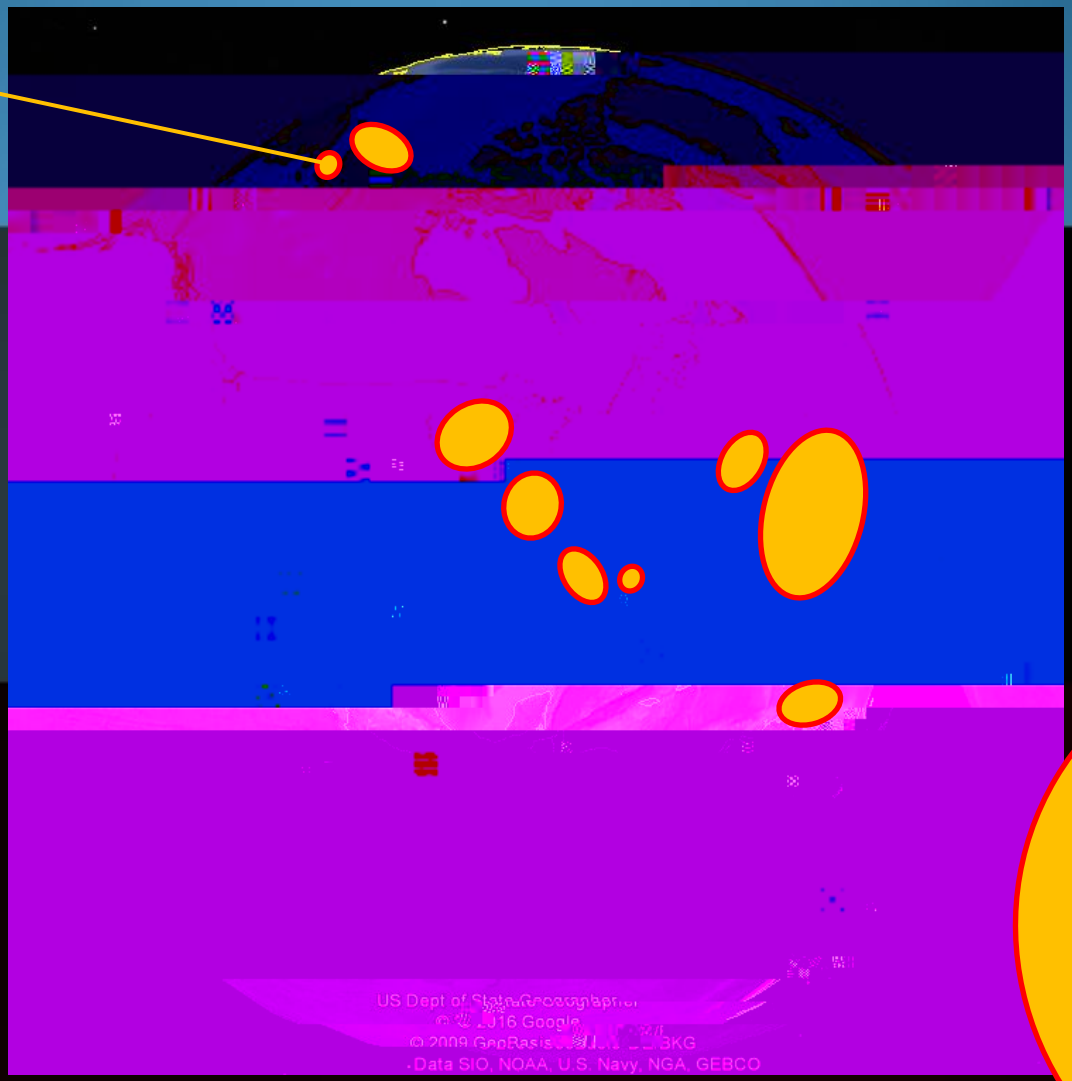
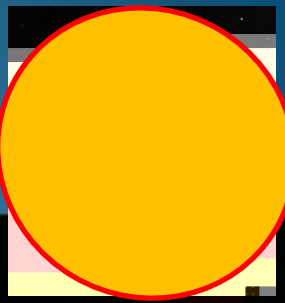
A Brief Update of Projects and Results from ^ D h [• ' } š Z Œ u o > š Z] •

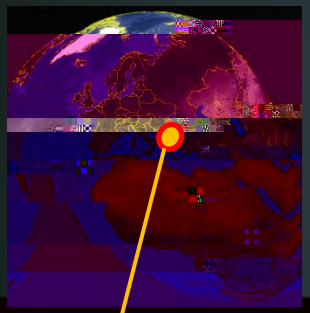
Matt Hornbach
Southern Methodist University

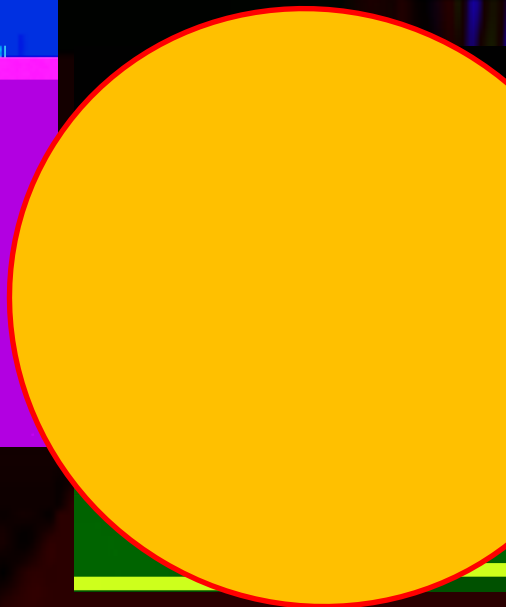
Major Sponsors of the SMU Geothermal Lab 2015-2016:

Lab Projects 2015-2016





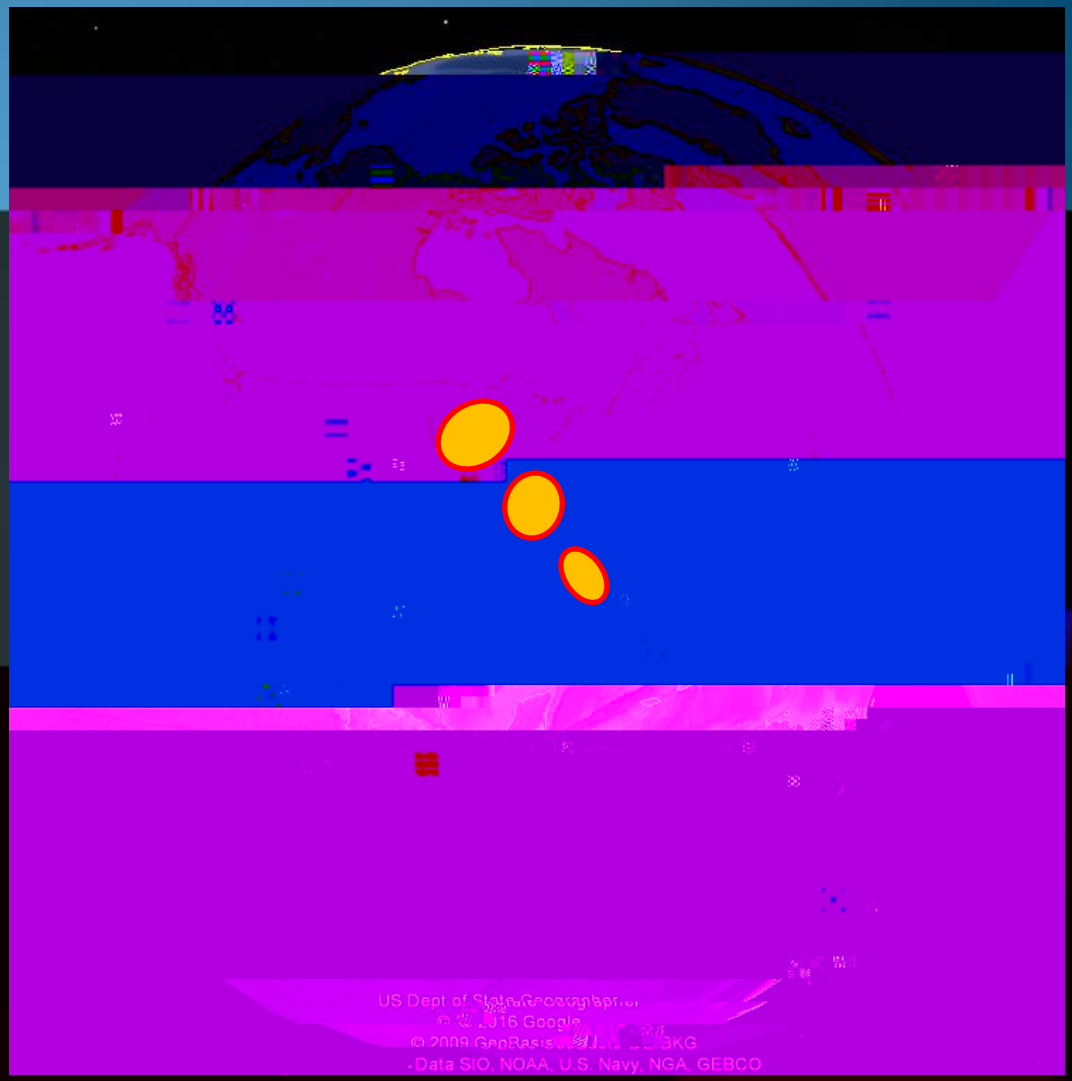




Initial Results from Three Projects

Focusing Today on Three Projects

(1) Heat-Flow/K Measurements and Modeling in the Denver Basin



The Basin-Scale HF Problem: Under-sampling ÆSpatial Aliasing

$$\nabla \cdot \left(\frac{k}{\mu} \nabla p \right) = \phi c_t \frac{\partial p}{\partial t}$$

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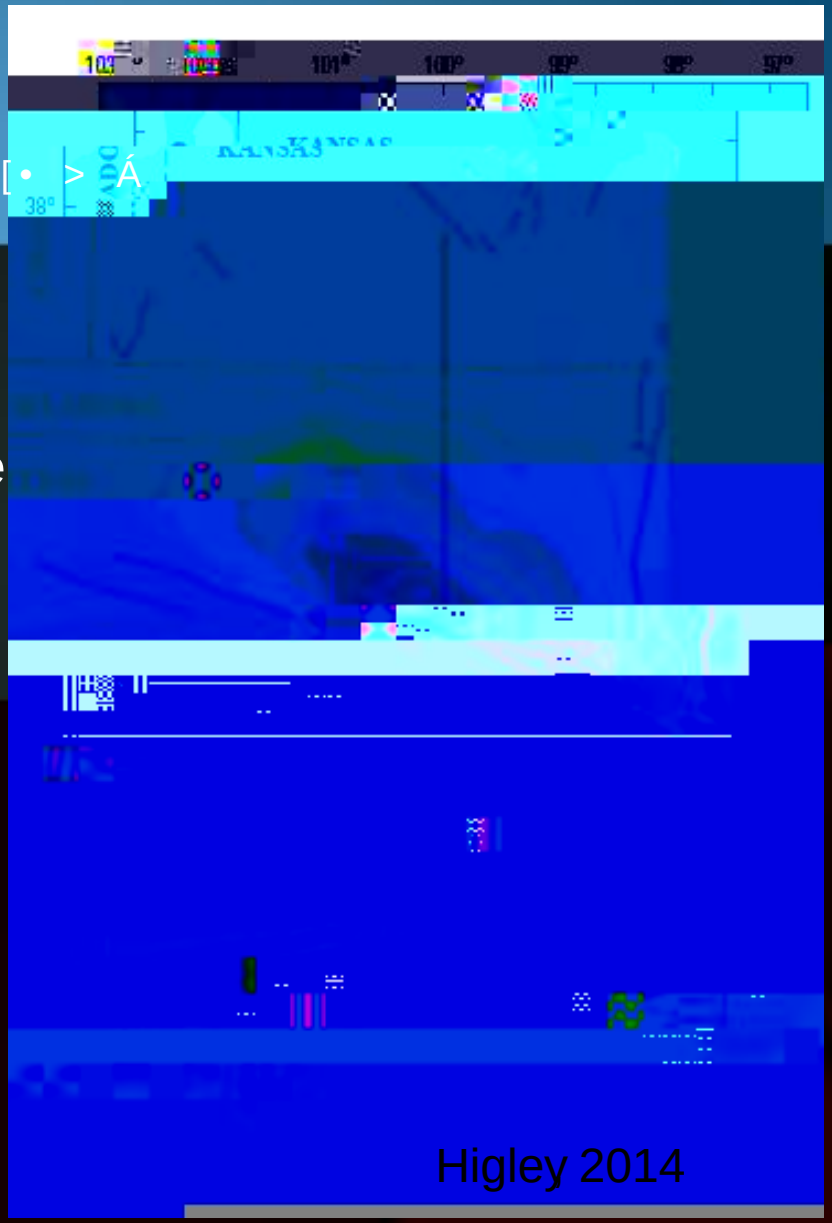
- Although thermal basin models report meter-scale resolution, most models use only a few thermal parameters interpolated across 10-1000kms.
- Some (such as VR) are empirical and observer dependent, resulting in widespread systemic error.
- Severe spatial aliasing is a limiting factor often both overlooked and misunderstood when interpreting thermal maturation models.



Constraining Denver Basin Heat Flow (Casey Brokaw)

Approach:

(1) Measure K in samples obtained from the USGS and Anadarko.

Constraining Denver Basin Heat Flow (Casey Brokaw)

RESULT 1# K values correlate with TOC and Maturity

Greater TOC Æ Lower K Greater Graphite Æ Higher K

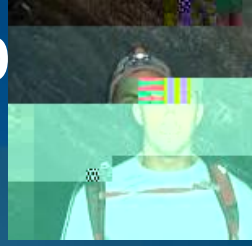
Why?

--Thermal conductivity of organic carbon, oil, and gas is 1-2 orders of magnitude lower than typical minerals found in sedimentary basins. Graphite K is 2 orders of magnitude higher than typical minerals.

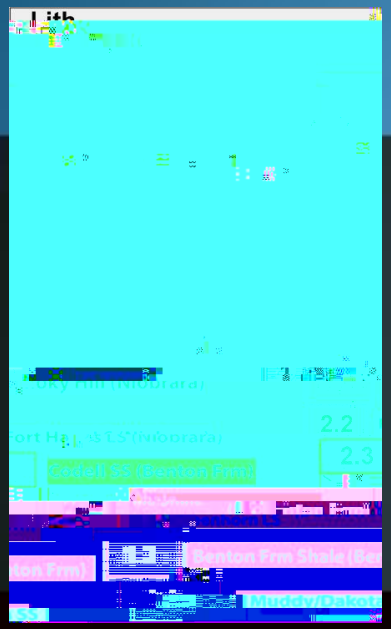
--A 2% change in gas/oil/TOC concentration results in a 12% change in conductivity for Quartz rich sediment.

Our partners can use this result to estimate missed O&G targets and for determining mature/over

Constraining Denver Basin Heat Flo (Casey Brokaw)



Result #2: New, More Precise HF and K Maps Suggest focused High Temperatures



--Results indicate >100 deg. C Temps in the NW. Corner of the Basin.

--High HF appears associated with the Colorado Mineral Belt and Salida Shear Zone.

--Model groundtruthing will occur this summer.

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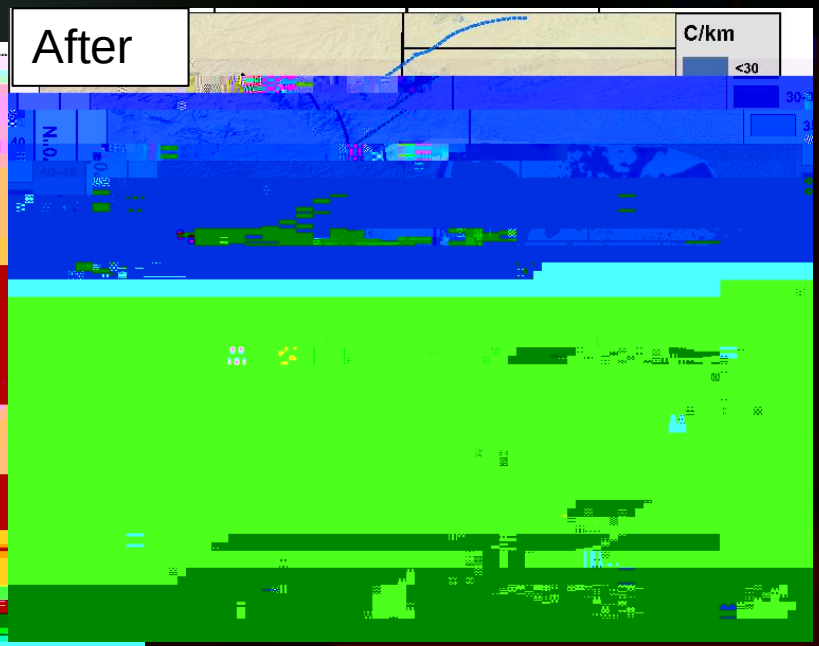
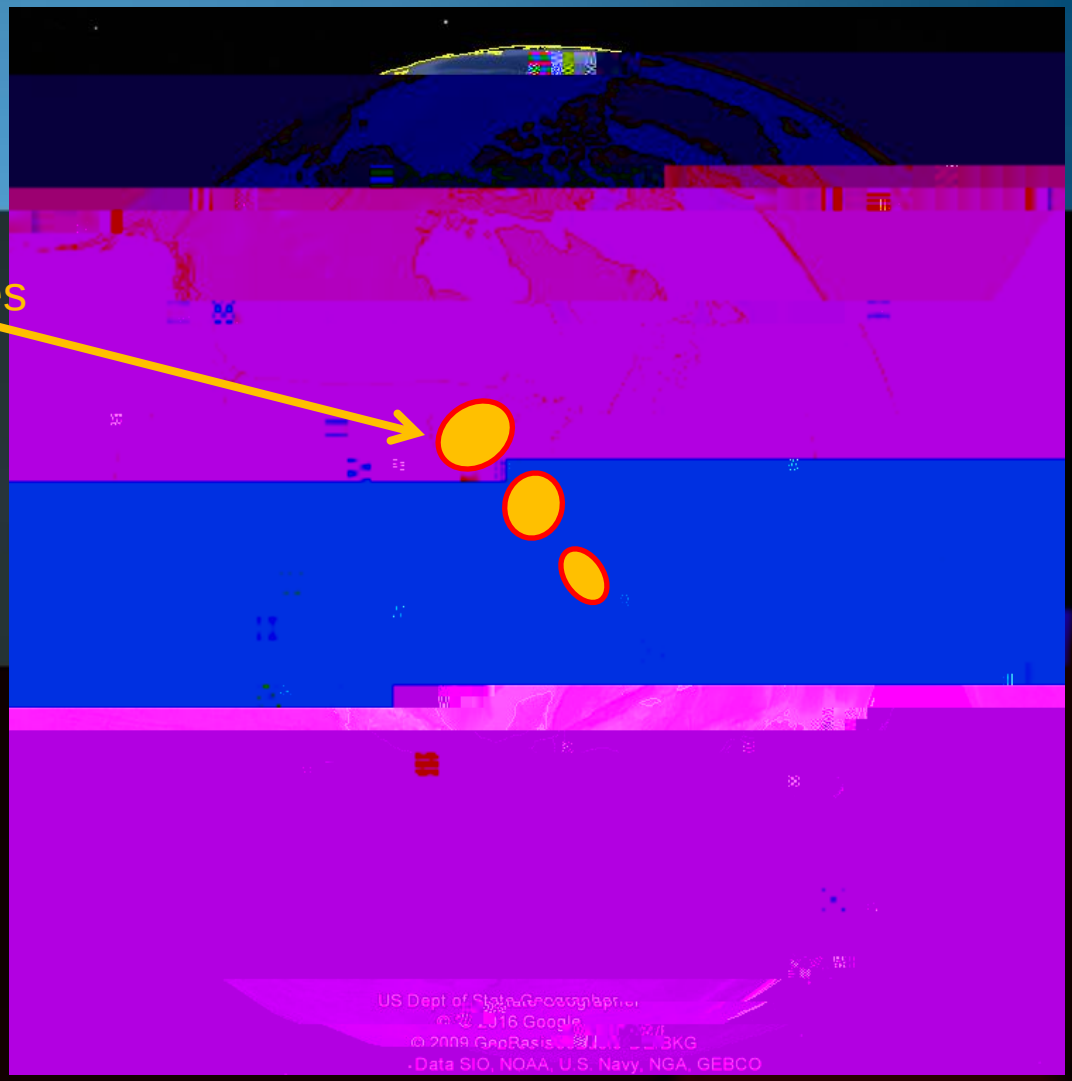


Initial Results from Three Projects

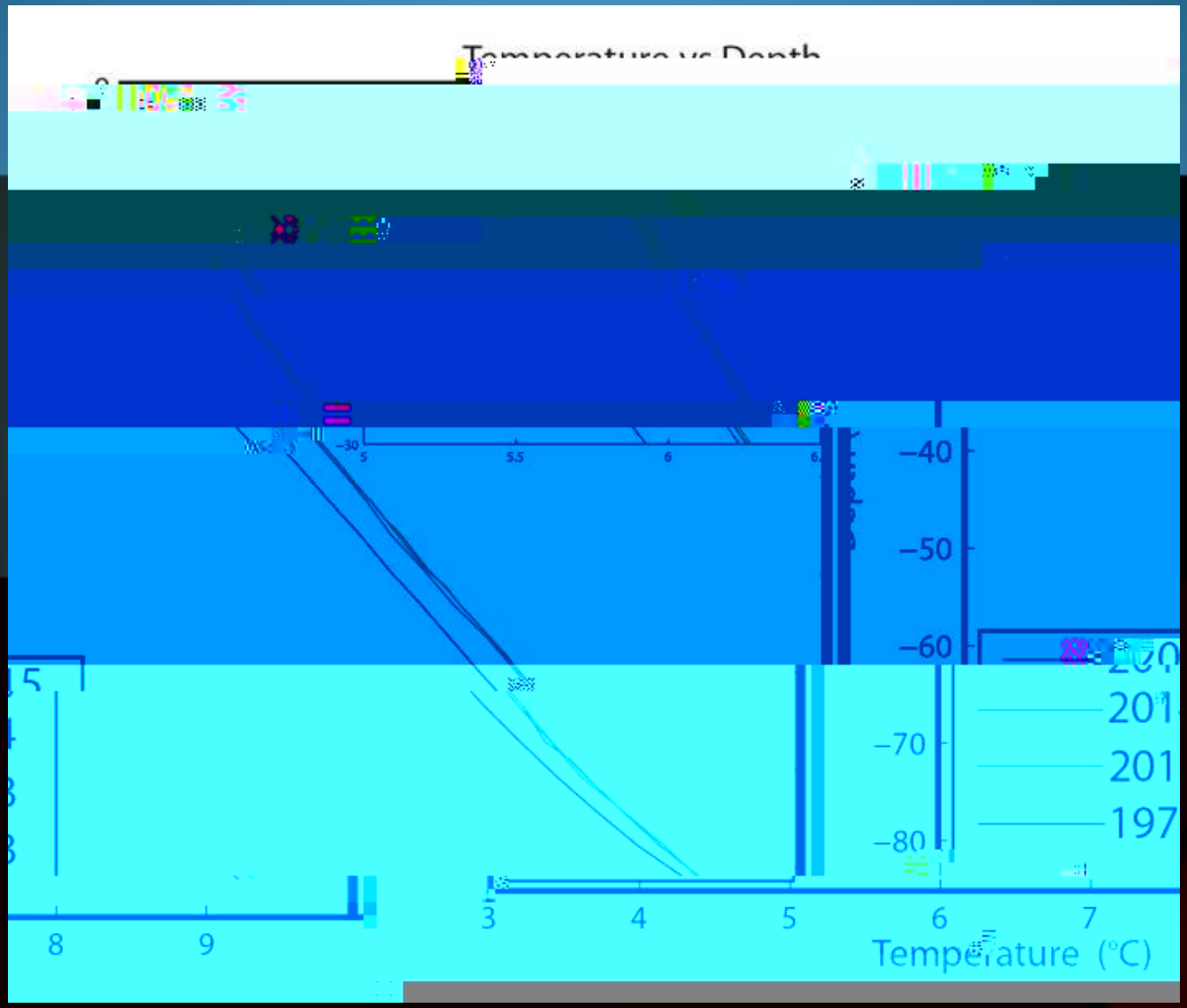
(1) Heat Flow Measurements and Modeling in the Denver Basin

(2) Surface Warming in the N. Rockies

(3) Quantifying/Mitigating Induced Seismicity in Texas

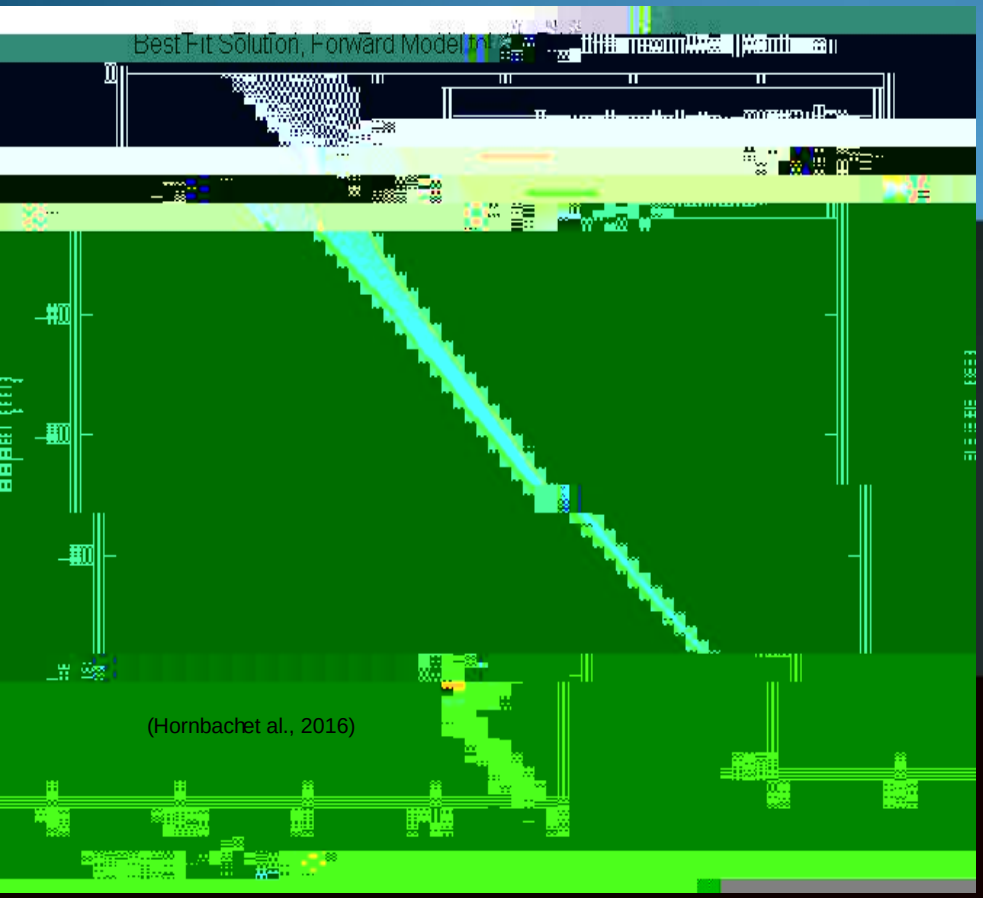


Northern US Rocky Mountain Winter Freeze Line Retreat (Cliff Mauroner)



Northern US Rocky Mountain Winter Freezeline Retreat

(Both Measured and Projected by SMU Geothermal Lab)



Key Findings from SMU borehole climate study:

-- The N. US Rockies have warmed at ~0.4deg. F per decade , or 1.5 deg. F since 1974.

--the rate of warming has accelerated (we get a best model fit if we increase warming rate with time).

--The warming rate appears higher at higher elevations.

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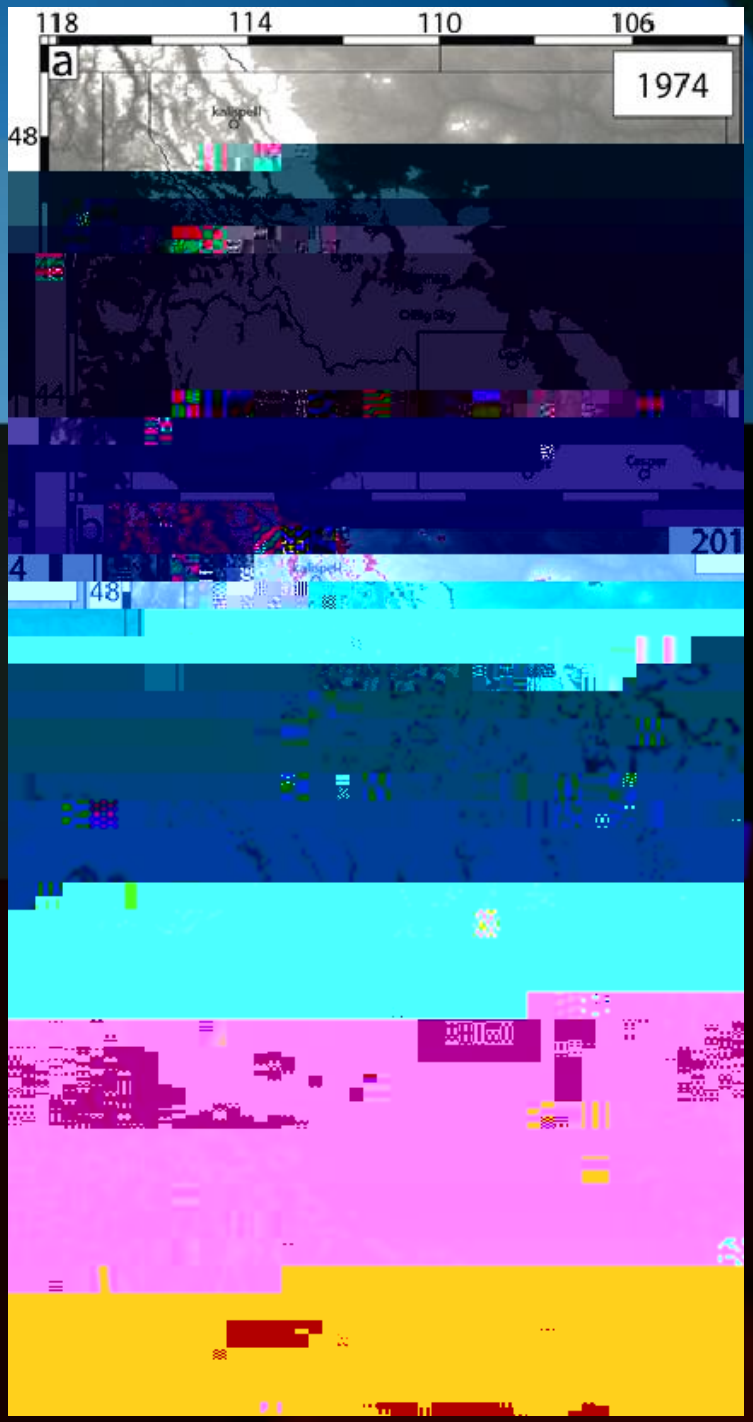

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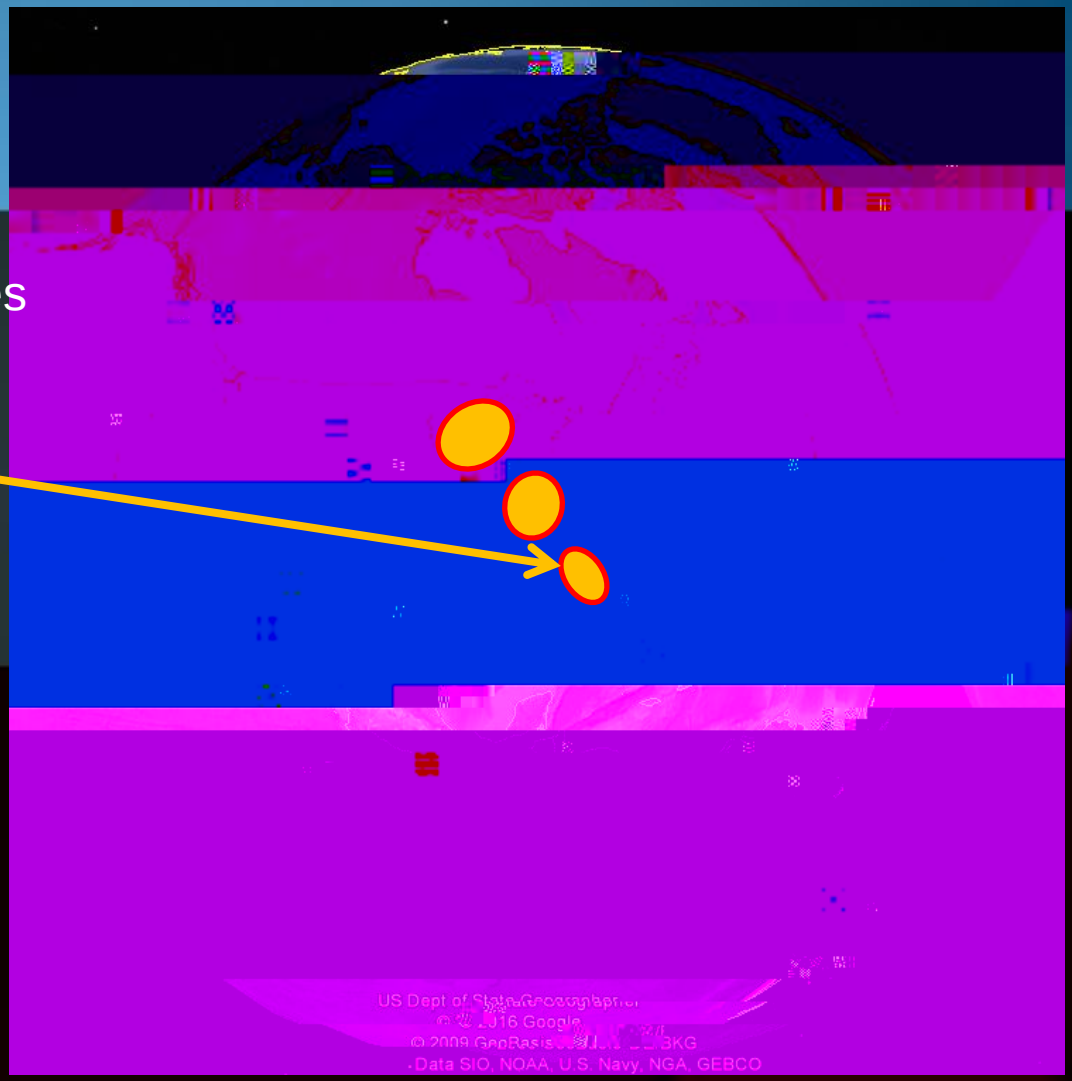

North Texas: An Ideal Testing Ground for Understanding/Mitigating Induced Seismicity associated with Geothermal systems

Why?

--Several large (>100,000 bbls/month) Wastewater injector sites exist

--Multiple Geological Geophysical datasets exist to constrain study.

--Plenty of induced seismicity

--SMU operates the only high resolution seismic networks in the area and maintains an extensive geothermal dataset in the region.

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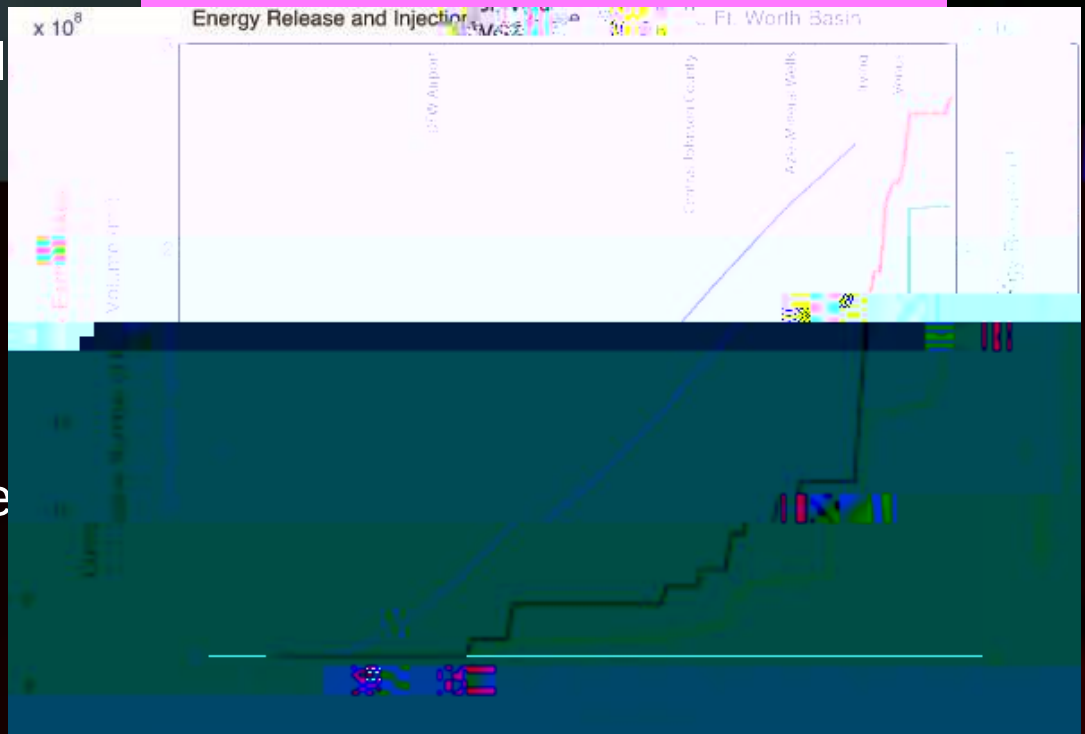

North Texas: An Ideal Testing Ground for Understanding/Mitigating Induced Seismicity associated with Geothermal systems

Key Preliminary Conclusions

--Areas of Highest Seismicity correlate to areas of highest injection volume.

--Basin-wide pressures have likely elevated by ~13 psi, but areas of induced seismicity show pressure increases of 50 600 psi.