Map-Scale Structures and Contact Relationships
Last Lecture

- The downward pull of subducting slabs drives plate motions
- All plate motions are rotations
- 3 kinds of plate boundaries create 3 different structural environments
- Gravity causes deformation at passive margins
- Continents grow by accretion at their edges
What type of plate boundary is there along the US East coast?
Passive Margin

- Continental shelf
- Salt structures
- Gravity-driven extension of the passive-margin wedge
- Thrust belt, at the toe of the wedge
- Coastal plain
- Stretched crust formed during the rifting stage
- Continental crust
- Moho
- Oceanic crust
Continental Growth

• Material plastered onto the continents at convergent boundaries

• Example:
  – Everything west of Nevada has been added to North America in last 700 Ma
Continental Growth
Today’s Outline

• Stratigraphic contacts
  – Unconformities

• Primary Sedimentary Structures
  – Younging direction

• Intrusive contacts
  – Sills and dikes
  – Batholiths

• Fault Contacts
  – Normal, thrust, strike-slip

• Folds
  – Anticlines, synclines
1. Superposition: younger layers on top

Tan sediment deposited over older rock

Red layers deposited over tan

Third layer is youngest and is on top

Young

Old
Stratigraphic Succession
Basalt Flows- Snake River Plain
Horizontality of Sedimentary Successions
North Slope, AK
Horizontality of Sedimentary Successions
North Slope, AK

Without vertical exaggeration
Basic Question:
Is the section conformable?

• Is the sedimentary pile continuous?
Unconformities

Disconformity

Angular Unconformity
Angular unconformity
Death Valley
The Great Unconformity
Grand Canyon, AZ
Angular Unconformity

In seismic data
Onlap Surface
North Slope, AK
Fossils & disconformities

Correlation = determine equivalent units
Is the sedimentary succession right-side up?

• How can we tell?

Which is older, A or B?
Is the sedimentary succession right-side up?

- How can we tell?
Primary Structures
Pillow Basalts
Sedimentary Structures
Stromatolites, Belt Gp., MT
Symmetric Ripple Marks

Wave motion near shore

Water

Sediment
A Graded Bed
Intrusive Contacts
They cut older rocks

• Dikes
• Sills
• Stocks
• Batholiths
Intrusive Structures

- Laccolith
- Ring dike
- Sill
- Dikes
- Sills
- Stock or batholith

Magma chamber
Shiprock, New Mexico

Stock

Dike
Sierra Nevada Batholith

Yosemite N.P.
Cross Cutting Relationships
Younger intrusive cuts through older folds

1.4 Ga Dikes
1.6 Ga Amphibolite

Amato photo, Burro Mts, NM
Geologic history of an area based on contact relationships
Deposition

Rock removed by erosion

Previous land surface

Erosion surface

Granite
Larsonton Formation during Deposition

- Larsonton sediment
- Water
- Sea floor
- Granite
Area before Intrusion of Dike

Larsonton Fm

Rock later removed by erosion
Area after Dike Intrusion

Rock later removed by erosion

Larsonton Fm
Area after Erosion

Larsonton Fm

Dike exposed on surface

Dike
Area before Valley Was Carved

- Skinner Gulch
- Hamlinville Fm
- Stream
- Limestone
- Foster City Fm
- Larsonnton Fm
- Tarburg Fm
- Dike
Orientation of a Plane

- Horizontal plane
- Line of strike
- Strike/dip symbol
- Dip direction
- Dip angle 30°

Water line
Salisbury Crags, Edinburgh, UK, BGS photo

Jointed gabbro sill
Strike and dip on a map
Angular Unconformity Map View

Alabama

IP₁ = Permian

uK₁ = Upper Cretaceous
Visualizing the 3D Structure

Cross Section
Folds

- **Syncline**
  - (concave up)

- **Anticline**
  - (concave down)
Domes and Basins

A. Dome

B. Basin

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Trend and Plunge

- Used for linear features
- Trend = Azimuth of a line
- Plunge = Inclination of a line
Plunging Fold

- Axial Plane
- Horizontal Line
- Trend
- Angle of Plunge
- Fold Axis
- Horizontal Plane
- Limb
Plunging Folds
Does the arrow point at a syncline or anticline?

A. Syncline
B. Anticline
C. Neither
Outcrop Patterns of Plunging Folds
Sheep Mountain Anticline, WY
Fault Contacts

- Normal
- Thrust, reverse
- Strike-slip
Dip-Slip Fault

Reverse fault

Normal fault

Dip-slip faults
Thrust Fault
B Strike-slip faults

C Oblique-slip fault

Strike-Slip Fault, Oblique-Slip Fault
Faults in Map View
Teeth Point down dip

Pen
Trias
Rose diagrams showing:
(a) vertical joints (n=164),
(b) copper mineralized veins (n=89),
(c) gold mineralized veins (n=28),
all showing a general strike between 300° and 320°.
Software

- Stereonet (free)
- Openstereo (free)
- StereoNet (free)
- Visible Geology (on line app - watch the tutorial)
- Lambert (iphone app)
- Rockworks (commercial)
How the compass works

- Rotation axis
- Geographic north pole
- Magnetic north pole
- Equator
- Magnetic south pole
- Geographic south pole
Magnetic Declination

True North

Magnetic North

Isogonic Lines Show The Pattern of Magnetic Declination

20° East
15° East
10° East
5° East
0°
5° West
10° West
15° West
20° West
USGS Topographic Maps

Morgantown Quadrangle

MN - Magnetic North

★ - True North

GN - Geomagnetic North

UTM GRID AND 1976 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET
http://www.ngdc.noaa.gov/geomag-web/#declination

Magnetic Field Calculators

Estimated Value of Magnetic Declination

Declination is calculated using the current World Magnetic Model (WMM) or the International Geomagnetic Reference Field (IGRF) model. Declination results are typically accurate to 30 minutes of arc, but users should be aware that several environmental factors can cause disturbances in the magnetic field.

Calculate Declination

Location
- Latitude: 39° 37' 43" N
- Longitude: 79° 59' 17" W

Model
- Model: IGRF 11, WMM 2010

Date
- Date: Year 2014, Month 9, Day 2

Result
- Result format: HTML, XML, CSV, PDF

Morgantown Declination
9° West
Adjusting Your Compass

Front

Back
Key concepts

• Stratigraphic contacts
  – Unconformities

• Primary Sedimentary Structures
  – Younging direction, right-side-up?

• Intrusive contacts
  – Sills and dikes
  – Batholiths
  – Cross cutting relationships

• Interpreting sequence of events

• Folds
  – Anticlines, synclines

• Fault Contacts
  – Normal, thrust, strike-slip