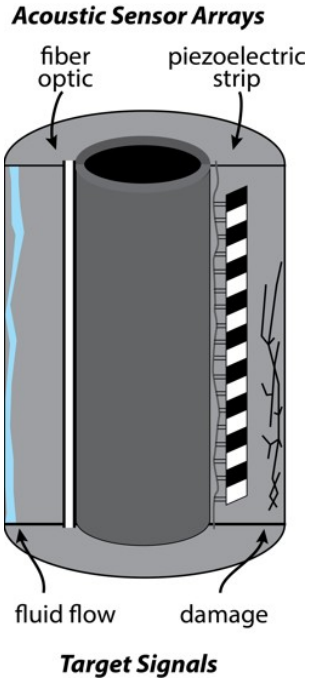
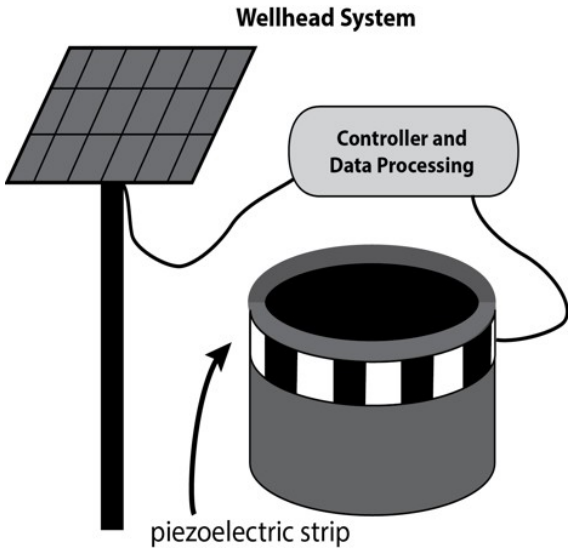




Autonomous monitoring of wellbore integrity applying Time Reverse Nonlinear Elastic Wave Spectroscopy (TR NEWS) and Fiber Optic Sensing and Communication

PIs: P. Johnson & G. Guthrie

Presenter Name : P. Johnson

Track Name

Project Officer: Alexandra Prisjatchew

Total Project Funding: $3My

November 14 , 2017

Relevance to Industry Needs and GTO Objectives

Objective: development of an autonomous system that can be deployed in wells for long-term (e.g., decades), unattended monitoring both wellbore integrity and associated stress changes

- targets the lack of an affordable autonomous system that can be used to wellbore integrity, particularly post closure.
- Impacts leakage-related issues in $C0_2$ monitoring efforts and impact geothermal energy development in regards to damage and stress assessment

Innovation: Combination of (i) passive long term monitoring of seismic signals associated with leakage applying machine learning approaches; (ii) fiber optics to follow anomalous stress evolution near the borehole; (iii) Time Reversal and Nonlinear Elasticity for localized damage assessment [*Time Reversal Nonlinear Elastic Wave Spectroscopy, TR NEWS*]

Relevance to Industry Needs and GTO Objectives

Impact the Geothermal Technologies Office's goal(s)

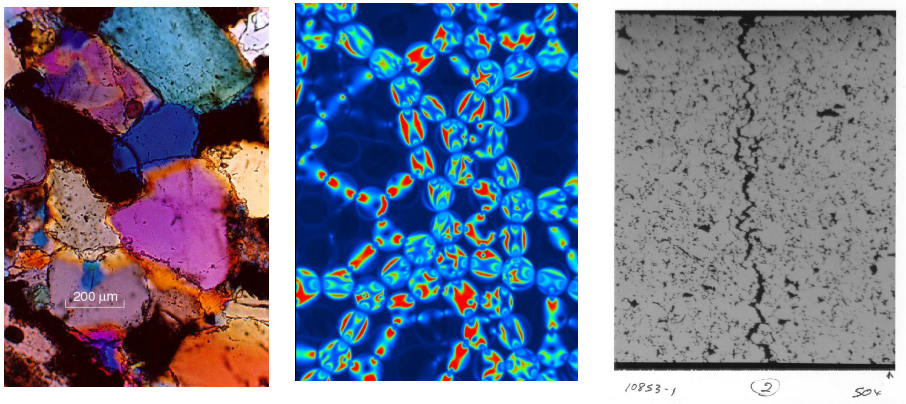
We develop a system applied to wellbore and near wellbore leakage monitoring. [note project is funded by DOE C02]–

Research Collaboration and Technology Transfer: we are working with Chevron and our goal is to develop the system

Methods/Approach: The novel approach is a combination of stress monitoring, listening to leakage and diagnostics applying TR-NEWS

Based on nonlinear elastic behavior of rock: Primary contribution to nonlinearity is mechanical damage.

"Distributed" "Localized"



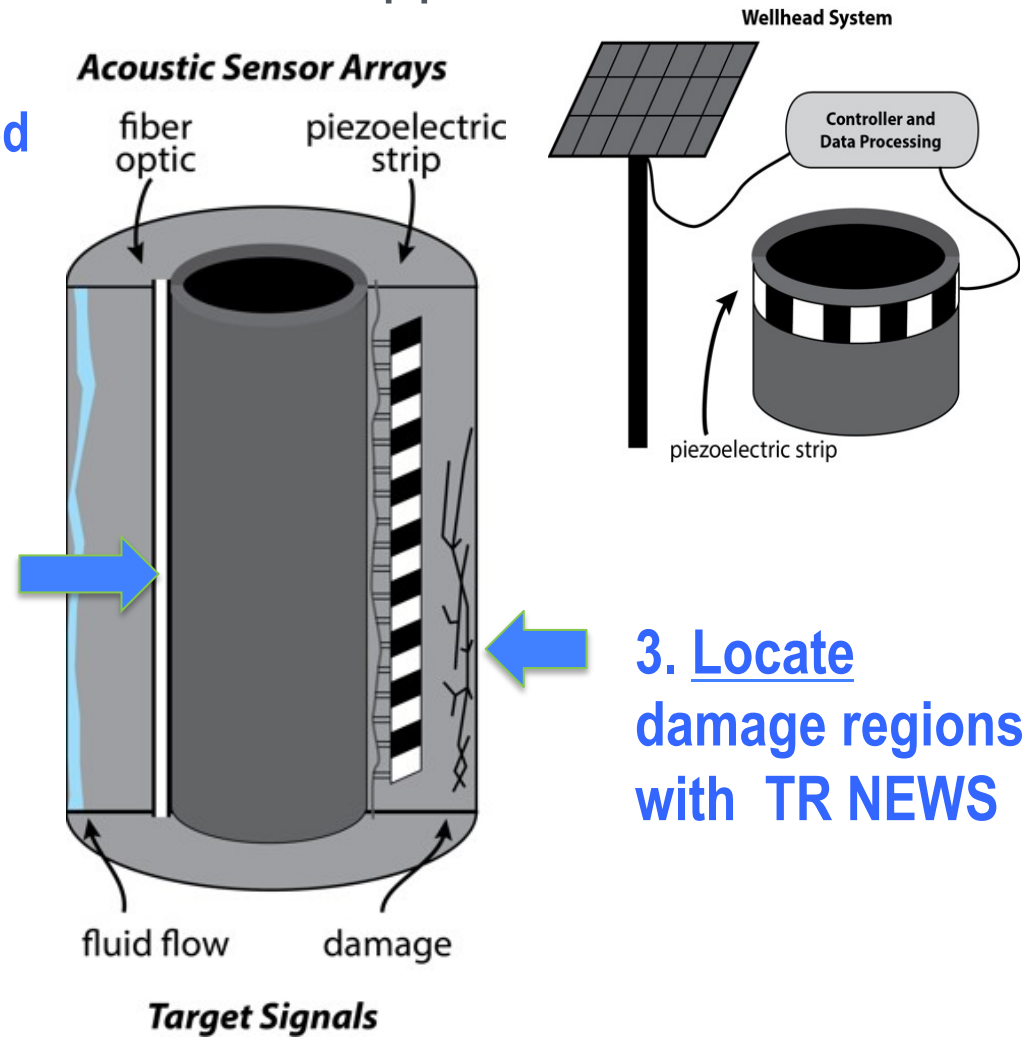
Methods/Approach

- scientific/technical approach:

1. Listen for leakage related noise

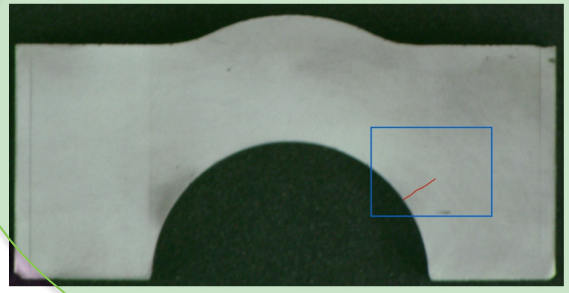
2. Monitor strain/stress evolution

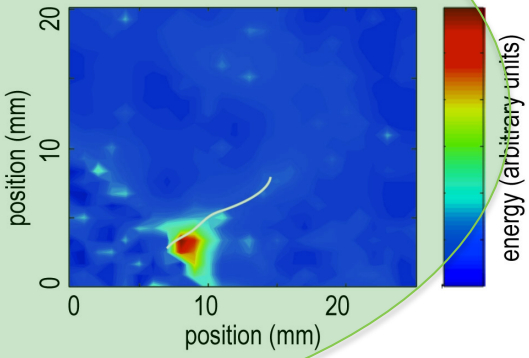
3. Locate damage regions with TR NEWS



Methods/Approach

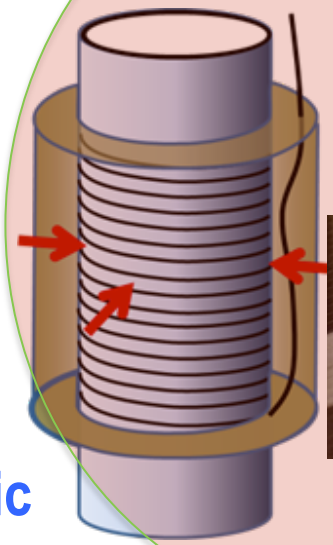
- scientific/technical approach:

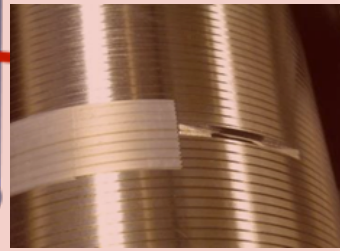


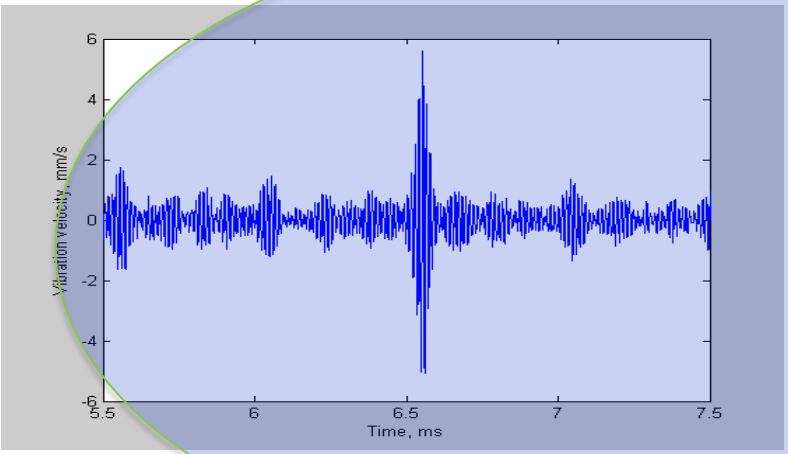


TR NEWS

Fiber optic measure of strain





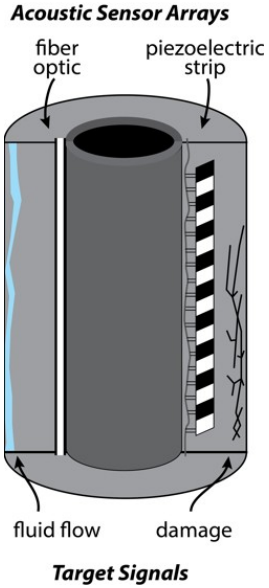


Monitoring acoustic signals with advanced methods —machine learning, waveform coherence….

Methods/Approach

- Key issues we are addressing: This proposal targets the lack of an affordable autonomous system that can be used to wellbore integrity, particularly post closure

Implementation of combined technologies in the borehole



Begin in laboratory and progress to field

simulation

lab

field

- We are only beginning our project tasks

Technical Accomplishments and Progress

Describe the most important technical accomplishments and progress and their significance. **Stay tuned!**

Tasks:

Task 1: Integration and Technical Project Management.

Task 2. Literature review and evaluation of proposed technology strategies.

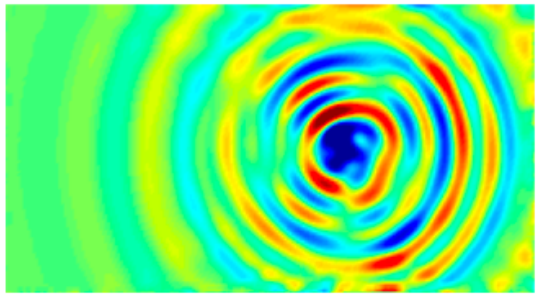
Task 3: Detect small seismo-acoustic signals associated with fluid flow in a damaged wellbore annulus.

Task 4: Use time reversal to focus energy within a wellbore system.

Task 5: Detect nonlinear responses of wellbore system as a function of integrity.

Task 6: Measure changes in stress along a wellbore system.

Task 7: Assess design for prototype field system.



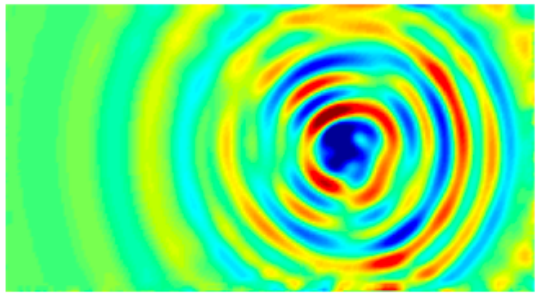
Research Collaboration and Technology Transfer

- Summarize any industry or academic engagement that is taking place under this project

We are working with Chevron to take this to completion. Partners are Chevron, LBNL, Clemson University and Los Alamos.

- Describe opportunities or efforts currently underway to transition technology to the private sector.

Stay tuned for this aspect of work…..

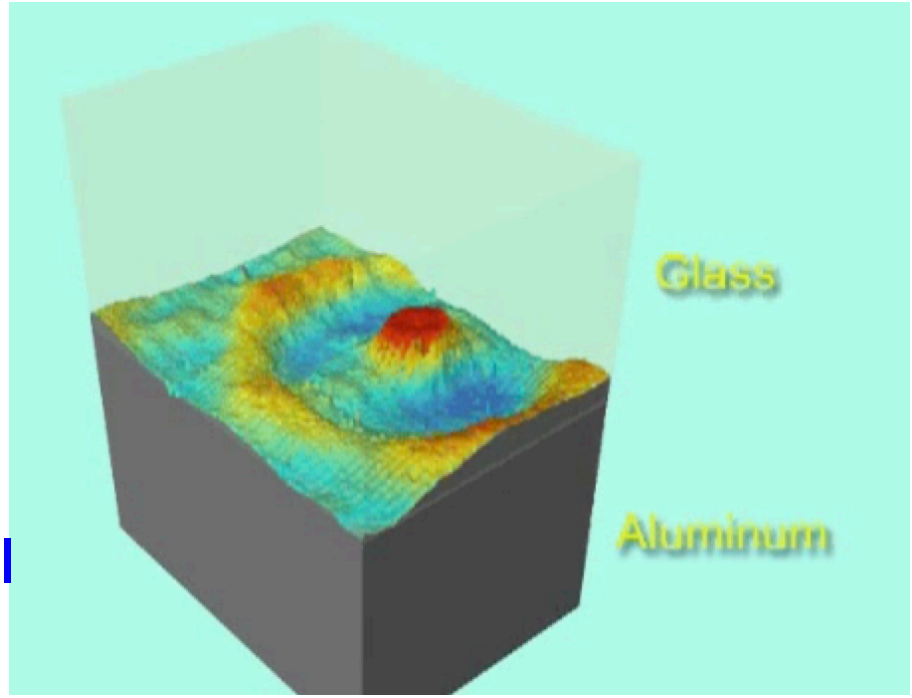


Future Directions

- Describe deployment strategy or expected outcome of this effort. Discuss future research, development or deployment needs.
- We intend to get to the design stage for a prototype system
  - Explain key activities for the rest of FY2018 and to project completion.

[see next slide]

Time reversal



Milsestones and deliverables

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Table 1. Timeline for project by task and project year (PY), with two go/no-go (G/NG) decision points.

Task	Task Description	PY1					PY2					PY3					Product	Dependencies
		Q1	Q2	G/NG	Q3	Q4	Q5	Q6	G/NG	Q7	Q8	Q9	Q10	Q11	Q12			
1.0	Technical Project Management (200)																• Quarterly reports; other sponsor requests	
2.0	Literature Review & Technology Evaluation (250)																• Briefing with detail to assess 1st go/no-go	
3.0	Detect Fluid Flow (250)																• Report documenting lab results on detecting small signals	"Go" at 1st go/no-go
4.0	Use TR to Focus Energy (200)																• Report documenting lab results on TR focusing of acoustic energy	"Go" at 1st go/no-go
5.0	Detect nonlinear Properties (750+																• Final report summarizing lab and field results and data	Successful completion of 4.0
5.1	Lab-scale Experiments (																• Initial report on lab results as needed to assess 2nd go/no-go	Successful completion of 4.0
5.2	Field-scale Experiments																• Data documenting field performance	"Go" at 2nd go/no-go
6.0	Measure Stress Field																• Final report summarizing lab and field results and data	
6.1	Lab-scale Experiments																• Initial report on lab results as needed to assess 2nd go/no-go	
6.2	Field-scale Experiments																• Data documenting field performance	"Go" at 2nd go/no-go
7.0	Re-assess design criteria																• Report assessing feasibility of commercial system based system, along with a development pathway	

Mandatory Summary Slide

Take Away

- Develop an autonomous system for long-term deployment in wells for unattended monitoring wellbore integrity and associated stress changes
- System consisting of wellhead and downhole components based on the combined signals of piezoelectric and/or optical sensors
- Signal target: (i) seismo-acoustic signals associated with moving (leaking) fluids; (ii) the stress field along the wellbore where changes in stress may presage damage and leakage; (iii) nonlinear properties in the near-wellbore region that arise when damage develops and progresses.