Resource from animation found at: <http://www.iris.edu/hq/inclass/search>

**Narration from the animation:**

**Focal Mechanisms Explained**

When an earthquake occurs, seismologists create graphics of focal mechanisms, informally referred to as beach balls,to show the faulting motions that produce the earthquake.

The focal mechanisms are based on the direction of the first arriving P wave.

Lets investigate the patterns of P-wave arrivals that result from different faulting mechanisms by *first* considering a strike-slip earthquake.

When an earthquake occurs, seismic waves radiate away from the epicenter in all directions. The parallel green lines in the Northwest and southeast quadrants have been compressed during the earthquake and the Northeast and southwest quads were stretched. This applies also to vertical faults.

Let’s look at the Pwaves moving away from the epicenter. We will inset slinkies to demonstrate and exaggerate the compression/dila**ta**tion features.

North*west* and South*east* of the epicenter the rock is compressed and the first arriving P waves at those stations are pushes ***away*** from the epicenter.

North *east* and South*west* of the epicenter the rock is ***stretched*** and the first P waves are pulls ***toward***the epicenter

The dilatational and compressional arrivals are often shown as plus and minus signs respectively.With observations from many stations, we see 2 quadrants of compressional arrivals and 2 quadrants of dilatational arrivals separated by perpendicular nodal planes. To simplify the illustration, compressional quadrants can be shaded, and **dilatational** quadrants are left un shaded producing a P-wave first-motion pattern that looks like a beach ball.

Notice that this pattern of dilatations and compressions can be produced either by right lateral strike-slipfaulting on a North-south fault plane, or *left* lateral strike-slip faulting on an east-west fault plane. Therefore you must use geological knowledge of the region to decide which nodal plane is the fault plane.

For example, if an earthquake with an epicenter on the san andreas fault had a focal mechanism that looked like this the most ***likely*** choice would be that the fault plane is oriented Northwest-Southeast, parallel to the strike of the fault we observe at the surface.

Let’s now consider a right-lateral strike-slip earthquake on the Kane Fracture Zone in the Atlantic. This earthquake will produce compression in the Northeast and Southwest quadrants, and dilatation in the Northwest and Southeast quadrants. Since there are no nearby seismometers, the P-wave first arrival patterns are observed at *distant* stations. Seismic energy travels away from the earthquake in all directions, ..so we need to consider the three-dimensional geometry of the ray paths.

To do this, it is convenient to imagine a sphere, called the focal sphere, surrounding the earthquake hypocenter. Rays that travel to distant stations will radiate from the earthquake through the lower hemisphere of the focal sphere. To keep things simple, let’s look at 2 cross sections at more-or-less right angles.

First, make a vertical cut into the Earth through the hypocenter in a northeast-southwest orientation. P waves leaving the earthquake and travelling to Lima Peru in the southwest quadrant or to Madrid, Spain in the northeast quadrant will have compressional first-arriving P waves that push *up*, *away* from the earthquake, and are observed as an initial upward vertical motion on those seismograms. The second cross section will show P waves travelling to Detroit and Seattle in the north*west* quadrant and to Cape Town, South Africa in the south*east* quadrant. These will have dilatational first-arriving P waves that are a pull *toward* the earthquake, observed as a downward vertical motion on their seismograms. By examining first-arriving P waves at many stations over a range of azimuths and distances from the earthquake, we can determine the pattern of compressions and dilatations on the lower hemisphere of the focal sphere. As we have seen, a strike-slip earthquake produces a crossing pattern of approximately *vertical* faults, or nodal planes that separate 2 compressional and 2 dilatational quadrants.

Let’s now look at the pattern of compressions and dilatations that result from an earthquake on a normal fault like on the east side of Steen’s Mountain in the Basin and Range Province. The block on the east side of this fault has dropped down with respect to the block on the west. Viewed in cross section, we see that compressional first-arriving P waves will radiate to the east and west from the hypocenter at shallow and intermediate downward angles. Dilatational first-arriving P waves leave the hypocenter at a steep downward angle. The resulting focal mechanism has perpendicular nodal planes that cut the lower hemisphere of the focal sphere in an “orange-slice” appearance with compressions on the outside and dilatations in the center. This is the focal mechanism signature of an earthquake on a normal fault produced by extensional forces. “because of the way the fault plane intersects the bottom of the focal sphere, the boundary between the regions on the focal mechanism is curved…”

Finally, let’s consider a thrust fault like that beneath Sierra Pie de Palo within Sierras Pampeanas of NW Argentina. This is a is a west-vergent thrust fault, wherein the block on the east moves up & over the block on the west. Viewed in cross section, we will see that dilatational first-arriving P waves radiate to the east and west from the hypocenter at shallow and intermediate downward angles, whereas the compressional first-arriving P waves leave the hypocenter at steep downward angles. The resulting focal mechanism has perpendicular nodal planes with the same “orange-slice” appearance observed for a *normal* fault. However, for a thrust fault earthquake, dilatations are on the outside and compressions are in the center. This “cat’s eye” focal mechanism is the signature of an earthquake on a thrust fault produced by compressional tectonic forces.

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Music:

“*Constellation*” by Water Strider ([www.waterstrider.com](http://www.waterstrider.com))

“*Diagonal Stride*” by Fadin’ by 9 (<http://www.fadinby9.com>)

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