Applying Cross-Correlation Methods to Broadband and Nodal Data to Detect and Locate Earthquakes Associated with the Socorro Magma Body

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Background

- 2nd largest known mid-crustal magma body
- \( \sim 3400 \text{ km}^2 \) in areal extent
- Planar surface
- Top-depth of \( \sim 19 \text{ km} \)
- Uplift rate 1 - 3 mm/yr

Socorro

Fialko and Simons [2001]
Geology of the SMB Region

- Dikes
- Volcanic Vents
- Faults
- SMB
- SSA
Outstanding Questions and Efforts

Emplacement?

Duration?

Migrating?

Thickness?

Geometry?

Magneto-telluric
[Matt Folsom; NMT]
[Jeff Pepin; NMT]

Geomorphology
[Brad Sion; NMT]

Emplacement Modeling
[Shuoyu Yao; NMT]

Tomography
[Nishath Ranasinghe; UNM]

Attenuation [Jon Schmidt; NMT]
Motivation

- Known associated earthquakes
  - The Socorro Seismic Anomaly
  - ~ 23% all NM M ≥ 2.0 events
  - Swarms every 8 - 10 yrs

- Potential volcanism

- Is there a magma diapir extending upwards from the SMB?

Morton MS thesis NMT [2013]
Earthquake History & Regional Stations

Digital waveform data available from 1999 - present.
Detect earthquakes using cross correlation

Obtain initial locations using existing 1D velocity model

Problem! Limited earthquake catalog

Deploy more instruments ⇒ More data!

Relocate earthquakes using 3D velocity model

Develop 3D seismic velocity model using tomography

[seismic - gravity joint inversion]

Diapir or no diapir?

Revise Project

Answer!

Results & Interpretation

Other seismic observations

Other seismic observations
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February 2015 deployment
- largest of its kind in SMB region

7 Broadband Stations
- operated ~1 month
- 500 Hz
- 3 component

804 Nodal Instruments
- operated ~2 weeks
- 250 Hz
- Z only
Geology of the SMB Region
Detect Earthquakes Using Cross Correlation

Cross Correlation: A measure of similarity between two signals as a function of a time lag applied to either of the signals, relative to the other.
Detect Earthquakes Using Cross Correlation

Template Waveform $\rightarrow$ Cross Correlation Threshold $\rightarrow$ Possible Detection
Obtain Initial Locations Using 1D Seismic Velocity Model

Hartse et al. [1992]
Develop 3D Seismic Velocity Model Using Tomography

Seismic Tomography:
Use measured travel times to solve an inverse problem to obtain seismic velocities.

Relocate Events Using 3D Seismic Velocity Model
## Preliminary Results

![Map of Preliminary Results](image.png)

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<tr>
<th>Template</th>
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<th># Verified Events</th>
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</table>
Preliminary Results Example

Template 2
M 0.87

CAR (EHZ channel, SC Network)

Time (s)
Example Nodal Recordings of Template 3 (M -0.32)
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Thank You!

Questions?