Refraction Microtremor and Optimization Methods for Site Strength and Earthquake Hazard Assessments

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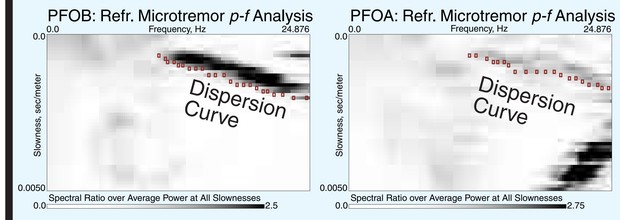
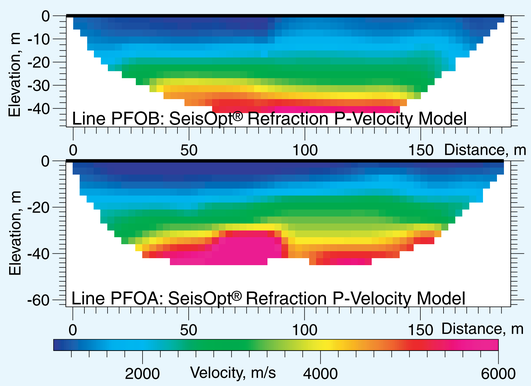
Refraction: Microtremor and Optimization

Methods

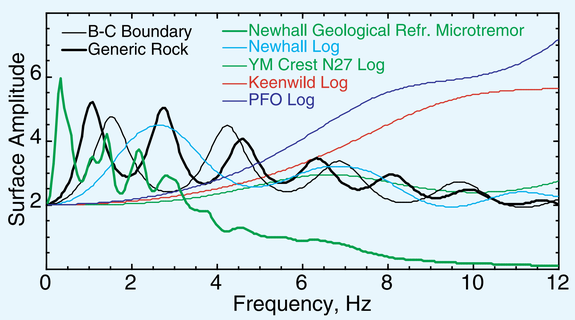
- **Refraction Microtremor** (*Louie, BSSA, 2001*): Noise on refraction array transformed to *p-f* space (below, gray), picked for dispersion, modeled for Vs with depth.
- **P-wave refraction SeisOpt®** (optimsoftware.com): Refraction arrivals optimized for 2-d velocity (below, color); horiz. averaged and converted to Vs using the Poisson-solid assumption.
- **Velocity Logs**: Downhole shear-wave profiles by Redpath or USGS (courtesy F. Vernon, UCSD); one hole with Rosrine OYO shear-velocity log.





Non-Generic Rock

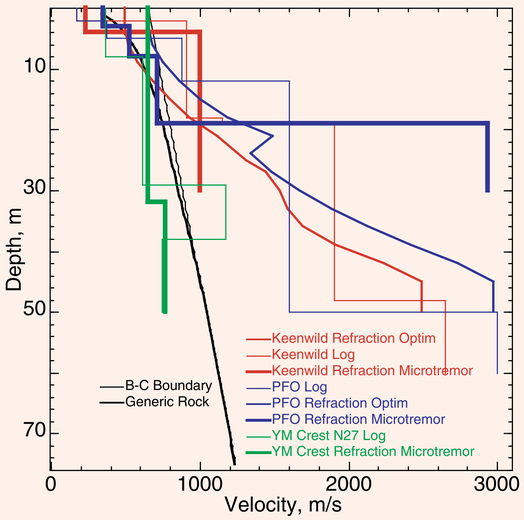
- "Generic Rock" of *Steidl et al.* is average of logs
- Keenwild and PFO logs are very different – Hard Rock
- "Generic Rock" implies deep soil as with Newhall log to 107 m



Borehole and Refraction Results

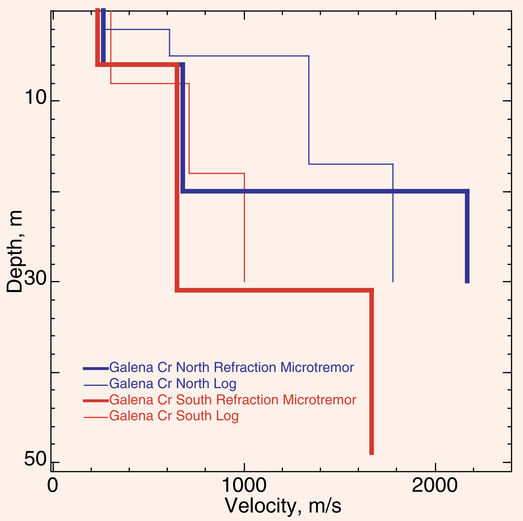
Velocity Data

- 3 sites with downhole Vs and refraction microtremor
- 2 sites with P-wave refraction SeisOpt®
- "Generic Rock" summary from *Steidl et al., 1996*
- B-C Boundary from *Frankel et al., 1996*



Reno I-580 Extension

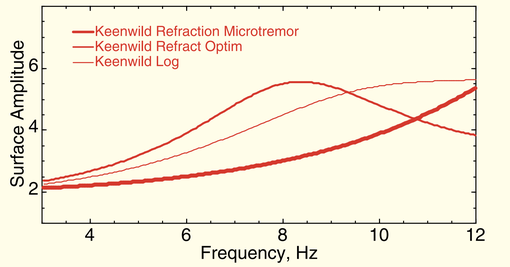
- Interstate extension requires concrete-arch bridge with 300-m span
- Redpath-logged holes at abutment sites
- Average Vs is a foundation design parameter



Model Spectra

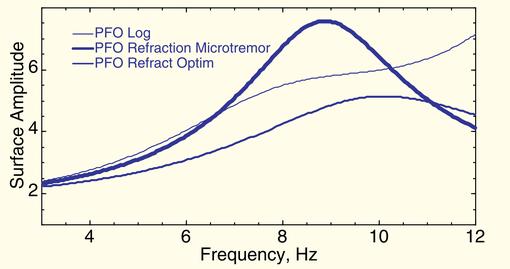
Keenwild – ***Hard Rock Site in the San Jacinto Mts.***

- Little data constraining response below 5 Hz
- Small details from borehole add confusion above 10 Hz
- Velocity gradient in refraction SeisOpt® gives 8 Hz peak



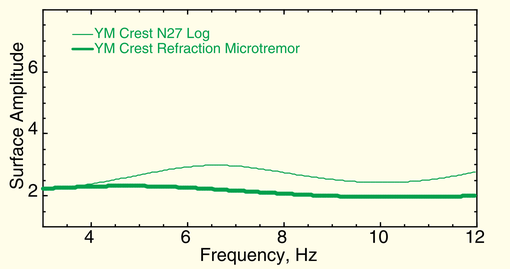
PFO – ***Hard Rock Site in the San Jacinto Mts.***

- Little data constraining response below 5 Hz
- Small details from borehole add confusion above 10 Hz
- Both refraction microtremor and SeisOpt® give 9-10 Hz peak



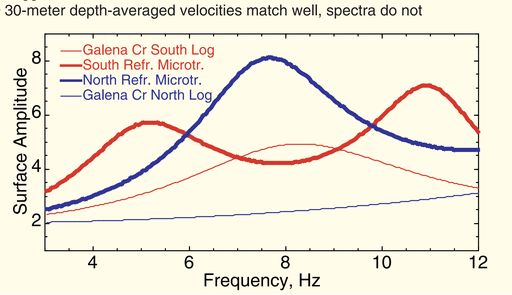
YM Crest – ***Yucca Mountain, southern Nevada***

- Almost no velocity gradient near surface
- No significant amplification in 3-12 Hz band
- Refraction microtremor data suggest but don't constrain velocity inversion



Reno I-580 Extension – ***Refraction Microtremor vs. Log Spectra***

- Refraction microtremor averages over 200-m-long section
- Logged boreholes are at ends of refraction lines
- 30-meter depth-averaged velocities match well, spectra do not

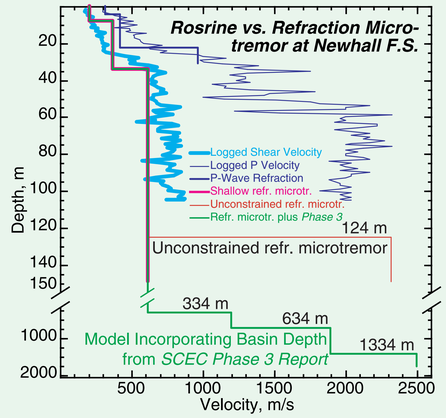


Results

- Velocity models estimated with refraction methods produce similar average velocities and spectra, versus models from borehole logging.
- The models must be estimated over the same depth intervals as the logs to produce similar spectra.
- Adding geological information to models suggests velocities from only the upper 100 meters are not adequate for estimating spectra.

Newhall – ***Rosrine OYO Log at Fire Station***

- Refraction microtremor matches log to 107-m logged depth
- Refraction microtremor suggested 124-m basin depth
- "Shallow refraction microtremor" avoids poorly constrained depth
- 1350-m basin depth from *SCEC Phase 3 Report* suggests a geologically realistic model



Newhall – ***Rosrine OYO Log at Fire Station, 107 m deep***

- Refr. microtremor could not constrain velocities below log depth
- To 100-m depth, log and refr. microtremor give same spectra
- Including basin depth from *Phase 3 Report* yields entirely different response