



# *Geophysical Society of Pittsburgh*



*Proudly Presents Tuesday, April 6<sup>th</sup>, 2021  
Zoom meeting*

## **Mappable Fracture Monitoring Utilizing Seismic Shear and Fluid Oscillations with Controlled Seismic Sources - 'FracMon'** **Robert (Bob) Brune, Geophysical Consultant**

Frac monitoring pilot/demonstration surveys have been acquired in the Marcellus shale (dry gas) using fundamentally new techniques. Some aspects of these surveys include:

- \* Primarily utilize seismic shear body waves and Krauklis (fluid oscillation) interface waves, both of which are sensitive to frac's, have good resolution, and have good signal strength.
- \* Use controlled compressional (P) and shear (S) seismic wave sources (Vibroseis on surface, including dipole configurations), such that measurements are possible at any time ("Life-of-Frac"), i.e., pre-pumping, during pumping, 'soak', flowback, and/or production.
- \* Compact, efficient, and economical field deployment, using surface multi-component geophones for measurements, with no well intervention needed.
- \* Simple differential data analysis workflows between baseline and monitor survey(s), with mappable results, suitable for real-time guidance of pumping.
- \* The field data acquisition and processing use existing equipment and software, but in novel ways.

Krauklis waves are a type of seismic wave that propagate along the frac face boundary between rock and fluid. They exhibit several particular characteristics, as seen in the data from these surveys. These include emergent onset and high Q resonance. Frac size (tip-to-tip) relates to resonant frequency. The data imply small individual frac sizes, analogous to small frac planes seen in passive microseismic source mechanism inversions. Krauklis waves have slow propagation velocity, with dispersion. Krauklis waves are excited by P, and particularly S, body waves; Krauklis waves then re-radiate body waves back to the surface. Krauklis waves have spatially evanescent decay away from the frac's. Krauklis waves depend strongly on fluid characteristics as well as frac geometry. Weak Krauklis effects are also seen in some baseline (pre-pumping) data, interpreted as a priori natural fractures.

Seismic shear velocity changes from pre- to post-pumping are seen in the data. Changes may be interpreted based on dominant azimuth Horizontal Transverse Isotropy (HTI) type models, or on random azimuth type models (e.g., Berryman). There are four travel times, or velocities, that are pertinent: 'fast' and 'slow', for both the baseline survey and also for monitor survey(s) at any time in the Life-Of-Frac.

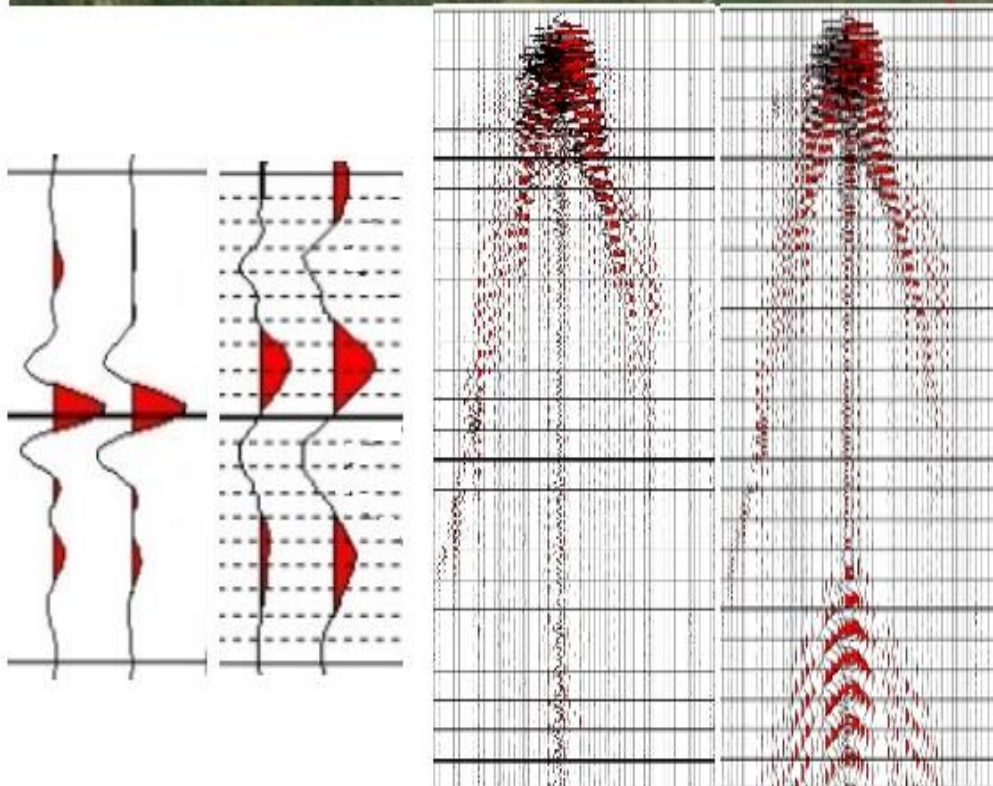
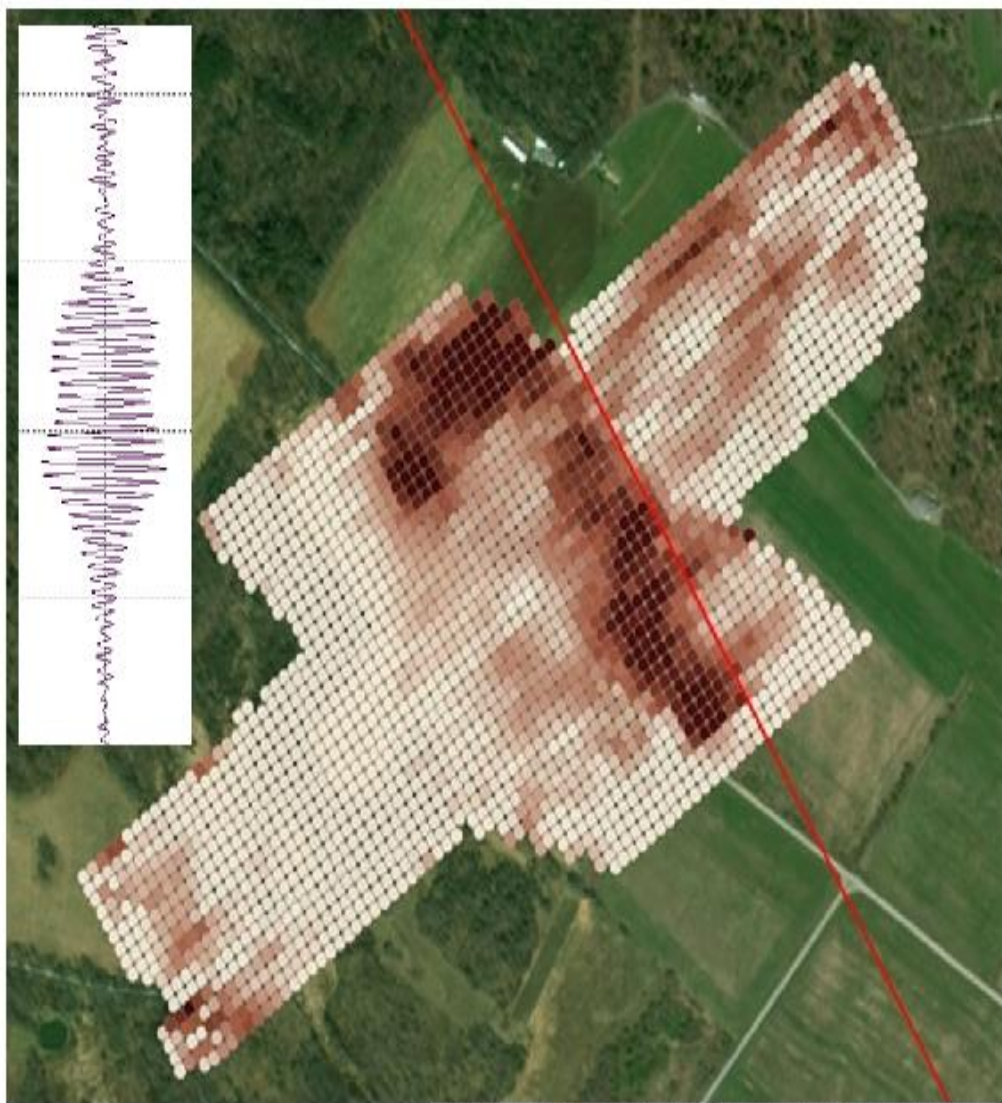
The data acquired to date show Krauklis wave changes at distances up to 2,000 and 3,000 ft from treatment wells, at times of hours to days after pumping. Depletion / stress shadow type effects are seen, due to production on an adjacent pad. Krauklis data (and corroborating passive surface microseismic data) show one treatment well with frac'ing dominantly on only one side. Near another treatment well, up to 20 msec. time shifts are seen in data post-pumping vs pre-pumping, which are significantly above a detectability threshold of a few msec. There is a qualitative indication of multiple (random?) frac azimuths.

Although only mentioned in passing in this presentation, there are various physical concepts and theory that are part of the background for interpretation of this type of data. Krauklis waves in particular are unfamiliar to many people in E&P. A quick overview of the scope of pertinent concepts and theory will be given.

These frac monitoring techniques are presented here as a significant step forward, available today to guide improved frac completions. These pilot surveys showed actionable results with significant economic impact: well sequencing, pumping rates, volumes, proppant load, and additives can be impacted in near real time. There are potentially further economic benefits in design regarding well, stage, and cluster spacing. This technology has the potential to monitor the evolution of the effective SRV through any soak period, flowback, and initial production. There are also future technology development paths for enhancements, refinements, and likely surprises!

However, significant commercial issues are problematic: this is new technology, it's unfamiliar to staff, frac plans are not readily altered, ... At this time, this new technology is effectively an 'orphan'. No E&P Operator, nor any Service Company is presently an advocate for this technology.

**Please RSVP using the PayPal link on the Geophysical Society of Pittsburgh website at: [www.thegsp.org](http://www.thegsp.org)  
Cost: Free for GSP Members, \$10 Non-members (\$10 for Students)**



*Data Montage: Upper left inset is a trace with an emergent onset, high Q, high amplitude Krauklis wave. Upper map is Krauklis wave post- vs pre-pumping; treatment well is long red line; 12.5 by 12.5 m subsurface bins within the surveyed area. Lower left is a shear body wave time shift, post- vs pre-pumping, for near vertical propagation through the SRV, for a single Source, Receiver polarization, but with a composite of S-to-R azimuths, showing ~20 msec time shift. Lower right is a surface receiver line for pre- vs post-pumping, showing emergent, high Q resonant, high amplitude, slow propagation velocity Krauklis wave in the post-pumping data.*

## Speaker's bio: Robert Brune

**Robert (Bob) Brune** is a Geophysical Consultant with a broad technical background in Geophysics and Oil & Gas. In recent years he has been focused on various fundamental technology issues, including rotational seismic, HSE issues, elastic wave, seismic acquisition technology, as well as fracture monitoring.

He has approached frac monitoring technology from several vantage points, based on his background and experience:

His experience in the oil and gas industry includes work in Exploration (including as an Exploration Mgr. for Sohio); Production (Mgr. of Regional Field Development in Alaska for BP); and in Technology (Mgr. of Geophysical Technical Services and R&D for Sohio).

His experience in the service industry includes work at GSI and at TGS (President, Offshore; and Chief Geophysicist), as well as consulting work for various companies, particularly in S. America.

His experience at the U.S.G.S. in Menlo Park, CA. included work on seismic sources.

Robert has a B.S. in Geology (U. of Missouri at Rolla; National Merit Scholar; graduated at 19); an M.S. in Geophysics (Stanford University; NSF scholarship; inaugural group of SEP consortium); and an M.S. in Computer Systems (U. of Denver). His Petroleum Engineering educational background is from Colo. School of Mines.

***Tuesday April 6, 2021***

***Agenda:***

***11:50 AM Zoom meeting opens***

***12:00 Noon Joel Starr will begin the meeting***

***12:15 Lecture begins***

***To receive a CEU certificate from this lecture please contact Bill Harbert***

*We would like to thank our 2020-2021 Corporate Sponsors. Please contact Joel Starr if you are interested in sponsoring the GSP*

**GOLD**



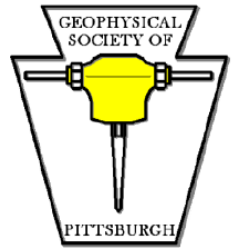
**SILVER**



**BRONZE**



# *Sponsorship Opportunities*



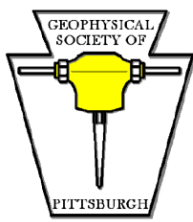
The Geophysical Society of Pittsburgh offers sponsorship opportunities. Our monthly meetings occur each first Tuesday of every month beginning in September through May.

Since our inception in 2010, meetings have been very well attended by industry professionals, averaging well over 50 attendees per meeting, peaking at more than 100 for our most highly attended meeting. Not only do our meetings offer exceptional technical presentations in the field of geophysics, but they provide an outstanding networking opportunity for oil and gas industry professionals working in the Appalachian basin.

Your generous donations will help in the following ways: 1) helping to bring in distinguished lecturers; 2) offsetting part of the cost of the monthly meeting venue; and 3) enabling a Scholarship Program for future Geophysicists to be awarded each year to an outstanding student enrolled in a Geophysics program at one of our local universities.

Your company logo will be boldly displayed during the social hour of each meeting on the front screen, as well as on all meeting announcements and on our website. We are offering corporate sponsorship opportunities at several levels this year, as well as opportunities to sponsor our social hour during the meeting. Please note that a secure payment link is now available on our website for your added enrollment convenience.

Please click [HERE](#) to download more information, then return to this page to enroll as a sponsor.



# *Geophysical Society of Pittsburgh*



The Geophysical Society of Pittsburgh successfully hosted the first Appalachian Basin Geophysical Symposium (ABGS), June 5<sup>th</sup> 2021 at the Noah's Event Center, Canonsburg PA. The event was a huge success with great speakers covering the latest innovations in geophysical research, technology and perspectives of the Appalachian Basin. We thank all our generous sponsors, speakers and organizers who made this event possible.

The positive feedback received from our community has prompted the GSP board to make the ABGS an annual event. With the addition of this yearly symposium, *it was determined that the monthly meetings should be reduced to a quarterly basis.*

The goals of this change are twofold:

1. Boost attendance numbers at our general meetings;
2. Focus Appalachian Basin centric talks for the ABGS.

Two of the quarterly meetings will occur in the fall and the other two during the spring. The ABGS will still be held around the beginning of June in tandem with the golf outing. This ensures that our members still have the opportunity to network on a semiregular basis.

We hope these changes help enhance the GSP's ability to promote the science of geophysics as well as promote the fellowship and cooperation among its membership. We look forward to seeing everyone at the first meeting this September.

Sincerely,

The GSP Board



## 2020-2021 GSP OFFICERS

*President:* Joel Starr

*Vice President:* Jianli Yang

*Treasurer:* Brian Lipinski

*Secretary:* Bill Harbert

Geophysical  
Consultant

Seneca Resources

Geophysical  
Consultant at  
Huntley and Huntley  
Energy Exploration.

Univ. of Pittsburgh



**Your Dues and Sponsorship in Geophysical Society of Pittsburgh go toward:**

- *Outstanding Monthly Lecture Series*
- *SEG Distinguished Lecturers*
- *Annual Scholarship Awards*
- *Annual Golf Outing*
- *Short Courses*

*Please contact Joel Starr, Jianli Yang  
, or Brian Lipinski for Sponsorship Opportunities.*

