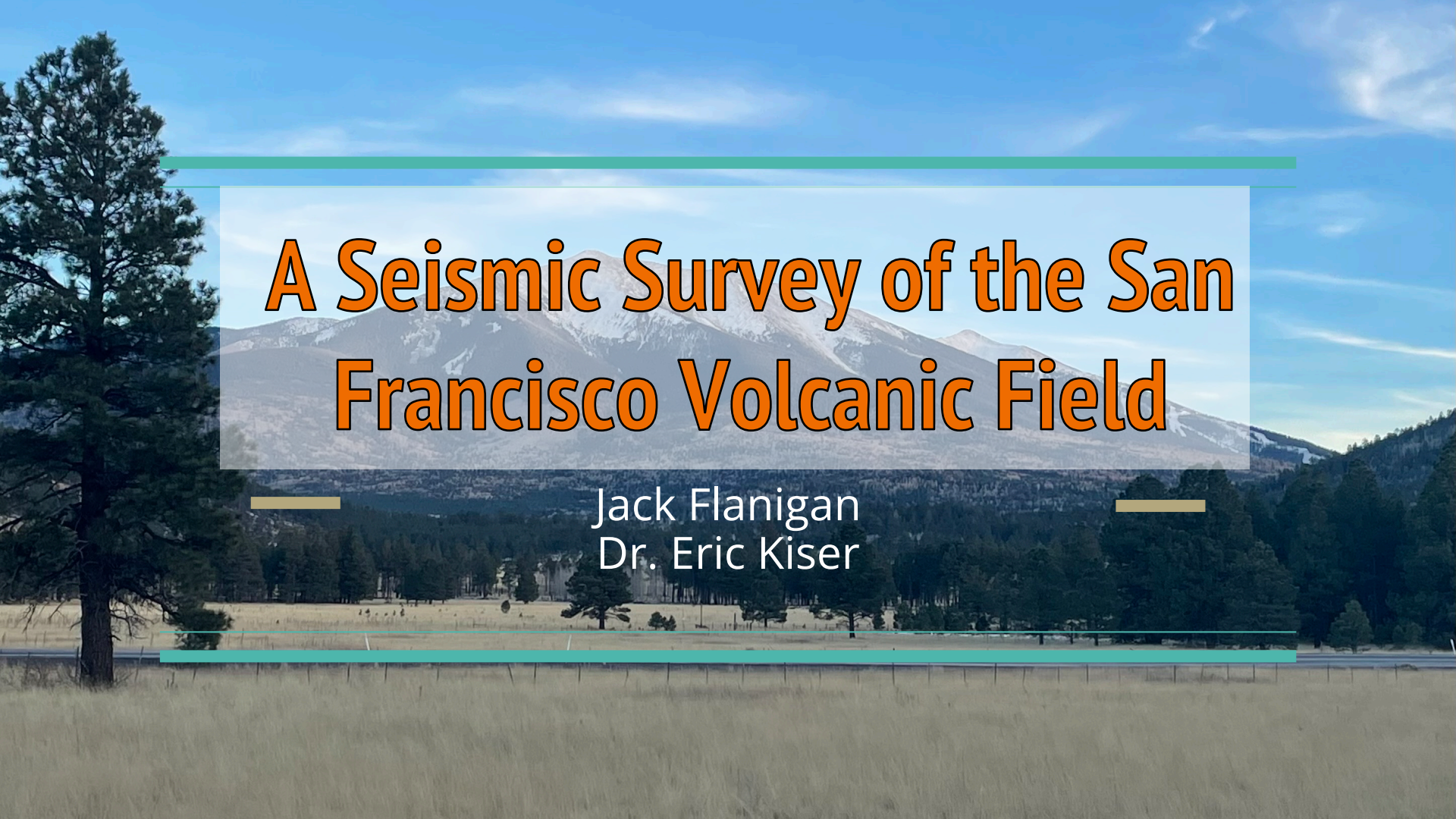
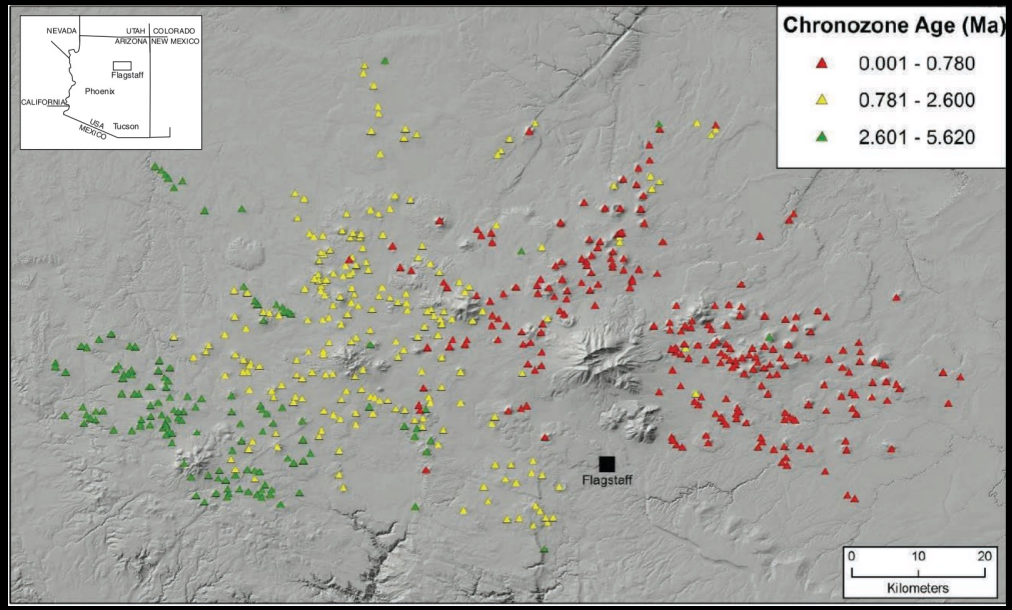


A Seismic Survey of the San Francisco Volcanic Field

Jack Flanigan
Dr. Eric Kiser

San Francisco Volcanic Field

- Just North of Flagstaff, AZ
- Over 600 volcanoes
- Basaltic
- Hashing of two fault systems combined with removal/replacement of lithosphere with asthenosphere driving volcanism
- Volcanic activity 938 years ago

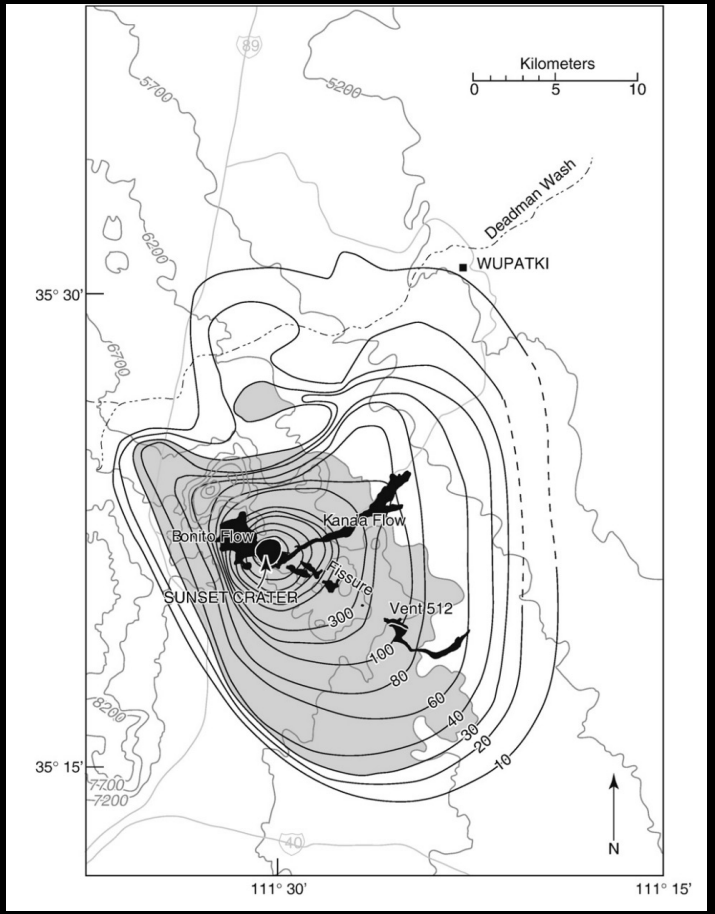


Riggs et al., 2019

https://www.azcentral.com/story/travel/arizona/2016/09/22/sunset-crater-volcano-national-monument/88806972/

Sunset Crater Eruption of 1085 CE

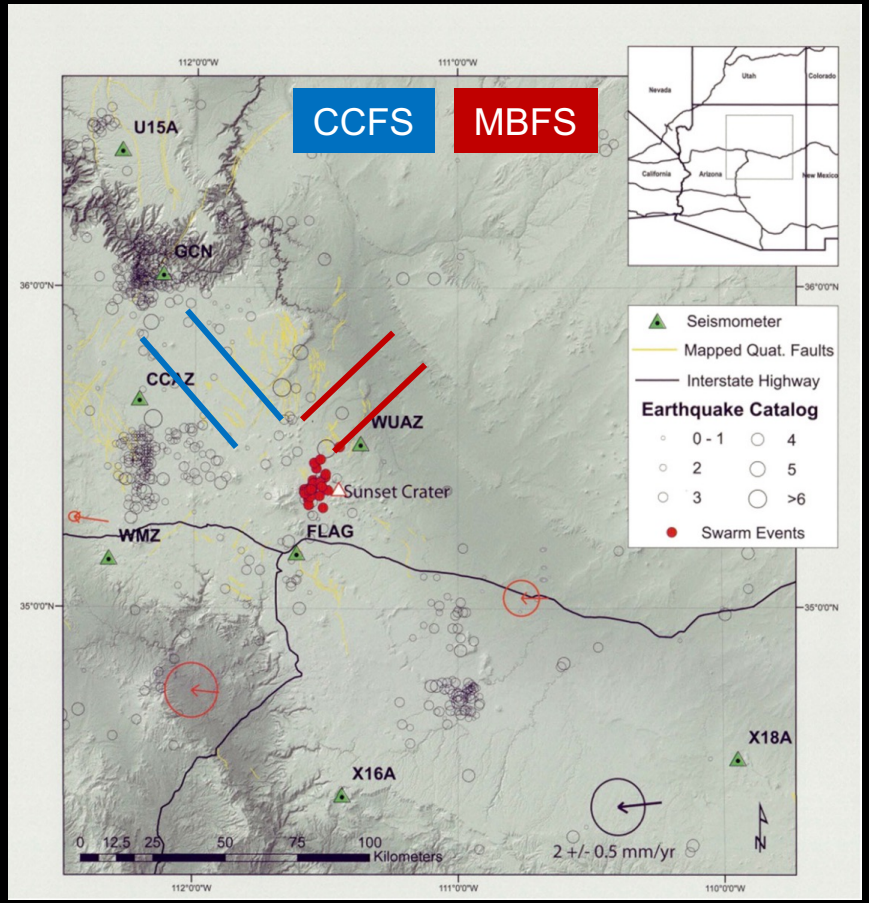
- Highly explosive basaltic eruption
- Ashfall covering over 700 km^2 of surrounding terrain
- Multiple lava flows
- Ruins of Sinaguan, Kayenta Anasazi, and Cohonina buried under ashfall



Ort et al., 2008

Sunset Crater Seismic Swarm

- Halloween 2009
- Series of small earthquake events frequently caused by the movement of fluid through the crust (i.e. Magma through a magma chamber/faults)
- Mid crustal depth, high b-value, high frequency, short duration, and proximity



Brumbaugh et al., 2014

Goals

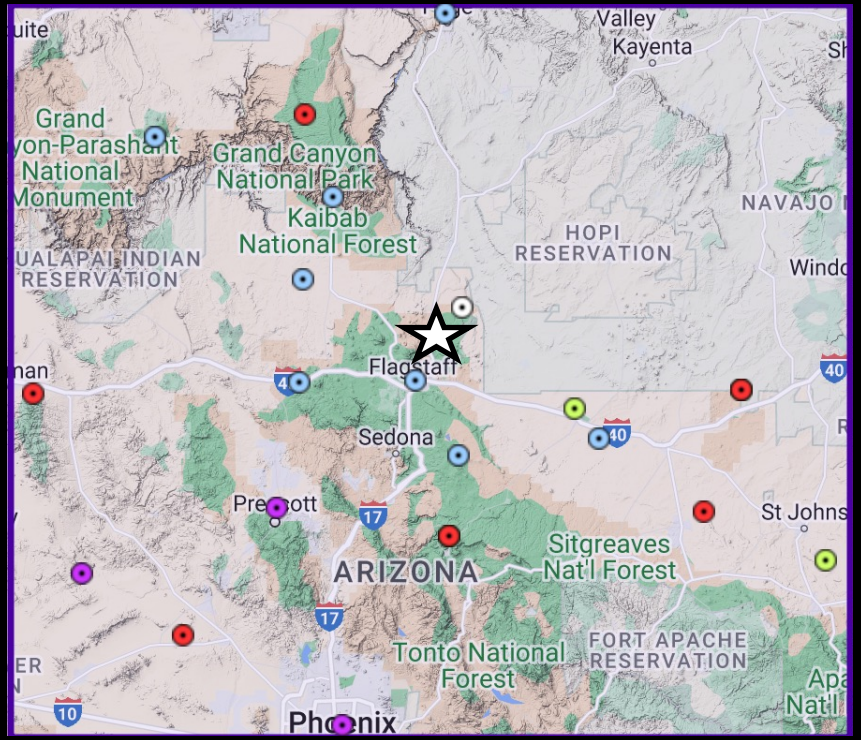
- Building upon previous research on this swarm event
- Download the continuous Halloween 2009 data
- Then use our methods to find a greater number of earthquakes with more accurate locations
- Which we will compile into a catalog for a better understanding of the relationship of this swarm and the magmatic structure under Sunset Crater...

Phasenet - a deep neural network

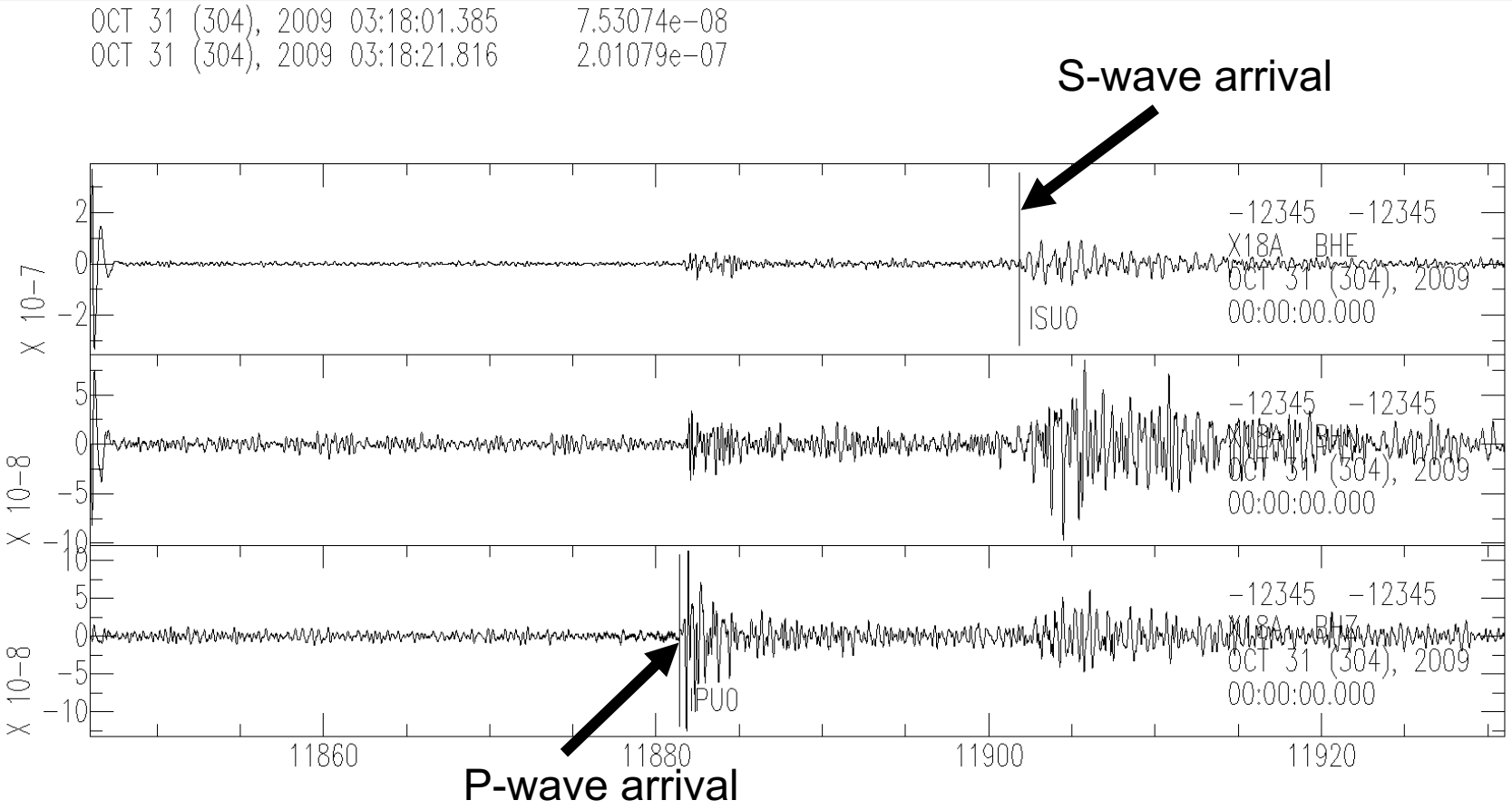
- Artificial intelligence seismic wave detecting code developed at Stanford
- Unsuccessful ☹

Hand Picking

- Hand picked P and S waves from known events to make template
- 34 events at 10 different stations
- Utilize template to reanalyze data from Halloween 2009 to create new earthquake catalog

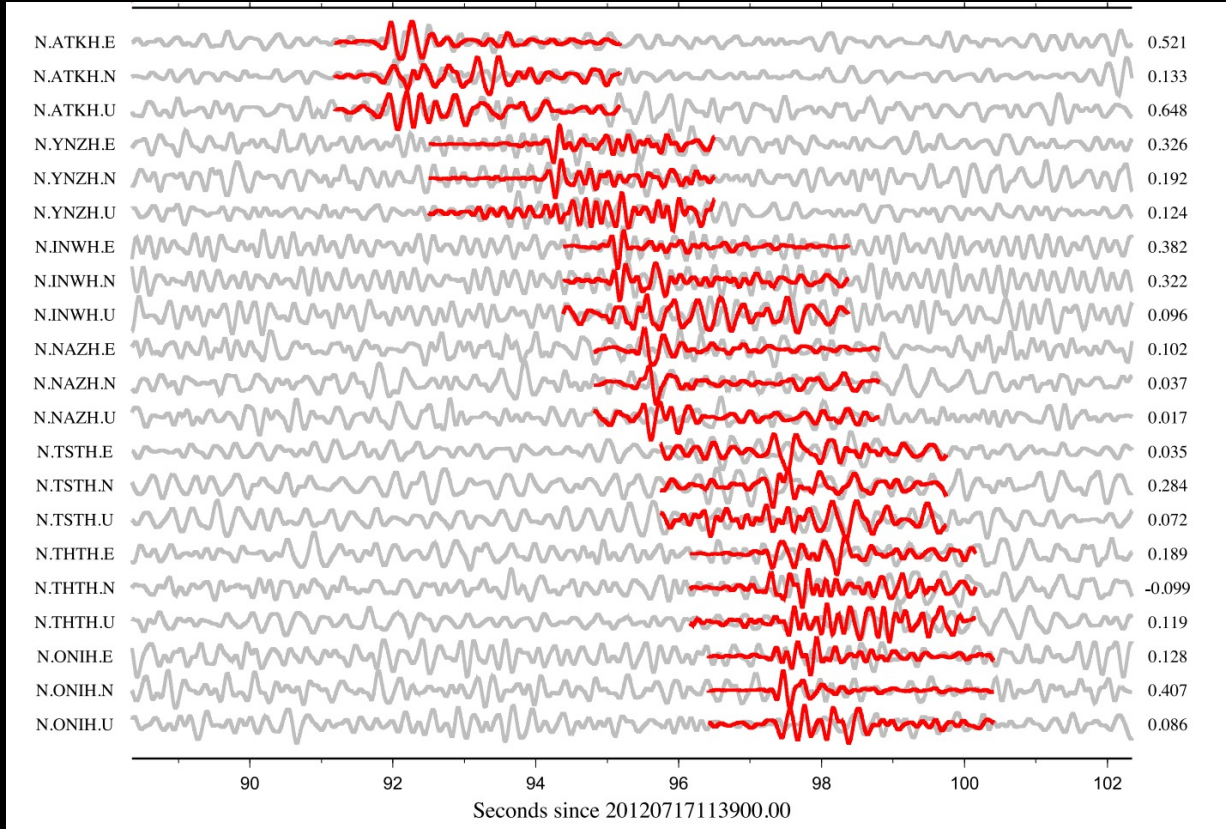


http://ds.iris.edu/gmap/#starttime=2009-10-31&endtime=2009-10-31&maxlat=37.004&maxlon=-109.0942&minlat=33.9342&minlon=-114.053&network=*&drawingmode=box&planet=earth

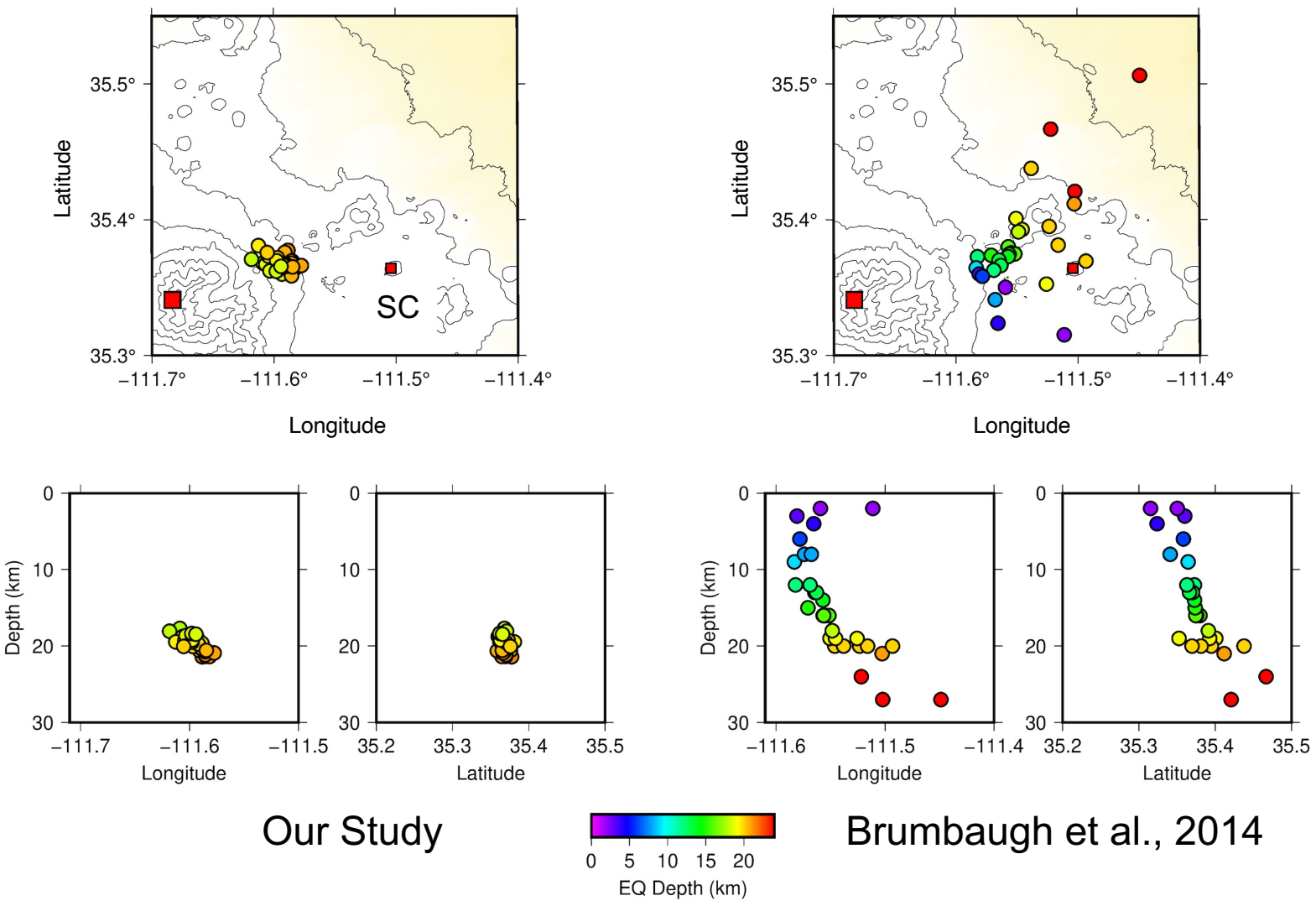

OCT 31 (304), 2009 03:18:01.385 7.53074e-08
OCT 31 (304), 2009 03:18:21.816 2.01079e-07
S-wave arrival
P-wave arrival
X 10-7
X 10-8
X 10-8
2
0
-2
5
0
-5
-10
10
5
0
-5
-10
-12345 -12345
X18A BHE
OCT 31 (304), 2009
00:00:00.000
ISU0
-12345 -12345
X18A BHN
OCT 31 (304), 2009
00:00:00.000
-12345 -12345
X18A BHZ
OCT 31 (304), 2009
00:00:00.000
IPU0
11860
11880
11900
11920

Template Matching

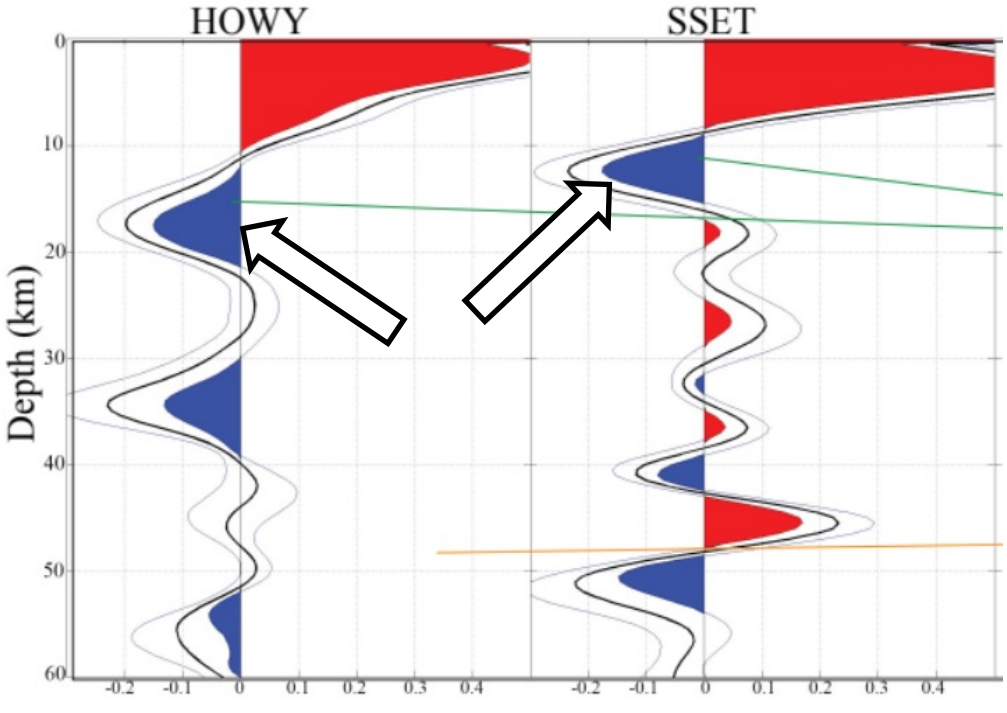
- 690 events, 89 having high correlations between 4 or more stations
- Cluster of 57



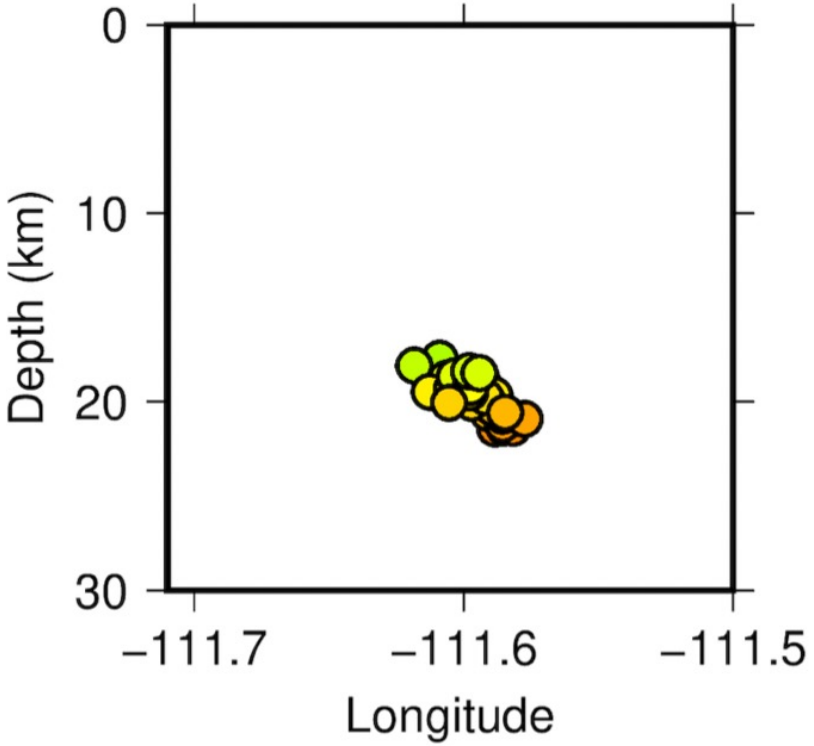
Zhang and Wen, 2014


35.5°
35.4°
35.3°
Latitude
−111.7°
−111.6°
−111.5°
−111.4°
Longitude
SC
35.5°
35.4°
35.3°
Latitude
−111.7°
−111.6°
−111.5°
−111.4°
Longitude
0
10
20
30
Depth (km)
−111.7
−111.6
−111.5
Longitude
0
10
20
30
35.2
35.3
35.4
35.5
Latitude
0
10
20
30
Depth (km)
−111.6
−111.5
−111.4
Longitude
0
10
20
30
35.2
35.3
35.4
35.5
Latitude
Our Study
0
5
10
15
20
EQ Depth (km)
Brumbaugh et al., 2014

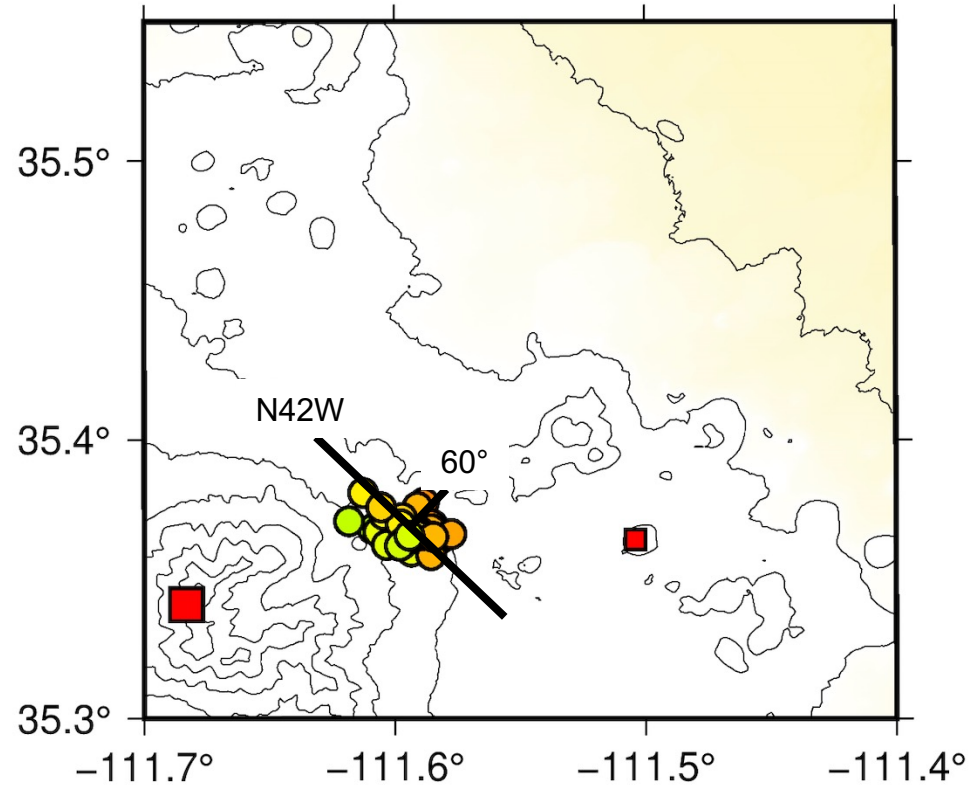
Magma Storage Depth

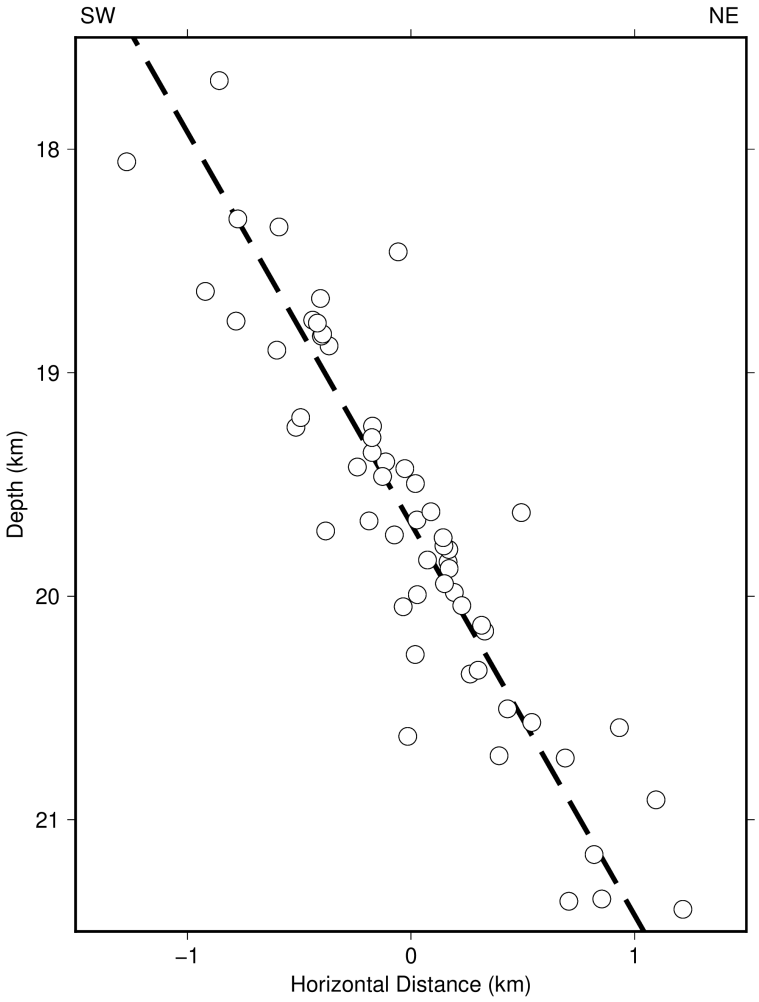


Netto and Porter, 2014



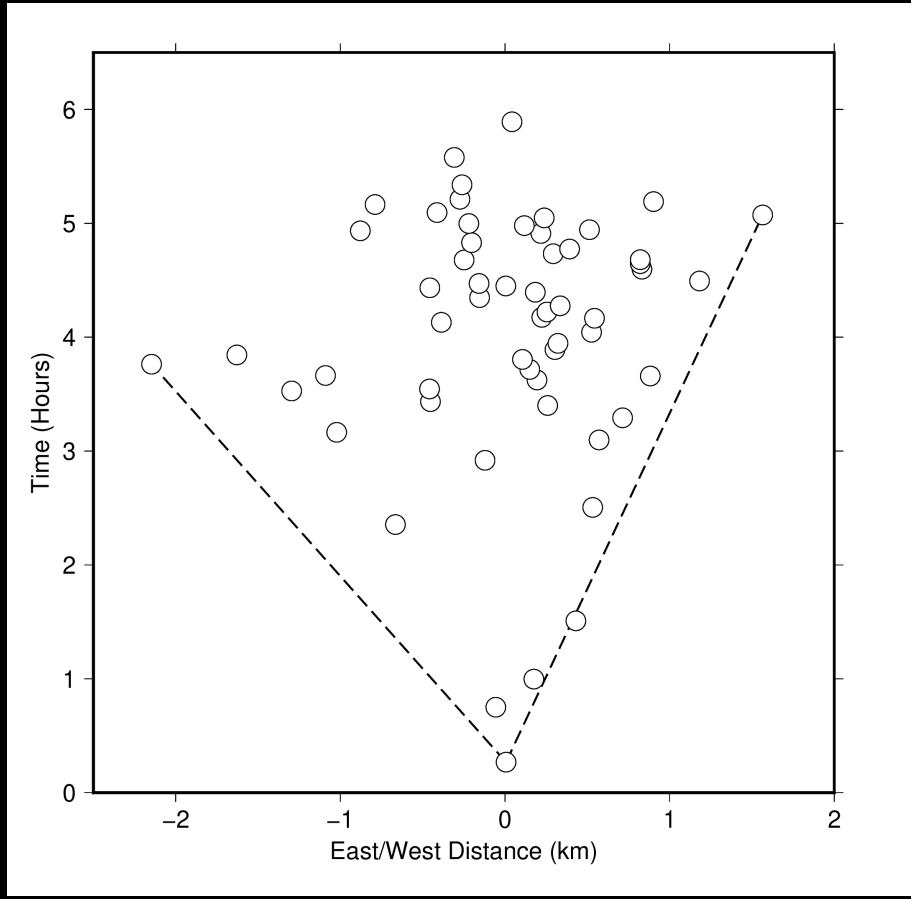
Fault Plane


35.5°
35.4°
35.3°
−111.7°
−111.6°
−111.5°
−111.4°
N42W
60°


SW
NE
18
19
20
21
Depth (km)
−1
0
1
Horizontal Distance (km)

Propagation Features

- Initial expansion phase (300– 600 m/hr)
- Then increased seismicity in the interior of the fault
- SPECULATIVE



Why Care?

- Flagstaff is a densely populated town in close proximity to this volcanism
- Sunset Crater is a highly EXPLOSIVE basaltic eruption
- Not much is known globally about this common type of volcanic setting
- Many civilizations are built upon the rich soils produced by cinder cones, living with these hazards

https://www.bbc.co.uk/newsround/59047884

Conclusion

- Phasenet does not work well in this seismic setting
- Possible magma storage depth of around 15km – 21km
- Plane of best fit correlates with the Cataract Creek Fault System (NW - SE) rather than Mesa Butte Fault System (NE - SW)

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Zhu, W. and Beroza, G.C., 2019. PhaseNet: A deep-neural-network-based seismic arrival-time picking method. *Geophysical Journal International*, *216*(1), pp.261-273.