



TexNet-CISR: An Integrated Response to Seismicity in Texas

Michael Young¹, Alexandros Savvaidis¹,
Peter Hennings¹, Ellen Rathje², Johnathan Osmond¹

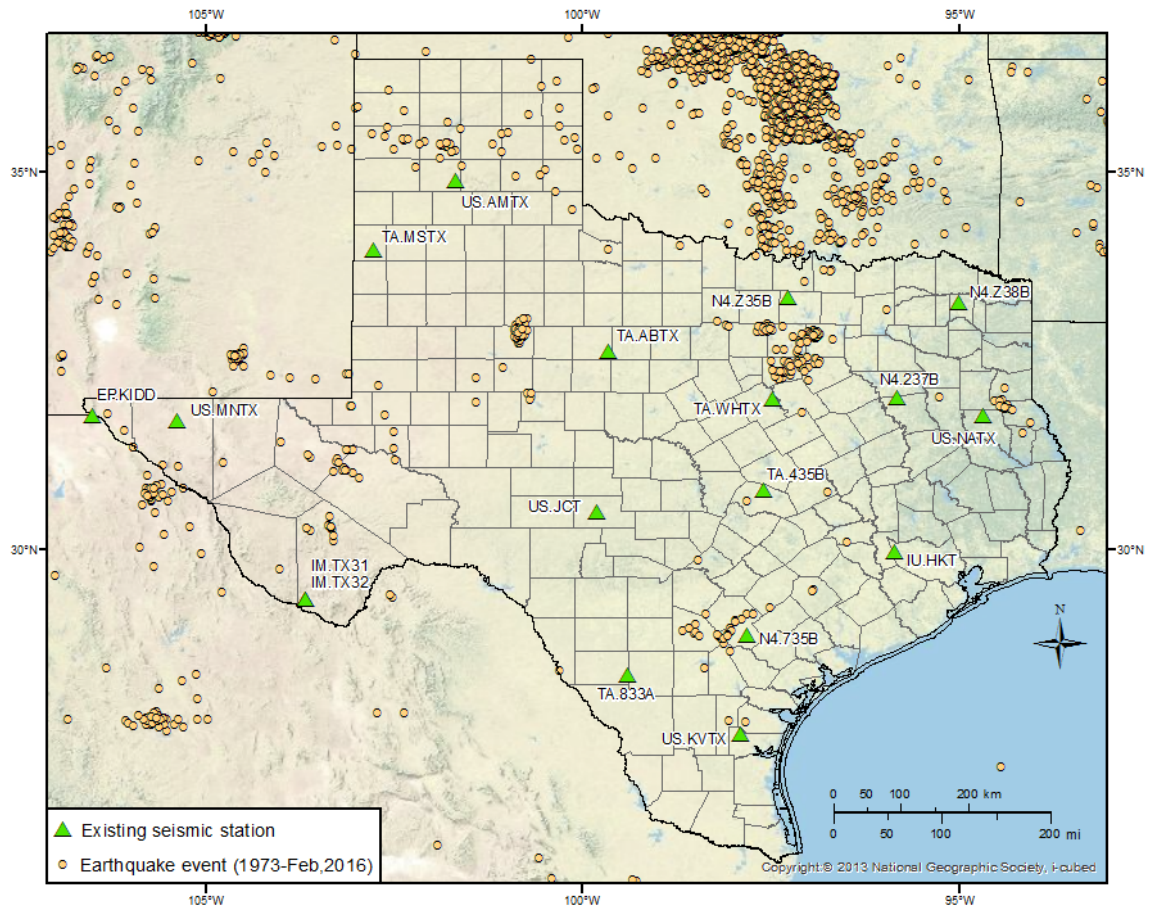
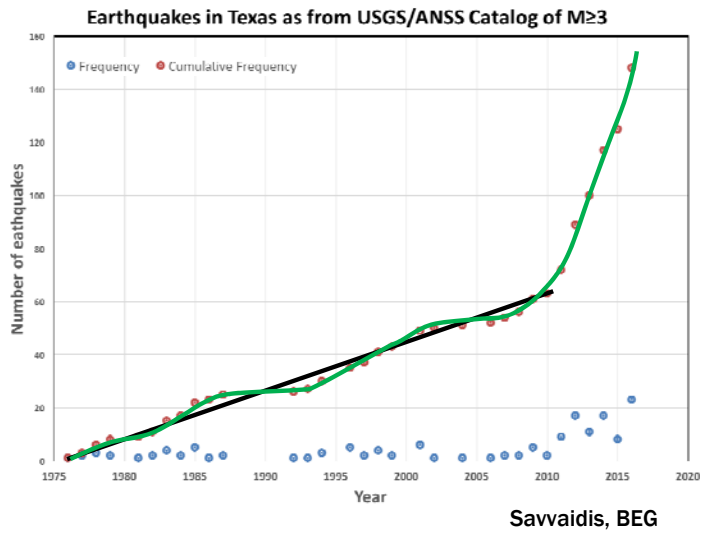
1 - Bureau of Economic Geology, University of Texas at Austin

2 - Department of Civil, Architectural and Environmental Engineering, University of Texas at Austin

AGI Critical Issues Program
State Responses to Induced Earthquakes
April 14, 2017



Seismic Activity in Texas



Texas' Response to Public Concerns about Increasing Rates of Seismicity

March 2014 – RRC hires a seismologist to provide technical support on earthquake issues

November 2014 – Railroad Commission of Texas issues new regulations designed to address disposal well operations in areas of historical or future seismic activity. Components include†:

- Applicants are required to search USGS seismic database for historical earthquakes within a circular area of 100 square miles around a proposed, new disposal well (~5.6 mile radius);
- Clarifying RRC's authority to modify, suspend or terminate a disposal well permit, or modify operations, if scientific data indicates a disposal well could be contributing to seismic activity;
- Increased disclosure of reported volumes and pressures, at RRC's discretion
- RRC may require applicant to provide additional technical information to demonstrate disposal fluid confinement.

Texas' Response to Public Concerns about Increasing Rates of Seismicity

Bill Text: TX HB2 | 2015-2016 | 84th Legislature

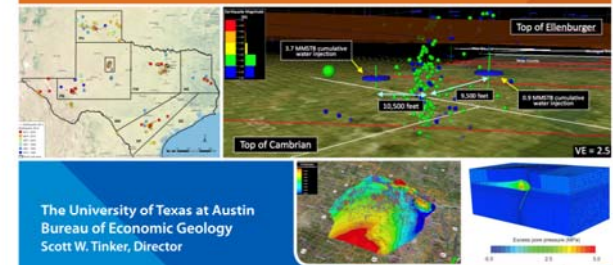


Texas House Bill 2 (In Recess)

TX State Legislature page for HB2

SECTION 16. THE UNIVERSITY OF TEXAS AT AUSTIN: BUREAU FOR ECONOMIC GEOLOGY. (a) In addition to amounts previously appropriated for the state fiscal biennium ending August 31, 2015, \$4,471,800 is appropriated out of the general revenue fund to The University of Texas at Austin for the two-year period beginning on the effective date of this Act for the purchase and deployment of seismic equipment, maintenance of seismic networks, modeling of reservoir behavior for systems of wells in the vicinity of faults, and establishment of a technical advisory committee.

Report on House Bill 2 (2016-17)
Seismic Monitoring and Research in Texas
December 1, 2016



The University of Texas at Austin
Bureau of Economic Geology
Scott W. Tinker, Director

by
Peter Hennings¹, Alexandros Savvaidis²,
Michael Young³, and Ellen Rathje⁴

with contributions from:
Mahsen Babazadeh⁵, Taylor Borgfeldt⁶, Rongqiang Chen⁷, Akhil Datta-Gupta⁸, Heather DeShon⁹, Peter Eichhubl¹⁰, Zhiqiang Fan¹,
Cliff Frohlich¹, Valerie Gomo¹, Jihoon Kim¹, Mike King¹, Casey Leimons¹, Tania Mukherjee¹, Jean-Philippe Nicot¹, Jon Olson¹,
Jaeyoung Park¹, Jake Walter¹, Xu Xue¹, Hyun Yoon¹, Bissett Young¹, and George Zalachoris¹

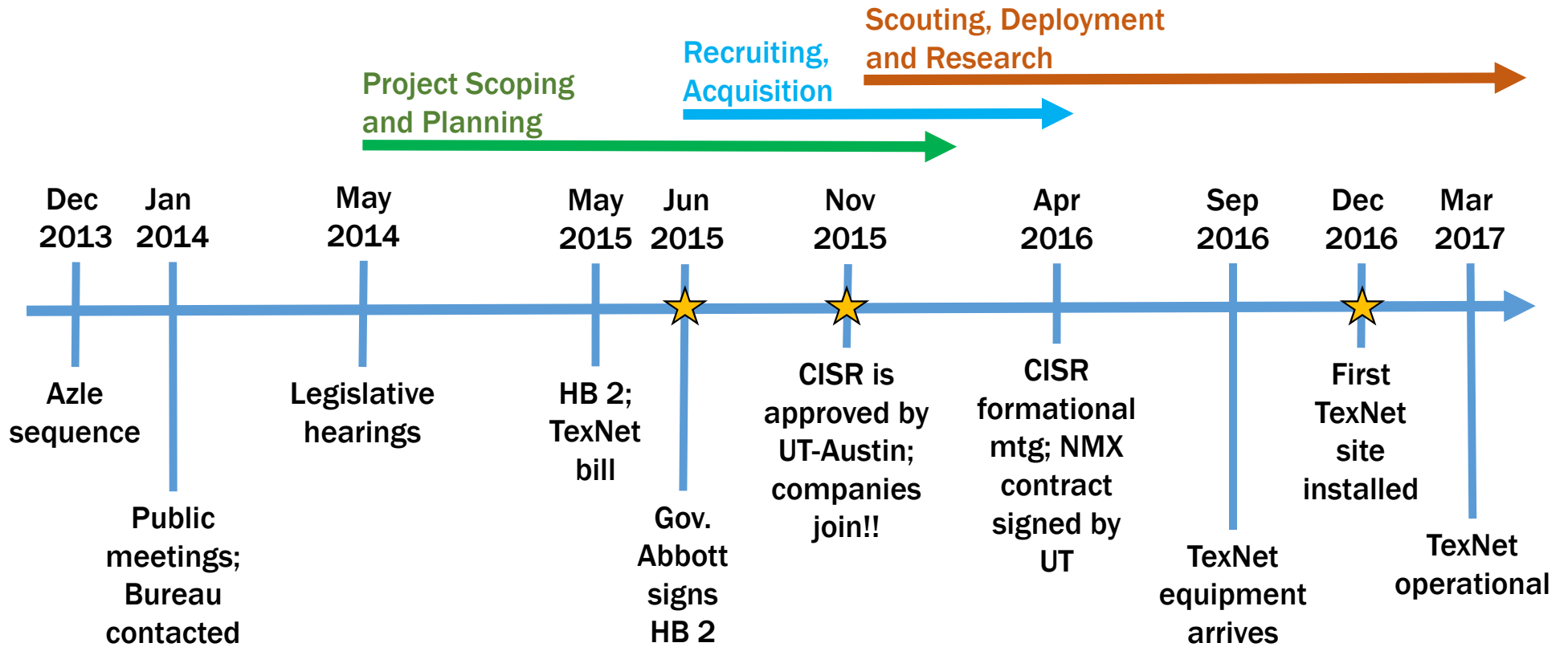


¹ The University of Texas at Austin Bureau of Economic Geology
² The University of Texas at Austin Department of Civil, Architectural and Environmental Engineering
³ The University of Texas at Austin Institute for Geophysics
⁴ Southern Methodist University Roy M. Huffington Department of Earth Sciences
⁵ The University of Texas at Austin Department of Petroleum and Geosystems Engineering
⁶ Texas A&M University Department of Petroleum Engineering

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<http://www.beg.utexas.edu/files/content/texnet/docs/TexNet-Report-2016.pdf>

Timeline of Significant Events and Bureau Involvement



Timeline not to scale;
dates reasonably close

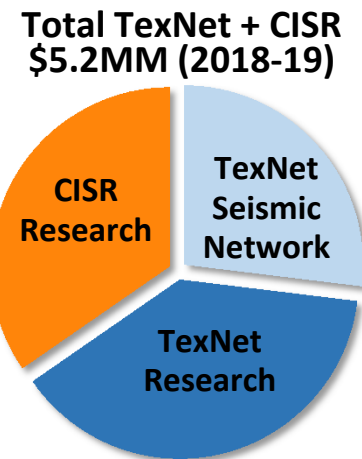
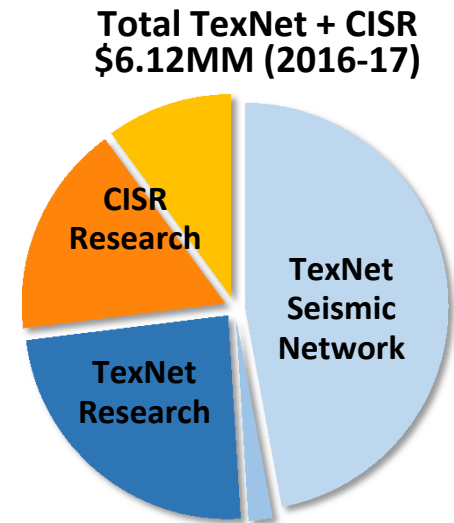
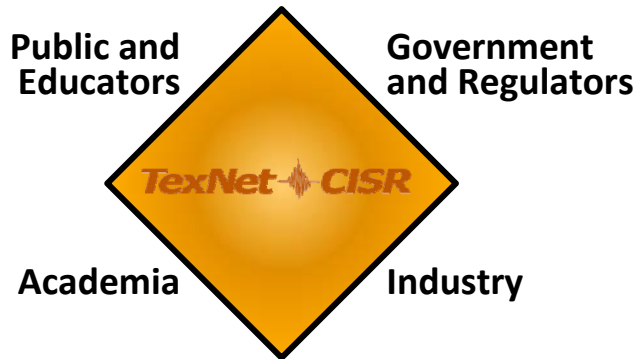
TexNet – CISR Background and Composition

TexNet

Will monitor, locate, and catalog seismicity across Texas, capable of detecting and locating earthquakes, minimizing uncertainties, with magnitudes $\geq M2.0$ using the new *backbone* network and improve investigations of ongoing sequences by deploying temporary seismic monitoring stations and conducting site-specific assessments.

Center for Integrated Seismicity Research

CISR will conduct fundamental and applied research to better understand naturally occurring and potentially induced seismicity and the associated risks, and to discern strategies for communicating with stakeholders and responding to public concerns regarding seismicity.



Organization

CISR Science Advisory Committee

SAC Representative	Organization	SAC Role
Peter Hennings	UT-BEG	CISR PI, SAC Chair, Reservoir Lead
Ellen Rathje	UT-CAEE	CISR PI, Earthquake Hazard/Risk Lead
Alexandros Savvaiddis	UT-BEG	TexNet Manager, Seismology Lead
Cody Comiskey	Anadarko	member
Cal Cooper	Apache	member
Rongmao Zhou	BHP Billiton	member
Jeff Nunn	Chevron	member
Seth Busetti	ConocoPhillips	member
Rod Gertson	Devon	member
Robert Kidney	EOG	member
Tim Tyrell	ExxonMobil/XTO	member
Klaas Koster	Occidental	member
Kevin Woller	Pioneer	member
Beatriz Garcia-Fresca	Statoil	member
Brian Casey	Texas Oil & Gas Inst	member

Bureau Directorship

Scott Tinker, Michael Young

CISR Research

PIs: Peter Hennings, Ellen Rathje, Alexandros Savvaiddis

TexNet Seismic Network

Alexandros Savvaiddis^B
 Bissett Young^B
 Mark Blount^B
 Caroline Breton^B
 Poe Chen^B

Seismology

Cliff Frohlich^I
 Jake Walter^I
 Taylor Borgfeldt^{I,3}
 Chastity Aiken^{I,1}
 Alexandros Savvaiddis^B
 Ellen Rathje^C

Hydrology, Faults, Geomodels

Peter Hennings^B
 Chris Zahm^B
 Casee Lemons^B
 Johnathon Osmond^B
 Katie Smye^B
 Livia Sivila^B
 JP Nicot^B
 Robin Dommissé^B

Geomechanics and Reservoir Modeling

Jon Olson^P
 Rich Schultz^P
 Peter Eichhubl^B
 Mohsen Babazadeh^{P,2}
 Valerie Gono^{P,2}
 Zhiqiang Fan^{B,1}

Seismic Hazard and Risk Assessment

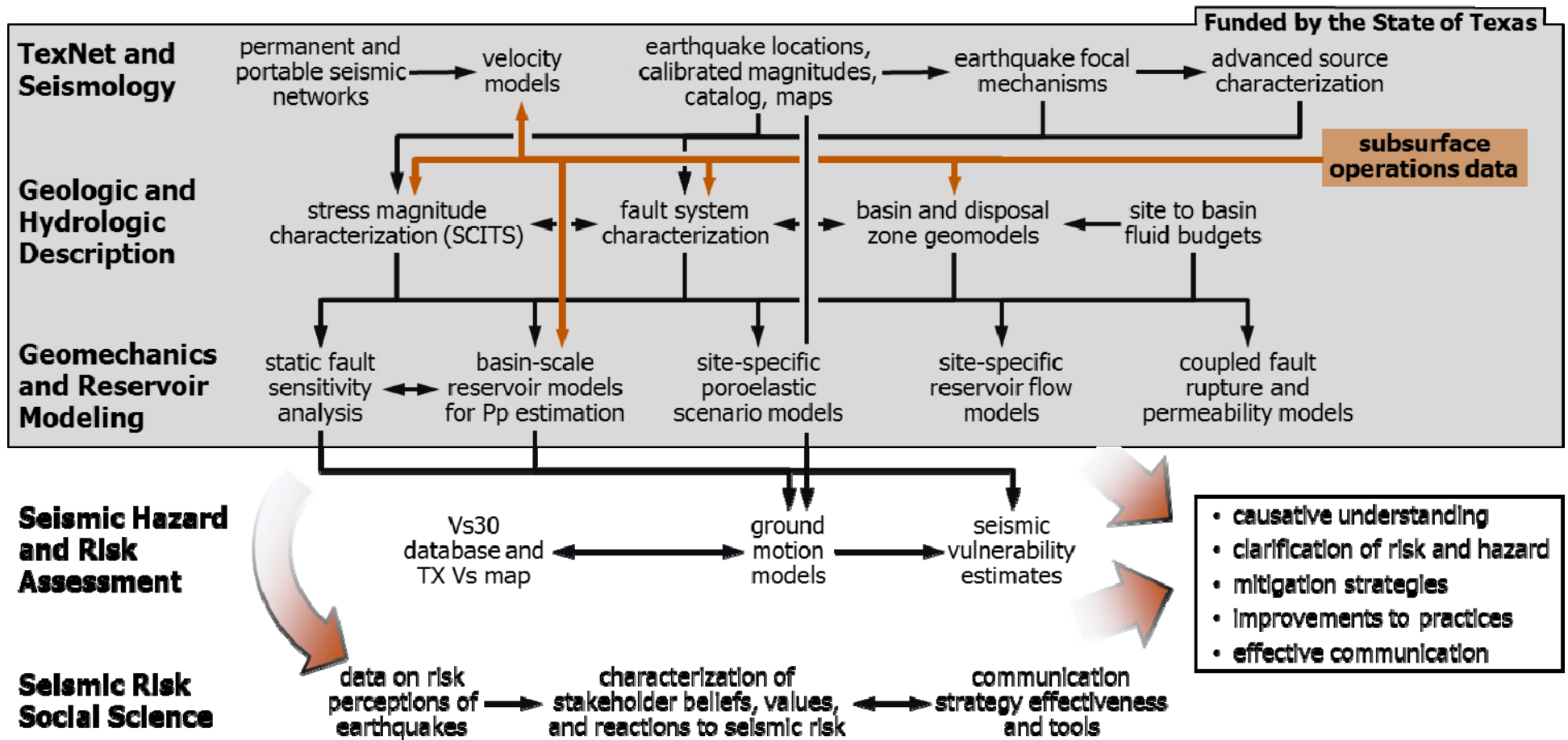
Ellen Rathje^C
 George Zalachoris^{C,1}
 Brady Cox^C
 Patricia Clayton^C

Seismic Risk Social Science

Lee Ann Kahlor^M
 Art Markman^{Ps}
 Mary Beth Deline^{M,1}
 Hilary Olson^{I,P}

^B Bureau of Economic Geology
^I UT Institute for Geophysics
^P UT Petroleum Geosystems and Engineering
^C UT Civil, Arch, and Envir Engineering
^{Ps} UT-Psychology
^M UT-Moody A&PR
¹ Post Doc ² PhD student ³ MS student

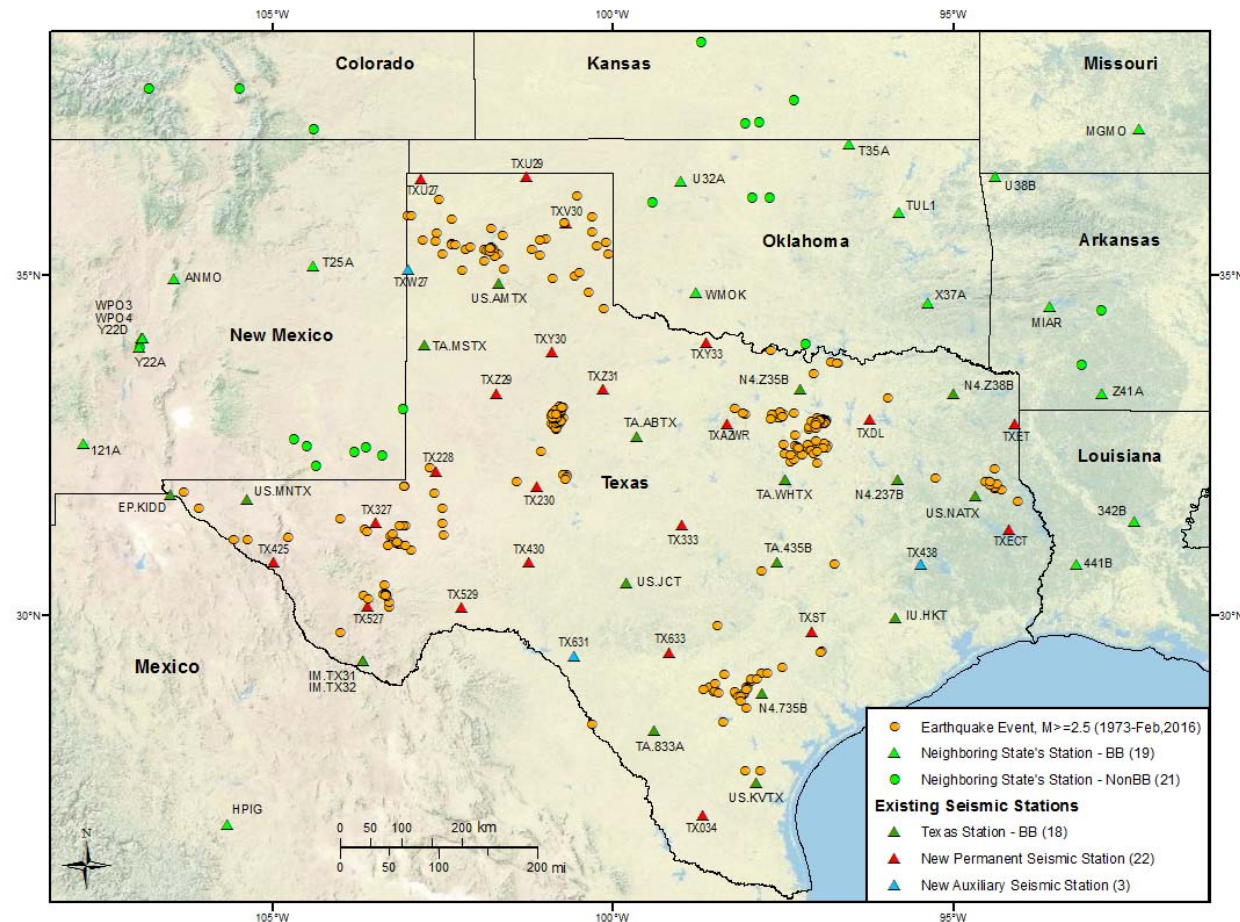
TexNet-CISR Project Integration Map



Recording Seismicity in Texas

New Station Deployments

- 22 permanent stations add to the 17 existing stations
- 3 auxiliary stations added to create an evenly space grid of seismic stations in Texas
- 30 portable stations in areas of recently recorded seismicity
- 3 Portable stations available for rapid deployment in case of emergency



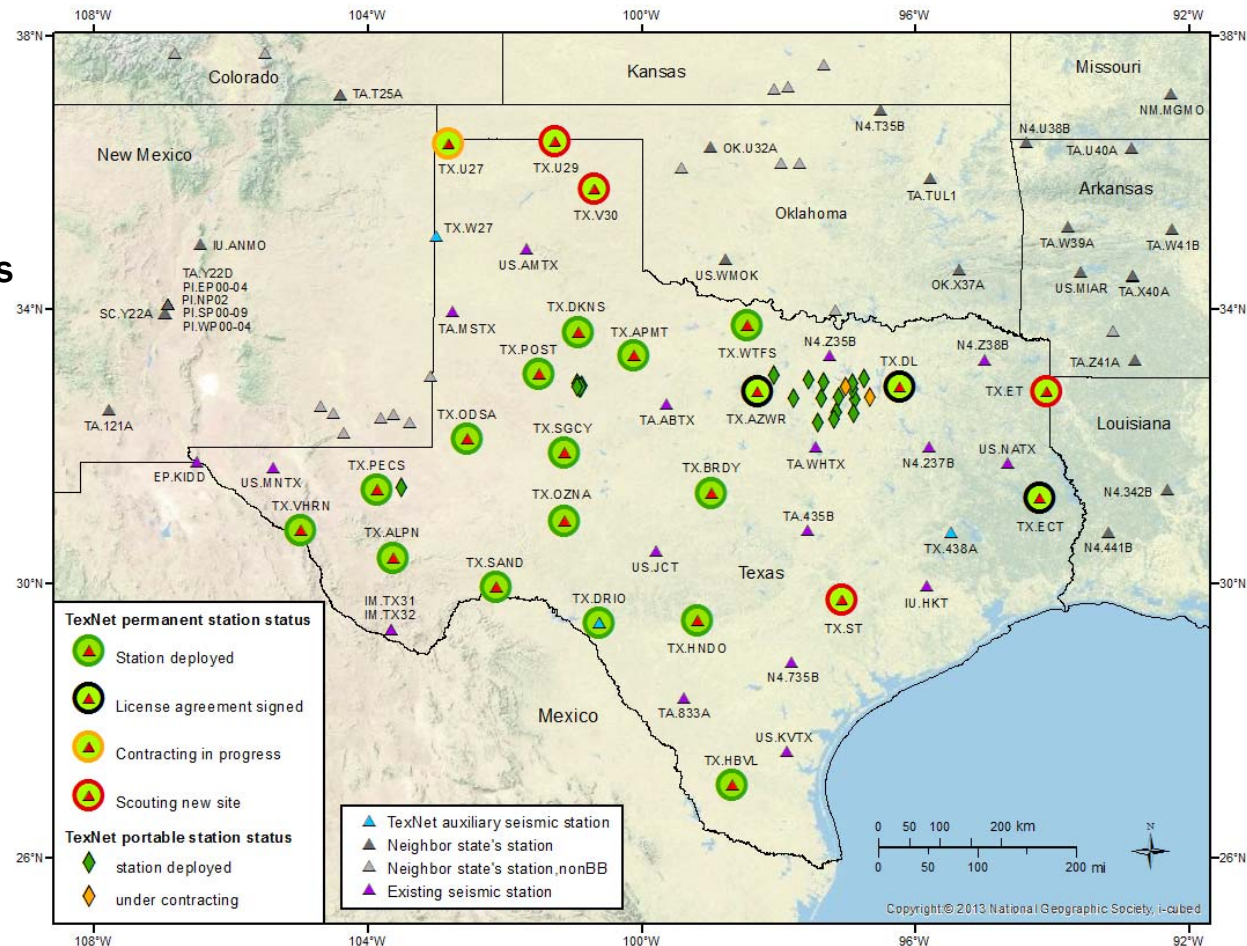
Status of TexNet Station Deployment

For the 22 Permanent Stations:

- 141 sites were evaluated
- 106 landowners were contacted
- 24h noise surveys were conducted at 59 sites
- 14 stations are deployed as of Mar 21, 2017

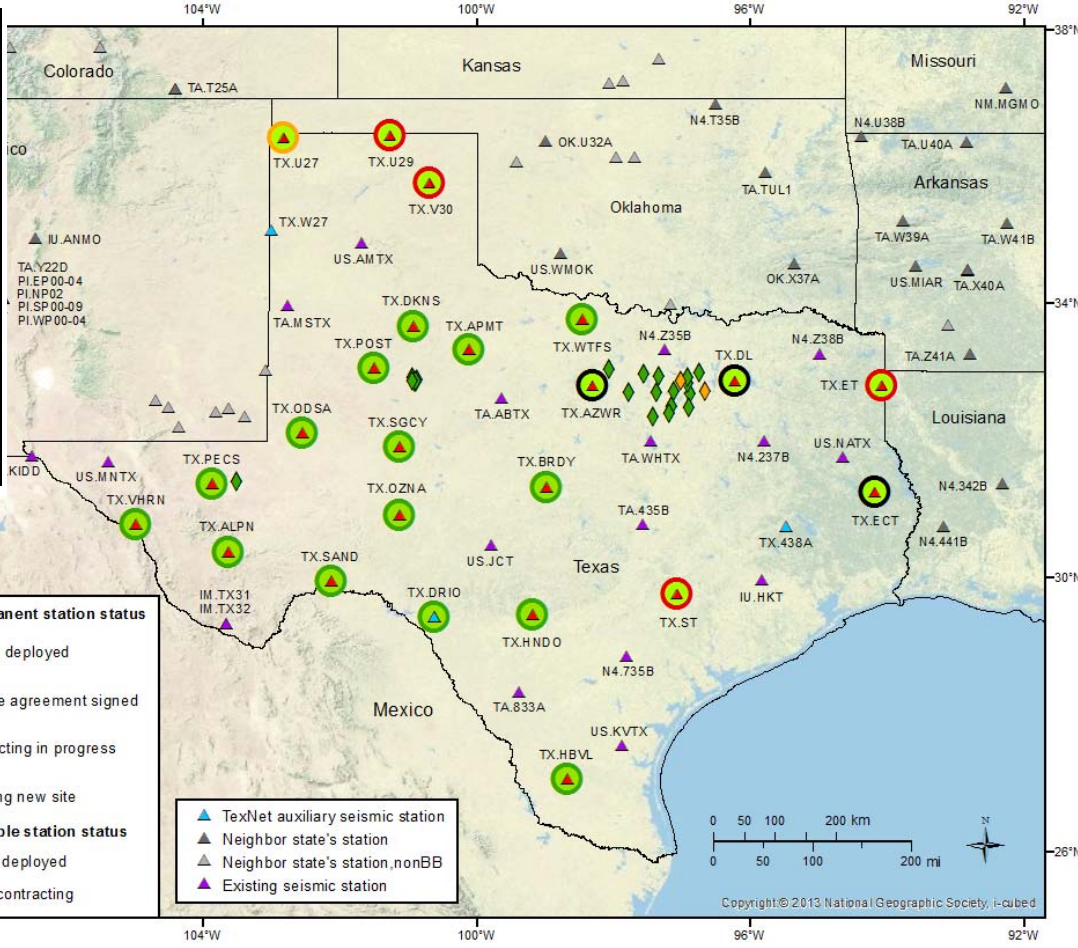
For the 33 Portable Stations,

- 18 are deployed as of Mar 21, 2017
- 10 are deployed in the DFW area
- 1 is deployed in Permian Basin area
- 6 are deployed in the Snyder area
- 1 is deployed in near Del Rio (Auxiliary)



TexNet Permanent Station Plan

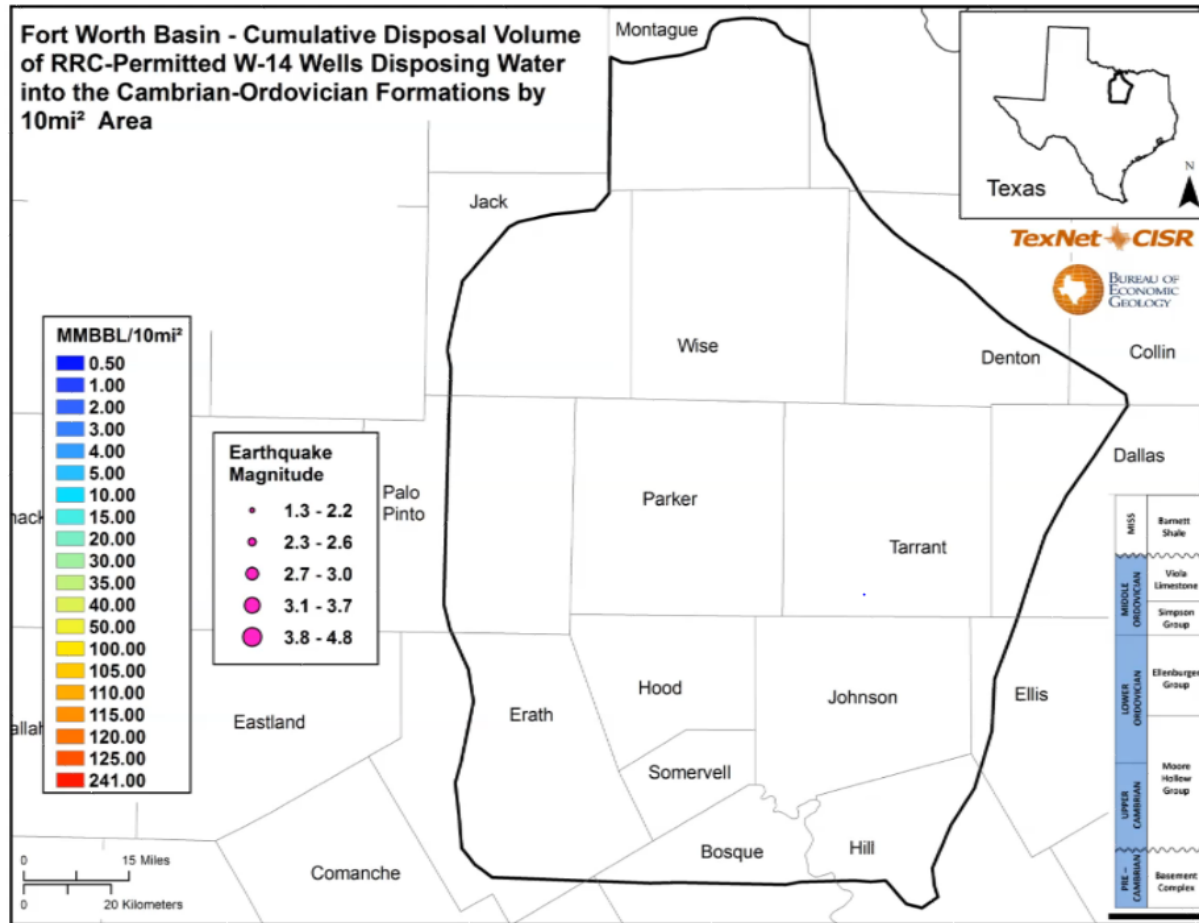
Legend	Permanent Station Name	2016												2017											
		Actual												Planned											
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Sites Selected	TX.ET																								
Site Landowner Contacted	TX.ECT																								
Sites Visited by BEG	TX.DL																								
Sites Approved by BEG	TX.ST																								
Sites Visited for 24-hr Survey	TX.Y33/WTFS																								
Station Approved	TX.AZWR																								
Contracting in Progress	TX.333/BRDY																								
License Agreement Signed	TX.633/HNDO																								
Borehole Drilling	TX.034/HBVL																								
Station Installation	TX.Z31/APMT																								
	TX.V30																								
	TX.Y30/DKNS																								
	TX.U29																								
	TX.230/SGCY																								
	TX.430/OZNA																								
	TX.229/POST																								
	TX.U27																								
	TX.228/ODSA																								
	TX.529/SAND																								
	TX.327/PECS																								
	TX.527/ALPN																								
	TX.425/VHRN																								



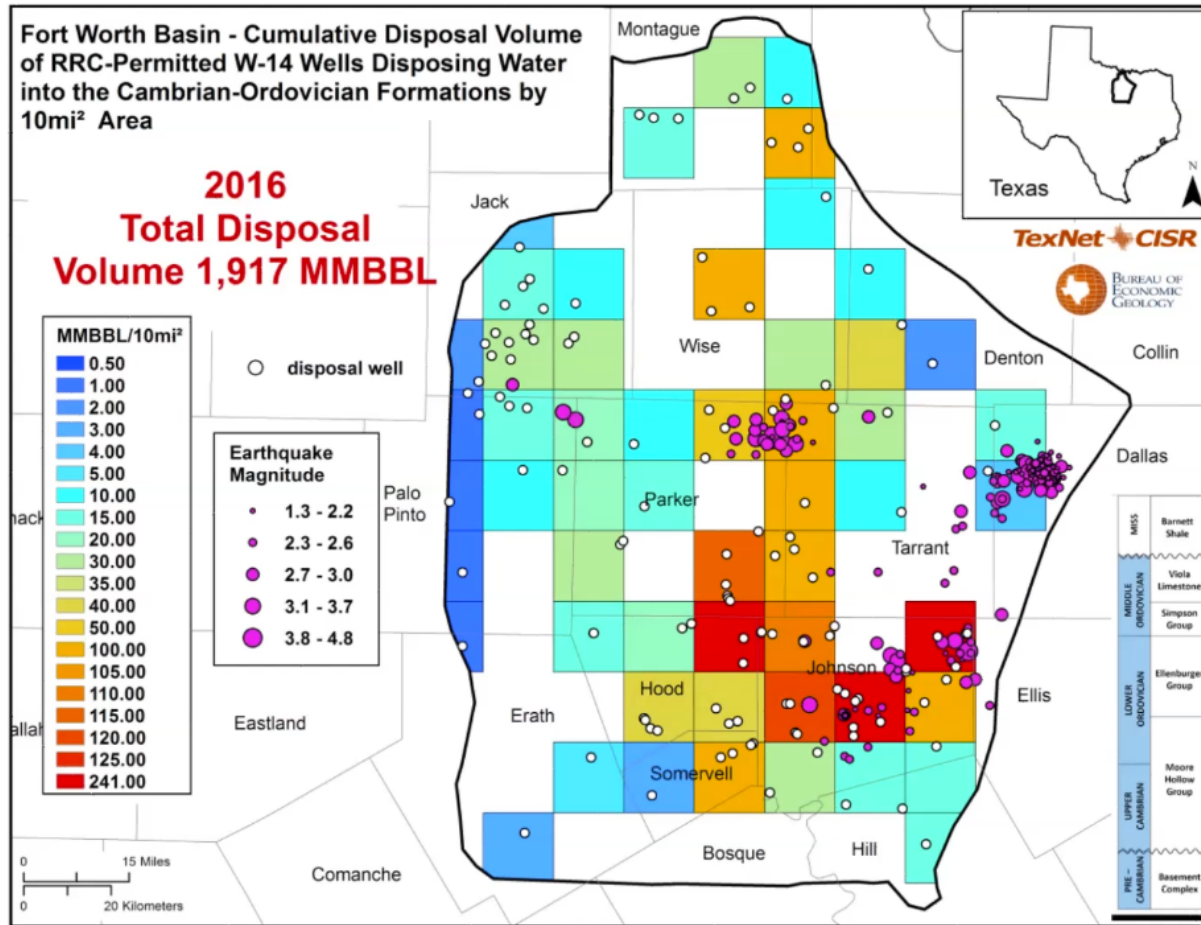
TexNet Seismic Network Data and Products

- TX Ground motion real time data available to the public through IRIS
- Earthquake source information soon to be available to the public will include
 - Minimizing the hypocenter uncertainties
 - Local and moment magnitude calculations
 - Fault plane solutions
- Results will be used for
 - Updating the crustal velocity model of TX
 - Near real-time Shakemaps
- Data will be used by
 - Research Scientists
 - Industry
 - Regulators
 - Texas Division of Emergency Management, other stakeholder groups

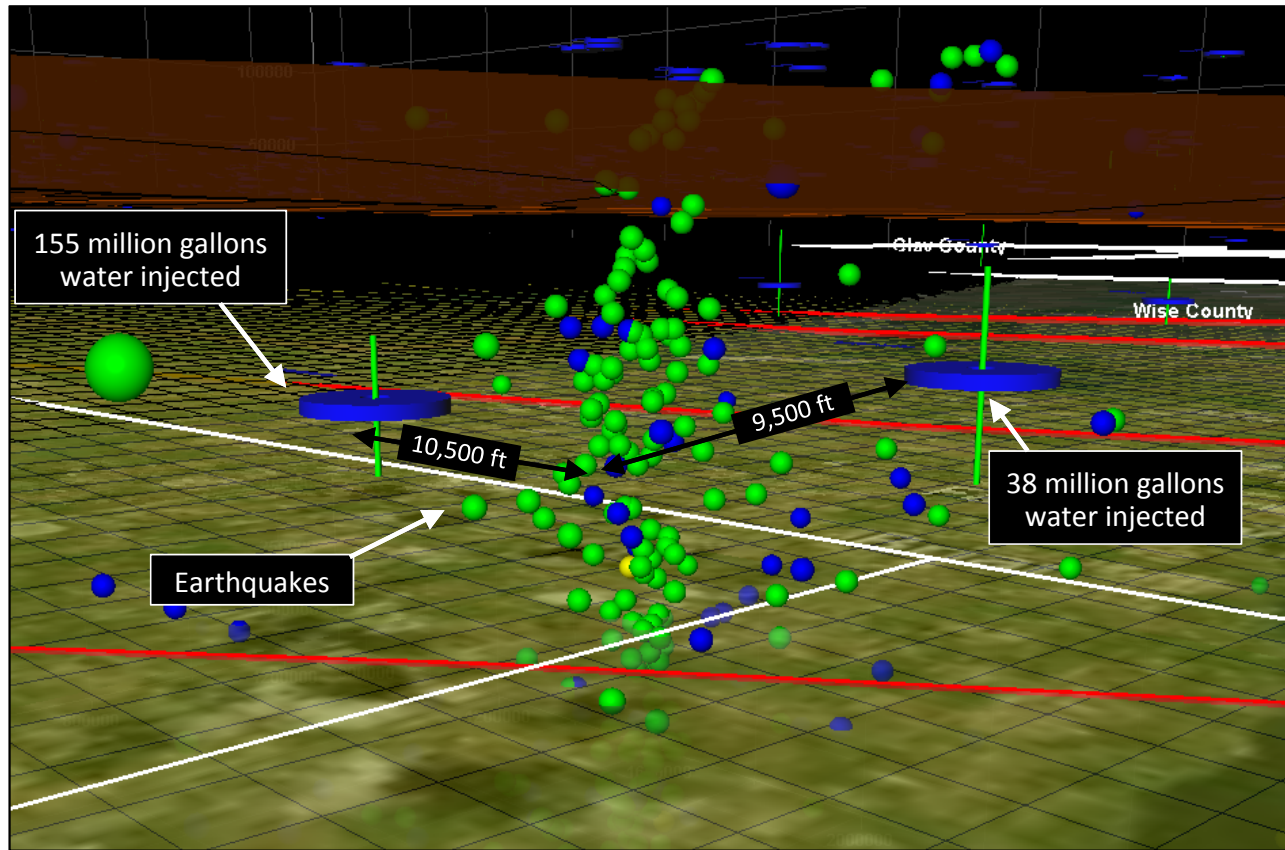
Injection and Seismicity in the Fort Worth Basin



Injection and Seismicity in the Fort Worth Basin

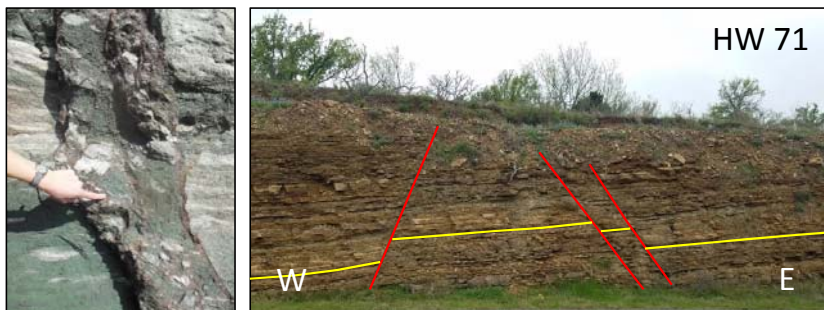
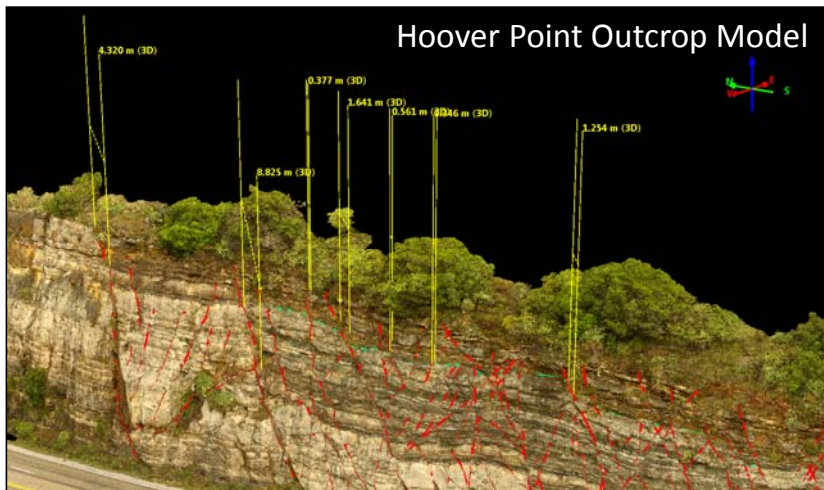


Integrating all Available Subsurface Data

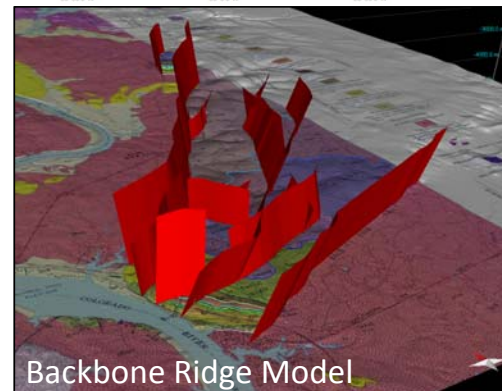
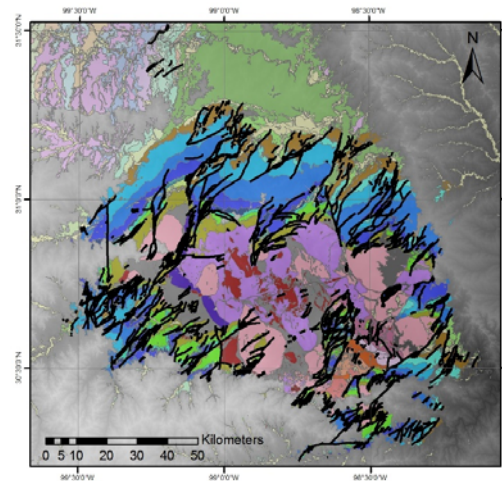


Characterizing Llano Uplift Outcrop Analogs

Outcrop Analog Characterization

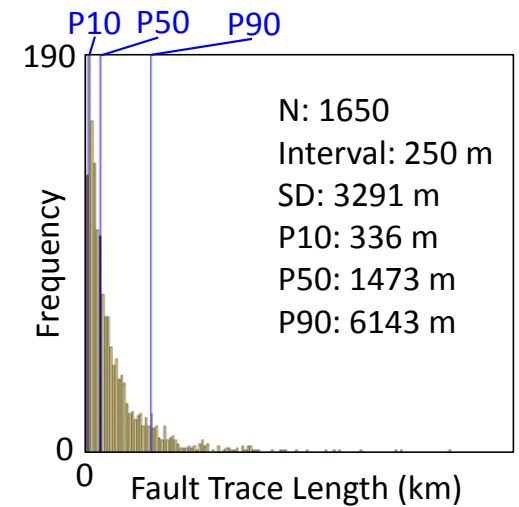


Regional Mapping and 3D Modeling

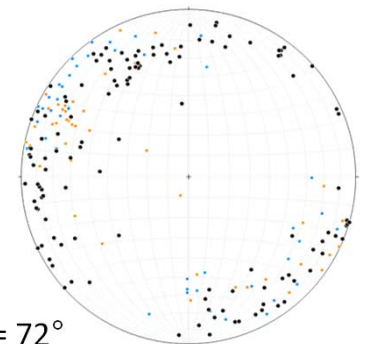


Geologic units mapped from USGS and Barnes, 1978, imagery by Google

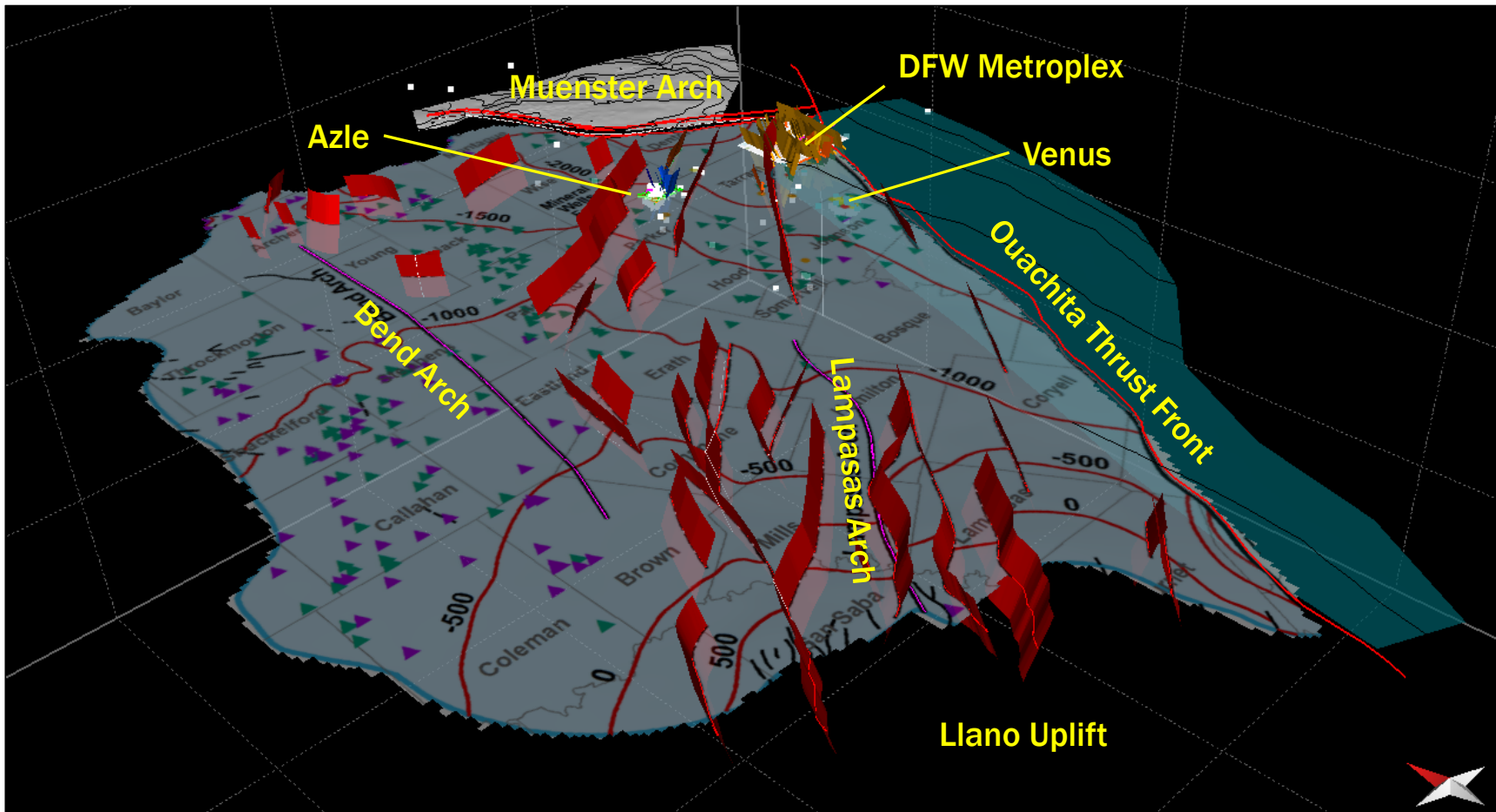
Detailed Fault Analysis



Fault S/D
N: 469
Avg. Dip = 72°



Creating Fault Models - Fort Worth Basin



Activities Timeline

State-Wide and General Topics

1. network procurement and installation
2. network management and data stream
3. R&D products to improve network performance
4. EQ compilations and characterizations
5. seismic risk communication and outreach

Ft Worth Basin Integrated Study

1. local seismic networks and EQ studies
2. basin-scale fluid budgets and pore pressure
3. stress characterization (Stanford)
4. fault characterization
5. 3D basin geo and hydrologic and modeling
6. fault reactivation analysis and mapping
7. reservoir modeling of seismicity mechanics
8. assessment of basin seismogenic potential

Greater West Texas Basin Integrated Study

1. local seismicity base-line studies and analyses
2. *Integrated geological characterization
3. assessment of basin seismogenic potential

Eagle Ford Operating Area Integrated Study

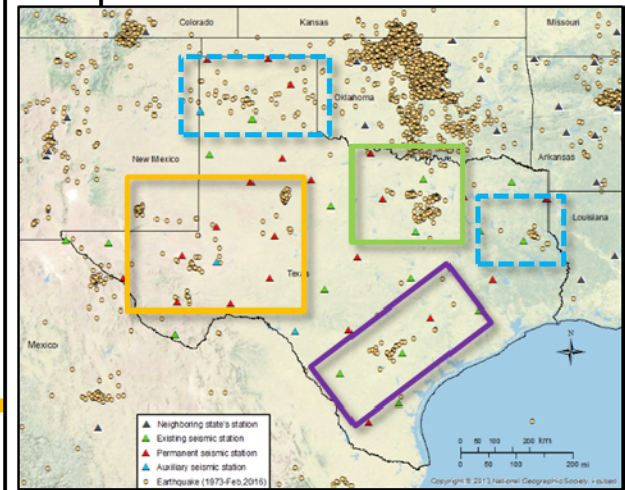
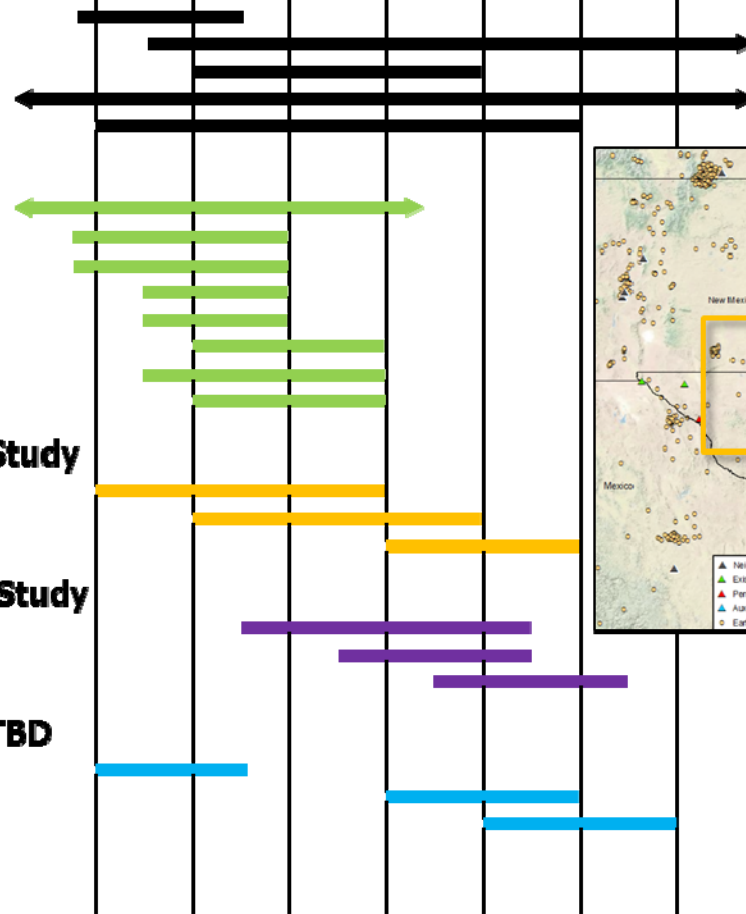
1. local seismicity base-line studies and analyses
2. *Integrated geological characterization
3. assessment of basin seismogenic potential

Panhandle, East Texas or other areas TBD

1. seismicity analysis (existing and TA stations)
2. *Integrated geological characterization
3. assessment of basin seismogenic potential

*Integrated geological characterization

2015 2016 2017 2018 2019 2020 2021 2022 (calendar year)



Thank You!!

