

CVT Workshop

October 31 - November 1, 2018

Vertical Force Scaling in Seismic Source Models of Underground Nuclear Explosions

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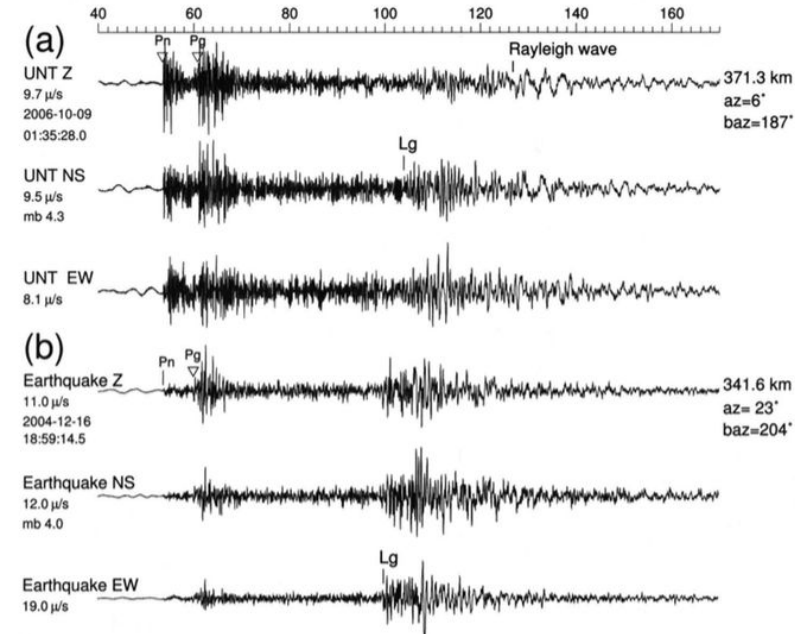
November 1, 2018



Introduction & Motivation

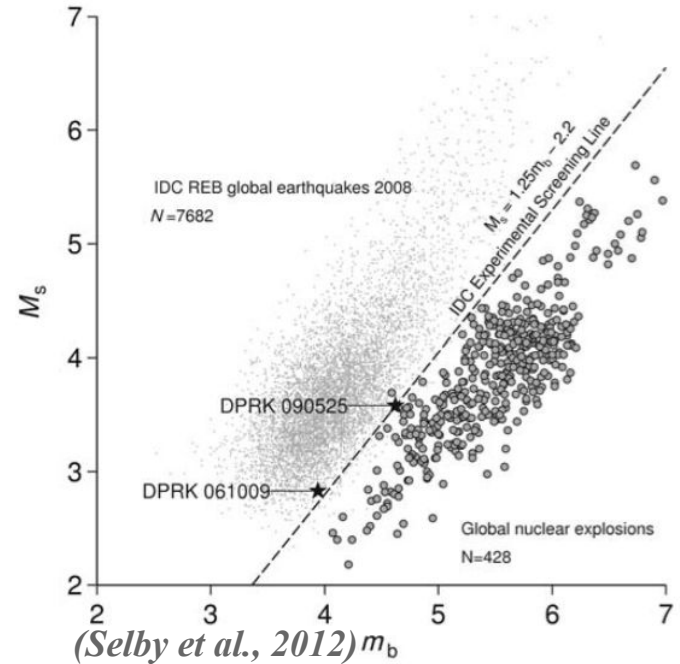
Earthquakes vs. Underground Nuclear Explosions (UNEs)

P/S Spectral Ratios



(Kim & Richards, 2007)

M_b - M_S



Introduction & Motivation

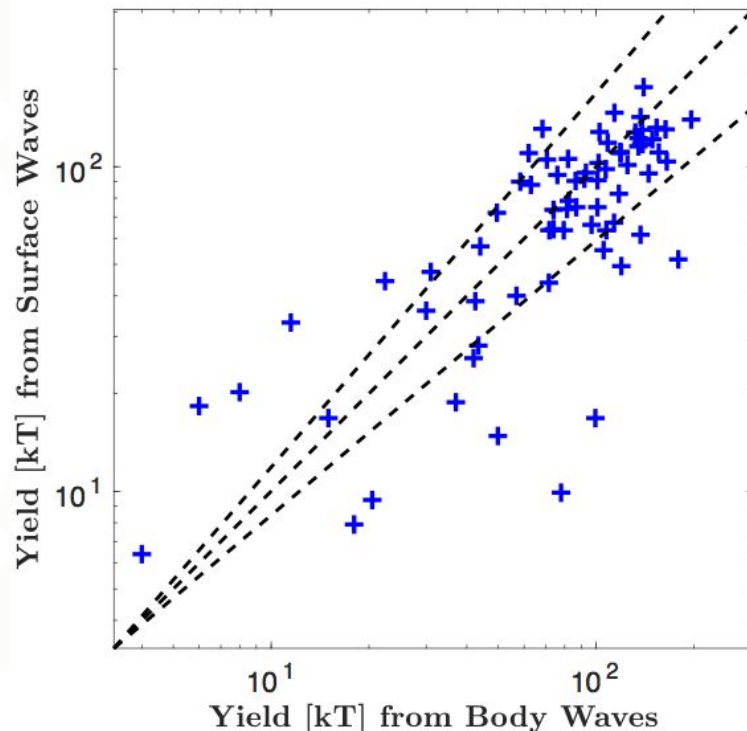
71 Underground Nuclear Explosions (UNEs) at the Semipalatinsk Test Site (STS)

Body Waves:

$$m_b = a + b \times \log(W)$$

Surface Waves:

$$W \sim M_{EX} = (1/3) (M_{xx} + M_{yy} + M_{zz})$$

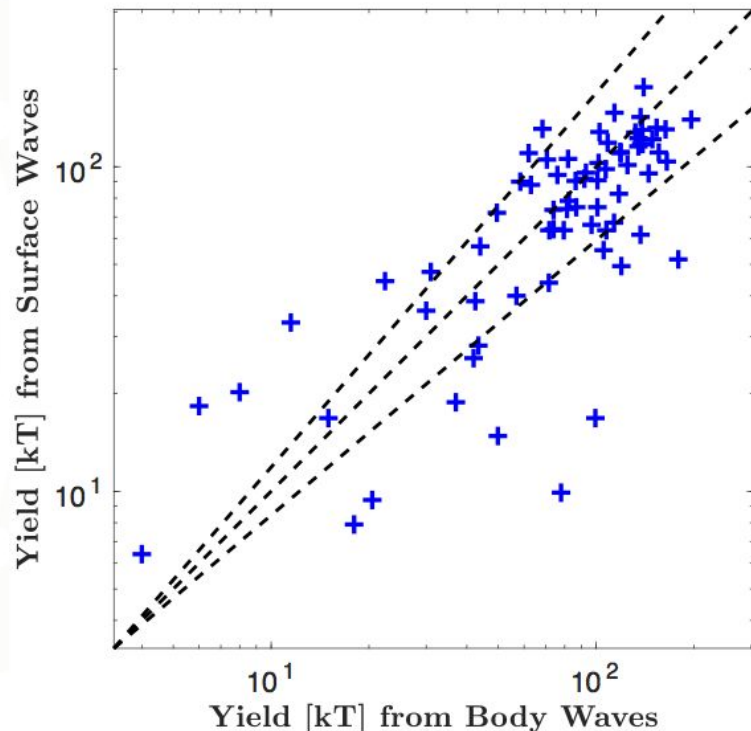
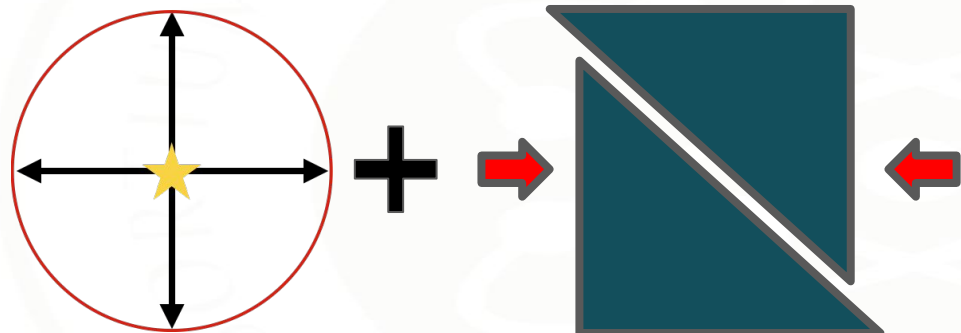


(adapted from Ekström & Richards, 1994)



Introduction & Motivation

71 Underground Nuclear Explosions (UNEs) at the Semipalatinsk Test Site (STS)



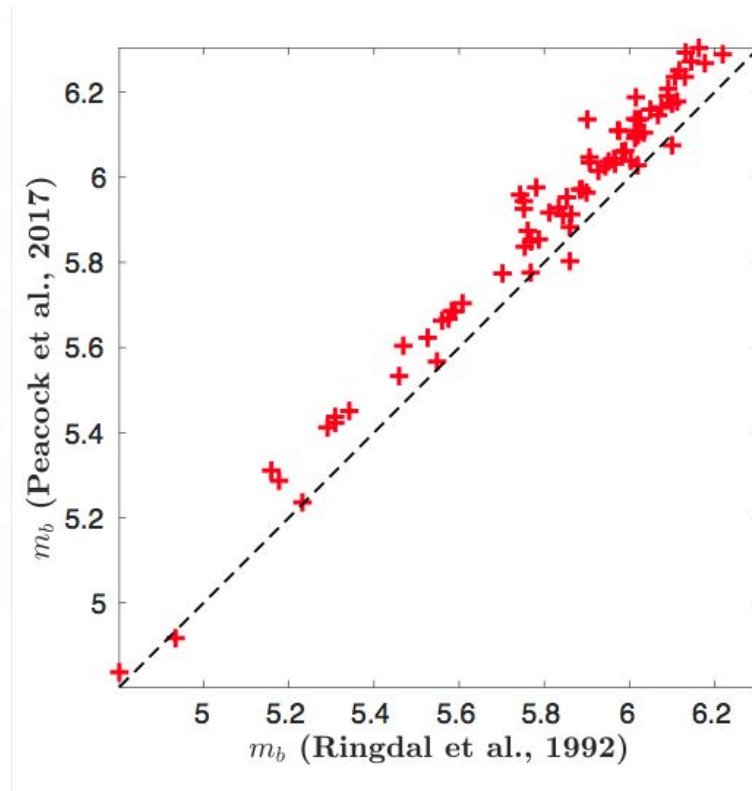
(adapted from Ekström & Richards, 1994)

- *Fundamental understanding of the generation of seismic signals from UNEs.*
- *Especially relevant in the context of the recent North Korean tests, which exhibited different characteristics than typical historical UNEs.*



Technical Work & Results

Revised Body-Wave Magnitudes

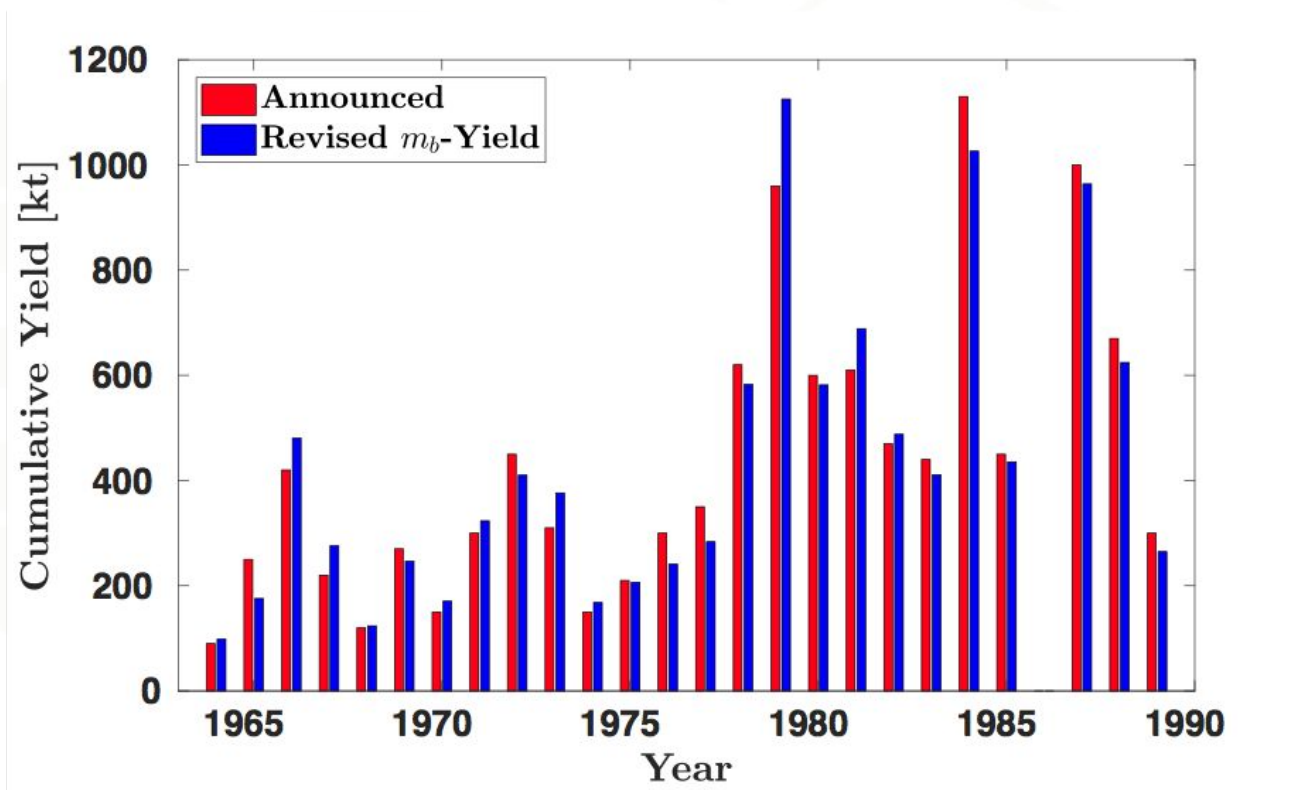


Technical Work & Results

Revised Magnitude-Yield Relationship

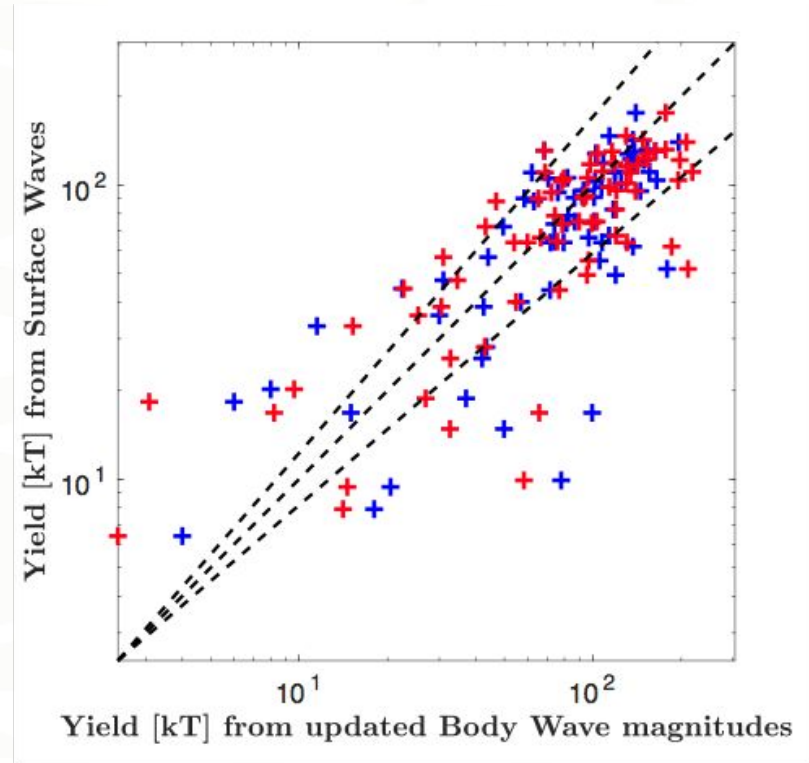
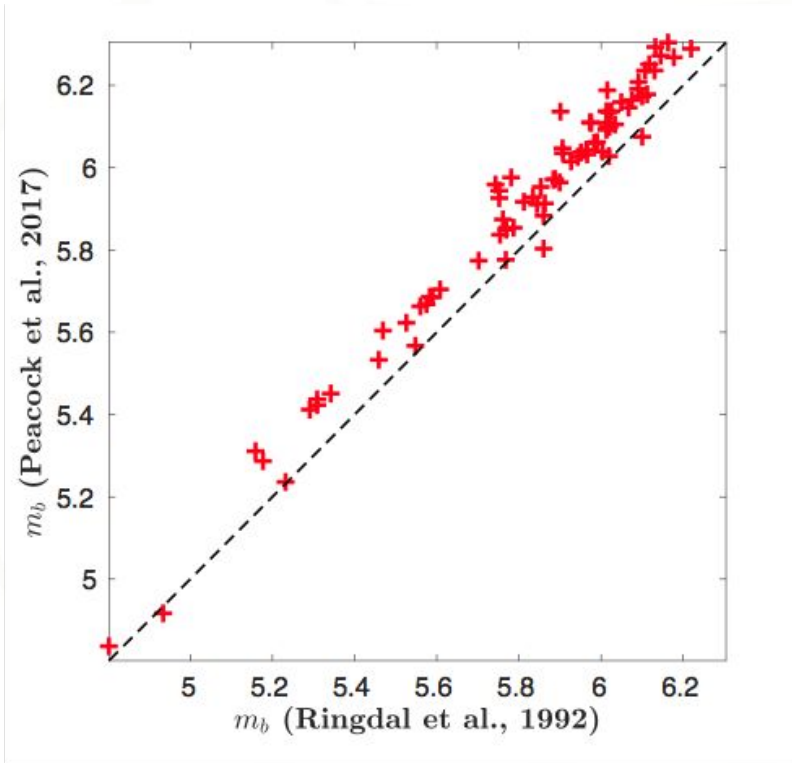
[1991]:
 $m_b = 4.45 + 0.75 \times \log(W)$

[2018]:
 $m_b = 4.55 + 0.75 \times \log(W)$



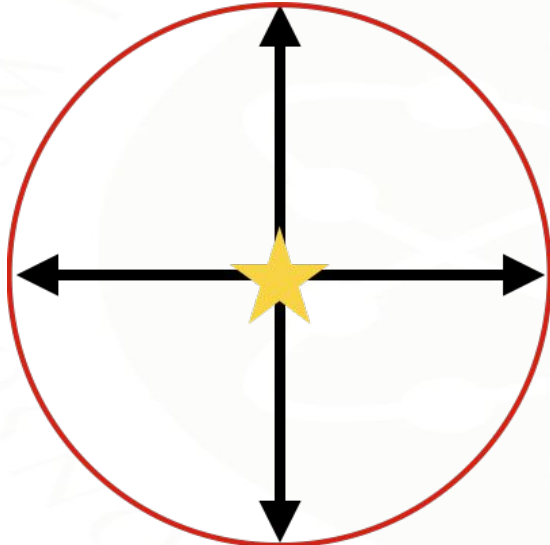
Technical Work & Results

Revised Magnitude-Yield Relationship

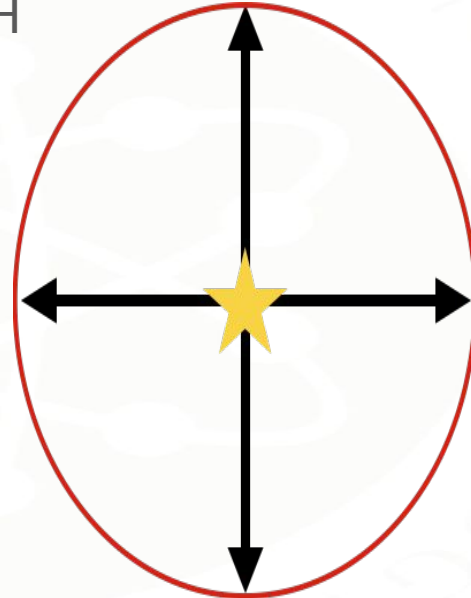


Vertical Force Scaling

$$C = M_{zz} / M_H$$



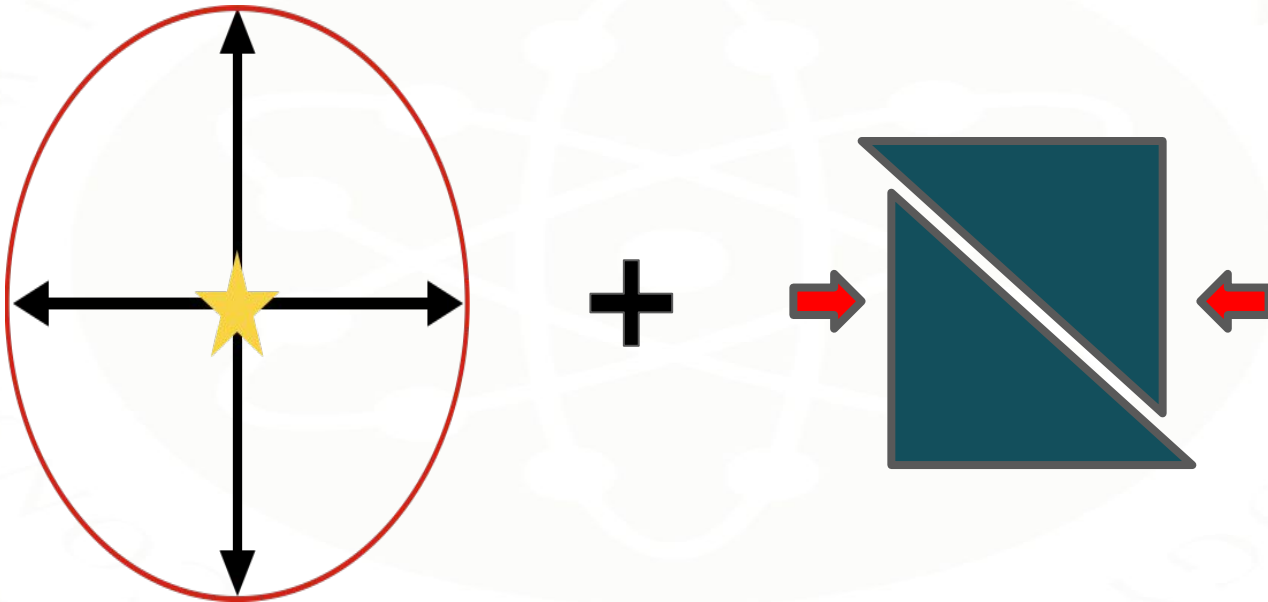
$$C = 1.0$$



$$C > 1.0$$

Technical Work & Results

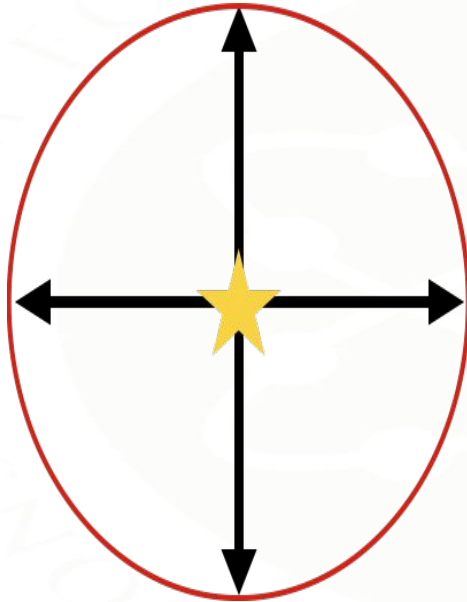
Vertical Force Scaling



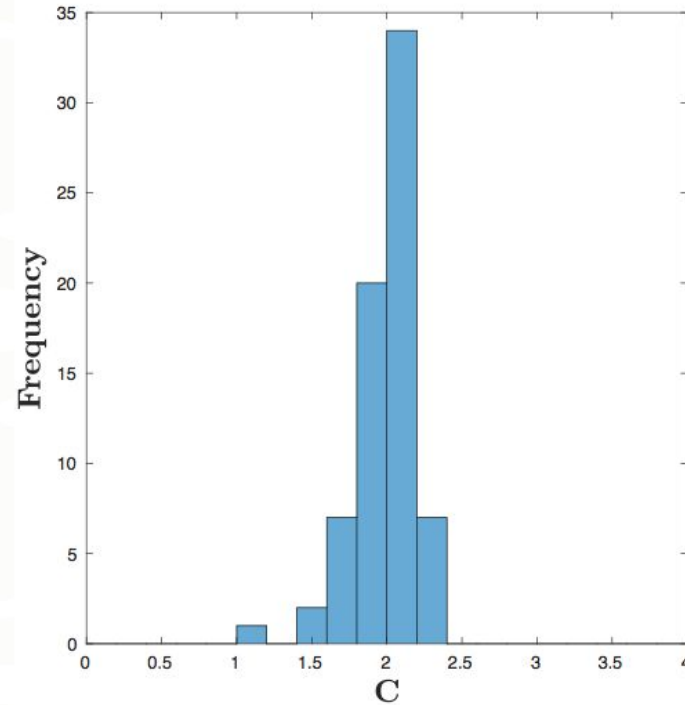
$C > 1.0$



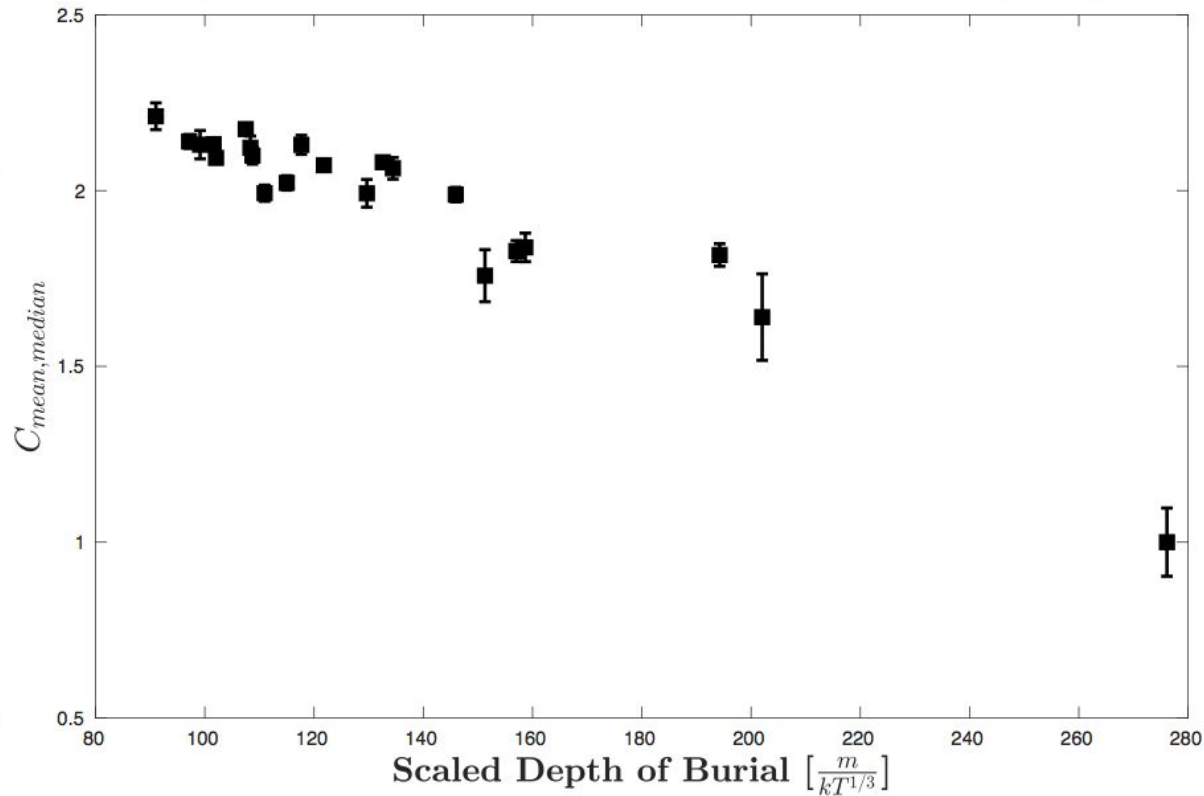
Vertical Force Scaling



$$C = M_{zz} / M_H > 1.0$$

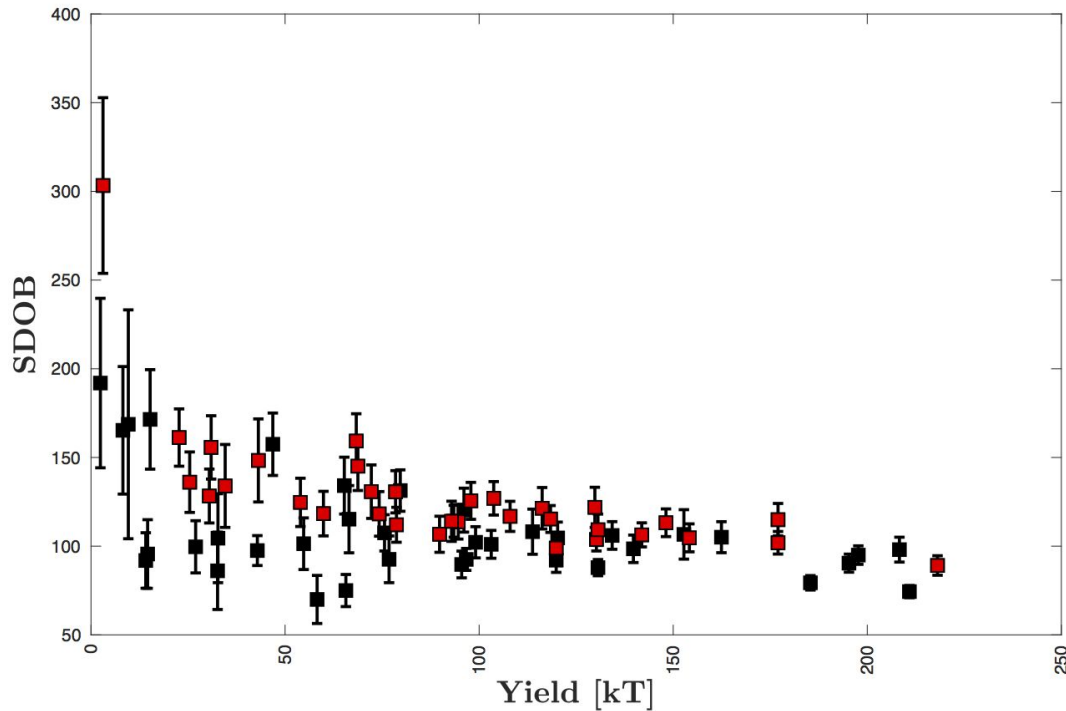


Correlation Discovered between C and Scaled Depth of Burial



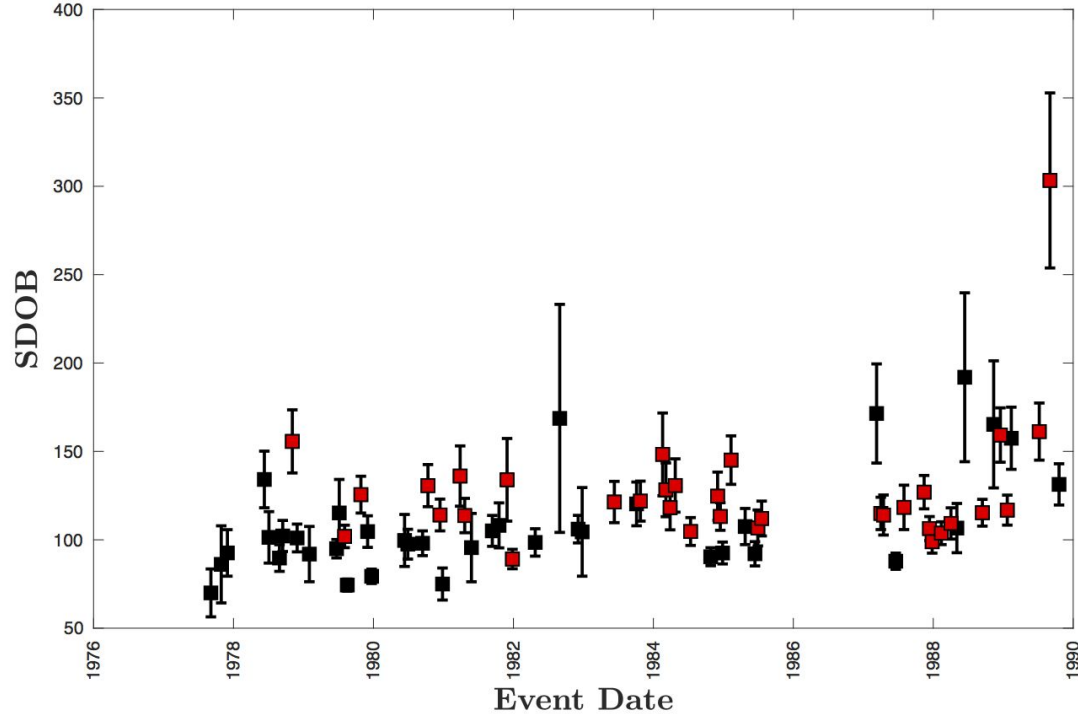
Technical Work & Results

Scaled Depth of Burial vs. Yield



Technical Work & Results

Scaled Depth of Burial vs. Time



- *Developed a revised source model that reconciles body-wave and surface-wave observations from UNEs.*
- *Discovered a clear relationship between C and Scaled Depth of Burial, which is a major advancement in the understanding of the generation of surface waves from UNEs .*

This work has greatly benefited from interaction with researchers at the national labs both at CVT workshops as well as face-to-face discussions and email correspondence.

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