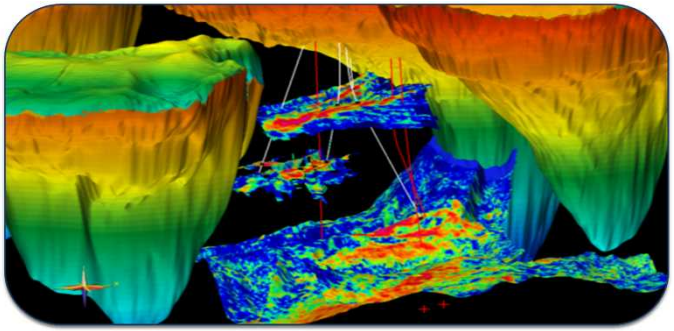
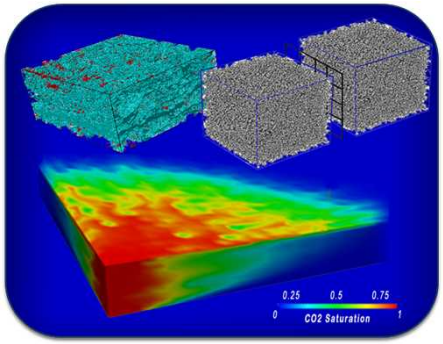
SAND2016-10723PE

Exceptional service in the national interest

Sandia National Laboratories





Geophysics Capabilities Brief

Leiph Preston

Robert Abbott, David Aldridge, Nedra Bonal,
Hunter Knox, Chester Weiss

Geophysics Department

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

Sandia National Laboratories is a multi-mission laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. SAND NO. SAND2016-1140 PE

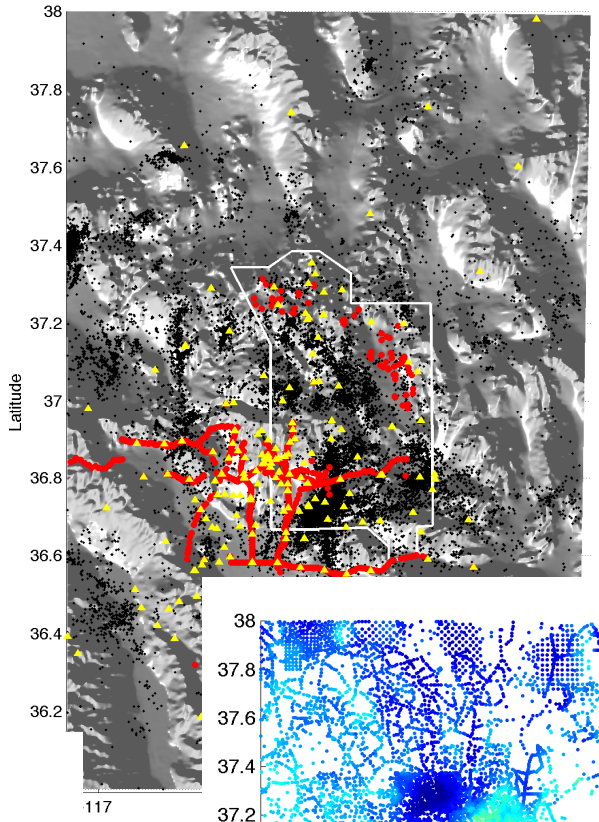
Capabilities Summary

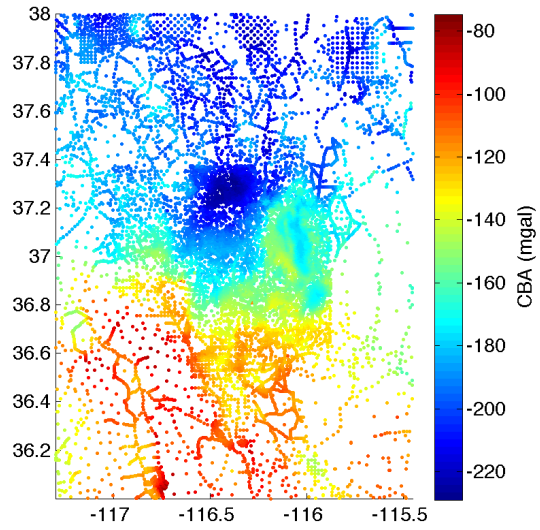
Sandia National Laboratories

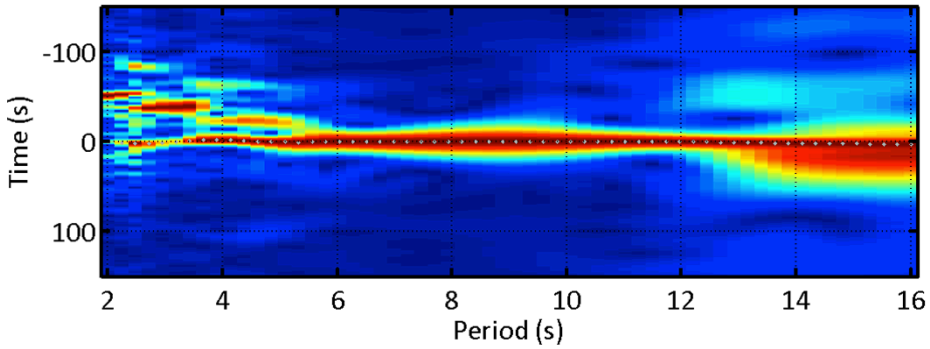
- Field data collections for active and passive seismic, acoustic, electromagnetic deployments
- Long- to short-term passive monitoring, array design, measurement tool development, and data processing
- Earth material characterization in complex, real-world environments including underground structures
- Source inversion, characterization, and localization
- Modeling and simulation tools for seismic, acoustic, electromagnetic, and hydroacoustic physics in realistic 3-D environments using massively parallel design

Geophysical Characterization for SPE

- P- and S-wave travel times from earthquakes and active sources
- Surface wave dispersion curves
- Surface observations of gravity



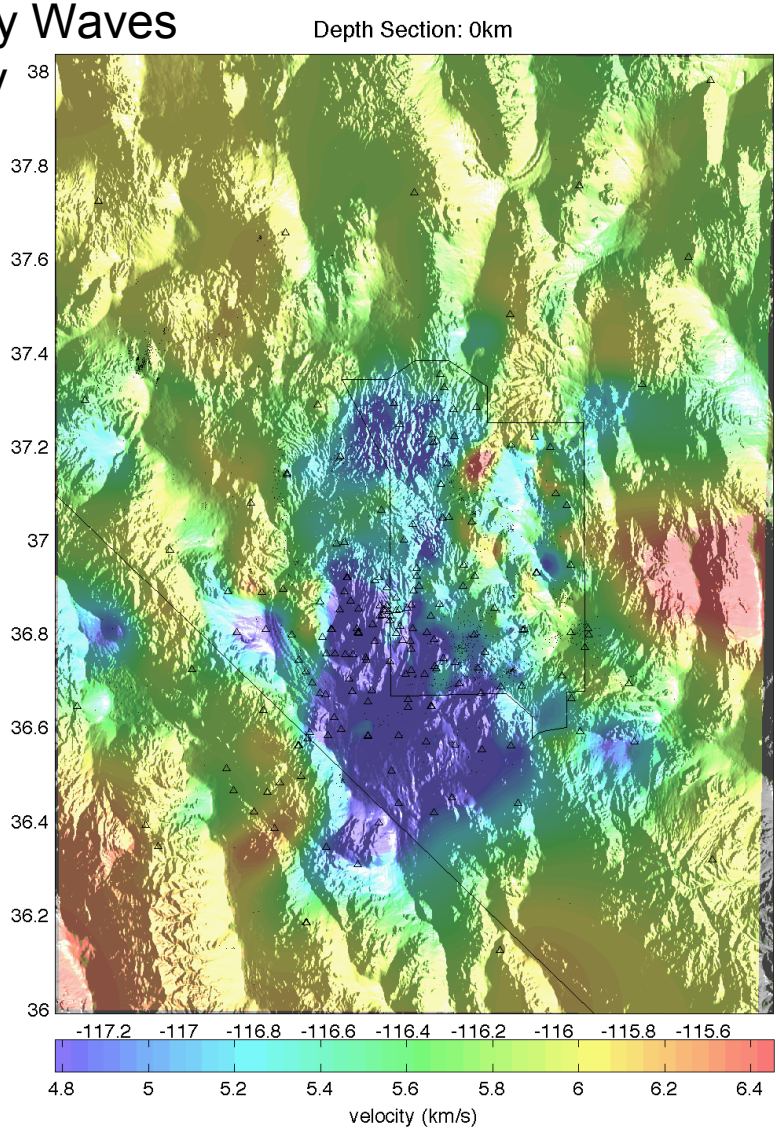




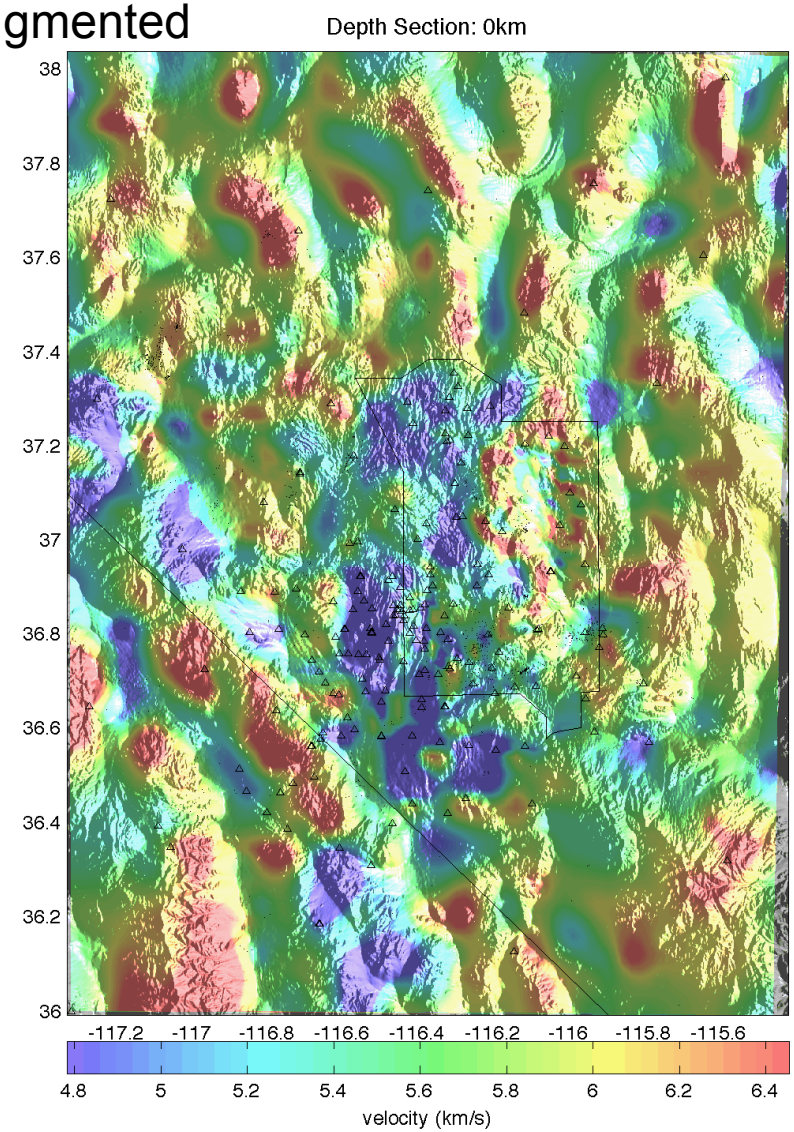
Effect of Gravity and Surface Waves

Sandia National Laboratories

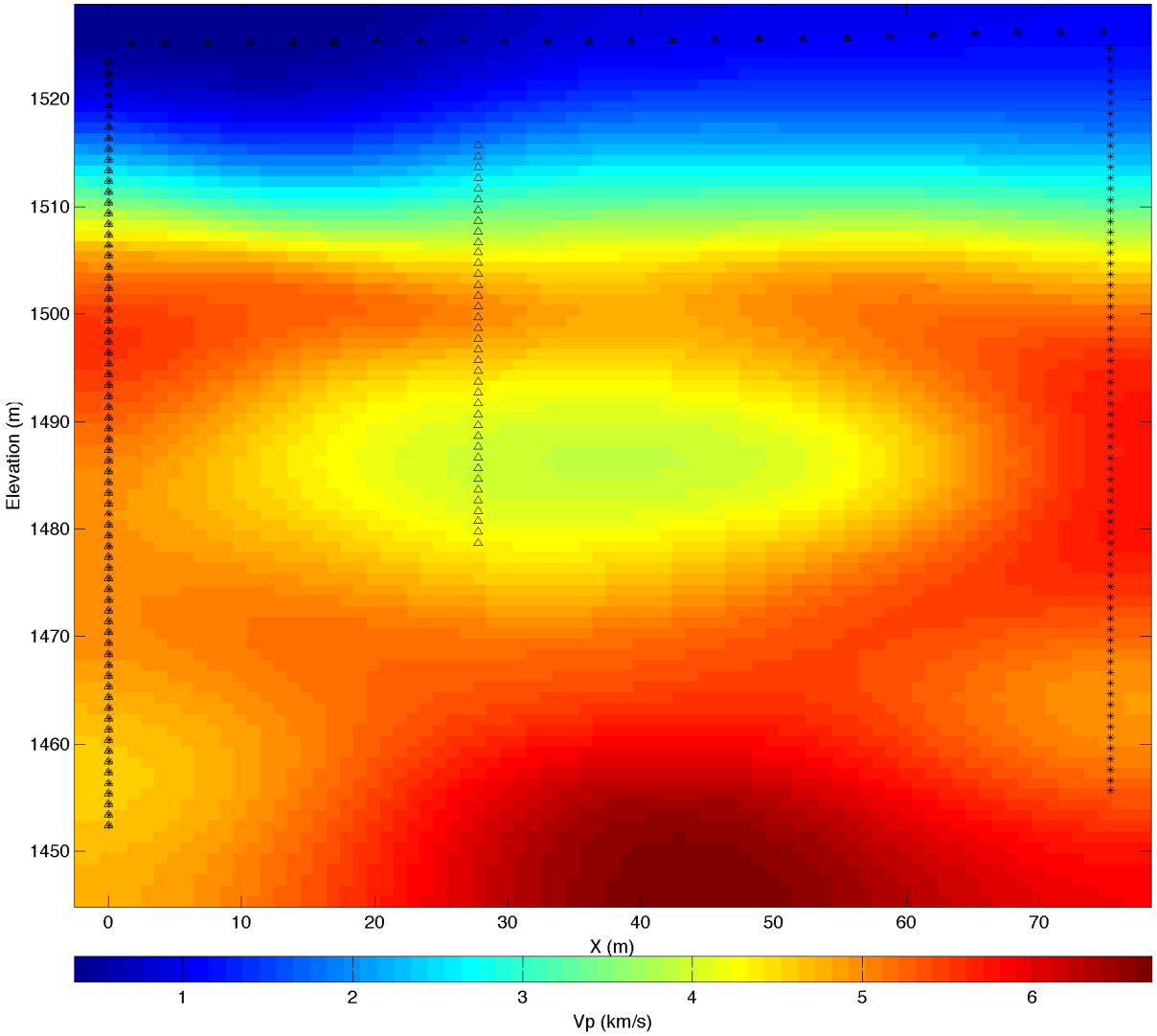
Body Waves Only



Augmented

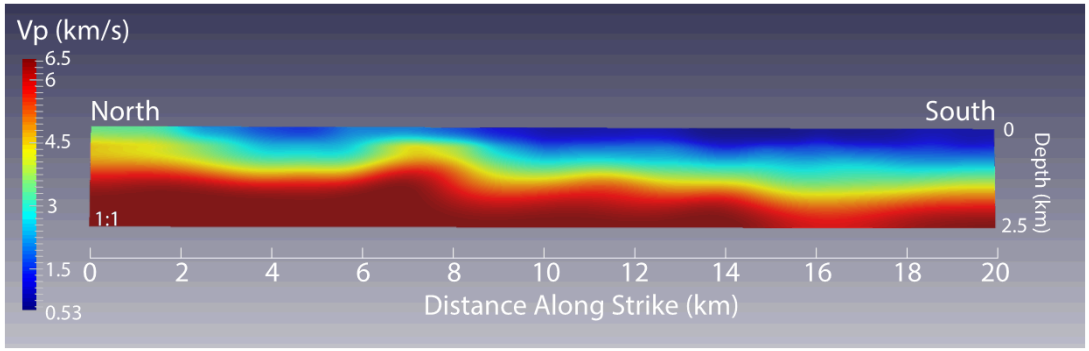


Cross-Borehole Tomography



Unique Seismic Sources

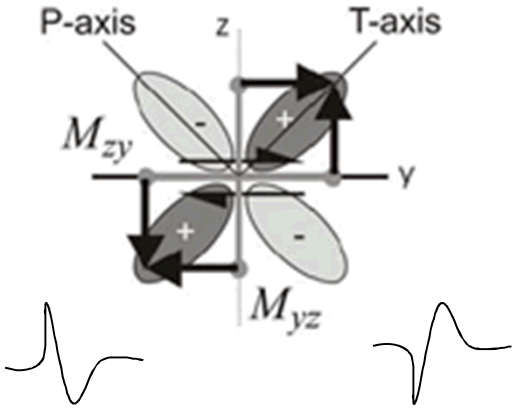
- Seismic Hammer™
  - Prototype weight-drop seismic source
    - 13,000 kg drop mass
    - 191,000 Joules of potential energy
  - Suitable for deep tunnel detection
    - Stackable for excellent signal-to-noise ratio
    - Deployed on surface, no drilling
    - Wide energy band, excellent low frequency generation

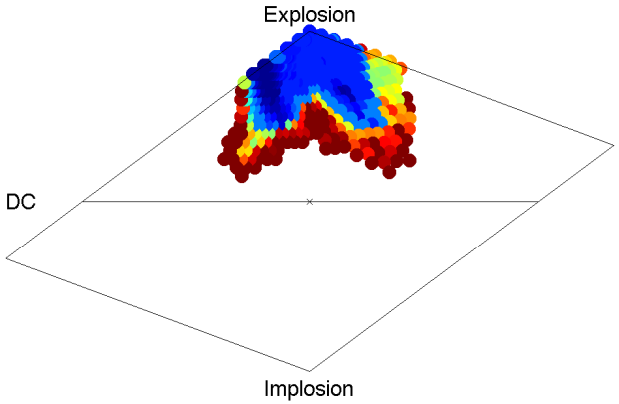


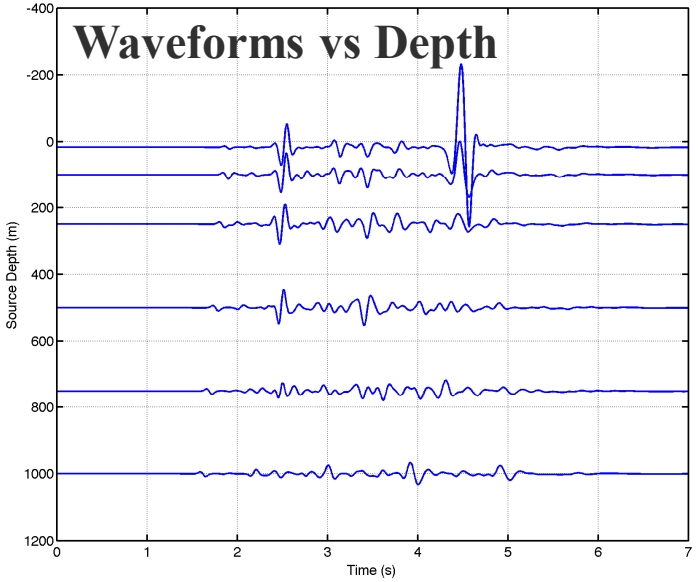
Yucca Flat Nevada

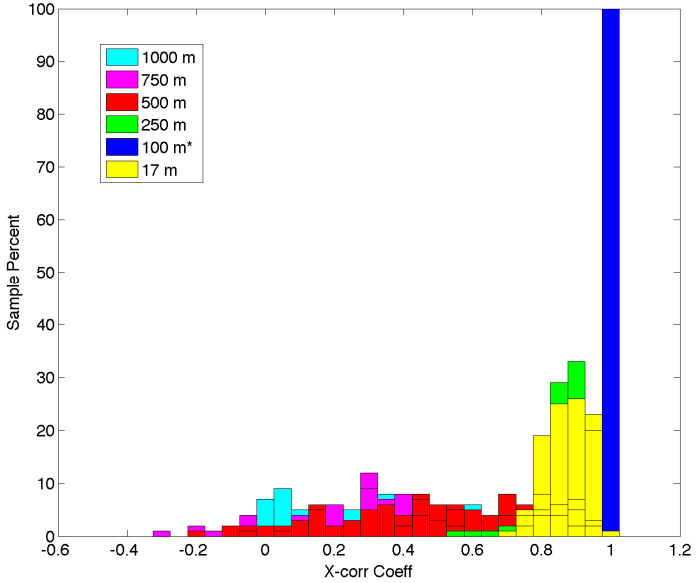
Seismic Hammer™ in Nevada

Seismic Source Inversion



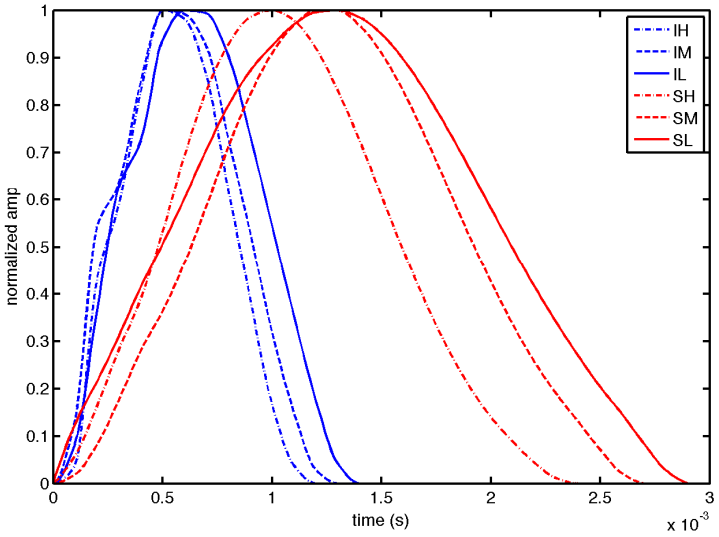




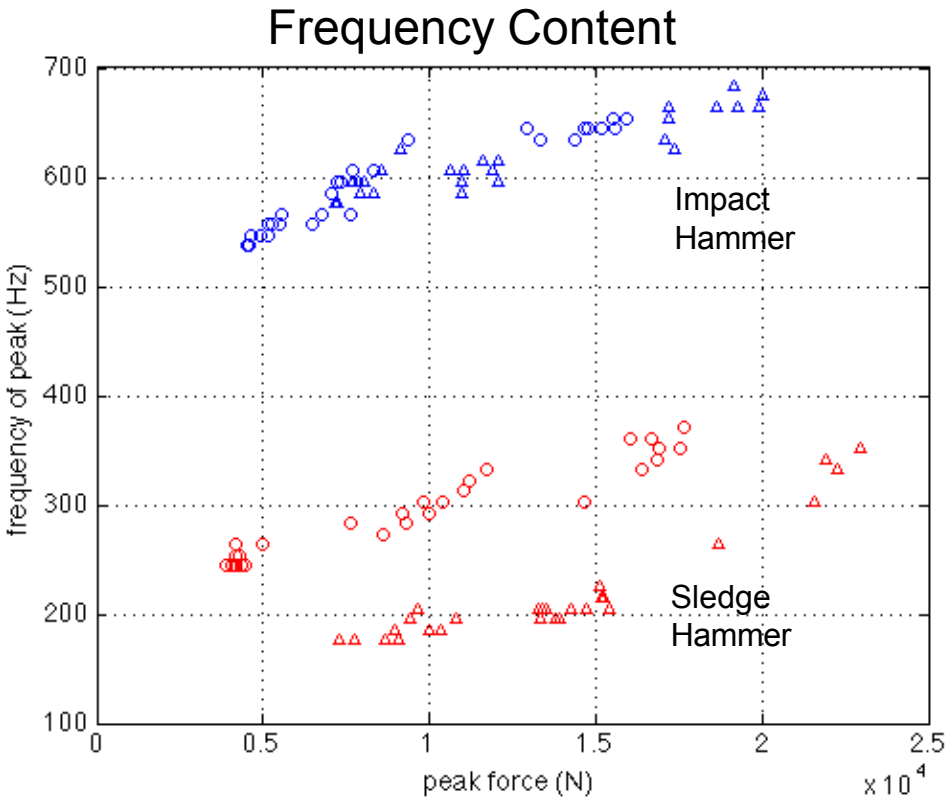


Tunnel Source Investigations

- Study frequency content and source time functions of common hand-held tools in tunnel excavations as a function of impact force



Source Time Functions



Geophysics Modeling Codes

Sandia National Laboratories

Describe the business and sponsor:

What is the capability?

- ***3-D seismic wave propagation***
  - ***ORTHORHOMBI – orthorhombic elastic media (up to 9 elastic moduli).***
  - ***PRELASTI – isotropic elastic medium subject to an ambient tectonic stress field.***
  - **ELASTI-ACUSTI – *Simultaneous elastic-acoustic wave propagation simulation in 3D mixed solid-fluid models (i.e., atmosphere overlying earth, or ocean overlying solid sub-seabed).***

Demonstrate customer driver to facility need:

What are the past/present/future NNSA mission applications?

- ***Application to physics-based modeling and analysis of Source Physics Experiment (SPE) seismic data supporting global nuclear explosion monitoring, treaty verification, and nuclear nonproliferation efforts.***

Demonstrate value of facility to customer program:

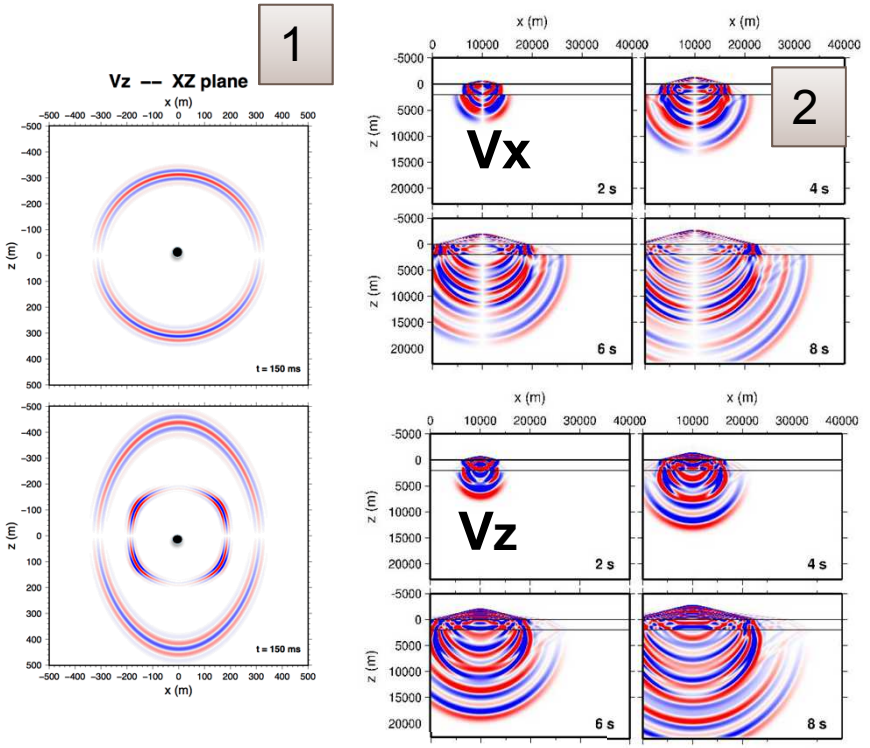
What are the major mission challenges this capability addresses; what is unique about the capability?

- **ORTHORHOMBI & PRELASTI - Provides a partial answer to fundamental SPE question "Why do buried nuclear explosions generate so much shear wave energy?"**
- **ELASTI-ACUSTI – Fully coupled elastic-acoustic wave propagation within a two-phase medium is achieved with high accuracy and efficiency.**

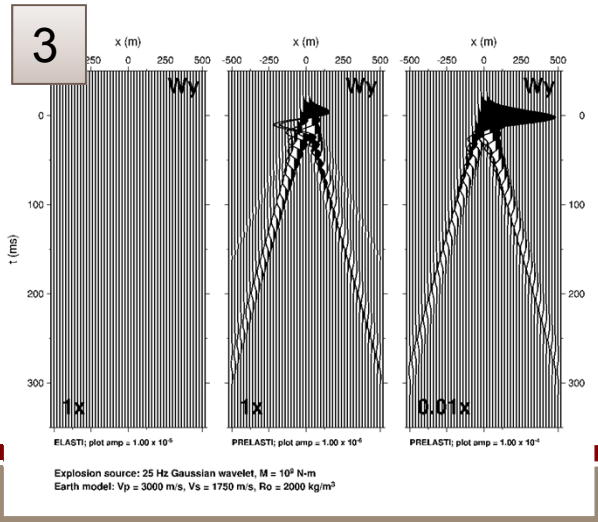
Describe link to NNSA

What specific NNSA past/present/future missions?

- ***Links to past/present/ future SPE projects and improved physics-based models for characterizing underground nuclear explosions, in general.***



Horizontal Receiver Array – Wy Traces



Rotation rate receivers particularly effective at detecting S waves.

Parelasti

Describe the business and sponsor

- 3-D massively parallel full waveform elastic and anelastic finite-difference simulation (multiple sponsors including NNSA, DTRA, industry, etc.)

Demonstrate customer driver to facility need

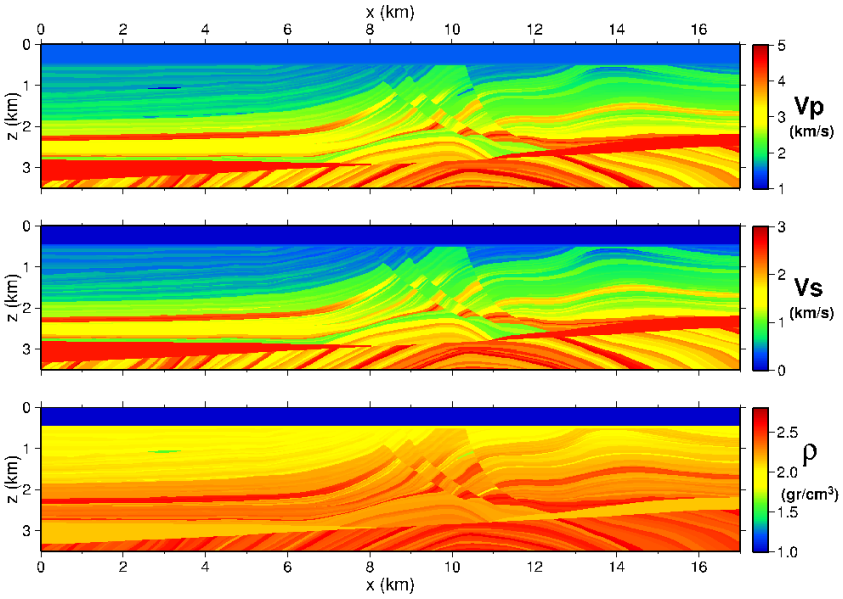
- Seismic source characterization, scenario modeling, subsurface characterization (e.g., for non-proliferation purposes)

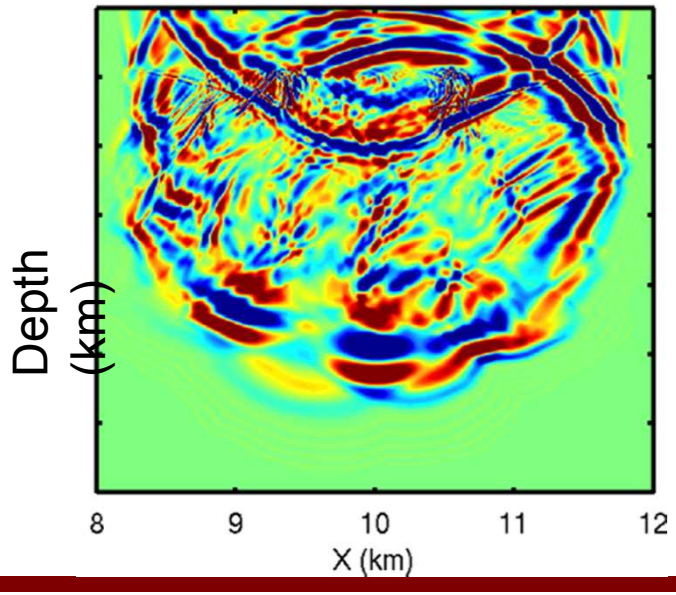
Demonstrate value of facility to customer program

- Seismic signal analysis for source characterization/identification forensics and predictions. Can utilize complex 3-D realistic geophysical models including underground voids.

Describe link to NNSA

- Past, present, and future uses for NNSA include non-proliferation scenario modeling, seismic signal prediction, and geophysical characterization of sources and underground structure.





TDAAPS

Describe the business and sponsor

- 3-D massively parallel full waveform acoustic, infrasound and hydroacoustic finite-difference simulation (multiple sponsors including DTRA, NNSA, DOE renewable energy, etc.)

Demonstrate customer driver to facility need

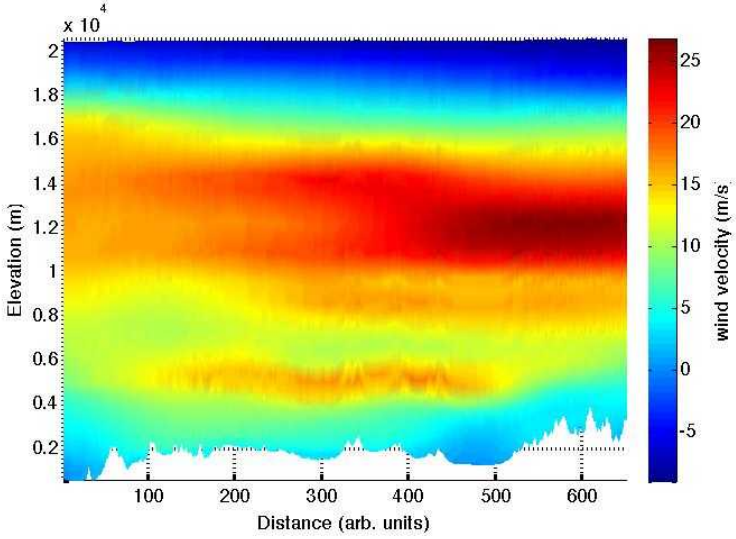
- Acoustic source characterization, scenario modeling in the moving atmosphere and oceans (e.g., for non-proliferation purposes)

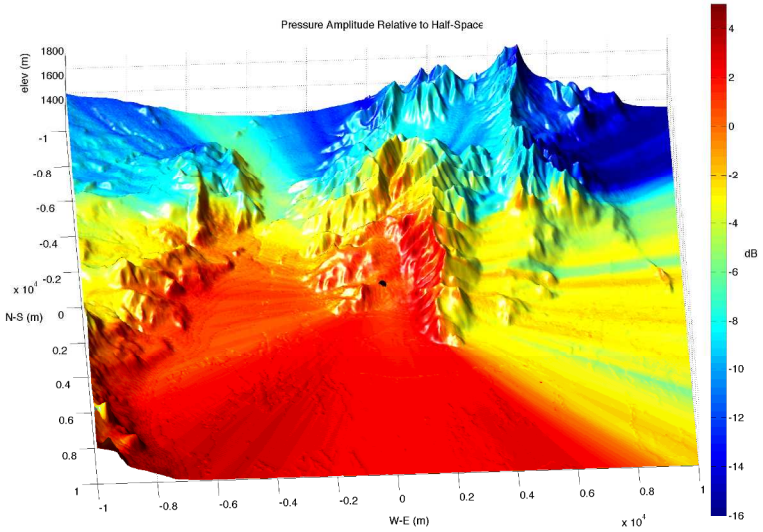
Demonstrate value of facility to customer program

- Acoustic signal analysis for source characterization/identification forensics and predictions. Can utilize complex 3-D realistic atmospheric models including winds.

Describe link to NNSA

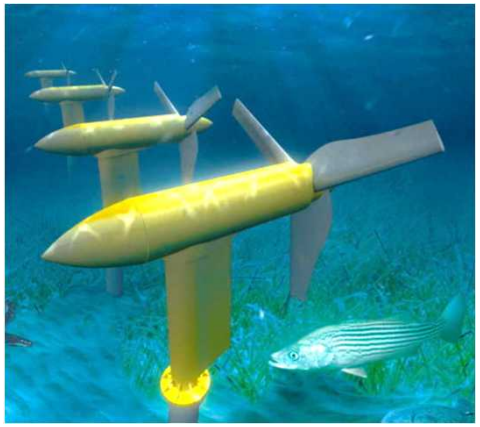
- Past, present, and future uses for NNSA include non-proliferation scenario modeling, acoustic signal prediction, and source inversion.



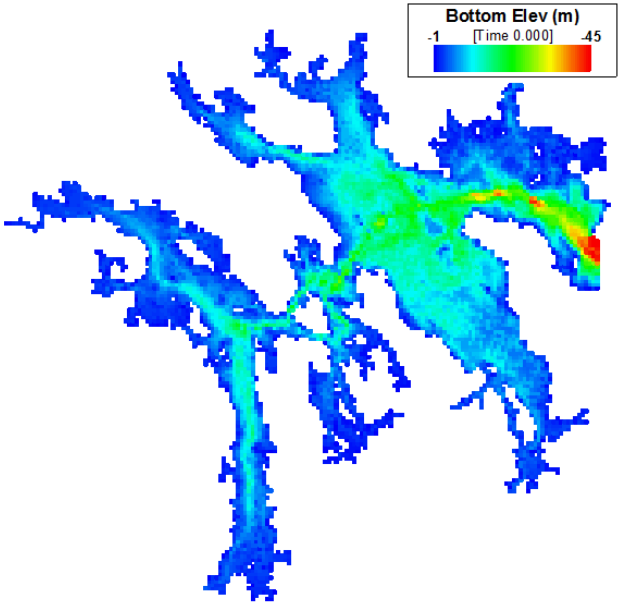


Hydroacoustic

- MHK- renewable source of energy from waves tides and currents
- 3-D models are needed for predicting noise generation and propagation of MHK devices
- Wide range of possible locations
  - Shallow-Deep Water
  - Complex bathymetries and domains
  - Varying salinity, temperature, sound speed, etc.
- Complex and wide spectra of noise
  - Low to high frequencies (<3 kHz)
  - Monopole, dipole, quadrapole contributions
  - Device and operation condition dependent
- Validation of the fixed acoustic algorithm is the first stage



www.verdantpower.com



Summary

Sandia National Laboratories

- Our toolset covers a wide variety of geophysical observables including seismic, acoustic, electromagnetic, hydroacoustic, and particle physics
- We provide capability from network planning, deployment, and data processing to modeling and simulation, source characterization and localization, and earth characterization
- We have experience in underground structure detection and characterization
- Current development activities include improving physics and computational efficiency for simulation algorithms, utilizing unique sources for geo-characterization, multi-physics data fusion, and data analysis in noisy environments