Evaluating the effectiveness of induced seismicity mitigation: Numerical modeling of wastewater injection near Greeley, Colorado

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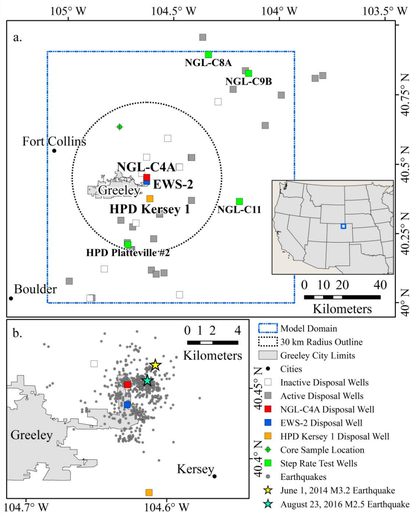
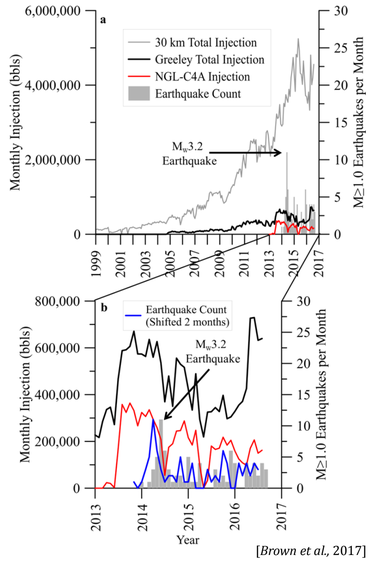
1. Introduction



[*Brown et al.,* 2017]

- June 2014, an M3.2 earthquake in Greeley, Weld County, CO.
- Small earthquakes have occurred from 2013-2017.
- 22 wastewater injection wells within a 30 km radius of the seismicity



[*Brown et al.,* 2017]

Greeley Well injection and seismicity are well correlated.

Injection and seismicity M > 1.0 history. Earthquake data between November 2013 and April 2015 are from *Yeck et al.* [2016].

2. Research Objectives

Quantify the influence of the well groups:

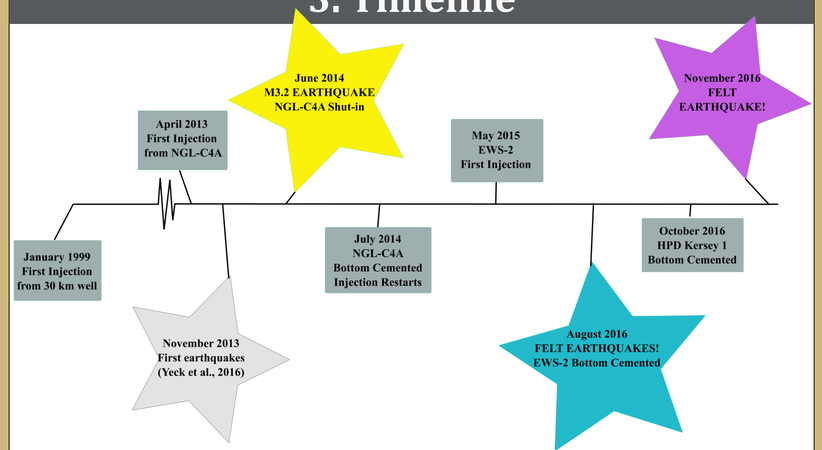
NGL-C4A (<1 km from seismicity)

Greeley Wells (0 – 15 km from seismicity)

Far-field Wells (15 – 30 km from seismicity)

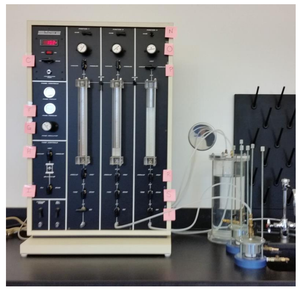
Evaluate effectiveness of mitigation

3. Timeline



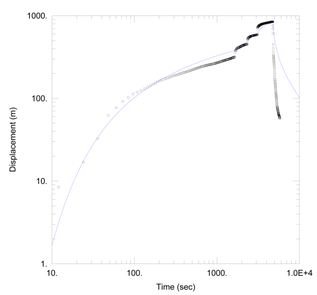
4. Hydrologic Parameters

Constant-Head Permeameter Tests



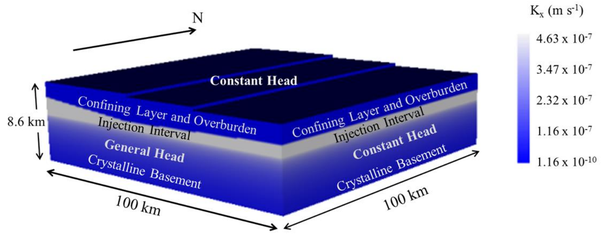
Hydraulic Conductivity: 10^{-10} to 10^{-6} m s^{-1}

Step Rate Test as Variable Rate Injection Test



Hydraulic Conductivity: 10^{-8} to 10^{-7} m s^{-1}

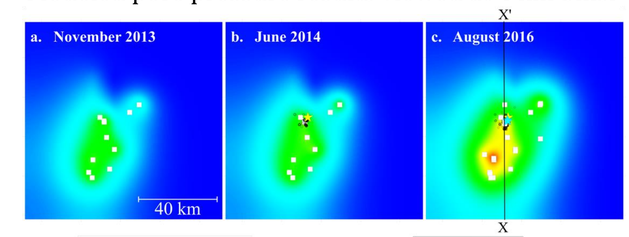
5. Groundwater Flow Model



MODFLOW-2005 Model Setup: Modeling pore pressure change caused by 22 wastewater disposal wells from January 1999 through August 2016. [*Brown et al.,* 2017]

6. Results

Modeled pore pressure results viewed at 4 km bmsl



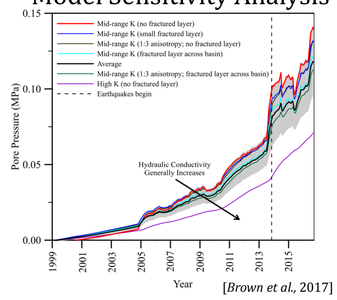
[*Brown et al.,* 2017]

Take Away:

Nov. 2013 = ~0.10 MPa change

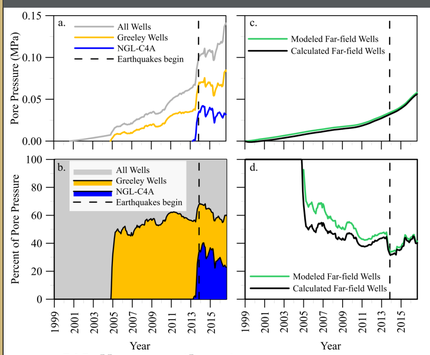
Aug. 2016 = ~0.15 MPa change

Model Sensitivity Analysis



[*Brown et al.,* 2017]

7. Conclusions



Well contributions to pore pressure change at a location in the area of seismicity, located at white dot in results figure d. [*Brown et al.*, 2017]

Percent contribution to modeled pore pressure increase:

- Greeley Wells = 56%
- Far-field Wells = 44%

Mitigation may be more effective with larger spacing between wells

8. References and Acknowledgements

Brown, M.R.M., S. Ge, A.F. Sheehan, and J.S. Nakai (2017), Evaluating the Effectiveness of Induced Seismicity Mitigation: Numerical Modeling of Wastewater Injection near Greeley, Colorado, *Journal of Geophysical Research Solid Earth,122,* DOI: 10.1002/2017JB014456

Yeck, W. L., A. F. Sheehan, H. M. Benz, M. Weingarten, and J. Nakai (2016), Rapid Response, Monitoring, and Mitigation of Induced Seismicity near Greeley, Colorado, *Seismological Research Letters*, *87*(4), 837–847, doi:10.1785/0220150275.

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