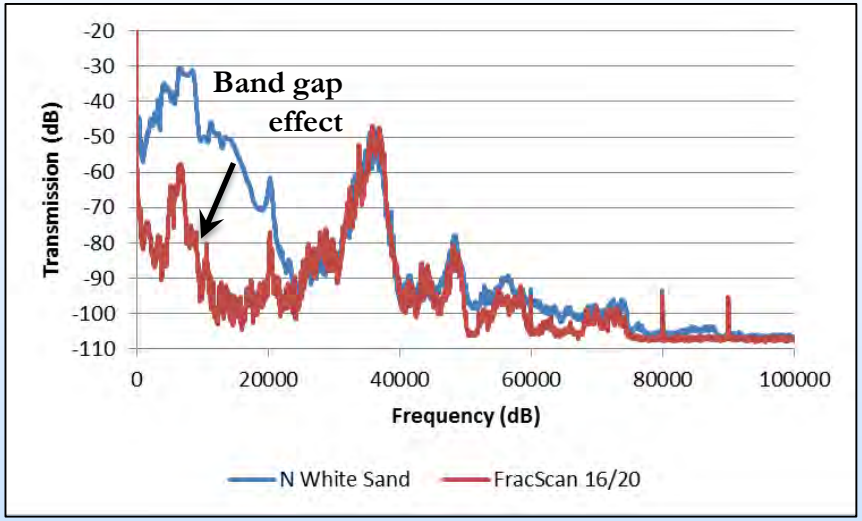


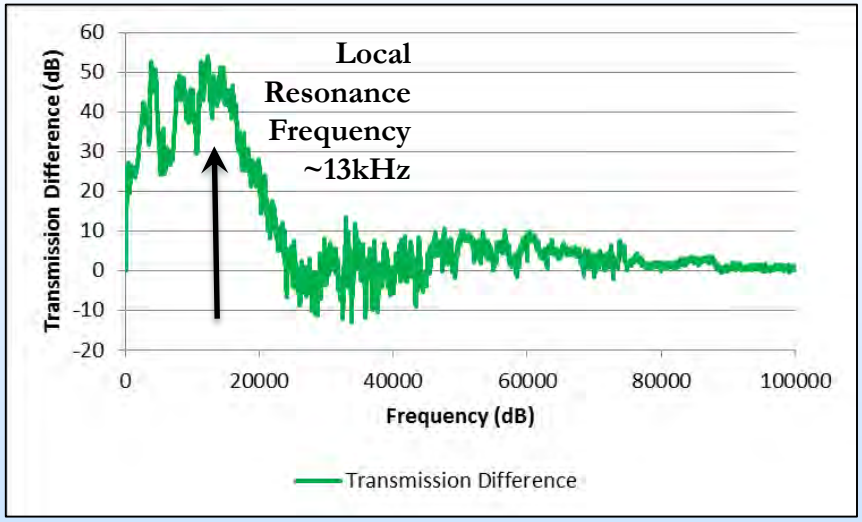




Pilot Field Study

VuFrac Pilot Field Study





VuFrac Pilot Field Study

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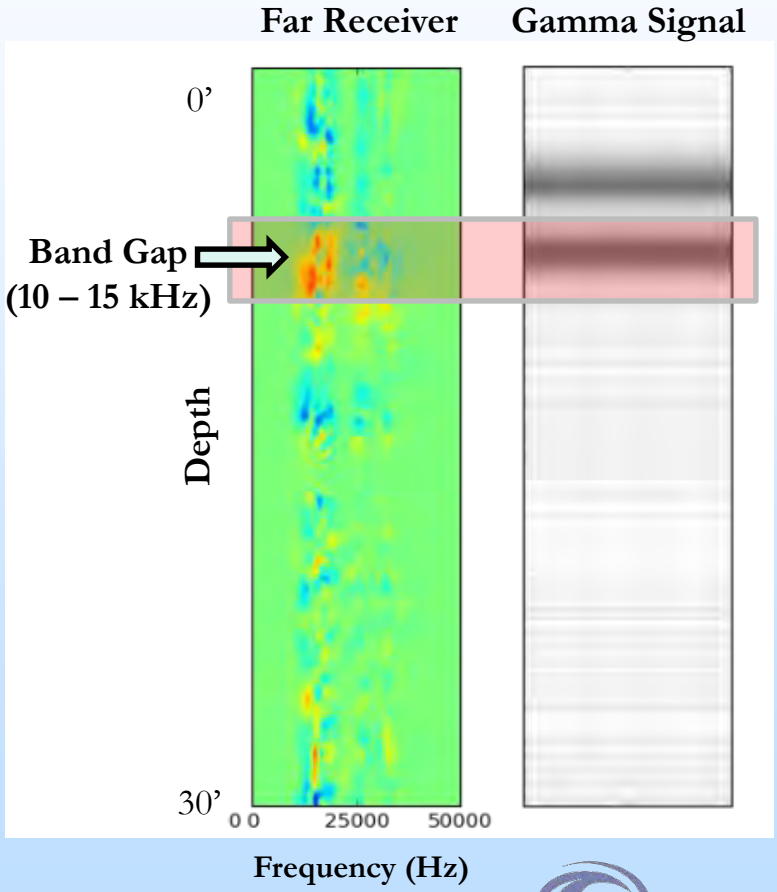
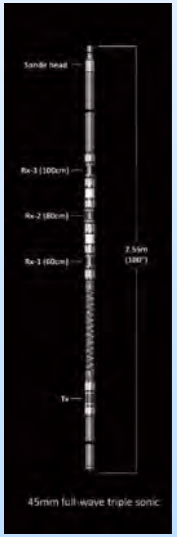
Acoustic Transmission Loss Difference Identifies VuFrac Location



6 kg Northern White Sand

6 kg Experimental VuFrac



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VuFrac Pilot Field Study

VuFrac Pilot Field Study

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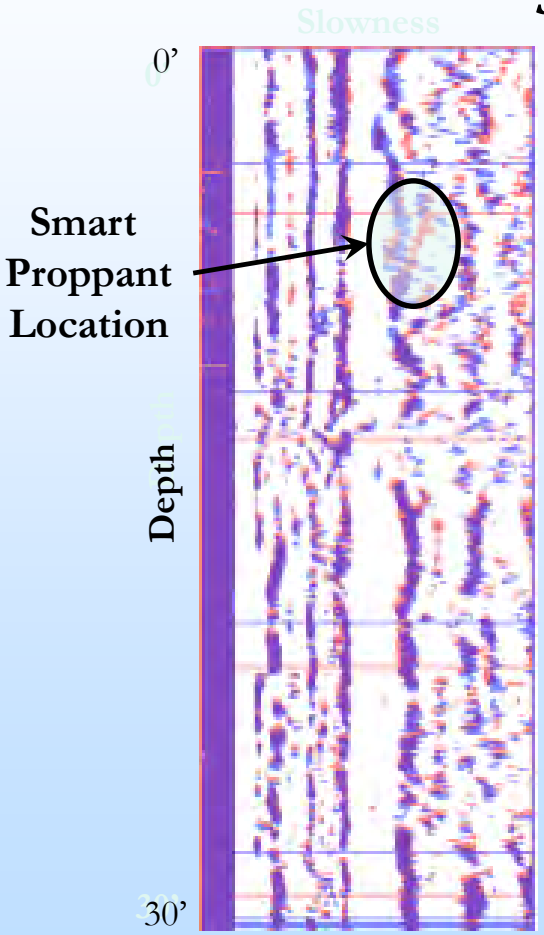
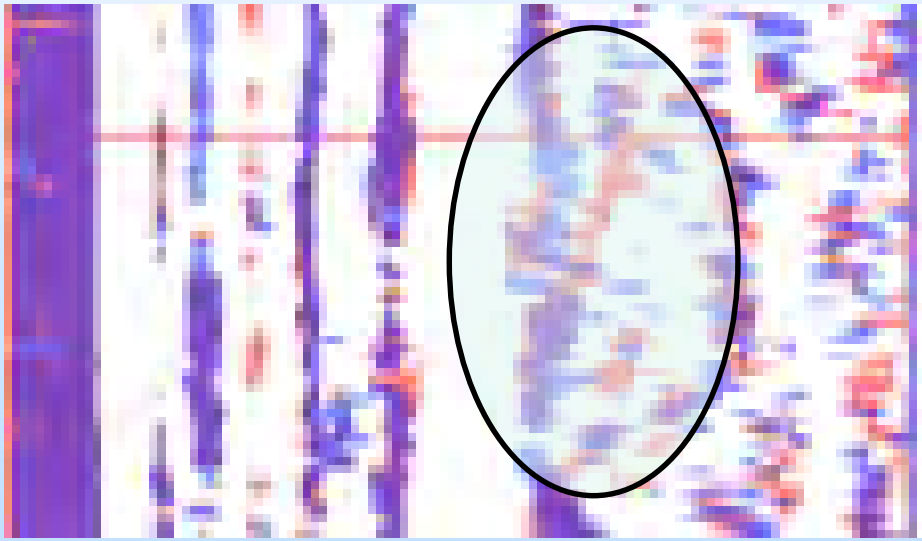
Semblance Logs



Sand – Blue

FracScan – Red

Match – Purple



VuFrac Lab Study

- Better match acoustic band gap of smart proppant to tool acoustic frequency range = improved detection.