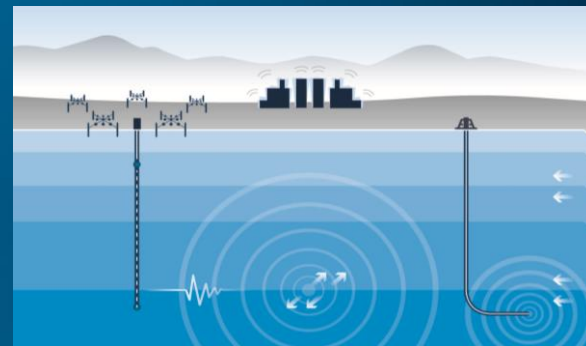


# Induced seismicity monitoring to enhance geothermal reservoirs

Volker Oye, NORSAR

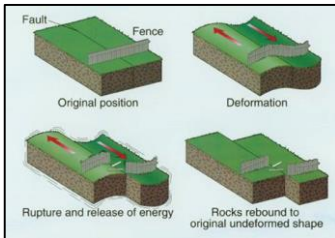
Inga Berre, UiB & CMR

Eirik Keilegavlen, UiB

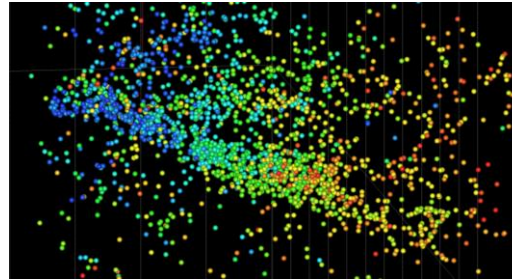


# What is microseismicity? When does it happen?

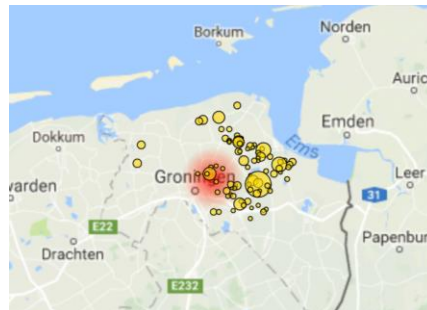
Tectonic earthquake, M7



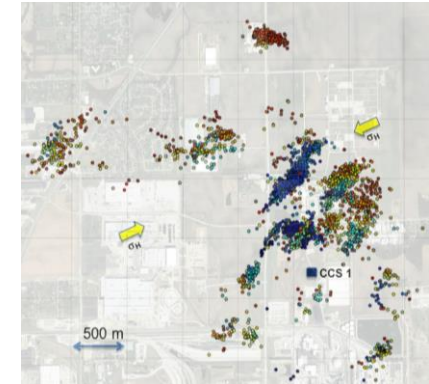
Hydraulic fracturing



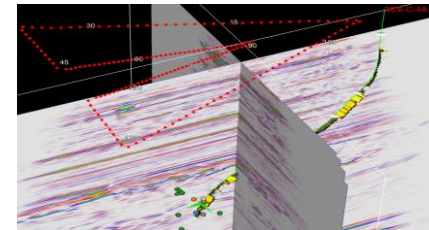
Gas production in the Netherlands



CO<sub>2</sub> storage, Illinois Decatur



North Sea waste water injection



# What do magnitudes mean ???

magnitude

$M \sim 2$



100 m

$\sim 4 \text{ mm}$

$M \sim 4$



1 km

$\sim 4 \text{ cm}$

$M \sim 6$



10 km

$\sim 40 \text{ cm}$

$M \sim 8$



100 km

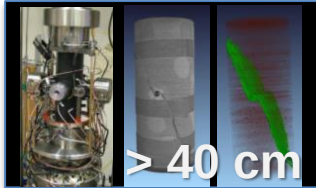
$\sim 4 \text{ m}$

**Avoid !**

size of fault  
slip on fault

magnitude

$M < -3$



$> 40 \text{ cm}$

$> 10 \mu\text{m}$

size of fault  
slip on fault

$M \sim -2$



1 m

$\sim 40 \mu\text{m}$

$M \sim 0$



10 m

$\sim 0.4 \text{ mm}$

$M \sim 1$



40 m

$\sim 1 \text{ mm}$

**Benefit!**



# ERiS – RCN EnergiX project



## Research partners

- University of Bergen (UoB)
- NORSAR



## Industry partners (confirmed)

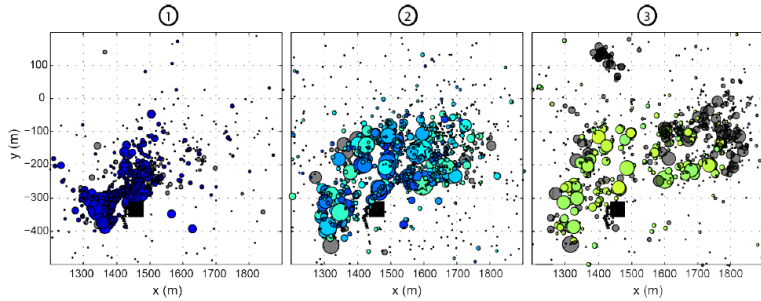
- Statoil



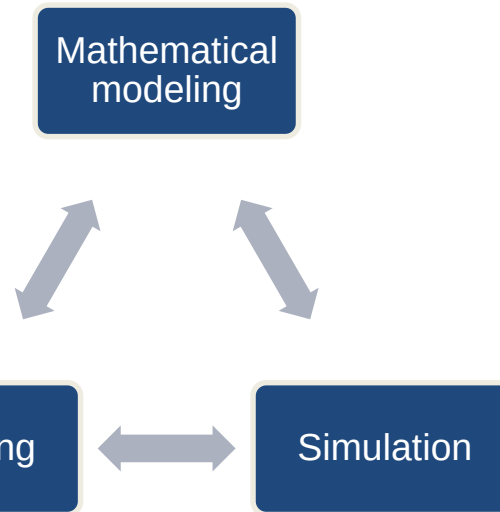
## Main international research collaboration

- Istituto Nazionale di Geofisica e Vulcanologia (INGV), Italy
- ISOR, Iceland
- Imperial College London, UK
- Stanford University, USA

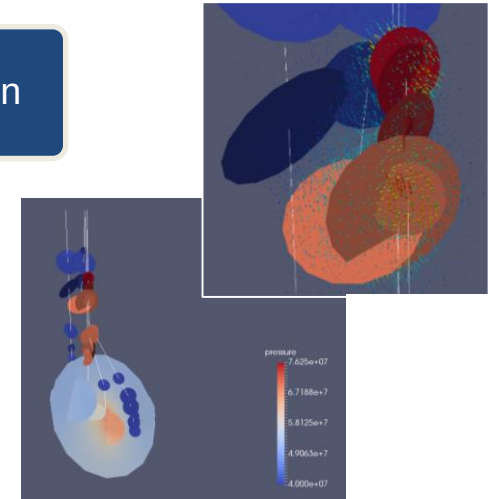




[Albaric, Oye et al., Geothermics, 2013]

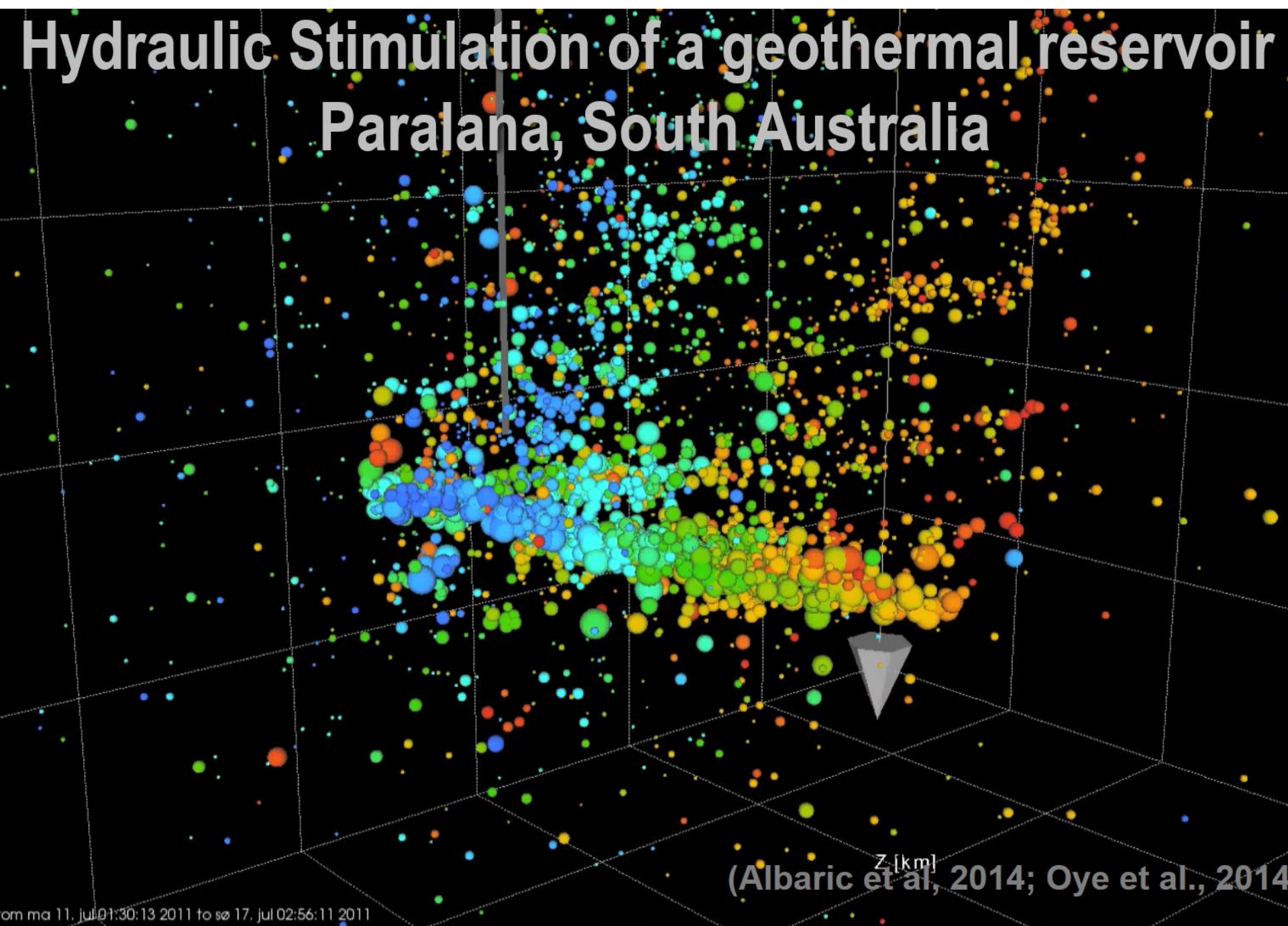


# ERiS approach



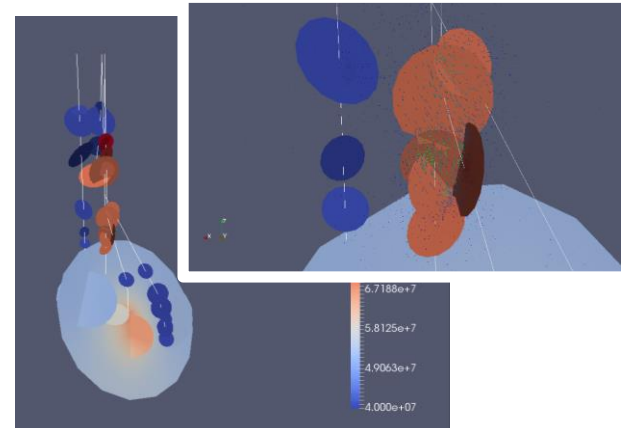
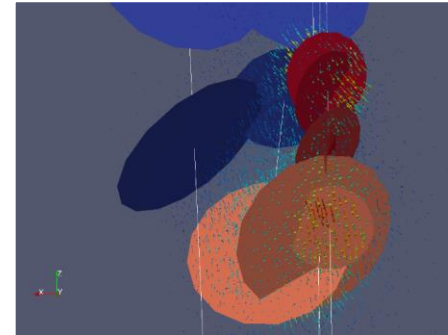
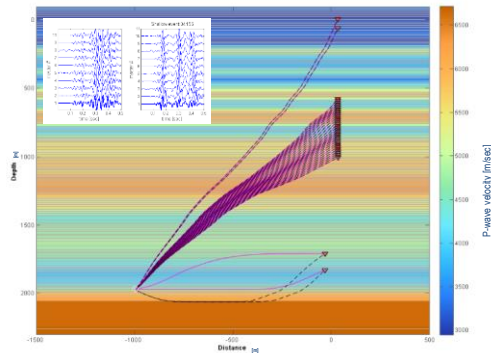
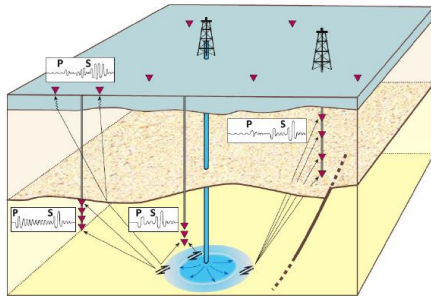


# Hydraulic Stimulation of a geothermal reservoir Paralana, South Australia



(Albaric et al., 2014; Oye et al., 2014)

**Integration of modelling of stress evolution and fluid flow** with fracture network detection methods for case studies, repeated combination of simulation and field data to improve the model framework, calibration of simulation model with respect to different datasets



**We aim at understanding the stress field changes when enhancing geothermal reservoirs**

# Thank you

Questions:

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