Brittle Structures

Faults

Whereas joints form by fracturing a rock in such a way that the two sides of the joint just move apart from each other, with faults the two sides of the fracture start to slide past each other. This may result in a lot of energy being released, as an _________________.

What is the most common type of location where faults occur?

______________________________________

The only reason that tectonic plates are able to move past each other is because of the faults between the plates.

Examples of faults at tectonic plate boundaries:

1. The _______________________ fault separates the North American and Pacific plates in California.

2. The _______________________ region has faults along the boundary of the North American and Juan de Fuca plates. An example of a recent earthquake in this region was the M6.8 ________________ earthquake on 2/28/01.

3. The _______________________ region, where many countries are prone to earthquakes (e.g., Japan, Taiwan, Phillipines).

Faults can occur a long way from the plate boundaries, producing a second class of earthquakes in regions referred to as _______________________. Some of these may be ancient faults that are no longer active, but many are still active today.

Where was the largest earthquake in the recorded history of the continental United States in the winter of 1811-1812? ____________________________________

There were 3 large earthquakes all above a magnitude 7, the largest an 8.1. The faults that produced these earthquakes are nowhere near a plate boundary.

What causes the two sides of a fault to slide past each other? ____________________

This stress comes from the motion of the tectonic plates and either pulls or pushes on the faults, causing them to slip.

Any fault that is inclined with respect to horizontal has the rocks on one side of the fault sitting on top of rocks on the other side of the fault.
In this case, each side of the fault has its own name:

The rocks on top of the fault define the _____________________ (HW)

The rocks underneath the fault define the ___________________ (FW).

You can remember this by imagining being able to walk through a tunnel inside the Earth that cuts through the fault zone. You would be standing on top of the fault plane with your foot on the footwall, and you would be able to hang a lantern on the hanging wall above your head.

The break between the HW and the FW, where the fault actually slips, is called the ________________.

Faults can vary in orientation from almost horizontal to vertical. We measure their orientation using:

___________ Definition: __________________________________________

and

___________ Definition: __________________________________________.

Faults that are vertical planes have a dip of ____°. As the inclination of the plane decreases, the dip value decreases towards ____________.

Make a sketch of these dips:

Faults come in a range of sizes. The smallest faults may only be a few meters long, with only a very small amount of sliding along them. In general, faults are several to tens of kilometers long with 10s of meters to many km of total accumulated sliding.

There are also places where a large region of the crust is broken up by many faults that form in a long line. This long line of faults is called a ________________.

Example: __________________________________________

**Types of Faults**

We can identify different types of faults based on how one side of the fault moves relative to the other side. The four types of faults are:

1. ____________ faults - these form as a result of the crust being stretched by tensional stresses.
   So the crust undergoes ___________________.
   The hanging wall always moves: UP or DOWN relative to the footwall.
The motion is always parallel to the dip of the fault plane, so this up/down motion is often called dip-slip motion.

Where a normal fault pierces the surface of the Earth, fault motion may produce a sudden slope called a _________________.

What is the typical dip of a normal fault plane? ________

Where are normal faults common in the USA?

______________________  and  ______________________

The highest mountain in Idaho, Borah Peak, formed because of the footwall of the Lost River fault moving upwards. This fault was the site of the Borah Peak earthquake in 1983 - one of the strongest earthquakes in recorded history in the continental USA. What was its magnitude? ____________

Sometimes, normal faults form in pairs with each fault either dipping towards the other, or away from the other. If the two faults dip towards each other, the block between them moves down forming a valley called a ____________ (also called a rift valley).

If the two faults dip away from each other, the middle block moves up, forming a type of mountain called a ________________.

2. ________________ faults  - these form when the crust is being squeezed by compressional tectonic stresses. So the crust undergoes _________________.

The hanging wall side always moves: UP or DOWN? relative to the footwall, which is opposite to normal faults. It is still dip-slip motion though because it involves up and down motions.

What is the typical dip of a reverse fault plane? ________

What do we call a reverse fault that dips at less than 45°? ________________

Reverse faults may eventually form mountains as the hanging wall uplifts.

Examples: ______________________  and  __________________________

3. ________________ faults  - these faults are usually vertical with one side sliding past the other side because of tectonic shear stresses. This type of motion is called _________________. They often form where one tectonic plate is sliding past the other one.

  e.g., ______________________ has allowed the North American and Pacific plates to slide past each other for the past 29 million years.

What types of offset features indicate the presence of a strike-slip fault?

____________________________________________________________

The sense of motion along a strike-slip fault may be one of two possibilities. If you stand on one side of a strike-slip fault and watch how the other side is moving with respect to you, the other side will
move either to the left or to the right. If the motion is to the left, it is a __________________ fault. If the motion is to the right, it is a __________________ fault.

This technique works no matter which side of the fault you are standing on when you look at the other side.

Example: the San Andreas fault is a LEFT-LATERAL or RIGHT-LATERAL?
strike-slip fault that moves at a rate of about ____________ per year.

4. __________________ faults - the sliding on these faults is some combination of strike-slip sliding and dip-slip sliding. So one side of the fault moves obliquely with respect to the other side.

Folding

Rocks get folded when strain rates are: VERY LOW or VERY HIGH?

Also, the temperatures and pressures are high enough to cause the rocks to behave in a ______________ manner.

Rocks can get folded into a gentle warping over 100s of km or they may get tightly kinked at the centimeter or meter scale.

What type of stresses in the crust cause folding? ____________________________

Types of Folds

In rocks that get folded, the parts that warp upwards in the middle are called __________ and the downward warps are called _____________.

Anti means "against" and syn means "with", so anticlines work against gravity (rocks move upwards) whereas synclines work with gravity.

Folds rarely occur in isolation. Instead we get an anticline next to a syncline, which is next to another anticline and another syncline, etc.

Fold Geometry

Folds consist of two sides that have the beds dipping in opposite directions to each other (away from each other in an anticline, and towards each other in a syncline).

Each side of the fold is called a ________________.

Every fold has 2 fold limbs with one always being shared with the fold right next to it.
If you fly over a region of folding like in the Appalachian Mountains, you often see very interesting patterns of rocks at the Earth’s surface.

What types of patterns are usually seen? ____________________________

This happens because tectonic forces in the Earth sometimes cause folds to be tilted over, parallel to their lengths, so they become inclined downwards into the Earth. Such folds are said to be _______________ folds.

**FINAL QUESTION:**

What do we call an isolated, single-limbed fold that forms above a buried fault?

______________________________