# Monthly Crisman/Berg-Hughes Newsletter

Volume 01 | Issue 03 | January 2020

## Announcements

- Mark your calendars for Friday, April 24, 2020, for the Crisman Spring Meeting.
- To access the Crisman website, please click link to be directed to member login, or visit: crisman.tamu.edu.
- February will feature the 2019 Annual Report. The next newsletter will be available in March.

## Inside This Issue

**Crisman/Berg-Hughes Project Update**

*January 2020*

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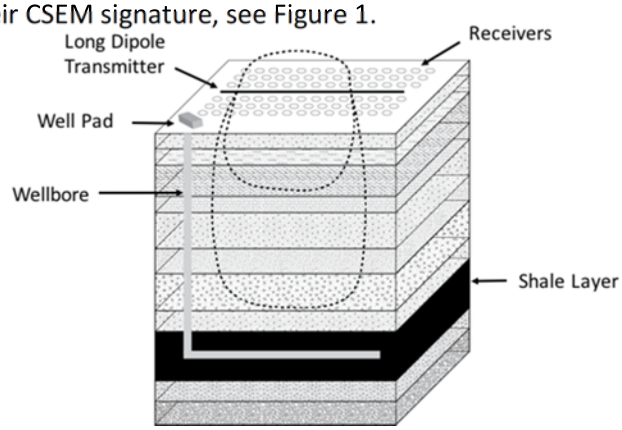
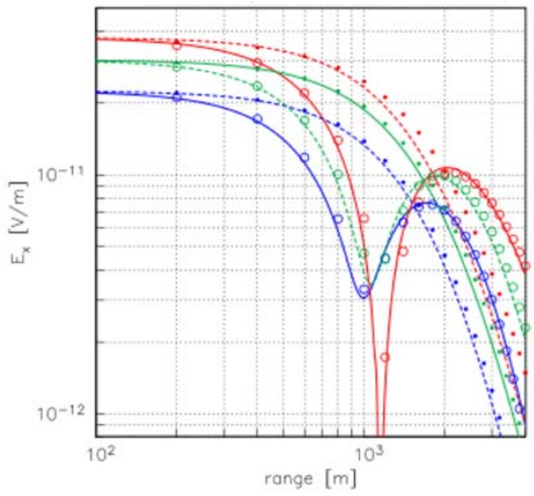
| Project Number | 3.16.16 |
| Project Title | Controlled Source Electromagnetic Monitoring of Hydraulic Fracturing |
| PI and co-PIs | Mark Everett |
| Graduate Students | Matthew Couchman |
| Project Start Mon/Yr | 08/2015 |
| Expected End Mon/Yr | 12/2019 |
| Project Objectives | • To develop methods which enable more reliable controlled source electromagnetic monitoring (CSEM) of the flow of injected fluids associated with hydraulic fracturing and to detect subsurface fluids based on their CSEM signature, see Figure 1.   Figure 1. CSEM acquisition configuration in tight shale environment. |
| Accomplishments | • Validation of finite element code against previously published analytical solutions, see Figure 2.   Figure 2. Validation of finite element code against analytic solution. |

- Determined the effect of steel casing on CSEM responses
- Compared inline and broadside CSEM responses
- Provided evidence that CSEM may monitor movement of conductive fluids in the subsurface, see Figure 3
- Determined that fluid monitoring from a lateral wellbore is made more difficult due to mutual inductance between the wellbore and conductive fluids

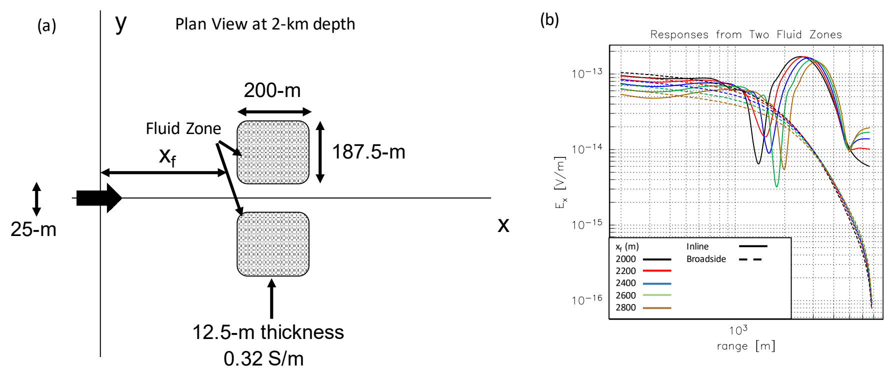



*Figure 3. Plan view at 2-km depth of response of two fluid filled fracture zones showing the inline and broadside (dashed) secondary electric field responses.*

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| Final Project Deliverable | • A finite-element software package called seatem that computes the CSEM response of modeling scenarios relevant to hydraulic fracture operations in unconventional shale reservoirs |
| References Completed or In Progress | • Couchman, M.J., 2019, Modeling controlled-source electromagnetic responses of idealized hydraulic fracturing scenarios*:* PhD dissertation, Texas A&M University.<br>• Couchman, M.J., and M.E.Everett, 2020, Modelling Terrestrial Controlled Source Electromagnetic Response of Fractured Steel Casing on Low Computational Performance Systems*,* Geophysical Prospecting*,* submitted<br>• Couchman, M., and M.E.Everett, 2018*,* Detection of Conductive Fluids Associated with Hydraulic Fracturing Using Surface Based CSEM: Steel Casing Effects*:* SEG Annual General Meeting, Anaheim, CA.<br>• Couchman, M., and M.E.Everett, 2017*,* Controlled-Source Electromagnetic Monitoring of Hydraulic Fracturing: Wellbore & Fluid Effects*:* AGU Fall Meeting, New Orleans, LA.<br>• Couchman, M., and M.E.Everett, 2017*,* Controlled-Source Electromagnetic Monitoring of Hydraulic Fracturin:. IUGG-IAPSO-IAMAS-IAGS Joint Assembly, Cape Town, South Africa. |

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**Crisman/Berg-Hughes Project Update**

*January 2020*

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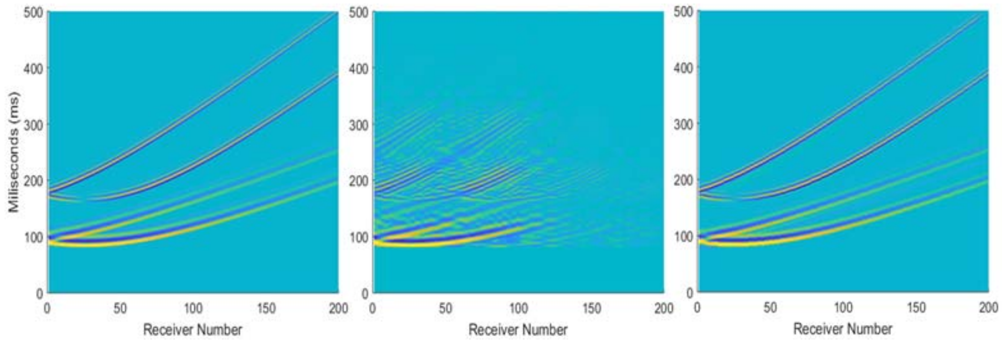
| Project Number | HF.12.19B |
| Project Title | Physics-Based Machine Learning Framework for Improved Hydraulic Fracture Implementations and Reservoir Management |
| PI and co-PIs | Eduardo Gildin (PETE); Mark Everett (GEOP), Richard Gibson (GEOP) |
| Graduate Students | Kildare George Ramos Gurjao (PETE); Milan Brankovic (GEOP) |
| Project Start Mon/Yr | 08/2019 |
| Expected End Mon/Yr | 08/2021 |
| Project Objectives | Create a cost-effective workflow to characterize growth and geometry of hydraulic fractures harnessed by microseimic data in a near real-time approach. This work will provide a greater degree of automation in comparison to conventional methods. |
| Accomplishments to Date | • Developed a new data decomposition algorithm referred to as Shifted SVD (single value decomposition).<br>• Shifted SVD is used to compress and denoise recorded seismic data.<br>• Seismic data is presented in a matrix in which row number represents the time of recorded displacement, and the column number represents the receiver recording the displacement.<br>• Shifted SVD works best on data recorded with many receivers, such as DAS (distributed acoustic sensing).<br>• SVD presents the original matrix as a sum of outer products between basis vectors.<br>• Shifted SVD shifts the columns of the matrix to maximize correlation between them before extracting a pair of basis vectors. This drastically reduces the number of basis vectors needed and gives better compression.<br>• We tested the Shifted SVD on synthetic data showing a P-wave, S-wave, and their reflections.<br><br>**Fig. 1: T**he original data set is plotted on the left, the reconstruction of the original data set using ten basis vectors from regular SVD is in the middle, and the reconstruction of the original data set using only five basis vectors from Shifted SVD is on the right. |

| Number of Basis Vectors | Relative Error of Regular SVD | Relative Error of Shifted SVD |
|---|---|---|
| 5 | 0.68 | 0.21 |
| 10 | 0.60 | 0.17 |
| 15 | 0.52 | 0.15 |
| 20 | 0.46 | 0.13 |
| 25 | 0.41 | 0.12 |

**Table 1:** Relative error in the reconstructed data when using the regular SVD method (middle column) and Shifted SVD method (right column). Relative error is ratio between the Frobenius norm of the difference between the original and reconstructed data, and Frobenius norm of the original data.

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| Expected Final Project Deliverables | • Develop physics-based Maching Learning (ML) techniques in combination with advanced data reduction methods to rapidly model fracture growth, proppant distribution and microseismic data<br>• Determine relevant parameters/data for hydraulic fracturing characterization using the novel machine learning framework developed in this project<br>• Provide prototype code, workflows and example results of ML approaches for modeling and inversion |
| References Completed or In Progress | • Yatsenko, M., Brankovic, M., Gildin, E., & Gibson, R. L. 2019.. A Novel Approach to Discovery of Hidden Structures in Microseismic Data Using Machine Learning Techniques. Paper SPE-195522-MS presented at the 81st EAGE Conference and Exhibition held in London, England, UK, 3-6 June 201.. doi:1.2118/195522-MS |

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