SnT 2019
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

Los Alamos NATIONAL LABORATORY EST. 1943

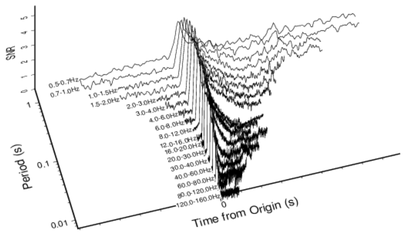
Source Models and Scattering Origin of Regional Phases from Coda Spectral Ratios

W.S. Phillips, wsp@lanl.gov; H.J. Patton, patton@lanl.gov; K.M. Cleveland, mcleveland@lanl.gov; C. Larmat, carene@lanl.gov; Los Alamos National Laboratory

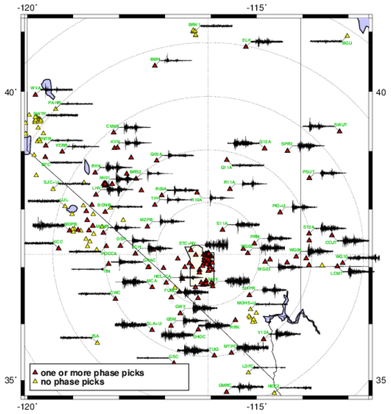
T2.3-P24

Goals and Objectives

- Apply high precision coda techniques to test, and improve source models, using ground truth explosions
- Understand wave propagation from the near source region to typical monitoring distances



SPE-5, Z, BP 4-8 Hz, 12-2 km/s, 100 km rings

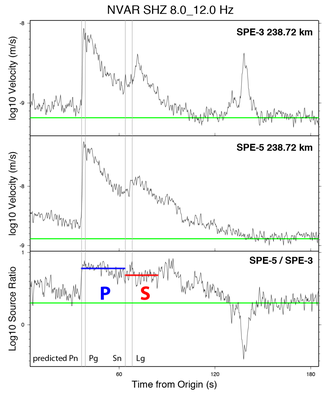


Introduction

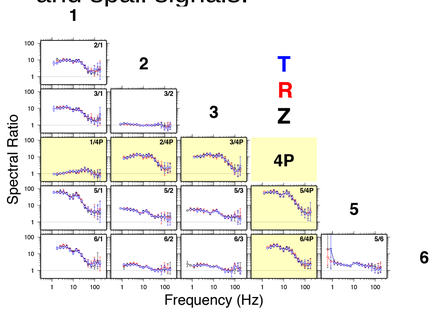
An important goal of monitoring research is to enable broad area discrimination and yield estimation. This requires source and path models relevant to any future nuclear test. Studies of well recorded, ground truth explosions allow us to test existing models and develop new ones.

Methods

Coda are scattered waves that allow high precision measurements due to their redundancy and relative insensitivity to path effects. We form coda spectral ratios between sources to study sources without complications from path and site effects.



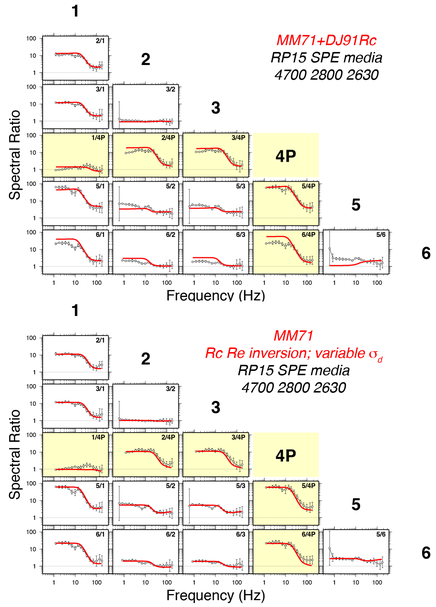
From the six Source Physics Experiment (SPE) explosions we measure ratios for all source pairs, using near-source recordings. Results are independent of component of motion. We observe distinct modulations, likely the result of interference between explosion and spall signals.



Major Findings

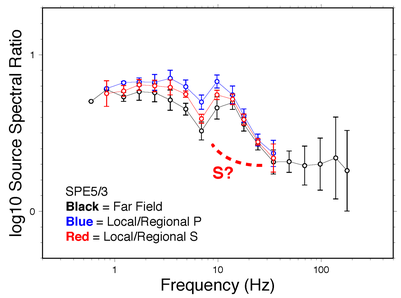
Source Models

A combination of MM71 and DJ91 models fits spectral ratios better than either model alone. Allowing cavity and elastic radii to vary fits ratios to within errors.



Regional Results

Once SPE-5 occurred, we could take ratios between events of different sizes at regional distances. In addition, P and S phases could be analyzed separately. Results are similar to those of near-source recordings, including the observed modulation.



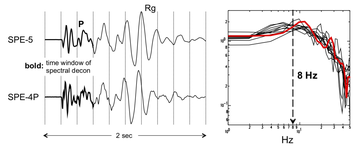
Discussion

Fisk Conjecture

The Fisk Conjecture is an empirical observation that P and S corners differ by their velocity ratio for nuclear explosions. This effect is not observed for SPE Phase 1 explosions, based on the similarity between P and S spectral ratios we observe at regional distances.

Spectral Modulation

We do not see modulation in spectral ratios of P waves from near source recordings. This leaves interference between prompt and late damage (spall) in the larger explosion as the most likely cause of the modulation. This is not predicted by classical source models.



Scattering Origin of Regional S (and P)

The modulation of observed for near-source Rg has been imprinted on the regional P and S phases, indicating that the latter phases arise from scattering of the near-source Rg into body waves that propagate to monitoring distances.

Impact

We have presented modified source models that perform better than classical models for small, shallow, overburied explosions in granite media.

Yield estimation of such explosions based on regional recordings must include quantitative estimates of near source interference between prompt and damage Rg, and the scattering of Rg into body waves.

If near-source Rg is the source of regional P and S, the scattering mechanism cannot account for the observed, relative effectiveness of high versus low frequency P/S ratios that we use for discrimination.

Future Work

We must develop forward modeling methods to estimate explosion related damage and it's effect on radiated seismic waves.

We must also develop fast techniques such as radiative transfer that can be used in iterative inversions for stochastic parameters.

LA-UR-19-21771