



Selected reference rock and issues for the CEUS

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SSHAC Workshop 2

Proponent Discussions and Remaining Critical Issues and Data Needs

Geotechnical Working Group

Next Generation Attenuation for CEUS (NGA-East)

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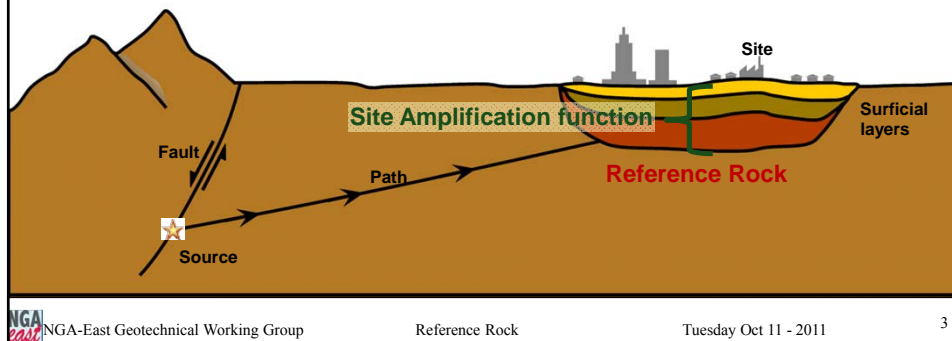
Outline

- Use of reference rock for NGA-East
- Current practice
- Collected data
- Data statistics and Proposed model



Use of Reference Rock for NGA-East

- It is the rock condition at which ground motion simulations will be conducted.
- The reference condition from which site amplification function(s) will be developed.



Current Practice EPRI (1993) $V_{s,ref}$

- P-Wave velocities from crustal models
- Divided CEUS into 16 regions
- Assumed Poisson's Ratio of 0.25
- Converted P-Wave velocities to S-Wave velocities
- $V_p = 4900$ m/s, $V_s = 2830$ m/s

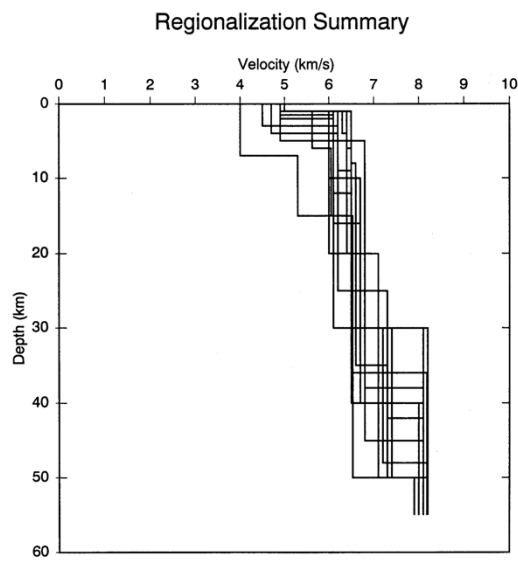
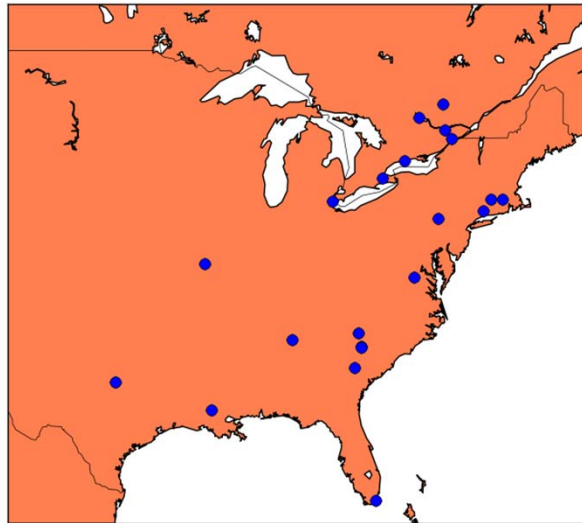


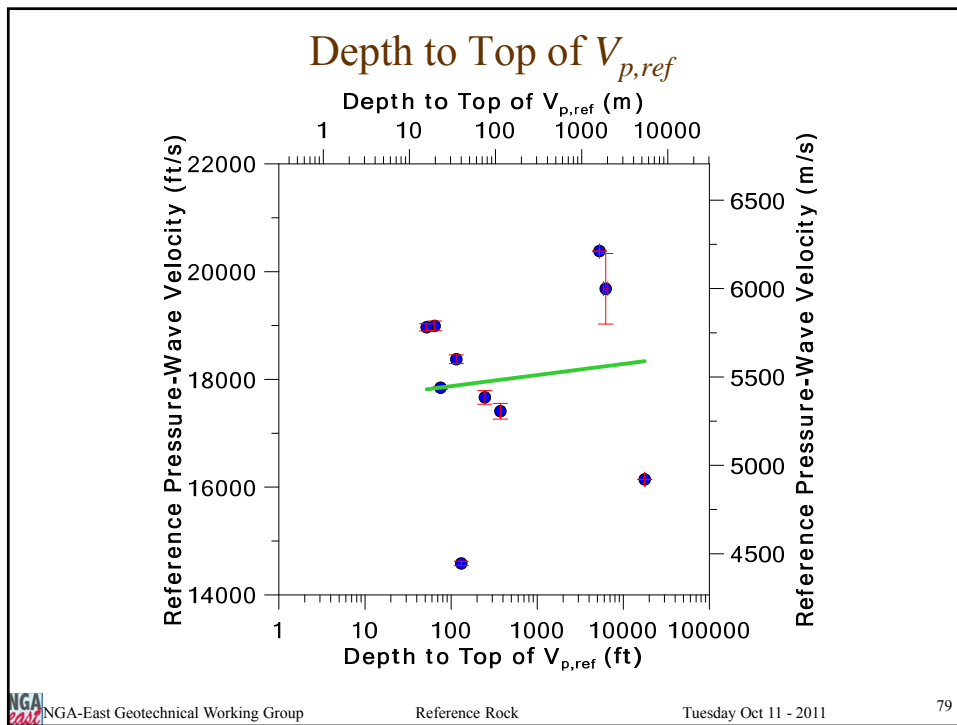
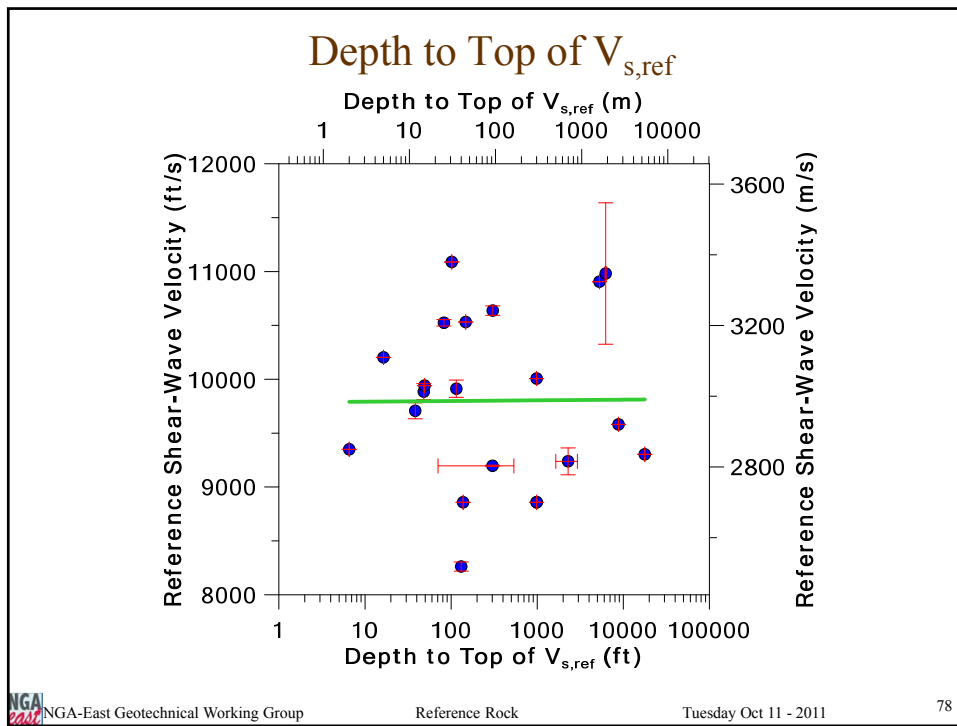
Figure 5-15. Summary of velocity models for the 16 regions shown in Figure 5-12.

Approach adopted to define Reference Rock

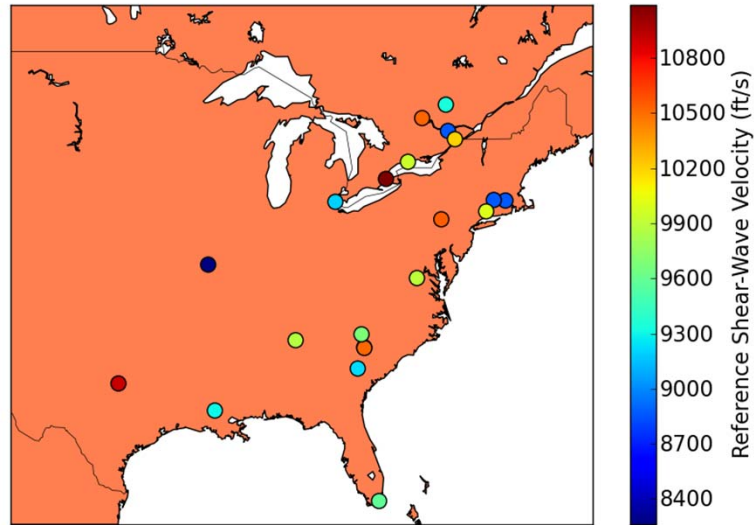
- Collected measured V_s and V_p data at CENA sites
- Collected corresponding geologic information
- Picked velocity values that are beyond a weathered (transition) zone in the rock where it exists.

Geographic Distribution of $V_{s,ref}$ Data

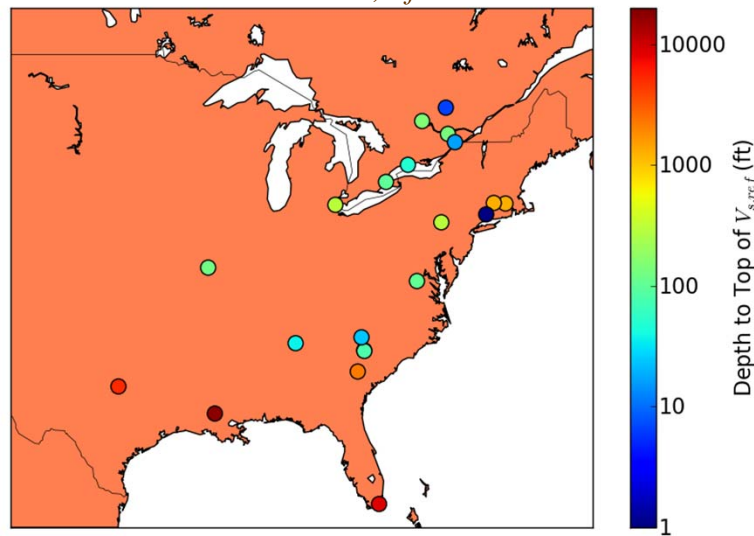


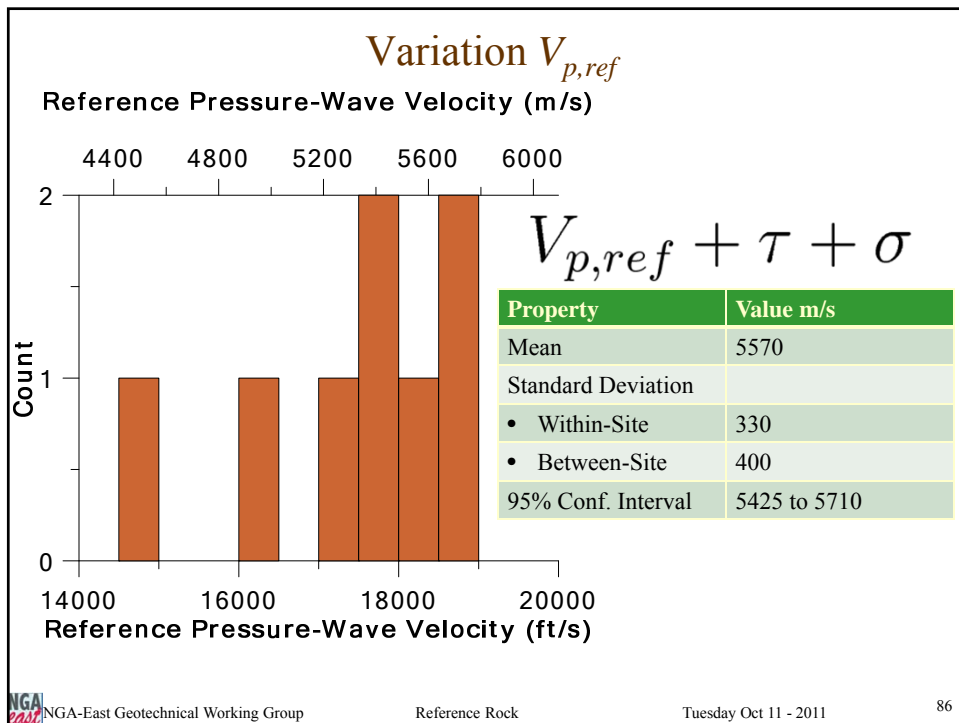
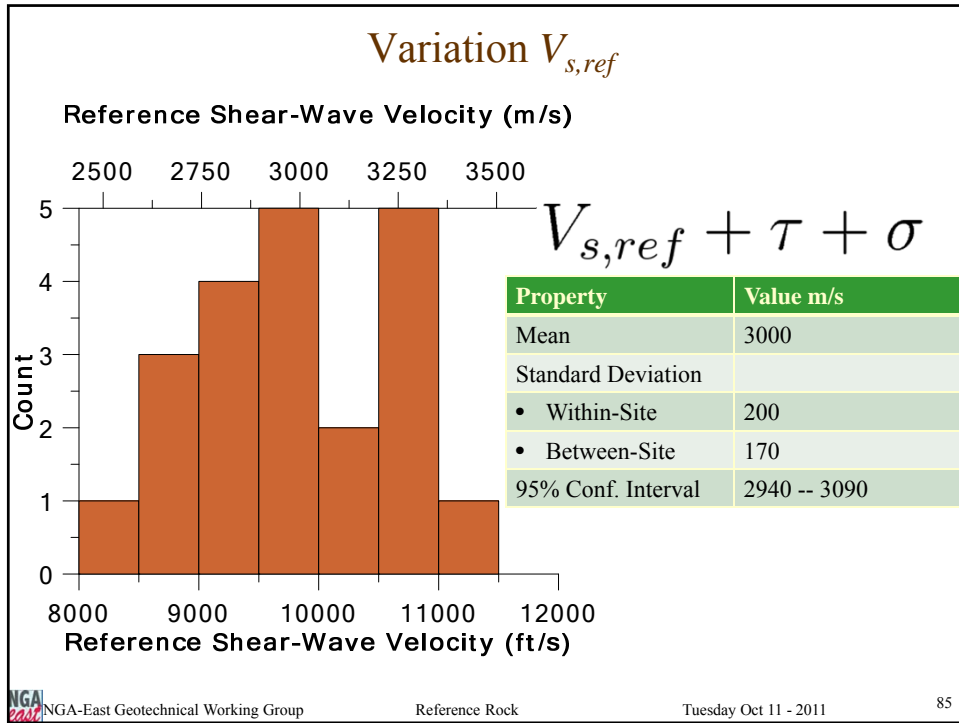


Geographic Variation of $V_{s,ref}$



Geographic Variation of Depth to Top of $V_{s,ref}$





Comparison with EPRI (1993) Recommendation

- Proposed:
 - $V_s = 3000$ m/s
 - $V_p = 5570$ m/s
 - Poisson's ratio = 0.28
- EPRI (1993):
 - $V_p = 4900$ m/s
 - Poisson's ratio = 0.25
 - $V_s = 2830$ m/s (inferred)
- If Poisson's ratio of 0.28 is used with EPRI (1993) $V_s = 2700$ m/s.

Preliminary Evaluation of Epistemic Uncertainty

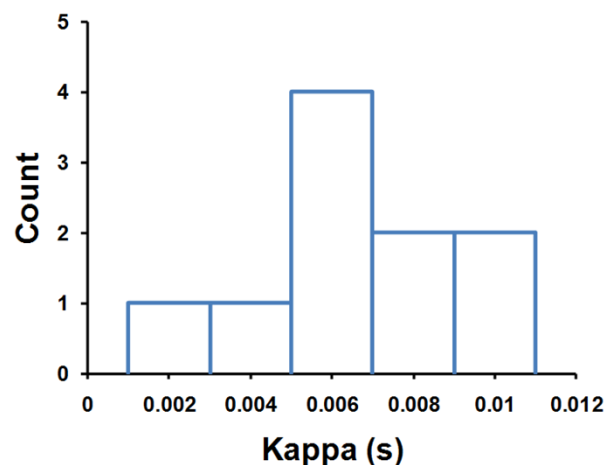
- Velocity selection is done graphically.
- Potential epistemic uncertainty due to differences in selected velocities, as well as judgment is reaching reference velocity.
- Velocities selected by two people compared to estimate epistemic uncertainty
 - Pick A – Albert Kottke: $V_s = 3000$ m/s, $V_p = 5570$ m/s
 - Pick B – Michael Musgrove: $V_s = 2980$ m/s, $V_p = 5663$ m/s
- Very preliminary assessment

Kappa

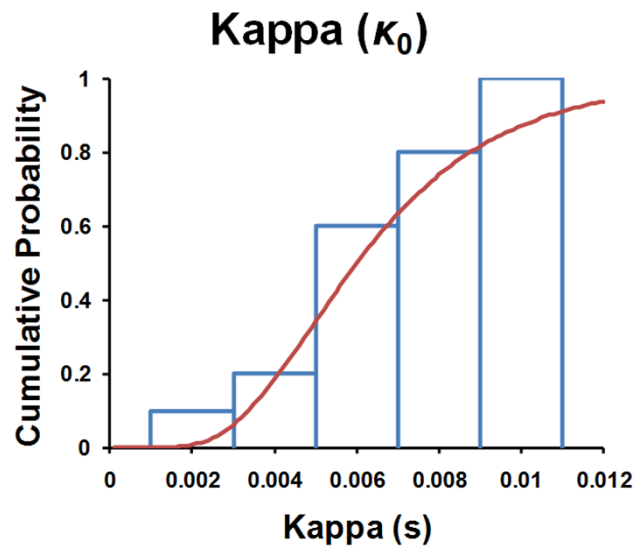
- Kappa (κ_0) is path-independent, site attenuation
- Multiple methods for determining κ_0
 - Log-linear slope above the corner frequency (Anderson and Hough, 1984)
 - Fitting models to observed acceleration response or Fourier amplitude spectrum (Atkinson, 1996; Chapman et al., 2003; Atkinson and Boore, 2006; Campbell 2009).
- All methods have to address the path attenuation (model dependence) which also influences the high-frequency attenuation

CENA Hard Rock Kappa (κ_0) Estimates

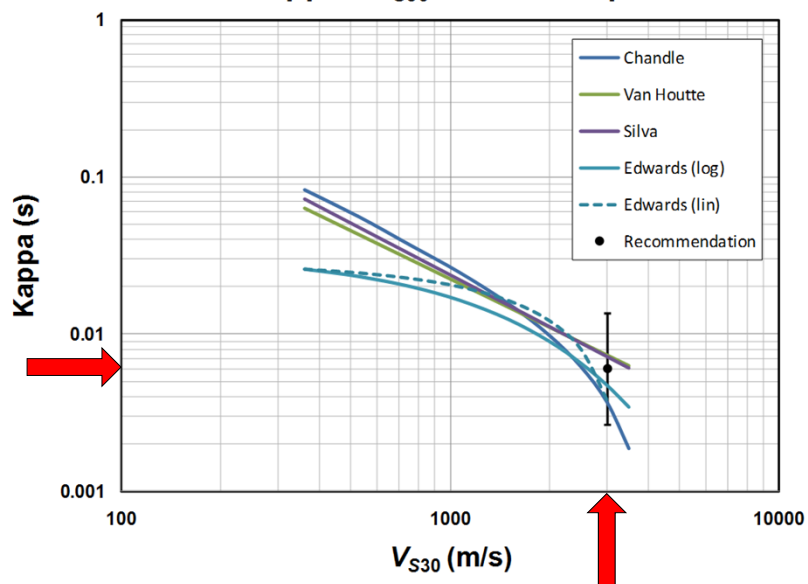
Kappa (κ_0)



Cumulative Distribution of Kappa Estimates



Kappa – V_{S30} Relationships



Uncertainty in Kappa

- Epistemic uncertainty of 0.45 determined from hard rock kappa estimates by various researchers.
- Aleatory uncertainty of 0.22 from Edwards et al. (2011)
- Edwards et al. (2011) also report standard errors of the mean of kappa that are consistent with a natural log standard deviation ranging from about 0.15 to 0.30.
- In order to avoid double-counting uncertainty from other aspects of the ground motion simulation, we believe that the standard error of the mean is the more appropriate aleatory variability to use and adopt a value of 0.22

Kappa Recommendation

- Median of 0.006 sec
- Log normally distributed
- Total standard deviation (σ_{\ln}): 0.50
 - Aleatory uncertainty: 0.22
 - Epistemic uncertainty: 0.45