USC Viterbi School of Engineering

Mork Family Department of Chemical Engineering and Materials Science

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Integrated workflow for characterizing fracture network in unconventional reservoirs using microseismic data

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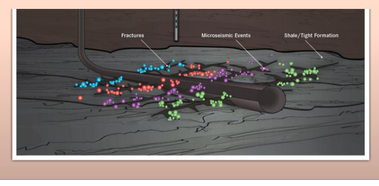
Introduction

Microseismicity caused by fracking is recorded during different stages of stimulation in unconventional reservoirs such as shale reservoirs, tight sand reservoir, and enhanced geothermal systems. We demonstrate how such data can be used to characterize the fracture network to provide us with better understanding of the fracture network geometry, con-nectivity, and density. We go beyond the existing methods that use the origination points of the microseismic events for locating the fracture network. Our technical analysis on microseismic data involves an integrated workflow to utilize other information content of the events such as their size, relationship with other events, their attributes and their relationship with other data (conventional seismic, well data, ..).

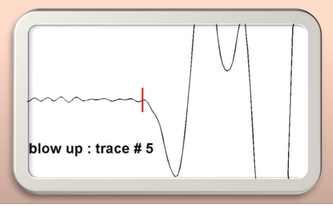
Workflow

Using downhole / surface geophones, store data in SAC, Segy ,or ASCII format.

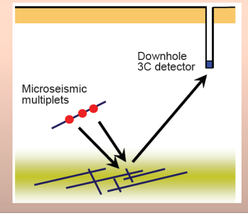


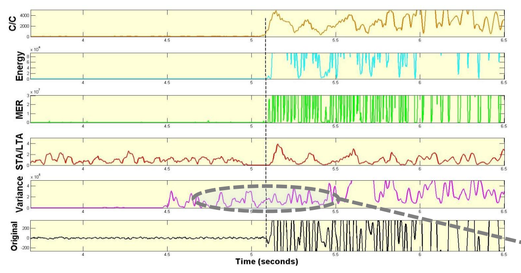
Recording the microseismic events

Our neural network based auto-picker could pick both P- and S-wave in low S/N ratio and noisy data



Picking the P-phase and S-Wave Arrivals using manual or auto picking methods





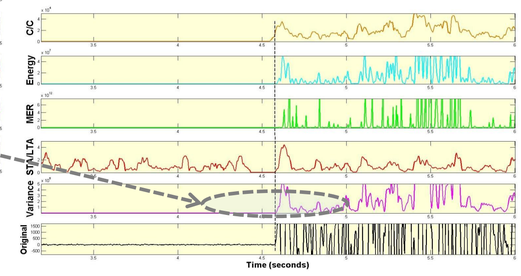
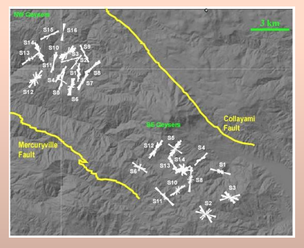
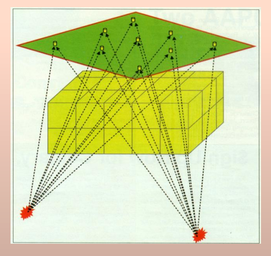


Figure 1 - ANN auto-picker

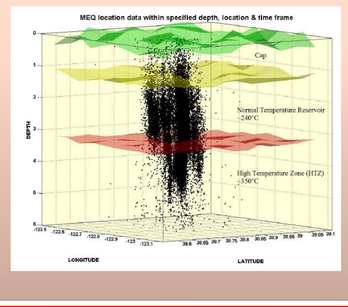
Shear Wave Splitting



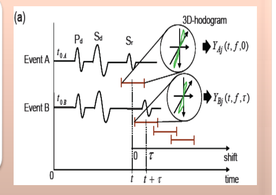
Creating both 3D compressional and shear velocity models



Calculating location and magnitude of events

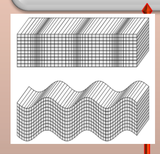


Multiplet analysis



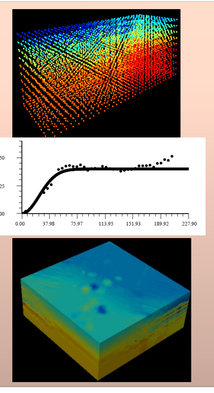
Estimate fracture orientation and density

Enhancing the resolution of Velocity models using Geostatistical tools



$$V_p = \sqrt{\frac{B + \frac{4\mu}{3}}{\rho}}$$

$$V_s = \sqrt{\frac{\mu}{\rho}}$$



Fractal analysis

$$C(r) = \left(\frac{2}{N(N-1)}\right) N_r(R < r)$$

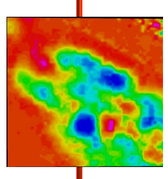
$$C(r) \propto r^D$$

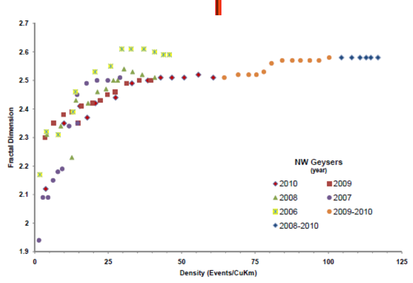
b- value analysis

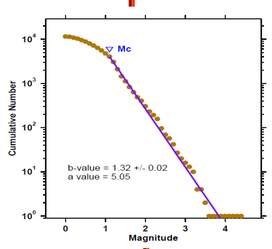
$$\log N(m > M) = a - bM$$

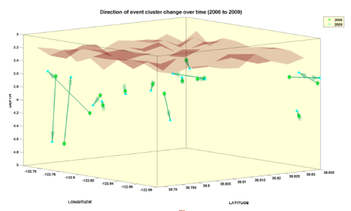
Fuzzy Clustering

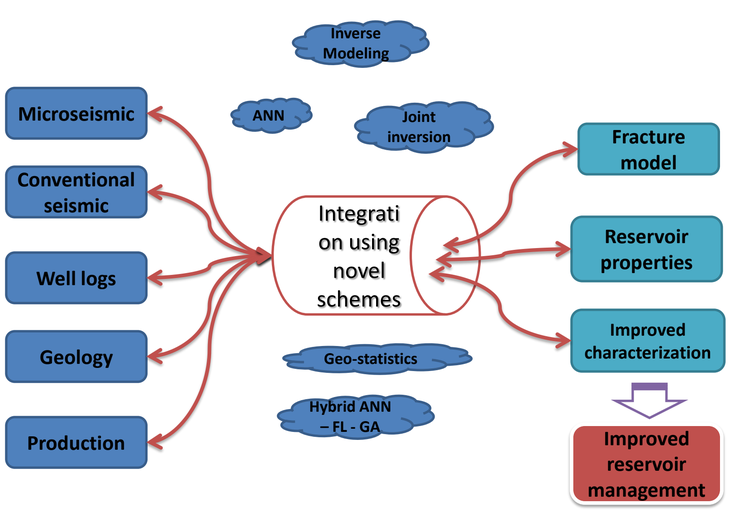
$$\nu = \frac{V_P^2 - 2V_S^2}{2\left(V_P^2 - V_S^2\right)}$$











Obtaining stress and elastic properties of the reservoir

Find fracture pattern, connectivity, and mechanism

Predict size distribution of fractures, investigate the source of fracture.

Find fracture movement direction and penetrating zones from stimulation.

Conclusions

With the advent of new and cost effective geophone sensor arrays and improvement in the analysis and interpretation techniques, use of microseismic data is expected to become a more routine process for fast, efficient, and accurate characterization of unconventional reservoirs and improvement in production methods where sufficient microseismicity is present. This additional information allows optimize the stimulation treatment plan for improved recovery. The new approach also provides useful in-formation for the well spacing plan, the well design, and the completion design.

Acknowledgements

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