

Deformation of rocks

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How Rocks Become Deformed

Rocks are deformed by:

folding and
faulting.

Deformation of rock involves **changes in the shape and/or volume** of these substances.

Changes in shape and volume occur when stress and strain **causes rock to buckle and fracture or crumple into folds.**

Types of stress: the forces associated with folds and faults

- **Stress:** is the **FORCE** acting on a body of rock
- **Strain:** is the response of a rock to stress. It generally involves a change in shape or volume of the rock.

There are **three types** of **tectonic forces** or stresses that deform rocks:

- **Compressional forces**
- **Tensional forces**
- **Shearing forces**

- When stress is applied, rocks initially respond by deforming **elastically**. These are **reversible** changes.
- When the stress is removed, the rock returns to its original size and shape.

Once the elastic limit of the rock is exceeded by the stress, the rock will:

- 1. **Deform plastically**, resulting in permanent changes in size and shape (such as folding),
or
- 2. **Fracture** (i.e. break)

- A **fracture** is a crack in a rock.
- A **fault** is a fracture along which **movement** has occurred.

- Strata will **break** if rocks behave in a **brittle** fashion and/or confining pressure is low.
- When rocks that contain hard minerals like quartz or calcite are shallowly buried, it results in **fractures**.
- Rocks nearer the surface of the Earth, where temperatures and pressures are **lower**, rocks will behave like a **brittle** solid and will fracture once their elastic limit is exceeded.

- If strata are **ductile** and/or the confining pressure is high, deformation result in bending or **folding**.
- Rocks will deform plastically and will **fold** under conditions of **high** temperatures and pressures, like those deep within the crust of the Earth.
- Rocks containing pliable (can be bent) minerals like gypsum or clays, or rocks that are deeply buried (>10 km depth) become folded when subjected to stress.

Whether a rock behaves in a **BRITTLE** or **DUCTILE** manner depends on:

1. **composition**

2. **rate of stress**

high rate (fast) -> brittle behavior.

3. **temperature**

high temp (deep) -> ductile behavior

4. **pressure of overlying rocks**

high (deep) -> ductile behavior

Compressional forces

Compressional forces – squeeze and shorten bodies creating:

- **anticlines,**
- **synclines and**
- **thrust faults.**

Associated with convergent boundaries.

Tensional forces

Tensional forces – **stretch** a body and pull it apart, creating:
normal or extensional faults.

Associated with **divergent boundaries** where plates are moving apart.

Shearing forces

- **Shearing forces** – push two sides of a body **in opposite directions** causing shearing zones in rocks and occurring at **transform fault boundaries.**

For plastic deformation of rock to occur a number of conditions must be met, including:

- The rock material must have **the ability to deform** under pressure and heat.
- The **higher the temperature** of the rock the **more plastic** it becomes.
- Pressure **must not exceed** the **internal strength of the rock**. If it does, fracturing occurs.
- **Deformation** must be applied **slowly**.

Fold

A fold can be defined as a **bend in rock** that is the response to **compressional forces**.

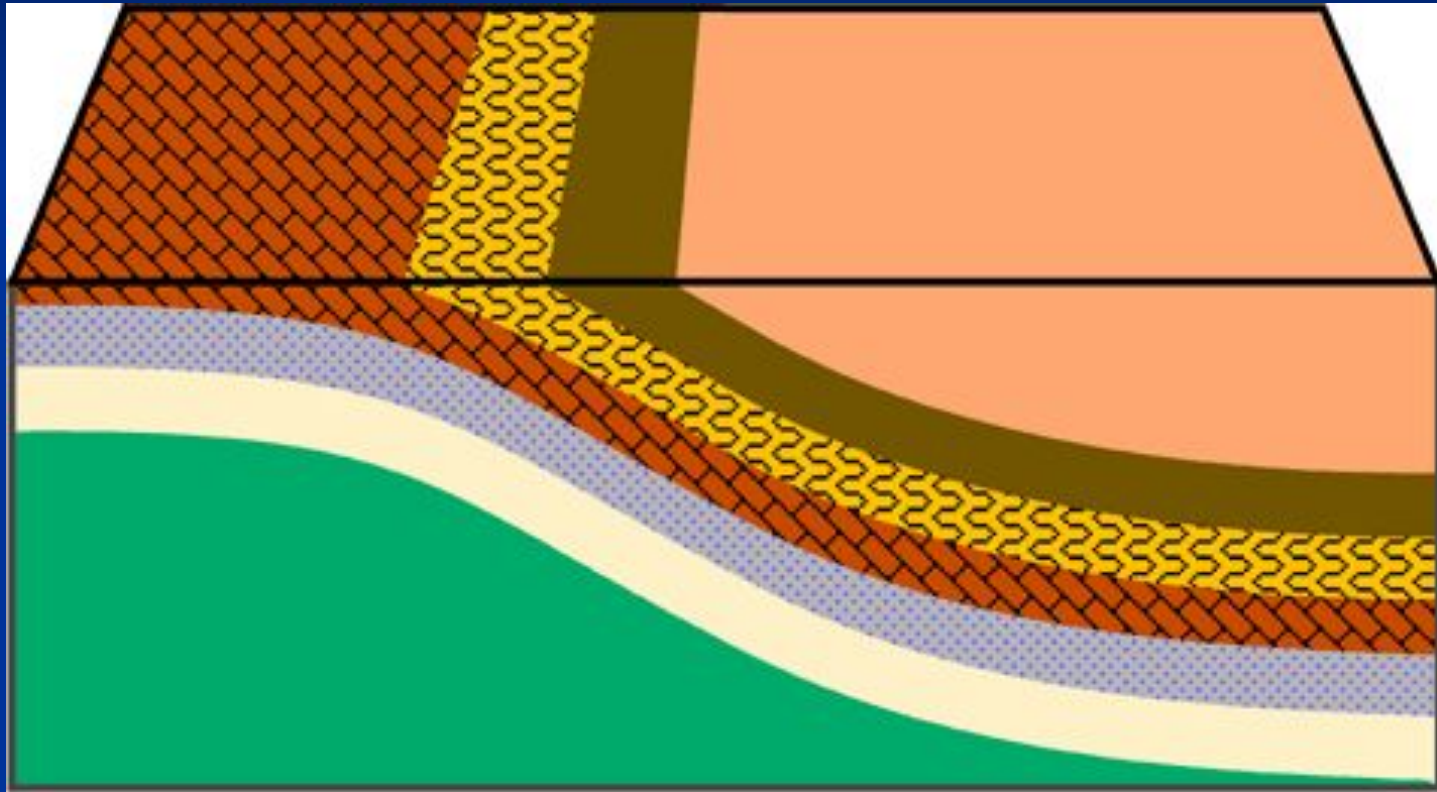
Folds are most visible in rocks that contain layering.

A number of different folds have been recognized and classified by geologists:

- **Monocline**
- **Anticline**
- **Syncline**

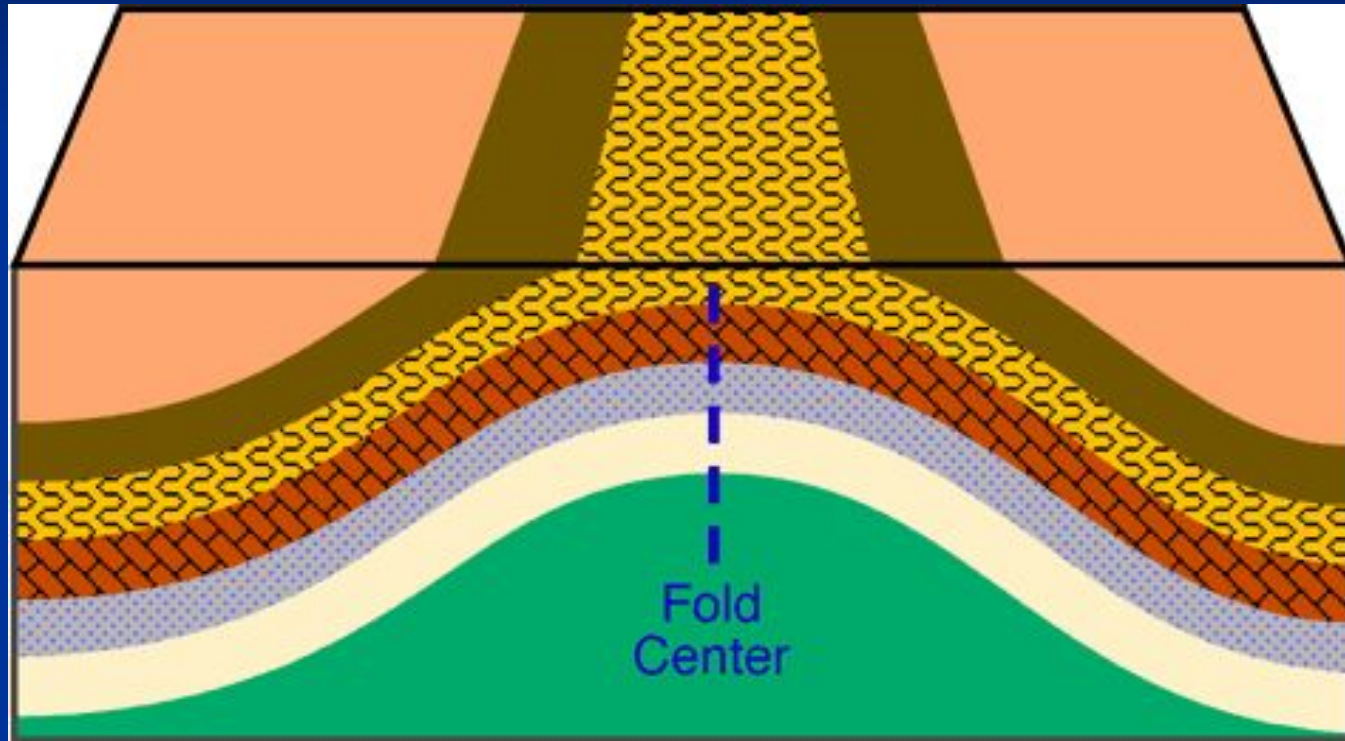
The simplest type of fold is called a monocline.

This fold involves a slight bend in otherwise parallel layers of rock.



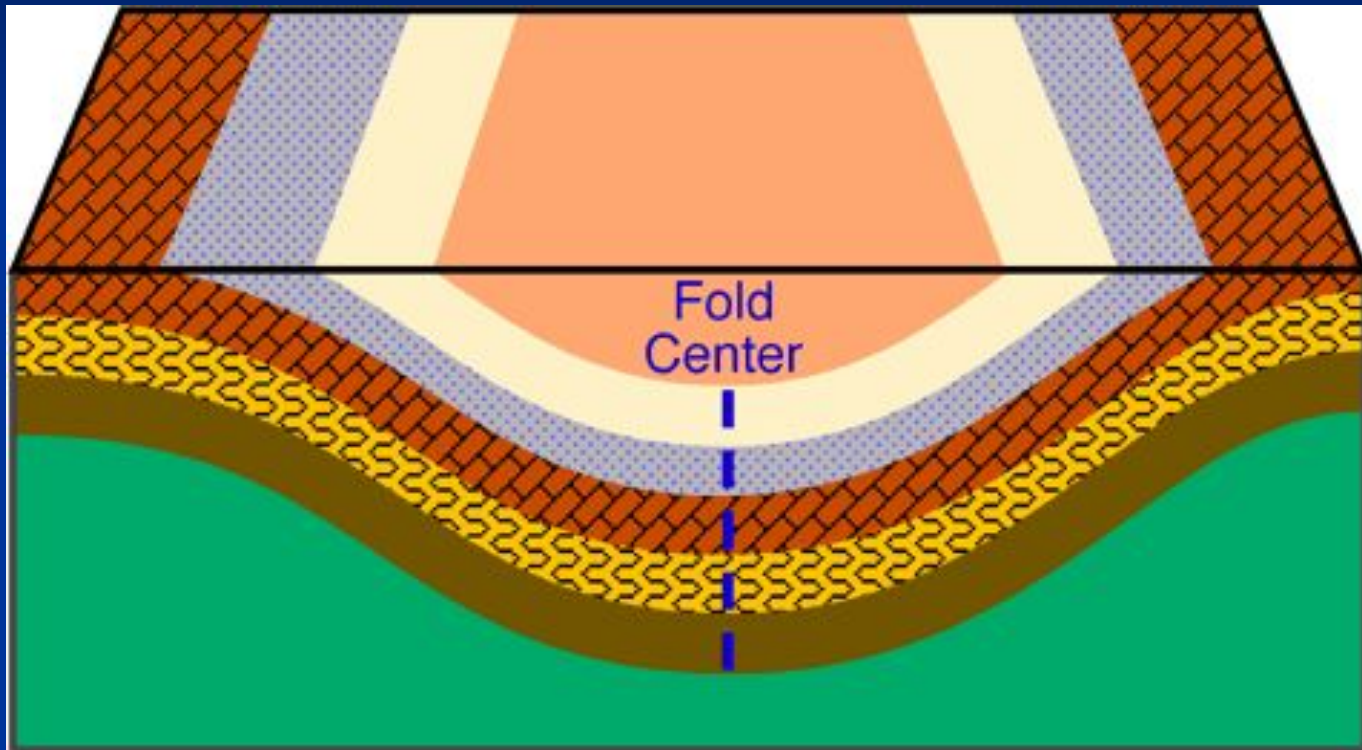
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An anticline is a convex up fold in rock that resembles an arch.



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A syncline is a fold where the rock layers are warped downward.



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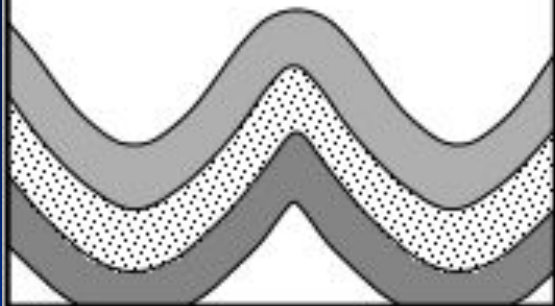
Synclinal folds in bedrock



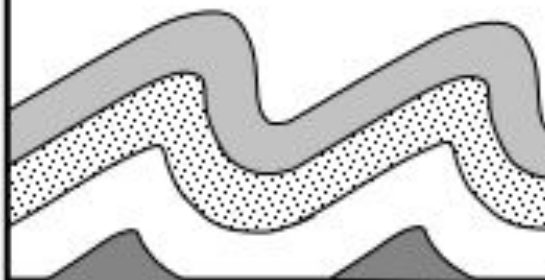
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Folds can be classified based on their appearance.

Symmetrical Folds



Asymmetrical Folds



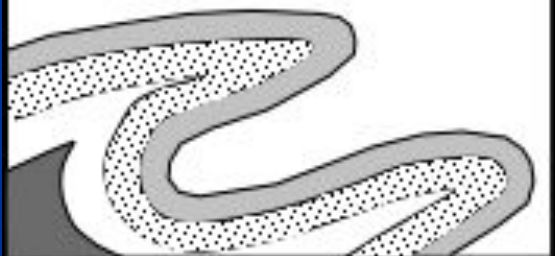
Isoclinal Folds



Overtured Folds



Recumbant Folds



Chevron Folds



Faults

- Faults form in rocks when the stresses overcome the internal strength of the rock resulting in a fracture.

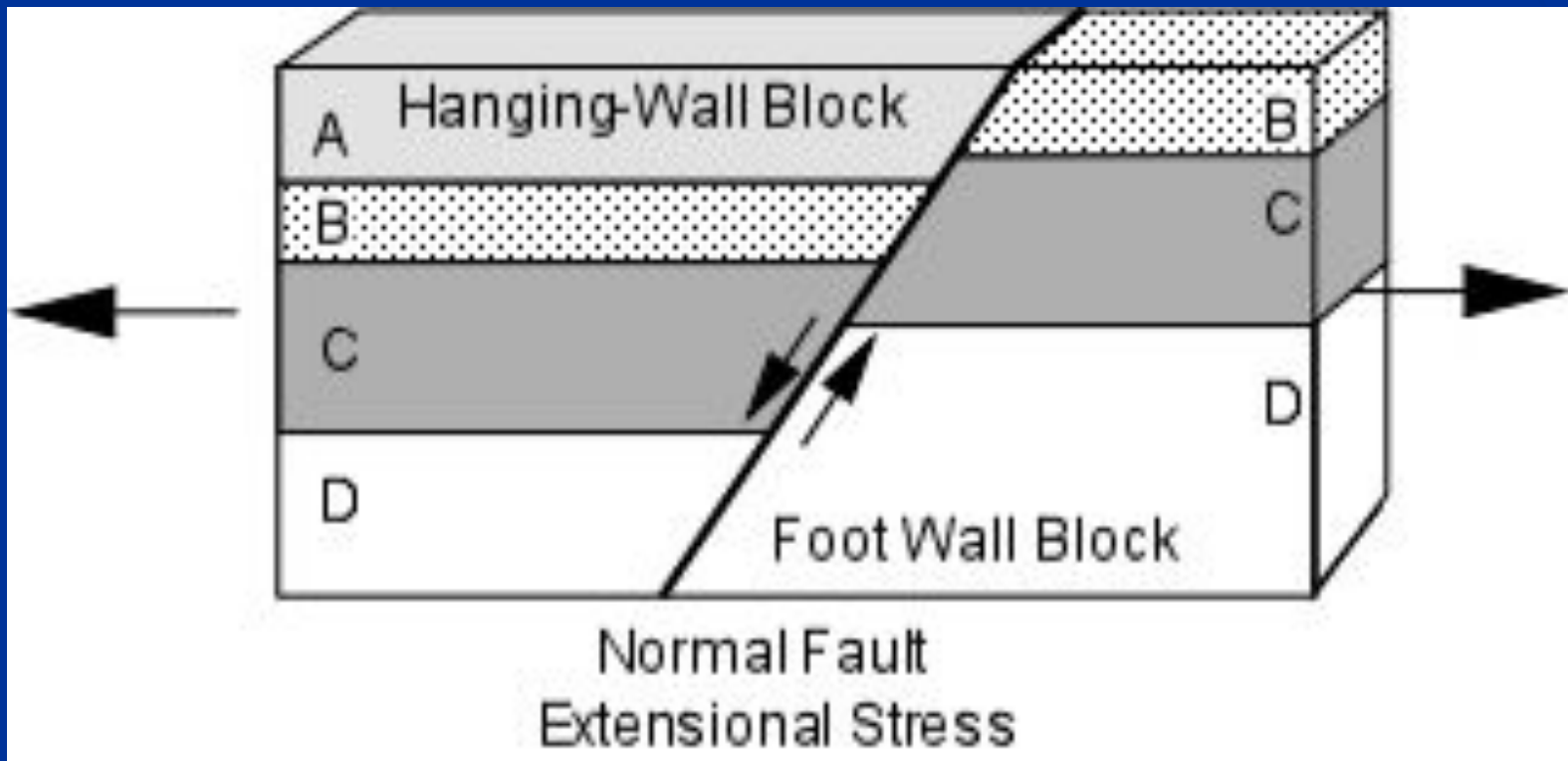
Faults occur from both:

- **tensional** (shearing) and
- **compressional** forces.

Hanging wall and Footwall

For any inclined fault plane:

- the block above the fault is the **hanging wall** block
- the block below the fault is the **footwall** block.



Different kinds of faults:

These faults are named according to the **type of stress** that acts on the rock and by the **nature of the movement** of the rock blocks either side of the fault plane.

- Normal fault

- Reverse fault

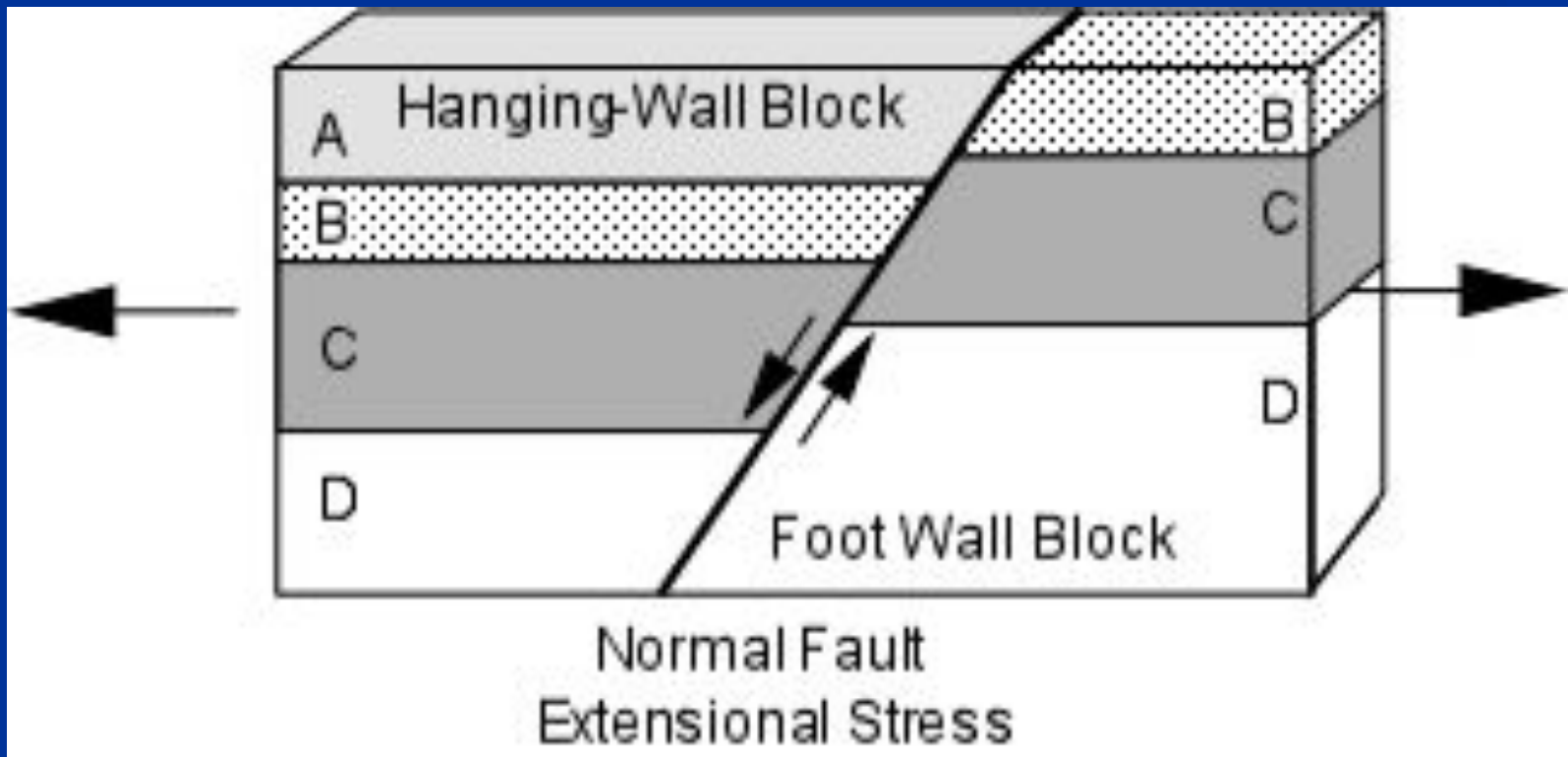
- Thrust fault

- Strike-slip fault

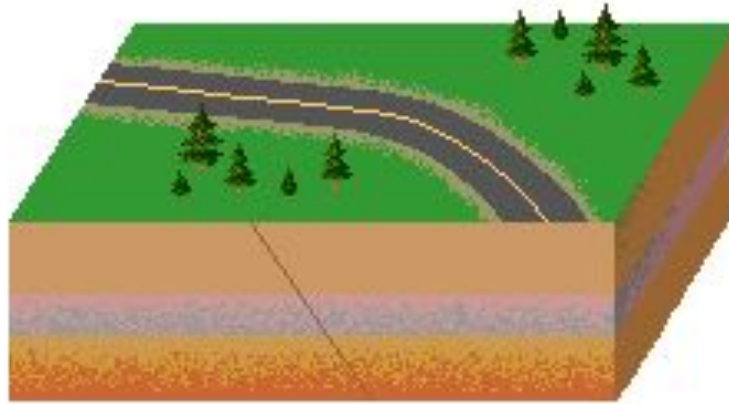
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Normal Faults

- are faults that **result** from **horizontal tensional stresses** in brittle rocks.
- the **hanging-wall block** moves **down** relative to the footwall block

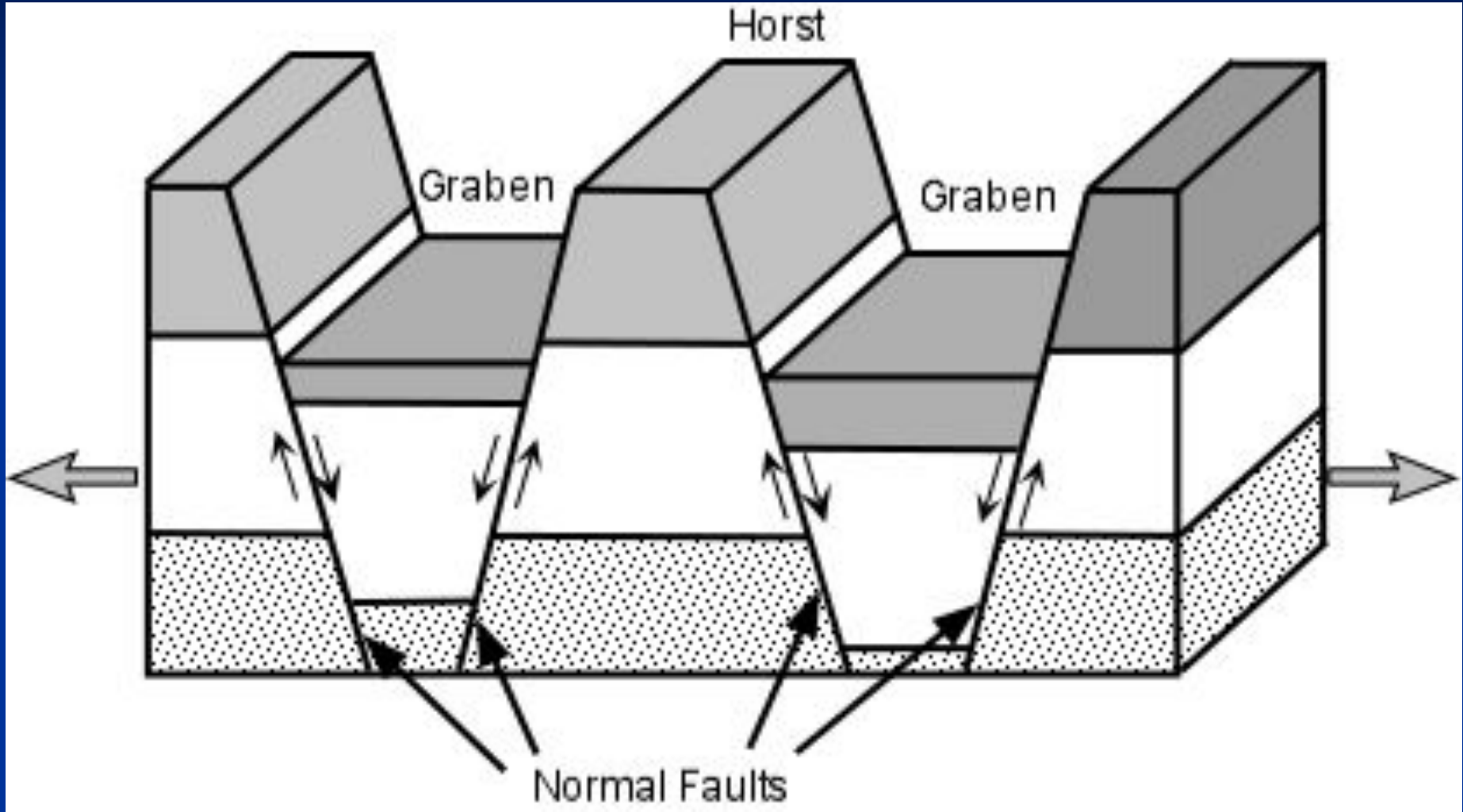


Normal Faults



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Normal fault

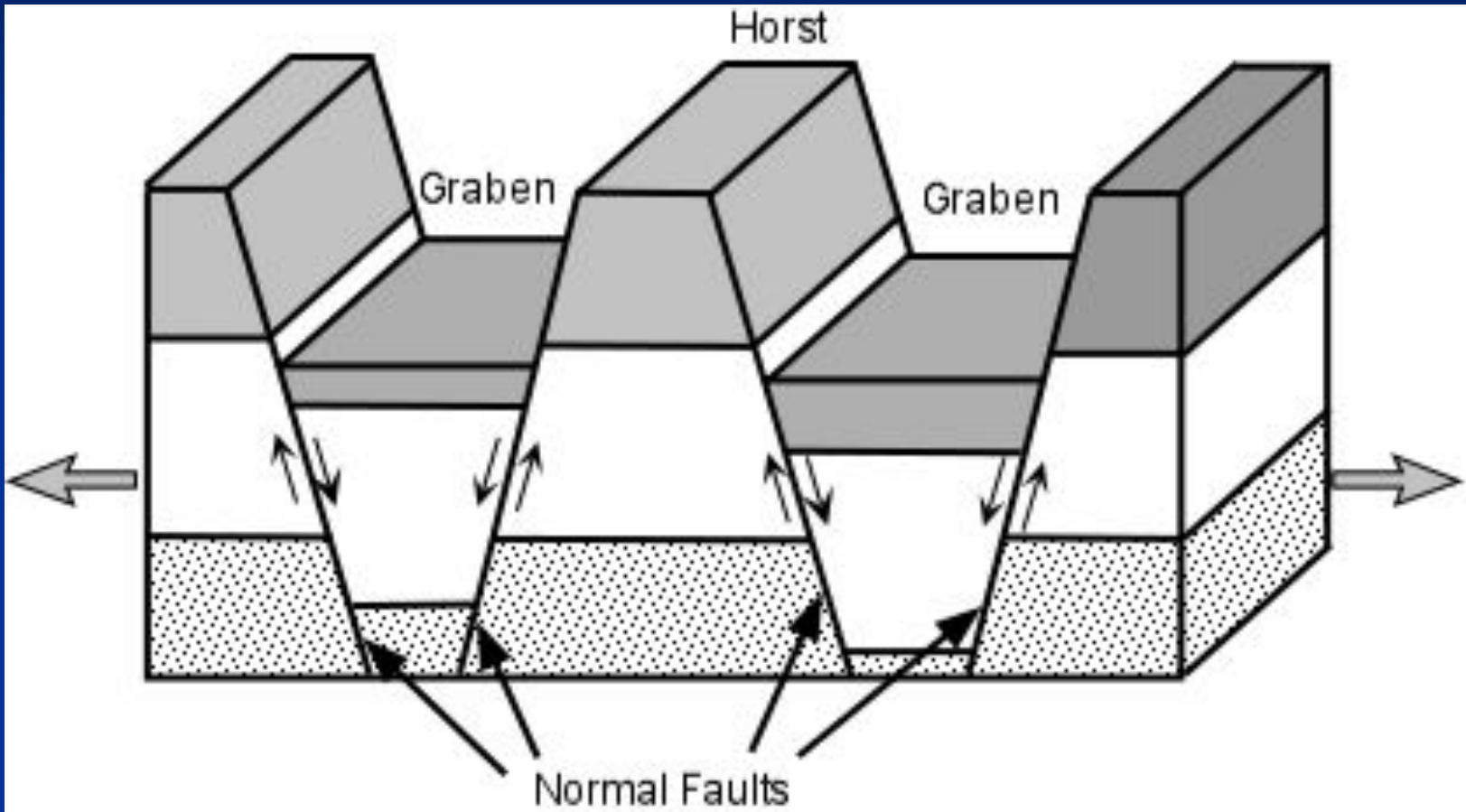


Normal Faults

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Grabens AND Horsts

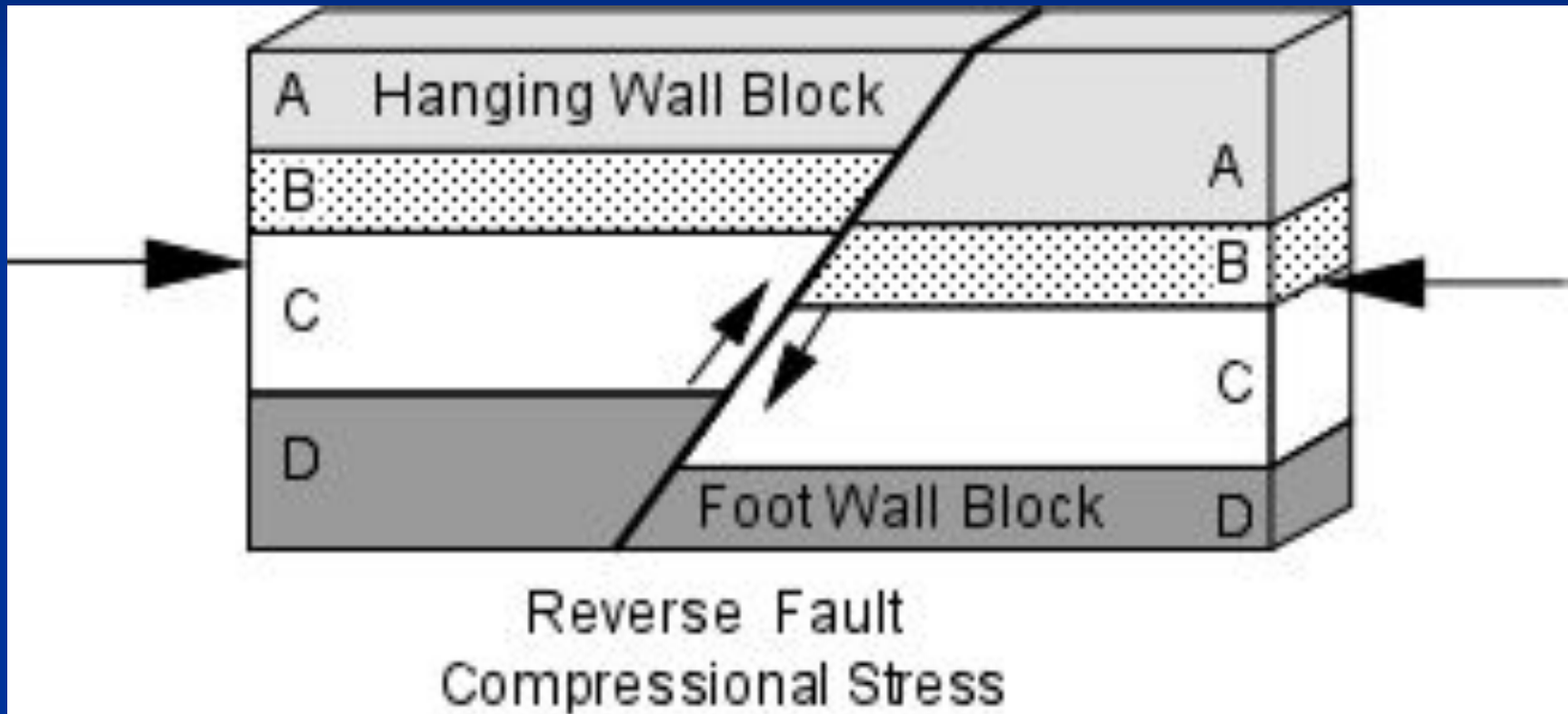
- the **down-dropped blocks** form grabens
 - the grabens may form **rift valleys**:
(The East African Rift Valley)



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Reverse Faults

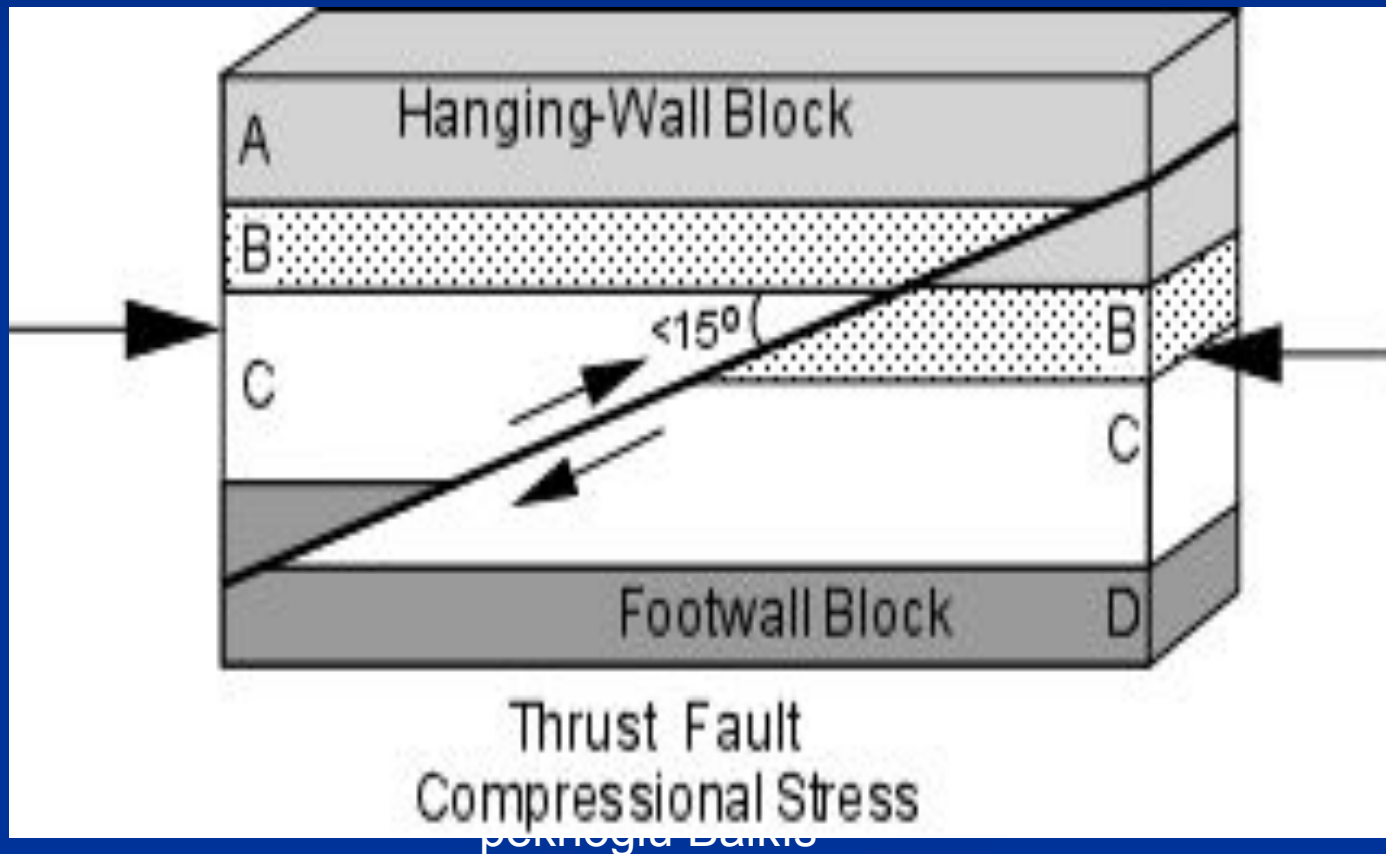
are faults that result from horizontal **compressional stresses** in brittle rocks, where the **hanging-wall** block has moved **up** relative the footwall block.



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A Thrust Fault

- A Thrust Fault is a special case of a reverse fault where the **dip** of the fault is **less than 15°** and
- can result in older strata overlying younger strata.



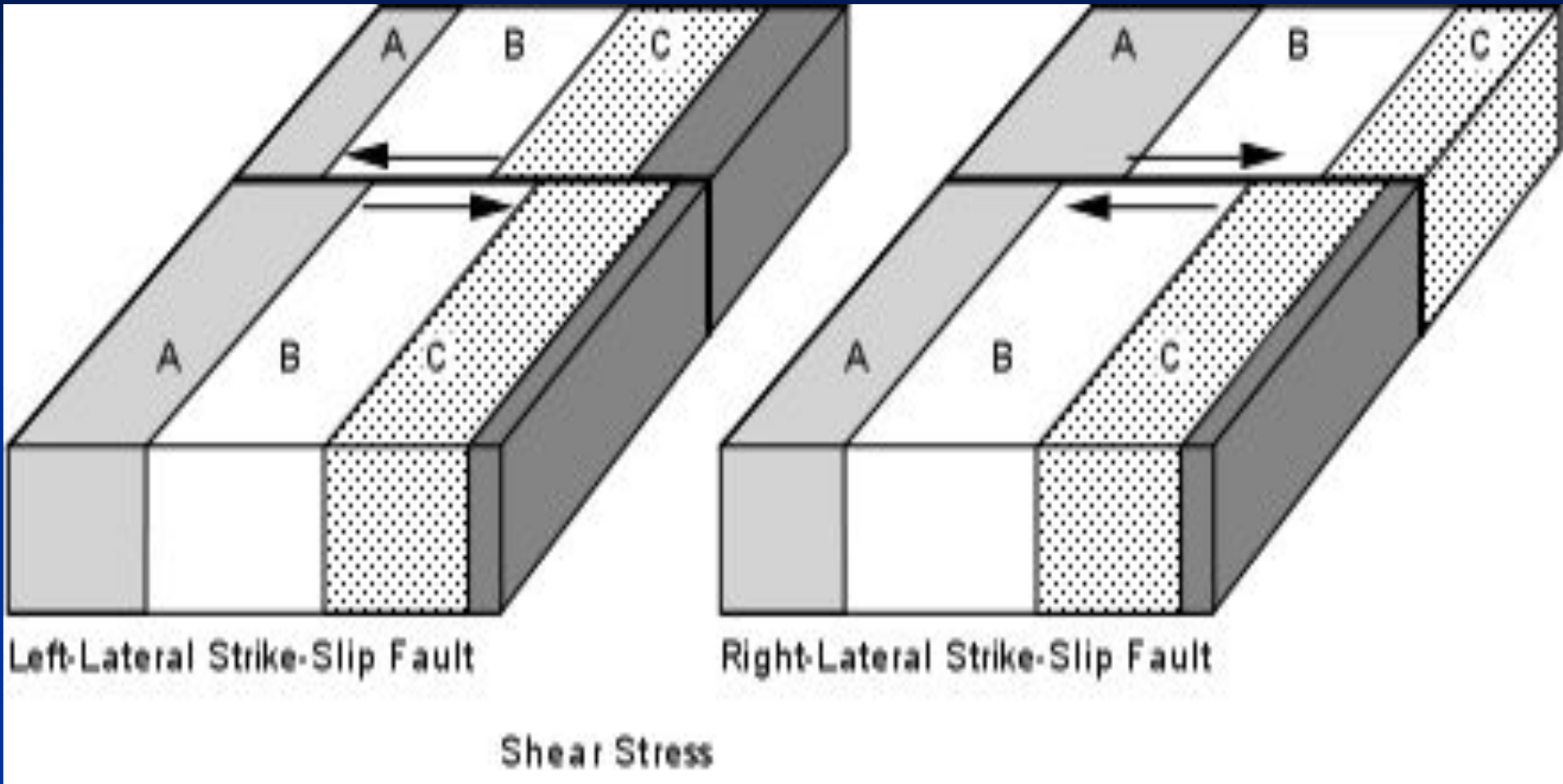
Strike Slip Faults

- relative motion on the fault has taken place *along a horizontal direction.*
- result **from shear stresses** acting in the crust.

Two varieties, depending on the sense of displacement:

- If the block on the other side **has moved to the left**, - the fault is a **left-lateral strike-slip** fault
- If the block on the other side has moved to the right, **a right-lateral** strike-slip fault.

Strike Slip Faults



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