



Induced Seismicity Consortium (ISC)



Semi Annual 2015 Review Meeting

ISC Overview and Status

Fred Aminzadeh

Los Angeles, CA
July 23, 2015



ISC Annual Review Meeting Agenda



- | | | |
|--------------|--|----------------------------------|
| 8:00 | Registration-Breakfast | |
| 8:15 | ISC Overview and Status Report | Aminzadeh |
| 8:40 | Seismicity rate changes and injection operations in Oklahoma and California | Goebel
(Cal Tech- USC) |
| 9:05 | Effect of the Earth Characteristics on Induced Seismicity Potential | Hosseini |
| 9:40 | 9:40-10:05 Creating a Water contamination mapping tool | Jabbari |
| 10:05 | Coffee Break | |



ISC Annual Review Agenda, Cont.



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|--------------|--|---|
| 10:20 | Discriminating characteristics of tectonic and human-induced seismicity | Zaliapin, Ben-Zion
(UNR- Reno, USC) |
| 10:45 | Laboratory measurement of permeability alteration under reservoir conditions and implications for field-scale systems". | Detwiler
(UCI) |
| 11:10 | Laboratory studies of induced seismicity and earthquake scaling | Young
(U. of Toronto) |
| 11:35 | An update on Oklahoma induced seismicity and fault database | Hatfield
(OIPA- Crawley) |
| 11:50 | Lunch Break | |



ISC Annual Review Agenda, Cont.



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|--------------|--|-----------------------------|
| 12:45 | Progress on next-gen techniques for monitoring and management of induced seismicity | White
(LLNL) |
| 1:10 | Upward Migration of Hydraulic Fracturing Fluid through Cement-Wellbore Interface | Rohani |
| 1:35 | MEQ data to validate fracture modeling results | Ouenes
(Fracgeo) |
| 2:00 | An update on different DOE supported Monitoring Projects in the US shale fields | Hammack
(NETL) |
| 2:55 | Coffee Break | |



ISC Annual Review Agenda, Cont.



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|-------------|---|--|
| 3:10 | Strategic and technical advisory board (STAB) meeting: discussion future research directions | All |
| 3:35 | Coupled Flow and Geomechanical Modeling of Induced Seismicity in Faulted Reservoirs | Jha
(MIT/USC) |
| 4:00 | Highlights o Strategic and Technical advisory board meeting(STAB) | Black, Karrenbach
(CRC, Optasens) |
| 4:30 | Brain storming for future plans | All |
| 5:15 | Concluding Remarks | Aminzadeh |
| 6:00 | Reception and Dinner- Dinner talk: Intersection of Energy,Economy and Environment | Gibson
(Former CEO of Halliburton Services) |



Strategic and Technical Advisory Board,



- **British Gas Group**, Hamish Macintyre,
 - **California Corporation of America (CRC)**, Victor Ziegler, Cynthia Rock
 - **City of Long Beach**, Quang Nguyen
 - **Frageo**, Ahmed Ouenes
 - **KMS Technology**, Kurt Strack,
 - **Paulsson Inc.** , Bjorn Paulsson
 - **SINOPEC** , Lin Zhengliang, Yang Xinchao,
 - **Optasense (formerly SR2020)** Bill Bartling, Martin Karrenbach,
- **California Division of Oil and Gas and Geothermal** Steven Bohlen
 - **California Mineral Resources Management**, Marina Voskanian
 - **Environmental Defense Fund (EDF)**, Scott Anderson,
 - **Gas Technology Institute**, Iraj Salehi, Dave Debotyam
 - **Interstate Oil and Gas Commission Corp. (IOGCC)**, Mike Smith
 - **Lawrence Berkeley National Laboratory**, Jens T. Birkholzer
 - **Lawrence Livermore National Laboratory**, Tarabey Antoun,
 - **National Energy Technology Laboratory**, Kelly Rose
 - **National Research Council**, Elizabeth Eide,
 - **Oklahoma Corporation Commission** ,Dana Murphy
 - **Oklahoma Geological Survey**, Austin Holland
 - **US Geological Survey**, Susan Hough

PhD Students

1. Magdalene Ante (Nigeria)
2. Abdulrahman Bubshait (Saudi Aramco)
3. Ahmed Bubshait (Saudi Aramco)
4. Rayan Dablul (Saudi Aramco)
5. Mehran Hosseini
6. Nima Jabbari (Intern at CSL)
7. Metin Karakas (Chevron Fellowship)
8. Debotyam Maity (now with Gas Technology Institute)
9. Noha Najem (Kuwait Oil Company)
10. Arman Nejad (Intern at FracGeo)
11. Mahshad Samnejad
12. Tayeb Tafti (now with Aera Energy)
13. Robert Walker (Chevron Fellowship)
14. Xiaoxi Zhao

Incoming Current Graduating Graduated

Other Members of ISC Team

Some of the Collaborating Faculty

- Yehuda Ben Zion
- Felipe De Barros
- Iraj Ershaghi (Coordinator STAB)
- Behnam Jafarpour
- Kristian Jessen
- Birendra Jha (Coming from MIT)
- David Okaya
- Donald Paul (Coordinator STAB)
- Charles Sammis
- Moe Sahimi
- Kelly Sandres
- Theo Tsotsis

Post doctoral Fellows

- Thomas Gobel (part time- CalTech)
- Yesser HajNasser, (formerly ConocoPhillips)
- Danielle Sumy (now at IRIS)

Staff

Joe Ivonetti (advisor)

Jason Ordonez (business analyst)



ISC 2014-2015 Project Plan

- 1. Comparative study of seismicity and injection activity in California and Oklahoma**
- 2. Geomechanical Modeling of Induced Seismicity**
- 3. Laboratory Tests to Analyze Induced Fractures and Faults**
- 4. Create a Water contamination mapping tool**

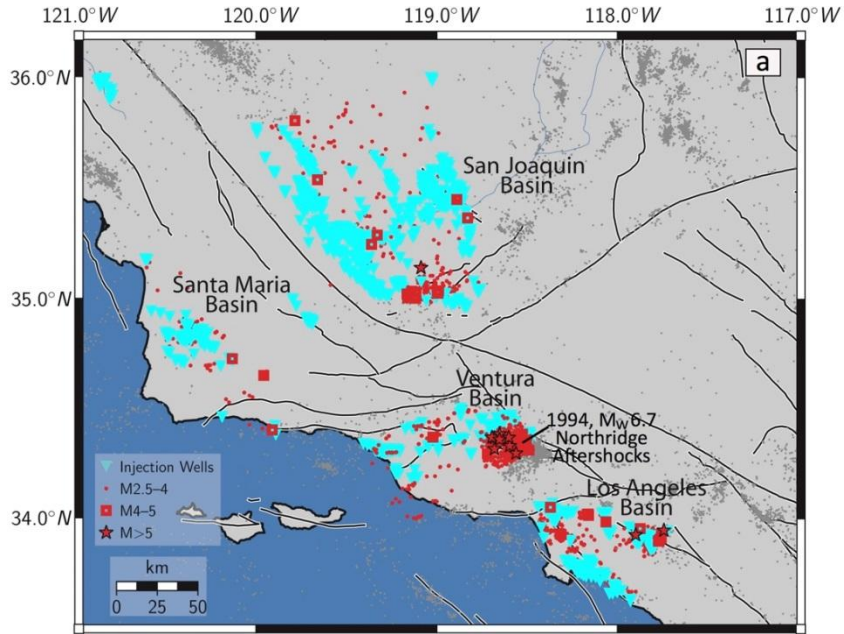


Comparative study of seismicity and injection activity in California and Oklahoma

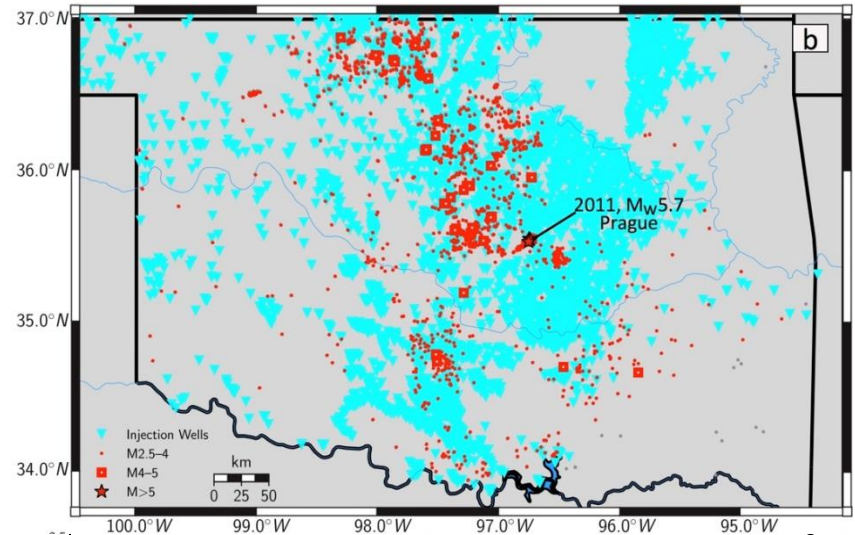
- **Extend our analysis to Los Angeles, Ventura and Santa Maria Basins. We will investigate the seismogenic consequences of fluid injection in each of these areas and place it in the context of the local tectonic regime.**
- **Compare injection-induced seismicity or lack thereof in California and Oklahoma.**
- **Develop an overall assessment of the seismogenic potential of injection, on the tectonic differences between intra-plate and plate boundary regions.**
- **Document differences in the geology, reservoir types and injection characteristics in California and elsewhere (eg OK) and investigate the impact on near-by seismic-activity.**



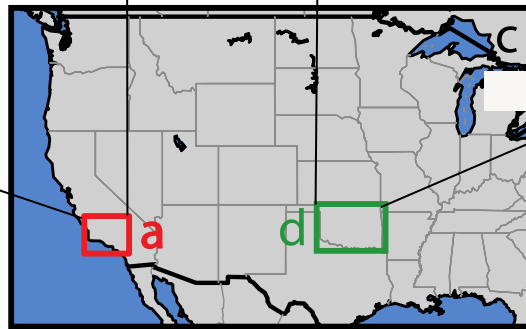
Comparing Oklahoma and California



Well density: 0.7 km²



Well density: 0.05 km²



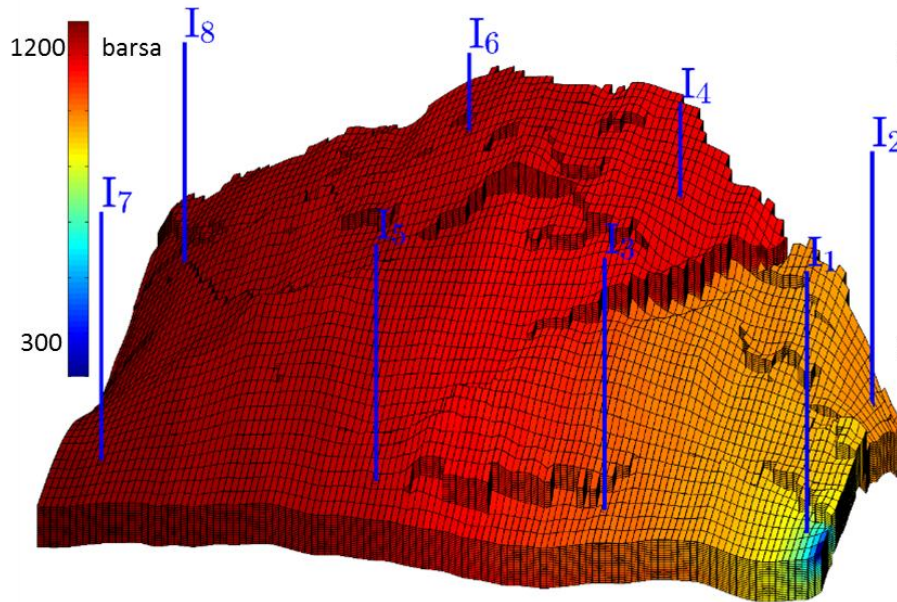


Geomechanical Modeling of Induced Seismicity

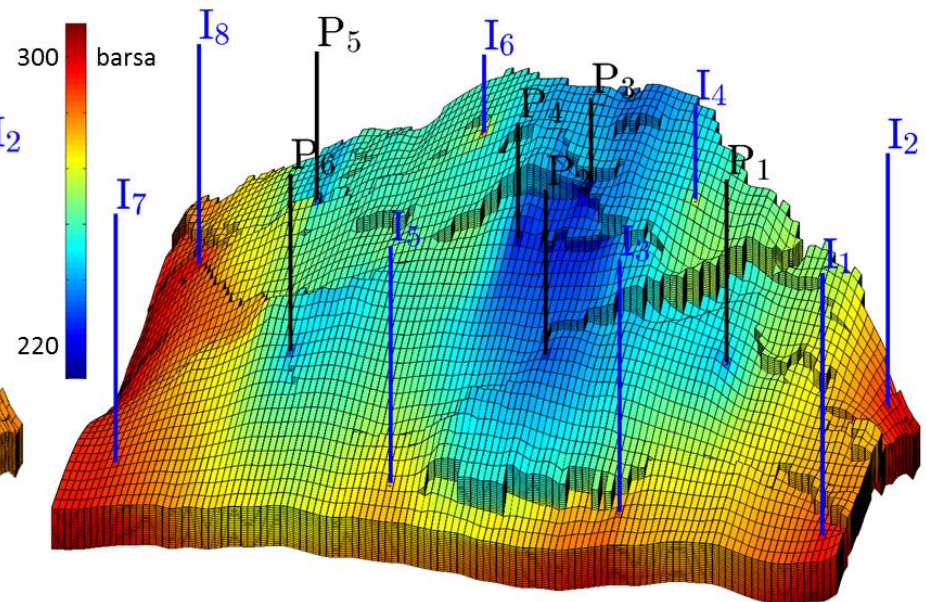
- **Apply the current stochastic induced seismicity analysis described in section 4 of this report to available induced seismicity cases (i.e. Oklahoma) in order to get insight about their mechanism and to come up with practical criteria to possibly avoid similar events.**
- **Include poroelasticity in the stochastic induced seismicity analysis framework.**



Geomechanical Modeling of Induced Seismicity



ΔP Waste Water Disposal



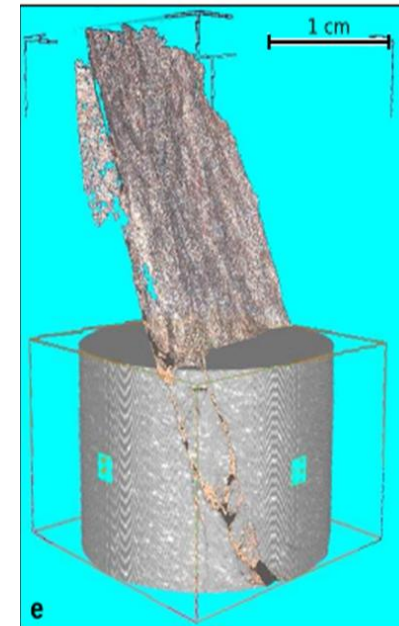
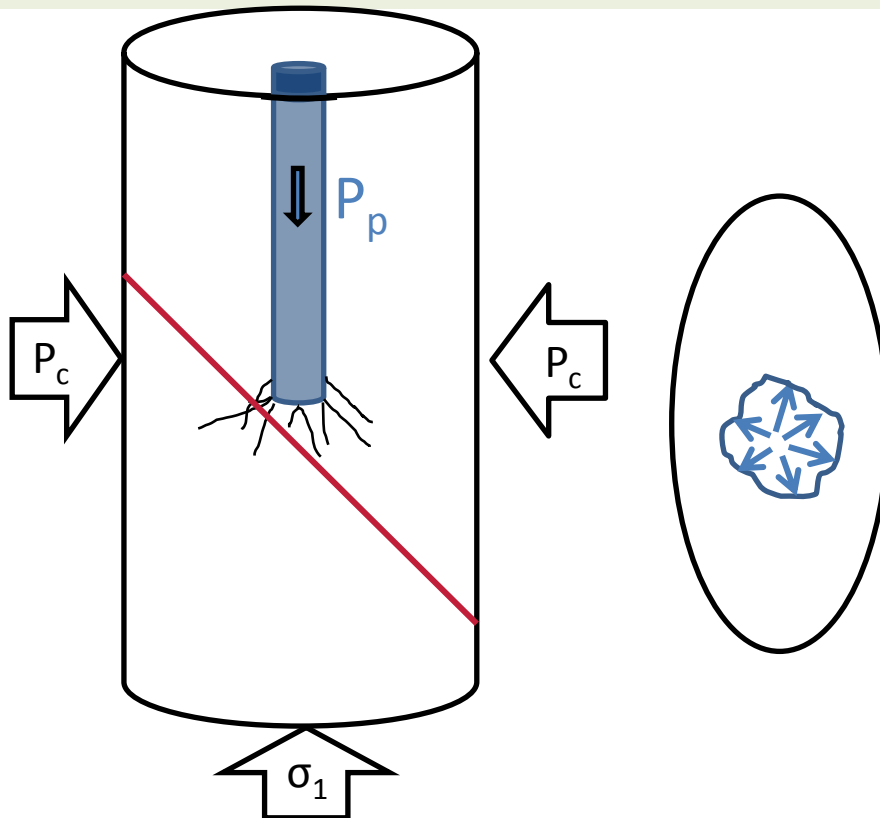
ΔP Simultaneous Injection
and Production

EOR versus Waste Water Disposal: Net Volume Effect



Laboratory Tests to Analyze Induced Fractures and Faults

- Conduct a series of laboratory experiments to investigate fault activation.
- Vary stress conditions and frictional properties and examine major controls on fault activation.





Create a Water contamination mapping tool

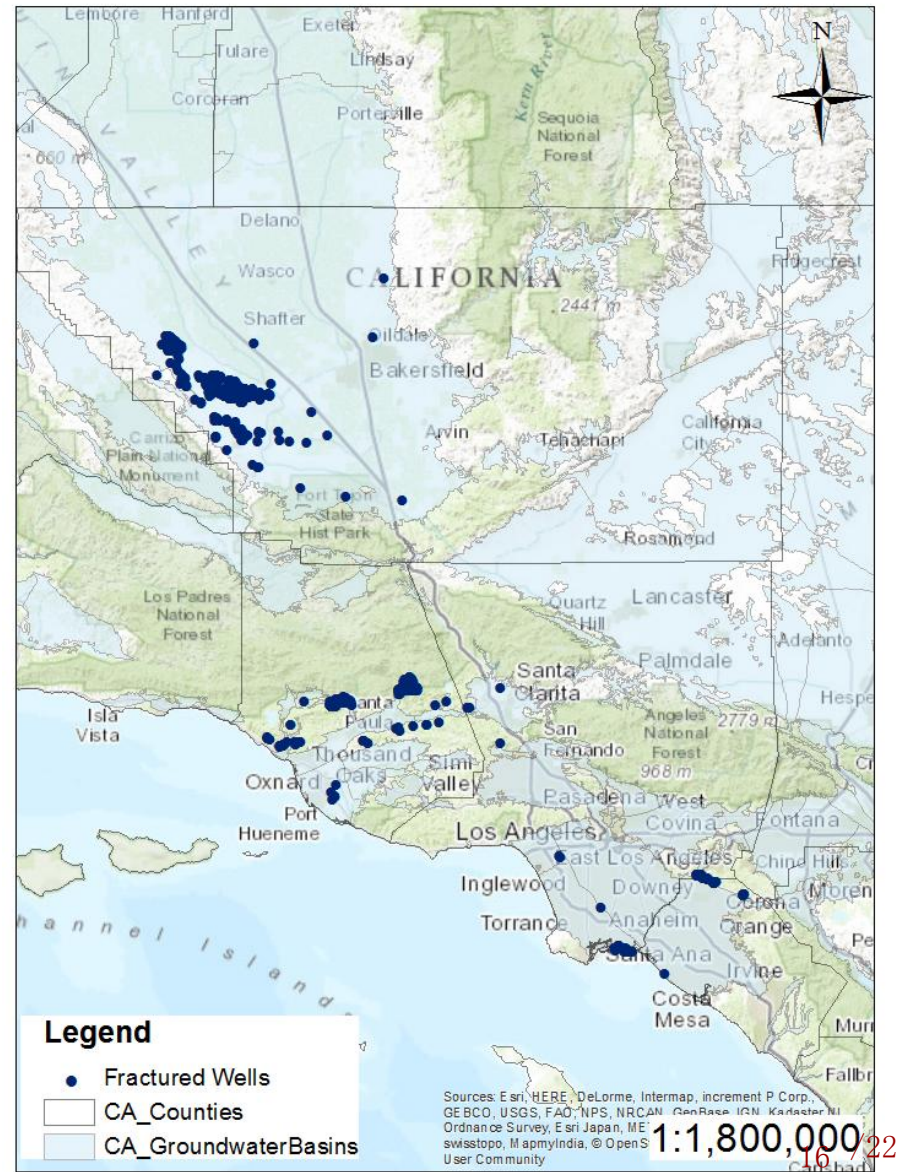
- Expand The Induced Seismicity Mapping (ISM) software to any evidence of water contamination and assess the correlation between SFIP and water contamination in California.
- Address well integrity issues including potential leakage from cement casing



Spatial Analysis



Fractured Wells-Ground Water Basin-

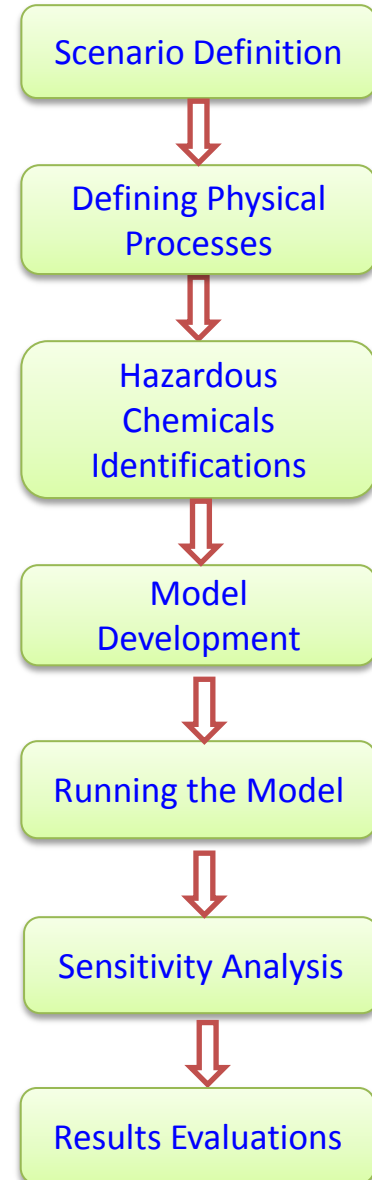
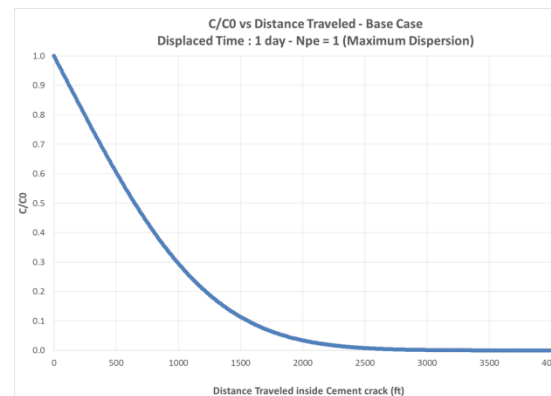
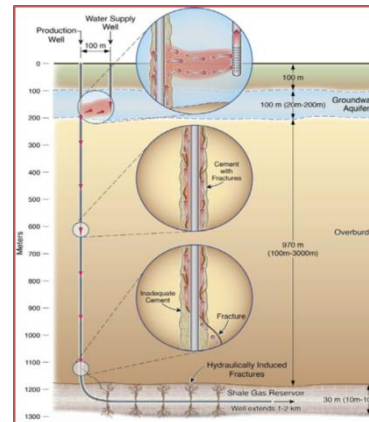
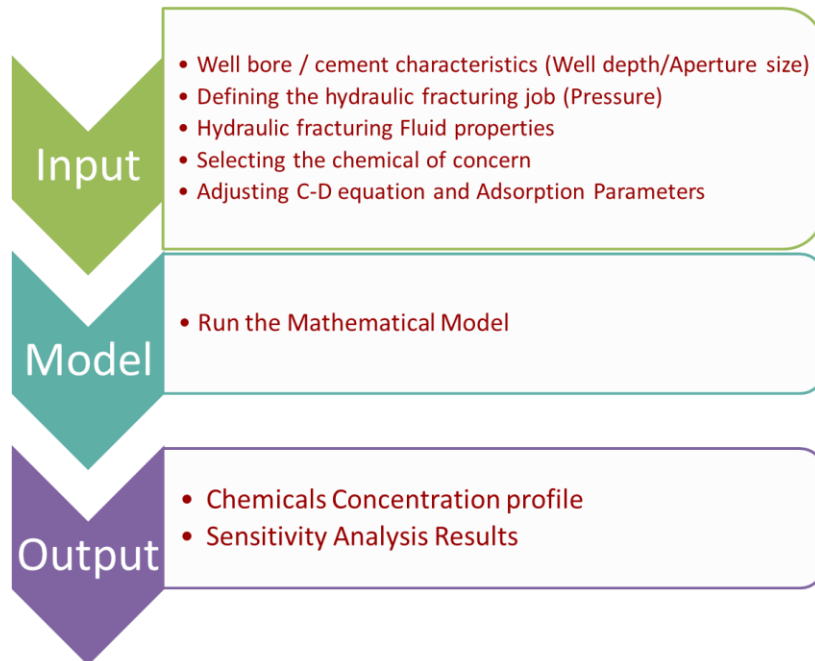




Upward Migration of Hydraulic Fracturing Fluid through Cement-Wellbore Interface

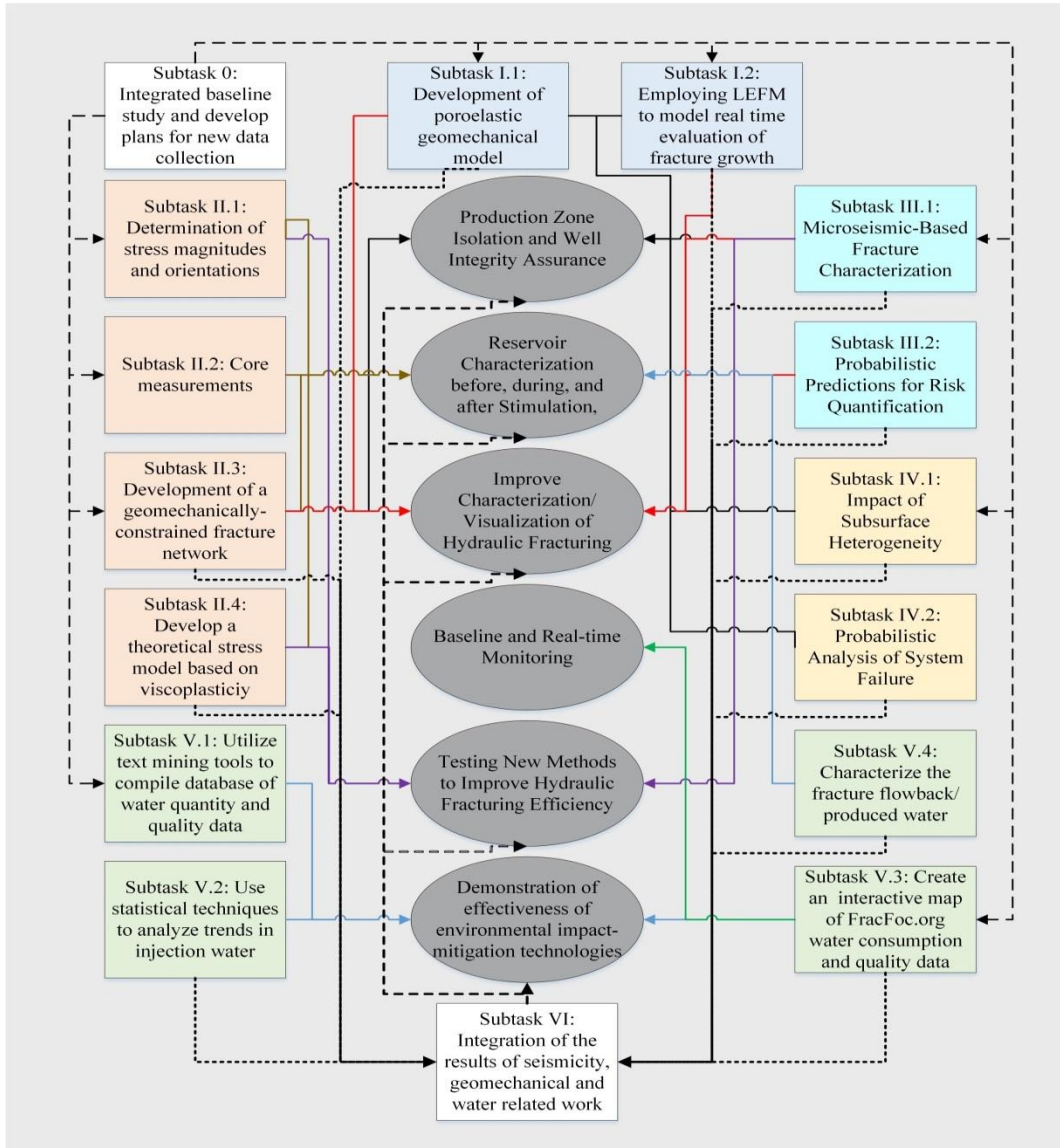
Main objective of this research:

- Evaluating the possibility of groundwater contamination by chemicals of hydraulic fracturing fluid through a cracked cement.



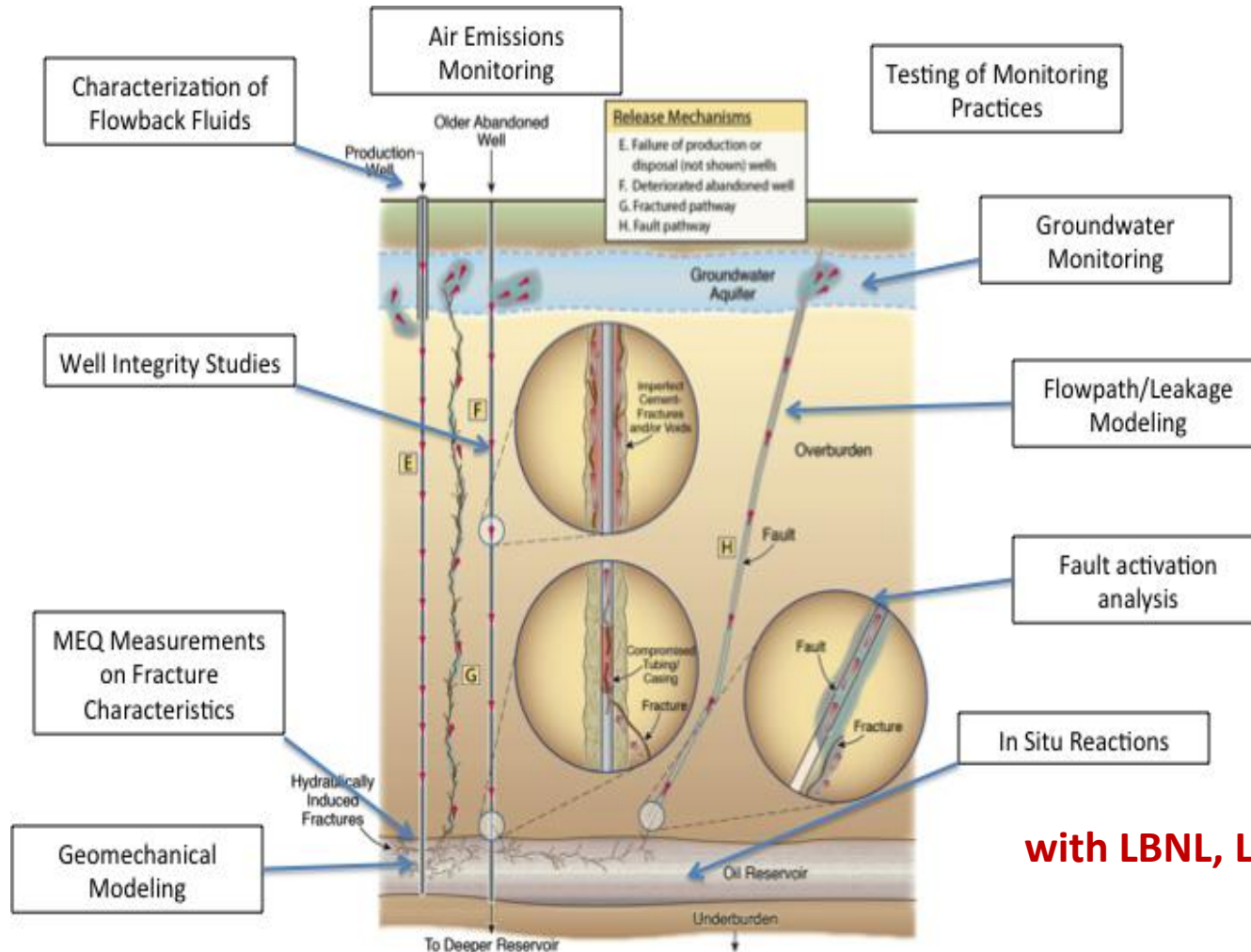


Field Testing To enhance efficiency and safety of shale production





Integrated Evaluation of Hydraulic Fracturing at a Field Laboratory in the San Joaquin Basin: A Pathway to Efficient and Safe Hydrocarbon Reservoir Exploitation in California



with LBNL, LLNL and NETL



Update on ISC Public Outreach



- Invited Talk at Western Region SPE Meeting
 - Invited Paper at Western Region SPE Meeting on Induced Seismicity- Aminzadeh,
- The Leading Edge of Geophysics
 - Comparison of California and Oklahoma seismicity, Goebel,
- Journal of Sustainable Energy Engineering
 - Well Integrity, Jabbari and Aminzadeh
- Journal of Geophysical Research
 - California Seismicity, Goebel, et al
 - Special Session on Induced Seismicity at AGU, San Francisco, Fall 2015
- Communication / Outreach
 - Aminzadeh visited DOGGR (with LBNL and LLNL) at Sacramento and discussed the plans for a new project with Steve Bohlen how best to address the recommendations of California Council on Science and Technology (CCST) and their committee on the study called for in Senate Bill 4 (mostly addressing hydraulic fracturing).
 - Held Biweekly meeting with LBNL, LLNL and NETL to develop a DOGGR Proposal