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# Electromagnetic Detection of Proppant

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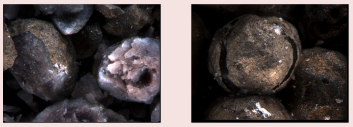
## RESEARCH OBJECTIVE

An important issue in oilfield development pertains to mapping and monitoring the fracture distributions controlling subsurface fluid flow. Although microseismic monitoring and analysis have been used for this purpose for several decades, ambiguities and uncertainties remain. We are investigating a novel electromagnetic (EM) technique for detecting and mapping proppant distributions using a **Four Pronged** approach.

## #1. Conductive proppant

Close-up photos showing the conductive proppant (left) and non-conductive ceramic proppant (right).



Two images showing the conductive proppant after crush testing. The conductivity is maintained after crush testing.

Proppant is used to prop open fractures and improve fluid flow. It can be as simple as sand or highly manufactured.

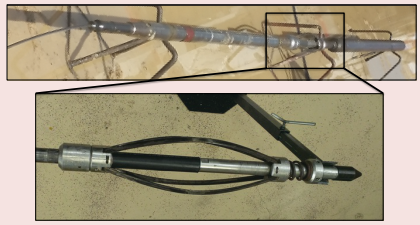
CARBO Ceramics has developed a conductive proppant by coating a low density ceramic proppant with a metallic alloy, know as FDP-950.

By injecting an electric current into the well, this conductive proppant will allow imaging of where the proppant is actually going in the fracture, as opposed to microseismic which only shows where changes in the stress field are occurring. The injected current is measured at surface receivers. The changes detected in the electric field will illuminate the fractures.

## #2. Engineering a Current Delivery Tool

**Design Requirements:**
1) Retrofitted oil field tool
2) Deployable on wireline
3) Maximize contact with casing
4) Lower contact resistance
5) Simplest tool possible
6) Sufficiently heavy - deployed past the turn
7) Precisely locate in well
8) Maximize current

Centralizer/Electrode Assembly



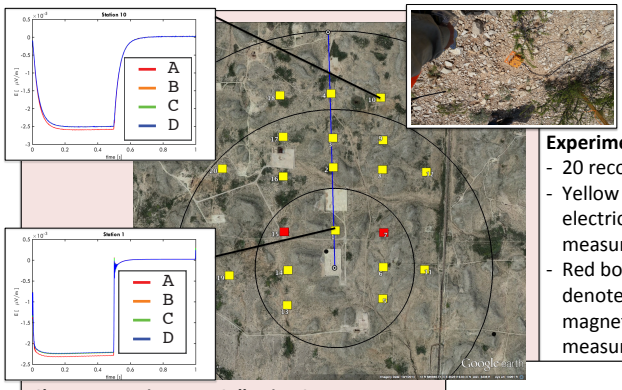
Tool Deployed in Lubricator

**Final Design:**

- Wireline directly welded to a centralizer tool, which was connected to a electrical insulator uphole and a sinker bar downhole.

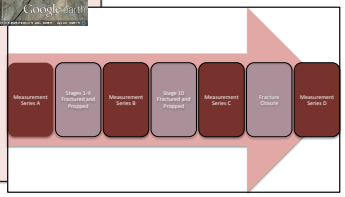
- Designated wireline truck for tool deployment ensured precise relocation of the source each time.

## #3. Geophysical Field Acquisition



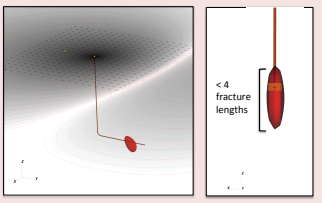

**Experiment Description**:
- 20 recording stations
- Yellow boxes denote electric field measurements
- Red boxes on map denote both electric and magnetic field measurements

**Change Detection Data Collection Sequence**:
*Measurement A*: before any fraccing
*Measurement B*: after all stages of "normal" fraccing
*Measurement C*: after the stage with the conductive proppant is fracced
*Measurement D*: after theoretical fracture closure

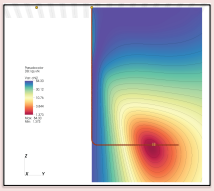


## #4. Forward and Inverse Modeling: Synthetic Inversion Example

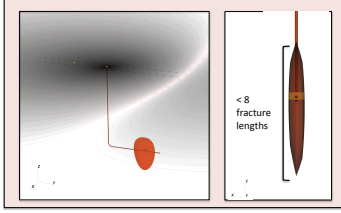
**Electrode Array 400 stations x 2 components = 800 measurements**



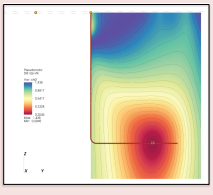

Inversion Results with Large N Show:
1) Fractures are poorly resolved in both depth and along wellbore.
2) However, fracture extent away from wellbore is well constrained.



**Electrode Array 20 stations x 2 components = 40 measurements**




Inversion Results with Small N Show:
1) General reduction in fracture resolution (laterally less so).
2) Perhaps an adequate solution for limited number of stations.



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