Microseismic processing for induced seismicity management at carbon storage sites

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Project Number: FWP-FEW0174 Task 1B

Lawrence Livermore National Laboratory

Carbon Storage R&D Review Meeting, Pittsburgh, August 12-14, 2014

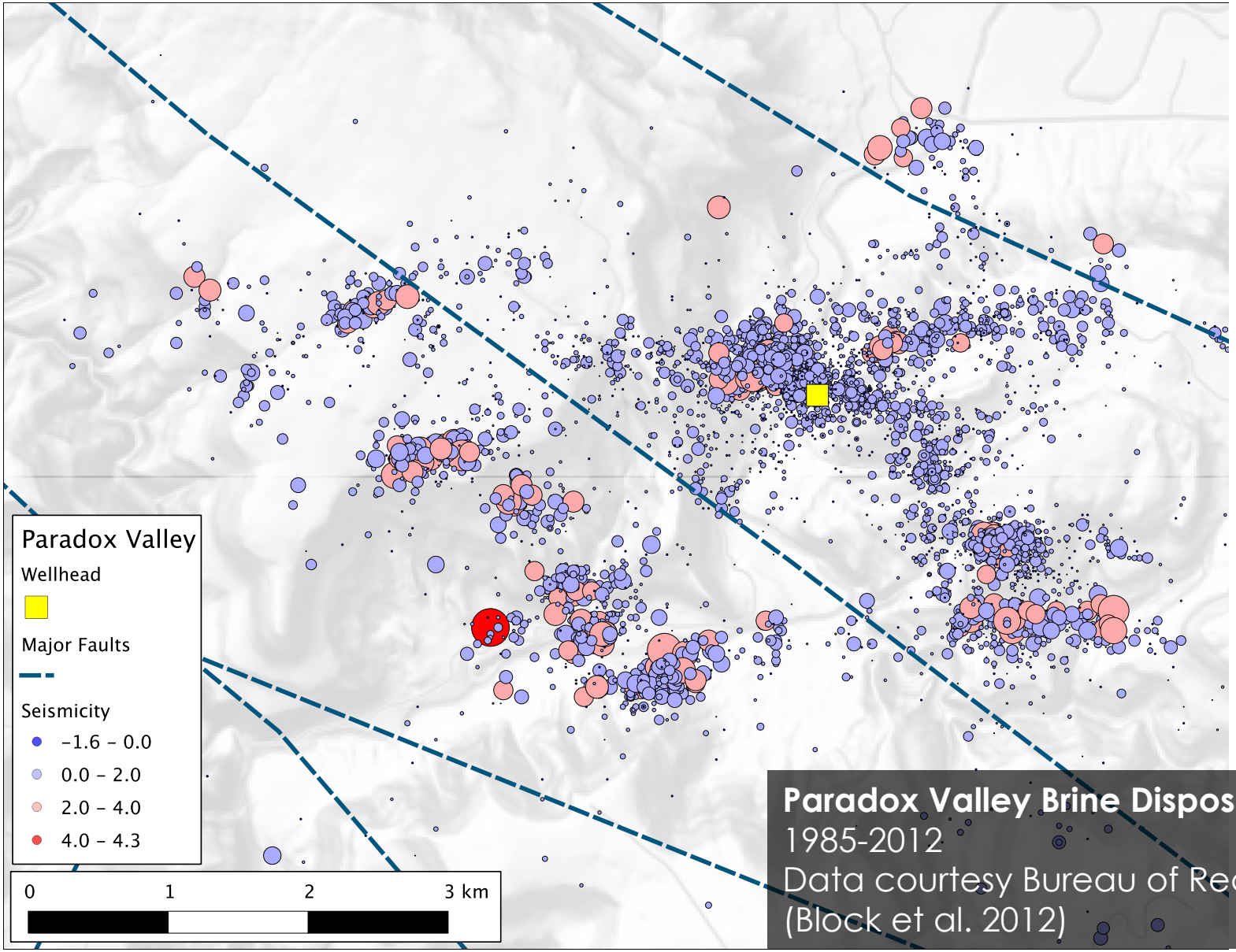
Program Goal No. 4

- Develop Best Practice Manuals for monitoring, verification, accounting, and assessment; site screening, selection and initial characterization; public outreach; well management activities; and risk analysis and simulation.

Benefit Statement

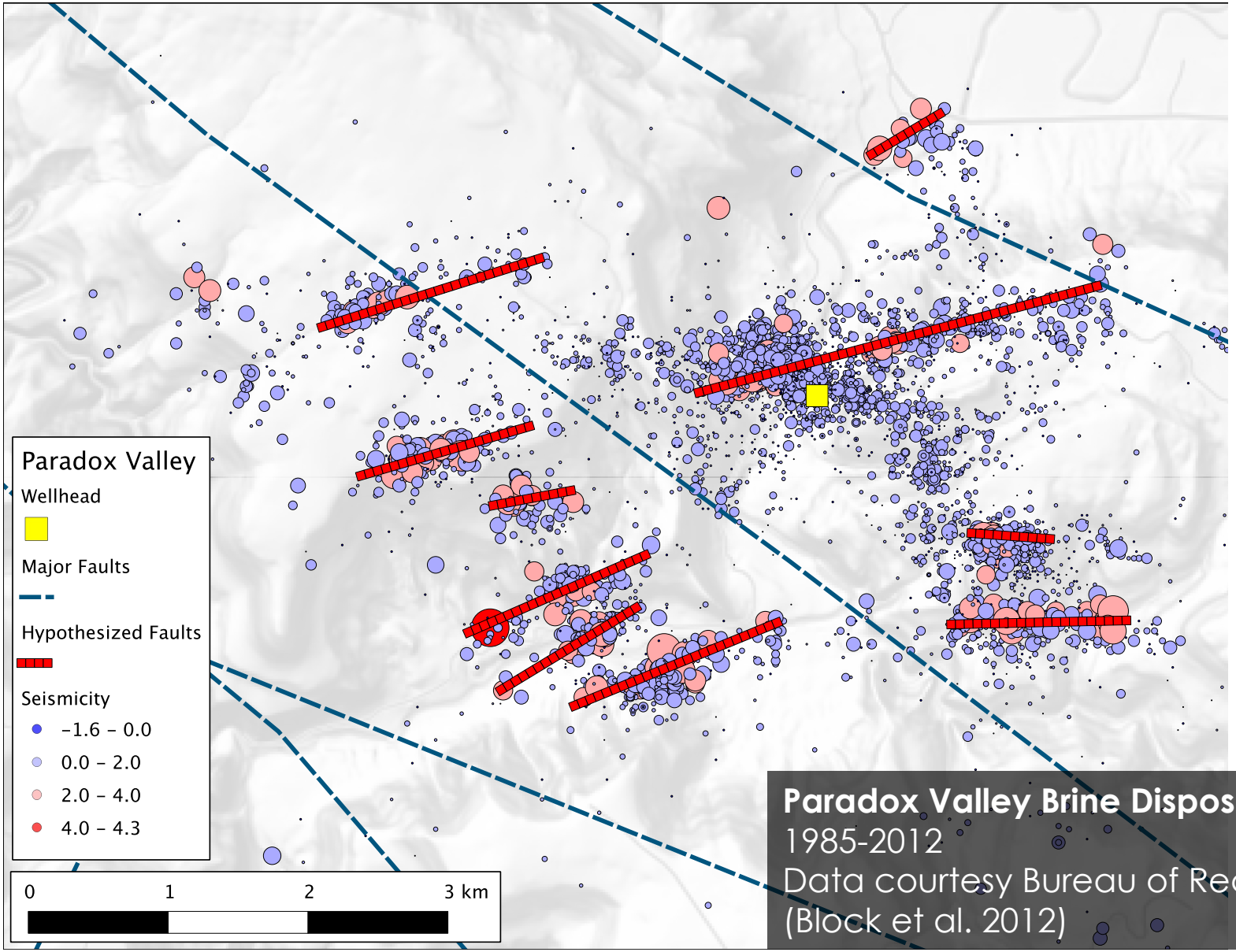
- The induced seismicity hazard is a key concern for many carbon storage projects.
- The goal of this project is to use microseismic data to better identify and characterize hazardous faults in the subsurface.
- If successful, this toolset can help operators rapidly respond to changing subsurface conditions. Timely response is a key component of effective risk management.

Faster detection of previously unobserved faults can help lower seismic risk



Paradox Valley Brine Disposal Project
1985-2012
Data courtesy Bureau of Reclamation
(Block et al. 2012)

Faster detection of previously unobserved faults can help lower seismic risk



Paradox Valley Brine Disposal Project
1985-2012
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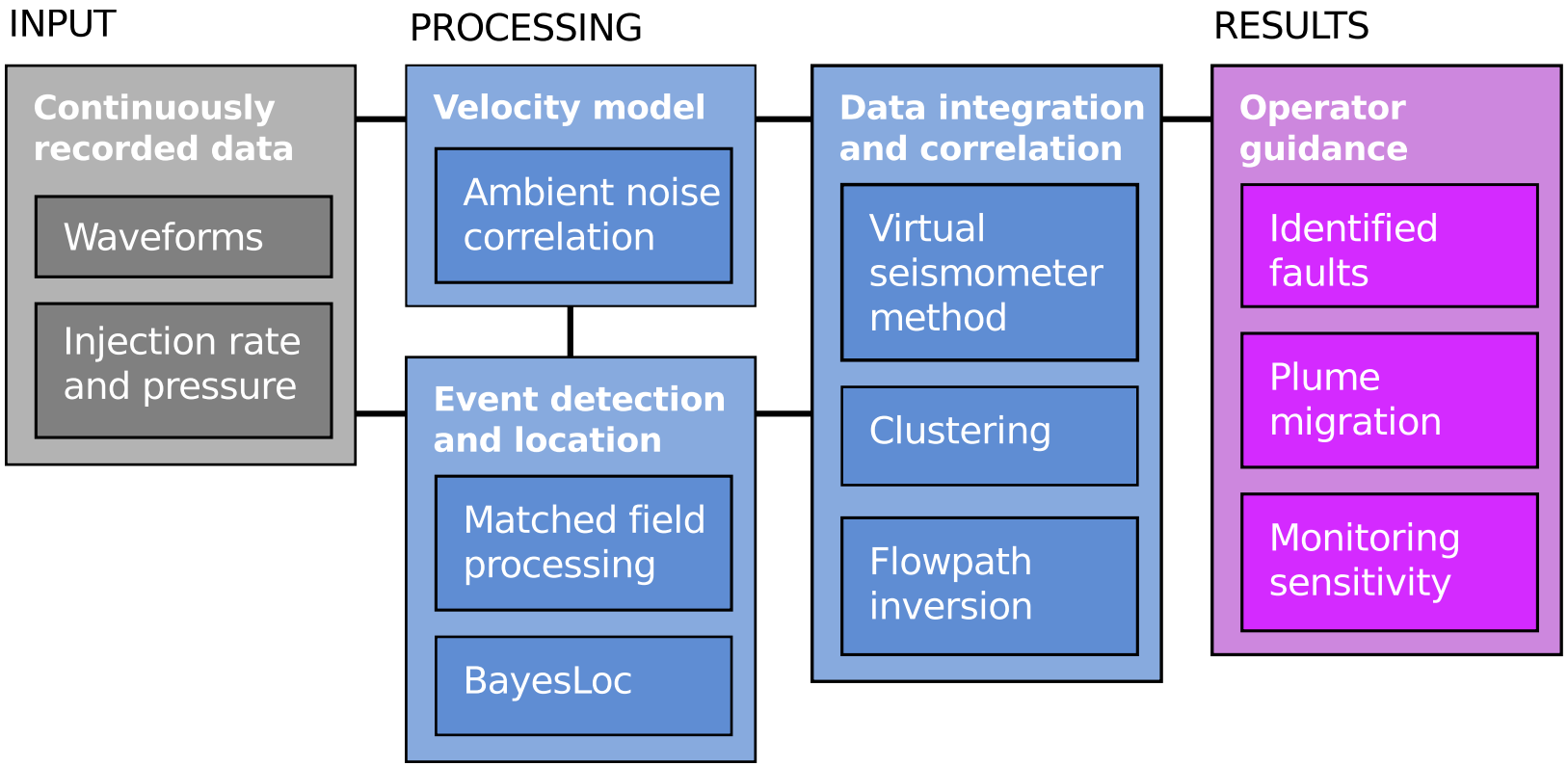
Microseismic processing toolkit



Key goal is to automate as much of this process as possible, to minimize the lag time between data aquisition and decision-making

Task Status

① Data-set acquisition and preprocessing	**Complete**
② CCS-analog site studies	**In Progress**
③ Weyburn-Midale CO_2-EOR study	**Start Oct. 1, 2014**
④ Active pressure management study	**In Progress**

Staff

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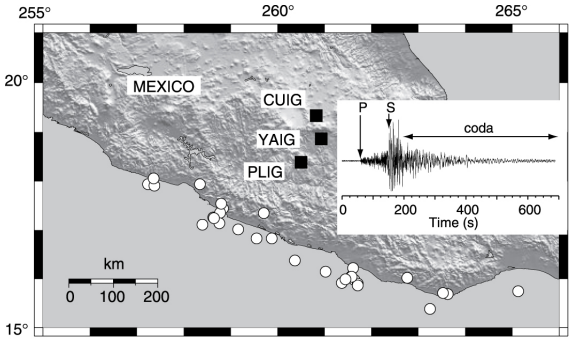
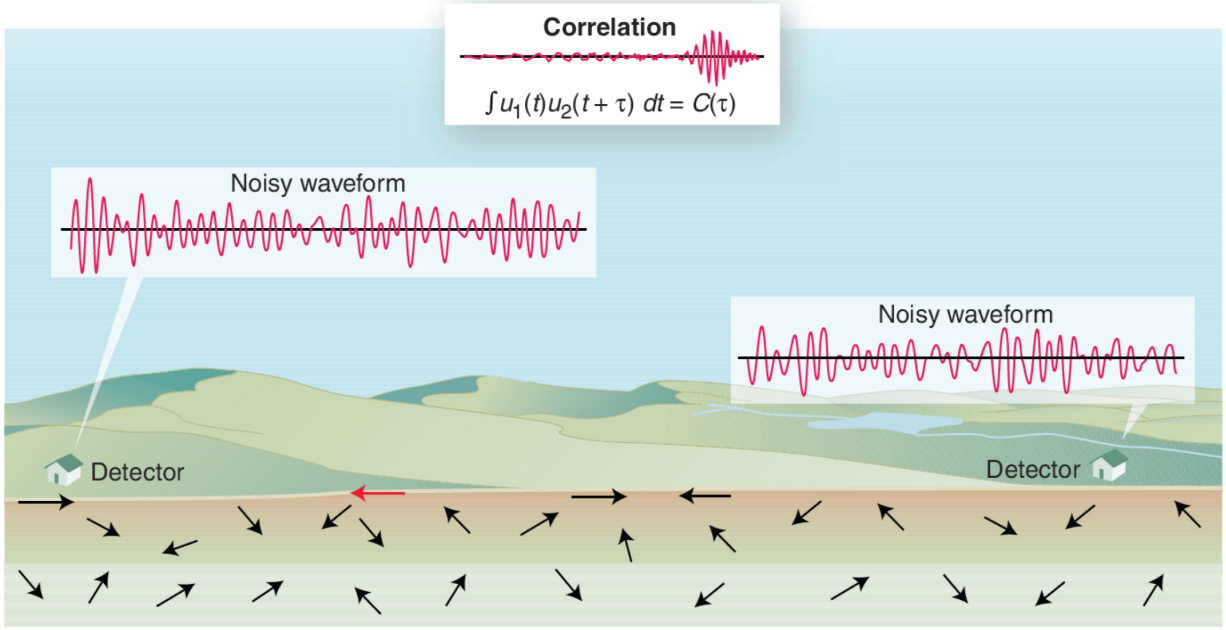
Ambient Noise Correlation

Previously discarded as noise;
The ambient seismic wavefield and the scattered energy that makes up the seismic coda have now proven to contain significant sensitivity to Earth structure.



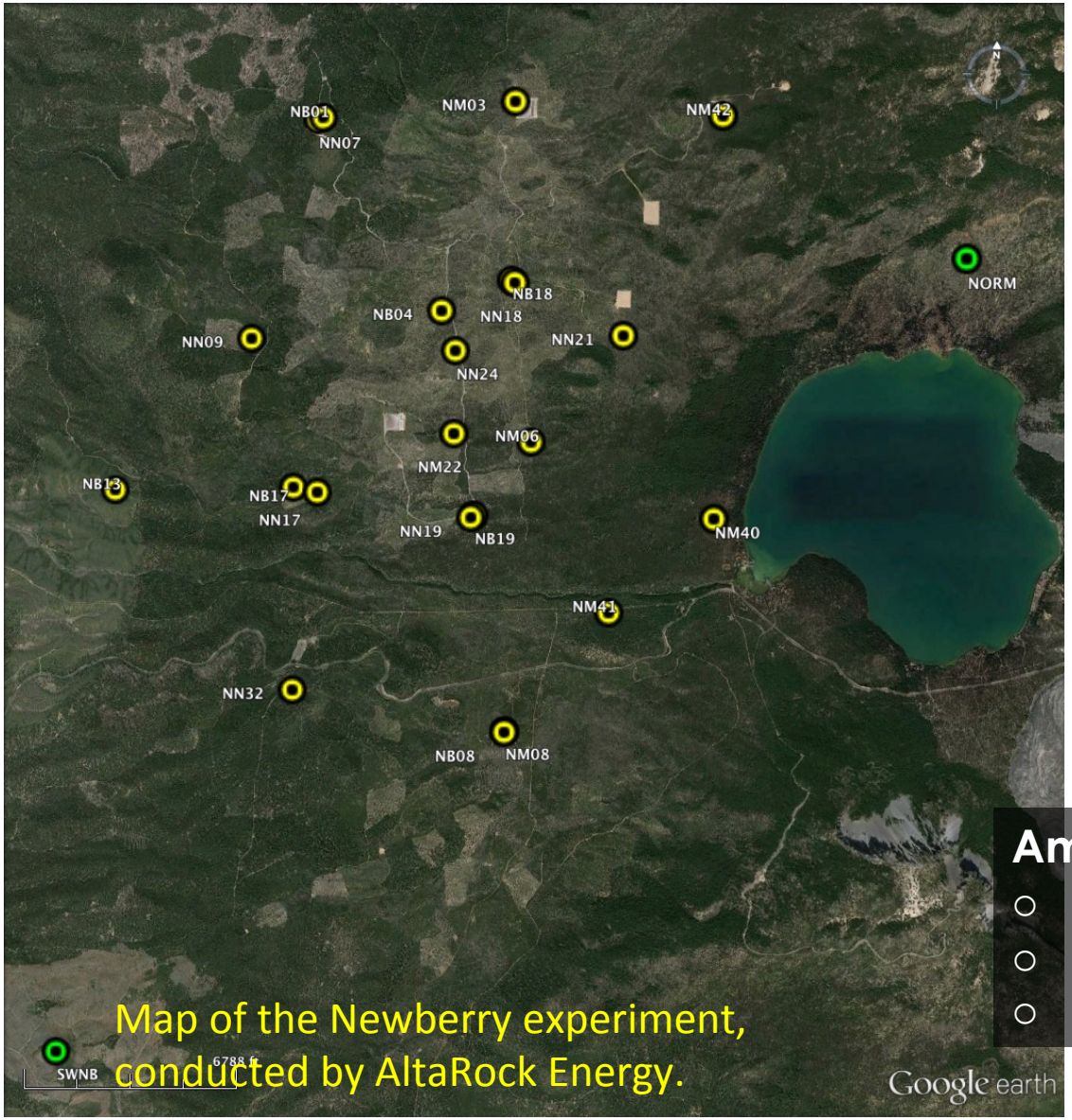
www.sciencemag.org SCIENCE VOL 299 24 JANUARY 2003
Michel Campillo* and Anne Paul



Using noise in seismology. When a diffuse wave field is generated by distant sources and/or by multiple scattering, detectors report random signals. Occasionally a ray (for example, the one shown in red) passes through both detectors. As a result, the signals are weakly correlated.

Richard L. Weaver 11 MARCH 2005 VOL 307 SCIENCE www.sciencemag.org

Creating a 3D model of the Newberry Geothermal Site

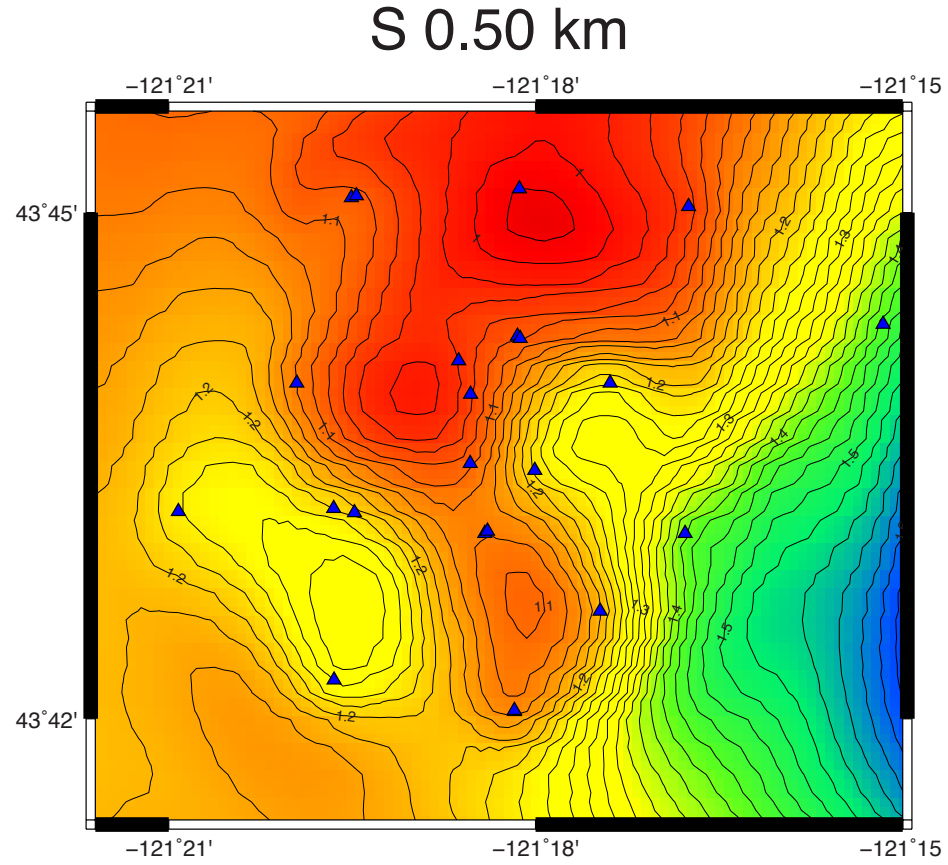


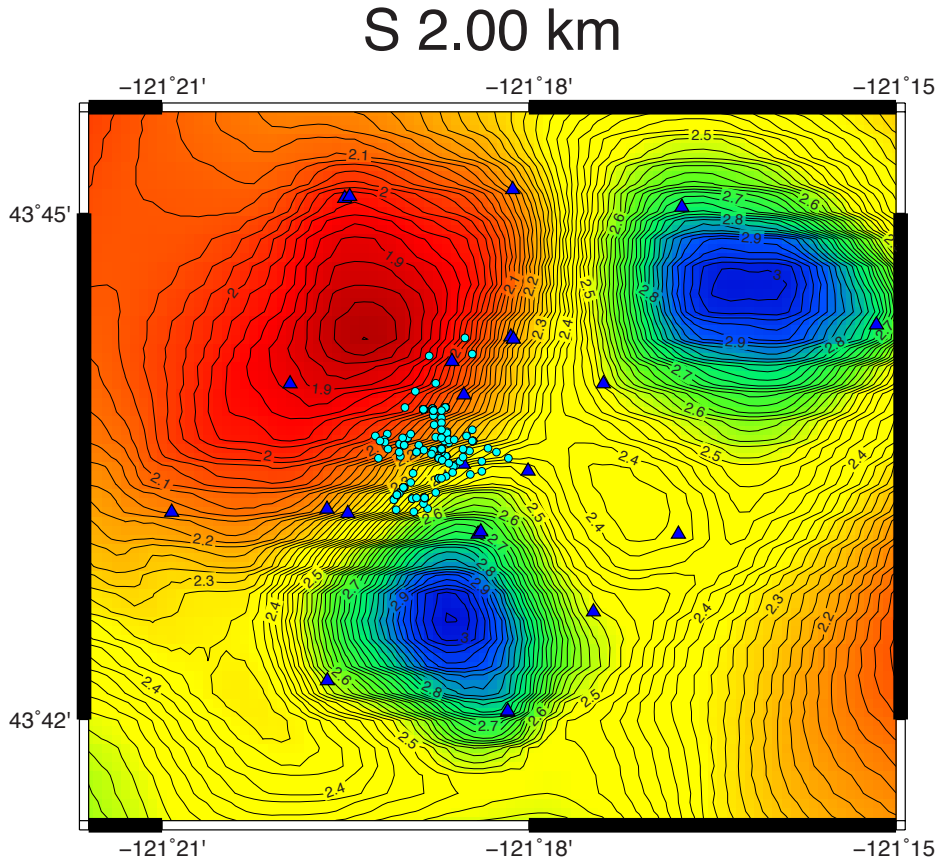
Map of the Newberry experiment, conducted by AltaRock Energy.

Ambient noise correlation

- 1 month of data
- Depth resolution ~ 5 km
- Vp, Vs, estimate of Qs

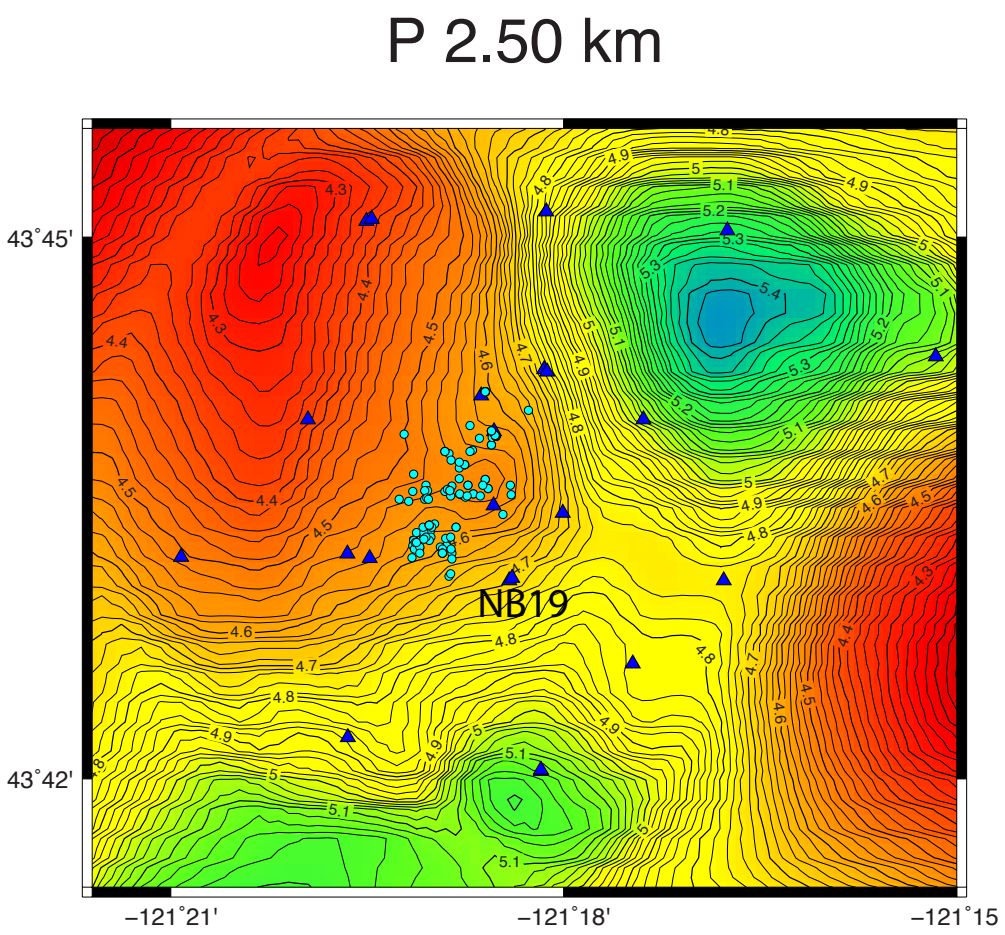
ANC identifies large variations in seismic velocity, both laterally and vertically

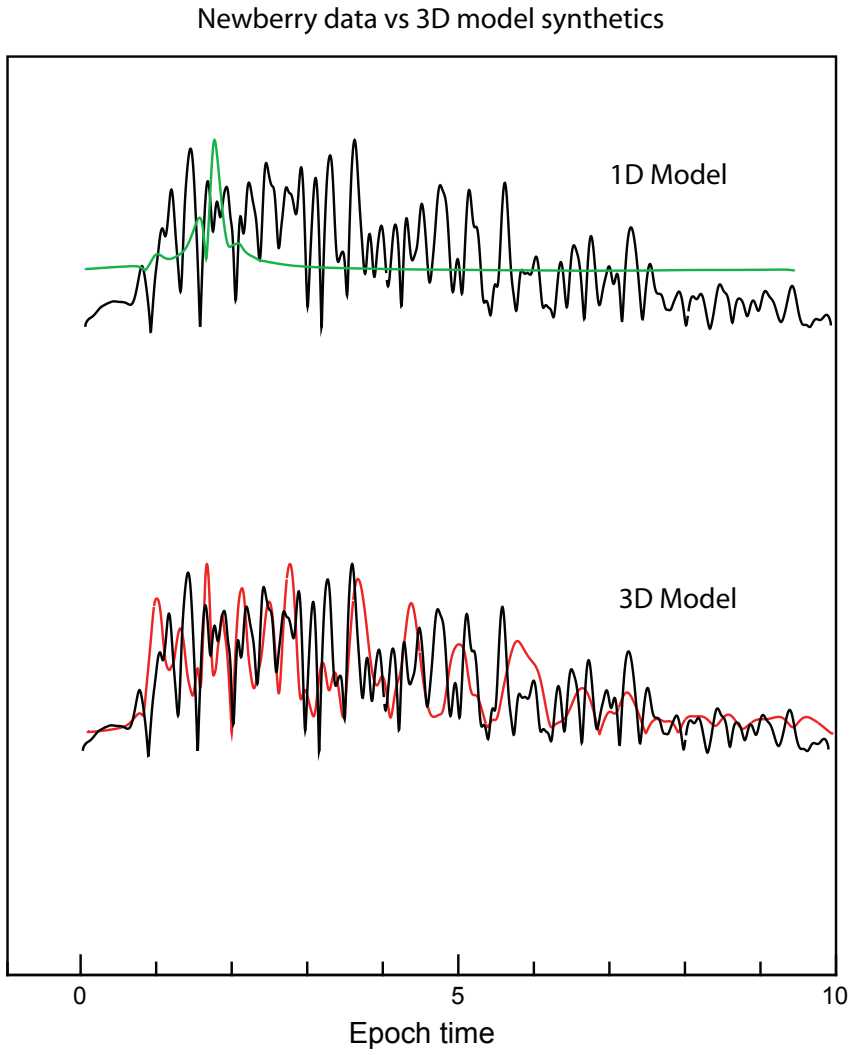




Shear velocity tomography at 0.50 km and 2.00 km below the surface of the Newberry site. (Note 50% variation in shear velocity laterally)

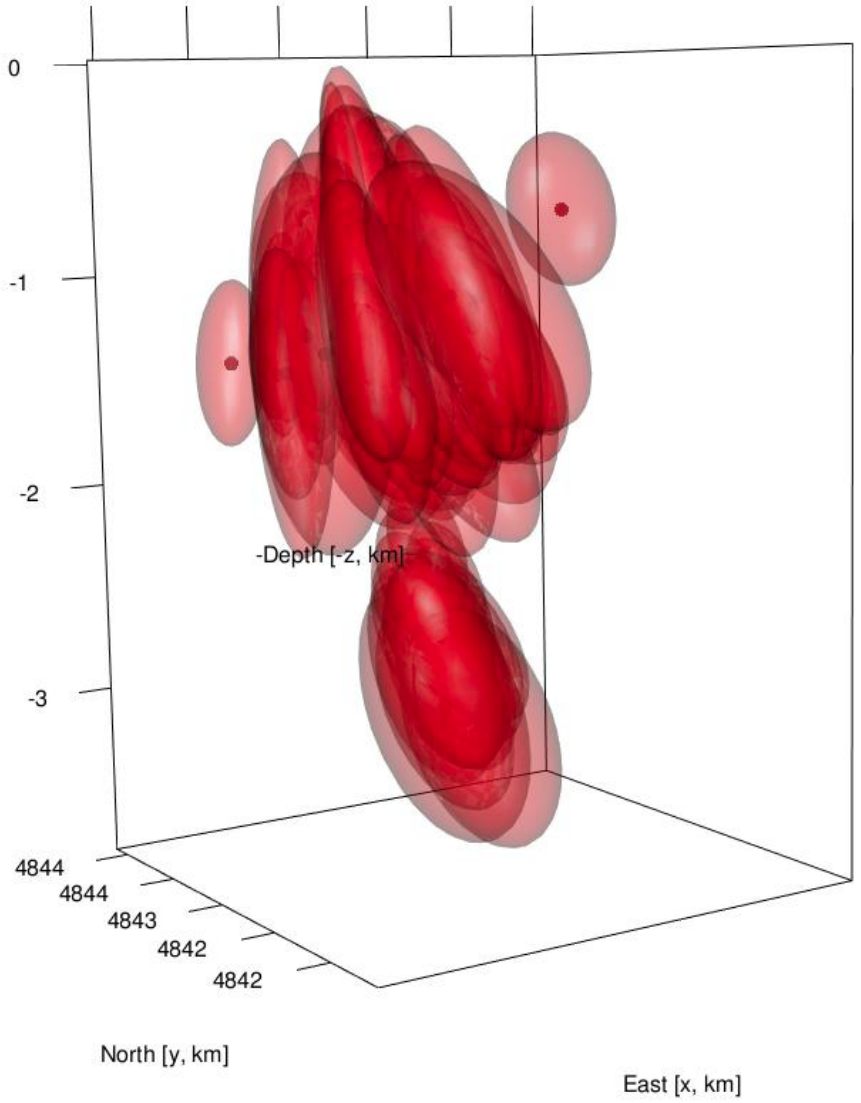
The 3D model allows us to identify the source of the scattered energy seen in the data. This information is typically discarded.





record of 12/01/2012 event at station NB19

Uncertainties in microseismic locations are very large.



Event locations with their 95% ellipsoids.

And the same is undoubtedly true of moment tensor estimates.

MicroBayesLoc locator used to characterize uncertainty associated with seismic location.

Summary

① Applying ANC to Newberry data, we are able to image detailed structures from the surface through the zone of microseismicity.

- This 3D image is accurate enough to predict the scattered energy seen in seismic records.
- Improved velocity model should benefit subsequent analyses.

② Matched Field Processing, MicroBayesLoc, and Virtual Seismometer method are also showing promising results.

③ Future work will focus on two data sets:

- Basel EGS
- Weyburn-Midale CO_2-EOR

Acknowledgements

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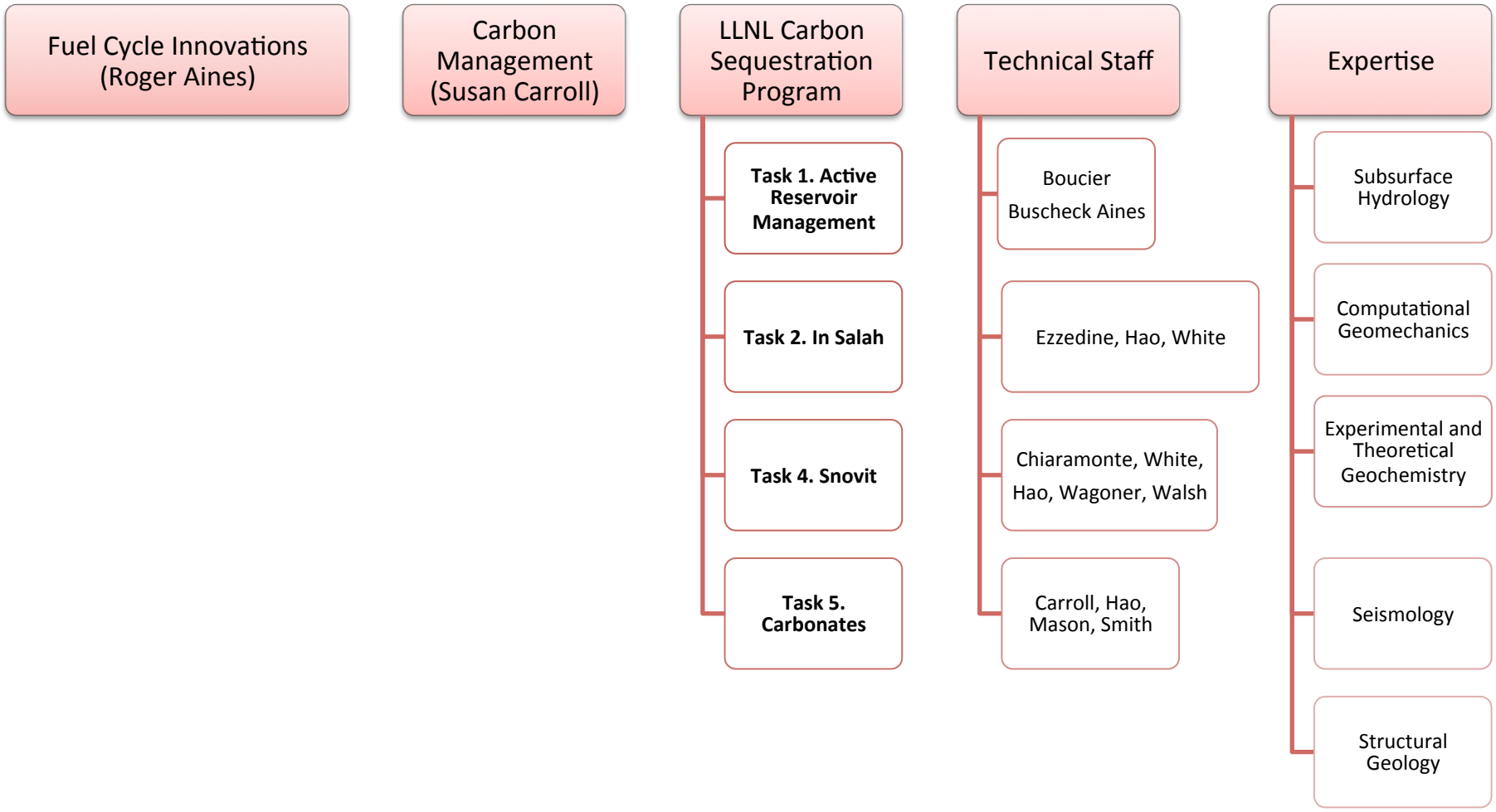
Appendix

Org Chart


Fuel Cycle Innovations (Roger Aines)
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Task 4. Snovit
Task 5. Carbonates
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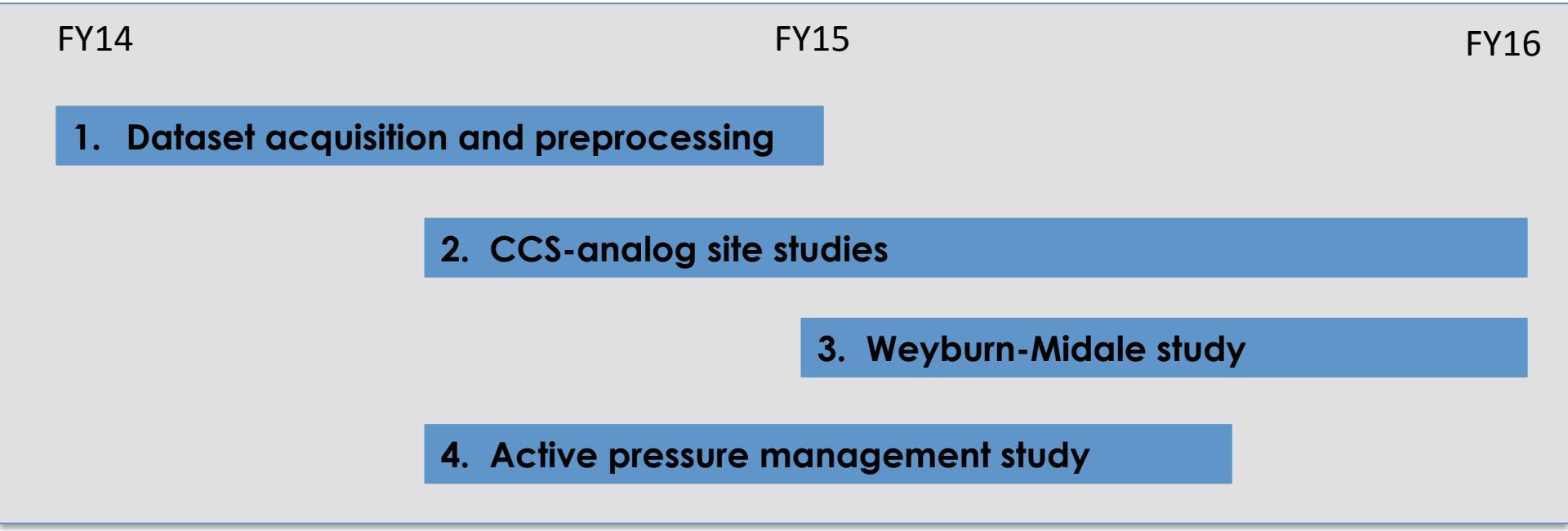
Structural Geology

Gantt Chart


FY14
FY15
FY16
1. Dataset acquisition and preprocessing
2. CCS-analog site studies
3. Weyburn-Midale study
4. Active pressure management study

Bibliography

① Matzel et al. (2014). Microseismic techniques for managing induced seismicity at carbon storage sites. *GHGT-12*, Austin, TX. In preparation.