Seismic Waves - for Physics

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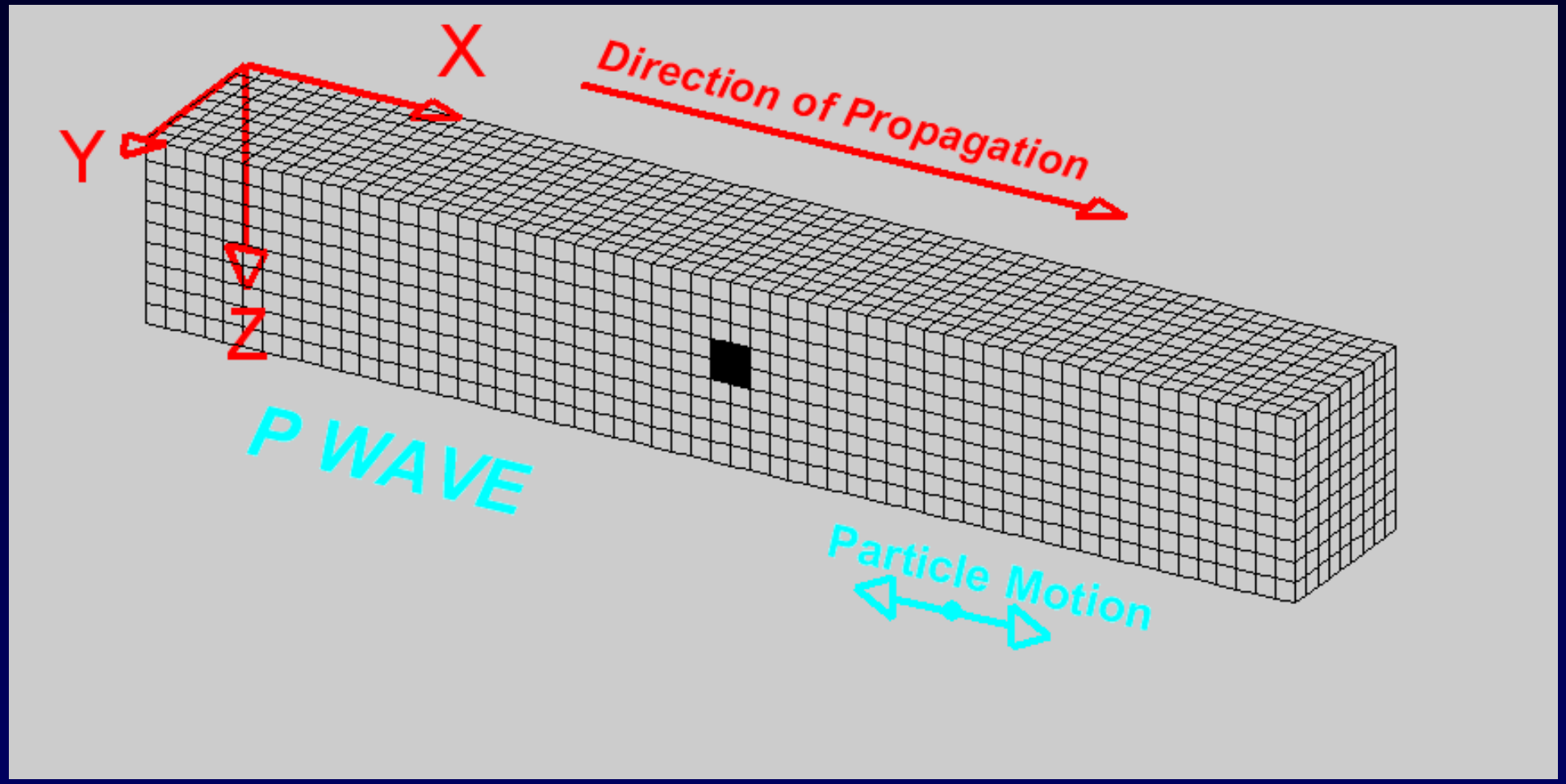
General earthquake & seismic wave information

- Earthquakes occur due to movement along faults.
- Volcanoes also produce earthquakes.
- Other sources of seismic waves: underwater landslides, meteorites, explosions, land settling.
- Earthquakes usually happen when stress builds up over time (sticks) then suddenly slips – “slip-stick” movement.
- Wave animations >> next slides >>

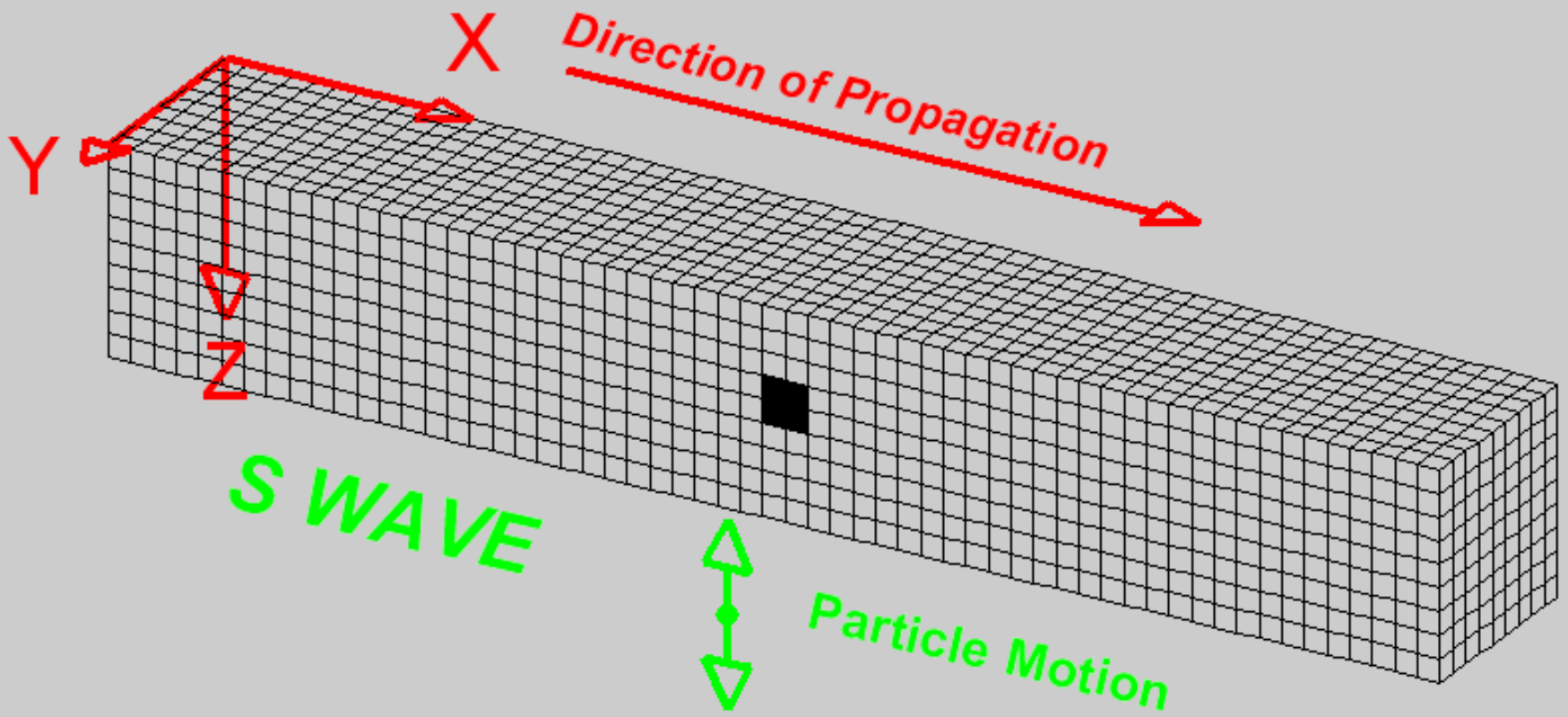
source: ttp://web.ics.purdue.edu/~braile/edumod/waves/WaveDemo.htm

Compressional Wave (P-Wave) Animation



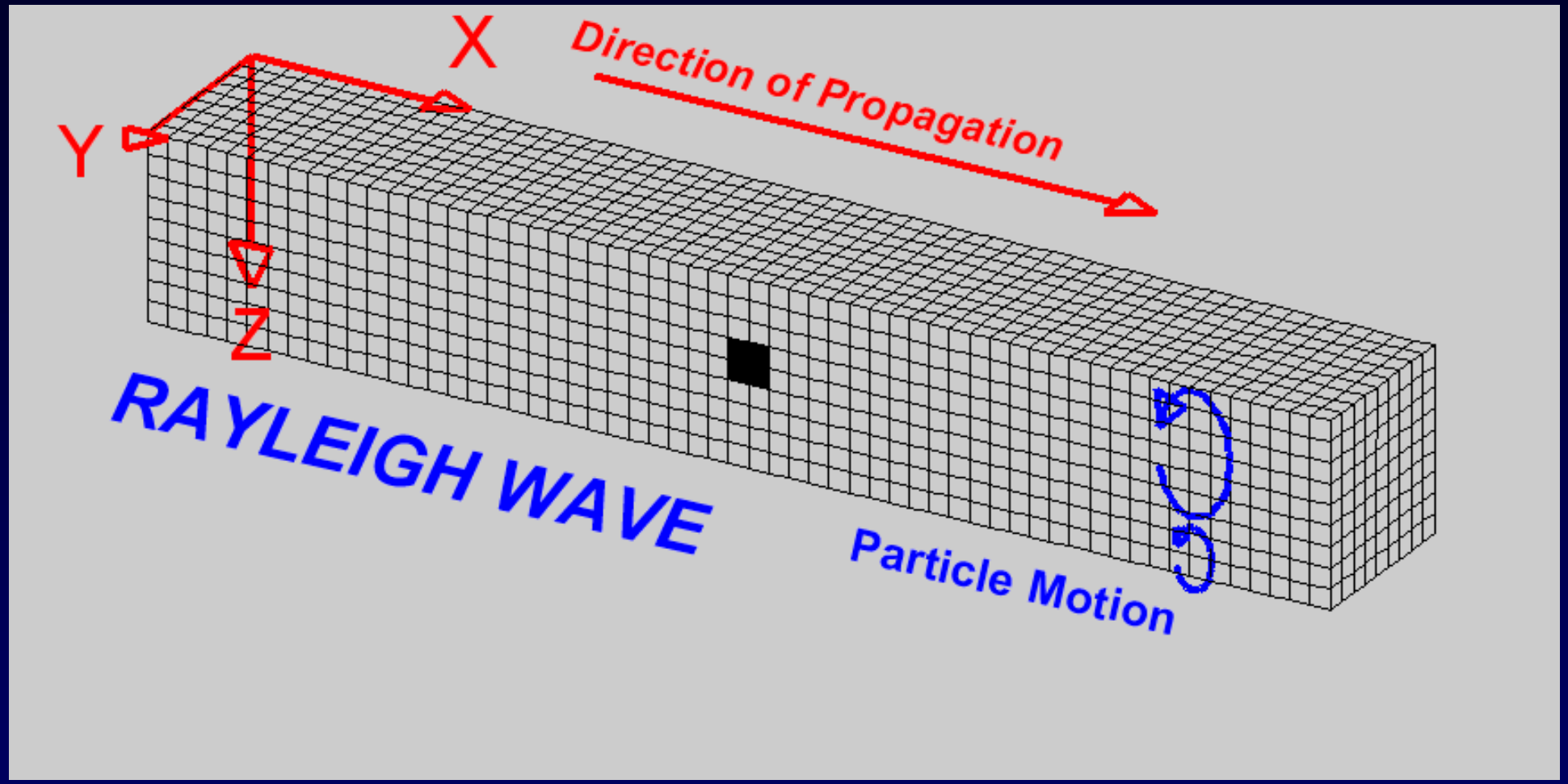
Deformation propagates. Particle motion consists of alternating compression and dilation. Particle motion is parallel to the direction of propagation (longitudinal). Material returns to its original shape after wave passes.

Shear Wave (S-Wave) Animation



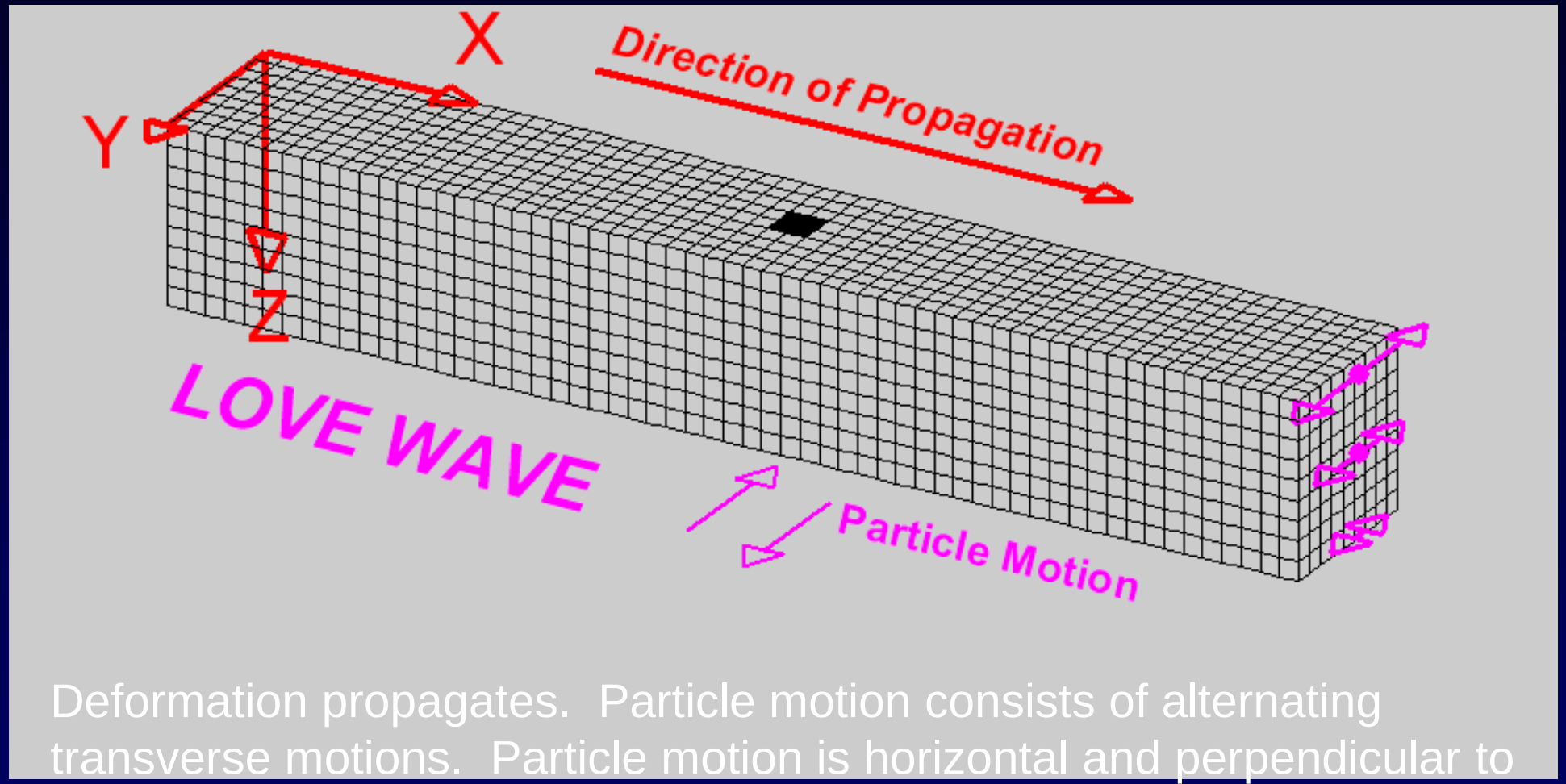
Deformation propagates. Particle motion consists of alternating transverse motion. Particle motion is perpendicular to the direction of propagation (transverse). Transverse particle motion shown here is vertical but can be in any direction. However, Earth's layers tend to cause mostly vertical (SV; in the vertical plane) or horizontal (SH) shear motions. Material returns to its original shape after wave passes.

Rayleigh Wave (R-Wave) Animation



Deformation propagates. Particle motion consists of elliptical motions (generally retrograde elliptical) in the vertical plane and parallel to the direction of propagation. Amplitude decreases with depth. Material returns to its original shape after wave passes.

Love Wave (L-Wave) Animation

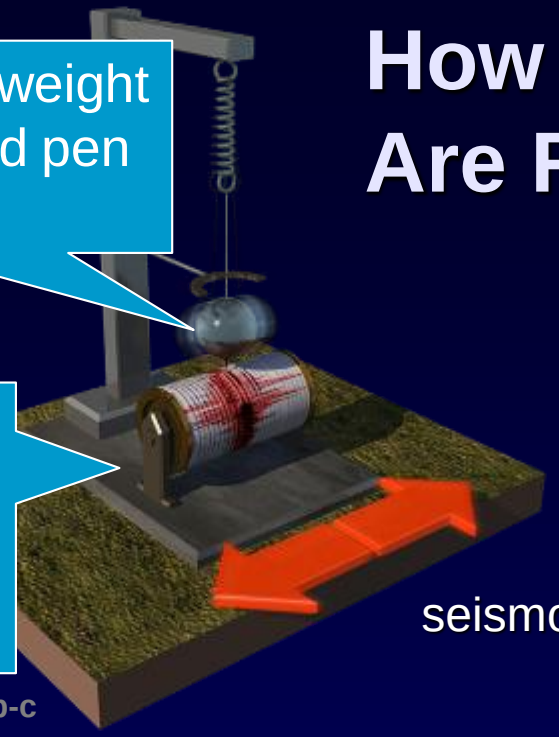


Deformation propagates. Particle motion consists of alternating transverse motions. Particle motion is horizontal and perpendicular to the direction of propagation (transverse). To aid in seeing that the particle motion is purely horizontal, focus on the Y axis (red line) as the wave propagates through it. Amplitude decreases with depth. Material returns to its original shape after wave passes.

How Seismic Waves Are Recorded

Inertia of hanging weight holds it & attached pen stationary...

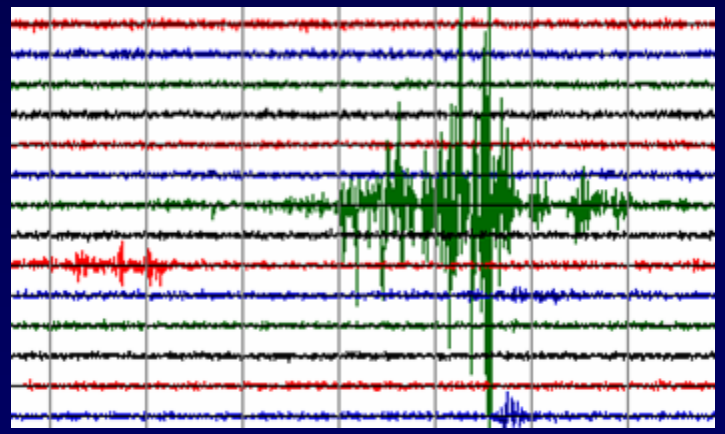
…as the ground & recording paper move below the weight.



12.05.b-c

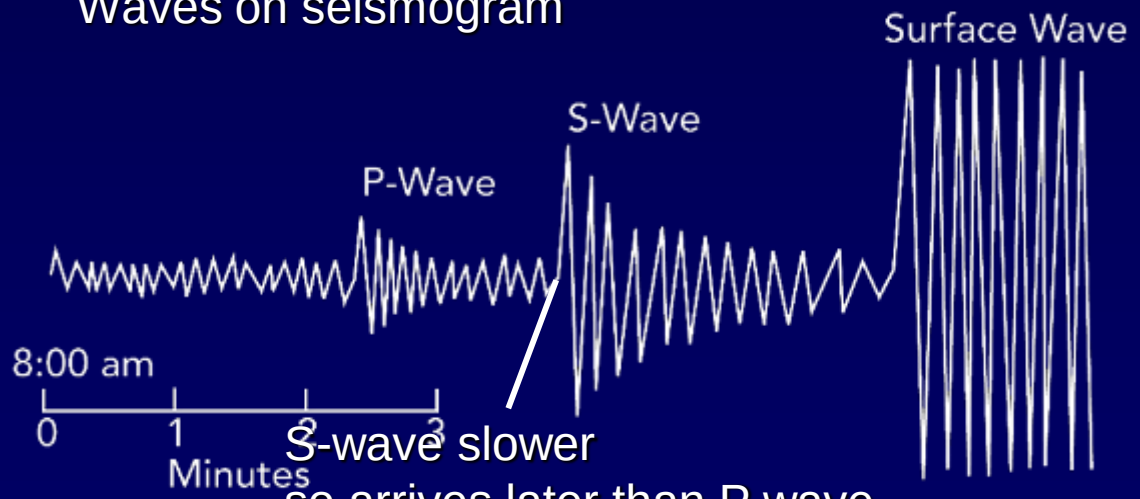
Basic seismometer

Modern seismometer



Seismogram

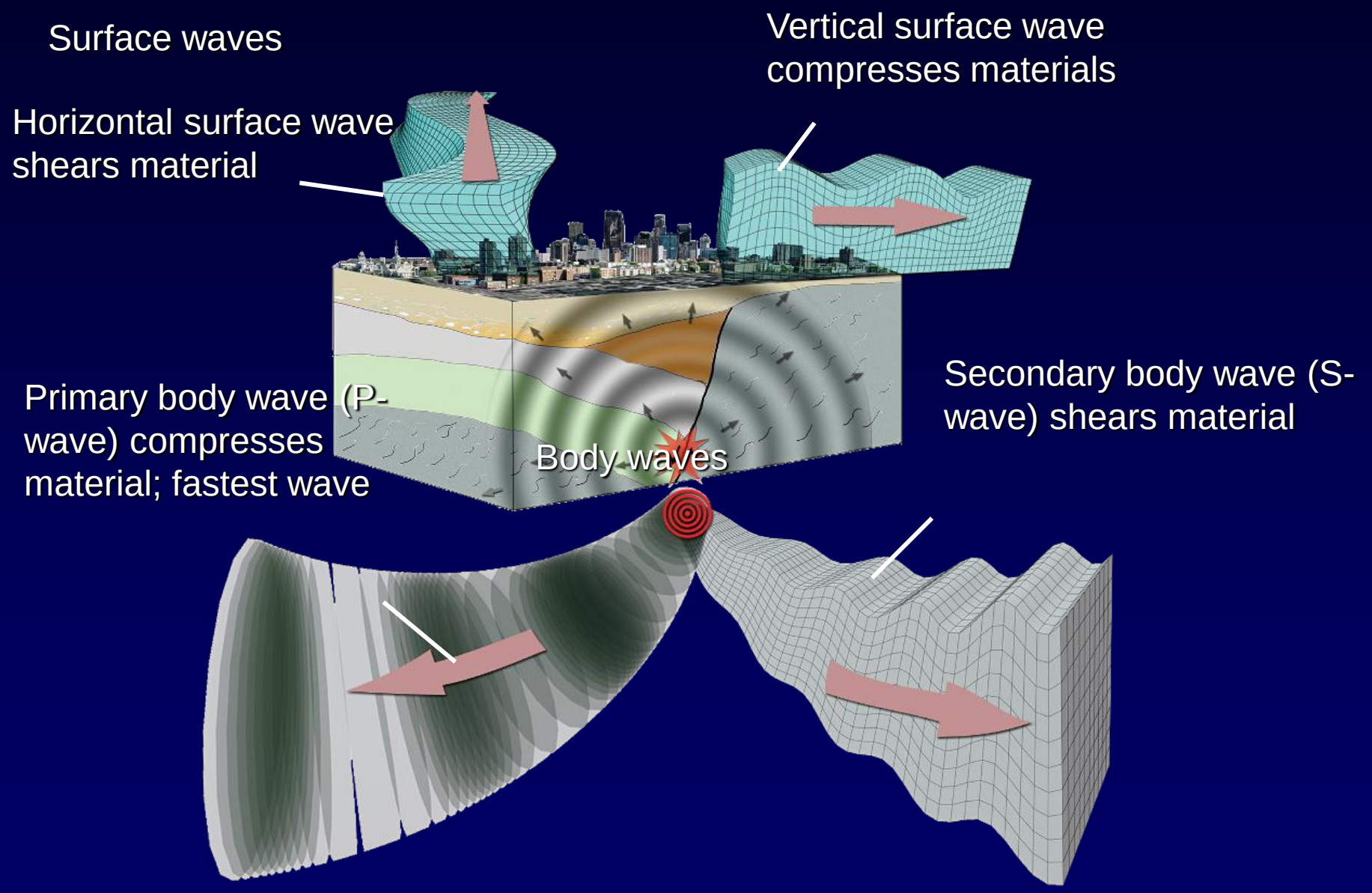
Waves on seismogram



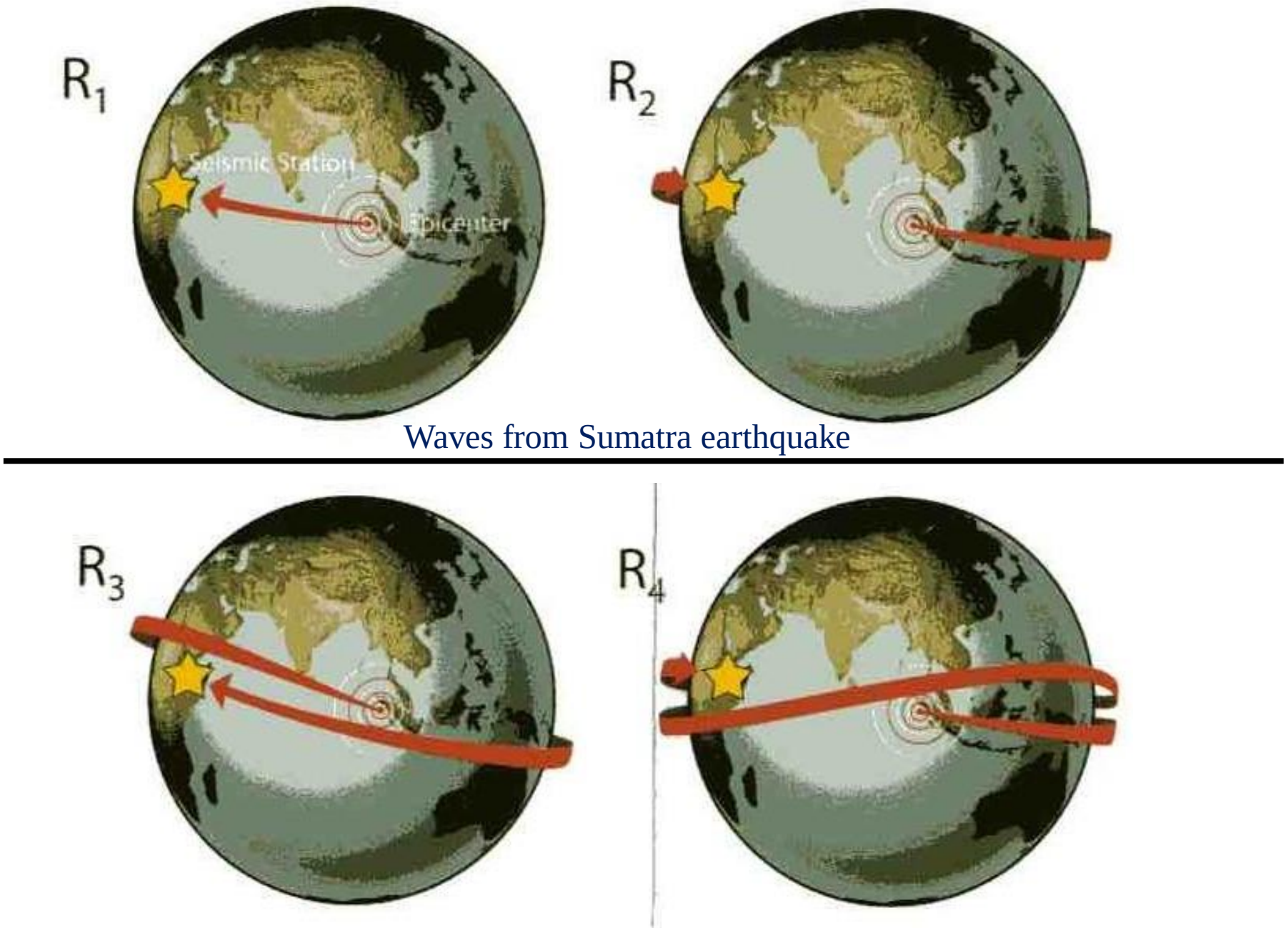
S-wave slower so arrives later than P wave

Real seismograms: http://rev.seis.sc.edu/

Different Kinds of Seismic Waves



How seismic waves travel around the Earth.



Waves from Sumatra earthquake

Magnitude 9.0 NEAR THE EAST COAST OF HONSHU, JAPAN

Friday, March 11, 2011 at 05:46:23 UTC

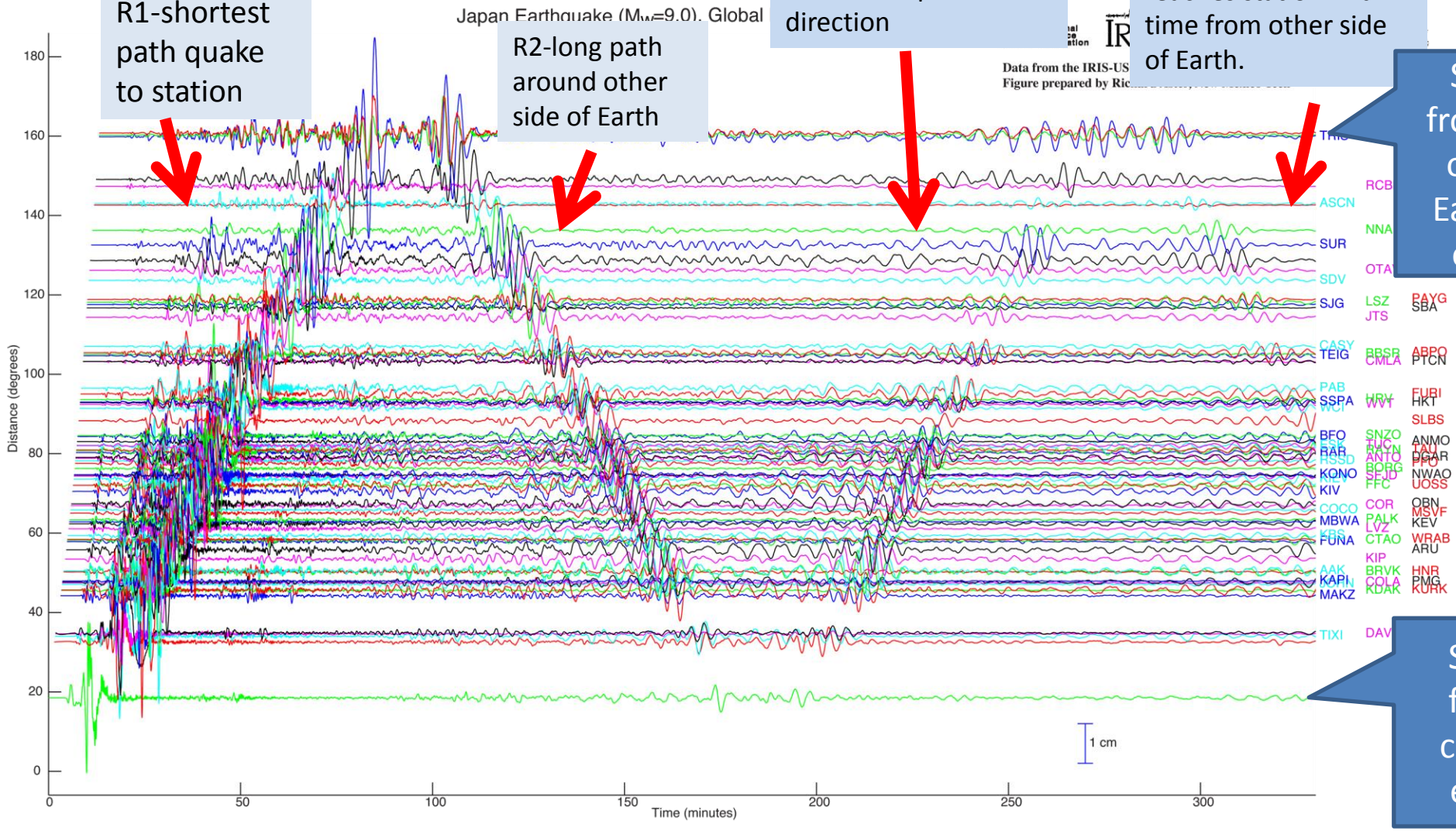
Seismic waves recorded around the world.

R1-shortest path quake to station

R2-long path around other side of Earth

R3 occurs when R1 wave continues around Earth & reaches station 2nd time from quake direction

R4 occurs when R2 wave continues around Earth & reaches station 2nd time from other side of Earth.



Seismogram from station on other side of Earth from the earthquake.

Seismogram from station closest to the earthquake.

Show ground motion animations:

Indonesia 2004

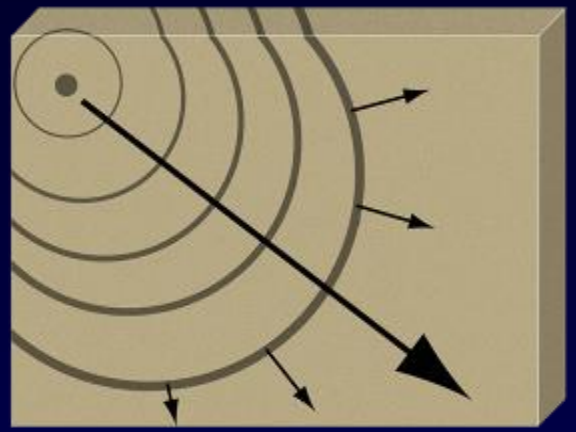
Japan 2011

Japan 2011 3-axis

Other quake with profile

Nevada quake

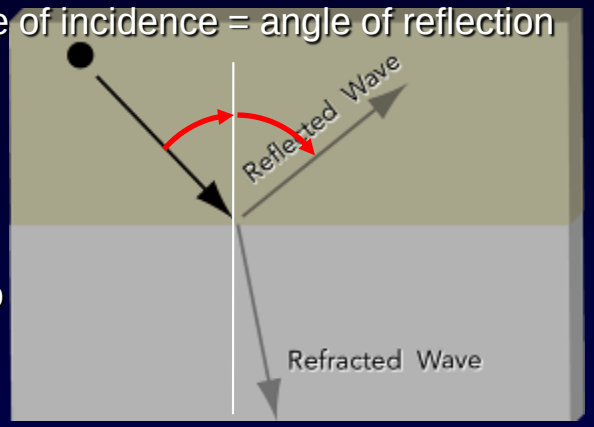
How Seismic Waves Travel Through Material



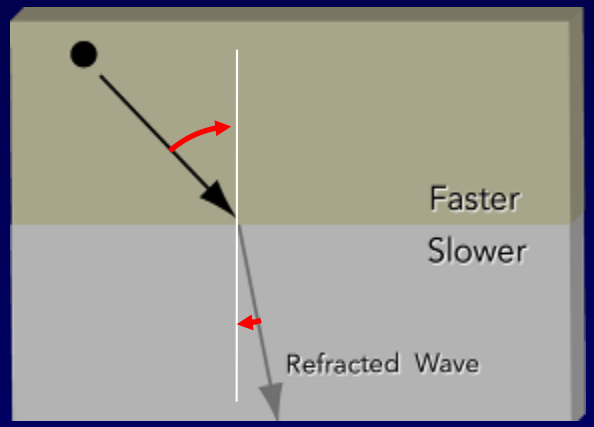
Seismic wave radiates in all directions

A "normal" = line at point where ray hits new medium, perpendicular to the boundary.

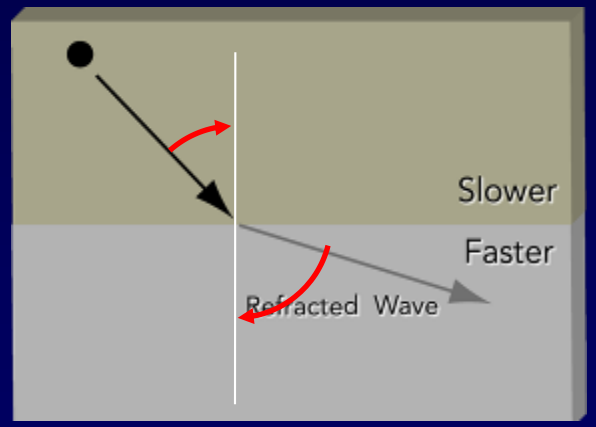
Angle of incidence = angle of reflection



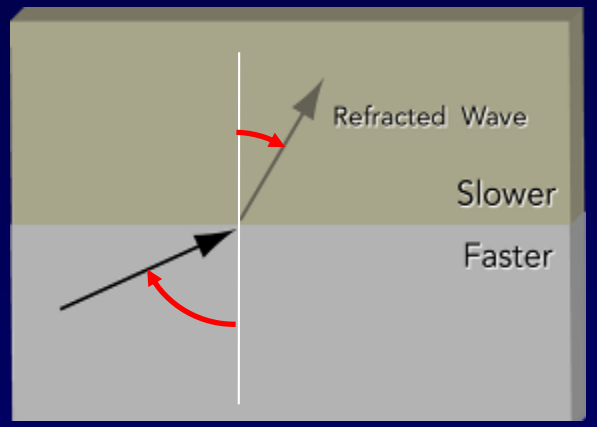
At a boundary, wave will reflect and/or refract



From faster to slower material - new direction closer to normal= steeper angle.

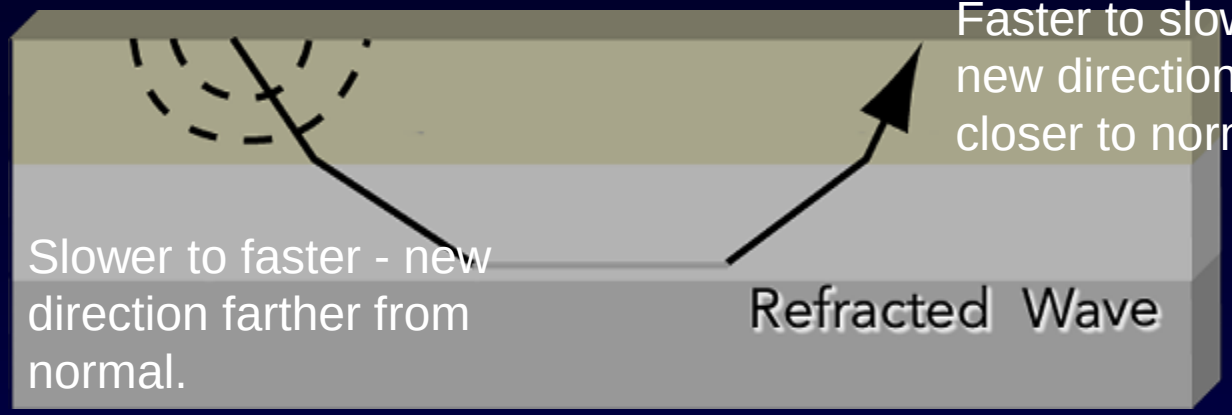


From slower to faster material - new direction away from normal= shallower angle.

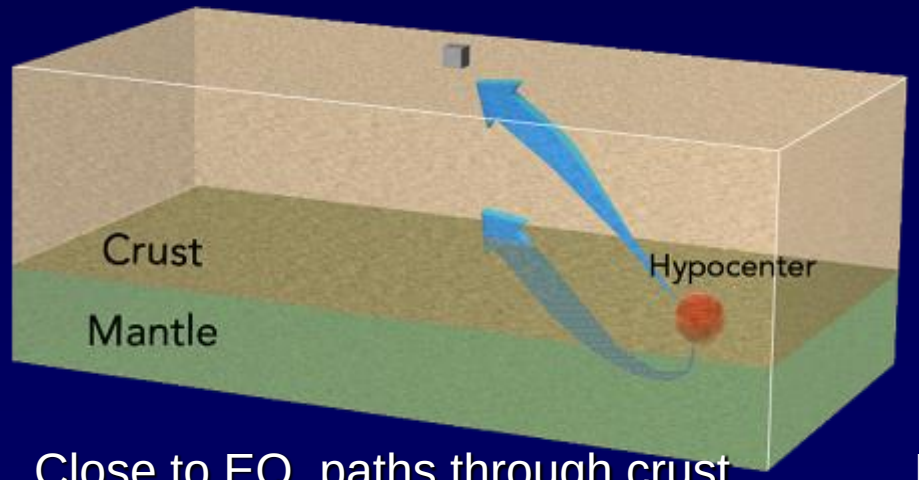


Rising wave from faster to slower - new direction closer to normal = steeper angle.

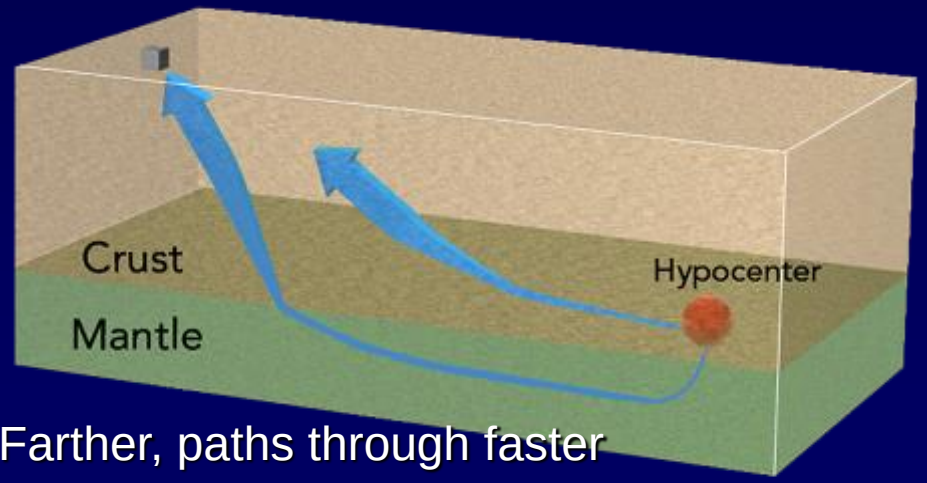
A seismic wave bends as it travel through crust and mantle



Curved paths permit us to find depth to crust-mantle boundary (Moho)



Close to EQ, paths through crust arrive first

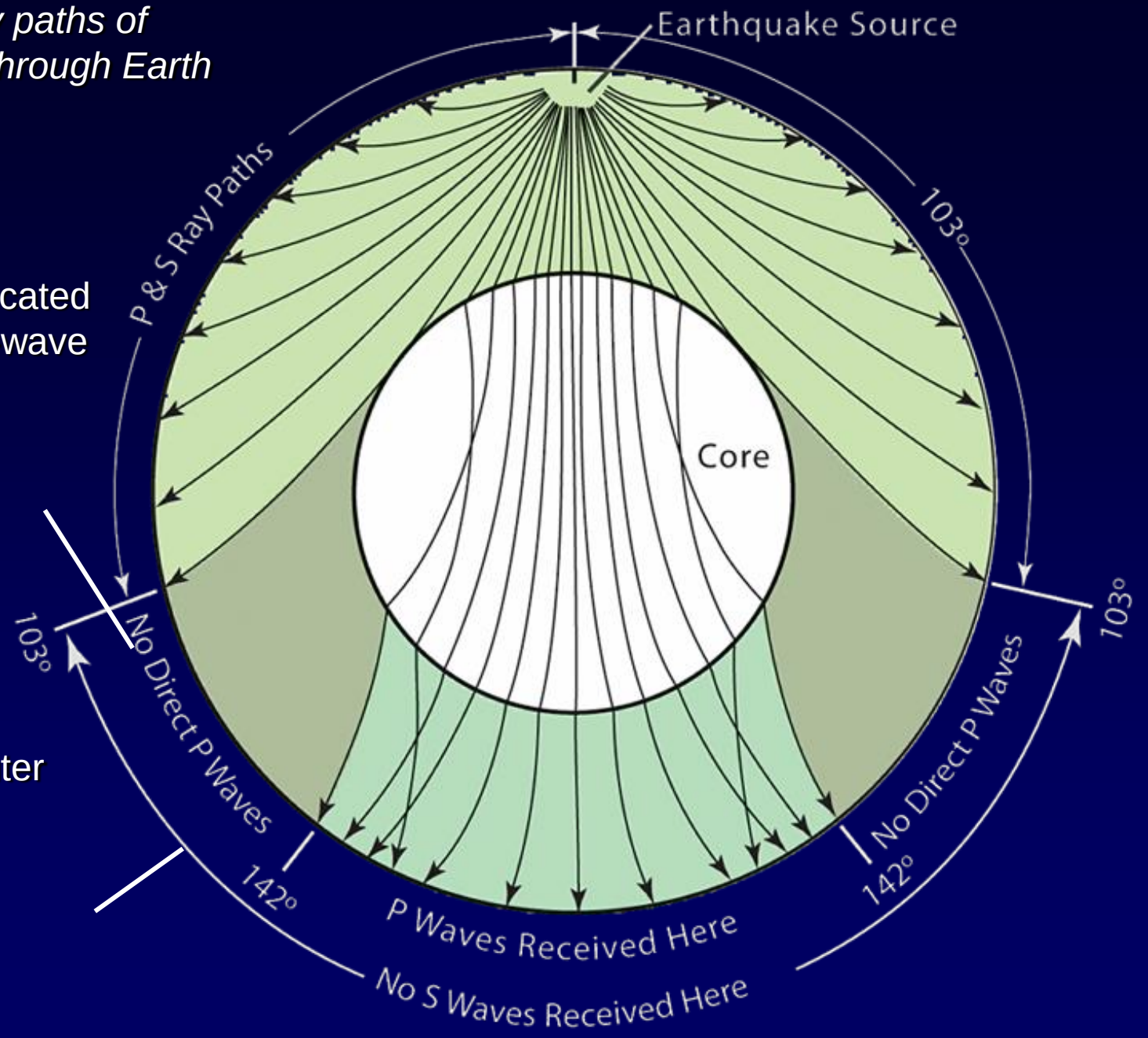


Farther, paths through faster mantle arrive first

Examine the ray paths of seismic waves through Earth

Size of core indicated by location of P-wave shadow zone

S-waves do not pass through outer core (so liquid)



Animation of waves travelling through the Earth:

http://ds.iris.edu/seismon/swaves/