Earthquakes:

An Informational Presentation

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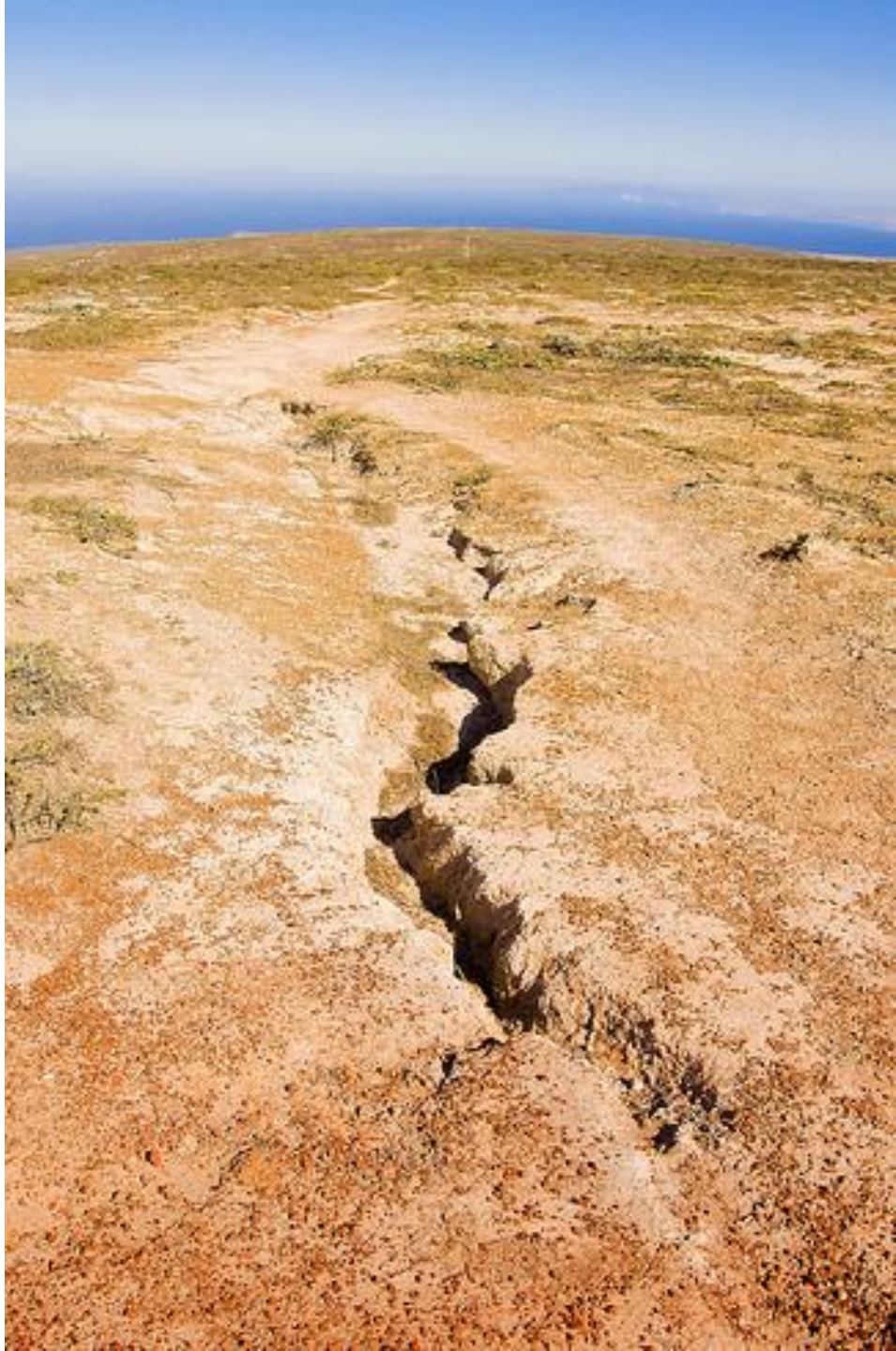

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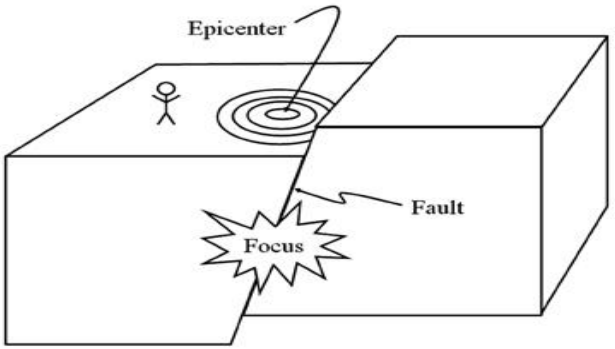
Overarching Objective

With a deeper understanding of earthquakes the class will be able to make more educated decisions as to which parameters may provide the simple stark model with material improvements

Cause of Earthquakes

Natural Earthquakes

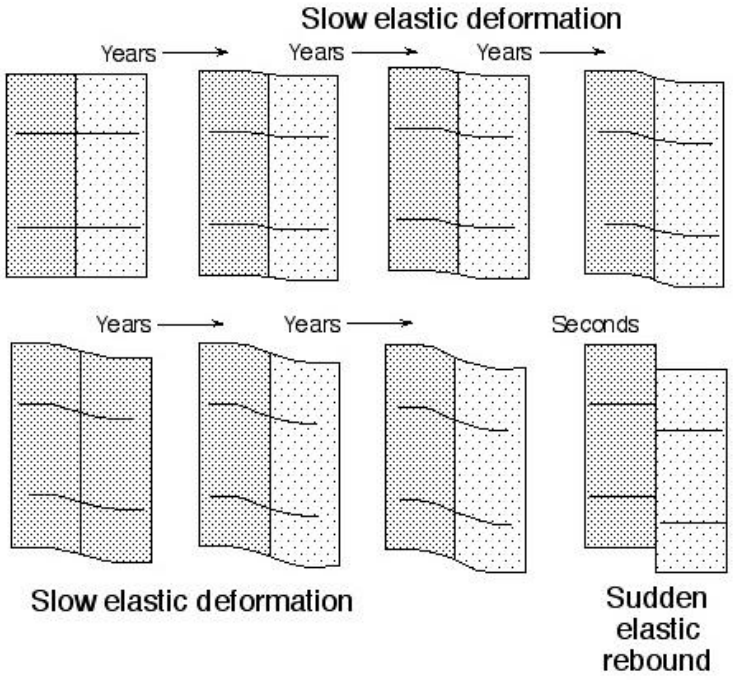
When tectonic plates move under the Earth's surface, energy is created and seismic waves are released. These waves stem from the epicenter and are responsible for the damage caused by quakes.



Building up Strain

As earthquakes build up stress the formation of the rocks between two faults become deformed.

These rocks are elastic, meaning they have memory of their original shape, so when frictional pressures become too much, the rocks rebound and all the stored energy is released.



Artificial Earthquakes

Less relevant are man made earthquakes, although they could be important in fine tuning the model.

Man made earthquakes typically result from changing the mass in specialized regions, such as when drilling, mining, or building a dam.

Fault Ruptures

Inter-Seismic Slip

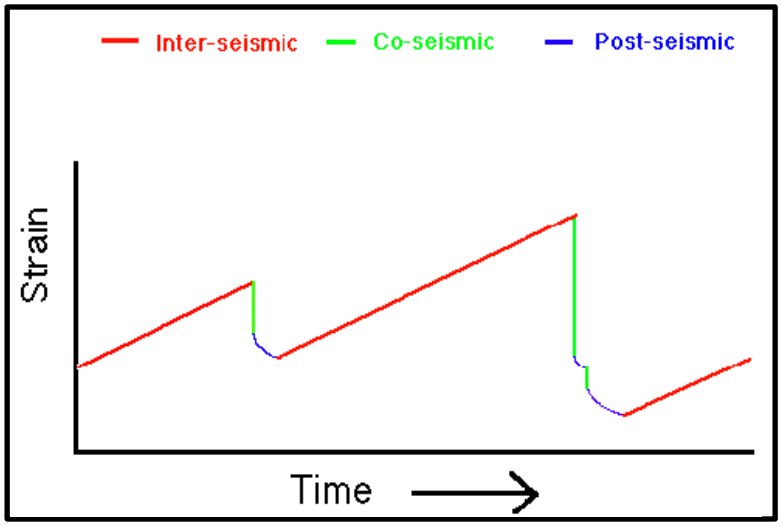
Period when strain accumulates irregularly but repeatedly rupture the fault. This is vast majority of the fault cycle.

Co-Seismic Slip

Moment when the earthquake happens and the faults have accumulated too much strain. Elastic rebound causes the earthquake.

Post Seismic Slip

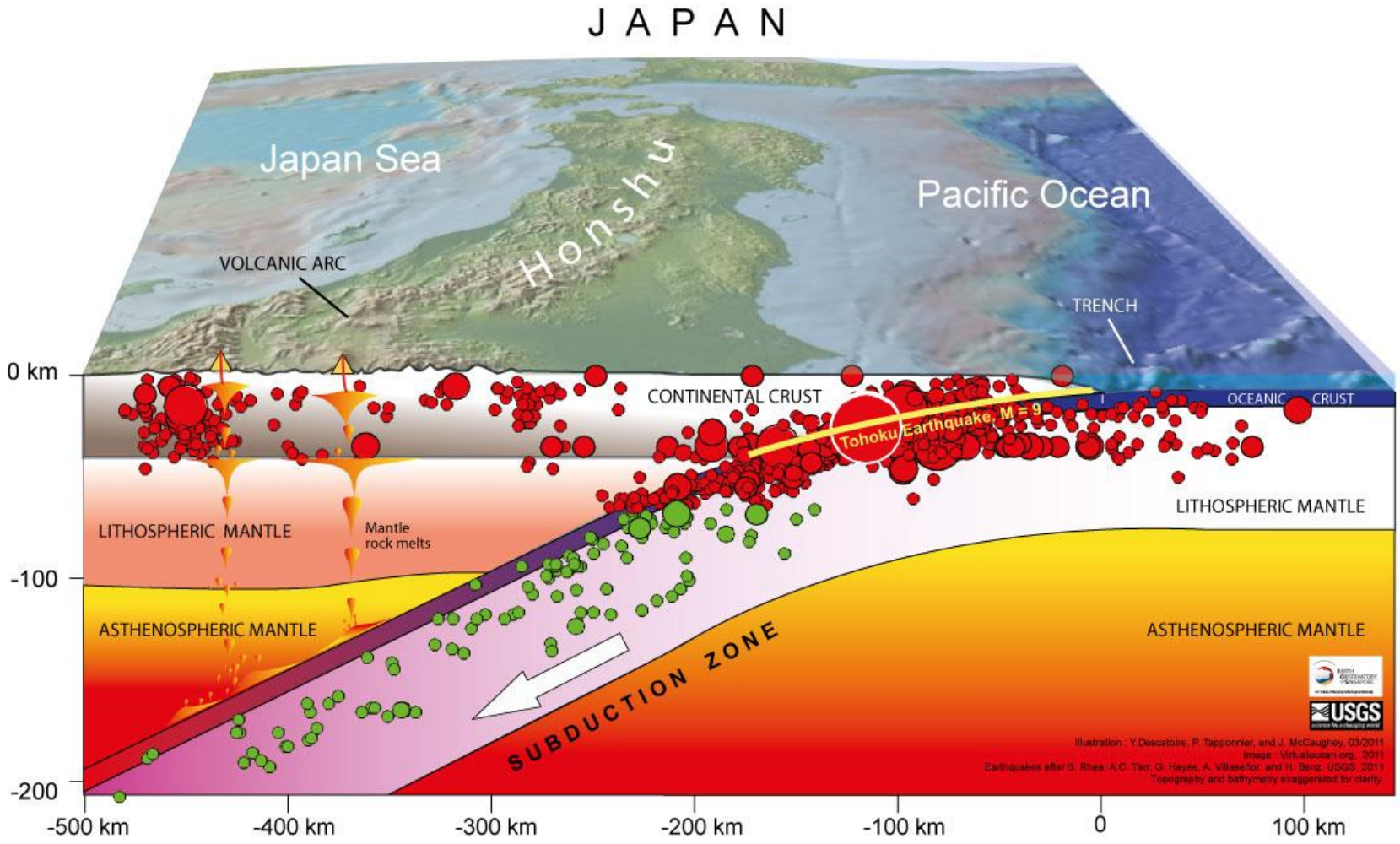
A fault will continue to accumulate significant slip after an earthquake, but this soon decays back to inter-seismic slip



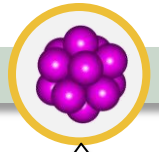
Super Earthquakes

Faults can only release so much energy, but sometimes faults borrow energy from nearby faults to create super earthquakes with magnitude 9 and above. Example: Tohoku Japan (2011, Magnitude 9). All of these earthquakes occur along subduction zones, where tectonic plates collide / dive under each other.

Example: Subduction Zone

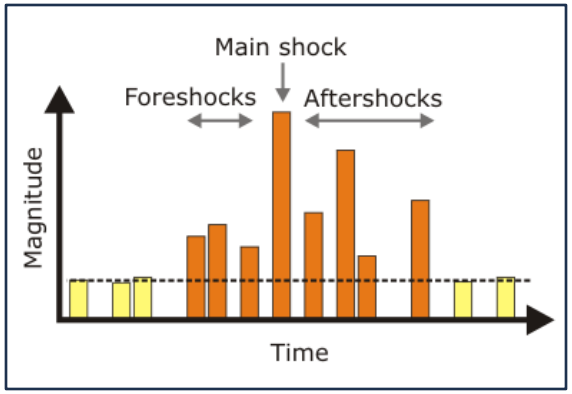


Earthquake Clusters



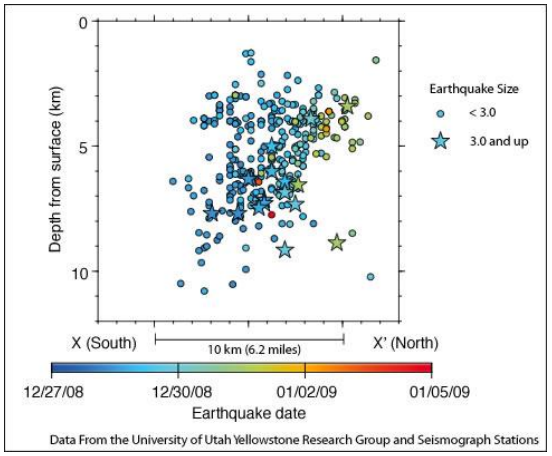
Aftershock

An earthquake that occurs right after the original earthquake. The aftershock is always of smaller magnitude. The challenge is classifying proceeding quakes.



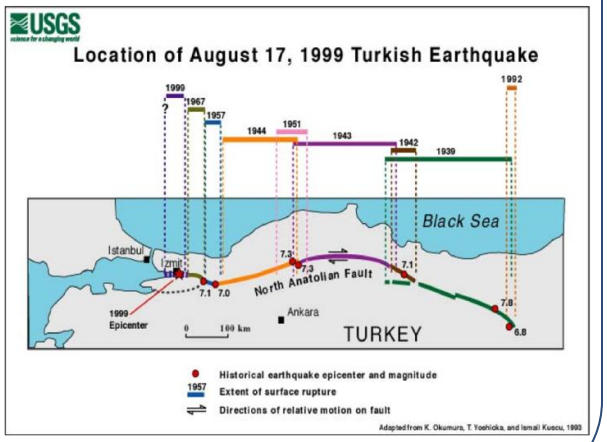
Swarm

An earthquake swam is a series of earthquakes hitting a small area in a short amount of time. Unlike aftershocks, there is no main earthquake. Ex. Yellowstone 2004



Storm

Earthquake storms are when earthquakes strike adjacent segments of a fault in clusters, over years. Triggered by stress redistribution of predecessors.



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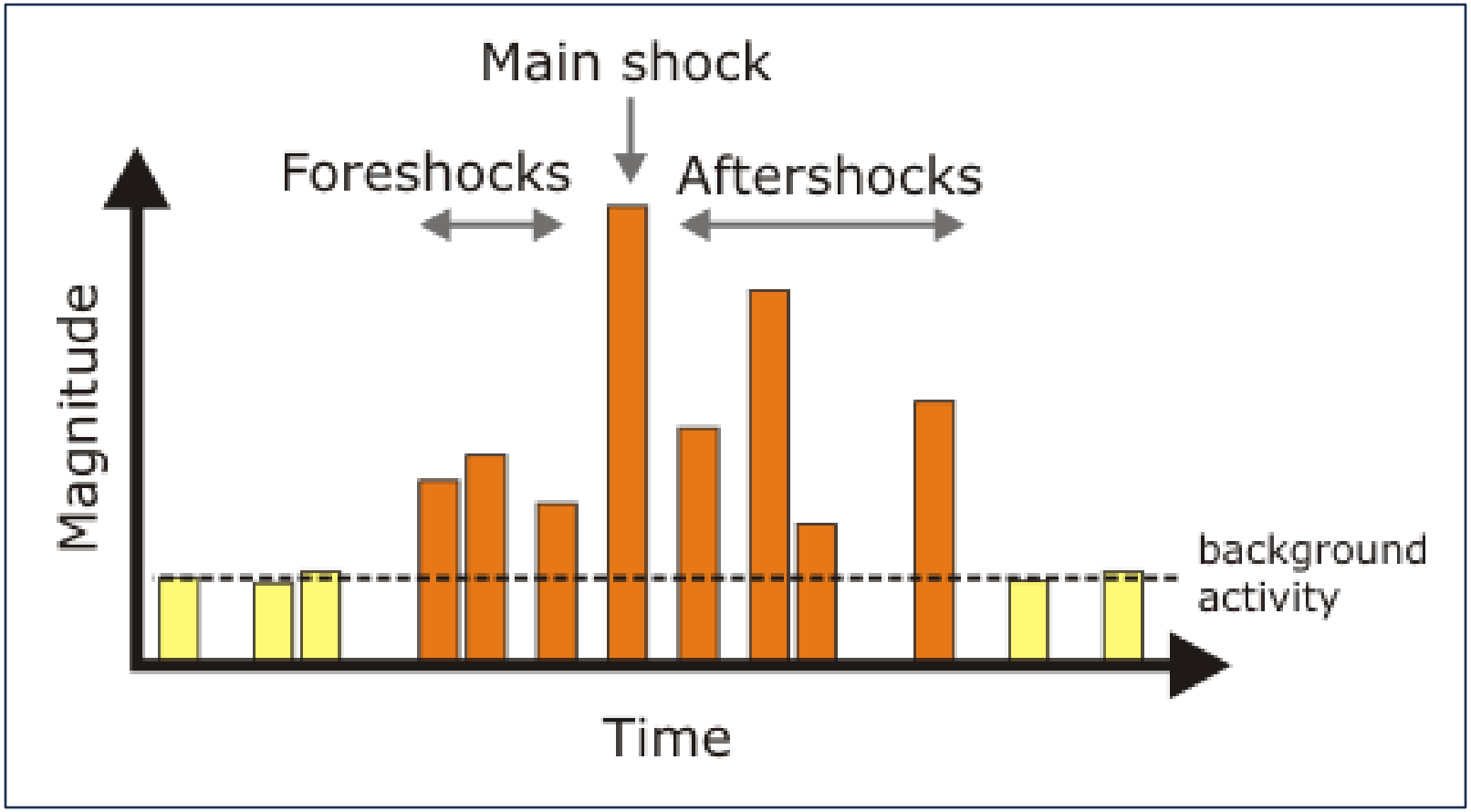
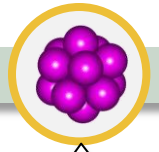

Main shock
Foreshocks
Aftershocks
Magnitude
background
activity
Time

Earthquake Clusters



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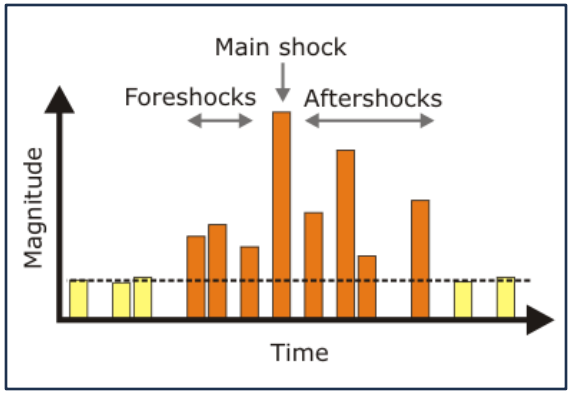

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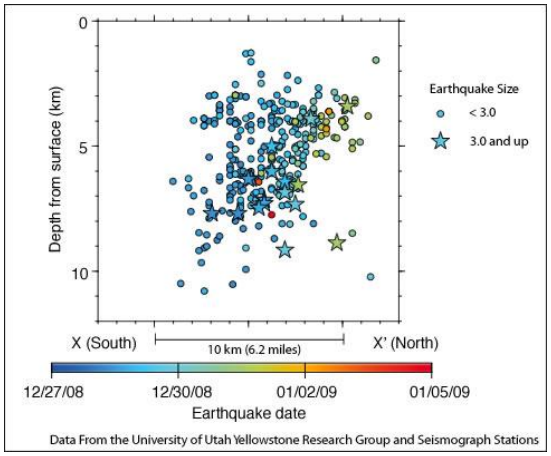

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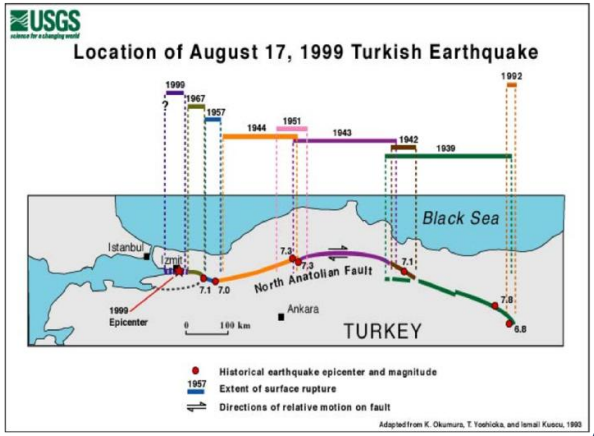

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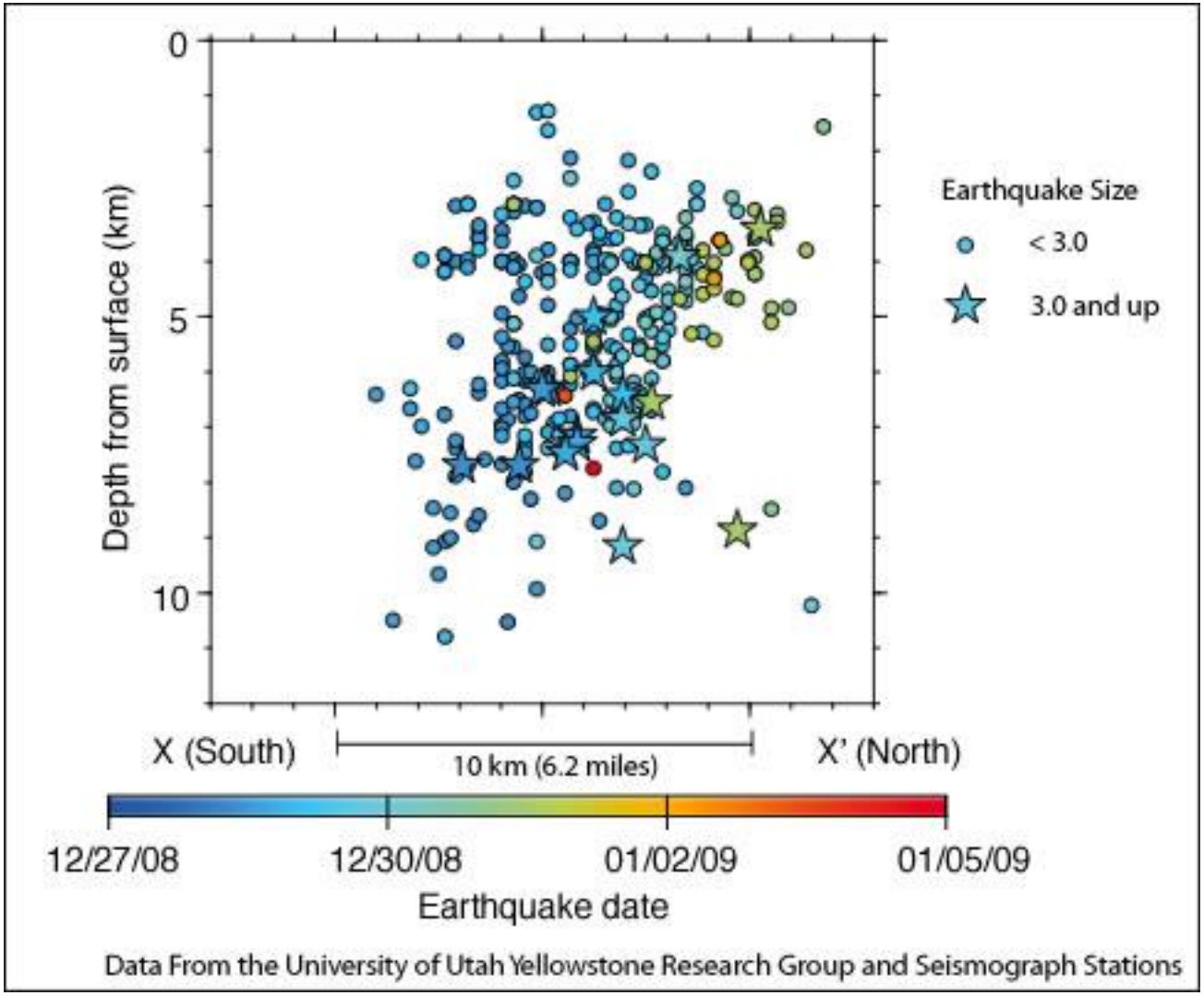
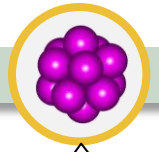

0
5
10
Depth from surface (km)
Earthquake Size
< 3.0
3.0 and up
X (South)
10 km (6.2 miles)
X' (North)
12/27/08
12/30/08
01/02/09
01/05/09
Earthquake date
Data From the University of Utah Yellowstone Research Group and Seismograph Stations

Earthquake Clusters



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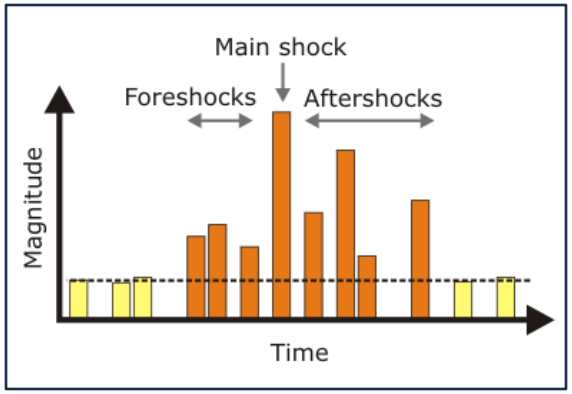

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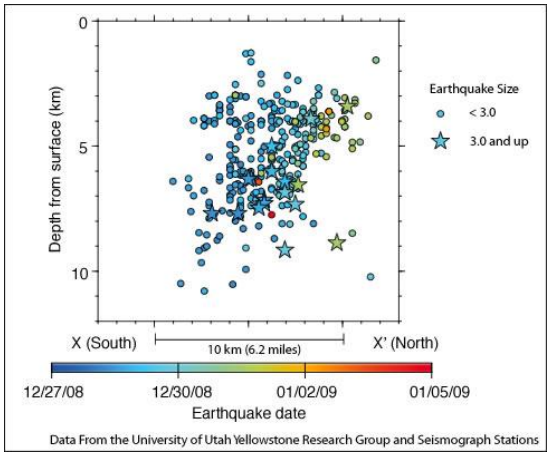

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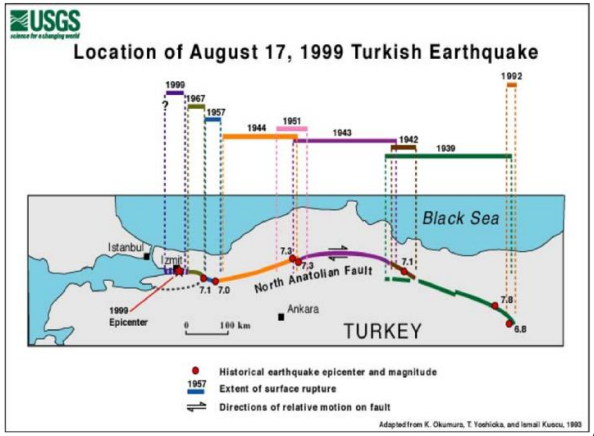

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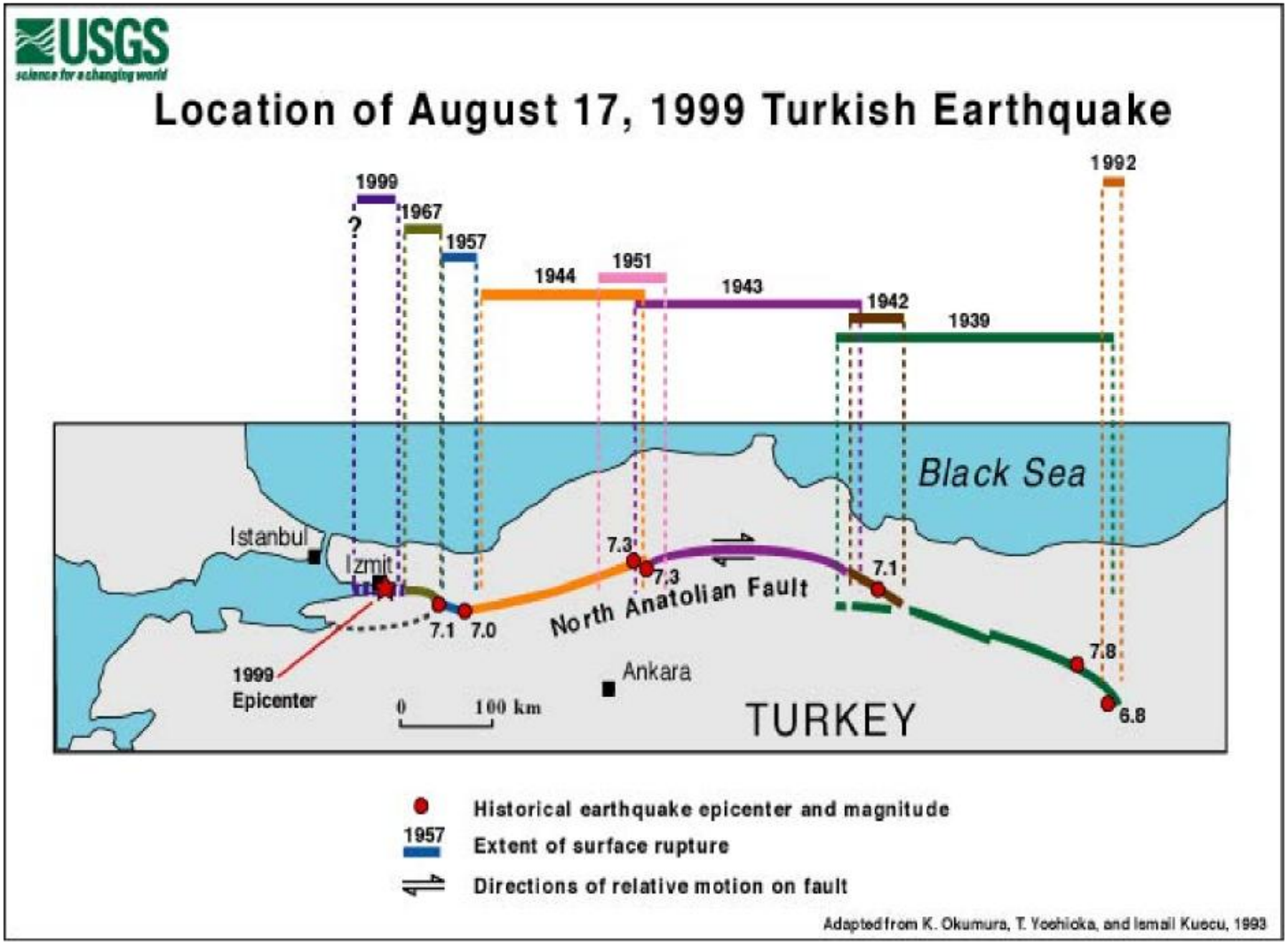

USGS
science for a changing world
Location of August 17, 1999 Turkish Earthquake
1999
?
1967
1957
1944
1951
1943
1942
1939
1992
Black Sea
Istanbul
Izmit
7.3
7.3
7.1
7.1
7.0
North Anatolian Fault
7.8
6.8
1999
Epicenter
0
100 km
Ankara
TURKEY
Historical earthquake epicenter and magnitude
1957
Extent of surface rupture
Directions of relative motion on fault
Adapted from K. Okumura, T. Yoshioka, and Ismail Kuscu, 1993

Effects of Earthquakes

Shaking / Ground Rupture

Landslides

Fires

Soil Liquefaction

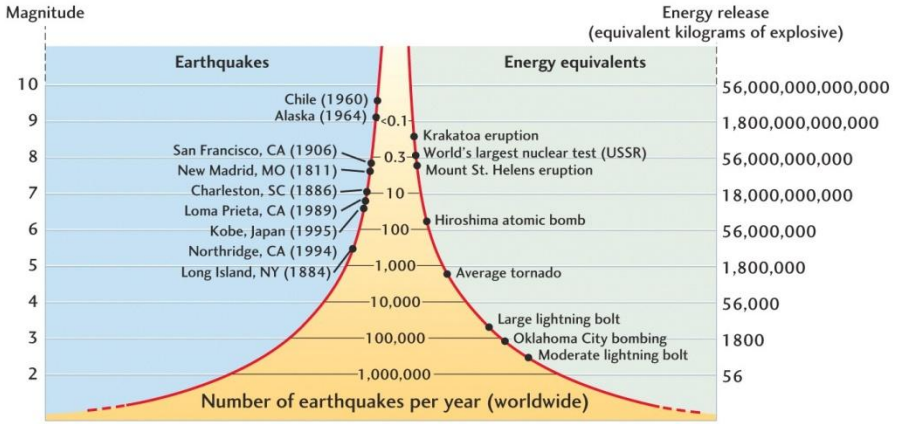
Tsunami

Floods

Measuring Magnitude

Moment Magnitude Scale

The successor of the Richter scale. The MMS measures the **energy released**. The Richter scale could not measure earthquakes accurately from further than 600km of the epicenter, and had an upper limit. The MMS corrected these shortcomings.



Mercalli Intensity Scale

Measures the **intensity** of an earthquake based on impact to Earth's surface and human made constructs. Goes from I (instrumental) to XII (catastrophic)

Level of Earthquake	Instrumental	Detected only by seismographs
I	Instrumental	Detected only by seismographs
II.	Feeble	Noticed only by sensitive people.
III	Slight	Resembling vibrations caused by heavy traffic
IV	Moderate	Felt by people walking; rocking of free standing objects
V	Rather strong	Sleepers awakened and bells ring
VI	Strong	Trees sway, some damage from overturning and falling objects.
VII	Very strong	General alarm, cracking of walls
VIII	Destructive	Chimneys fall and there is some damage to buildings
IX	Ruinous	Ground begins to crack, houses begin to collapse and pipes reak.
X.	Disastrous	Ground badly cracked and many buildings are destroyed. There are some landslides
XI.	Very Disastrous	Few buildings remain standing; bridges and railways destroyed. water, gas, electricity and telephones out of action
XII	Catastrophic	Total destruction; objects are thrown into the air, much heaving, shaking and distortion of the ground.

Seismic Waves

There are three types of waves: P waves, S waves, and surface waves. P and S waves are body waves, and precede the surface waves. Seismic waves are responsible for the movement of the Earth and the damage quakes cause.

	P Wave	S Wave	Surface Wave
Description	▪ Primary, and fastest wave following an earthquake ▪ Can move through solid rocks, liquids, and even gases	▪ Second wave felt after an earthquake ▪ Move only through solids and displace rock particles outwards, perpendicular to its path	▪ Arrives after body waves and have lower frequency ▪ Rayleigh – Rolls along the ground, causes shaking ▪ Love – Moves horizontally across the crust, fastest surface wave
Facts	▪ Dogs can hear P waves and bark hysterically before a quake hits ▪ Moves by compression and dilation ▪ Arrives as an abrupt thud	▪ The properties of S waves are the reason scientists believe Earth's outer core is liquid ▪ Stopped at the liquid layer in the Earth's core	▪ Surface waves are primarily responsible for the destruction caused by earthquakes ▪ Effects are diminished for deeper earthquakes
Impact			

ETAS Model / Stark Model

https://docs.google.com/presentation/d/1yf3W22eAIX-bPgmVdqkRFfsfIgCHmbtXclF3-S92Us8/edit#slide=id.g122d8c01c_018

Next Steps: Potential Parameters