Sweetwater 3D: An Innovative Active + Passive Seismic Survey

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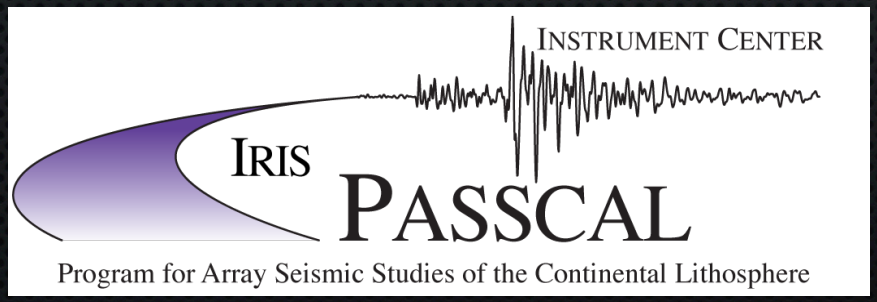
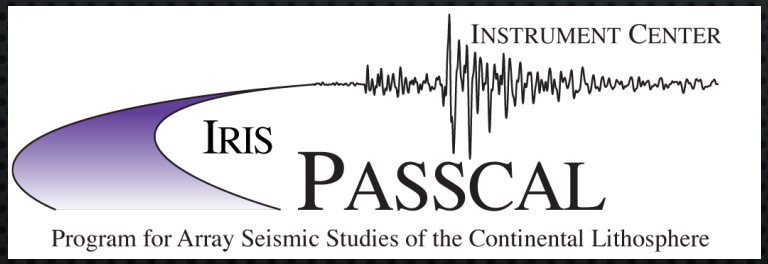


ACKNOWLEDGMENTS

- NodalSeismic – Dan Hollis, Bill Erickson, Paul Cox, Rich Rowland, James Hollis
- Nanometrics – Neil Spriggs
- IRIS/PASSCAL – Tim Parker, James Gridley, Bob Woodward, Bruce Beaudoin, Danielle Sumy, Field Staff



- **Background**: NodalSeismic acquired data for Gunn Oil near Sweetwater, TX using an innovative survey design
- **Objective**: The objective of this talk is to introduce the Sweetwater dataset and stimulate ideas for large-N research
- **Agenda**
  - Data Acquisition (10-15 min)
  - Data Management (10-15 min)
  - Data Analysis (10-15 min)

NodalSeismic

- High quality seismic acquisition system
- Completely cable-free/wire-free
- Flexible Design
- Autonomous
- Fast, safe, and low-impact
- Efficient in all terrains

NodalSeismic

real cable-free data acquisition

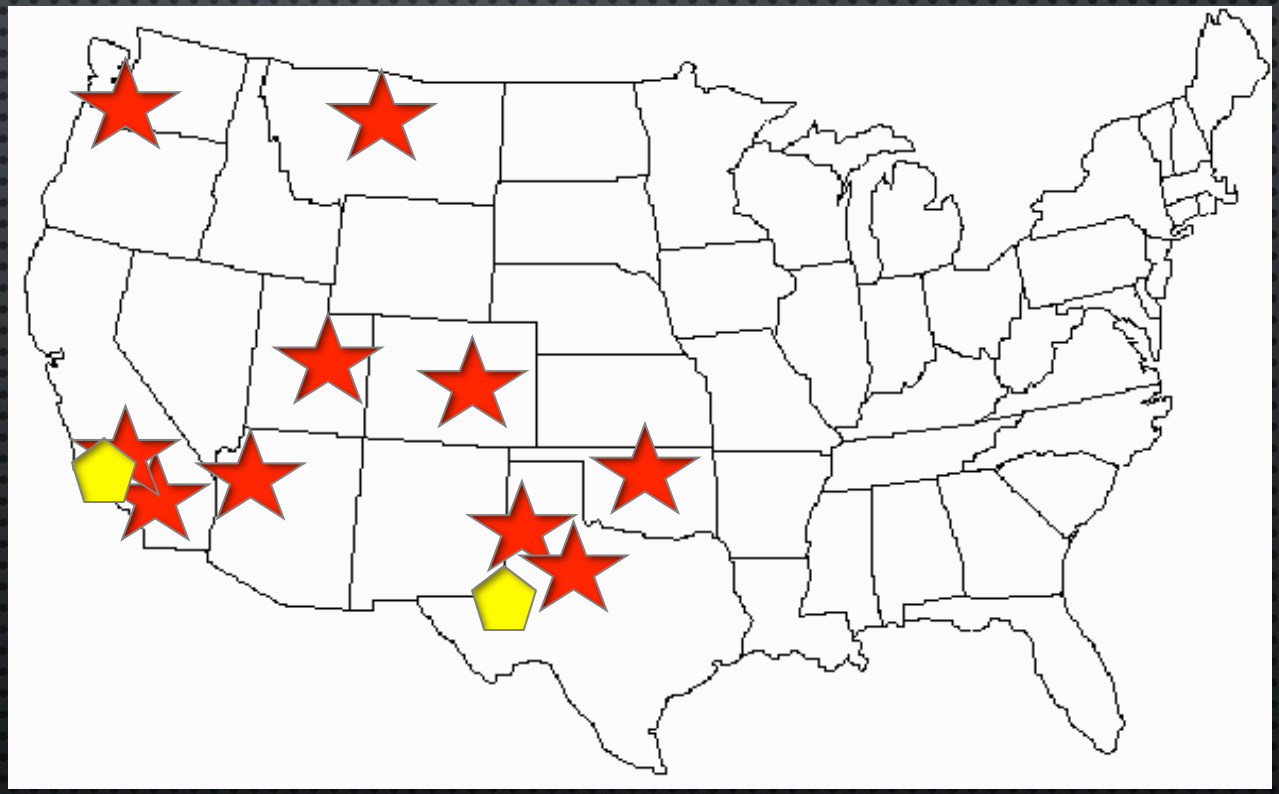
Recent projects:

California

Oklahoma

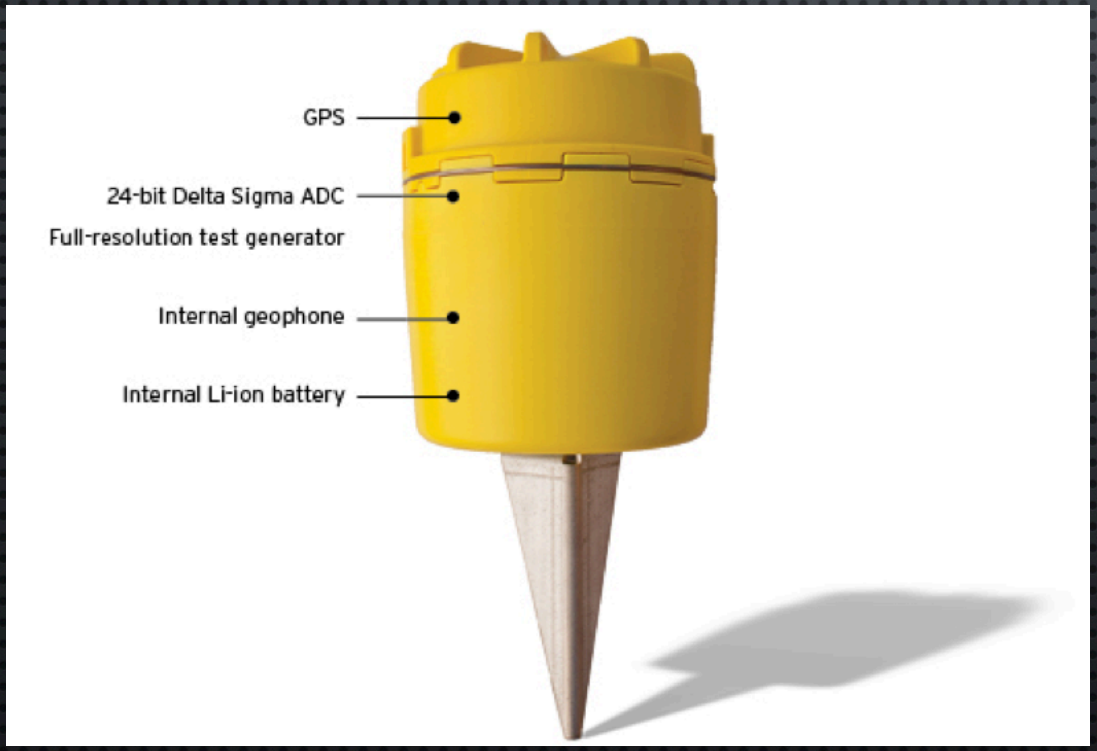
Arizona

Texas



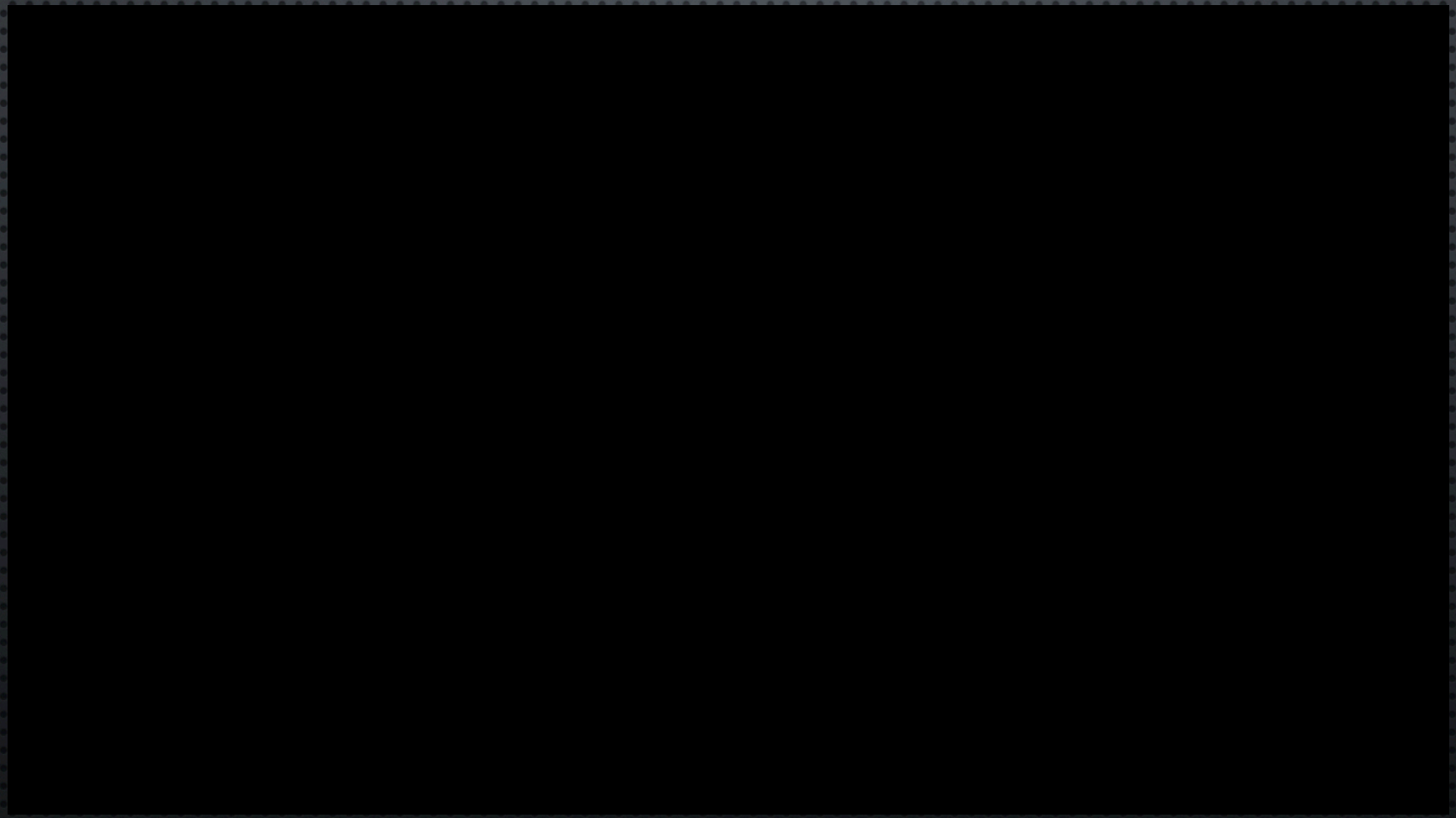
NodalSeismic offices

Zland Node – Autonomous data acquisition system



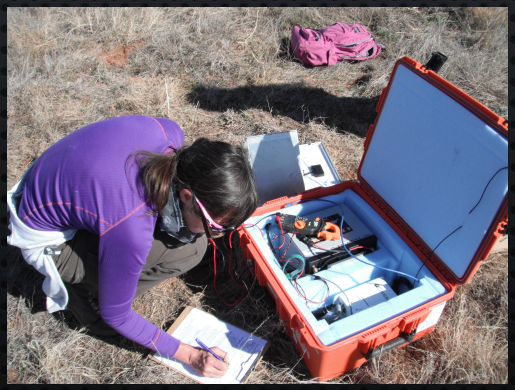
- 5" diameter
- 6" height
- Total weight 4.8lbs
- Internal GPS clock
- Flash memory drive
- Single component vertical geophone, 10 Hz natural freq
- 2 week battery life in continuous record mode

Nodal Seismic Operations

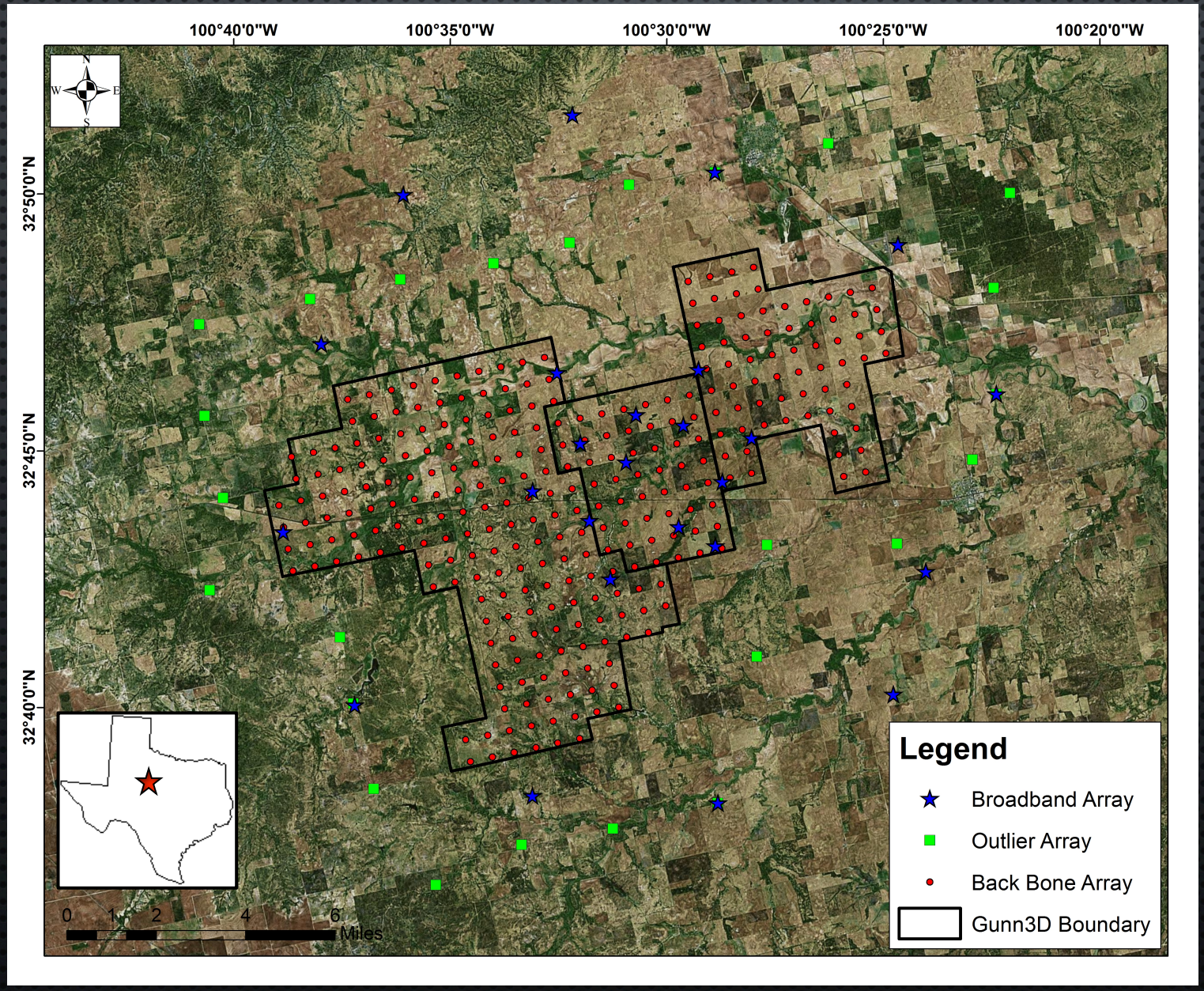


Sweetwater 3D

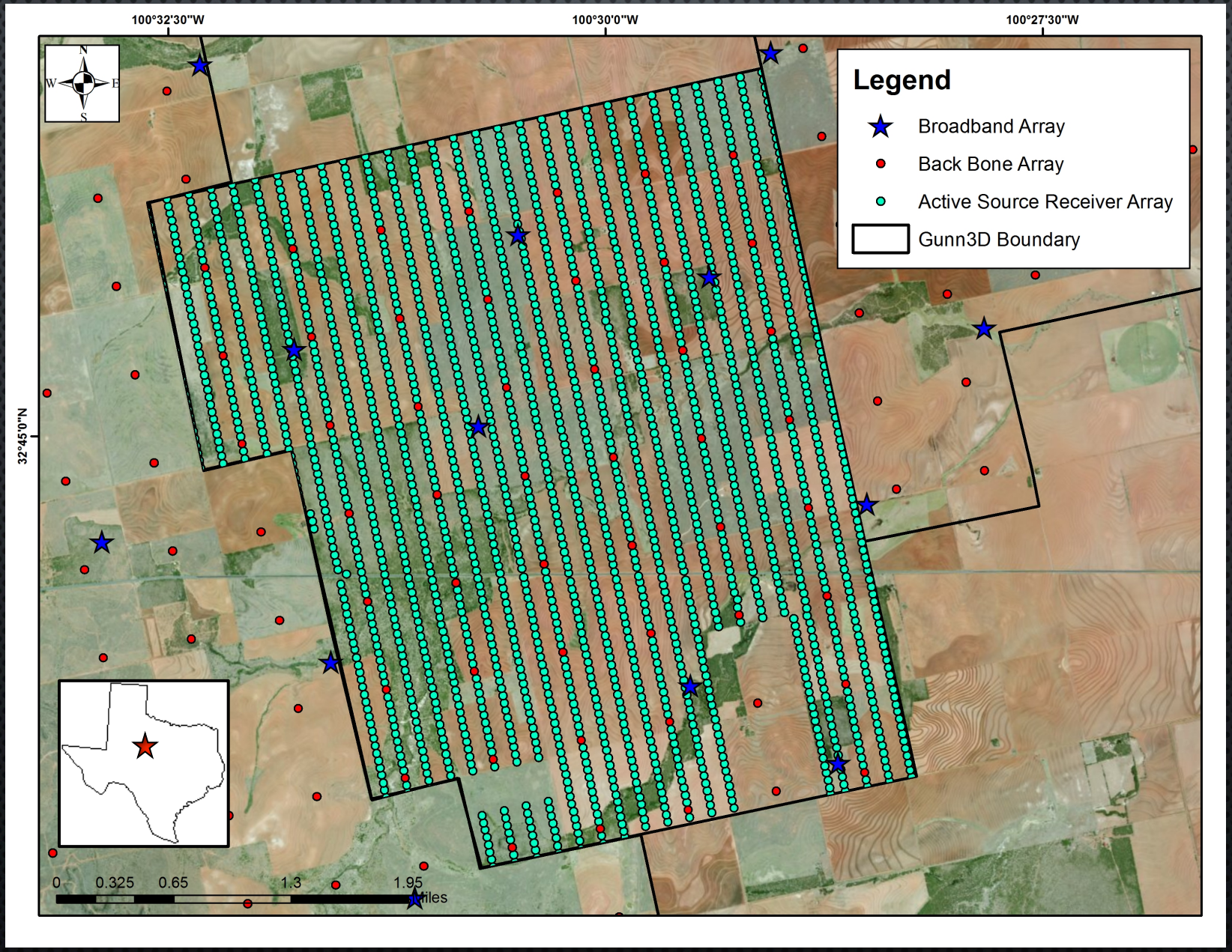
- Collaborative mixed sensor seismic survey incorporating broadband sensors and nodes (NodalSeismic, Nanometrics, IRIS/PASSCAL)
- Data acquired March 7 – April 30, 2014.
- Primary objective is oil and gas survey for Gunn Oil Company.
- Gunn Oil has agreed to make continuous data available to academic and industry seismologists.
- Opportunity to test new techniques with dense arrays.
- Data available by the end of July/August.



Sweetwater 3D Seismic Array



Sweetwater 3D Seismic Array



25 broadband stations

- 5 Polar Trillium 120PHQs (From NSF equipment at PIC)
- 21 Trillium Compact Postholes from Nanometrics
- Centaur digitizers from Nanometrics
- 25 Polar quick deploy enclosures

2639 nodes from NodalSeismic

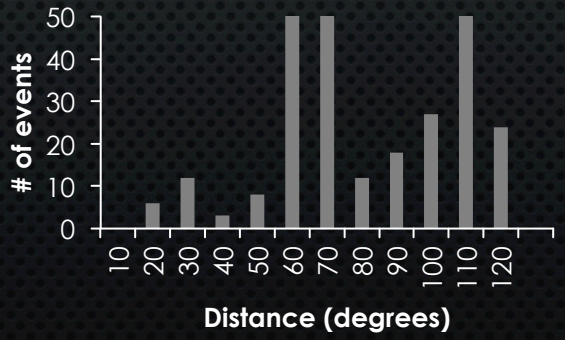
- 6" height - 5" diameter - 4.8lbs
- Single component vertical geophone
- 10 Hz natural frequency
- 2 week battery life
- GPS for timing
- 24 bit analog to digital converter

Sweetwater 3D Sources

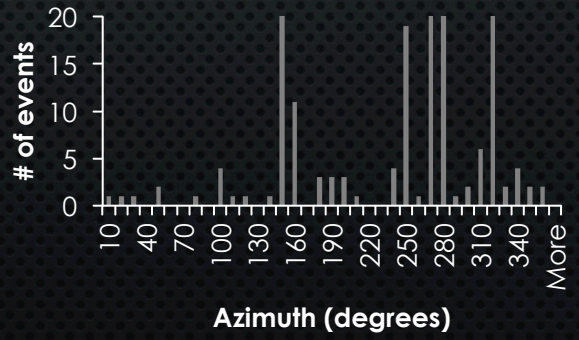
- Vibroseis sweep
- Teleseismic Earthquakes
- Injection wells
- Oil Pump Jacks
- Microseismic earthquakes
- Large wind farms
- Fracking wells
- Roads
- Farm machinery
- Trains

Teleseismic EQs	
M>8	1
M>7	6
M>6	27
M>5	267

Distance Distribution of Teleseismic Events

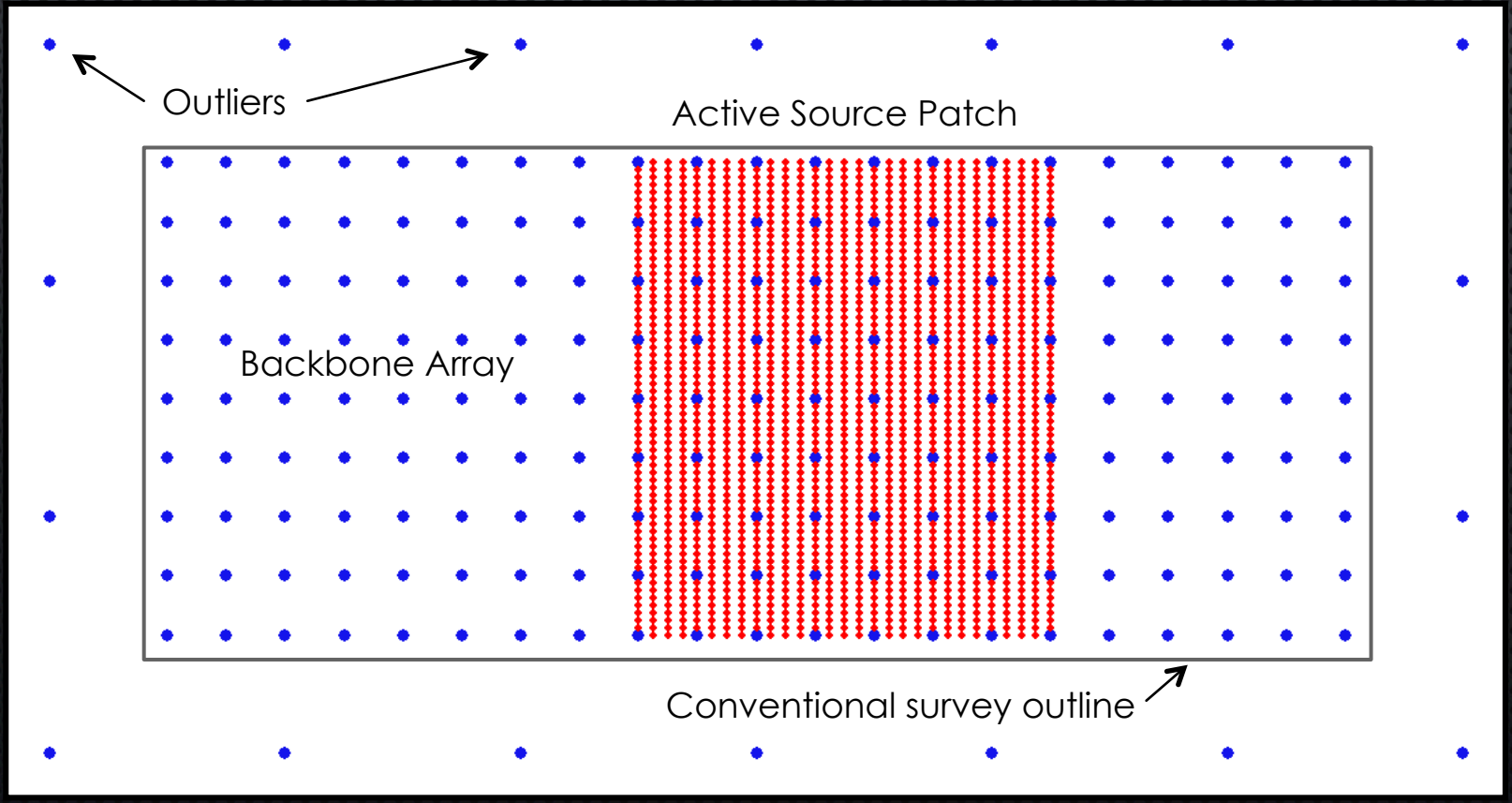


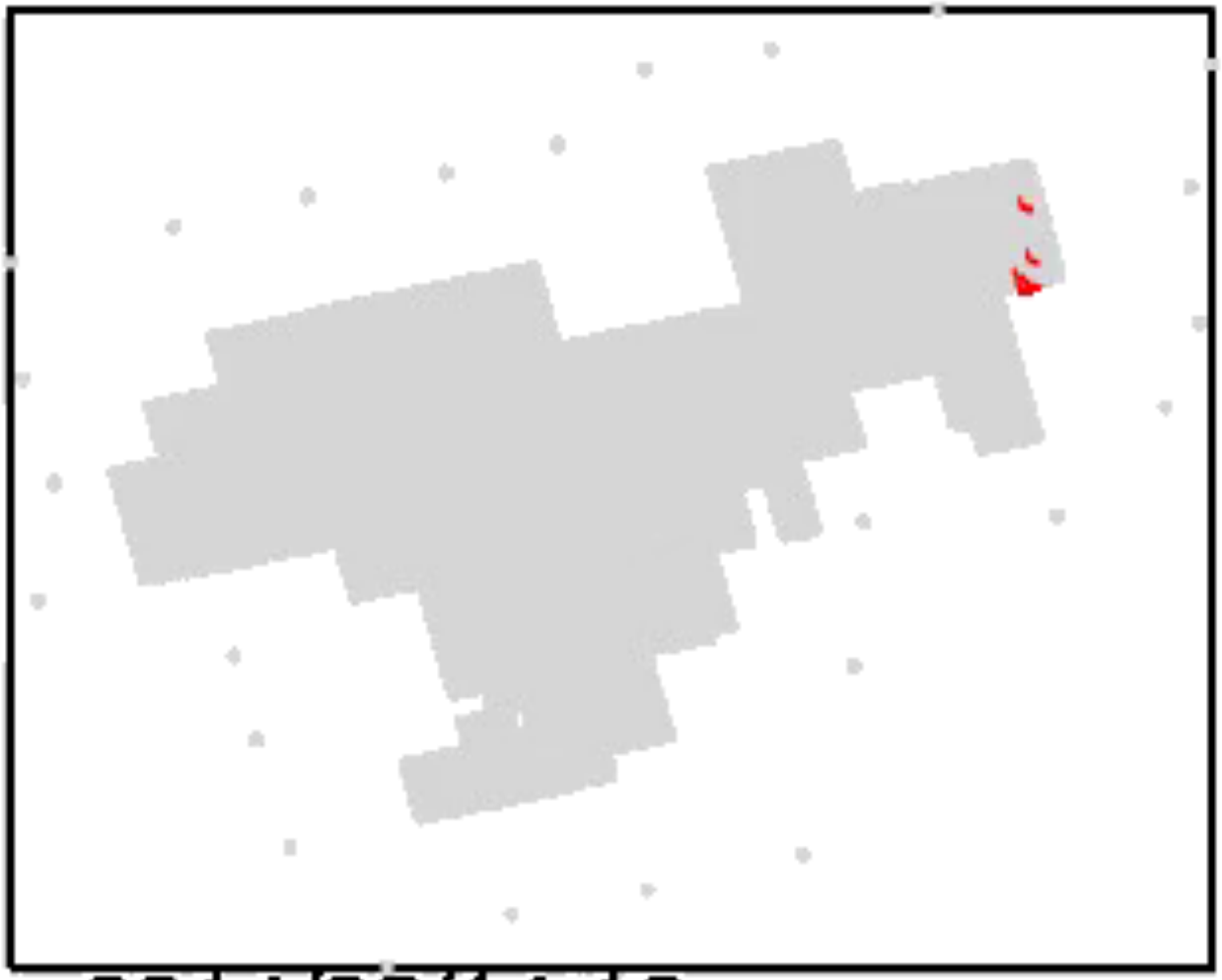
Azimuth distribution of Teleseismic Events



Survey Design

- Background Array – Prvents gaps in areal coverage for large surveys during receiver line roll
- Outlier Array – Provides additional far offsets and valuable edge constraints for passive data analysis



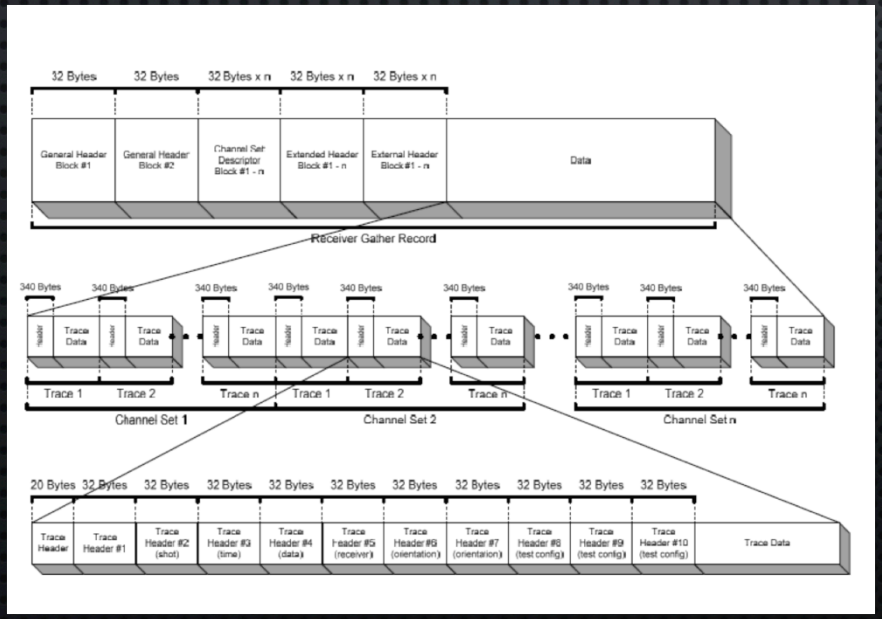

2014/03/14:19
5

DATA ACQUISITION

- ARE THERE OTHER ELEMENTS TO SURVEY DESIGN THAT MAY IMPROVE PASSIVE DATA ANALYSIS?
- ARE THERE ADDITIONAL TYPES OF SENSORS THAT WOULD ADD VALUE TO THIS DATA?
  - 3C, STRONG MOTION SENSORS, MICROPHONES, DAS, STRAIN SENSORS, ROTATIONAL SENSORS, ETC
- IS THERE A WAY TO USE CONTROLLED SOURCES WITH LOW FREQUENCY CONTENT (<2HZ)?

DATA MANAGEMENT

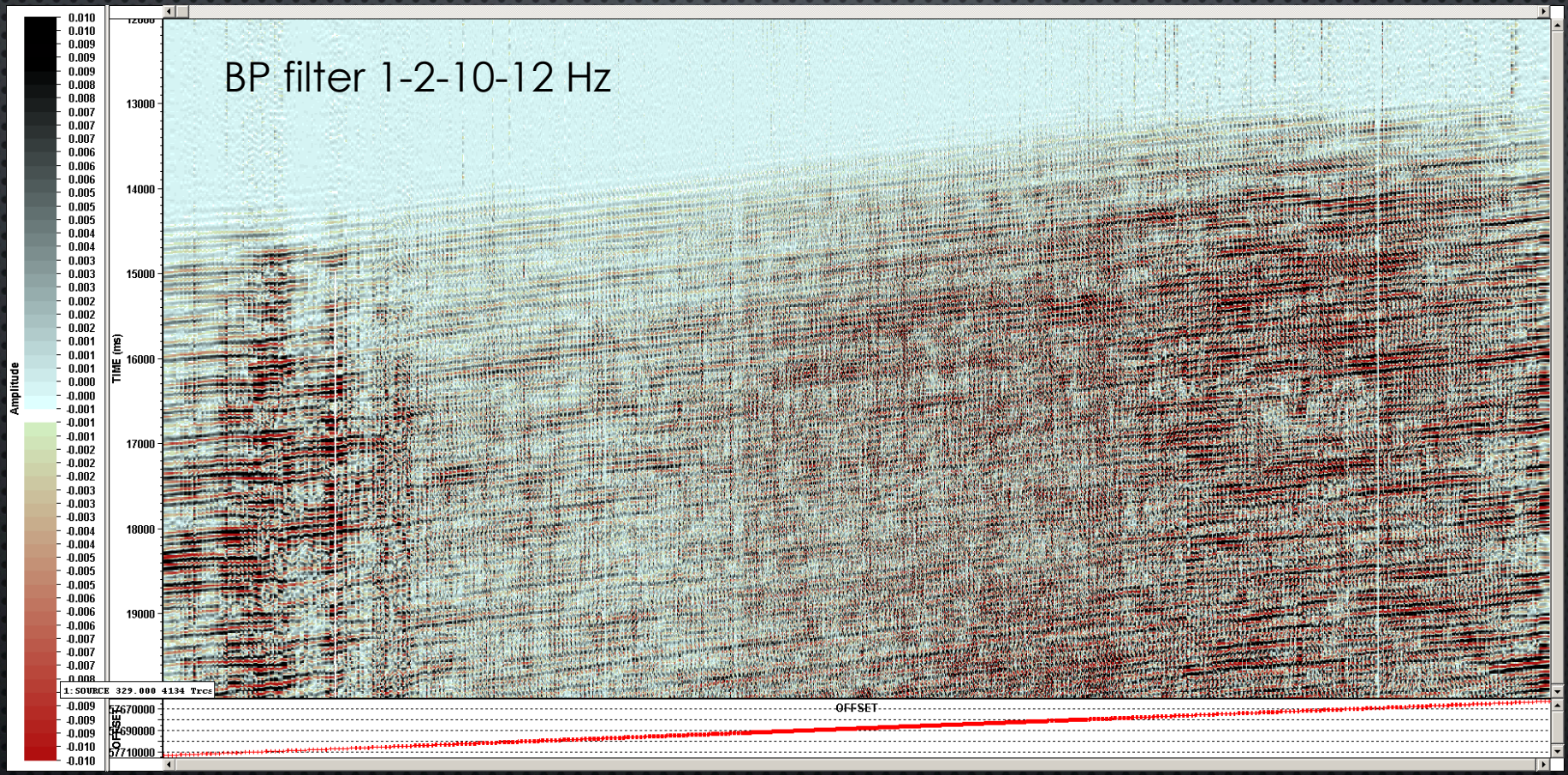
- End of Survey – Extract Data From Nodes
- Write Data To External Disk
  - Sweetwater 3D – 85 500GB hard drives
- Copy data to HPC for analysis (~35TB)
- Make Backups and archive
- Convert to useful format for analysis



DATA MANAGEMENT

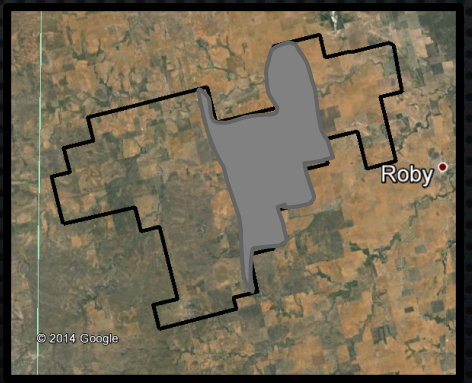
- What data format is best suited for these type of surveys?
- How to get instrument manufacturers to deliver these formats out of the box?
  - Pisces, (NetCDF, HDF5, and ADIOS), SEED, SEGY/SEGD, Integer or Float, Other?
- Where to House these large datasets?

M4.3 earthquake in Oklahoma



- 4193 traces displayed using variable density plot
- First few seconds of P-wave arrival shows significant variation beneath the array

M4.3 earthquake in Oklahoma

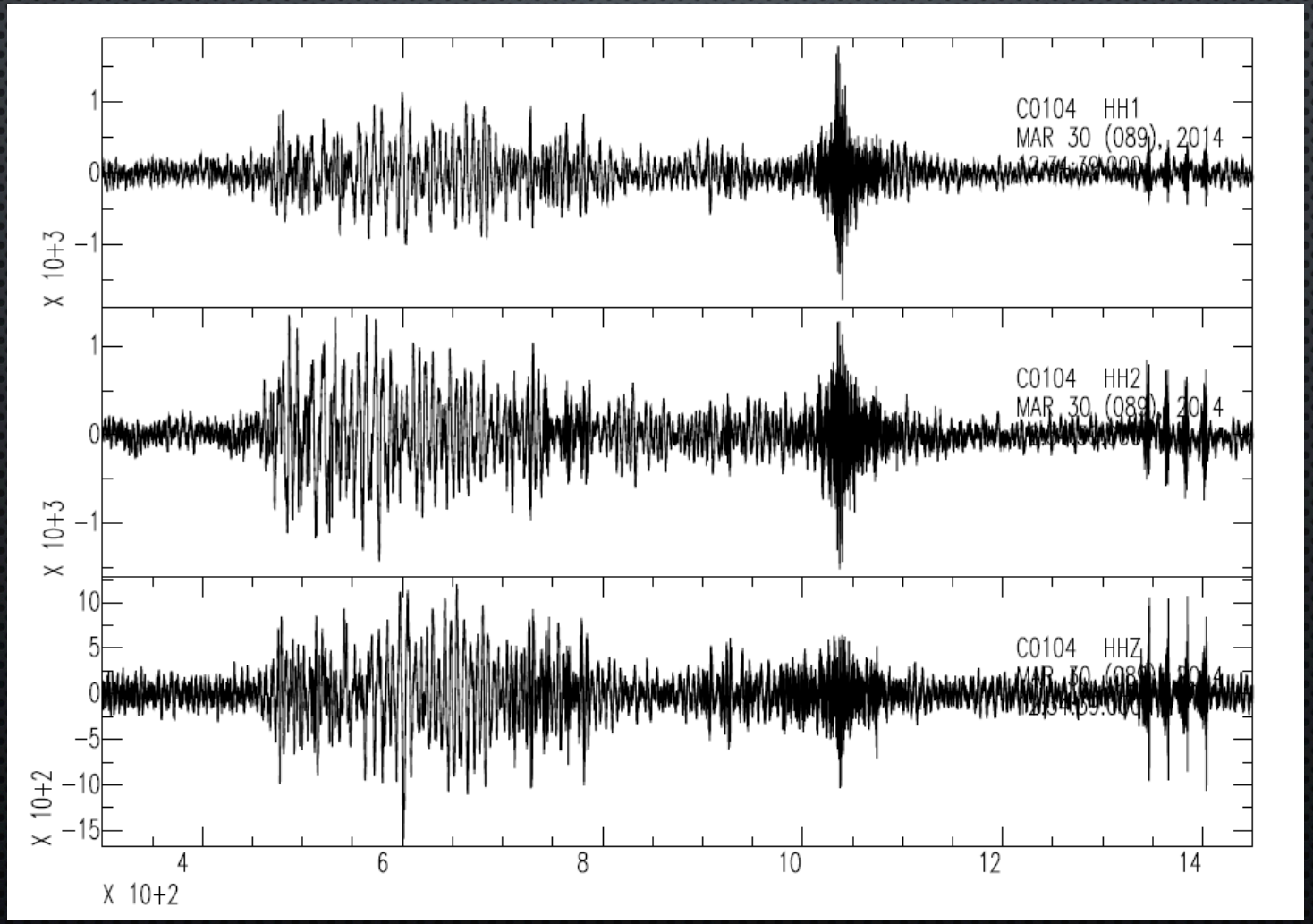


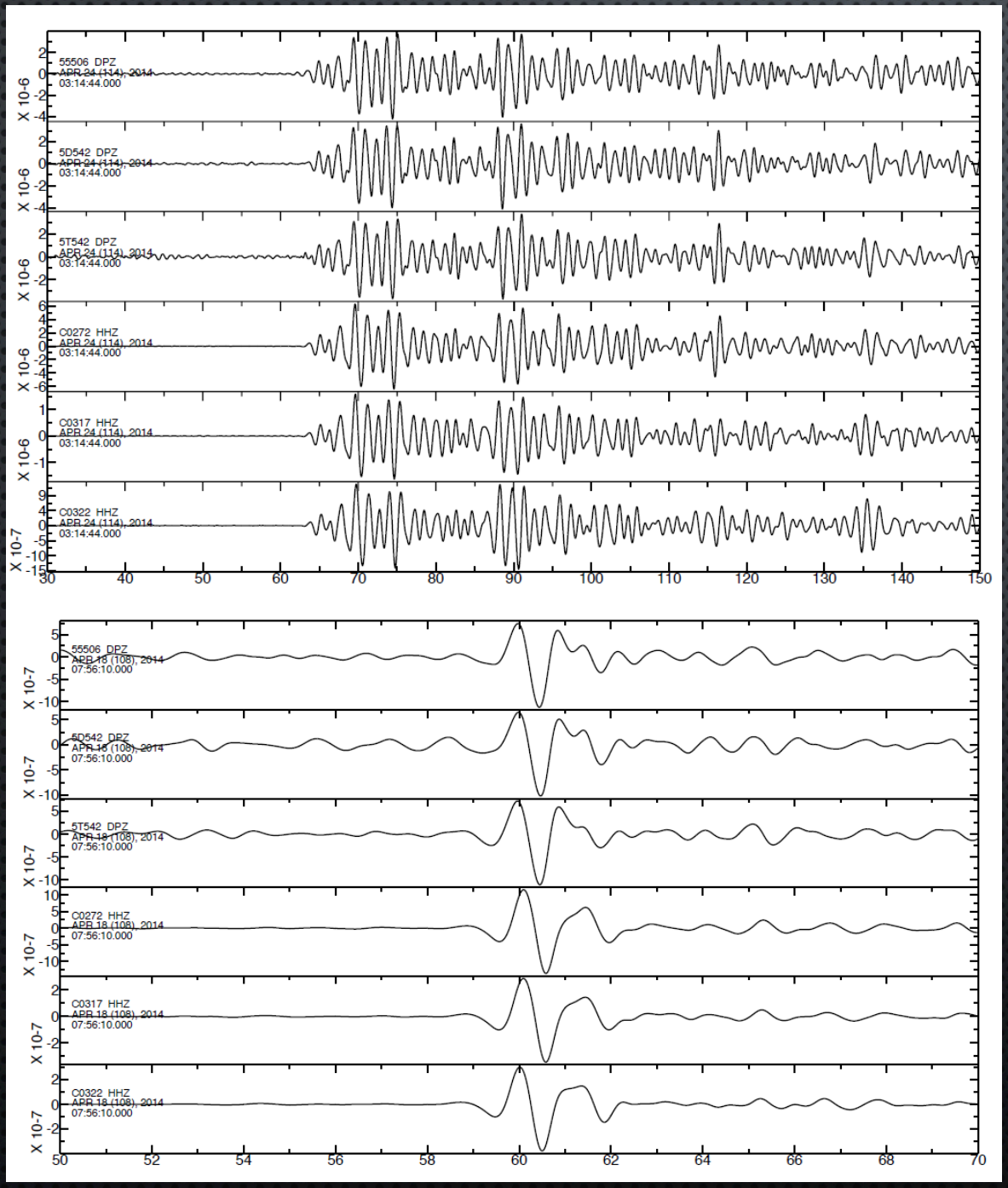
MULTI-SCALE IMAGING

Yellowstone Teleseismic

Oklahoma Regional

Vibroseis Local





Node Data

Broadband

M6.5 Canada

All traces instrument corrected and bandpass filtered 0.3-1 Hz

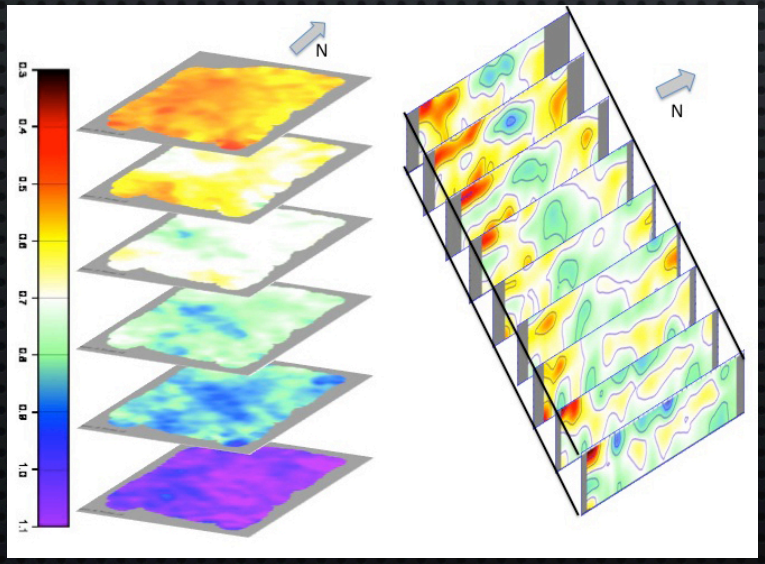
Node Data

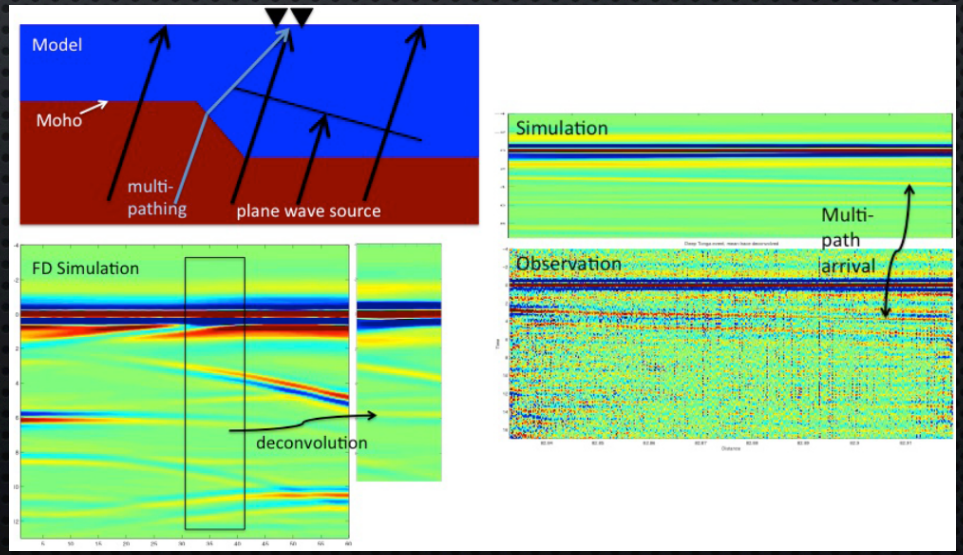
Broadband

M5.2 Argentina

DATA ANALYSIS

- What strategies are available for imaging reservoirs with surface waves?
- How can we utilize nearby wind farms to image the subsurface?
- Can the Broadband data be utilized to constrain early iterations of a full waveform inversion?





Conclusions

- The sweetwater dataset is available via the IRIS DMC
  - Network XB – open access
  - Network 1B – Restricted (email dan.hollis@nodalseismic.com)
- Presents a unique dateset available for testing large-n data analysis techniques
- Node data can be used to supplement and enhance temporary broadband areas to aid body wave tomography, receiver functions, scattered wavefield imaging, etc