Strong Body-to-Surface Wave Scattering off the Southern California Continental Borderland

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A $M_w$ 6.5 deep event (depth=510 km) forms the Kermadec subduction zone.

Transverse component

Bandpass: 0.02 ~ 0.1 Hz

Time reduced by S-wave arrival at the reference station (1281 s from earthquake origin time)

1. What are those phases?
2. Where are their sources?
3. How are they generated?
Array analysis

\[ c(t) = \frac{1}{N} \left| \sum_{j=1}^{N} e^{i\Phi_j(t)} \right| , \]

\[ 0 \leq c(t) \leq 1 \]

1. Same back azimuth as the earthquake source
2. Horizontal slowness ~30 s/° (apparent velocity ~3.7 km/s)
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2. Horizontal slowness 30 s/° (apparent velocity ~3.7 km/s)
3. No apparent amplitude decay with distance
4. Central frequency ~0.1 Hz
5. Transverse component

Scattered Love wave
Four other deep events from the Kermadec-Tonga subduction zone

Scattered Love wave
Strongly scattered Rayleigh and Love waves observed at the SKIPPY array from a regional deep earthquake (Furumura et al., 1998 GJI).

Coda of a local earthquake (Aki, 1969, JGR).

Japan Trench
Scattered Rayleigh wave following the arrival of teleseismic P waves recorded at the Hi-net array (Maeda et al., 2014 EPSL).

“The modification of seismic wave caused by the three-dimensional heterogeneities is broadly called seismic wave scattering.” – Wu & Aki, (1988).
Weaker *P*-to-*Rg* and *SV*-to-*Rg* scatterings

**P wave (vertical)**

**SV wave (vertical)**
Location of SH-to-Love scatterers

- Back projection
  - Cross section
    - Scatterer
    - Station
    - Love wave
  - SH
  - SH

- Map view
  - Station
  - Event
  - Back azimuth
  - Isochron

- Patton escarpment
- Continental borderland
- Santa Cruz Basin & San Nicolas Basin

Assume constant Love wave velocity 3.2 km/s

Miller, 2002 GSA Bulletin
How scatters are generated?

Waveform modeling

Global 2D finite-difference using GPU (Li et al., 2014)

1 km grid size
Highest frequency ~0.5 Hz
Line → point source correction
GCMT moment tensor
2 GPUs ~ 20 minutes

3 km change in bathymetry well predict the amplitude of scattered Love wave
SH-to-Love wave scattering

V.E. = 34
Azimuthal variations in scattering

1. SH-to-Love wave scattering widely exists
2. Strongest for events from SW
Azimuthal variations in $A_{\text{scatter}}/A_{\text{SH}}$

1. $SH$-to-Love wave scattering widely exists
2. Strongest for events from Fiji-Tonga-Kermadec subduction zone
Scatters can potentially cause artifacts in structural images

Top-side Ssxs reflection imaging

Receiver functions
Potential application to Love wave tomography

Scattered Love wave propagation direction & time delay

Measured slowness at each station

Event cluster from Tonga-Kermadec subduction zone
Summary

• *SH-to-Love* wave scattering can be a prominent feature on seismic waveforms.

• Strong scattering from regions with pronounced bathymetric/topographic relief, such as Patton escarpment.

• Scatterings can potentially cause artifacts in subsurface images.

• Scatterings can potentially be used to constrain subsurface velocity structures.
Thank you!

Questions?