



Joint meeting of IEA-GIA Annex XI and IPGT IS Working Group  
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# Research Interests: Induced Seismicity in Korea

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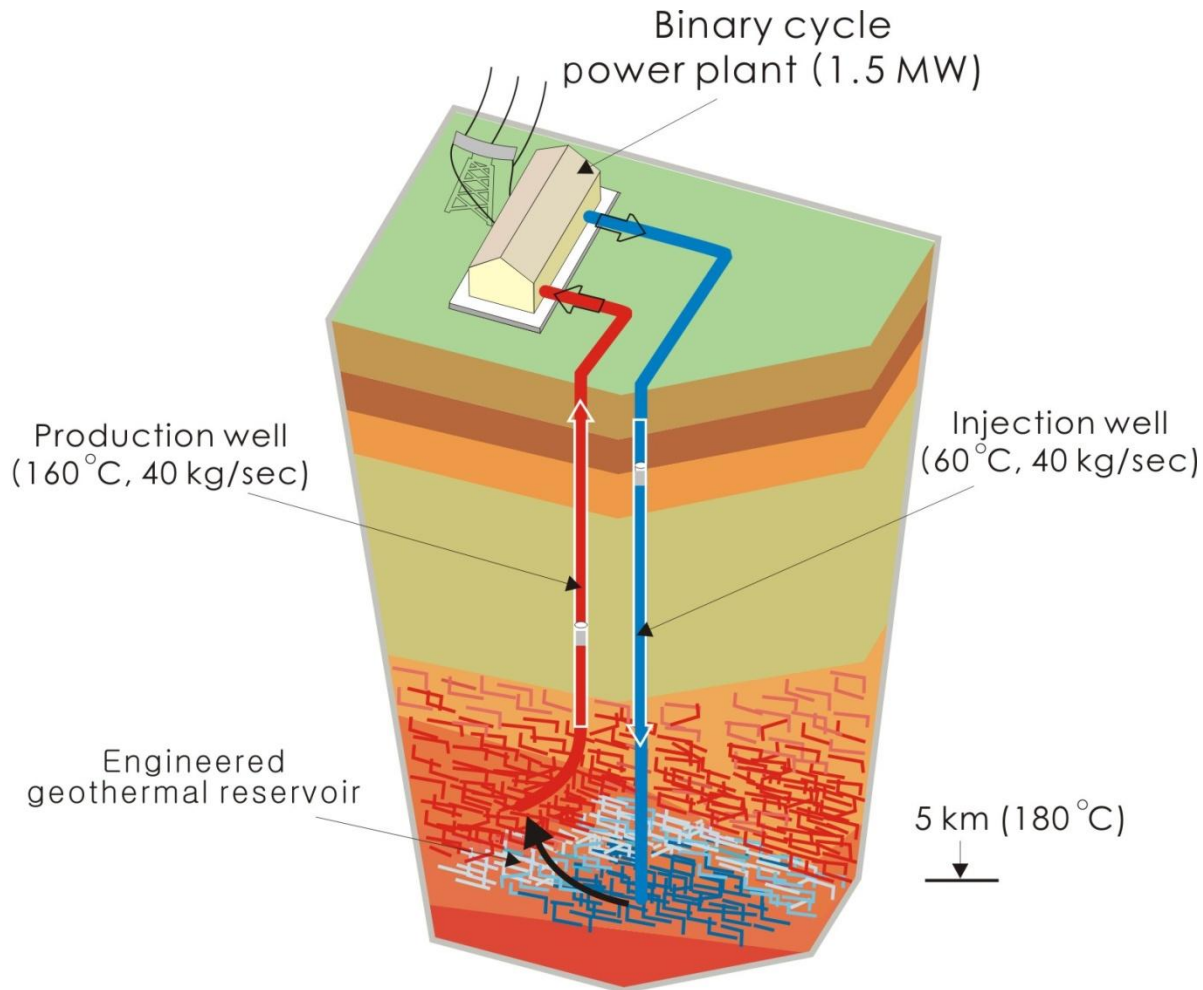
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# Background

- No experience of deep geothermal exploitation
- No domestic oil and gas fields
- Increasing overseas oil and gas projects
- Recently launched R&D projects on EOR and micro-seismicity
- A proof-of-concept EGS project has started
- Needs of international collaboration on Induced Seismicity

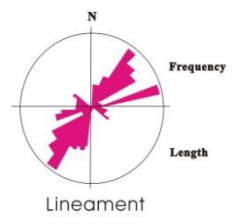
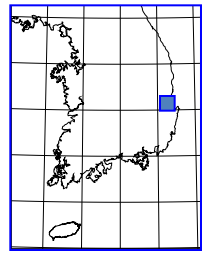
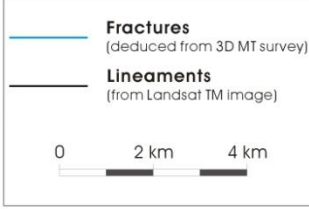
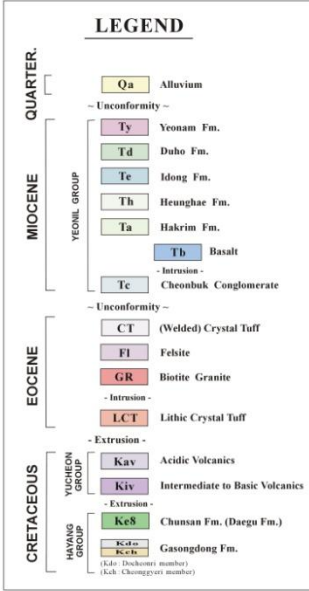
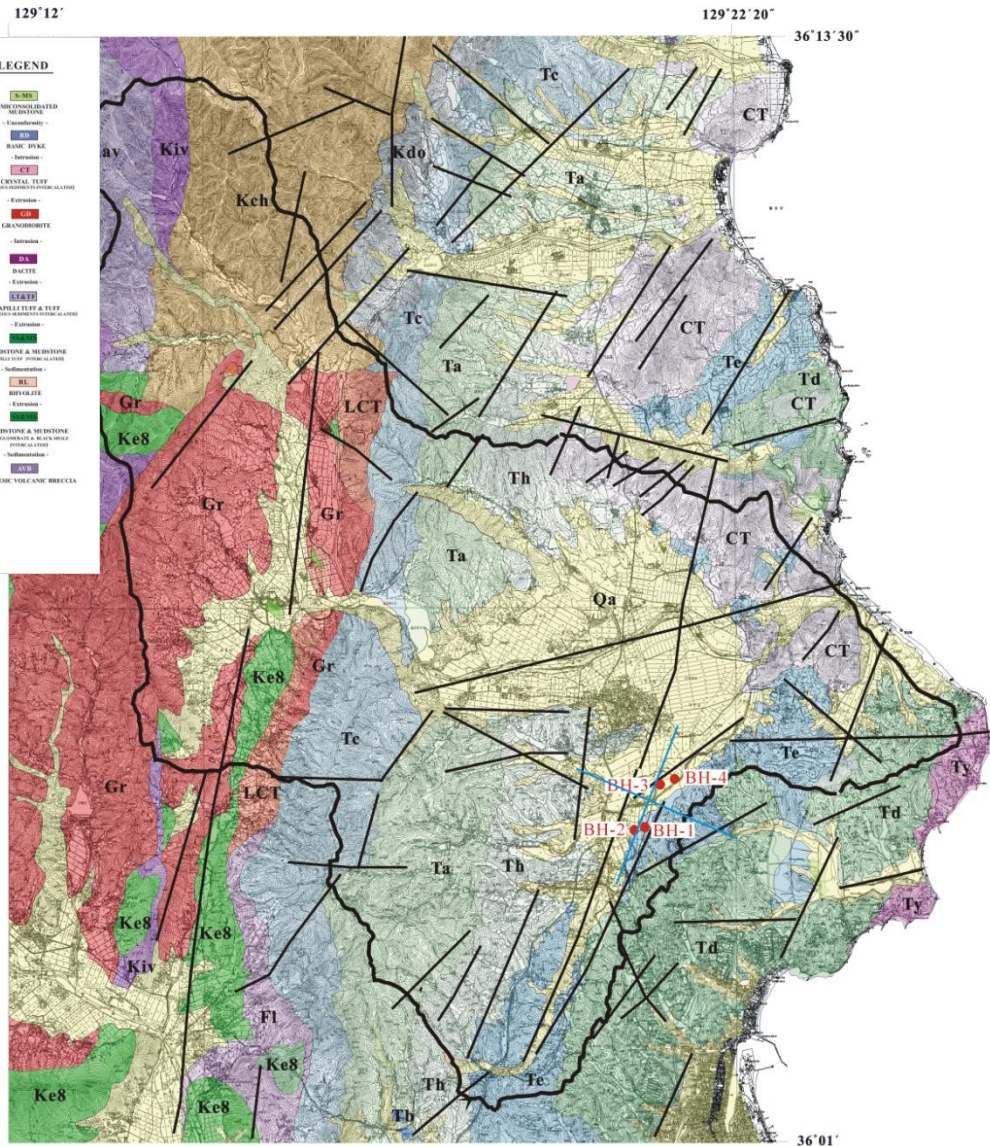
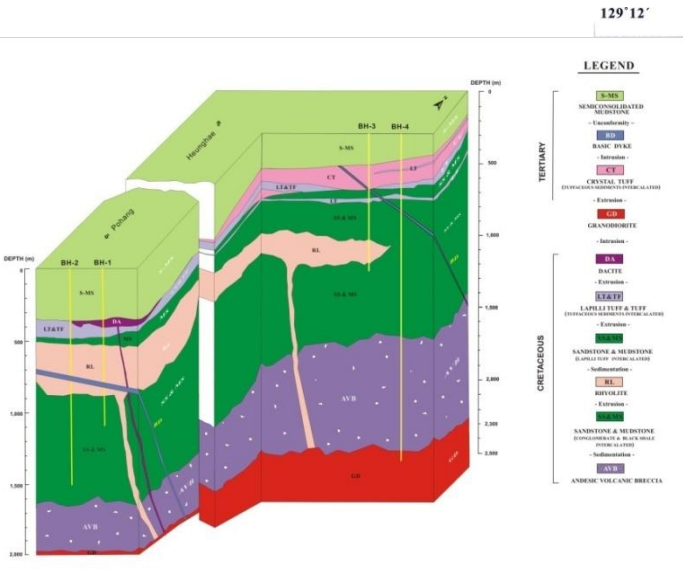
# Conceptual model of Korean proof-of-concept EGS project



# Power generation capacity

- Assuming doublet system
- Reservoir:
  - Reservoir temperature: 180 °C (33 °C/km × 5 km + 15 °C )
  - Fluid temperature: 160 °C
  - Flow rate: 40 kg/sec
- Gross capacity:
  - $W = (160-60) \text{ °C} \times 40 \text{ kg/sec} \times 4.2 \text{ kJ/kg}\cdot\text{°C} \times 0.11$   
= 1,848 kW
  - Net capacity = gross capacity - parasitic load
  - Parasitic load: ~ 370 kW (including pumping power; 1.3 kW/(m<sup>3</sup>/h) and binary cycle; 10%)

# Pohang Site: Location and geology



# Planned time line

- Five year project: Dec. 1, 2010 - Nov. 30, 2015 (~USD 40 million)
- First phase: two years
  - Site specification including stress measurements (1 km deep)
  - Micro-seismicity monitoring network
  - Drilling the first well to 3 km depth (5 km deep well design)
  - Min. 100 °C at 3 km, stress measurement and borehole survey
- Second phase: three years
  - Extending 3 km deep well to 5 km depth to make it injection well
  - Hydraulic stimulation and monitoring
  - Drilling 5 km deep production well
  - Hydraulic stimulation, circulation test and reservoir evaluation
  - Surface installation: Kalina cycle?
  - Test operation of the binary plant and planning further development

# Participant in Annex XI



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## ➤ Education

- 1995. 08. ~ 2000. 05. Ph.D. Applied Geophysics, University of California at Berkeley
- 1991. 03. ~ 1993. 02. M.S. Exploration Geophysics, Seoul National University
- 1987. 03. ~ 1991. 02. B.A. Mineral and Petroleum Engineering, Seoul National University

## ➤ PROFESSIONAL EXPERIENCE

- 2005 ~ Present *Associate Professor*, Department of Natural Resources and Geo-environmental Engineering, Hanyang University, Seoul, Korea
- 2002 ~ 2004 *Postdoctoral fellow*, Massachusetts Institute of Technology, Cambridge, MA, USA
- 2001 ~ 2002 *Scientist*, SensorWise, Inc. (Research & Development company of acoustic logging), Houston, TX, USA
- 2000 ~ 2001 *Research Assistant Professor*, Department of Geoscience, University of Houston, Houston, TX, USA

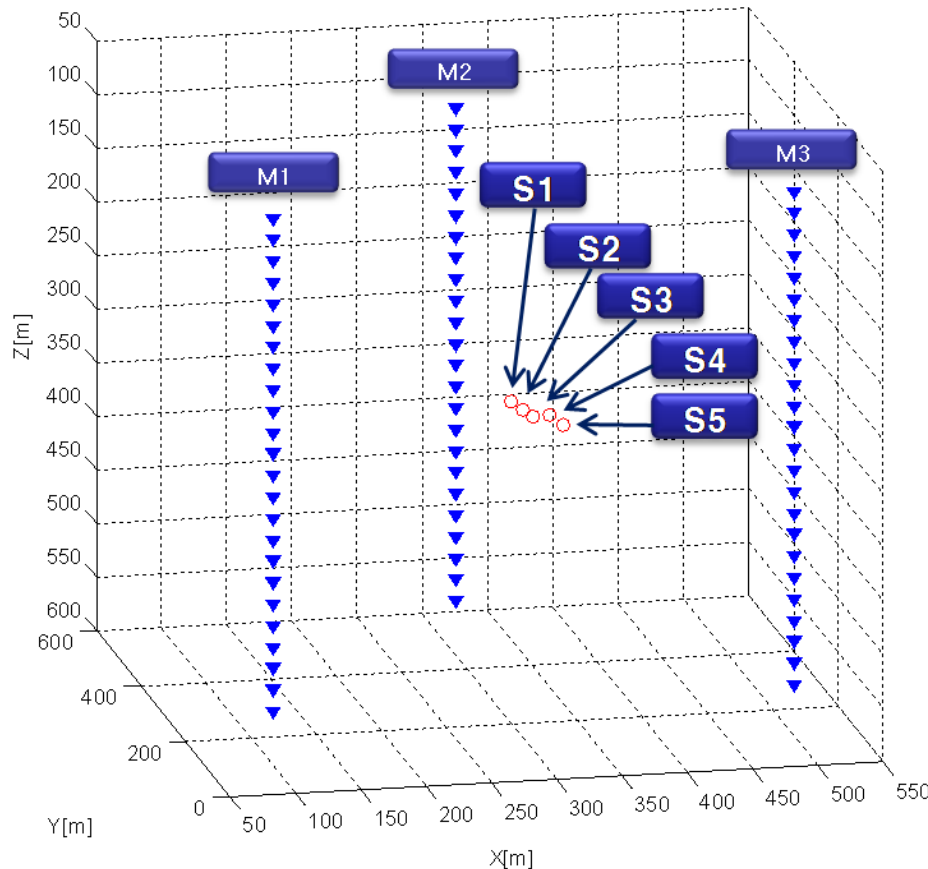
## ➤ PROFESSIONAL ORGANIZATION ACTIVITIES

- 2011 ~ Present *Country representative*, Society of Exploration Geophysicists (SEG), U.S.A.
- 2009 ~ Present *Associate editor*, 'Exploration Geophysics', ASEG, Australia
- 2008 ~ Present *Faculty advisor*, Committee on University and Student Programs of SEG, U.S.A.
- 2007 ~ Present *Executive committee member*, Korean society of earth and exploration geophysicists

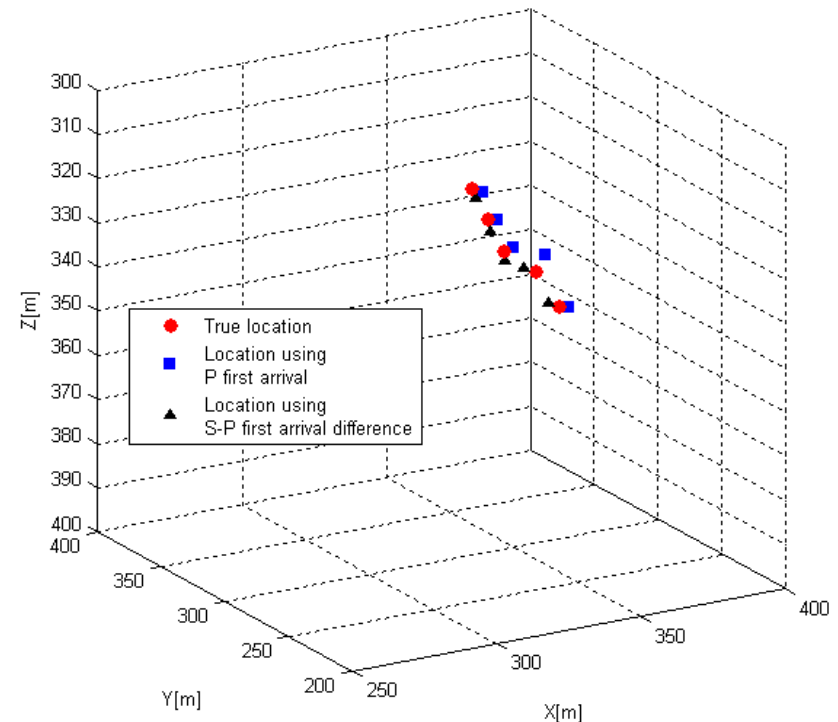
# Related Project

## Characterization of Unconventional Reservoir and Development of monitoring technique using borehole survey

- ✓ Estimates microseismic locations by using P and S-P wave traveltime



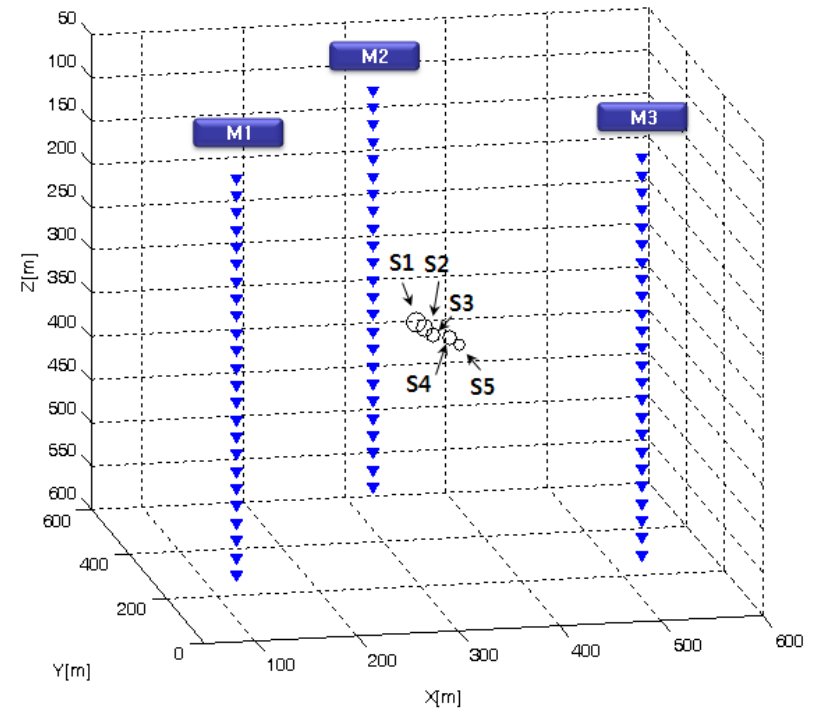
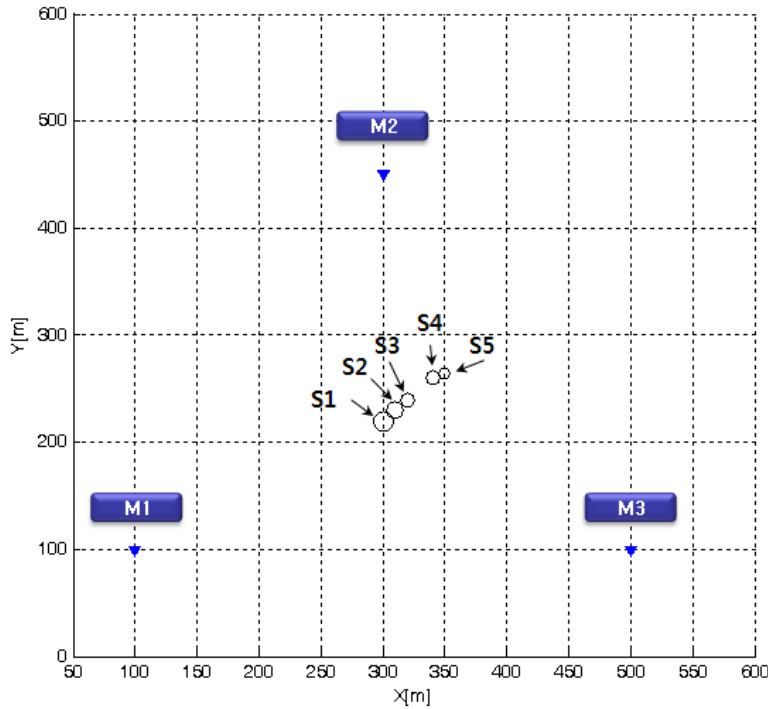
Locations of 5 microseismic events



Microseismic locations estimated by the developed module. The red circles indicate true locations of microseismic events. The blue rectangles and black triangles represent the locations estimated by using P first arrival only and by using the difference between P and S first arrivals.

# Related Project

- ✓ Estimates moment magnitude from source parameters

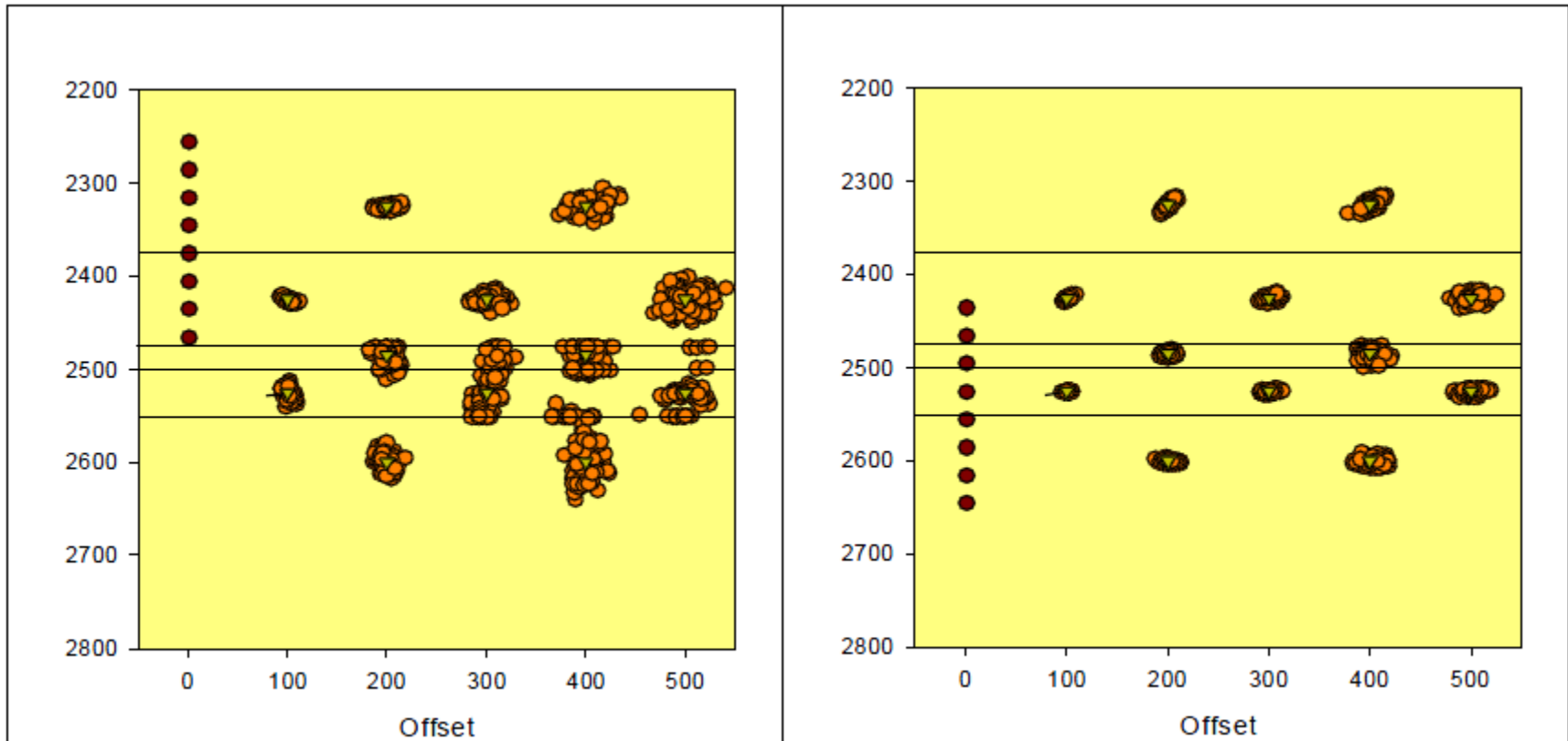


Mapping of microseismic events considering the moment magnitude. The size of symbol corresponds to the moment magnitude.

# Future research plan

## Optimization of microseismic monitoring system

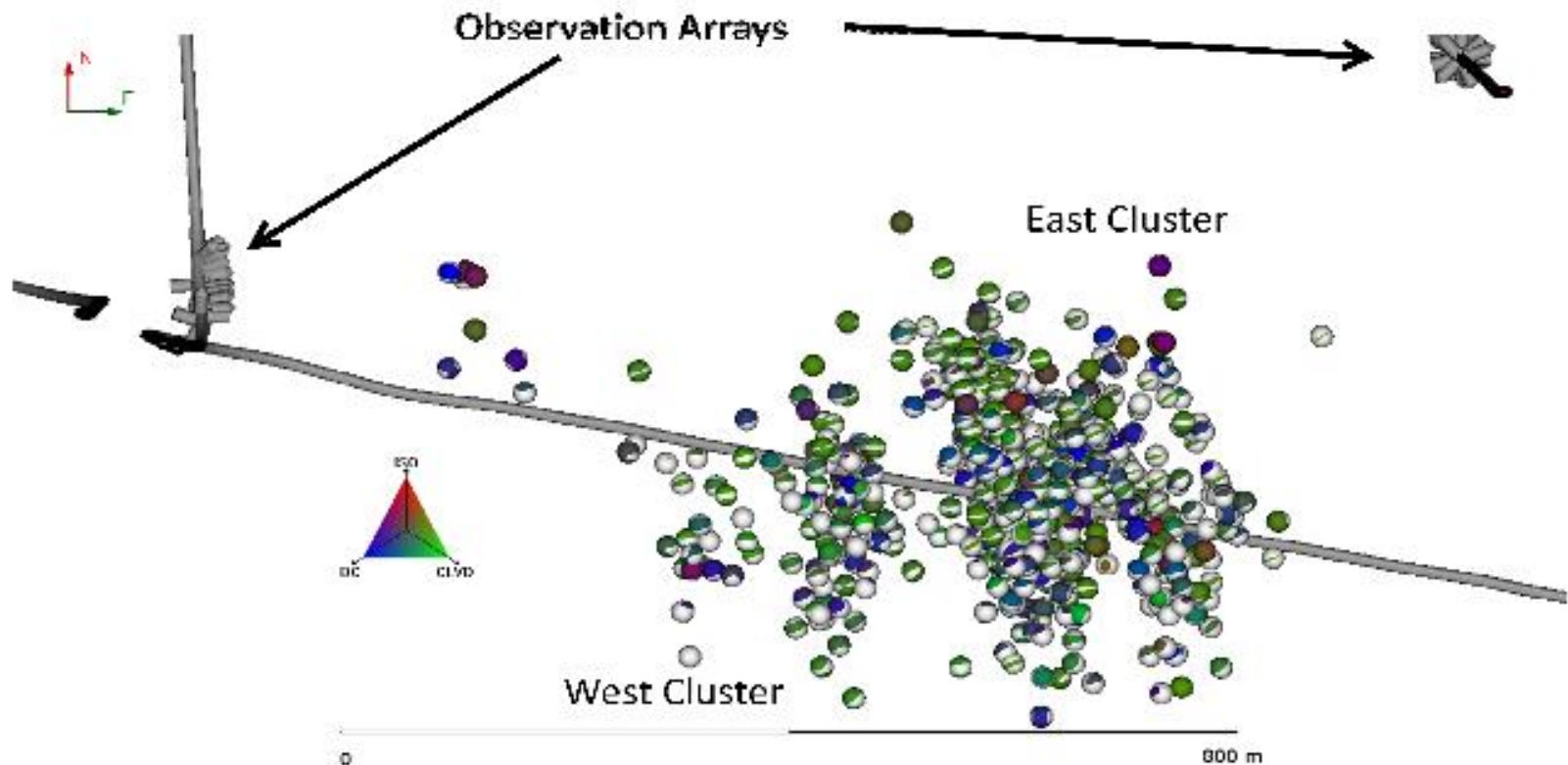
- ✓ Optimize array geometry (Maxwell et al., 2010)



100 realizations of a Monte Carlo simulation, perturbing velocities in each layer for a relatively shallow array (left) and deeper array (right).

# Future research plan

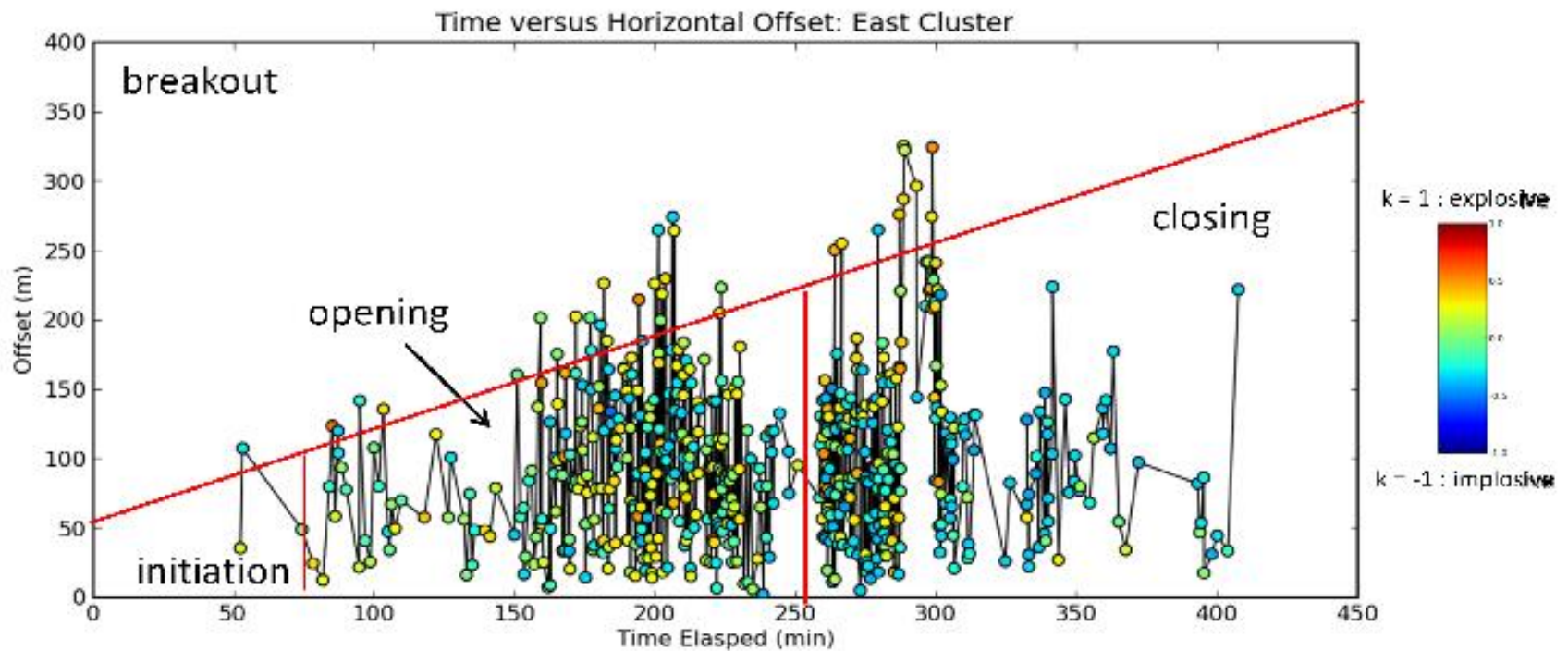
## Source mechanism analysis (Baig et al., 2010)



Plan view of the event distributions and moment tensors for 701 events recorded during the fracture stimulation. The moment tensors are represented by the radiation patterns colored according to the relative proportion of failure components as indicated by the triangle to the left.

# Future research plan

## Source mechanism analysis (Baig et al., 2010)



A breakout plot of time versus distance from the treatment well for the events in the East cluster. The farthest out (breakout) events propagate further away from the treatment. From the colorscale of these events, they feature mostly opening components in the early part of the treatment close to the well transitioning to closures later.