# Focal Mechanisms of Semi-Volcanic Low-Frequency Earthquakes

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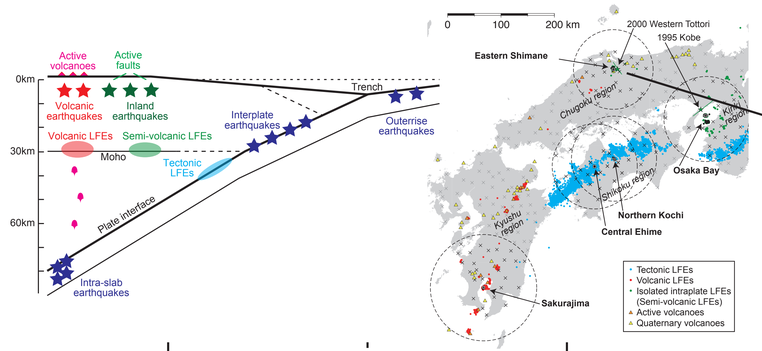
## Abstract

The focal mechanisms of (semi-)volcanic deep low-frequency earthquakes (LFEs) are not understood well. We estimated the **focal mechanisms** of tens of semi-volcanic LFEs in a region by waveform inversion.

The dominant focal mechanism is CLVD, and its axis oriented to the NNE direction, which is sub-parallel to the lineation formed by the **source distribution**.

## 1. Introduction

Three conditions for deep low-frequency earthquakes (LFEs)







| | Volcanic LFEs | Semi-volcanic LFEs | Tectonic LFEs |
|---|---|---|---|
| Location | Around Moho beneath active volcanoes | Around Moho far from active volcanoes | On the plate interface |
| Waveform | Sharp spectral peak (Monochromatic) | | Broad spectral peak |
| M2 Tidal response | No (not obvious) | | Yes (obvious) |
| Amplitude distribution | G–R law (b~2) | | Upper limit ($M_{max}$~1) |
| Hypocenter distribution | Relatively vertical than horizontal | | Nearly horizontal |
| Focal mechanisms | Various mechanisms (relatively random) | | Thrust fault |

Previous work on mechanisms of (semi-)volcanic LFEs

a. Various mechanisms in various regions
   - Is it various even for each cluster in each region?
b. Small portion of waveforms (e.g., polarization)
   - High S/N ratio is desired for waveform inversion
c. Small number of events
   - Many events are required to analyze statistical distrubution

So, LFEs in eastern Shimane

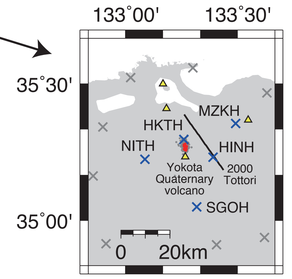
a. A linearly-aligned cluster
b. Less noise from volcanism or human activities
c. Second-most frequent (semi-)volcanic LFEs in Japan

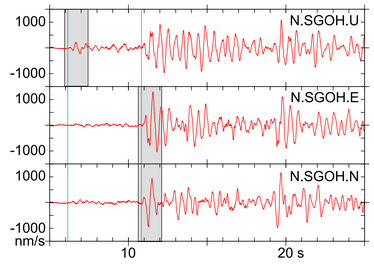
## 2. Data

1Hz 3-comp. velocity seismograms at 5 stations (Hi-net)

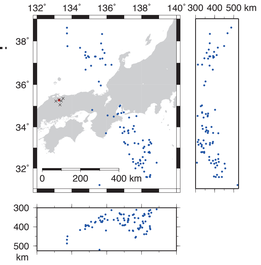
38 events
- 2002 – 2010
- $M_{JMA}$≧1.2
- JMA picked all P&S at 5 stations

20 Hz resampled
1.5-sec windows
- Vertical: $t_p$–0.2
- Horizontal: $t_s$–0.2

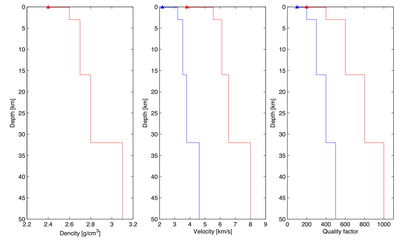



Amplitude was corrected to remove site effects using far-field events




The structure is 1-D

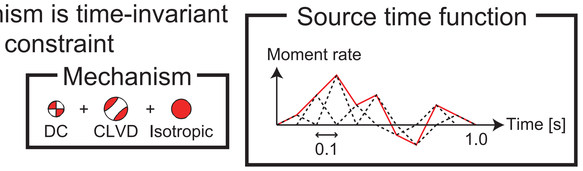



[Fukuyama et al., 2003; Pulido&Dalguer, 2009; Hi-net borehole data]

## 3. Methods

Assumptions

- A point source
- Temporally aligned first-order spline functions (T=1.0, ΔT=0.1)
- The mechanism is time-invariant
- Without any constraint

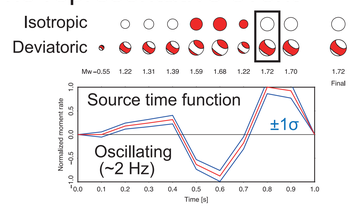


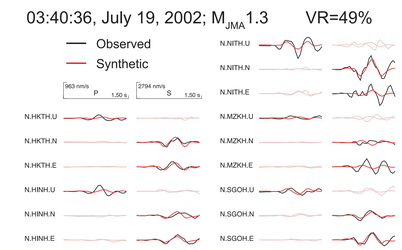

Routines

i. Assume various mechanisms
   - Grid search in moment tensor space ($m_{jk}$)
ii. For an assumed mechanism, obtain a source time function by a linear inversion.
   - Theoretical waveforms are calculated by a discrete wavenumber integration method [Takeo, 1985]

## 4. Result

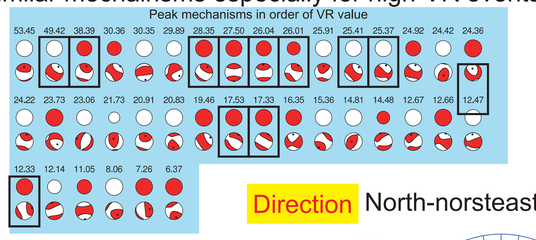
The representative event



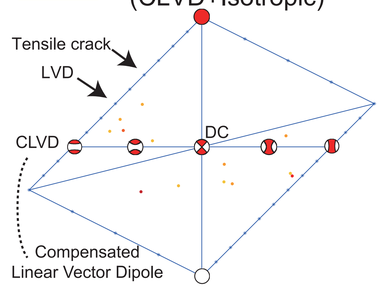

All 38 events

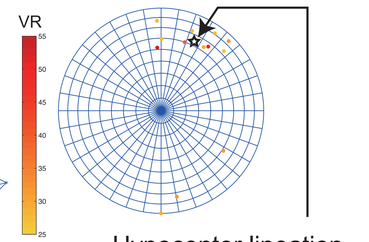
Similar mechainsms especially for high-VR events



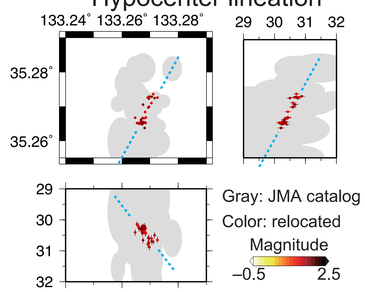

Direction North-norsteast (dip~20–30º)

Type Non-Double-Couple (CLVD+Isotropic)




Hypocenter lineation




## 5. Discussion

Reliability checks

- ✓ Shifting pick time
- ✓ Changing the station selection
- ✓ Using other velocity structures
- ✓ Allowing time-varying orientations
- ✓ Constrained to only deviatoric or only DC

Possible model: in progress with Victor!!

- How is stress accumulated?
- How is the accumulated stress released?
- How is the oscillation excited?