Crustal Deformation
(Building Earth’s Surface, Part 1)

Mapping geologic structures

When conducting a study of a region, a geologist identifies and describes the dominant rock structures:

- Usually only a limited number of outcrops (sites where bedrock is exposed at the surface) are available.
- Work is aided by advances in aerial photography, satellite imagery and Global Positioning Systems (GPS).
A geologic map illustrates the geologic structures of an area.

**Mapping geologic structures**

- Describing and mapping the orientation or attitude of a rock layer or fault surface involves determining the features.
  - **Strike (trend)**
    - The compass direction of the line produced by the intersection of an inclined rock layer or fault with a horizontal plane.
    - Generally expressed as an angle relative to north.
Mapping geologic structures

Dip (inclination)

- The angle of inclination of the surface of a rock unit or fault measured from a horizontal plane
- Includes both an of inclination and a direction toward which the rock is inclined
Folds

During crustal deformation rocks are often bent into a series of wave-like undulations called folds.

Characteristics of folds

Most folds result from compressional stresses which shorten and thicken the crust.

Parts of a fold

- Limbs – refers to the two sides of a fold
- Axis – a line drawn down the points of maximum curvature of each layer
- Axial plane – an imaginary surface that divides a fold symmetrically
Common types of folds
- Anticline – upfolded or arched rock layers
- Syncline – downfolds or troughs of rock layers
- Depending on their orientation, anticlines and synclines can be described as
  - Symmetrical
  - Asymmetrical
  - Recumbent (an overturned fold)
  - Plunging

*A horizontal (A) and plunging (B) anticline*
A series of anticlines and synclines

Plunging anticlines and synclines
Folds

- Common types of folds
  - Monoclines
    - Large, step-like folds in otherwise horizontal sedimentary strata
- Other types of folds
  - Dome
    - Upwarped displacement of rocks
    - Circular or slightly elongated structure
    - Oldest rocks in center, younger rocks on the flanks
Monoclines are often the result of movement along buried faults

My favorite monocline:
**Black Hills, South Dakota: a large dome**

Approaching Bear Butte / Black Hills from the North

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**Folds**

- **Other types of folds**
  - **Basin**
    - Circular or slightly elongated structure
    - Downwarped displacement of rocks
    - Youngest rocks are found near the center, oldest rocks on the flanks
Circular outcrop patterns are typical for both domes and basins.

Faults

- Faults are fractures in rocks along which appreciable displacement has taken place.
- Sudden movements along faults are the cause of most earthquakes.
- Classified by their relative movement which can be:
  - Horizontal
  - Vertical
  - Oblique
**Faults**

**Types of faults**

- **Dip-slip faults**
  - Movement is mainly parallel to the dip of the fault surface
  - May produce long, low cliffs called *fault scarps*
  - Parts of a dip-slip fault include:
    - *hanging wall* (rock surface above the fault)
    - *footwall* (rock surface below the fault)
Faults

Types of dip-slip faults

- Normal fault
  - Hanging wall block moves down relative to the footwall block
  - Accommodate lengthening or extension of the crust
  - Most are small with displacements of a meter or so
  - Larger scale normal faults are associated with structures called fault-block mountains
Normal fault:

Types of dip-slip faults

- Reverse and thrust faults
  - Hanging wall block moves up relative to the footwall block
  - Reverse faults have dips greater than 45° and thrust faults have dips less then 45°
  - Accommodate shortening of the crust
  - Strong compressional forces
On a reverse fault, the hanging wall moves up relative to the footwall.

Thrust fault: Lewis Thrust, Montana
**Faults**

- **Strike-slip fault**
  - Dominant displacement is horizontal and parallel to the strike of the fault
  - Types of strike-slip faults
    - Right-lateral – as you face the fault, the block on the opposite side of the fault moves to the right
    - Left-lateral – as you face the fault, the block on the opposite side of the fault moves to the left

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**A block diagram showing the features along a strike-slip fault**
Faults

- Strike-slip fault
  - Transform fault
    - Large strike-slip fault that cuts through the lithosphere
    - Accommodates motion between two large crustal plates

The San Andreas fault system is a major transform fault
Joints

- Joints are among the most common rock structure
- Technically, a joint is a fracture with no movement
- Most occur in roughly parallel groups
- Significance of joints
  - Chemical weathering tends to be concentrated along joints

Joints

- Significance of joints
  - Many important mineral deposits are emplaced along joint systems
  - Highly jointed rocks often represent a risk to construction projects