

Baseline DAS VSP of the Chester 16 Field (Reef), Michigan

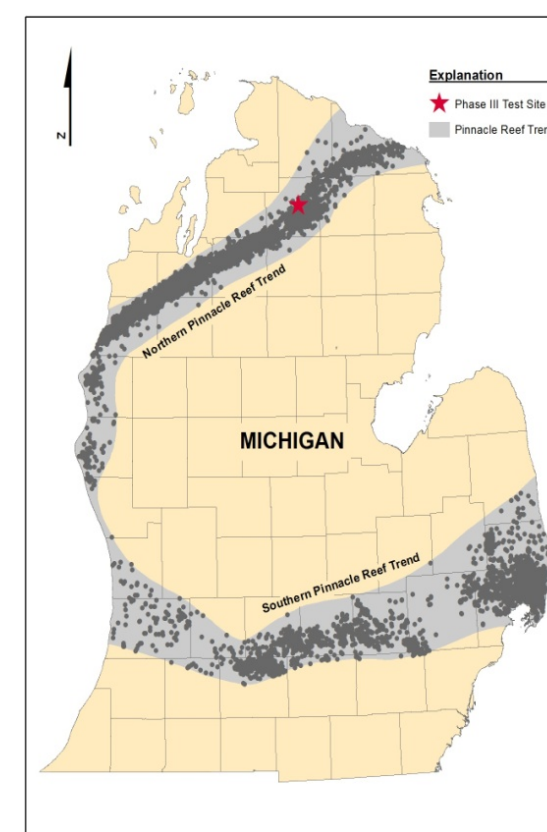
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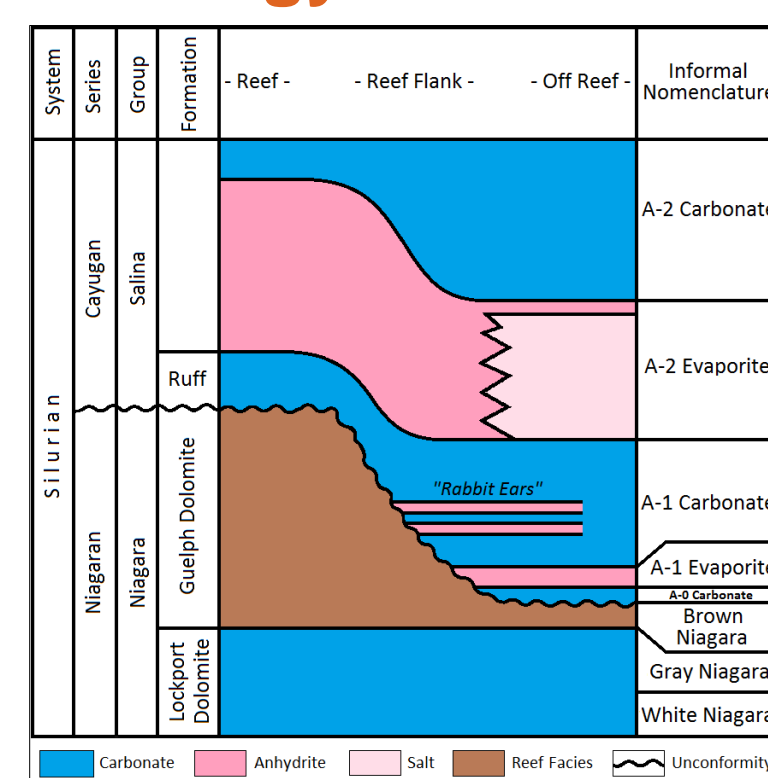
INTRODUCTION

The Midwest Regional Carbon Sequestration Partnership (MRCSP) is implementing a commercial-scale carbon capture utilization and storage (CCUS) project in multiple Silurian-age carbonate pinnacle reefs in northern Michigan that are in various phases of enhanced oil recovery. This poster presents results of a DAS (Distributed Acoustic Sensing) based Vertical Seismic Profile (VSP) seismic survey at CORE Energy's Chester 16 field in Michigan.



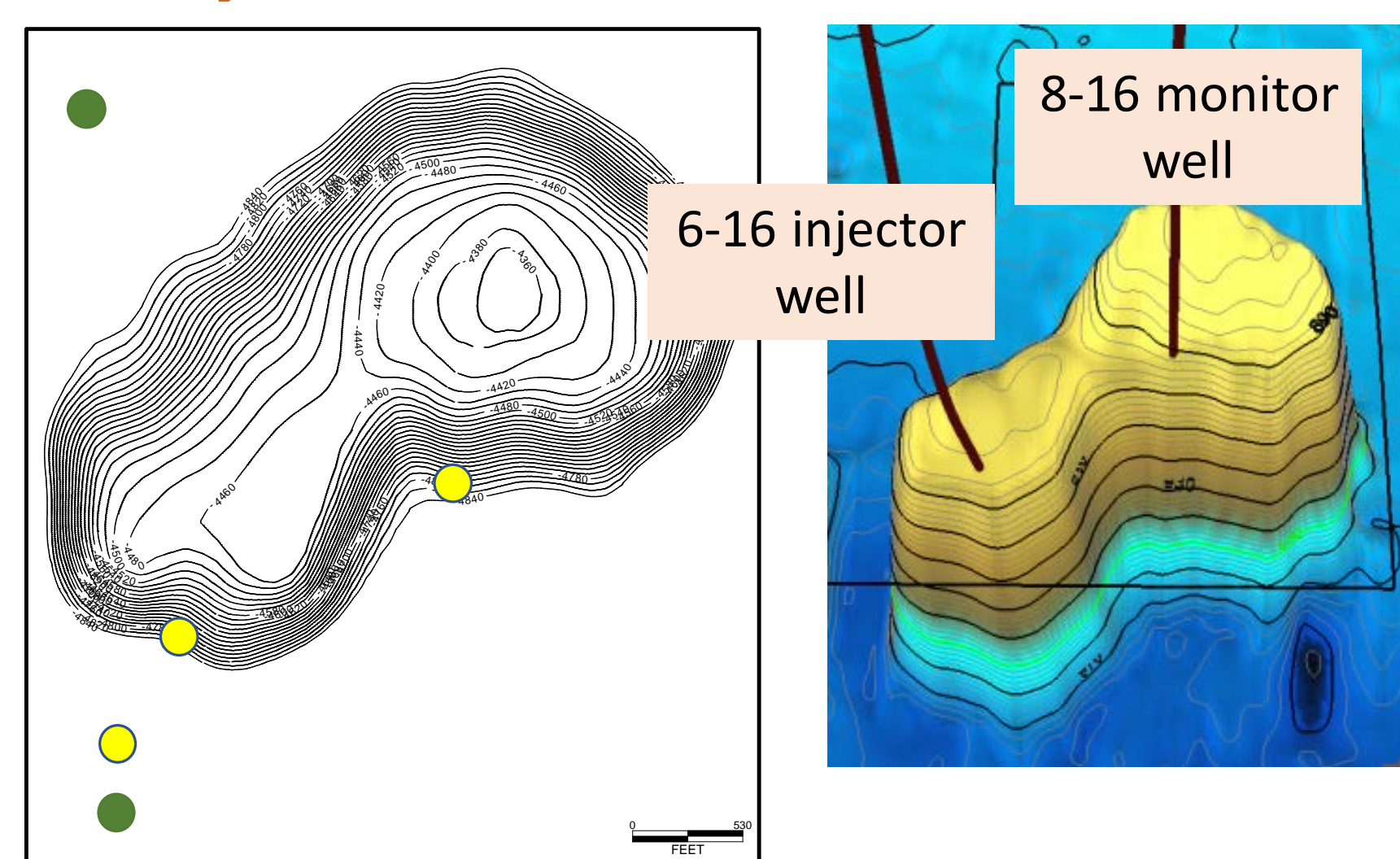
Location of the Study Reef within the Northern Pinnacle Reef Trend

Geology of the Chester 16 Reef



- Producing formations: A-1 Carbonate and the upper part of the Brown Niagara
- Principal source rock for oil: A-1 Carbonate
- Top seal: A-2 Evaporite
- Seals on the reef flanks: A-1 evaporite and A-1 Carbonate anhydrite ("rabbit ears")

History of Chester 16 Reef



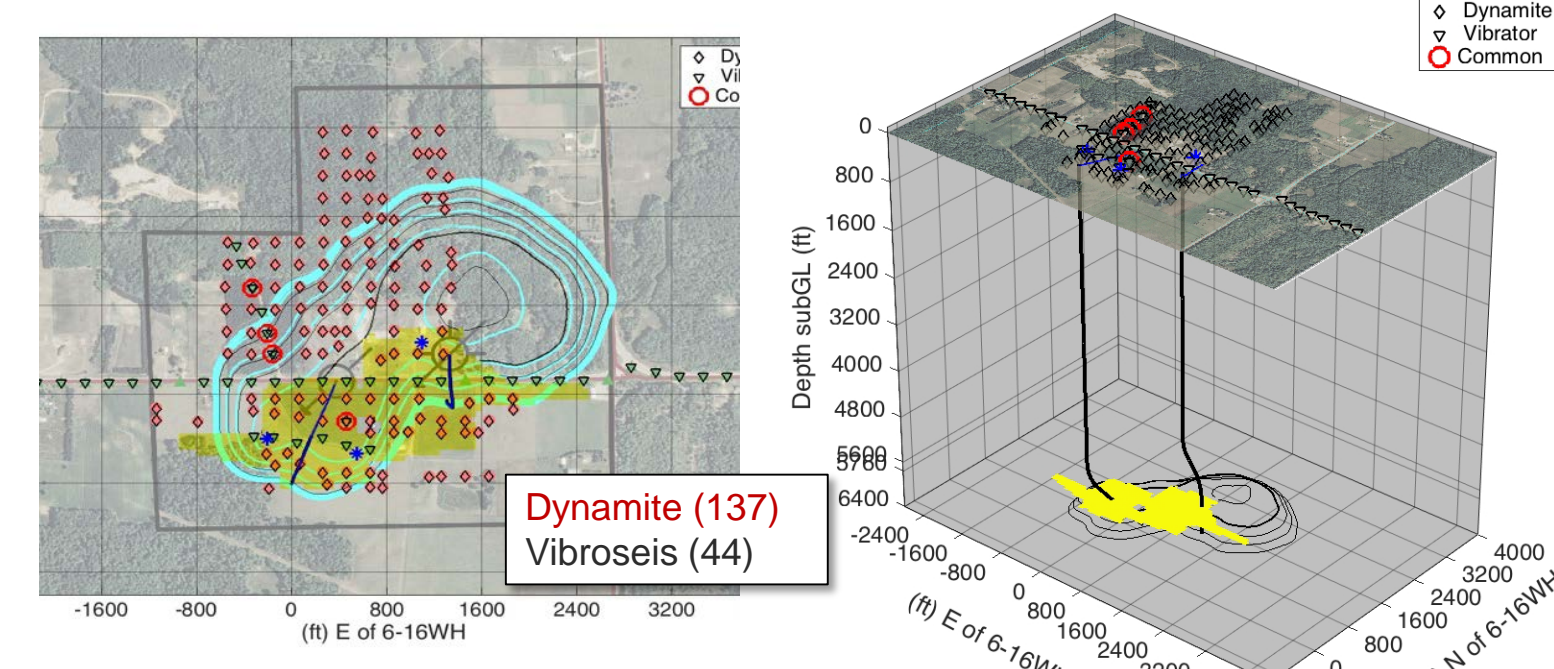
- Original Oil in Place = 6.85 million barrels
- Primary production period (1973-1984)
- Water flooding (1984 to 1990)
- 5 original wells plugged (July 1990)
- Shut in (1990 – 2017)
- New injection well and production (monitoring) well drilled in late 2016/early 2017 for CO₂-EOR

Objectives of DAS VSP

CO₂ will be injected for approx. 18 months to increase pressure of reservoir necessary to begin CO₂ EOR

- DAS VSP is being used to monitor the CO₂ plume resulting from CO₂ injected during the ~18 month re-pressurization period
- The baseline DAS VSP was collected before CO₂ injection began to provide a pre-CO₂ seismic image of the reservoir
- A repeat DAS VSP at the end of the re-pressurization period will be compared against the baseline DAS VSP to delineate the vertical and lateral extent of injected CO₂
- The Baseline DAS VSP will be used to assess feasibility of this technology in a challenging setting (thick glacial till, carbonate rock, deviated wells, uncemented casing strings).

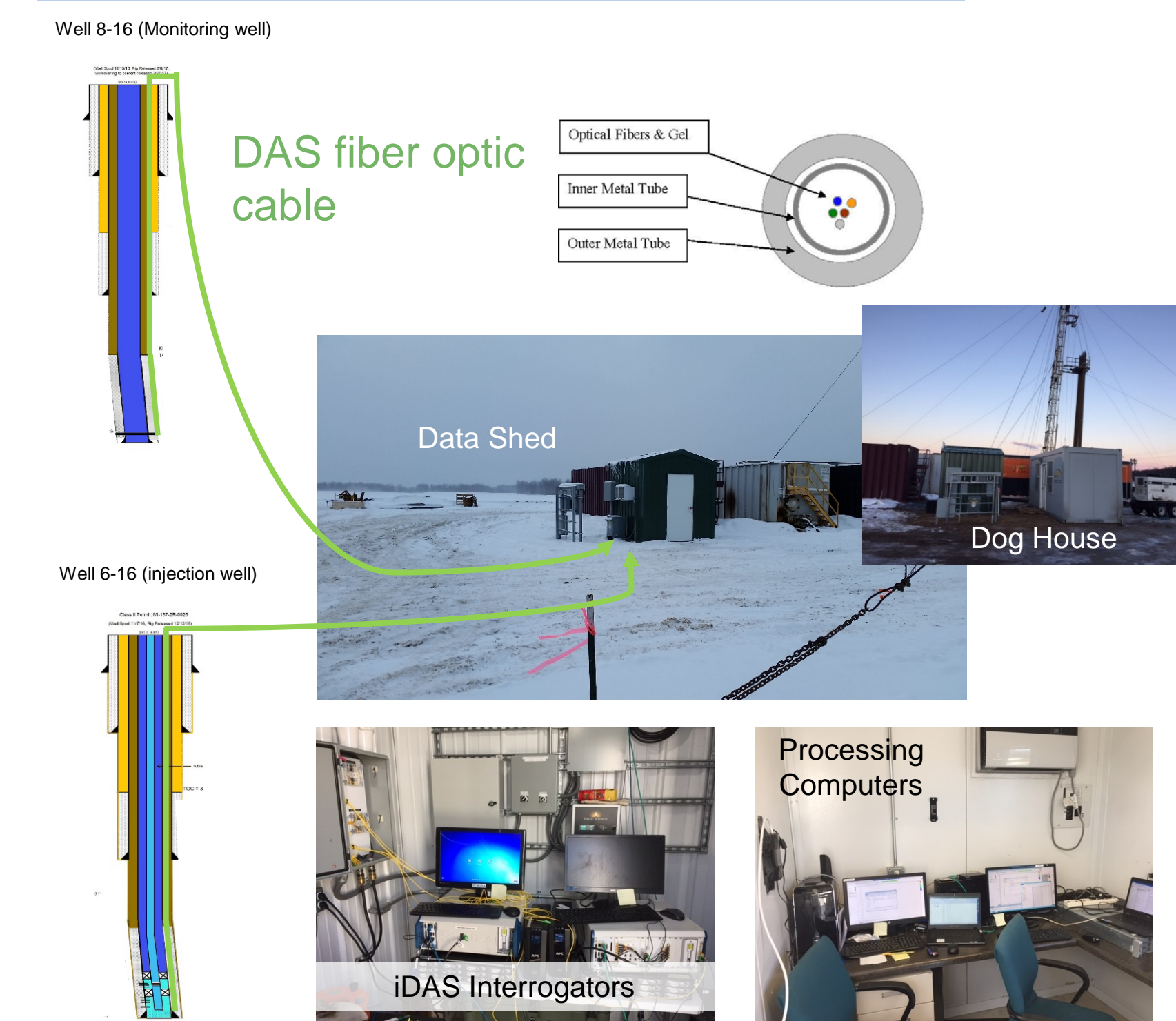
Source Layout Show



Four Source Points were acquired with both Vibe and Dynamite

Acquisition Equipment

- TIMELINE**
- 2 wells (and fiber optic system) installed Dec. 2016 – Feb 2017
 - Baseline VSP was conducted Feb. 17-20
 - CO₂ injection began Feb. 22



- Well design presents challenge for DAS VSP**
- Multiple casing strings, partially cemented annuli
 - Wells are deviated

DAS VSP Imaging Workflow

Preprocess:

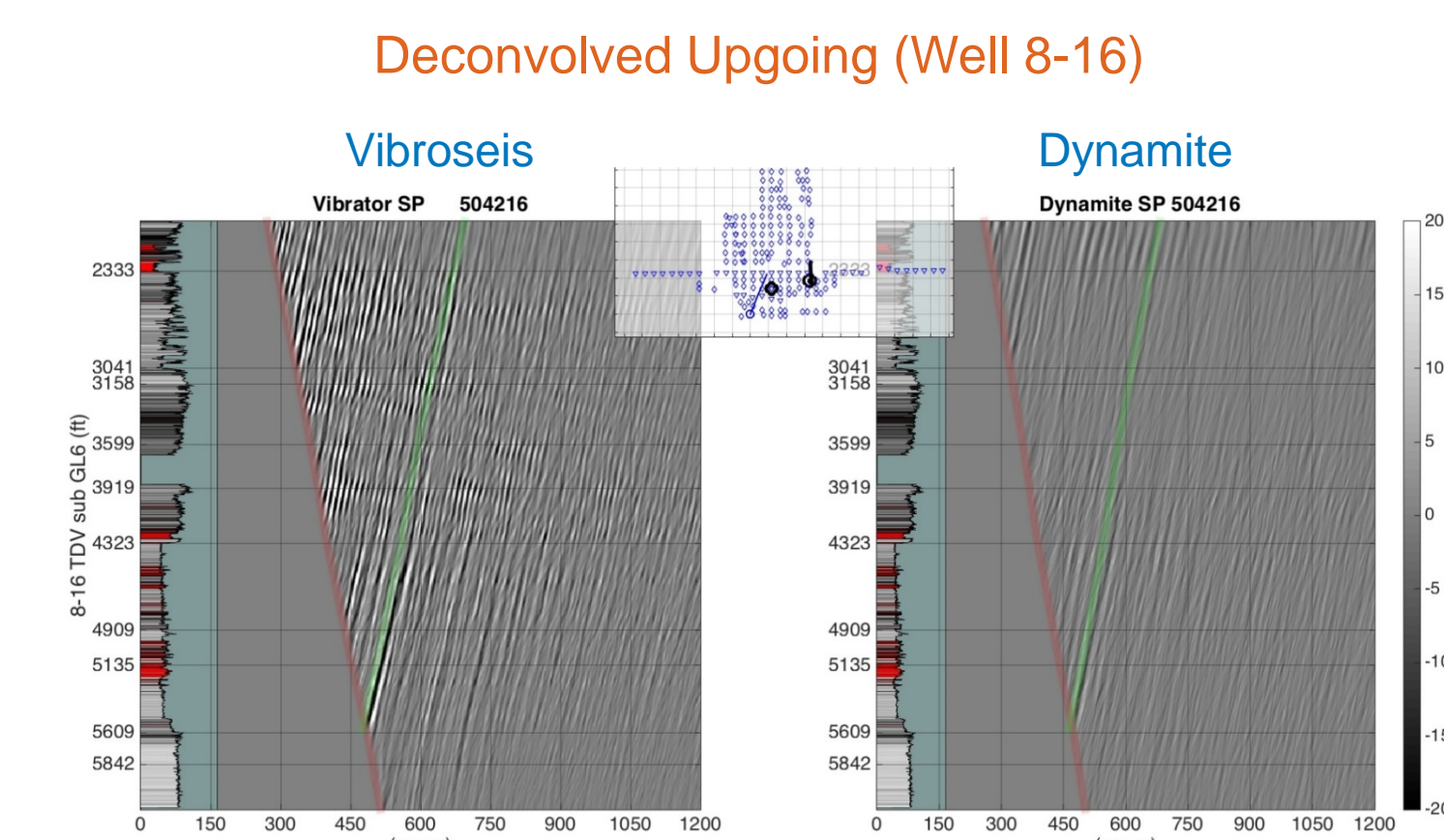
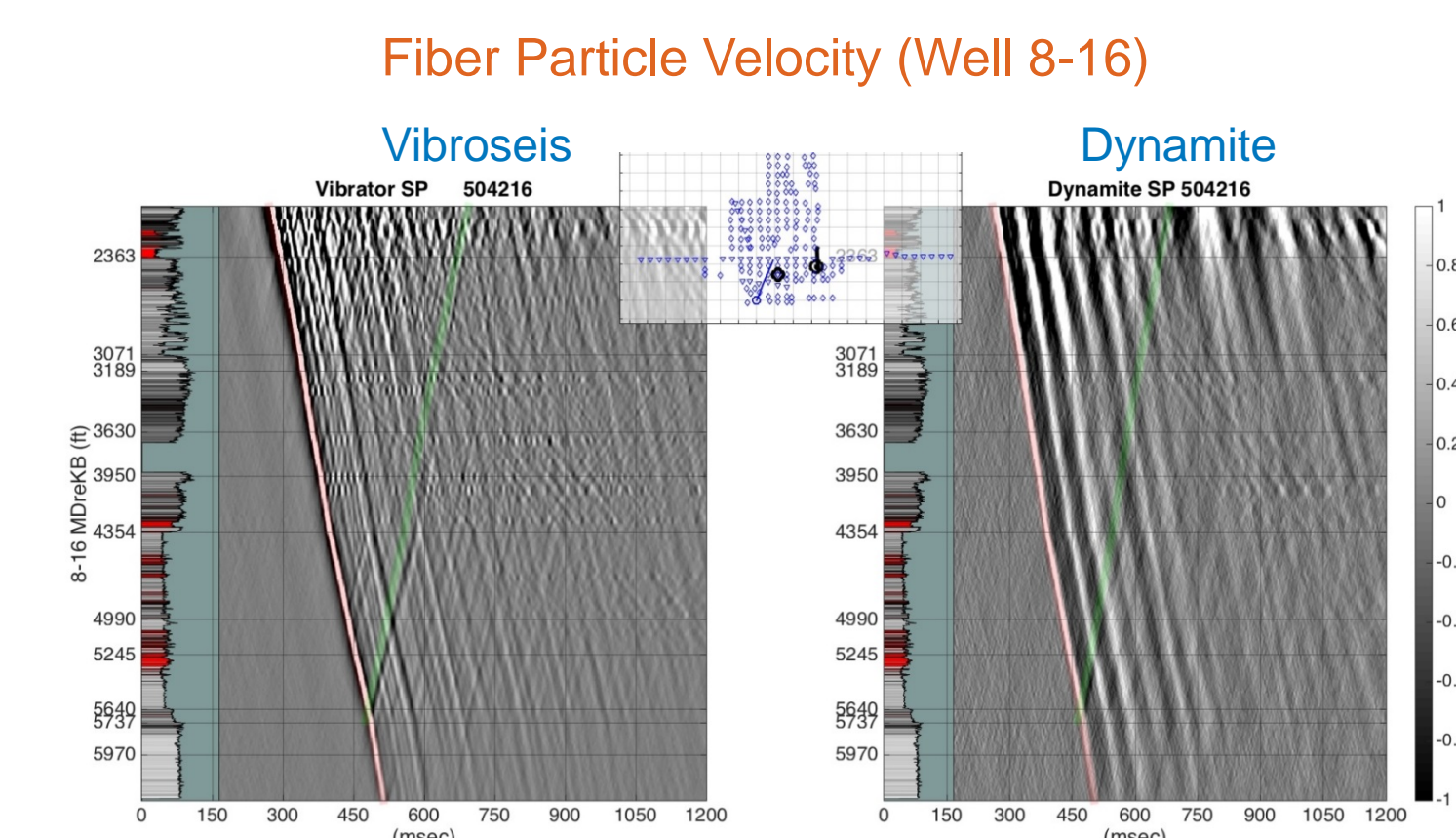
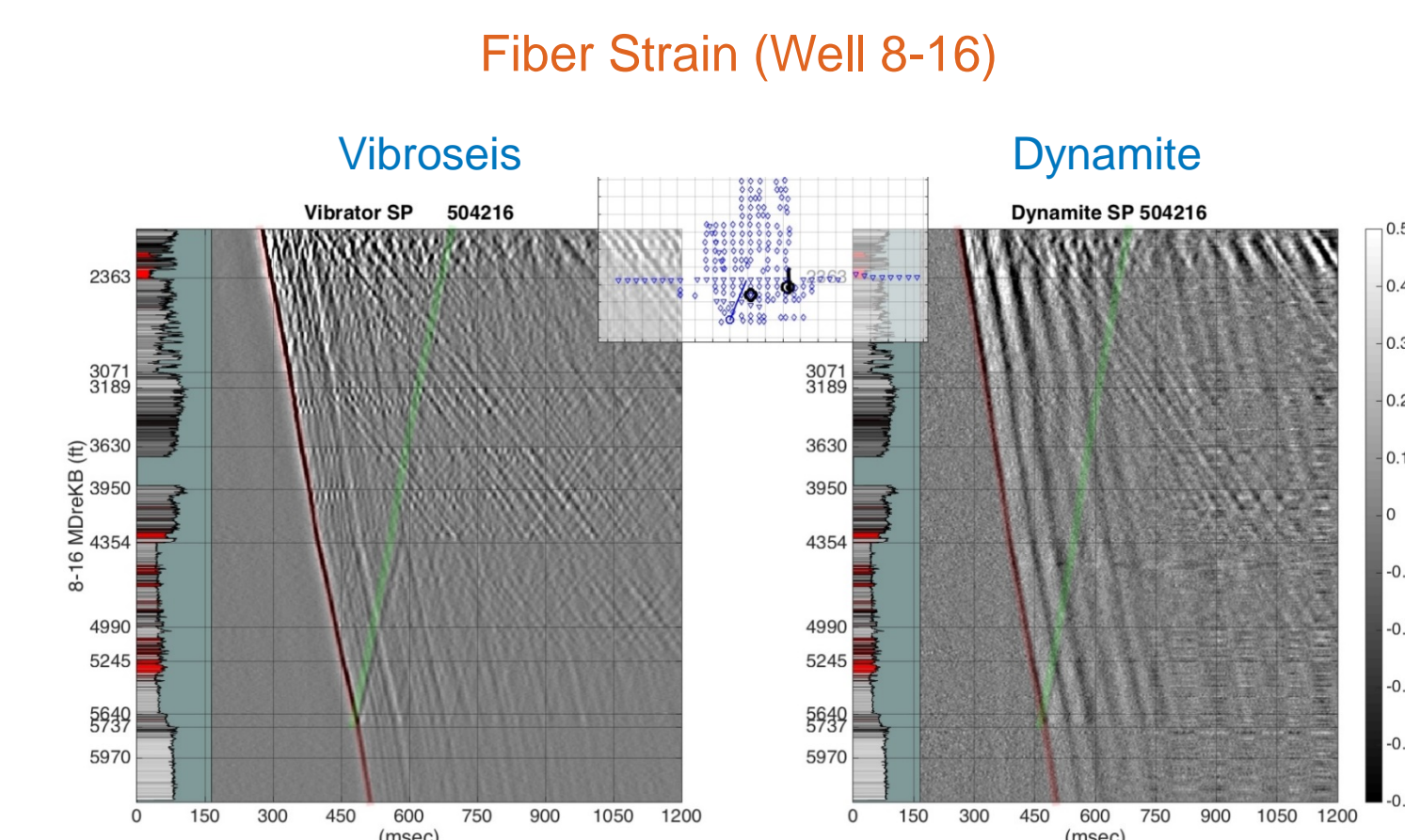
- Stack to one file per source point
- Correlate Vibe data with sweep
- Denoise and remove common signal generated by interrogator vibration

Deconvolution

- F-K domain rescale from strain to particle velocity
- Separate up/down
- Extract downgoing signature, picked travel times, deconvolution operator
- QC modeled travel times

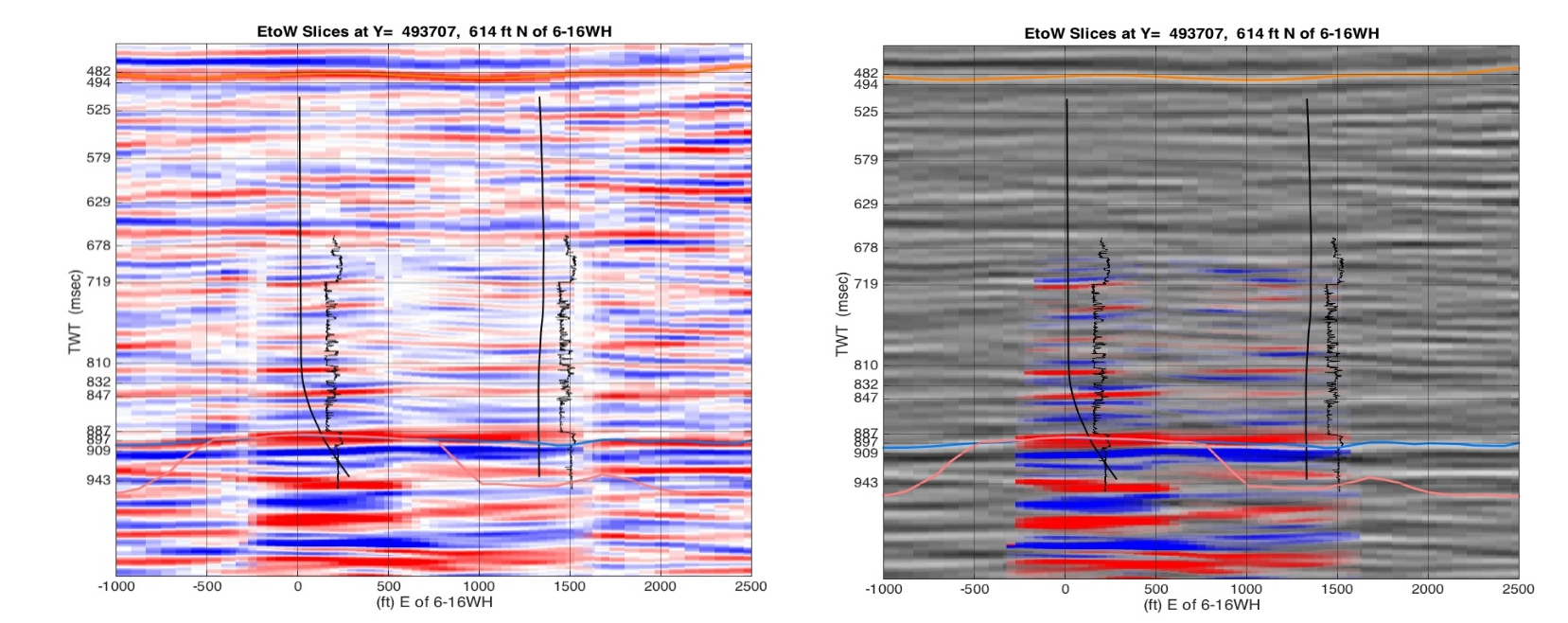
Migration

- Input is deconvolved upgoing
- Output is weighted diffraction stack to fill 3D image volume
- Image depth dimension re-parameterized as two-way-time to match surface seismic

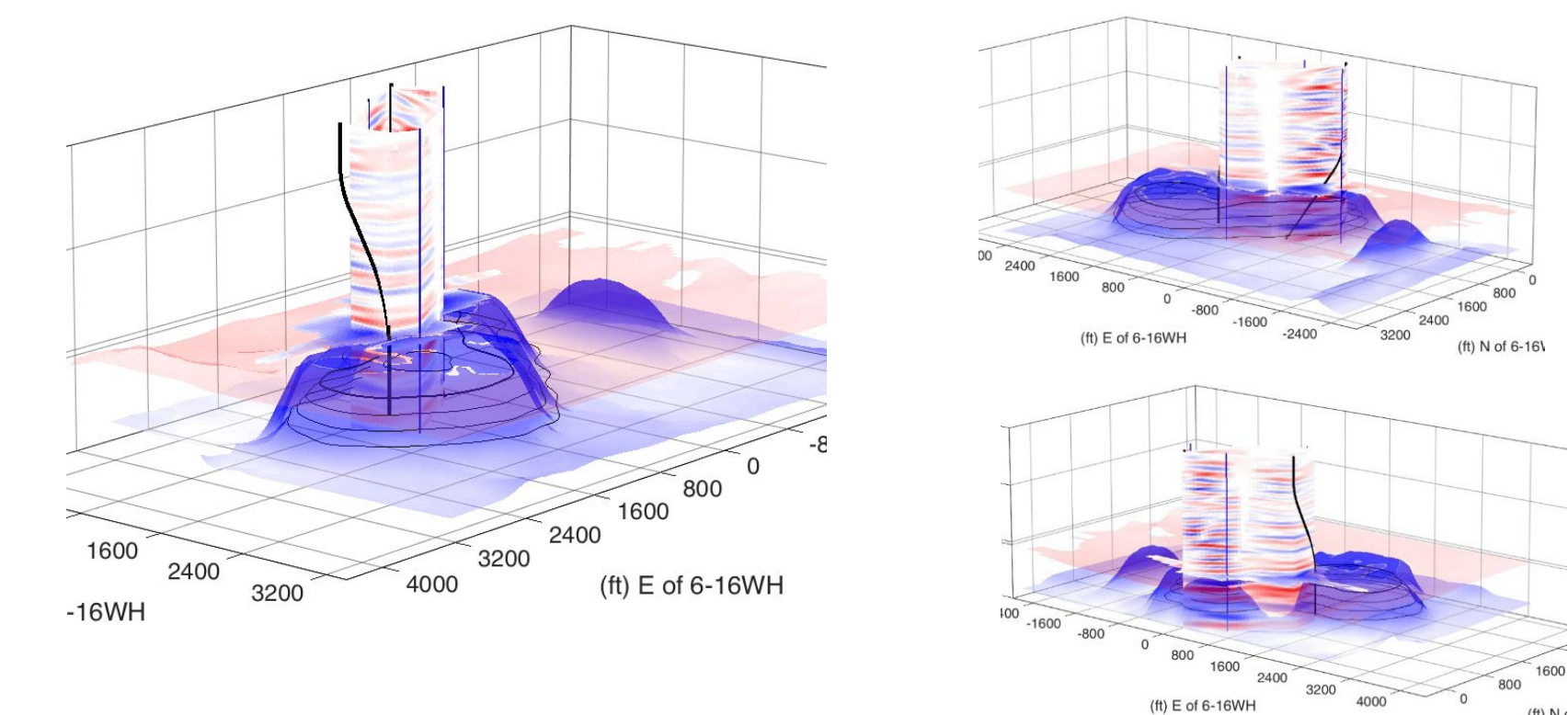


RESULTS

DAS VSP Image Overlain on 3D Surface Seismic Image



3D Perspectives Showing Area of Coverage



CONCLUSIONS

- The DAS images match well with previous 3D seismic, indicating the DAS VSP processing methods are sound
- When compared side-by-side, vibrator recordings look better than dynamite, perhaps because more energy was put into the earth. Two vibrator trucks (rather than three) may be sufficient.
- Both dynamite and vibroseis data are good enough for imaging after the full sequence of processing steps
- The quality of the baseline DAS VSP is sufficient to use as a reference for future repeat survey(s) to image and track the injected CO₂

ACKNOWLEDGMENTS

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