Text to accompany the IRIS animation “Earthquake Faults, Plate Boundaries, & Stress” (<https://www.iris.edu/hq/inclass/animation/635>)

 The dramatic mountains and valleys of Earth’s landscape, as well as the continuous occurrence of global earthquakes, provides evidence that Earth’s thin, brittle outer shell of rock is under a constant state of stress. Let’s explore how this stress impacts the formation of small local faults, ***and*** broader tectonic plate boundaries. First, what IS stress? Stress, is the force that. can deform or move rock. Here, stress is equal to the amount of force, in this case compressional or squeezing force, acting on the contact between the two blocks shown. The amount of stress is described as a force per unit area. For example, a 150-pound person standing on the ground exerts about six pounds per square inch on the sole of their foot. The type of stress describes the ***direction*** of the forces acting on it. For example, tension pulls, compression pushes, and opposing horizontal forces shear. Thirty miles deep, rock undergoes a compressive stress in all directions that is nearly 200,000 pounds per square inch.

In response to such extreme stress, rocks bend and/or break through a process called deformation. The following factors control whether the deformation is elastic, plastic, or brittle.:

High pressure deep in Earth inhibits breaking,

High temperatures deep in Earth make rock more flexible, and

the minerals making up some rock makes it more flexible than others with a different makeup .

Let’s explore the process of Elastic Deformation first. We’ll use a strand of uncooked spaghetti. You can deform the spaghetti by applying a compressive force to the ends. When the force is removed it returns to its original shape: a process called elastic rebound. We can also demonstrate that solid rock can deform elastically by using a split piece of granite or marble:

[john lahr speaks],.

Blocks of rock, 100s, or even 1000s of miles across require immense slow, steady stress to deform elastically. For example, crustal material deforms with a steady bending near either side of a pre-existing, locked fault. Sudden movement along the fault occurs when accumulated stress overcomes friction and stored elastic energy is released as the ground returns to its original shape.

* Ductile deformation occurs when rocks undergobendingthat remains even after the stress is removed. Using the spaghetti analogy again, an uncooked noodle undergoes] ductile deformation when placed in boiling water and compressed against the bottom of the pan. When the stress is removed we see that the deformation remains. Similarly, the same rock that can deform elastically could, under different temperature and pressure conditions found deep in Earth, undergo ductile deformation. We can see evidence of ductile deformation when rock layers, deformed at depth are later uplifted and revealed at the surface, as in this road cut.
* We have already explored how uncooked spaghetti can deform elastically. However, when the force applied to the spaghetti exceeds its strength limit, the spaghetti will bend and then break. This type of permanent deformation is called brittle deformation. In rock bodies, a fracture is a break that has experienced no movement along the crack. In contrast, a fault initiates on a fracture but one side shifts relative to the other side. Most faults are locked by friction, unable to move except by elastic deformation or the abrupt jerk of an earthquake

Throughout the rest of this animation, we’ll ignore ductile deformation, and focus on earthquakes that occurs in Earth’s uppermost cool layers of rock, called tectonic plates. Faults can be separated into three broad classes based on the ***direction*** of the stress that caused the fault offset.

When **tensional** stress is applied, the rocks extend, initially forming fractures usually at an angle of less than 70 degrees to the surface. When the hanging wall drops relative to the foot wall, it is called a normal fault.

If compressive stress is applied to rock, the effect is to shorten it. The fractures that form look a lot like a normal fault, but the motion is in the opposite direction. These are called reverse faults.

When rock is pushed horizontally in opposite directions, the shearing produces strike-slip faults. Most strike-slip faults are close to vertical and involve little to no vertical motion.

These stress regimes that act locally on faults, also act at a larger regional scale to create the three basic types of plate boundaries.

**Tensional** stress occurs at divergent plate boundaries where two plates move away from each other. Examples include oceanic spreading ridges that form the longest mountain ranges in the world. As the plates pull apart, hot, and therefore lower-density, mantle rock, rises to support the 3000-9,000-foot high spreading ridges. As the plates move away from the ridge, they cool, become brittle and break into normal faults.

Compressive stresses occur at convergent plate boundaries where two plates move toward each other. If two continental plates collide, they produce a broad uplift like the Himalayan Mountain Range with reverse faults parallel to the plate boundary. If an oceanic plate subducts beneath a continental plate, most of the faults occur within the overlying plate as it is compressed and buckles forming coastal mountains ranges parallel to the plate boundary. The sloping contact between the plates is under high friction as the subducting plate shoves the overlying plate backwards.

Shear stress occurs at transform boundaries where two plates slide horizontally past each other with strike-slip motion. Transform faults link offset boundary segments. Most transform faults are found in the ocean basin where they connect offsets in the mid-ocean ridges. Transform faults can also connect a spreading ridge with a subduction zone, such as the San Andreas Fault that separates the Pacific and North American Plates.

Geologists have defined plate boundaries by the dominant forces acting on the plates. These are usually shown on maps as continuous connected segments. While shown as lines, they are actually broad ***zones*** of deformation that are affected by the regional stress from constant plate motion.

For example, the San Andreas Fault is not a simple long strike-slip fault, but is actually a ***Fault Zone*** that includes over 200 related faults that generate thousands of earthquakes every year.

In conclusion, stress is a force that acts on rocks to change their shape or volume. How the rock responds, depends on the type of stress and the conditions the rock is being subjected to when it encounters stress. It is this change in Earth’s crust that generates different types of faults and plate boundaries and results in the dramatic mountains and valleys that we see in Earth’s landscape.