Seismology

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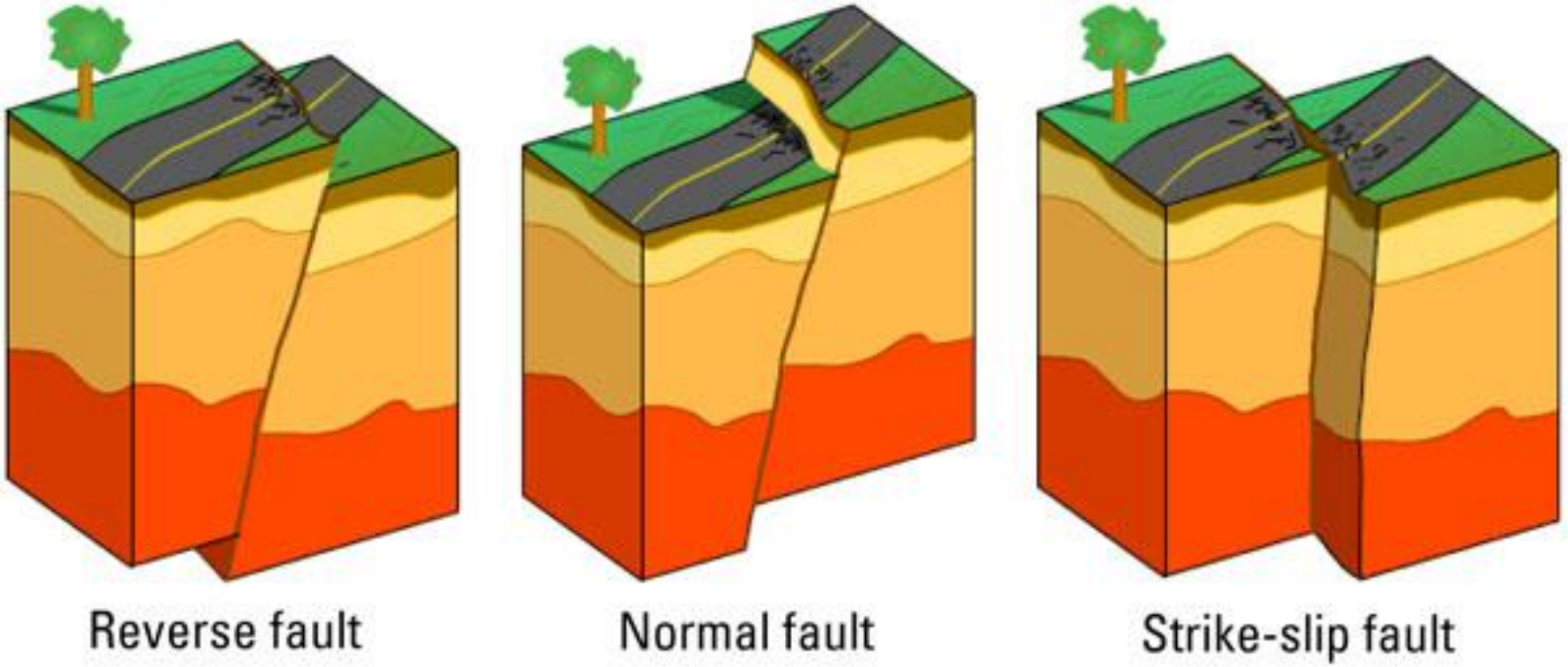
Seismic Waves

- Sources
  - Earthquakes
  - Volcanoes
  - Hurricanes
  - Oceans
  - Anthropogenic (e.g., traffic, mining, trains, etc.)
  - Nuclear explosions
- Show videos

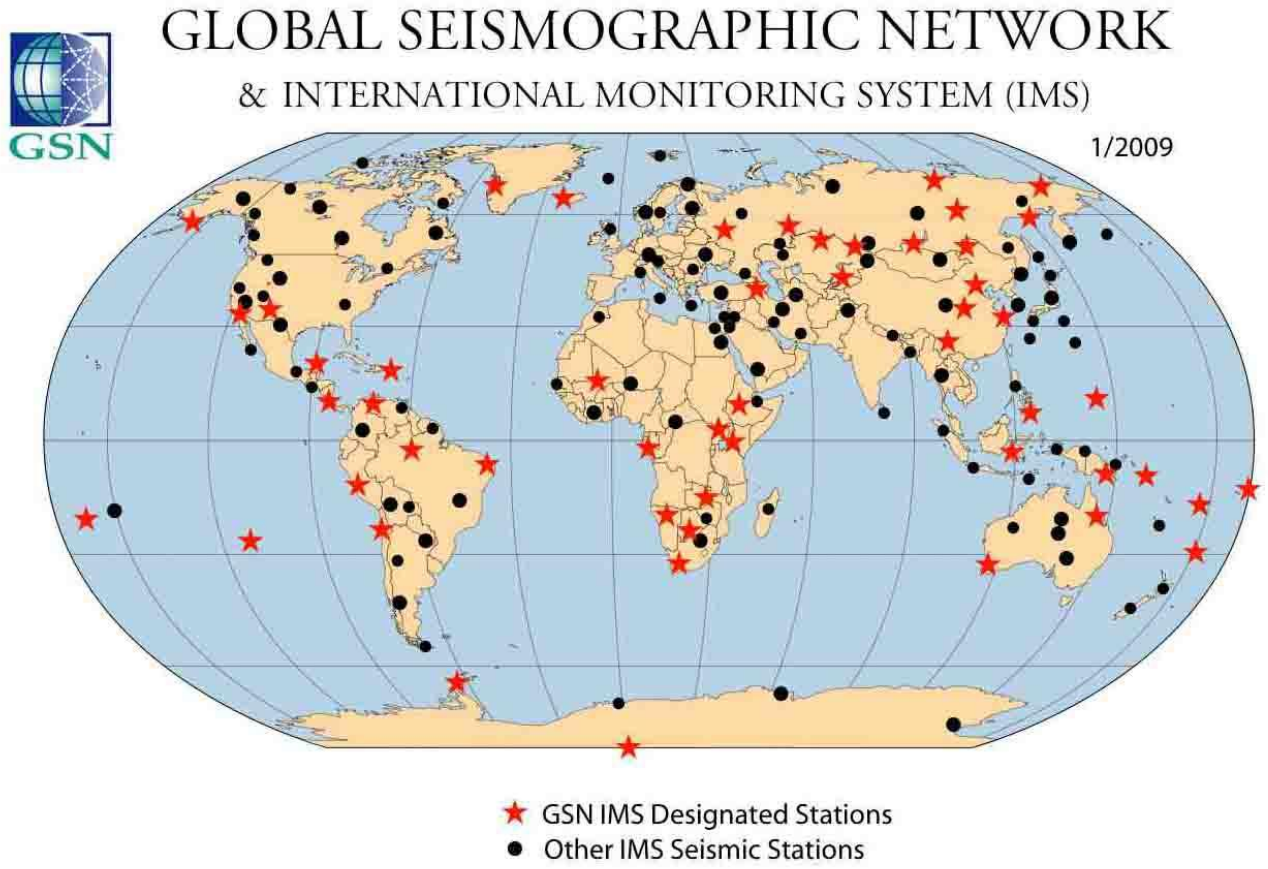
Earthquakes



http://soundwaves.usgs.gov/2009/11/FaultTypesLG.jpg

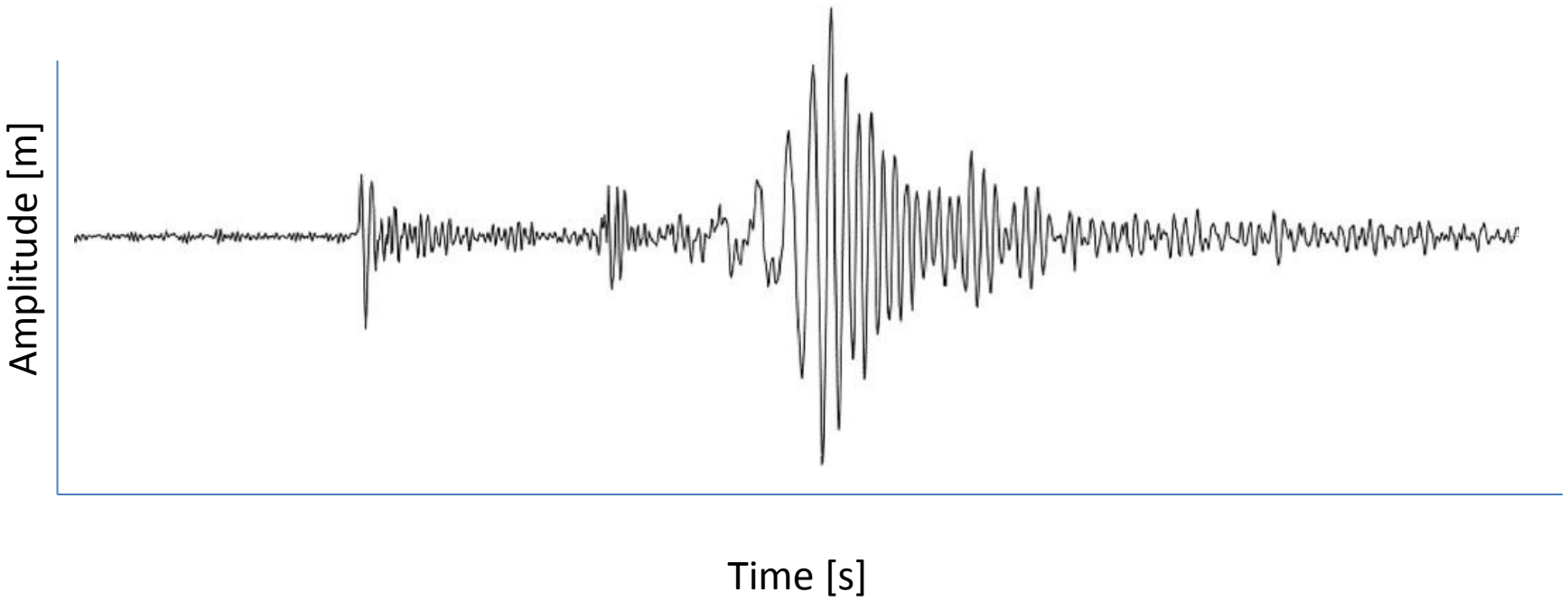
What do we record when earthquakes happen?

Ground motion all over the world

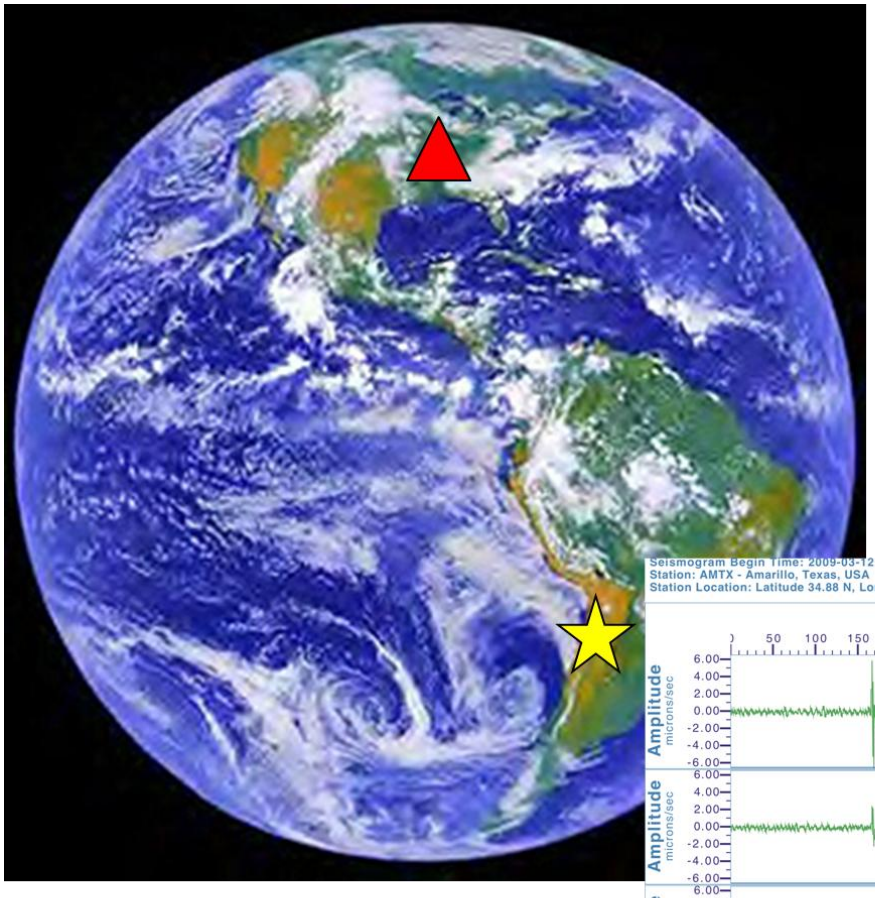


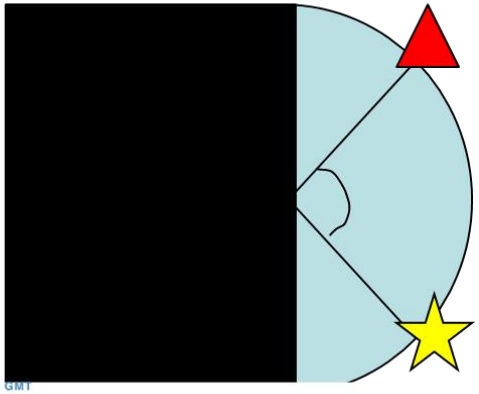
http://www.iris.edu/hq/files/programs/gsn/maps/GSN_IMS_1-2009_map.jpg

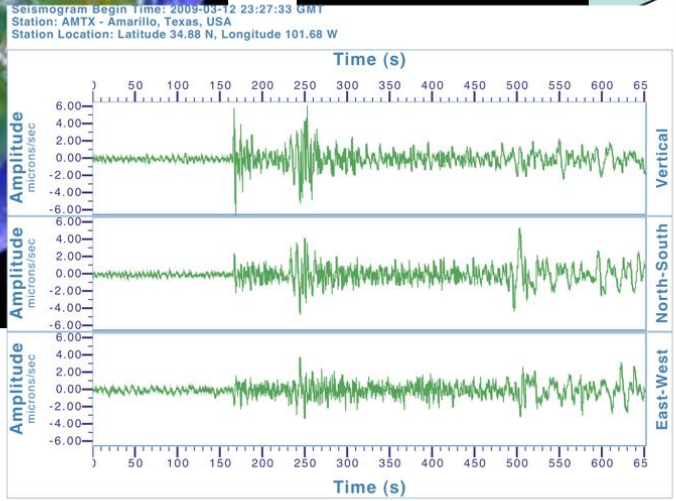
What does the ground motion look like?



3 component data

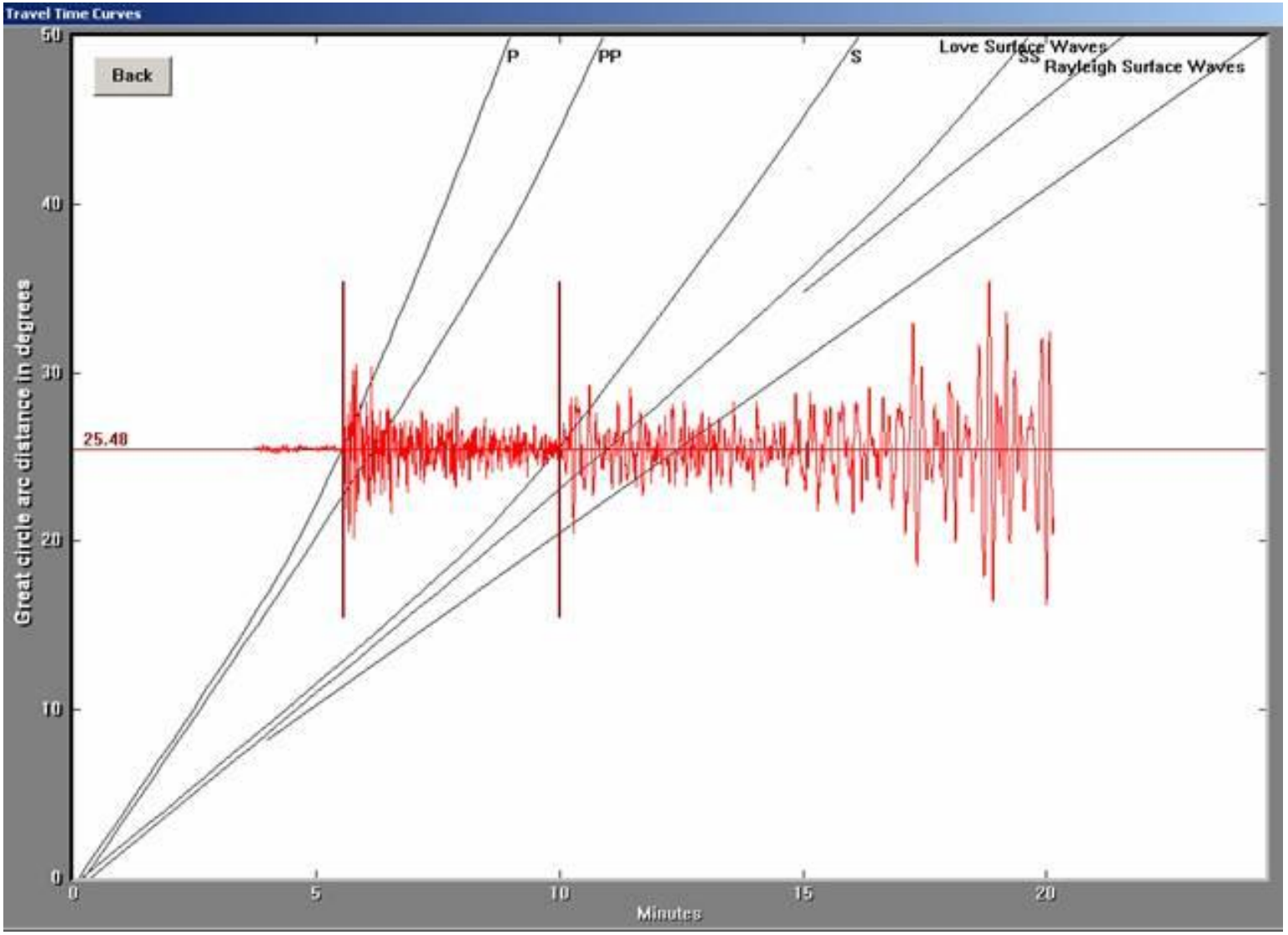






REV_EarthStructure.ppt

Types of waves



http://web.ics.purdue.edu/~braile/edumod/as1lessons/UsingAmaSeis/UsingAmaSeis_files/image059.jpg

Seismic Canvas activity

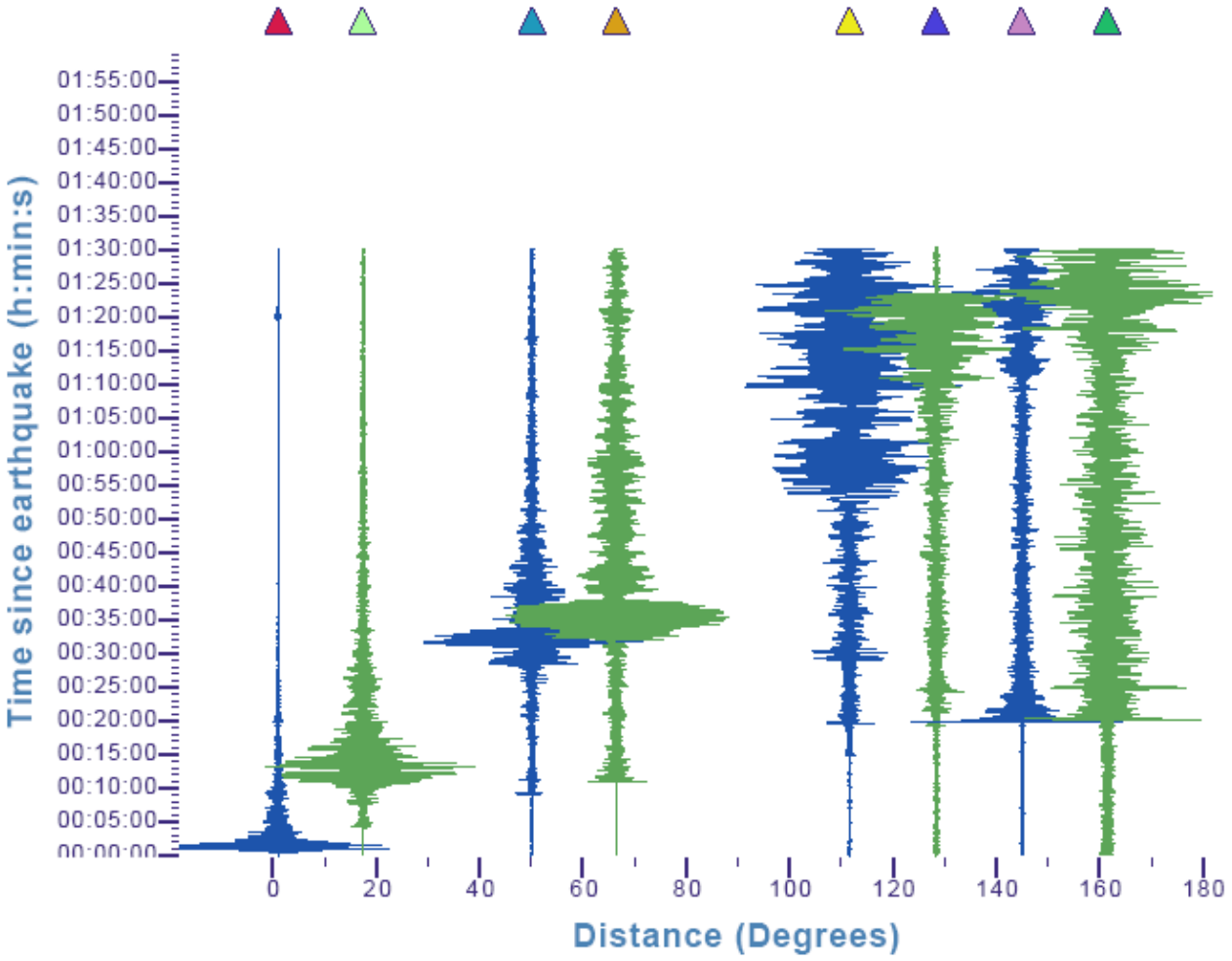
- Based on IRIS lesson
  - Determining and Measuring Earth's Layered Interior

    (http://www.iris.edu/hq/resource/determining_internal_structure)
- Students look at P wave first arrivals
- Compare predicted first arrivals with observed first arrivals from earthquake(s)
- Make inferences about 1D Earth structure

Objectives

- IRIS Lesson
  - Implications: If your findings match the findings of the theoreticians then Earth is homogeneous or all rock throughout. However, if your observations do not match the theoreticians' findings, than we can reasonably assume that the Earth is not homogenous or made entirely of rock and will need to develop a new model.
- New Lesson
  - Waveform processing (e.g., filtering, gaining, etc.)
  - Arrival identification
  - Forward modeling
  - Inverse modeling
  - Create further interests in seismology and applications

Observational seismologists



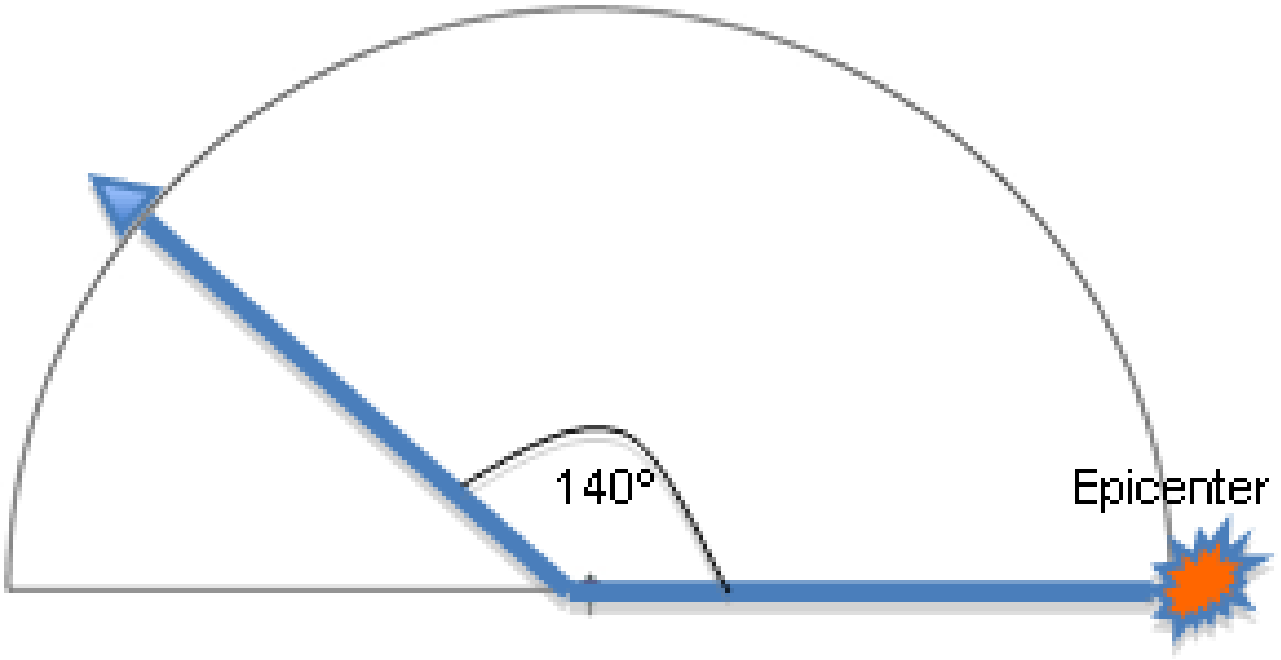
Observed data

Station Number	Station Distance (degrees)	Travel time (min)

Improvements

- Frequency filtering to highlight different arrivals
- Signal gaining to boost low amplitudes
  - Could even incorporate beach ball diagrams from java_program_synthesizer.jar to look at amplitude as a function of recording position relative to fault plane and auxiliary plane
- Digital picking at many more stations
- Picking multiple earthquakes rather than just one
- Ability to use the same data for many lessons

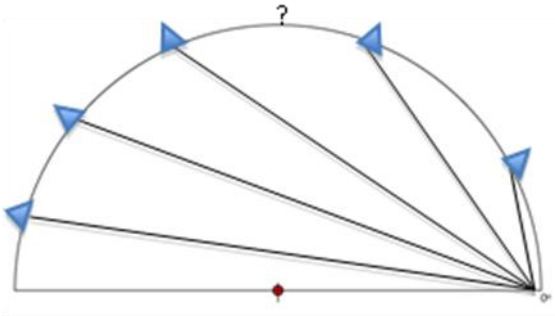
Theoreticians



Homogeneous Earth model

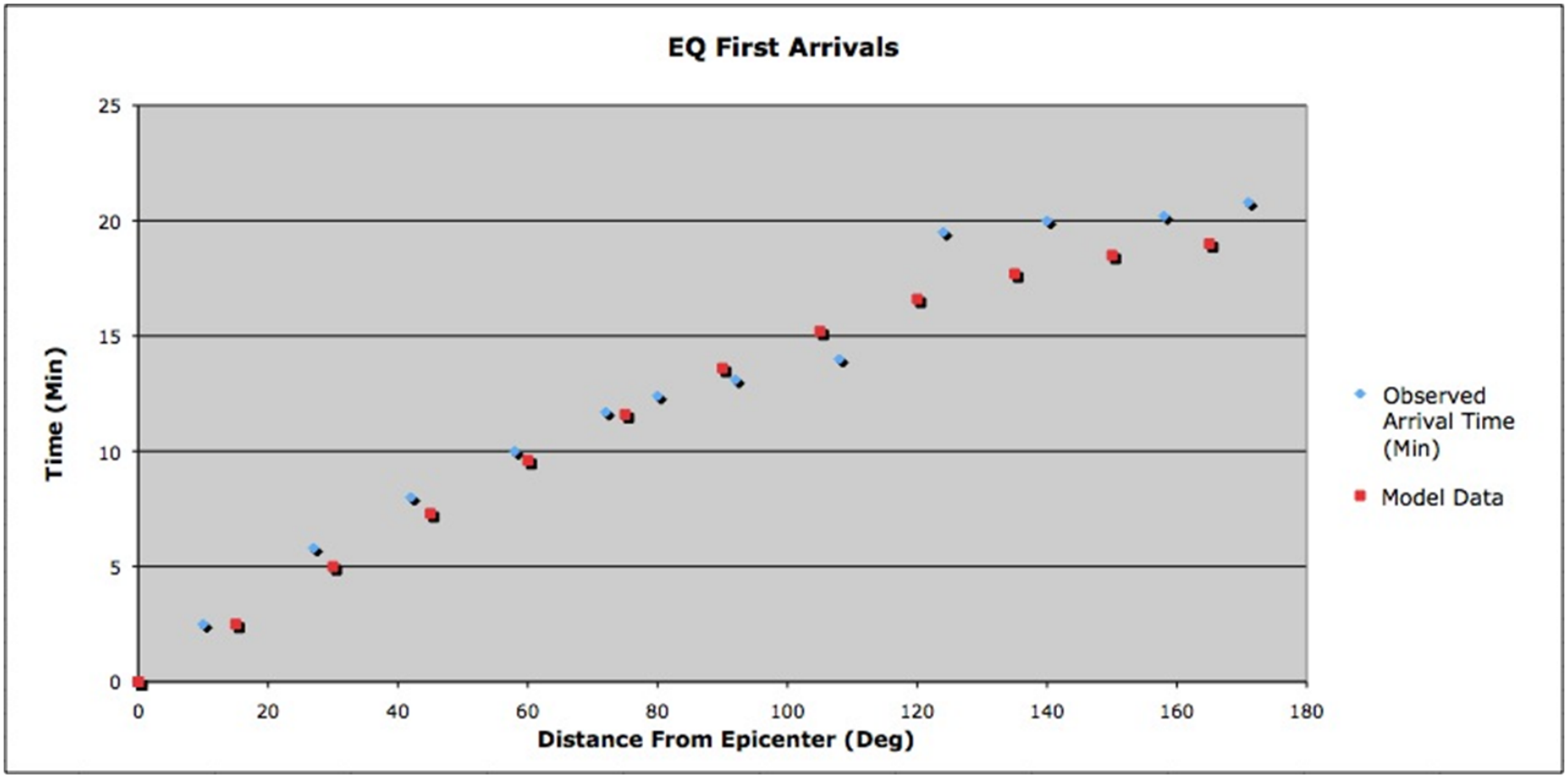
Predicted data

Homogeneous Earth model: Vp = 11 [km/s]



A	B	C	D	E	F
Station Number	**Station Location** Δ (degrees)	**Distance seismic waves travel in model** (cm)	**Actual Distance seismic waves travel** (km)*	**Travel Time** (s)**	**Travel Time** (min)

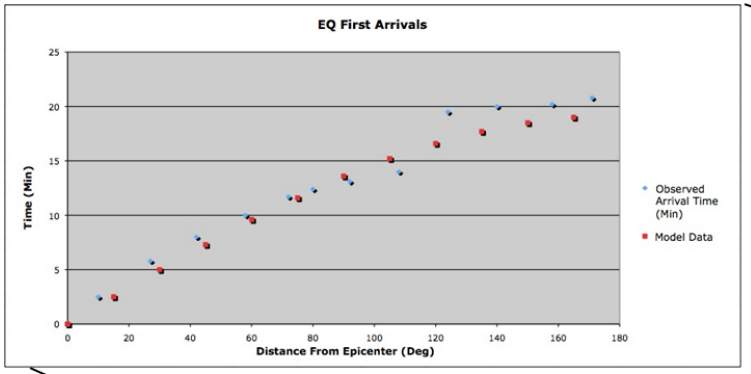
Comparison

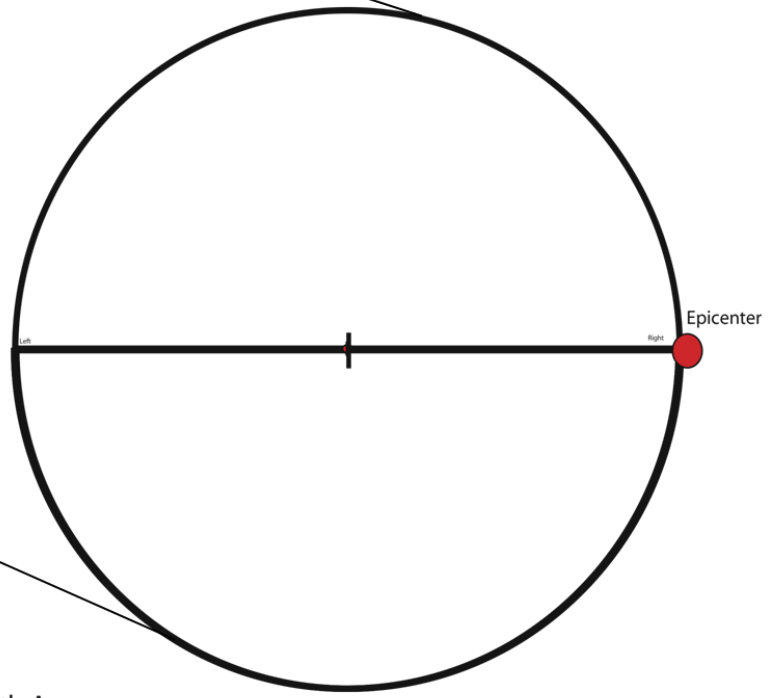

EQ First Arrivals
Time (Min)
25
20
15
10
5
0
0
20
40
60
80
100
120
140
160
180
Distance From Epicenter (Deg)
Observed Arrival Time (Min)
Model Data

Improvements

- Homogeneous model vs. layered model
- Predict arrival times at more stations
- Change seismic velocity
- Emphasize repeatability using multiple earthquakes

What does this tell us about Earth?

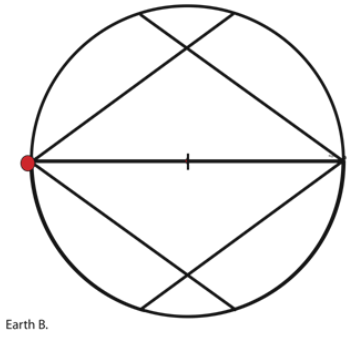


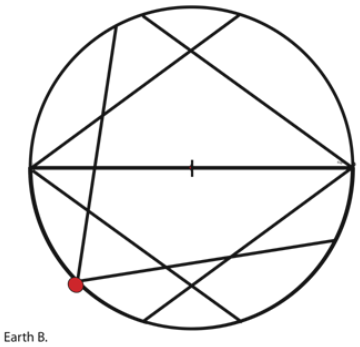


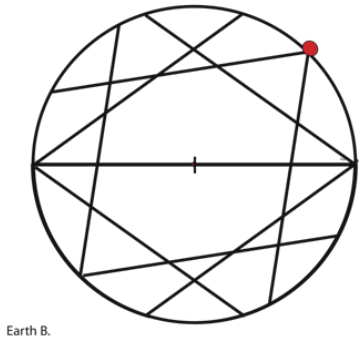
How does this anomaly in the data translate back to Earth?

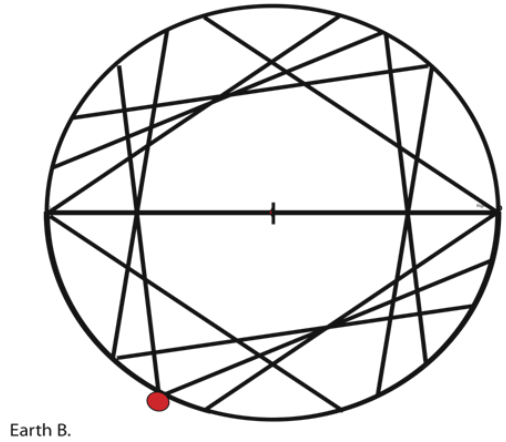
Earth A.

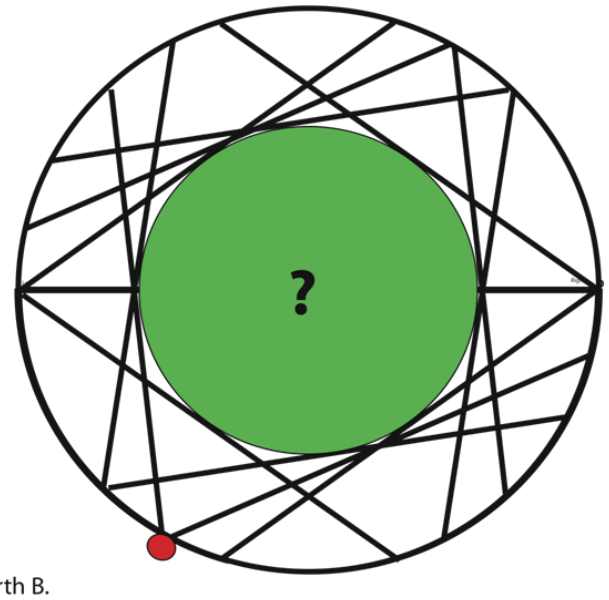
The ah-ha moment

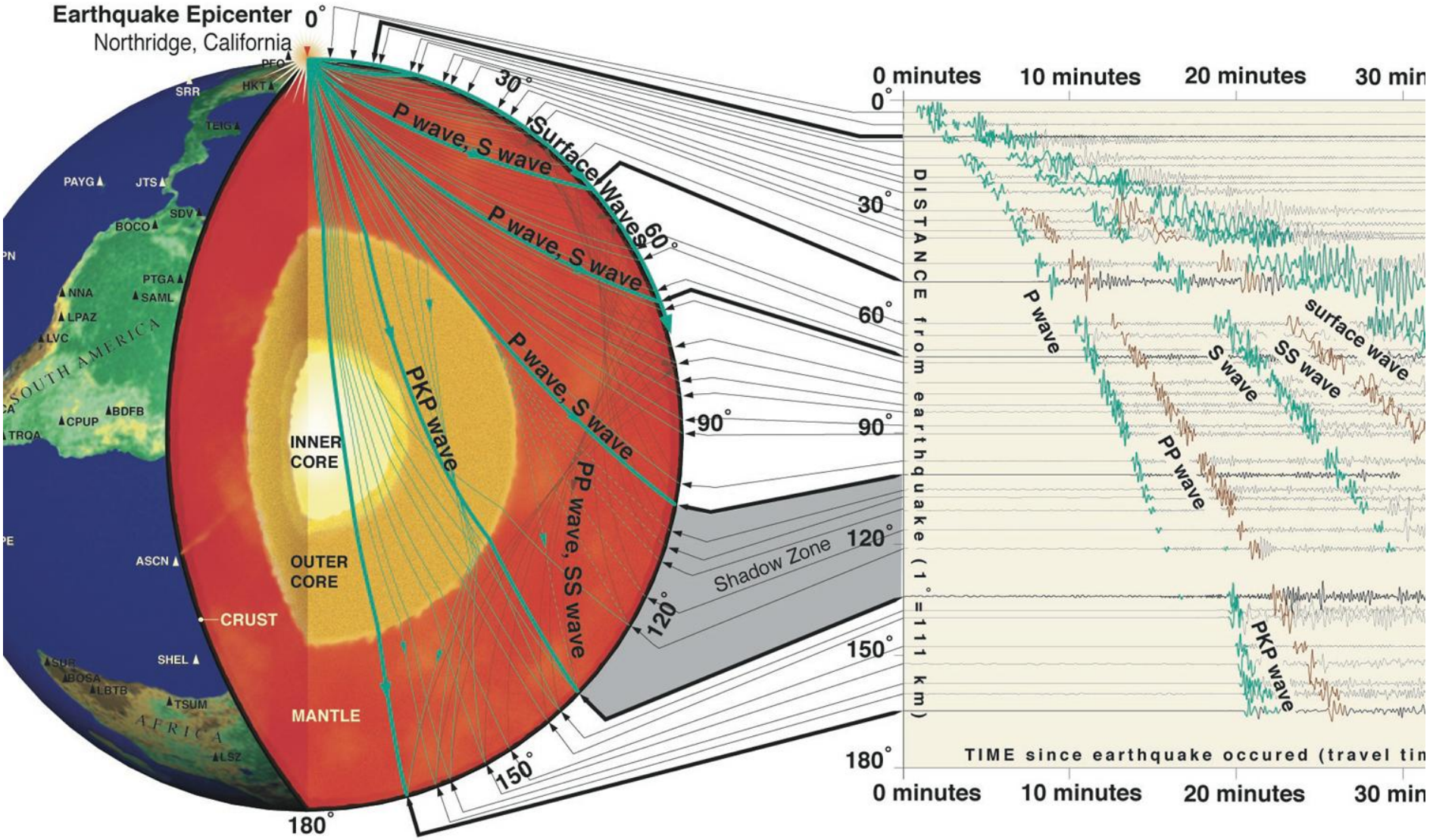











Earthquake Epicenter
Northridge, California
0°
30°
60°
90°
120°
150°
180°
Surface Waves
P wave, S wave
P wave, S wave
P wave, S wave
PKP wave
PP wave, SS wave
INNER CORE
OUTER CORE
MANTLE
CRUST
Shadow Zone
PFO
HKT
SRR
TEIG
PAYG
JTS
SDV
BOCO
PTGA
SAML
NNA
LPAZ
LVC
CPUP
BDFB
TROA
ASCN
SHEL
BOSA
LBTB
TSUM
LSZ
SOUTH AMERICA
AFRICA
0 minutes
10 minutes
20 minutes
30 min
DISTANCE from earthquake (1° = 111 km)
P wave
S wave
surface wave
SS wave
PP wave
PKP wave
TIME since earthquake occured (travel tim

Where do we go from here?

- This activity
  - Predict arrivals for a 2-layer model
- Other activities
  - Earthquake location using travel time curves
    - Plate boundaries activity?
  - More complex waveform analysis
    - Instrument corrections, geometric spreading correction,…?
  - Incorporating other wave types
    - PP, PkP, S, surface waves, etc.
  - …..it’s open to anything