Microseismic Monitoring of CO$_2$
Injection at the Aneth Oil Field

Jim Rutledge
Los Alamos National Laboratory

Nobukazu Soma,
National Institute of Advanced Industrial Science and Technology

Brian McPherson,
University of Utah - Energy and Geosciences Institute
Monitoring Induced Microseismicity

Seismicity should be expected during CO2 sequestration due to increased the pressure and volume accompanying injection.

It should be an important component of MVA

- Map pressure fronts
- Infer preferred fracture flow direction and map containment of CO2 in target reservoir
- Sense of deformation and stress field
- Monitor and map fault activation and growth
- Mitigating felt seismicity
Outline

• Field setting and monitoring set up
• Data and data analysis
• Interpretation of the microseismicity
• Summary
Project CO₂ Monitoring Area

- Stratigraphic trap
- Discovered in 1956
- Waterflood initiated in 1961
- CO₂ initiated in 1985
- Current gross production rates
  - Aneth - 3,500 BOPD
  - McElmo Creek - 3,400 BOPD
  - Ratherford - 2,600 BOPD
Contour interval 20'

1 km

Cl = 6 m

- Producer
- Injector

Monitor well

SWD
Geophone cable deployment – October, 2007
Cumulative and Weekly Event Counts

Data Gaps
Microseismic Waveforms from Aneth
Microseismic Source Location

- Clustering and waveform correlation
  - extract precise arrival time picks
  - improve “image” resolution
- Velocity analysis
- Investigating use of reflected phases to help constrain source depth
Master Event Location Scheme

- Stack multiplets to build S/N
- Get best estimate of true 1st arrivals
- Locate event and compute travel time residual
- Apply the residuals as time corrections to the remaining events of the cluster
Search for best-fit Vp/Vs
Using Reflected Phases to Constrain Depth
CO₂ Injection and Seismicity

- CO₂ Injected
- Microseismicity
- H₂O + CO₂ Injected
- Microseismicity
- Net Volume Change
Salt Water Disposal and Seismicity

Salt Water Disposal

Microseismicity

Events per Week

SWD

Cumulative Volume (m$^3 \times 10^3$)

Cumulative Events

Number of Events per Week

Depth (m)

East (m)

Geophones
Desert Creek Reservoir

Los Alamos National Laboratory
EST. 1943
Shake Intensity – Bluff M3.6 Earthquake June 6, 2008
Summary

- Microseismic locations reveal NW-SE striking structures near the margins of the reservoir
  - The main structure resolved is beneath the reservoir
- Microseismic activity does not correlate with current injection activity in the reservoir
- Seismicity does not appear to correlate with deeper salt-water disposal.
- June 6 Bluff M3.6 earthquake may have affected production and reservoir seismicity
  - Stress transfer driving pore pressure increase?
Needs in Understanding Induced Seismicity

Cheap, reliable placement of downhole receivers and sensors.

- improve coverage for better source location and mechanisms
- improve imaging coverage and resolution
- lower detection thresholds
- identify changes earlier