GEOLOGIC STRUCTURES

- Stress and Strain
- Active deformation along faults
- Geologic maps and cross sections
- Folding
- Faulting
GEOLOGIC STRUCTURES

“Architecture of bedrock”

- **Structural Geology** - concerned with shapes, arrangement, interrelationships of bedrock units & forces that cause them.

- **Important to understanding:**
  - How mountains form
  - How continents evolve
  - How plate tectonics works
  - Safe siting of public facilities, dams, power, etc.
  - Search for energy resources

TECTONIC FORCES AT WORK

- **Stress & Strain:**
  - Stress (force per unit area)
    - **Compressive** stress
      - Shortening strain
    - **Tensional** stress
      - Stretching or extensional strain
    - **Shear** stress
      - Shear strain
  - Strain (change in size, shape, during stress)
Behavior of rocks under stress

- **Elastic** (recovery to original shape)
  - Elastic limit
    - Beyond this stress, permanent strain

- **Plastic (ductile)**
  - Permanent strain by flow, or folding
  - Typical at higher P, T within crust

- **Brittle**
  - Permanent strain by fracture, failure
  - Typical at lower P, T near surface
  - Rocks fracture when strain rates are high
Present Deformation of the Crust

• Active *fault*
  – Fracture along which movement has occurred rapidly

• “Creep”
  – Slow sustained movement along a fault
Structures Record Geologic History

- Geologic maps and field methods
  - Observations of *outcrops*
  - Geologic maps
    - Observations from many outcrops
  - Geologic cross section
    - Vertical slice through portion of Earth
    - Like a roadcut
    - *Important—used extensively!*
• Measuring strike and dip

• Geologic map

• Cross section
FOLDS

- Bends or wave-like features in layered rocks
  - Plastic strain, compressive stress
- Geometry of folds:
  - **Anticline vs. syncline**
    - *Hinge line, limb, axial plane*
    - Plunging fold (hinge lines dip)
    - Structural dome
    - Structural basin
Aerial view, Himalayan Foothills, northern Pakistan

Plunging folds
FOLDS

• Bends or wave-like features in layered rocks
  – Plastic strain, compressive stress
• Geometry of folds:
  – Anticline vs. syncline
    • Hinge line, limb, axial plane
  – Plunging fold (hinge lines dip)
  – Structural dome
  – Structural basin
East Side of Cerro Chalten, Patagonian Batholith
East of Cerro Fitzroy, Patagonian Fold Belt

FOLDS

- Interpreting folds
  - Open fold
  - Isoclinal fold
  - Overturned fold
  - Recumbent fold
Types of Folds and Movement

A Strata before folding

B Open folds—the two diagrams show alternate ways that stresses may have been distributed to have caused the folding.

C Isoclinal ("hairpin") folds

D Overturned folds

E Recumbent folds
Energy and Structures

Recipe for oil
- dead plants & animals deposited with sediments
- sedimentary rock buried (<1000m)
- cook at 100°C for 2-5 million years
- voila!

To trap oil need:
- an impermeable layer
- a structure, e.g. anticline, fault, unconformity
TECTONIC FORCES AT WORK

- Stress & Strain:
  - Stress (force per unit area)
  - Strain (change in size, shape, during stress)

Fractures in rock

- Joints
  - *break in rock along which no movement has taken place*
    - Columnar jointing
    - Sheet jointing
    - Joint set

- Faults
  - *break in rock along which movement has taken place*
Weathered, jointed rock
Fractures in rock

- Faults
  - Dip-slip faults - normal and reverse
    - Footwall vs. hanging wall
  - Normal fault
    - Graben; Rift
    - Horst; fault-block mountain range

Faults

Fault types

1. Dip Slip Faults
Faults

Some fault terminology

• Hanging wall vs. Footwall
Fault scarp, Death Valley

Rift Valley development
Fractures in rock

- Faults
  - Reverse fault
    - Thrust fault - low angle reverse fault
  - Strike-Slip fault
    - Left-lateral vs. right-lateral
Reverse Fault in Volcanic Ash Beds

What type of fault is this?

Cambrian (530 Ma) limestone

Silurian (430 Ma) limestone
• **Thrust Fault** = low angle **Reverse Fault**
  - Alps, Northern Rockies, Appalachians thrust faults with > 50 km of displacement

Fractures in rock

• Faults
  – **Reverse fault**
    • Thrust fault- low angle reverse fault
  – **Strike-Slip fault**
    • Left-lateral vs. right-lateral
San Francisco Bay Area
San Andreas Strike Slip Fault

San Francisco Bay Bridge, damaged in 1989 Loma Prieta Earthquake

Please read Chapter 7 (Earthquakes) for next lecture