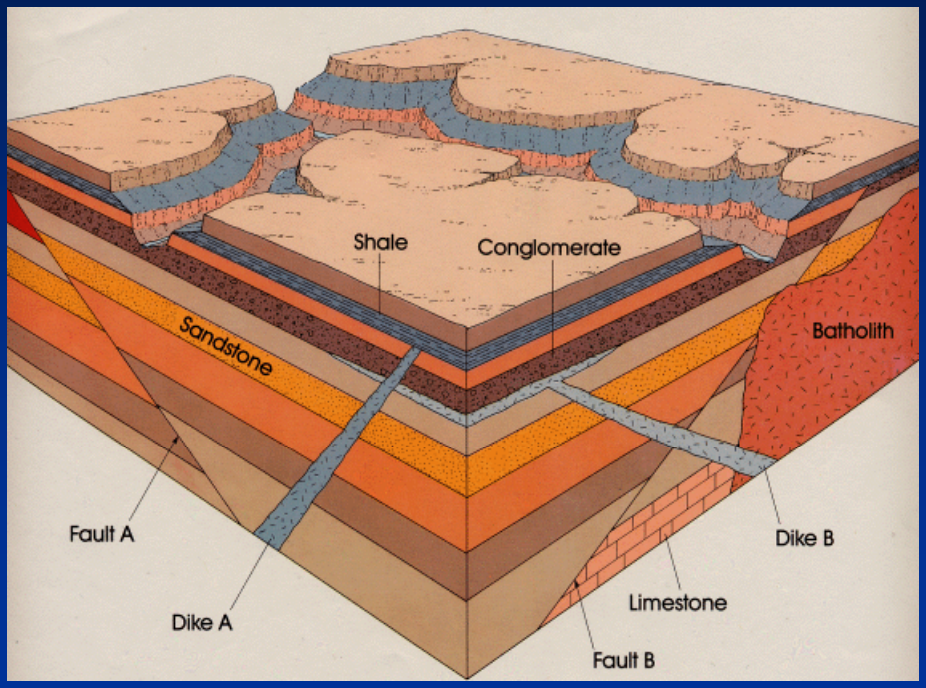
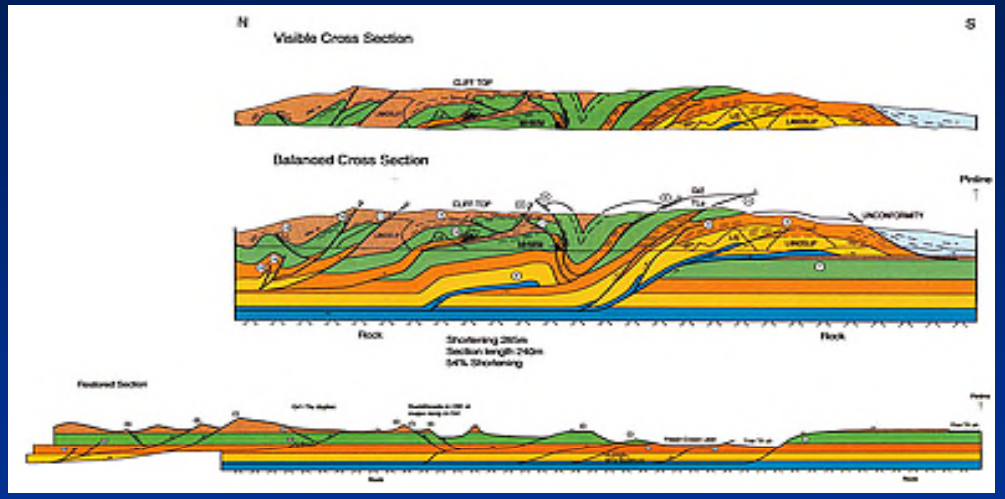
Structural Geology and Geology Maps Lab



Geology 101 Lab

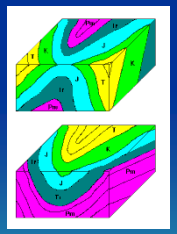
Ray Rector: Instructor

Structural Geology Lab
Pre-Lab Resources

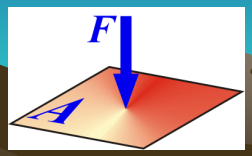


Pre-Lab Internet Links

1) Fundamentals of Structural Geology



2) Visualizing Bed Attitude



Structure Lab Learning Objectives

By the end of this lab, the student should be able to:

1) Explain the terminology and basic concepts of structural geology

2) Apply the general rules of structural geology to solving structure problems.

3) How to use field compass and inclinometer to determine strike and dip.

4) Identify the types of folds and faults, and correctly measure their attitude.

5) Correctly interpret and draw geologic block diagrams.

6) How to read a simplified geologic map.

General Geologic Terms of Structure

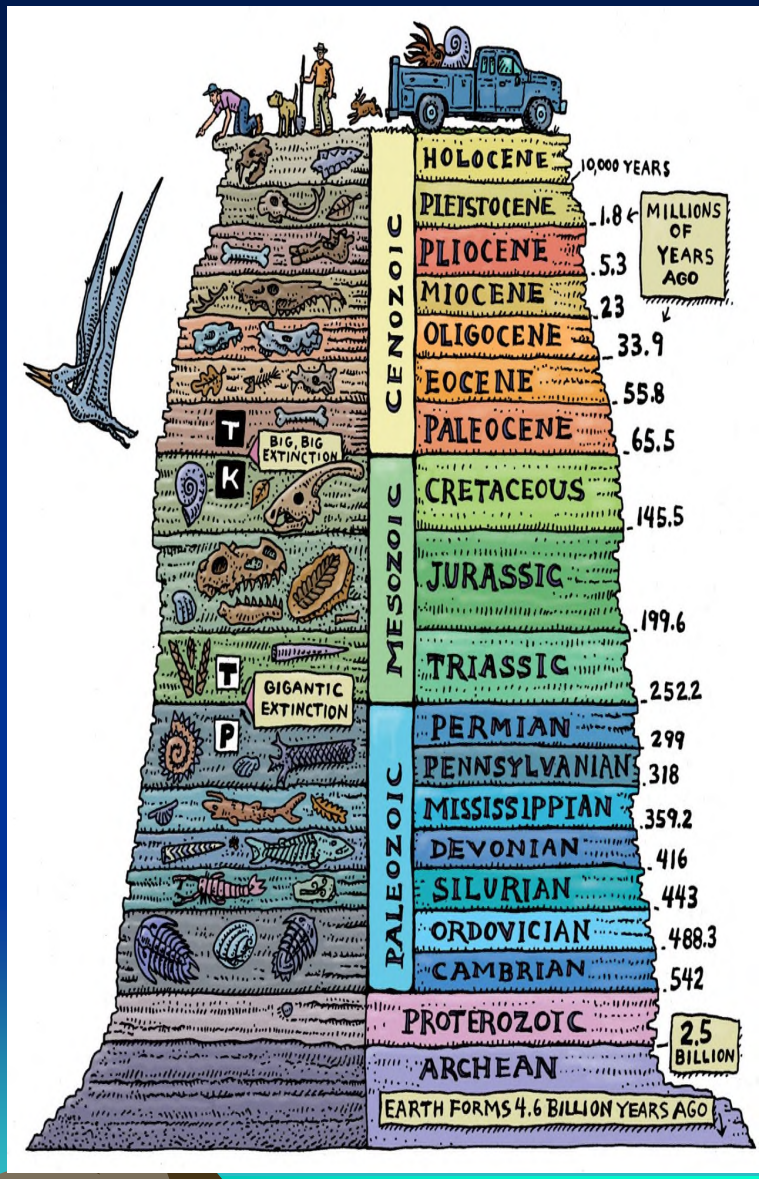
Outcrop: Exposure of bedrock at earths surface

Formation: mappable body of rock with definite age, lithology, and external boundaries (contacts)

Contact: Boundary between adjacent rock bodies or structural elements

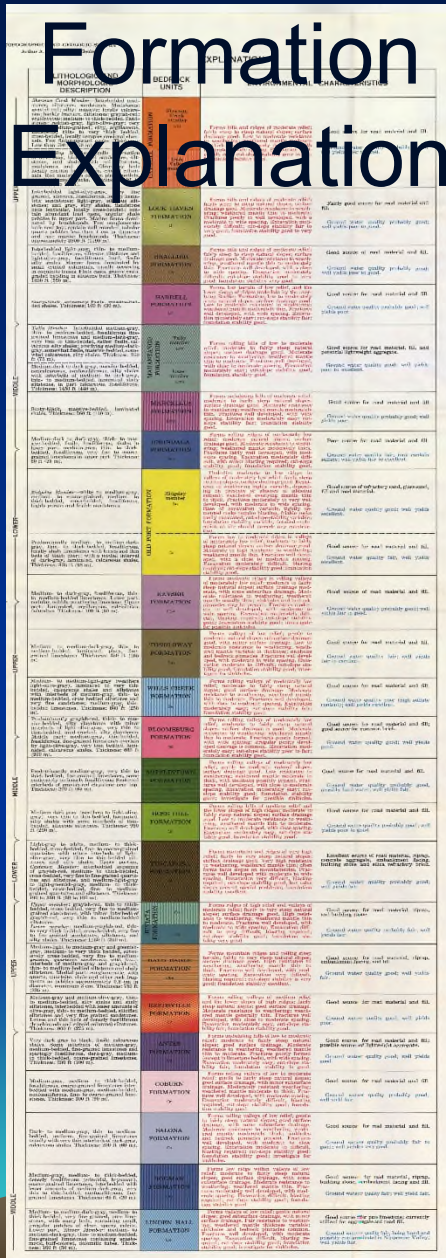
Rock Formations and Geologic Time

1) All geologic rock formations have a specific assigned age
2) All geologic rock formations have a specific range of lithology
3) Rock formations are listed in a temporally-ordered sequence in the "explanation" of a geologic map
4) Each rock formations has an assigned geologic period
5) Geologic period assignments of formations are further divided into lower (older), middle, and upper (younger)

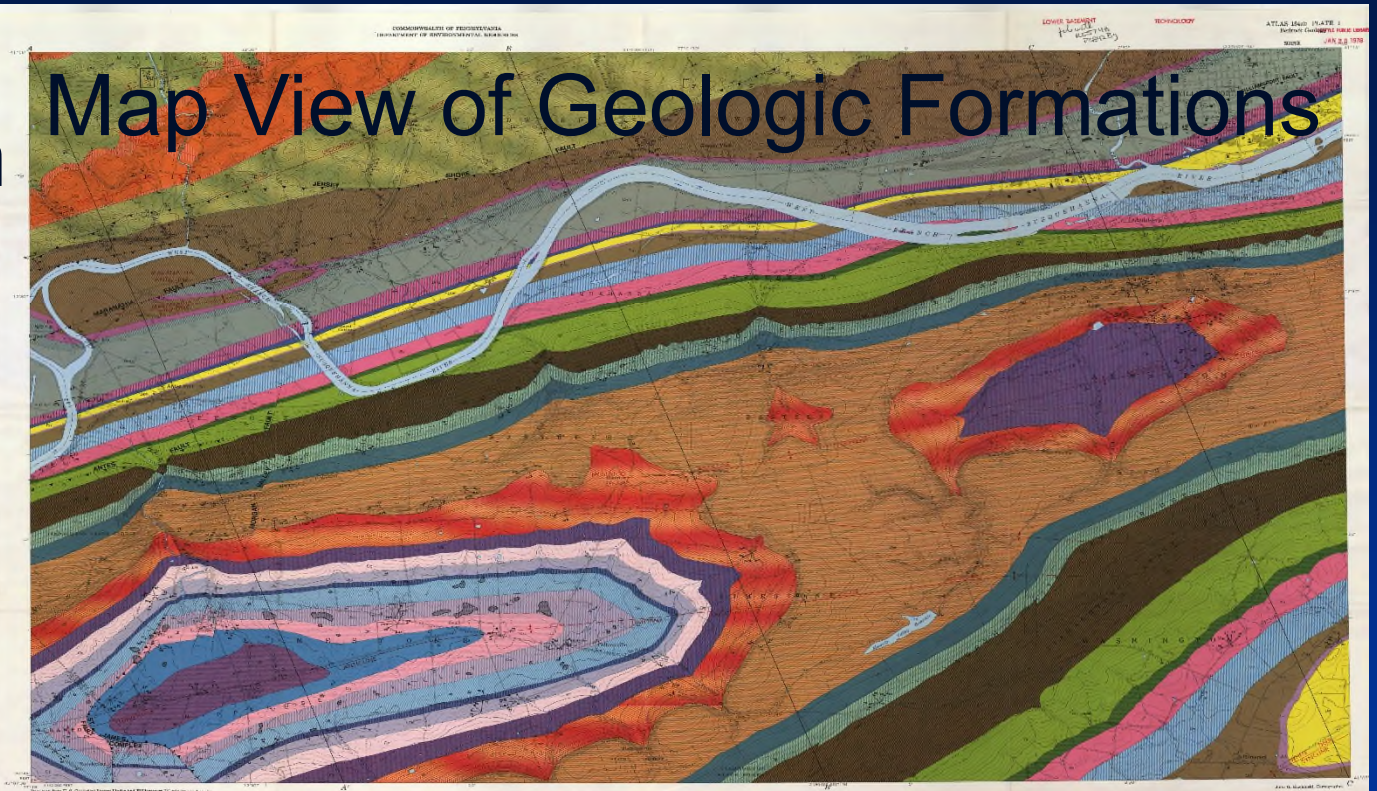


A Complete Geologic Map

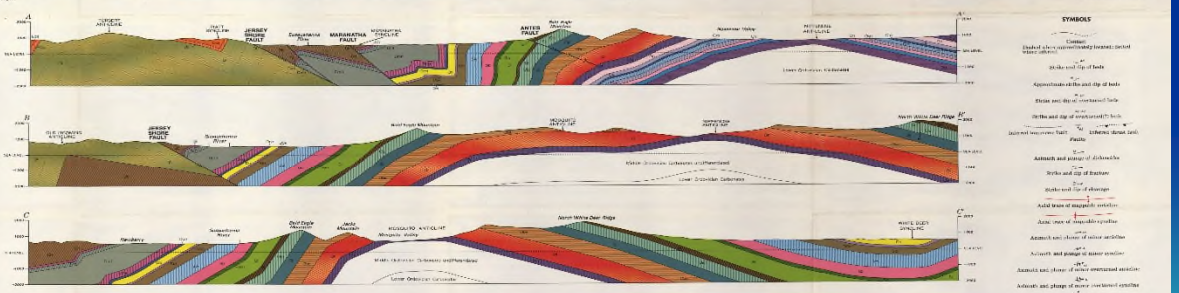
Formation Explanation



Map View of Geologic Formations



Cross Sections of Formations

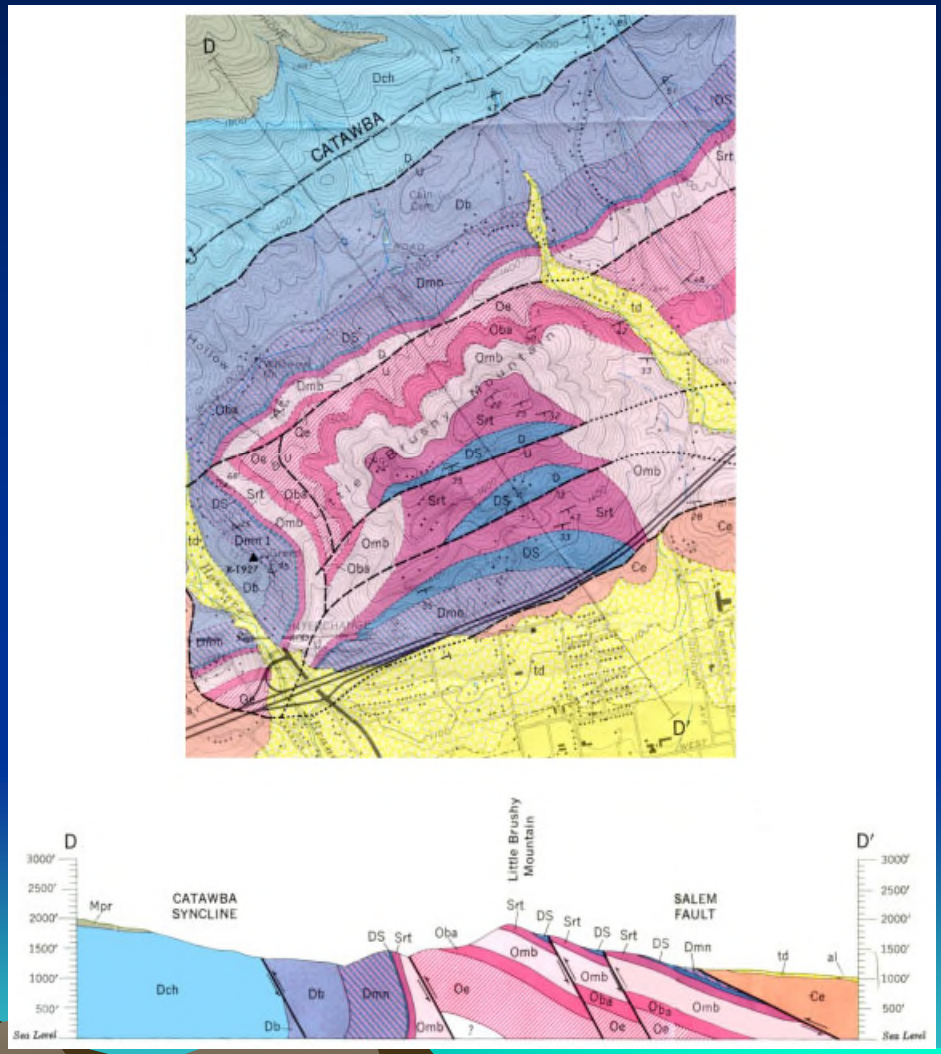


Rock Formations and Contacts on a Geologic Map

1) Rock formations, contacts and structural elements are illustrated in a geologic map and cross sections

2) A geology map depicts the types of rock that crop out at the earth's surface over a given area of the earth, including the type of contact between adjacent rock formations.

3) Contacts types include depositional, erosional, intrusion, and tectonic/fault

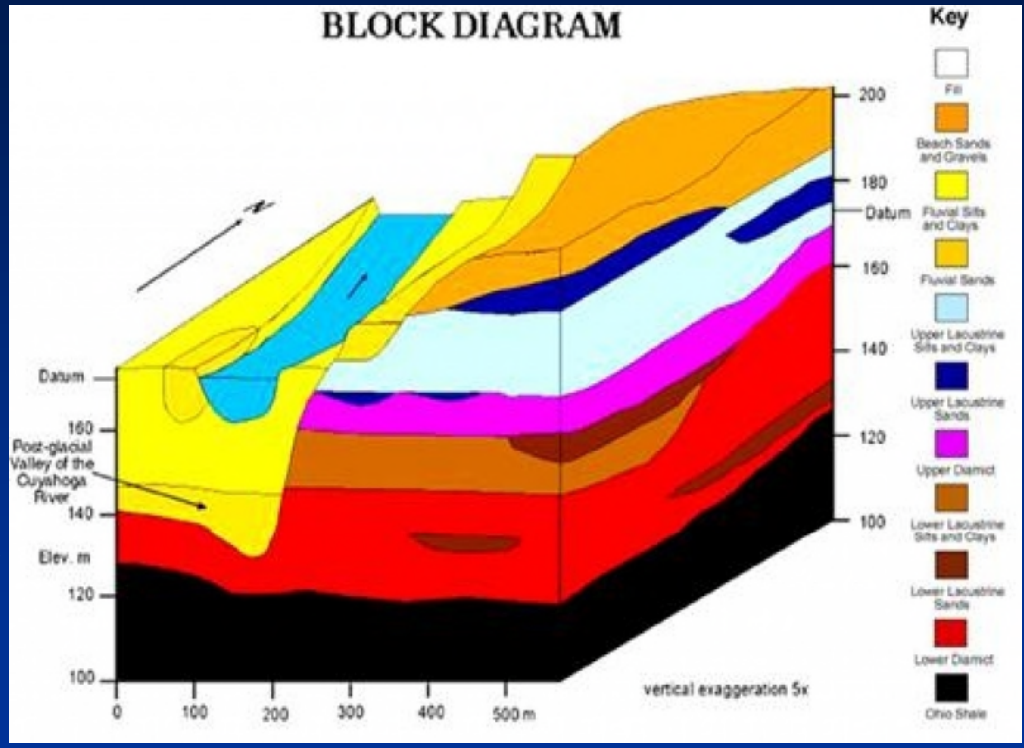


Rock Formations and Block Diagrams

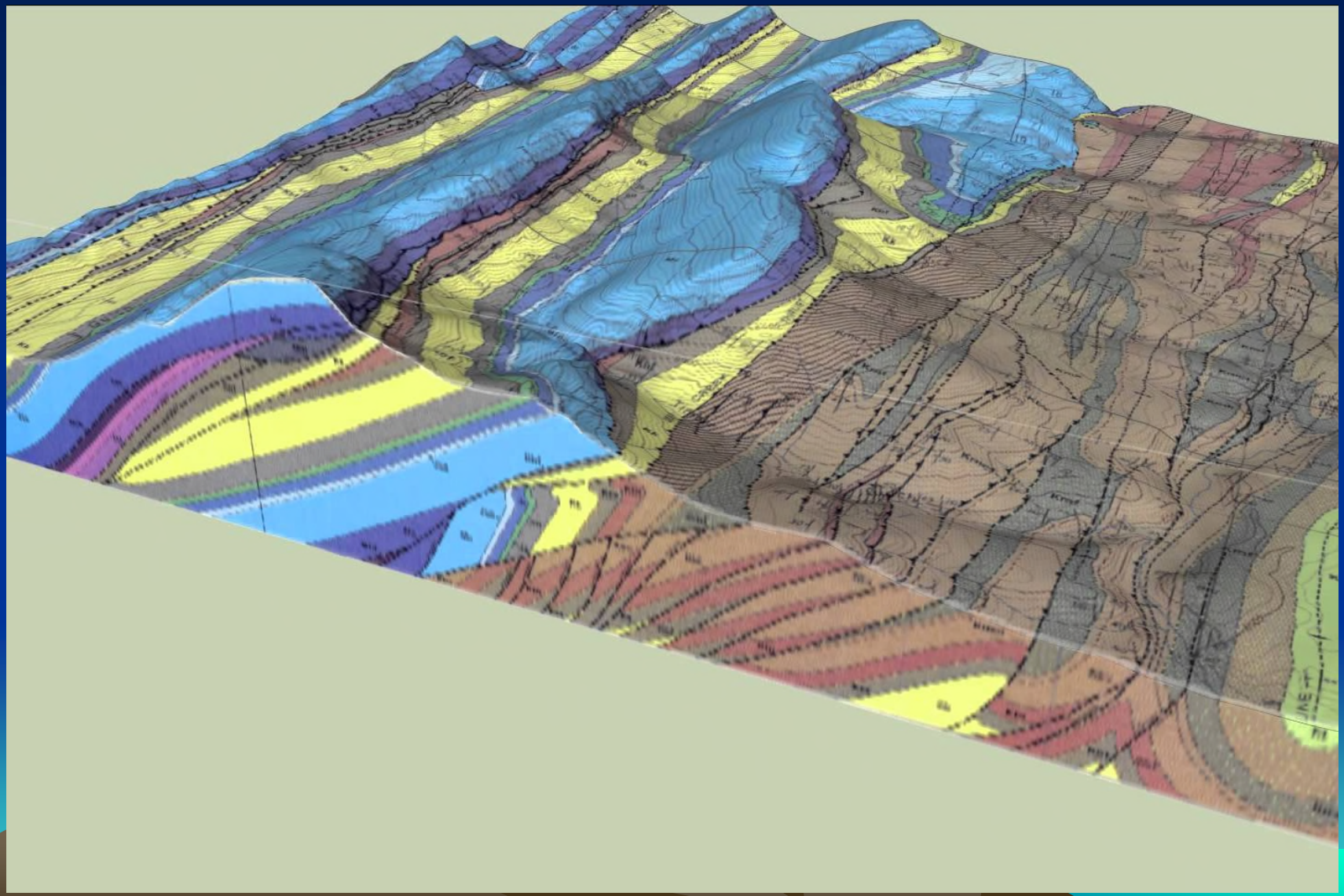
1) Geologic block diagrams combine a geologic map (top) with two cross-sections (sides) to create a three-dimensional block model of the crust.

2) Most block models are oriented in a particular way in respect to cardinal directions.

3) Block diagrams can be very helpful in analyzing various types of geologic structures, like stratigraphy, intrusions, folds and faults.



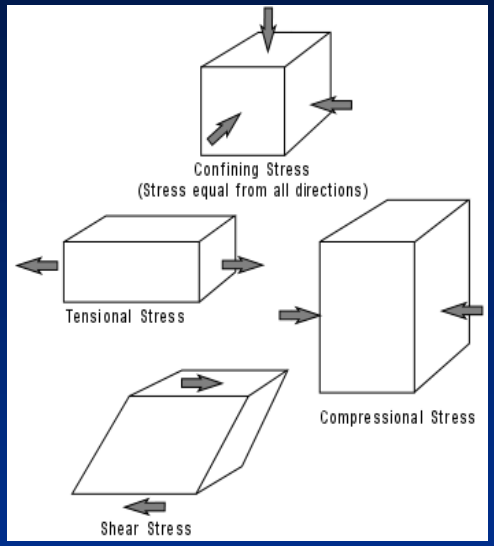
3-D Geologic Map Block Diagram

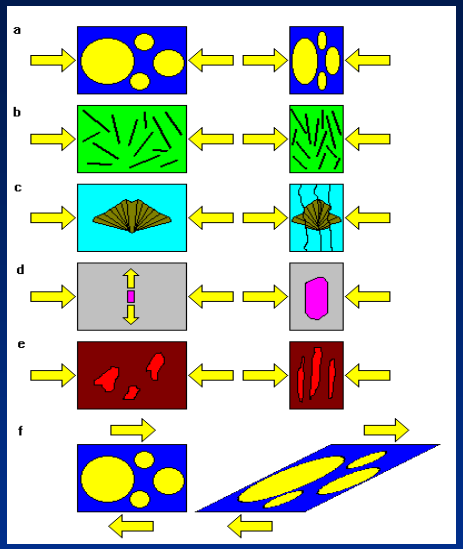


Origin and Nature of Rock Deformation

A. Stress Leads to Strain

- ✓ Stress is an applied force over an area
- ✓ Strain is the deformation of a solid body



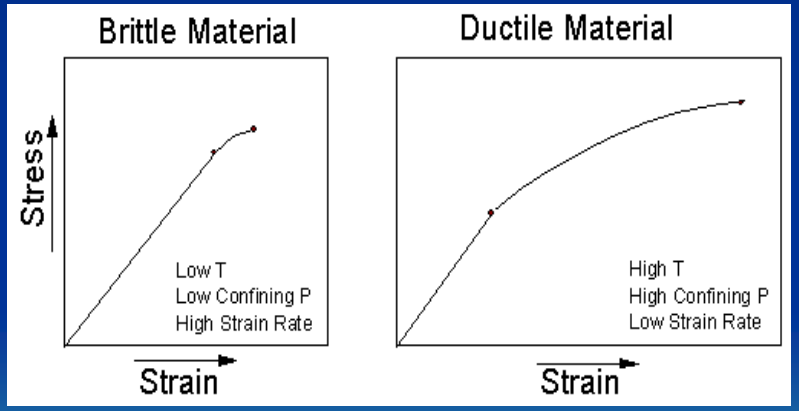


B. Different Types of Stress

- ✓ Tensional = pulling apart forces
- ✓ Compressional = pushing together forces
- ✓ Shear = grinding past each other force

C. Different Types of Strain

- ✓ Brittle = breaking into pieces
- ✓ Ductile = changing shape without breaking
- ✓ Elastic = deformed body returns to normal shape after stress released
- ✓ Plastic = deformed body remains deformed after stress released



Rocks strain in a predictable fashion, according to the amount and duration of strain under a given set of temperature-pressure conditions

Resultant Rock Strain from Specific Stresses

A. Undeformed Strata

- ✓ Original Horizontal layering

B. Compressional Stresses

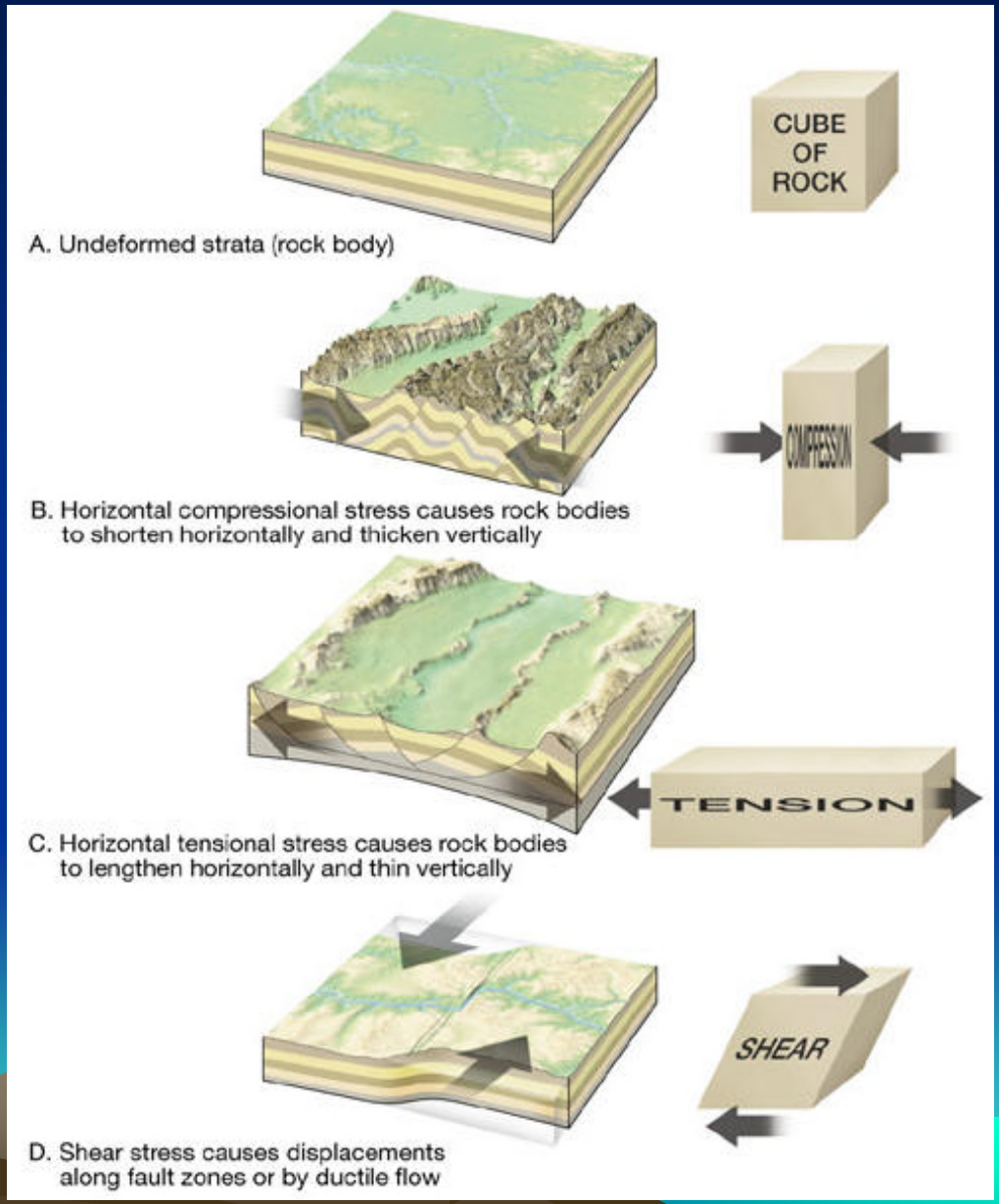
- ✓ Shorten horizontally
- ✓ Thicken vertically
- ✓ Folding and Reverse Faulting

C. Tensional Stresses

- ✓ Lengthen horizontally
- ✓ Thin vertically
- ✓ Tilting and Normal Faulting

D. Shear Stresses

- ✓ Lateral displacement
- ✓ Strike-slip Faulting



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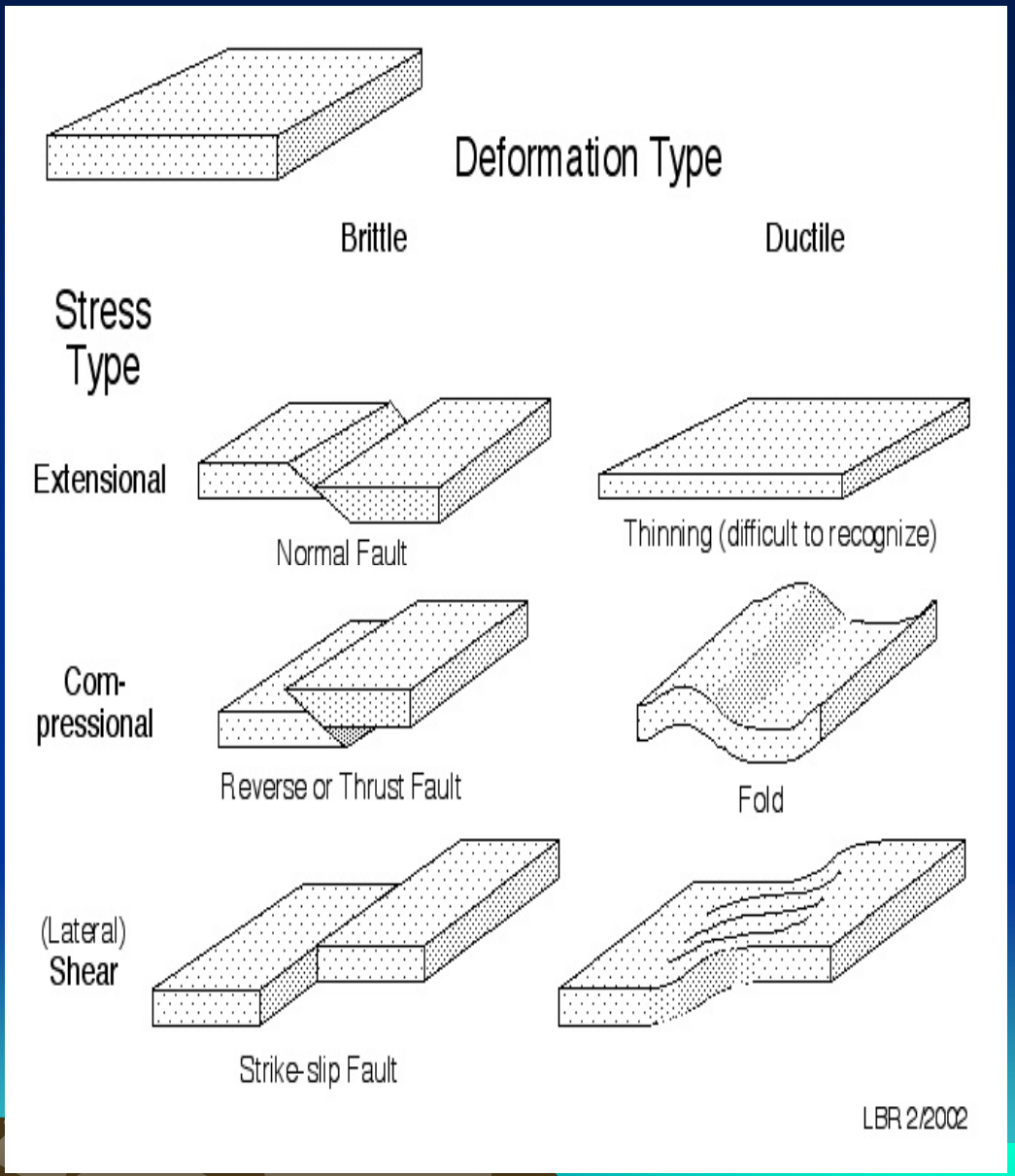
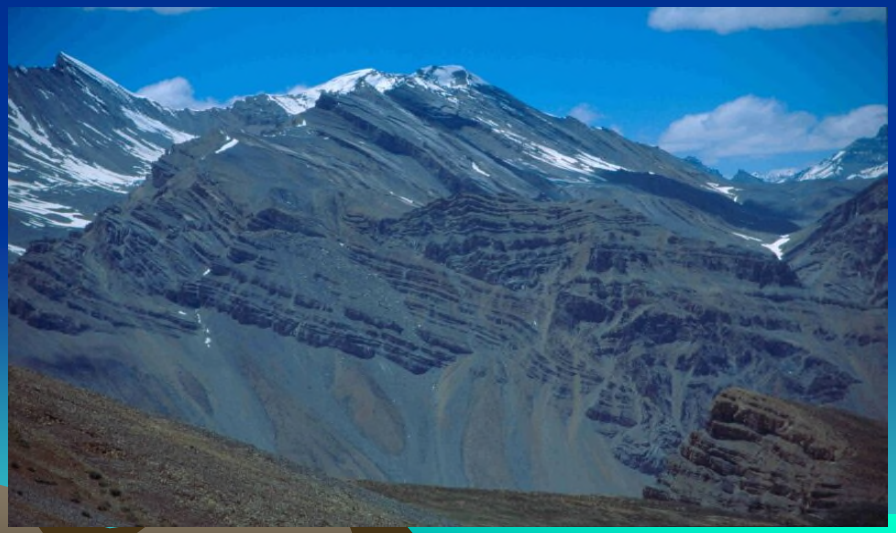


Geologic Structures

Rock Layering

Tilted Rock Layers

Folded Rock Layers



Faulted Rock Layers

The Basic Rules of Structure

1) Strike of beds is always parallel to the direction of the contacts.
2) Rock layers dip towards the youngest exposed rock layers.
3) Oldest rocks exposed in the center of eroded anticlines and domes.
4) Youngest rocks exposed in the center of eroded synclines and basins.
5) Horizontal folds form parallel sets of belt-like outcrop patterns.
6) Plunging anticlines form “V” of "U" shaped, belt-like outcrop patterns.
    - Anticline fold plunges toward *closed* end of “V” or “U” pattern.
7) Plunging synclines form ”V” of “U" shaped, belt-like outcrop patterns.
    - Syncline fold plunges toward *open* end of “U” pattern.
8) Steeper the dip of the layer, the more narrow the width of its outcrop.
9) Hanging wall is towards the fault dip direction; foot opposite to fault dip direction
10) Hanging wall *moves up* relative to foot wall in reverse and thrust faults.
11) Hanging wall *moves down* relative to foot wall in normal faults.
12) Slickenside grooves oriented horizontal in fault scarp indicate strike-slip offset.
13) Slickenside grooves oriented vertical in fault scarp indicate dip-slip offset.

Spatial Orientation of Layers

Strike and Dip

1) The spatial orientation, or ***attitude*** of a planar rock layer or structural feature can be measured and recorded in the field.

2) Two spatial aspects are needed:

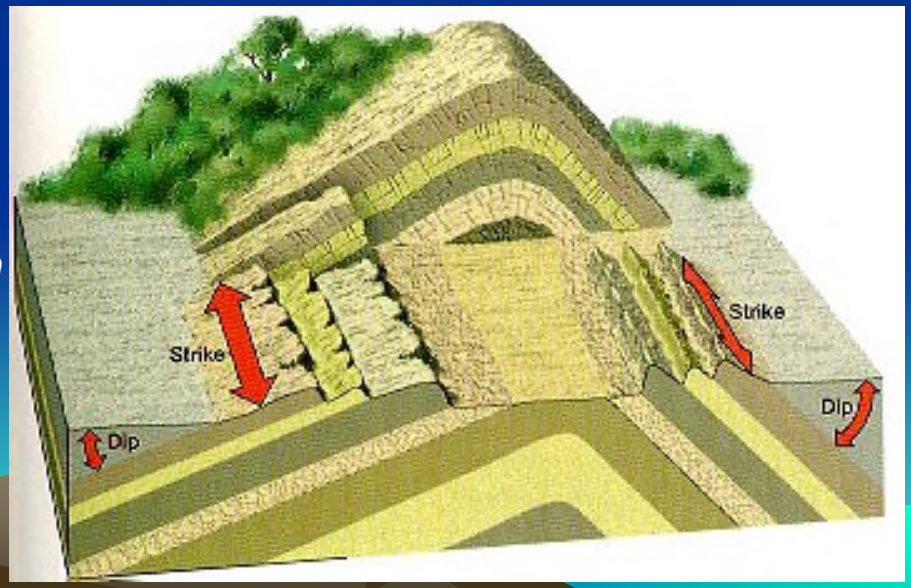
- ✓ **Strike** = horizontal component
- ✓ **Dip** = angle below the horizontal

3) The **Strike** is the line, or *trend* that represents the intersection of the planar feature with the horizontal.

4) **Strike** is measured with a compass.

5) **Dip** is the downward angle, or *inclination* of the feature from horizontal at a right angle to the strike.

6) **Dip** is measured with a clinometer.

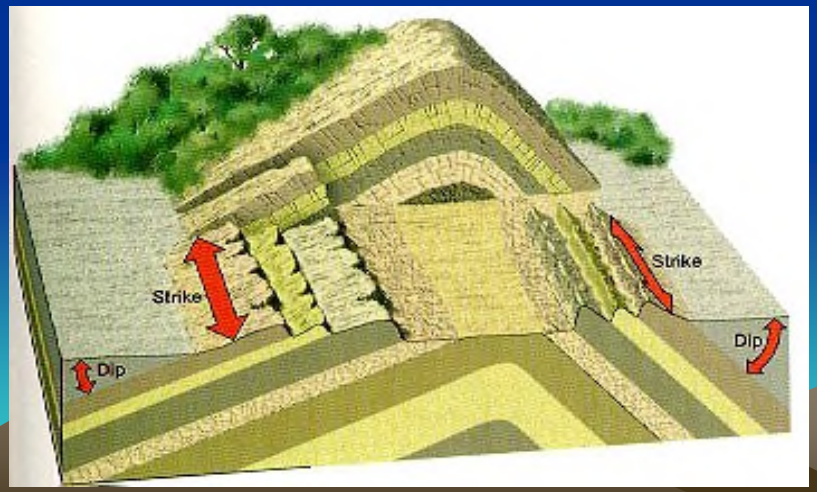


Using a Compass/Inclinometer to Determine Spatial Orientation of Layers

Strike and Dip

Measuring Strike Azimuth

Measuring Dip Angle



Strike Azimuth and Dip Angle

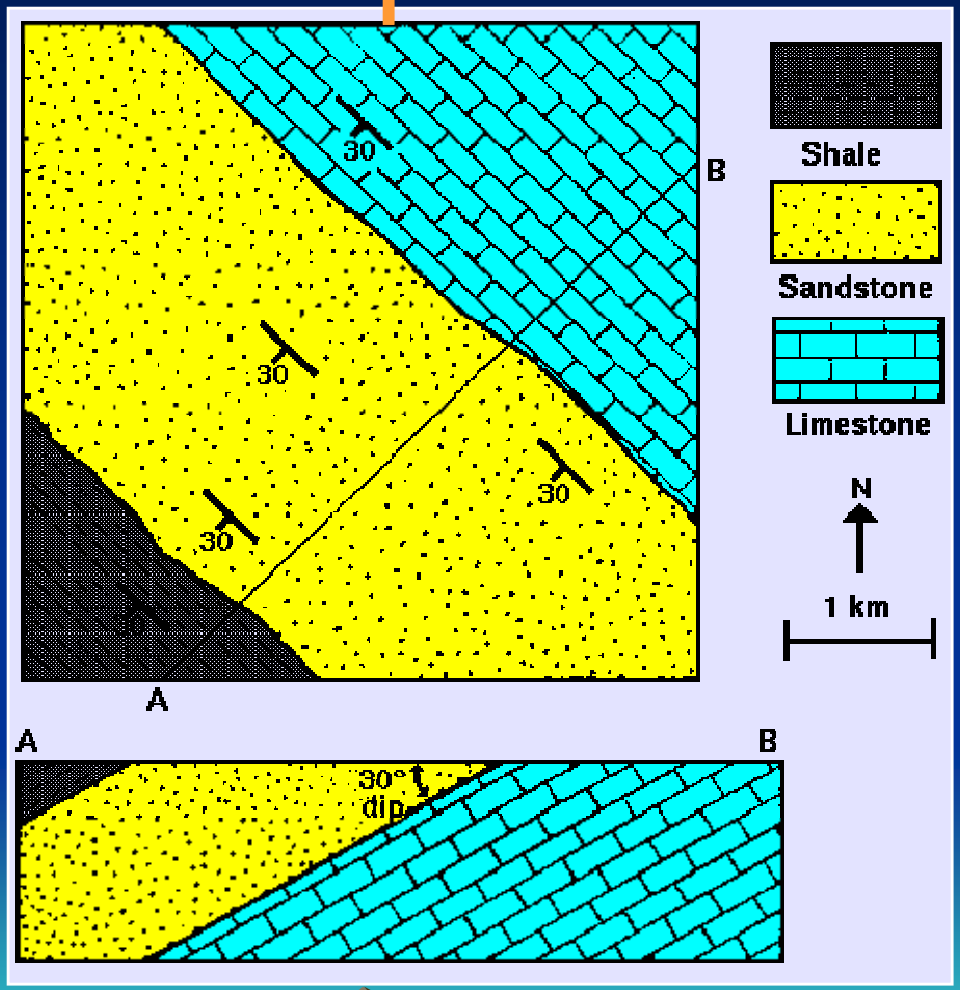
Completed Strike and Dip Measurement

Spatial Orientation of Layers

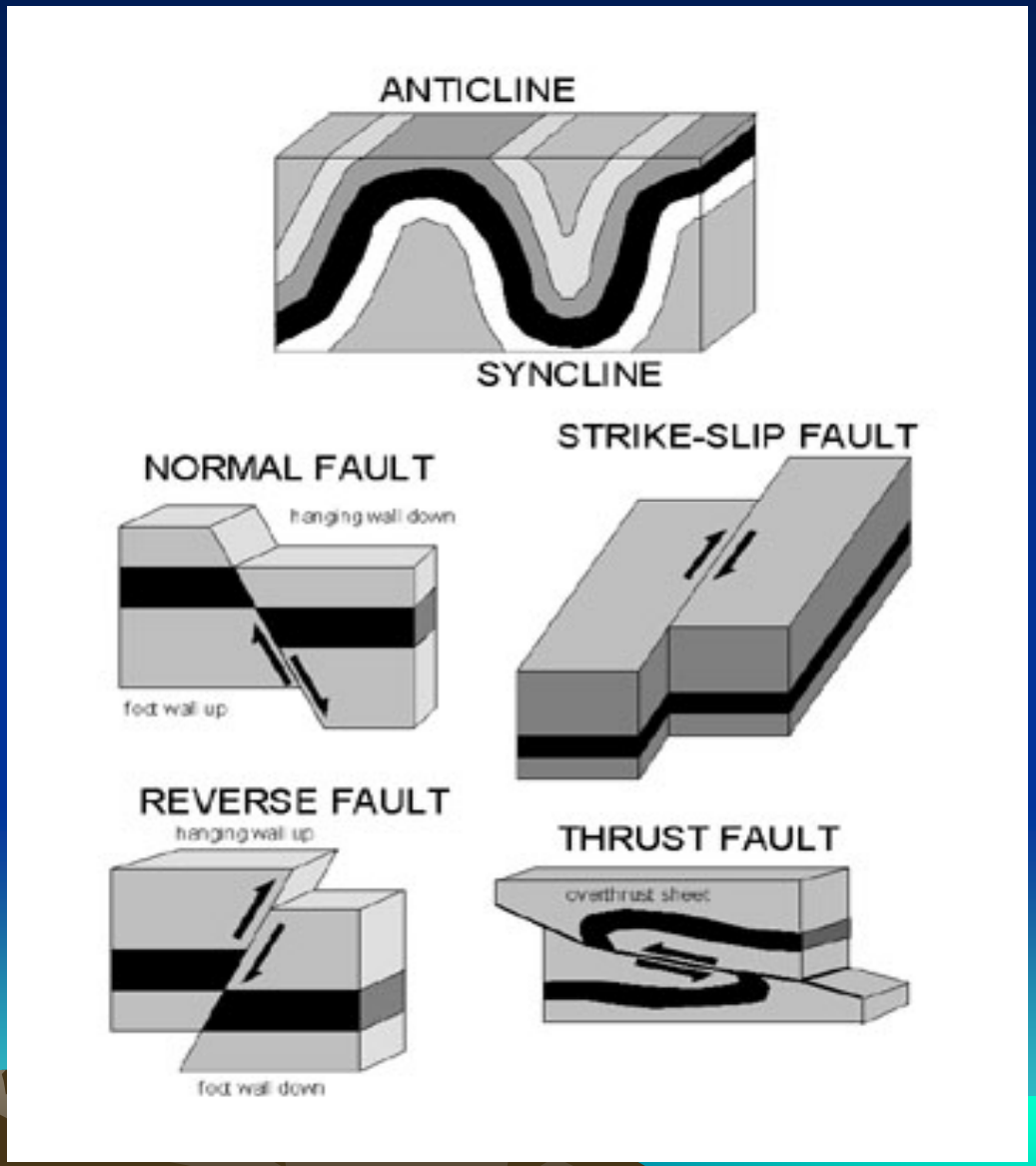
Strike and Dip

The **Strike** and **Dip** of a planar rock layer or feature is symbolized on a geology map by a

- ✓ The long bar is the strike trend
- ✓ The short bar points to the down dip direction with dip angle



Folds and Faults



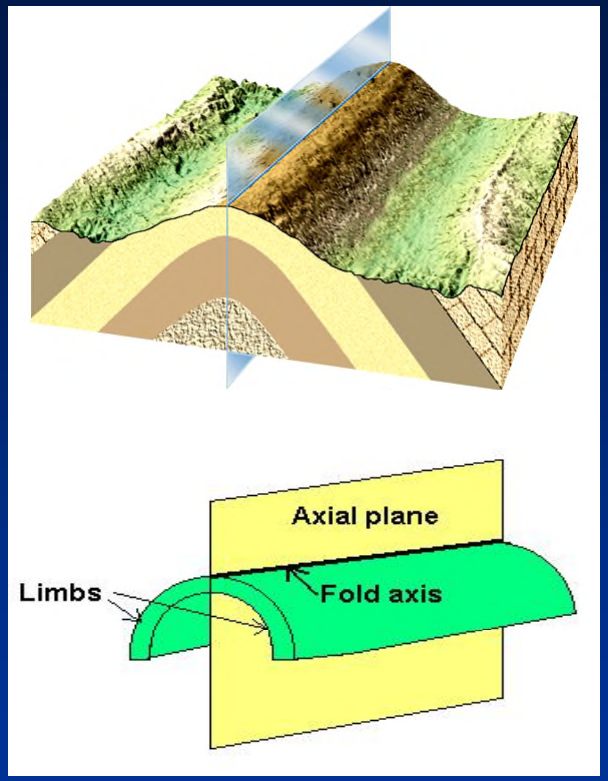
General Geologic Terms of Folds

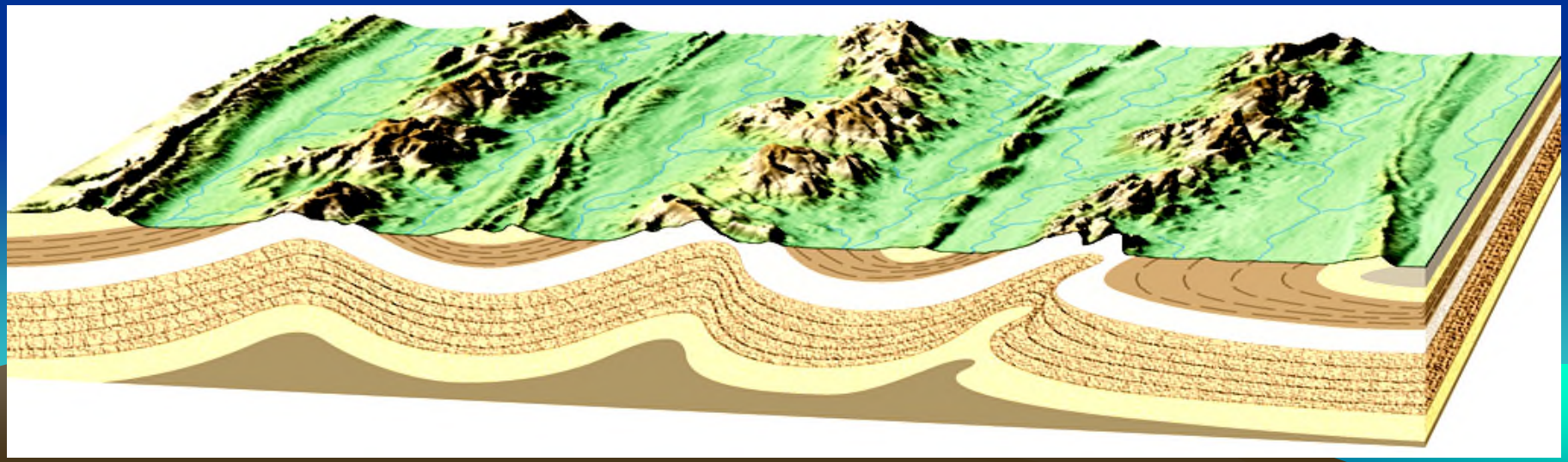
Folds: Buckled layers of rock formed by compressive stresses

Anticline: Upwards-buckled fold with oldest rock at center and outward-dipping limbs

Syncline: Downwards-buckled fold with oldest rock at center and outward-dipping limbs

Fold Basics





Fold Basics

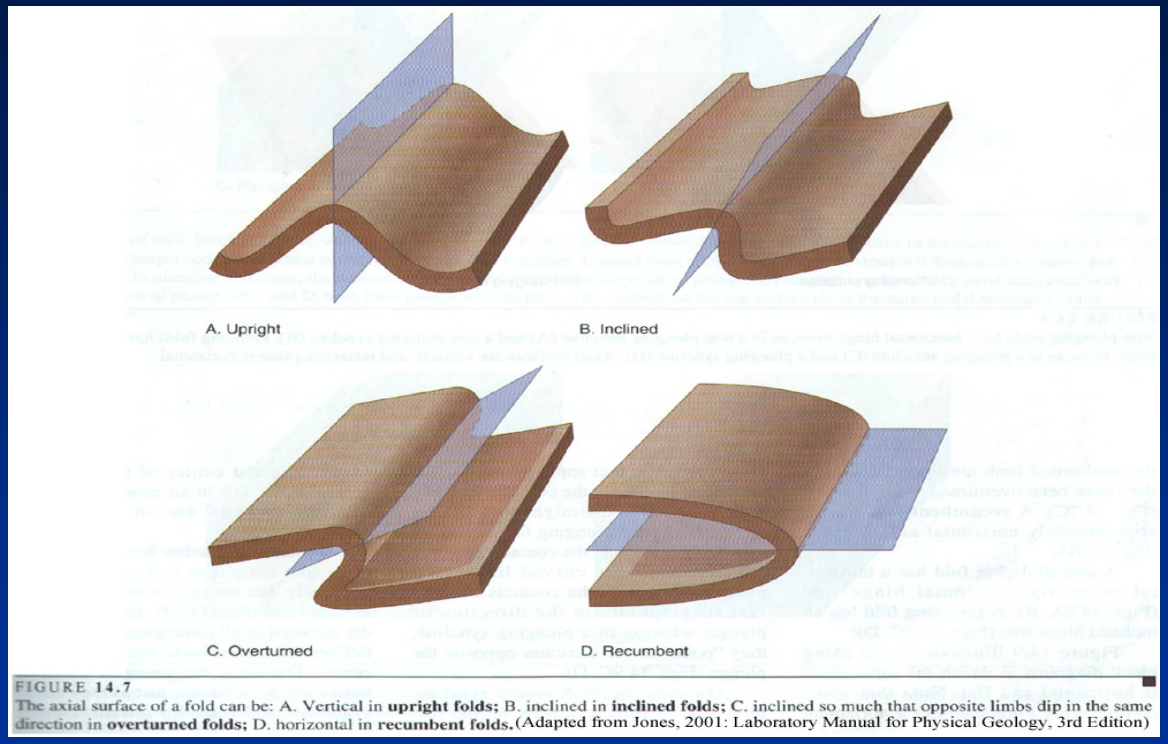
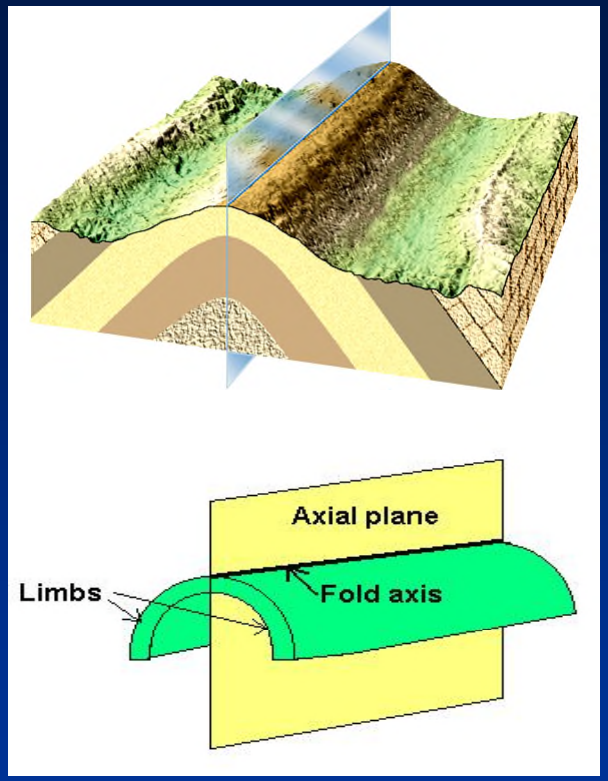
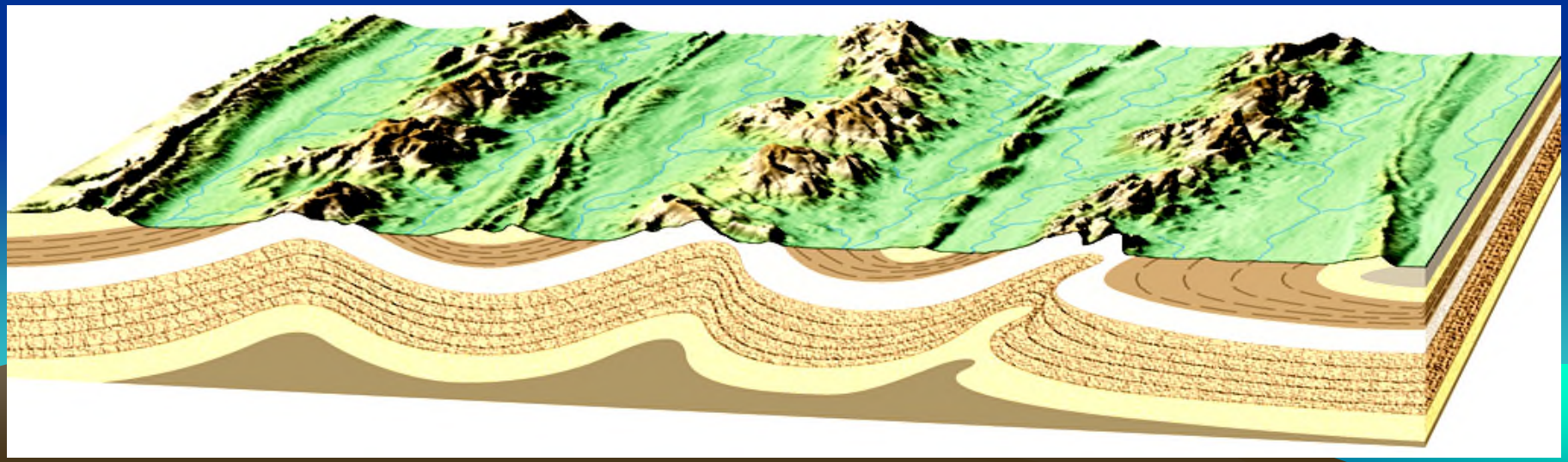
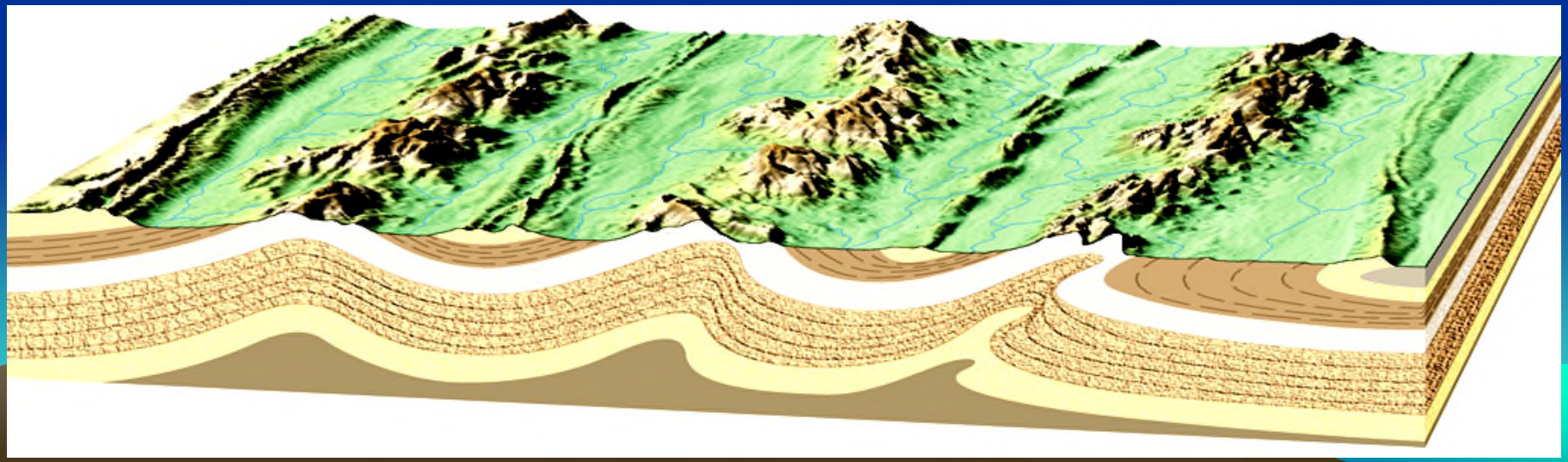


FIGURE 14.7
The axial surface of a fold can be: A. Vertical in **upright folds;** B. inclined in **inclined folds;** C. inclined so much that opposite limbs dip in the same direction in **overturned folds;** D. horizontal in **recumbent folds.** (Adapted from Jones, 2001: Laboratory Manual for Physical Geology, 3rd Edition)





Fold Basics



Rules of Folds

Anticlines

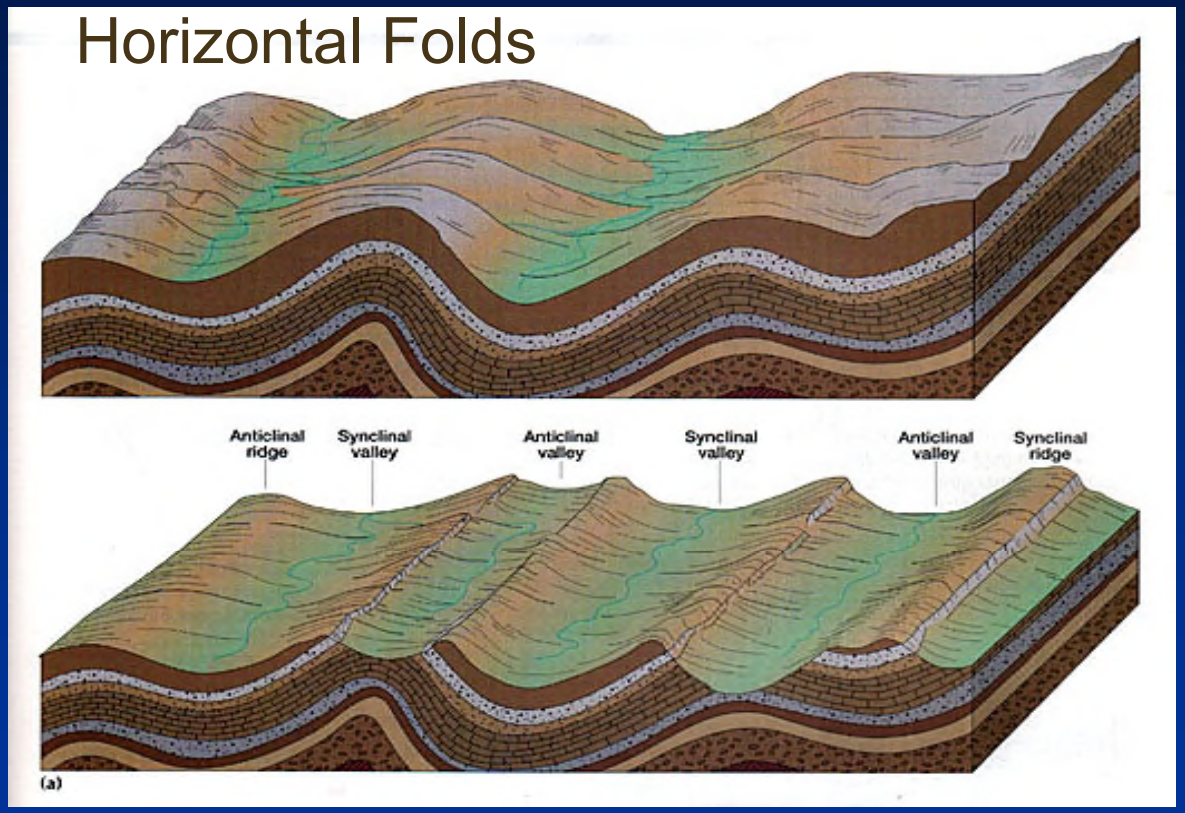
1) Oldest unit in center
2) Limbs dip outward

Synclines

1) Youngest unit in center
2) Limbs dip inward

Horizontal Folds

1) Strikes of opposing fold limbs are all parallel
2) Folds form parallel striped pattern on geology map

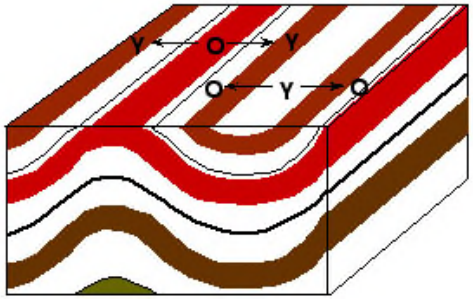


Plunging Folds

1) Strikes of opposing fold limbs are not parallel
2) Folds form V-shaped pattern on geology map
3) Anticlines plunge toward closed end of “V”-shaped bedding pattern
4) Synclines plunge toward open end of “V”-shaped bedding pattern

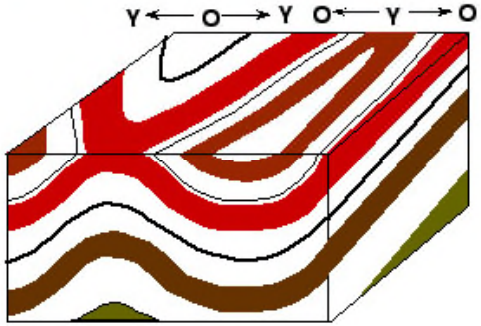
Plunging Folds

Plunging Folds

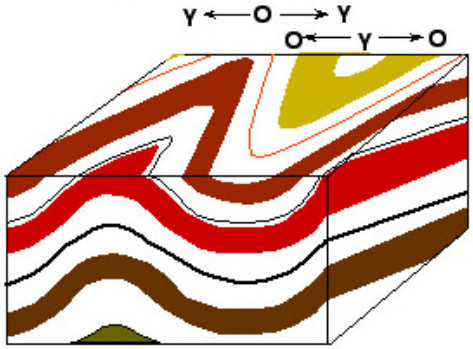


Anticline and Syncline in 3-dimensional view

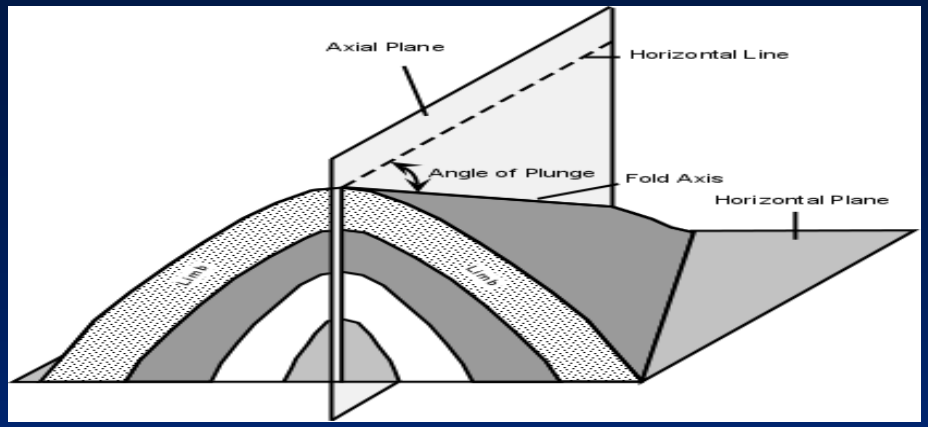
Oldest beds are in centers of anticlines; youngest beds are in centers of synclines.

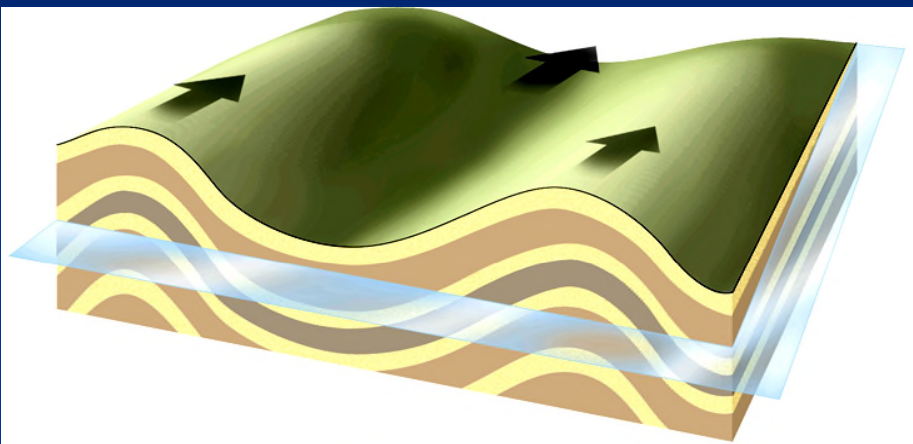


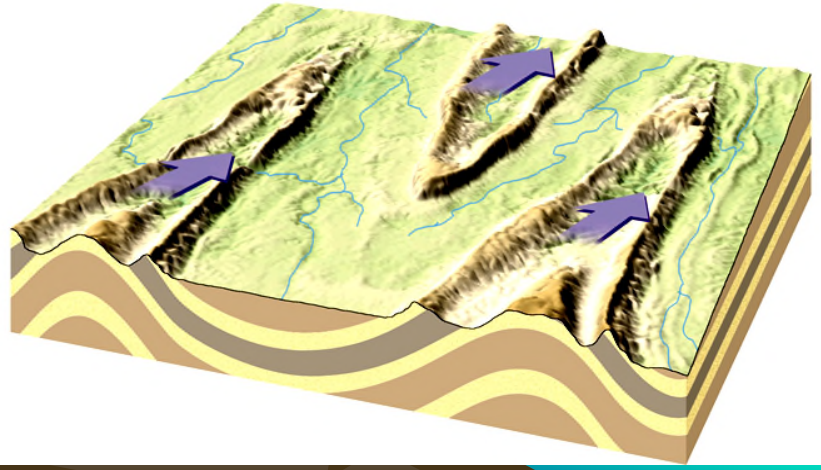
Anticline and Syncline plunging toward viewer



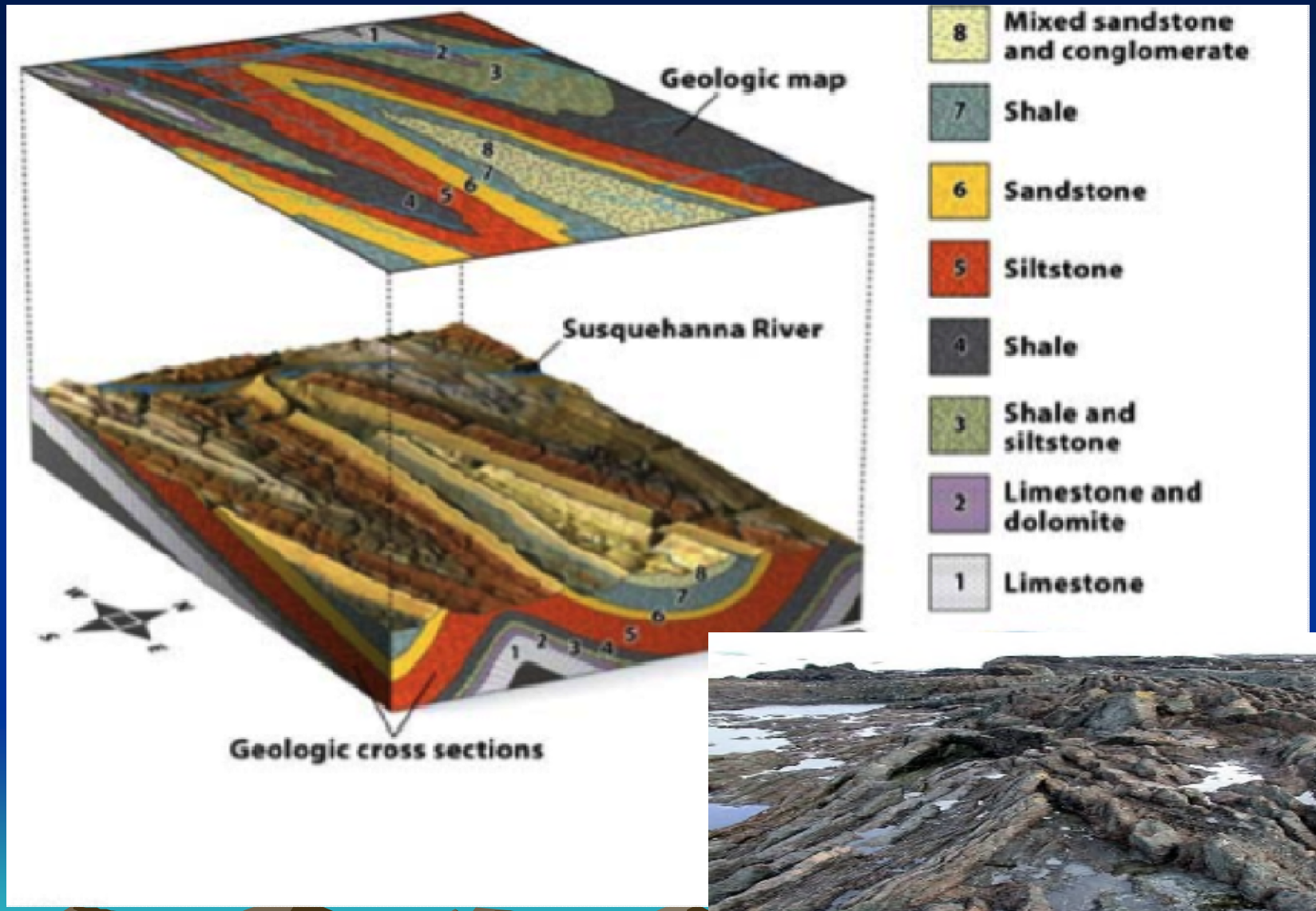
Anticline and Syncline plunging away from viewer



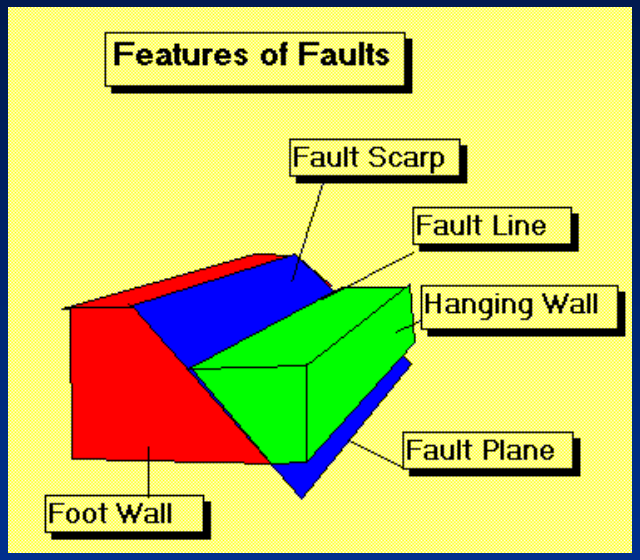


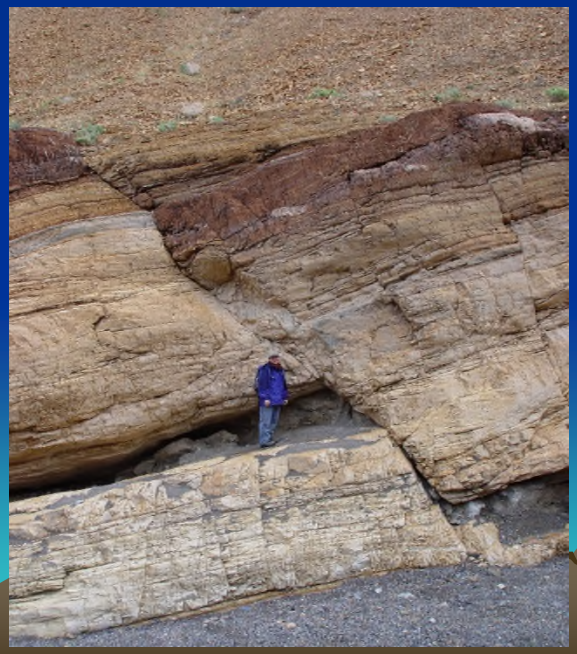


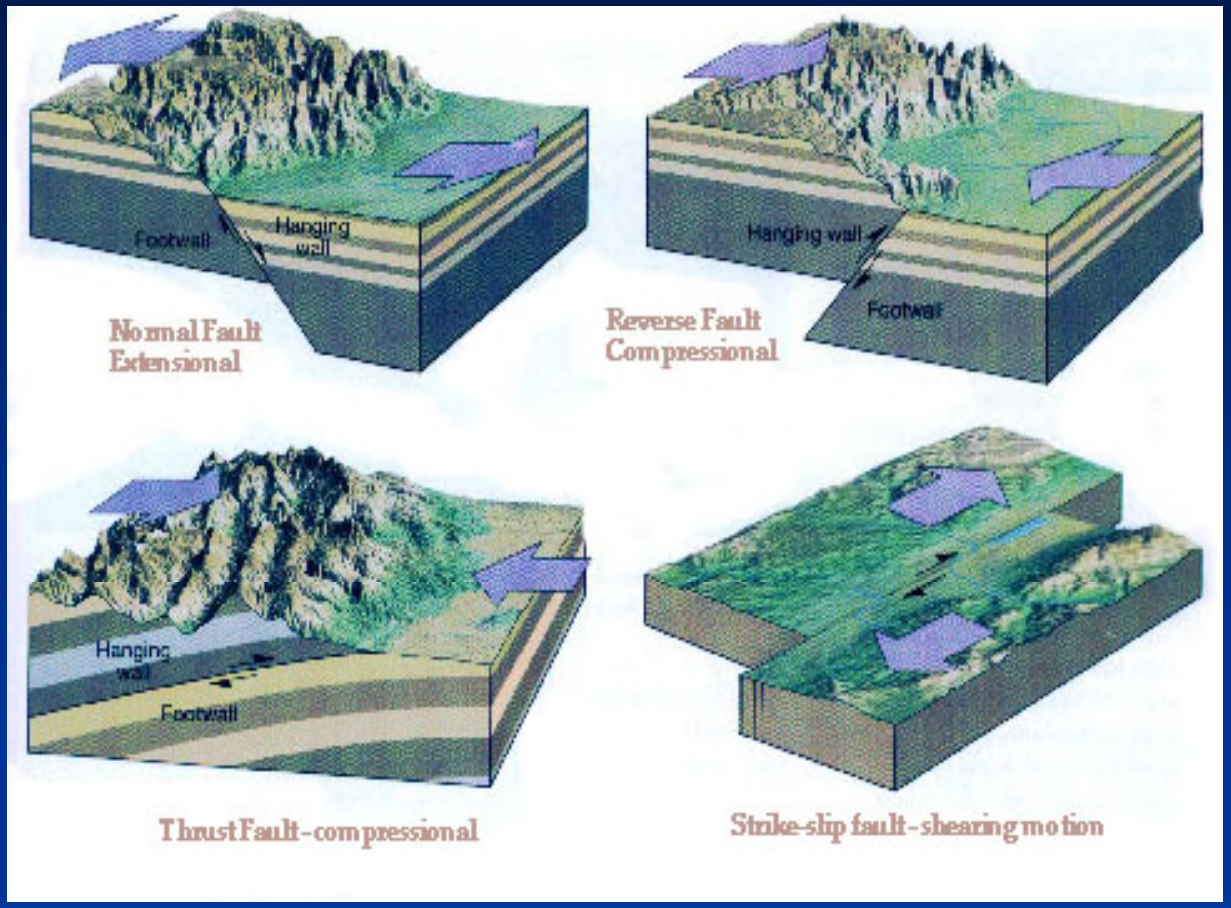
Plunging Folds



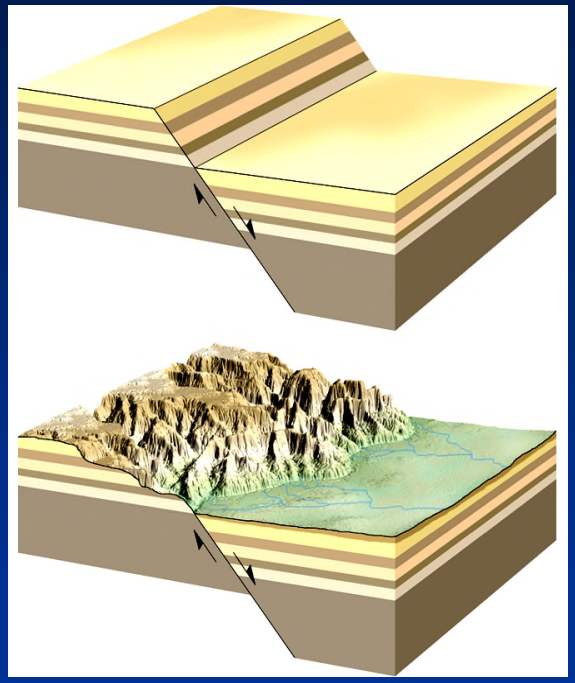
Fault Terminology



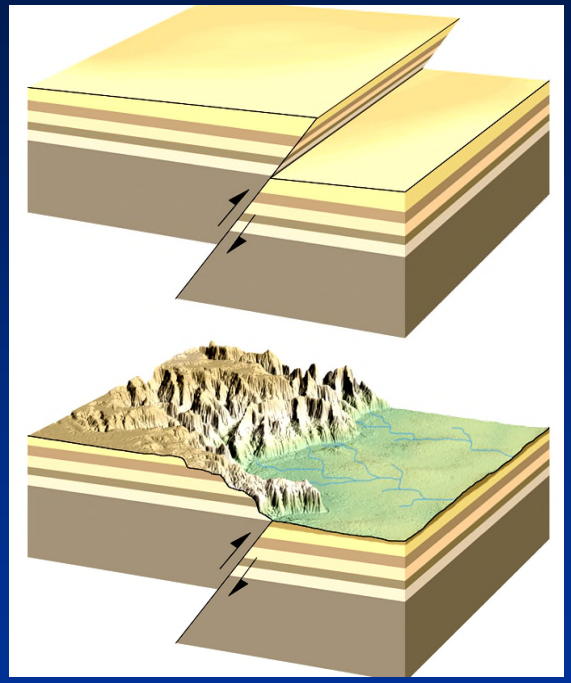




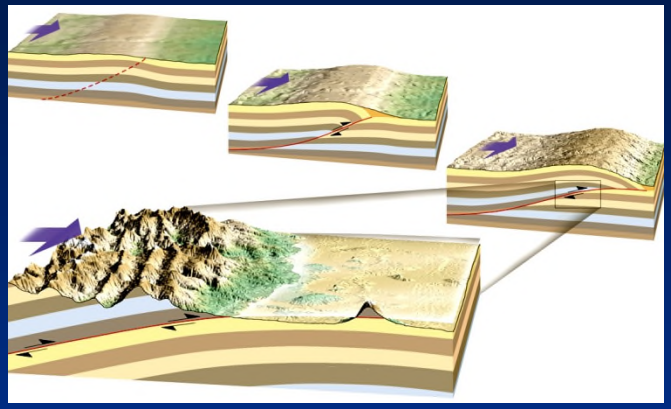
Types of Faults



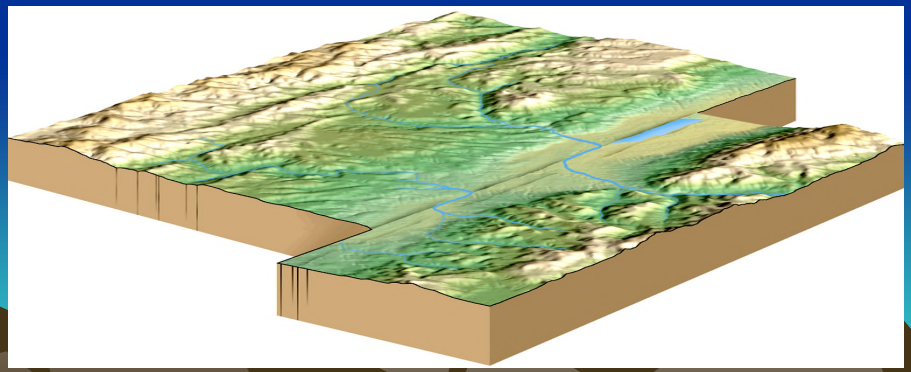
Normal Fault



Reverse Fault

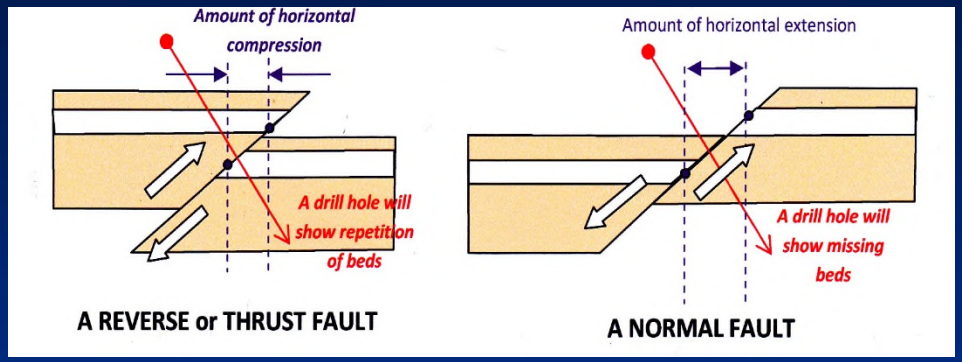


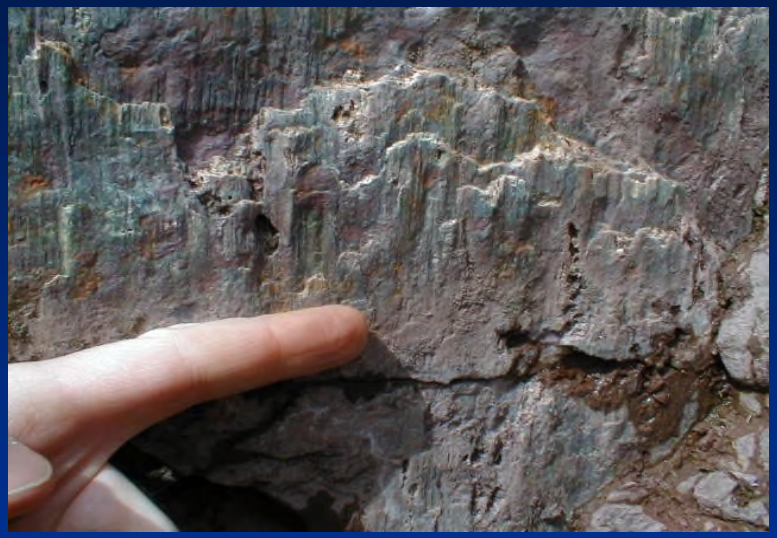
Thrust Fault



Strike-Slip Fault

Fault Offset and Slickensides



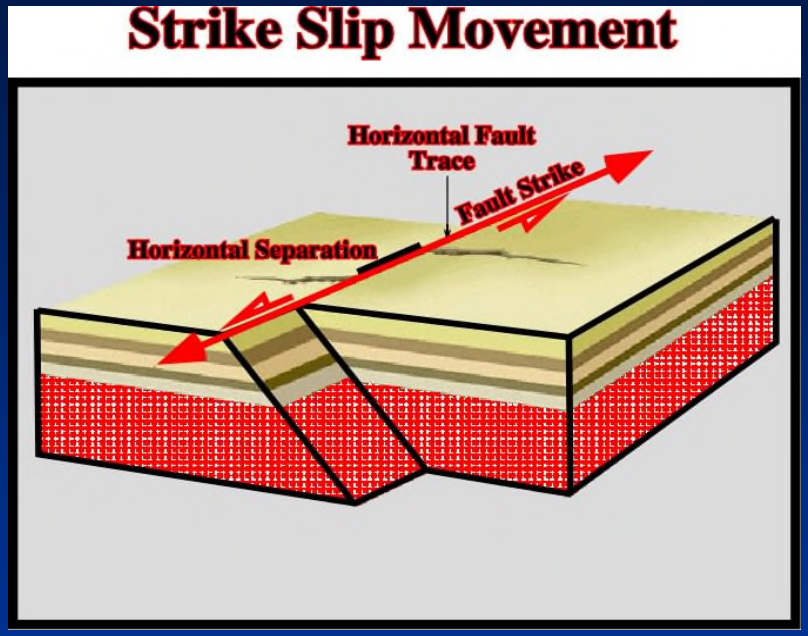


Dip-slip oriented slickensides

Normal-sense, dip-slip offset

Reverse-sense, dip-slip offset

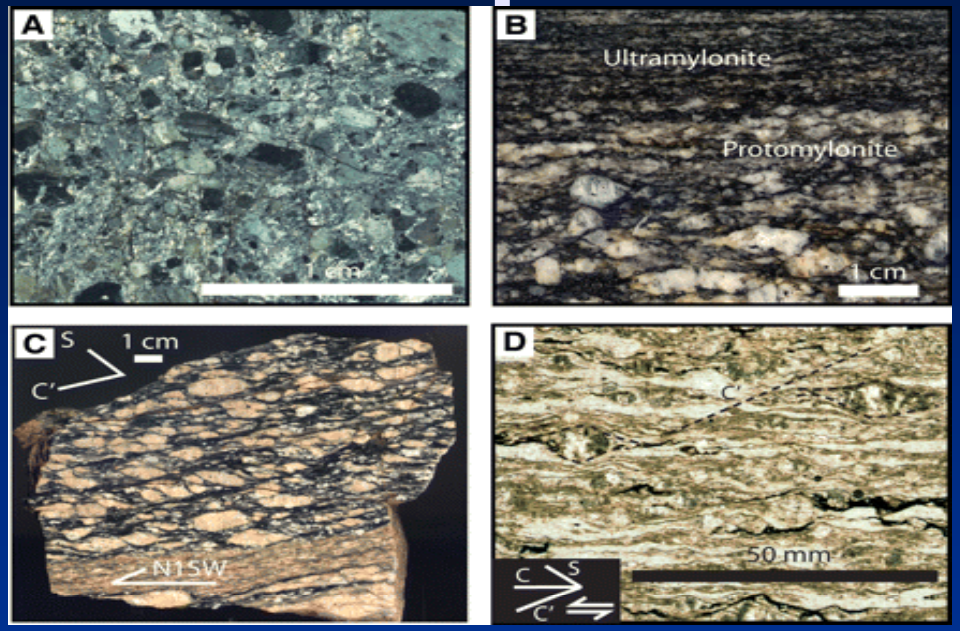
Fault Slickensides

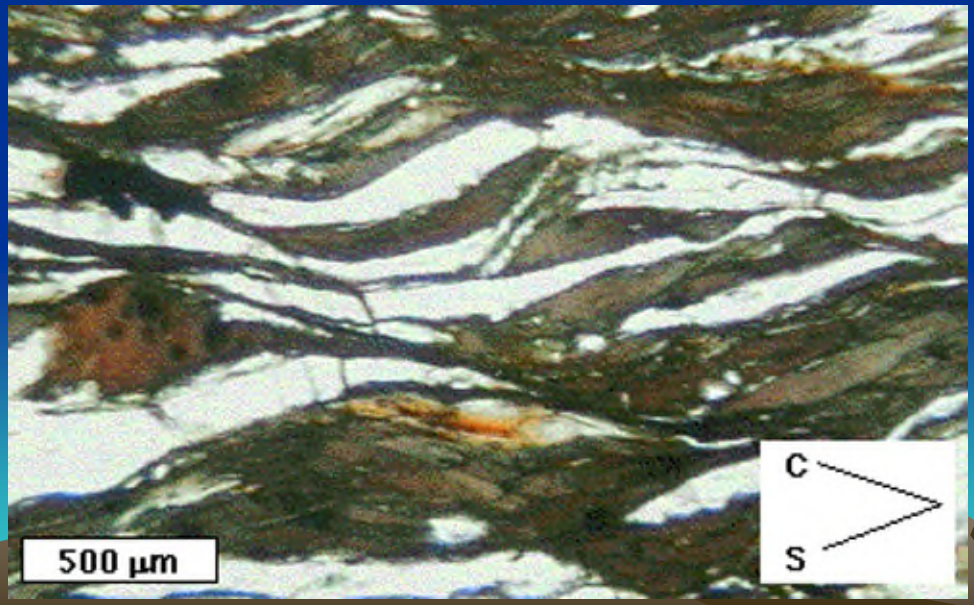


Strike-slip oriented slickensides

Right-lateral, strike-slip offset

Special Fault Rocks





Mylonite

Brittle-ductile shear-like deformation along fault zone resulting in a special kind of foliation termed “S-C fabric”.

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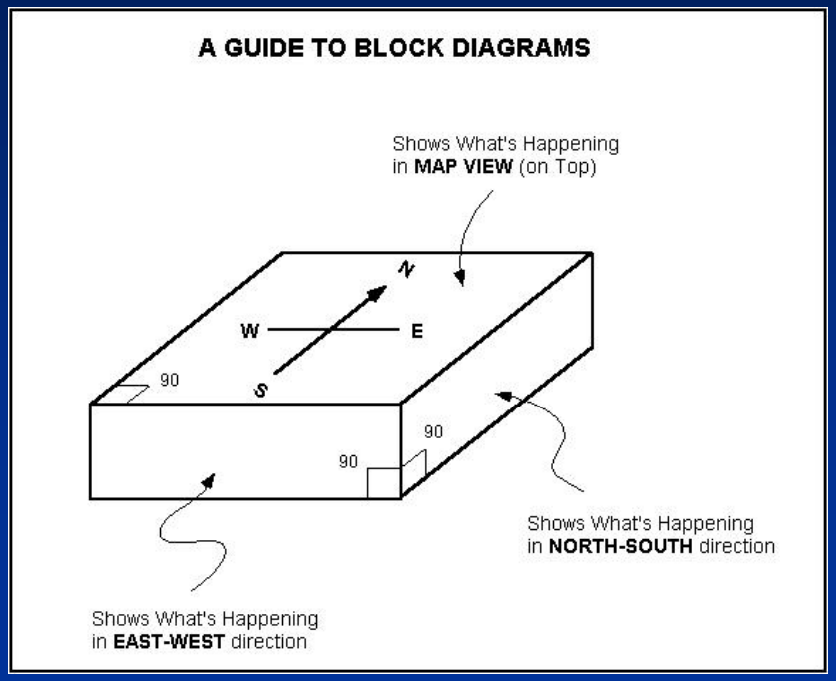
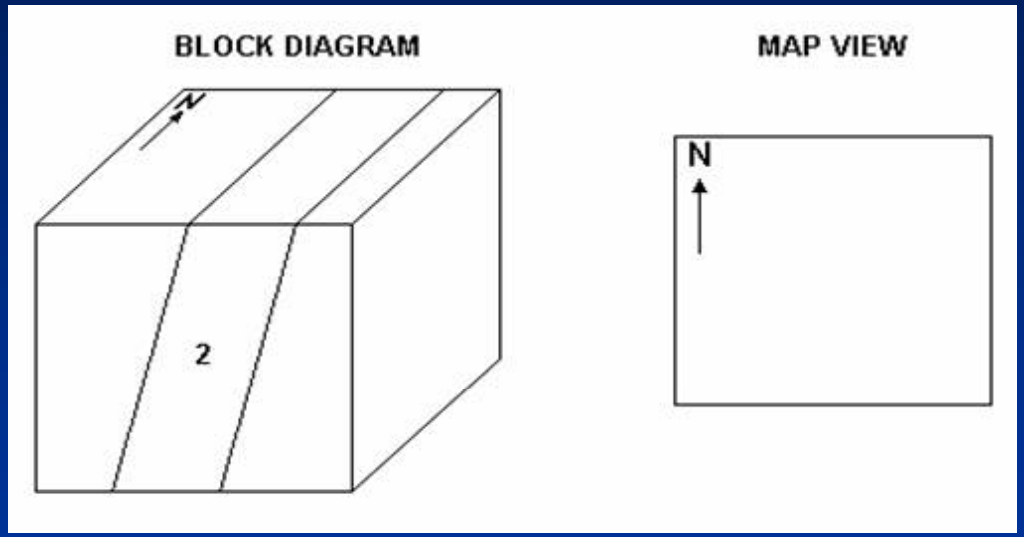
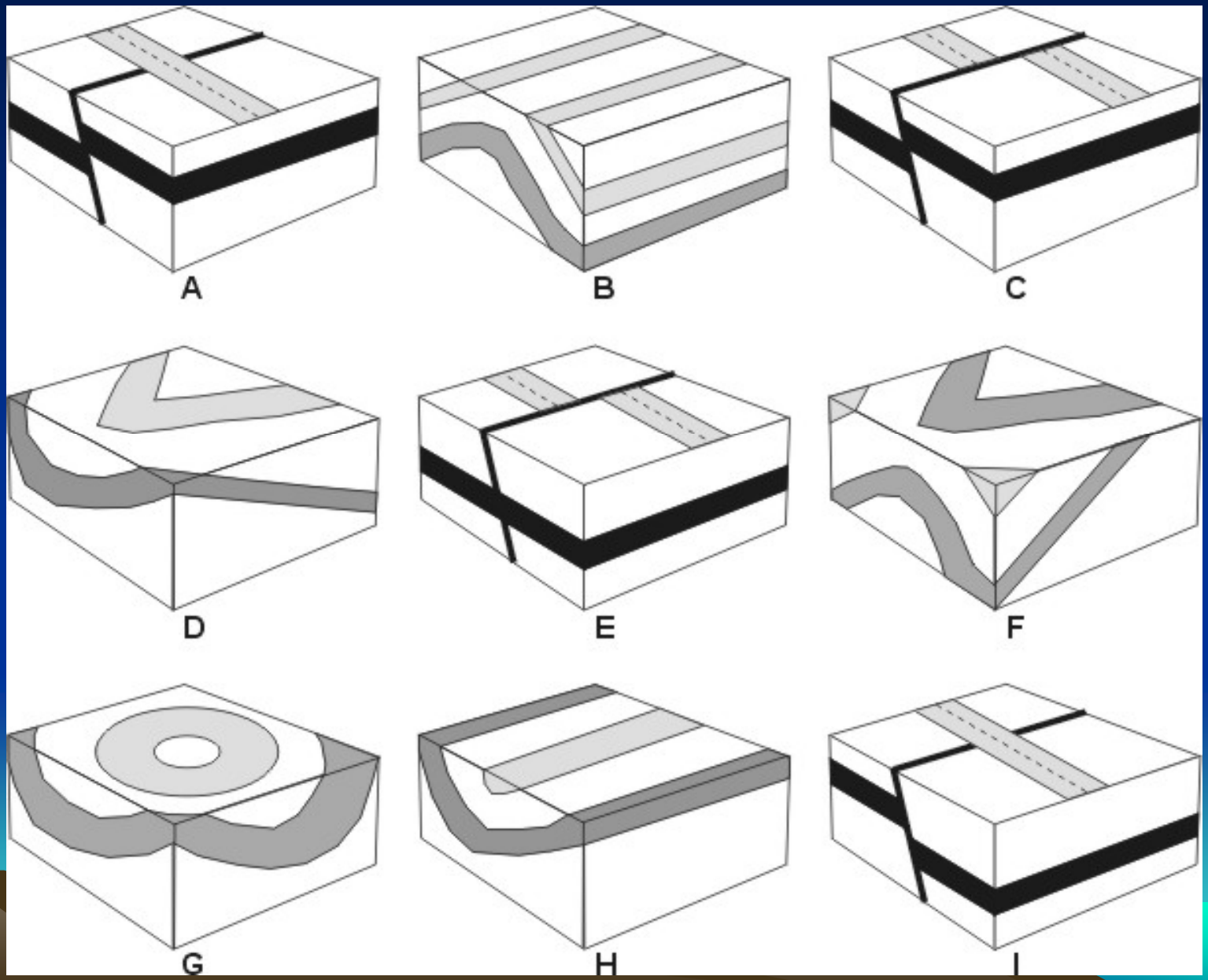
Working with Block Diagrams





Working with Block Diagrams



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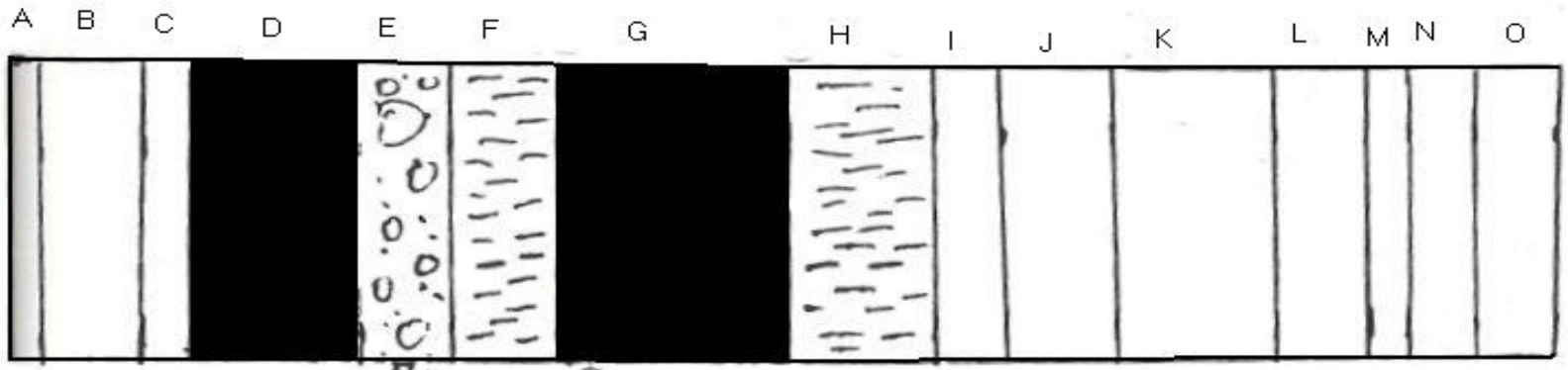
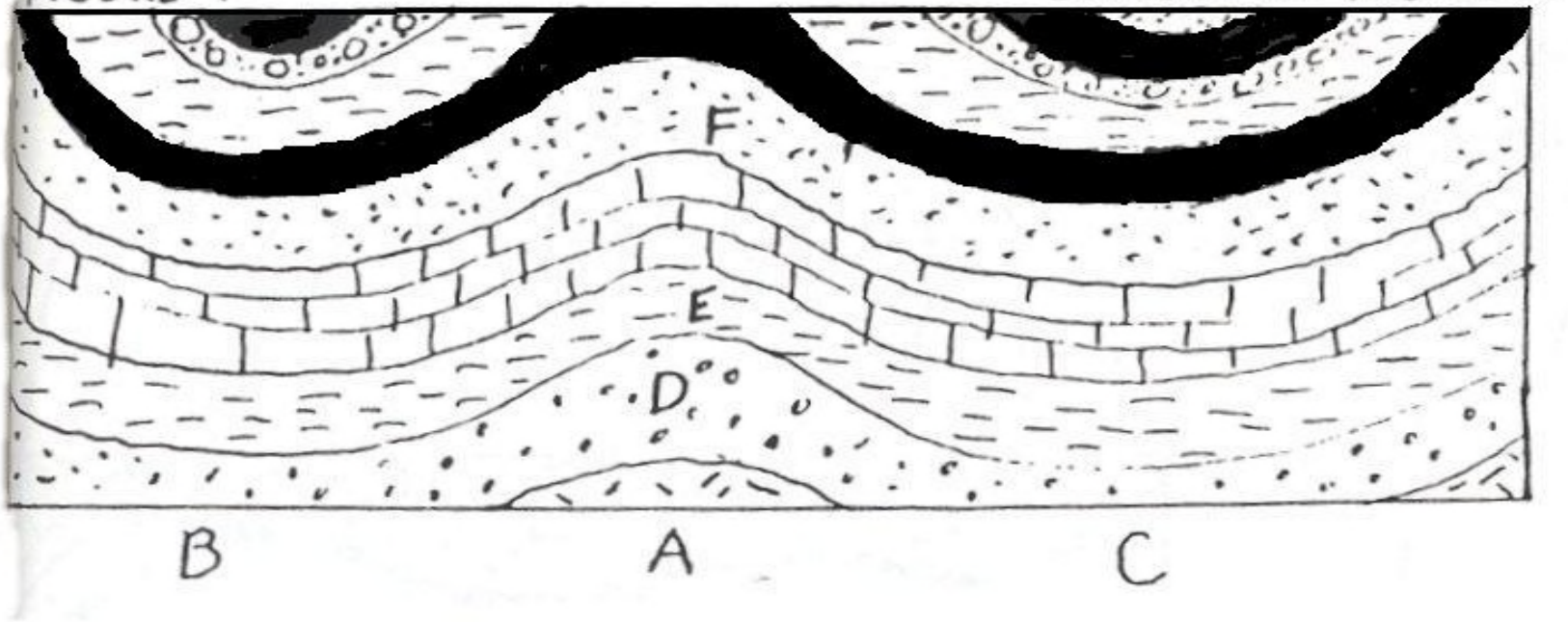
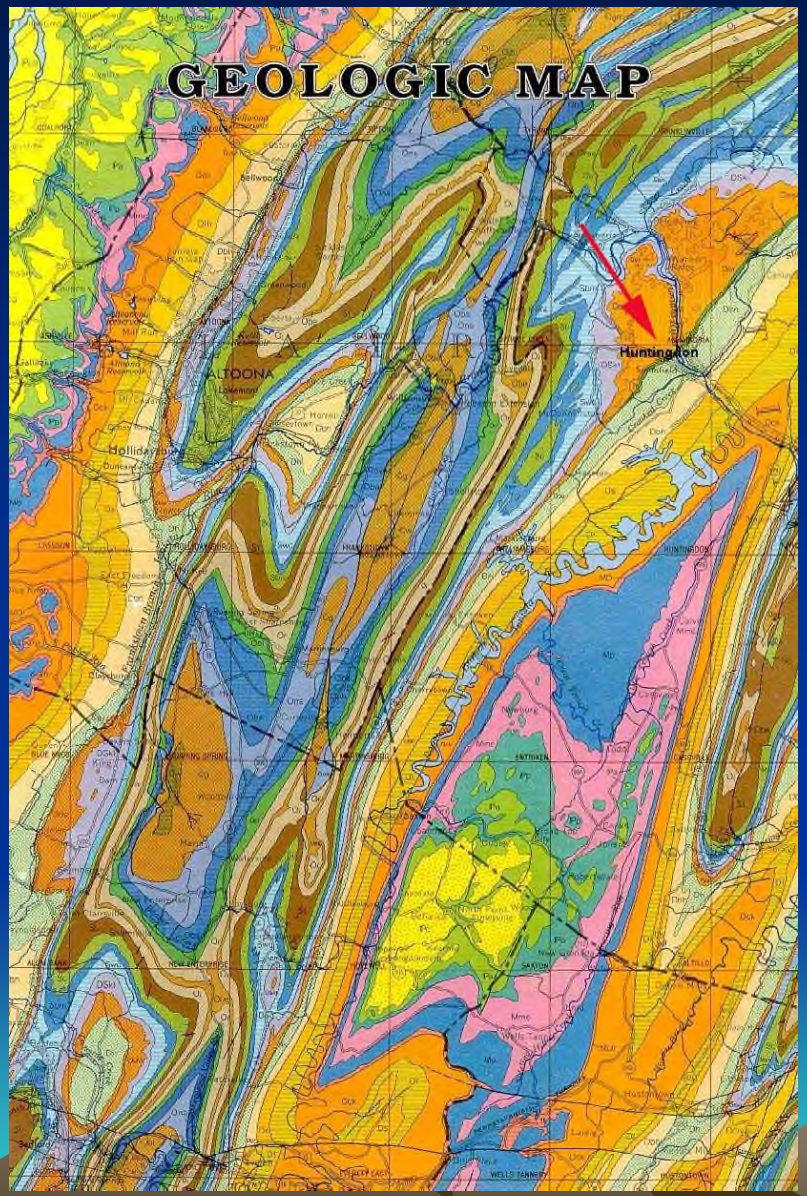


Figure 2

FIGURE 1



Geologic Maps = Science + Art



Union County Geology

The map below is a scan from the Geologic Map of Pennsylvania (1980) focusing on Union County. The location of Bucknell University is represented by the green circle located along the eastern portion of the map. Descriptions for the rock types have been modified from the original map to more accurately describe the geology of the Union County area (from mapping by Dr. Richard P. Nickelsen, Bucknell University).

EXPLANATION FOR THE ROCK TYPES IN THE LEWISBURG AREA

Dh Hamilton Group
Gray, brown and olive shale, siltstone; marine fossils; char. by coarsening upward cycles. Black carbonaceous shale with Tioga Bentonite at base.

Doo Onondaga and Old Port Formations
Gray calcareous shale; argillaceous limestone; marine fossils. Dark gray chert interbedded with calcareous shale and limestone; very fossiliferous.

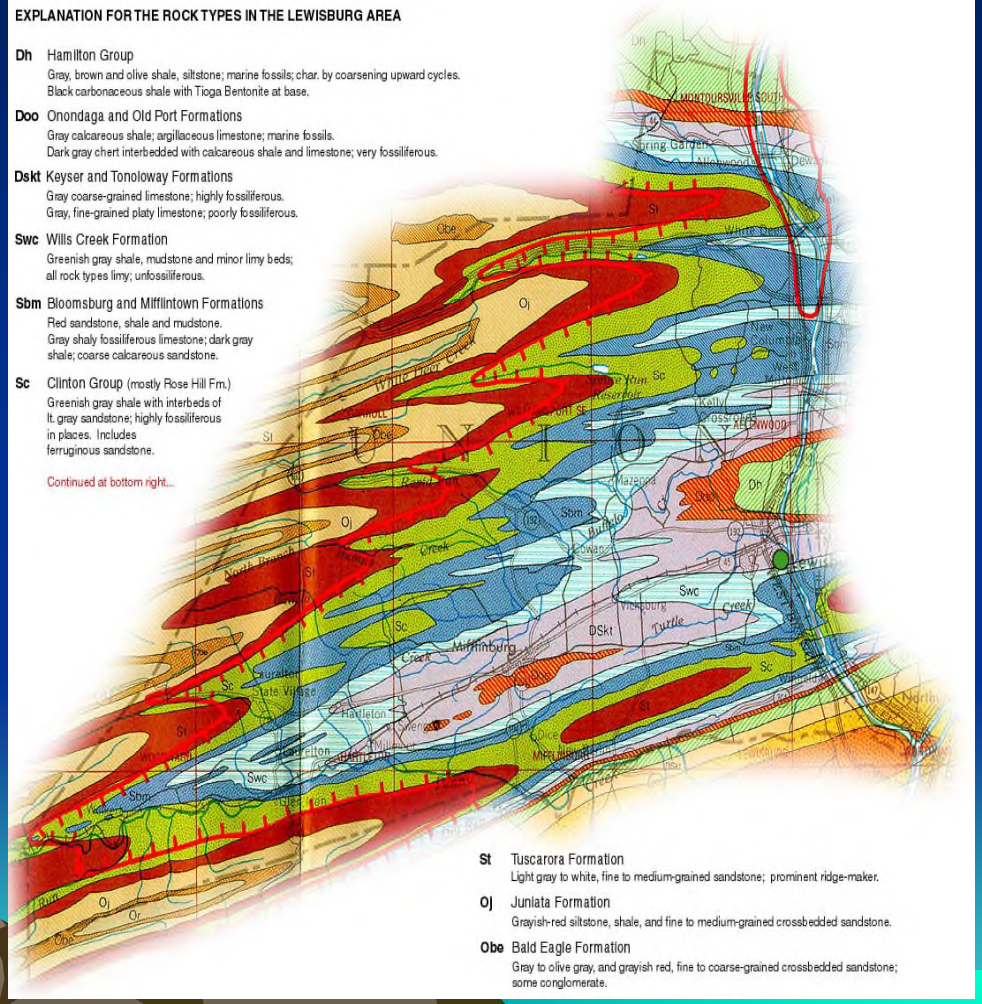
Dskt Keyser and Tonoloway Formations
Gray coarse-grained limestone; highly fossiliferous. Gray, fine-grained platy limestone; poorly fossiliferous.

Swc Wills Creek Formation
Greenish gray shale, mudstone and minor limy beds; all rock types limy; unfossiliferous.

Sbm Bloomsburg and Mifflintown Formations
Red sandstone, shale and mudstone. Gray shaly fossiliferous limestone; dark gray shale; coarse calcareous sandstone.

Sc Clinton Group (mostly Rose Hill Fm.)
Greenish gray shale with interbeds of lt. gray sandstone; highly fossiliferous in places. Includes ferruginous sandstone.

Continued at bottom right...



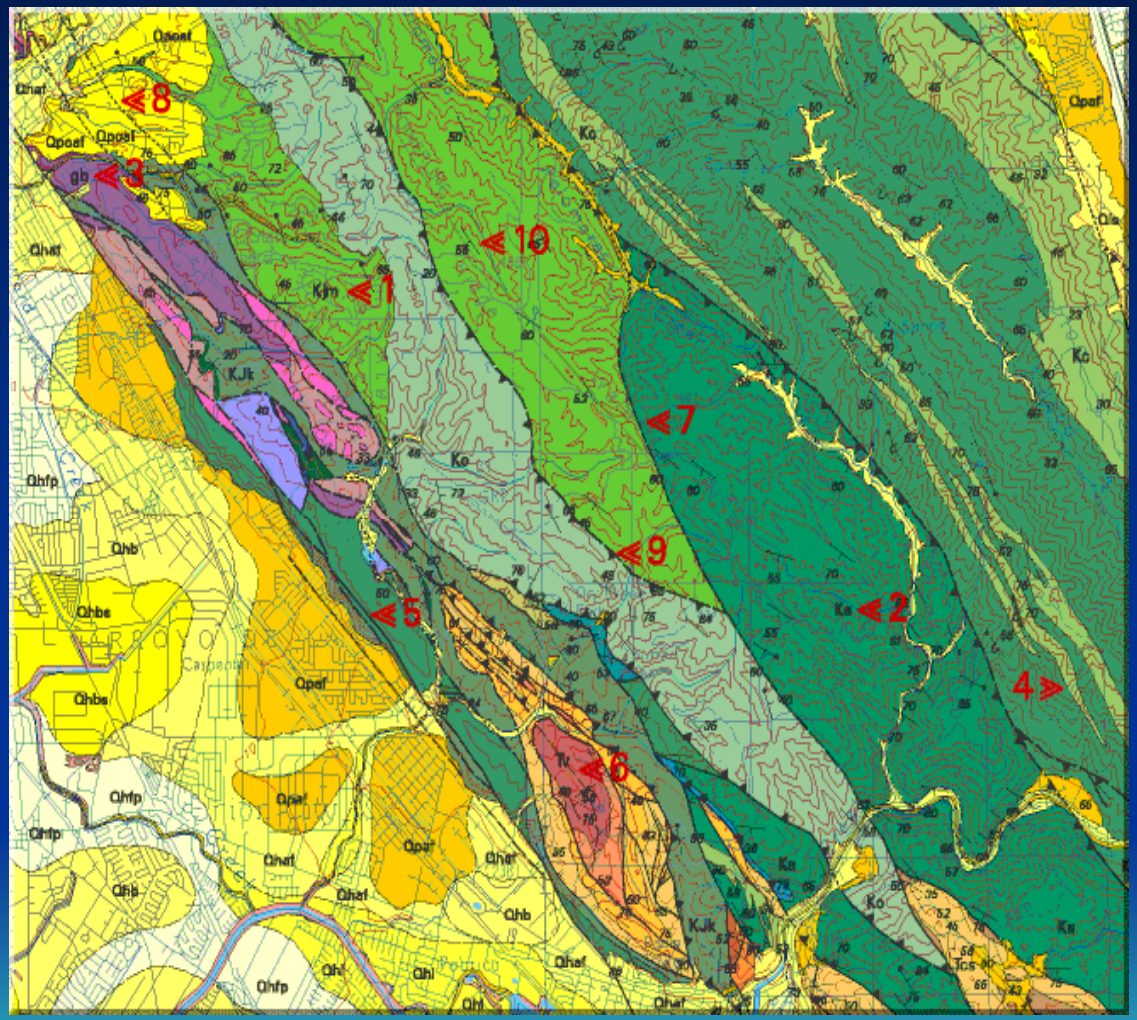
St Tuscarora Formation
Light gray to white, fine to medium-grained sandstone; prominent ridge-maker.

Oj Juniata Formation
Grayish-red siltstone, shale, and fine to medium-grained crossbedded sandstone.

Obe Bald Eagle Formation
Gray to olive gray, and grayish red, fine to coarse-grained crossbedded sandstone; some conglomerate.

What is a Geology Map

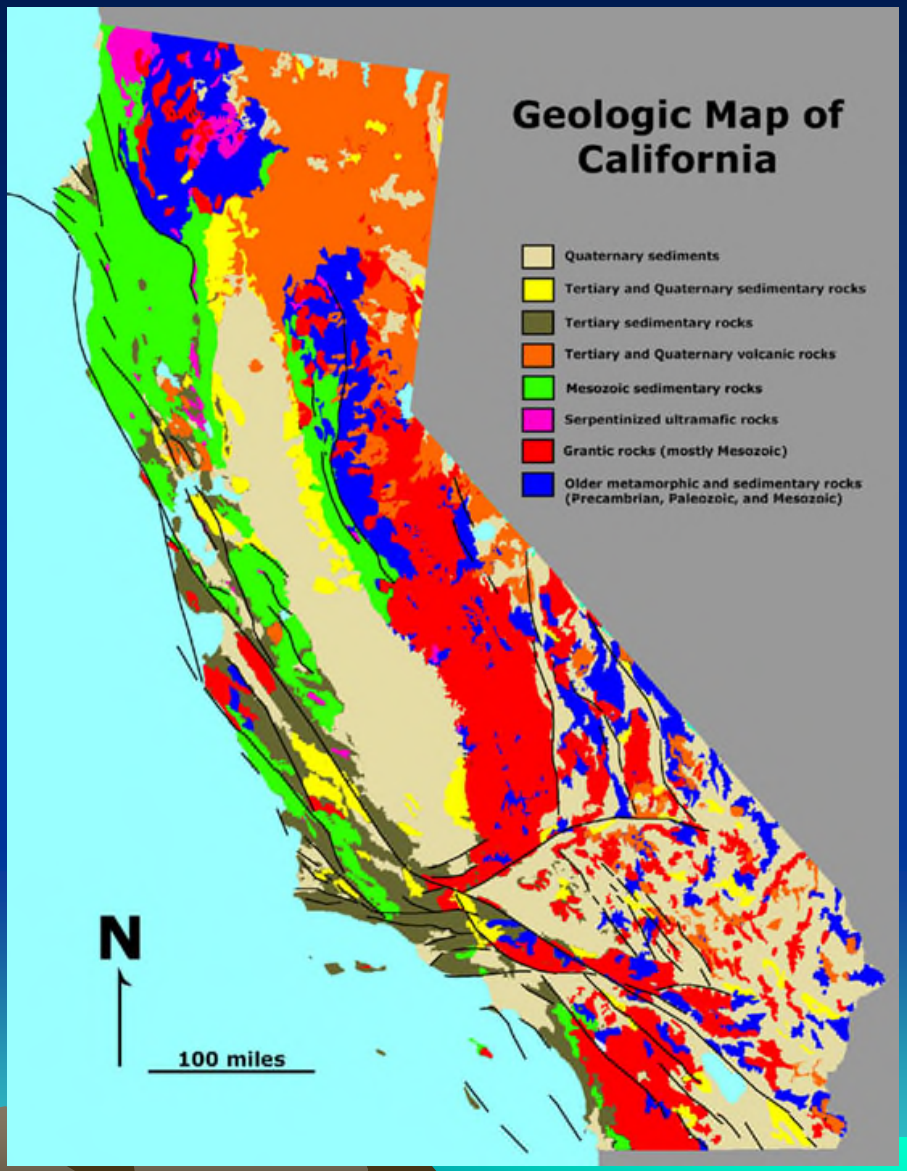
1) A map that displays the types of rocks and sediment exposed at the surface
2) Displays the spatial orientation of rock units and rock structures like folds and faults.
3) Geology information is typically overlain on a topographic base map



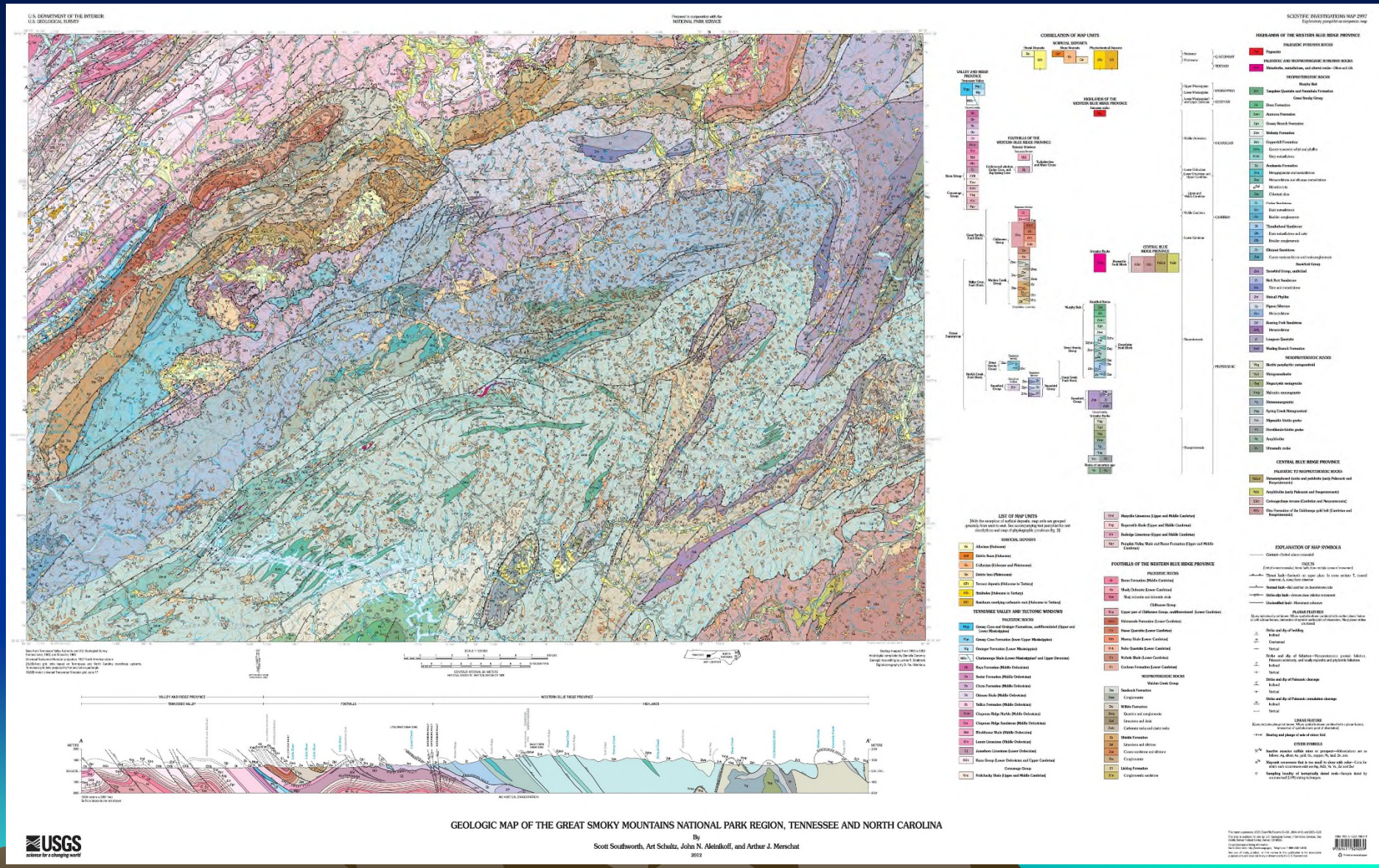
Usefulness of Geology Maps

1) Geology maps have many vital uses:
   - ✓ Mineral Prospecting
   - ✓ Engineering
   - ✓ Earthquakes
   - ✓ Historical geology
   - ✓ Landform studies
   - ✓ Soil development
   - ✓ Biological studies

2) Geology maps are even useful when buying a home. Why?

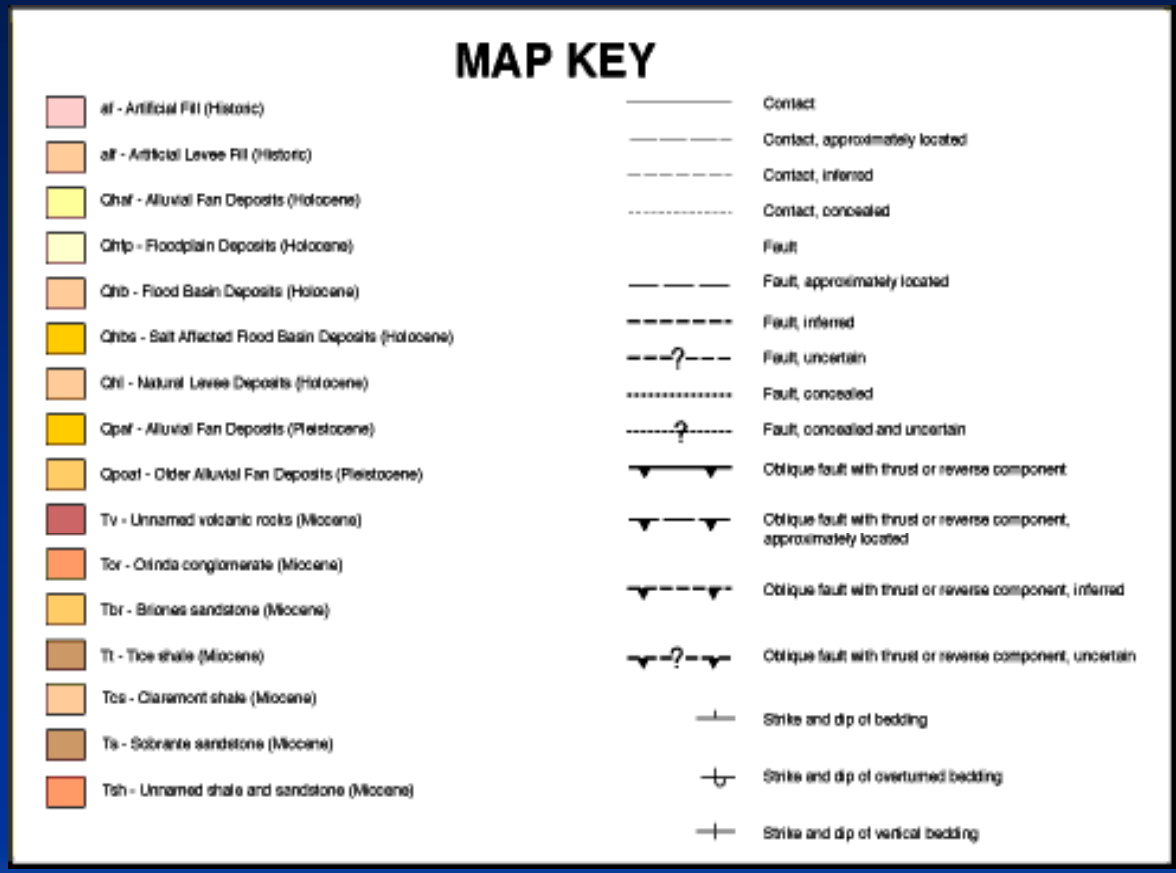


Geology Map of the Smokey Mtns



Geology Map Key or Legend

1) The map key lists and explains the geologic rock formations and the structural symbols
   - ✓ Rock Names
   - ✓ Rock Types
   - ✓ Rock Ages
   - ✓ Contacts
   - ✓ Strike and Dip
   - ✓ Faults and Folds

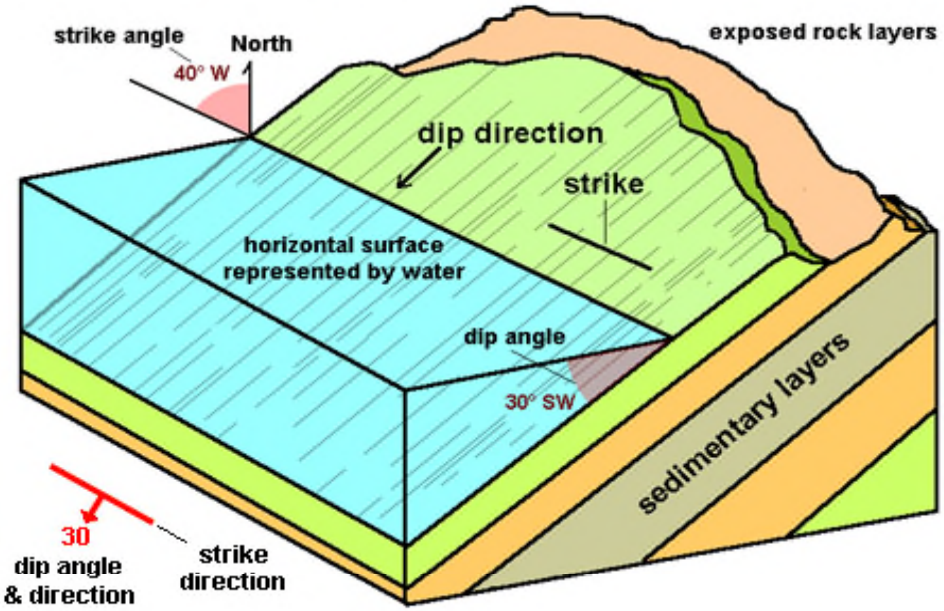


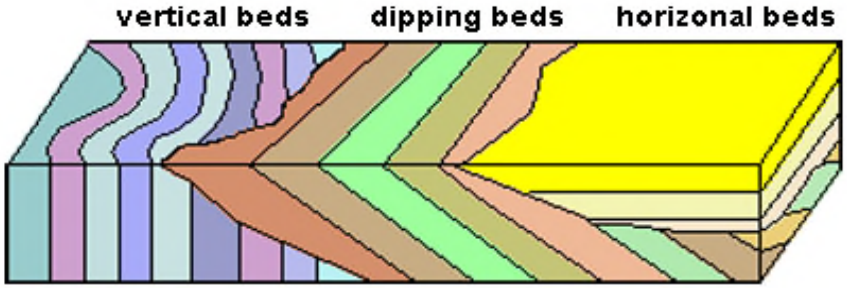
2) Each rock unit has a unique letter symbol and is color-coded

3) Map key is vital to understanding the accompanying geology map

Common Geologic Map Symbols

Describing orientation of geologic features with strike and dip

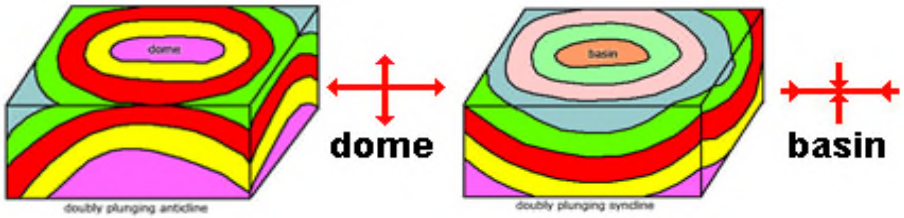




beds inclined straight up

36 strata inclined at an angle

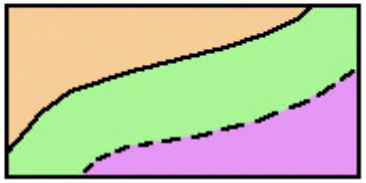
flat-lying strata

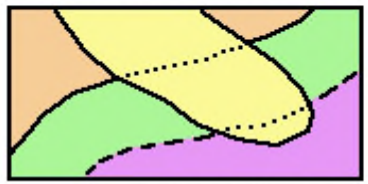


dome

basin

Rock Unit Boundaries - contacts between rock units of different agea and/or different composition





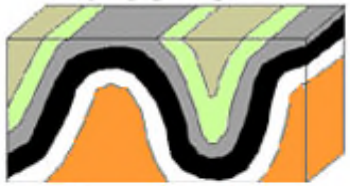
——— contact certain

- - - - - - contact inferred

····· contacts inferred beneath sedimentary cover

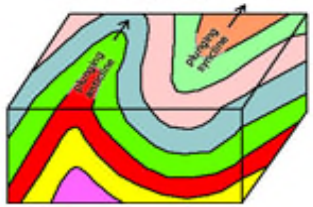
FOLDS

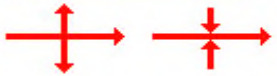
anticline syncline



anticline syncline

plunging folds





plunging anticline

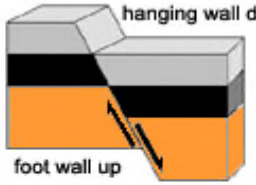
plunging syncline

monocline

arrow points in fold dip direction

FAULTS

normal fault

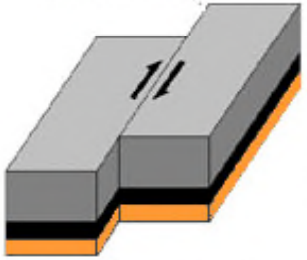


U

D

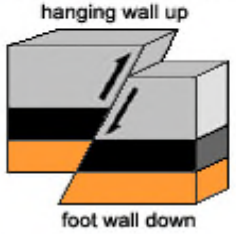
U is on the uplifted side (foot wall)
D is on the down-dropped side (hanging wall)

strike-slip fault



half arrows show direction of fault motion

reverse fault



triangles on upper plate (hanging wall)

thrust fault

triangles on upper plate

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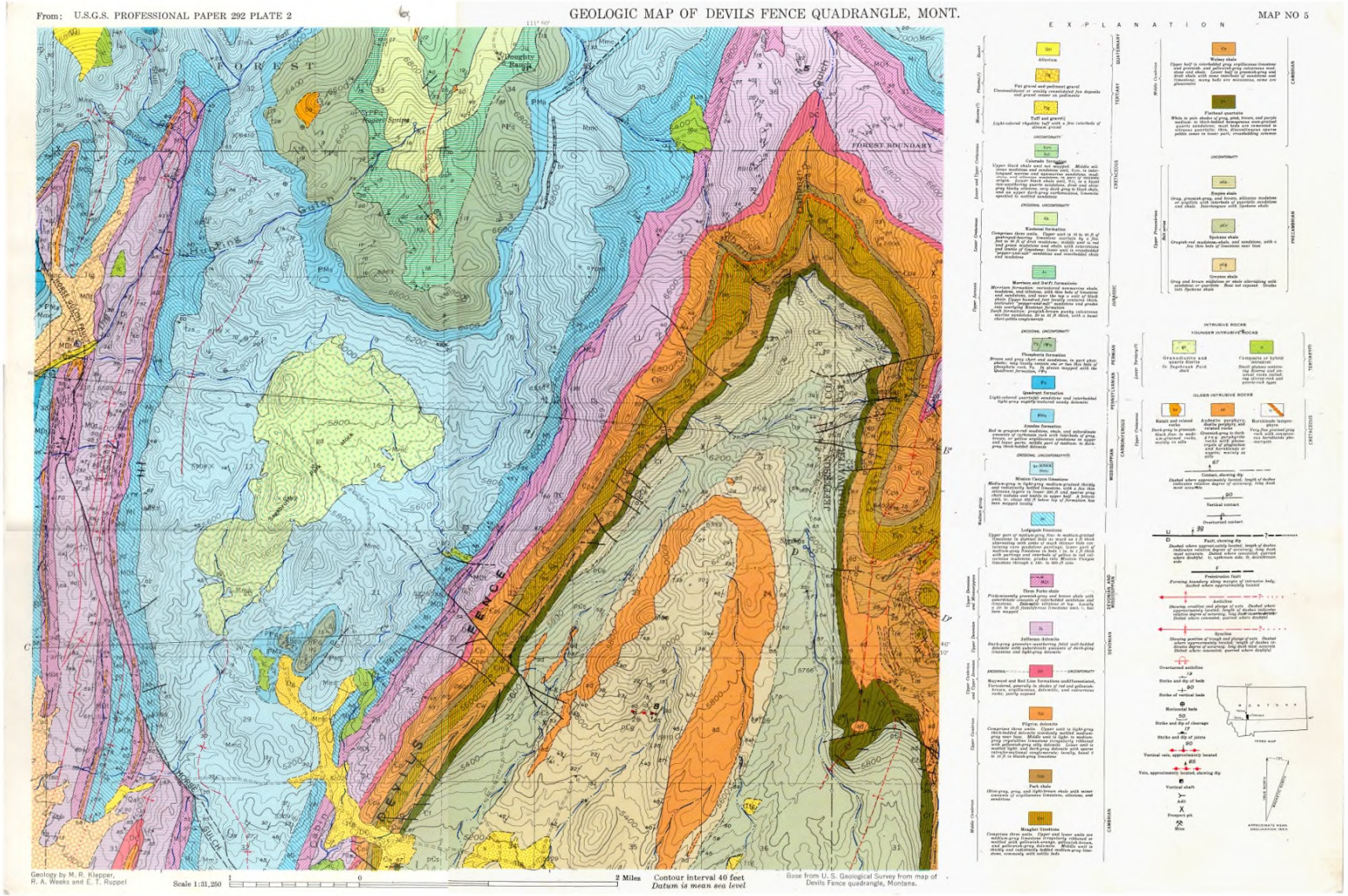
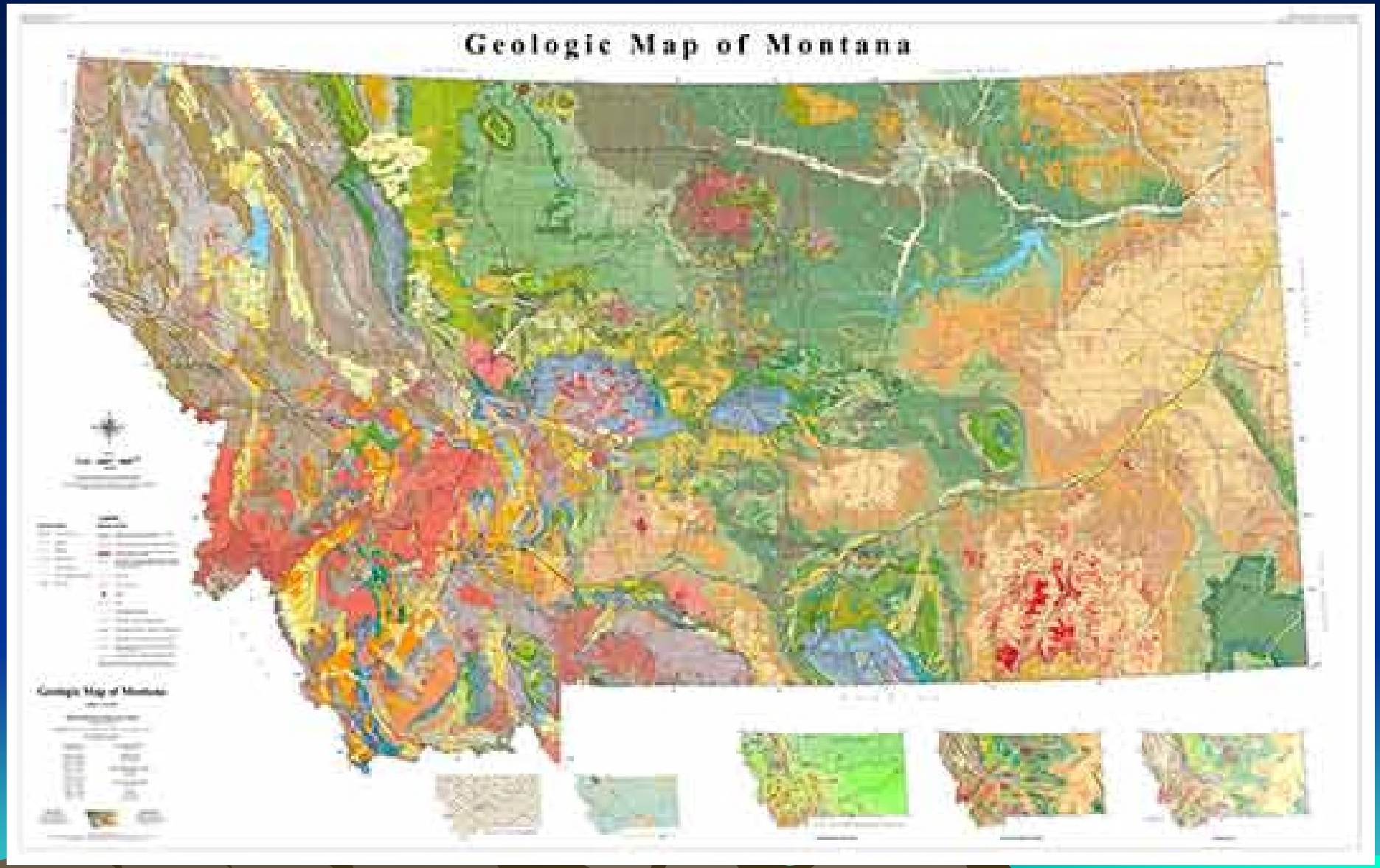
Geologic Maps – Devil's Fence Quad



Geologic Map of Montana



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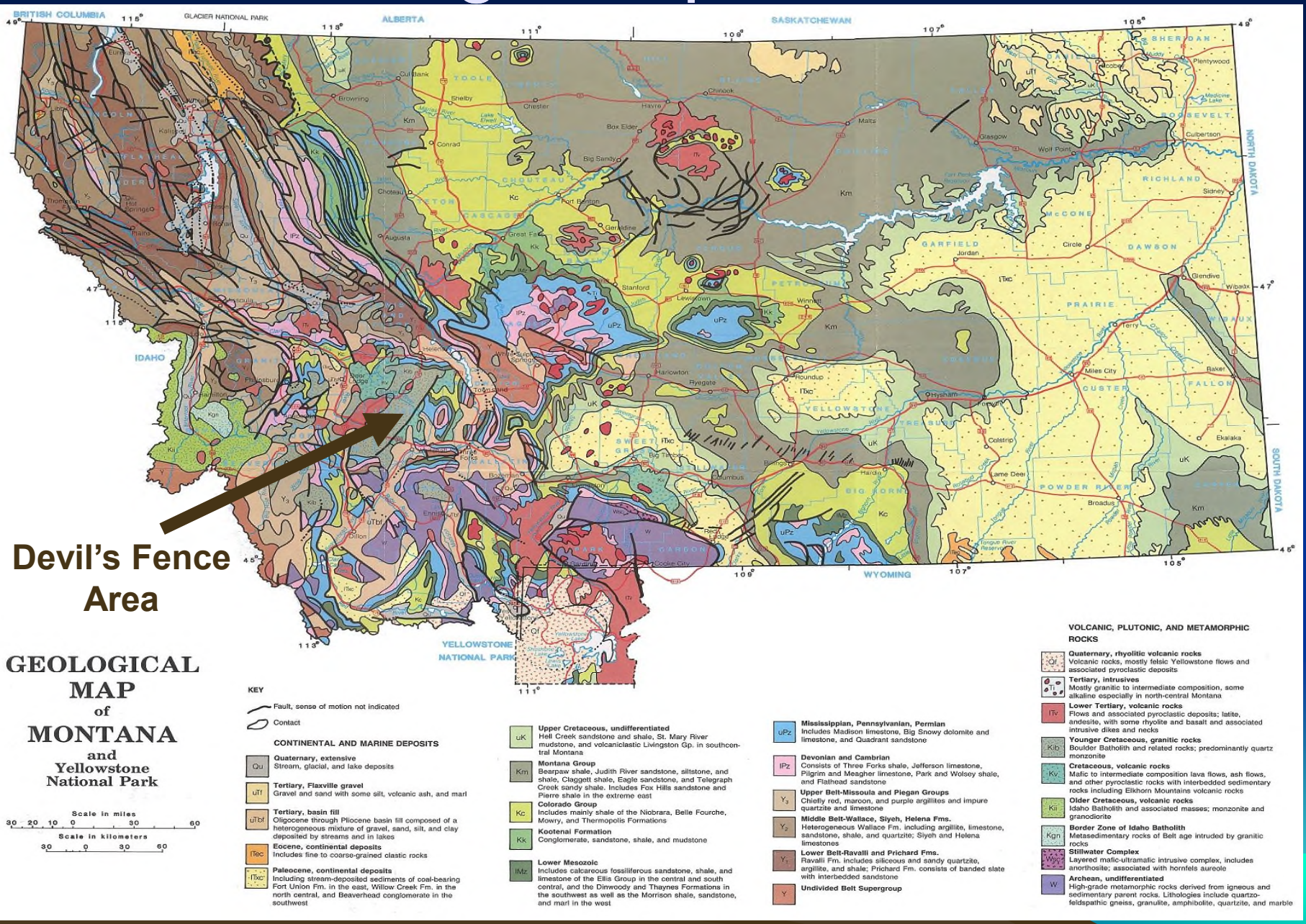

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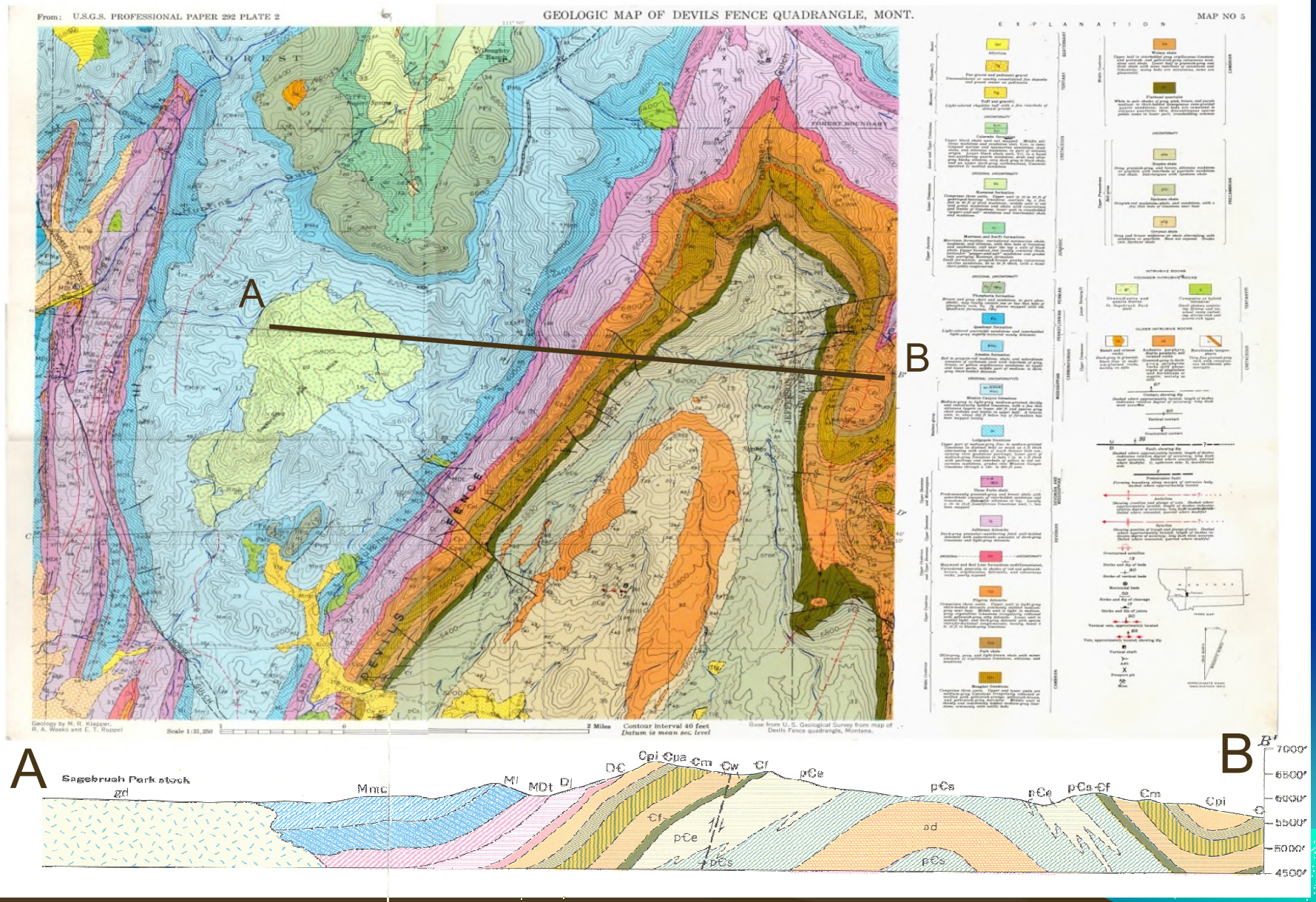
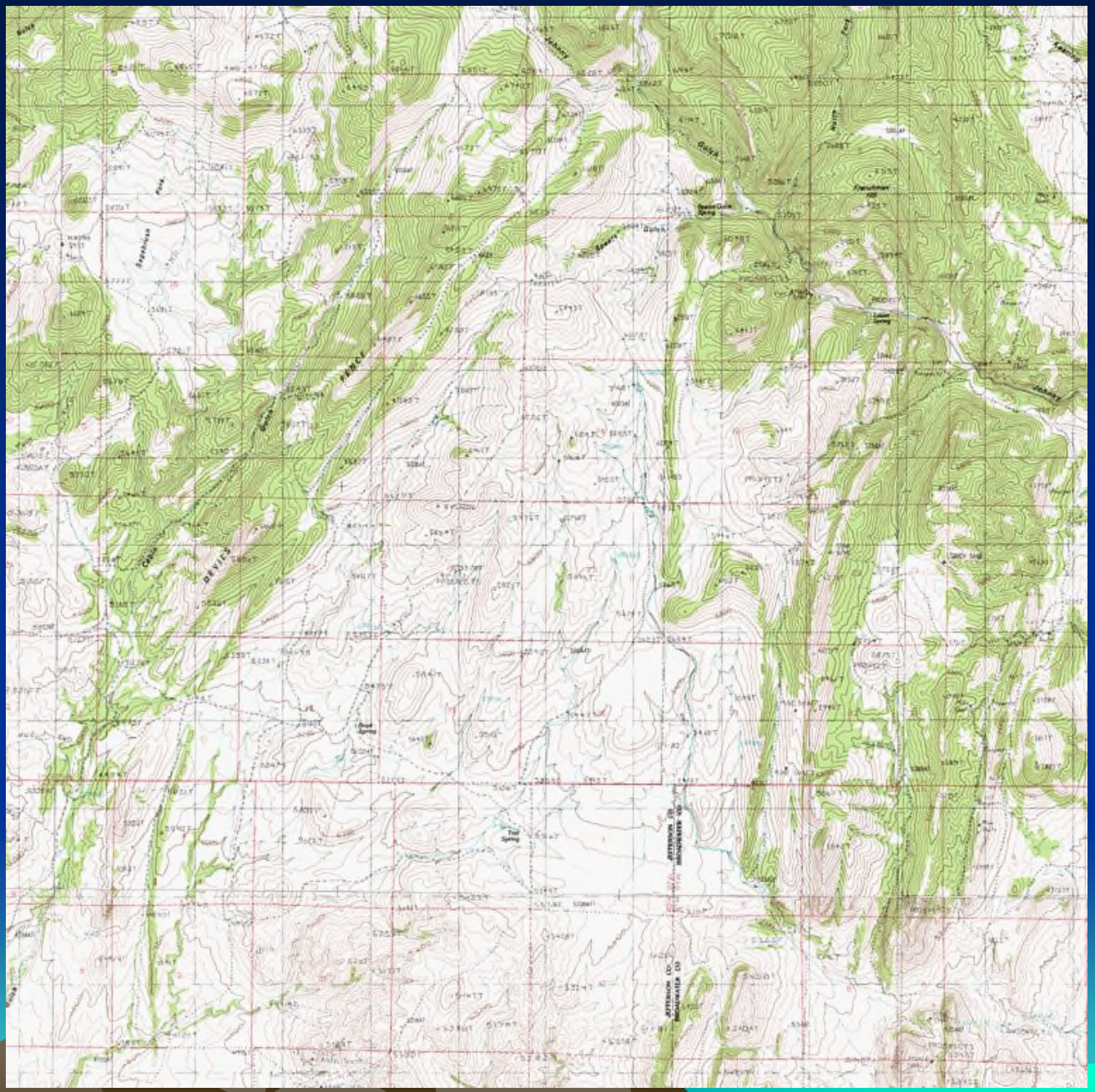
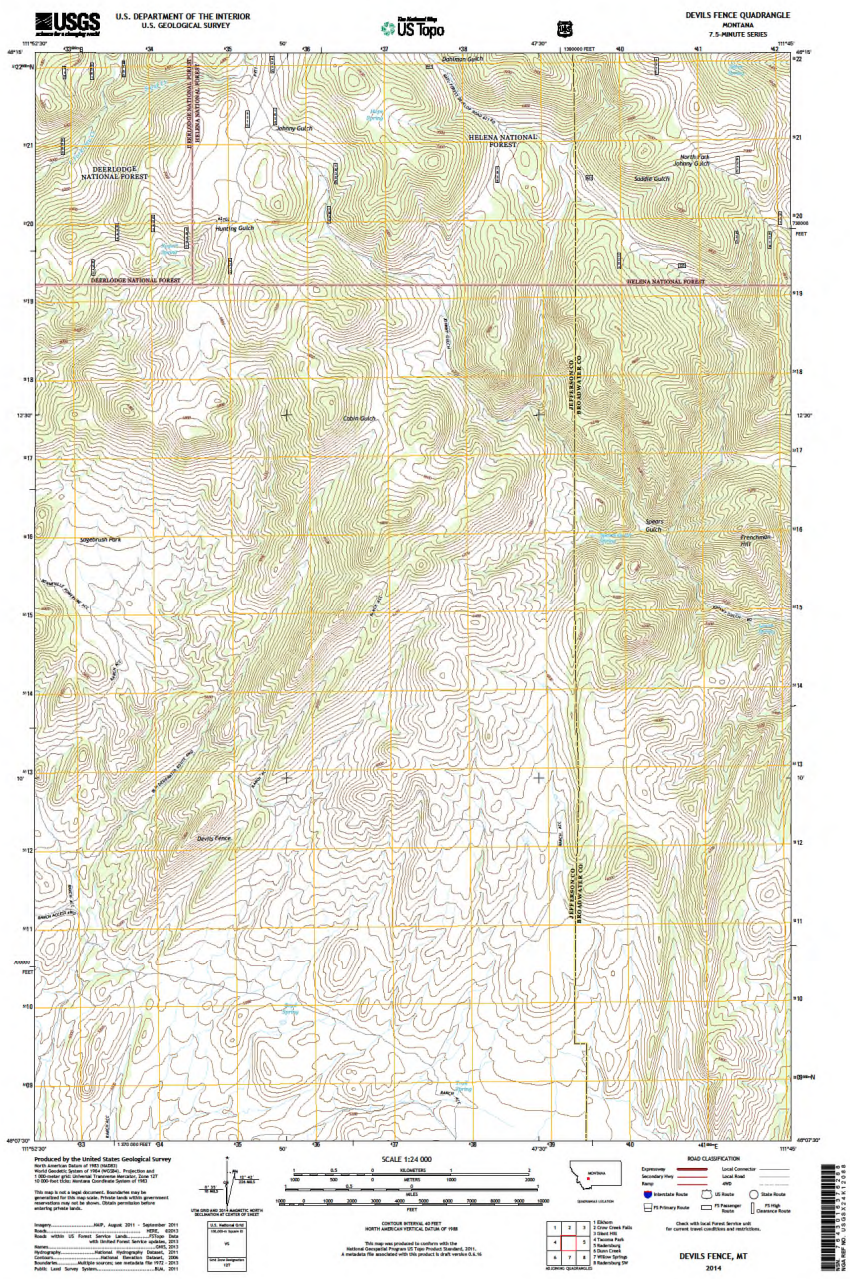


Devil's Fence Topo Quad

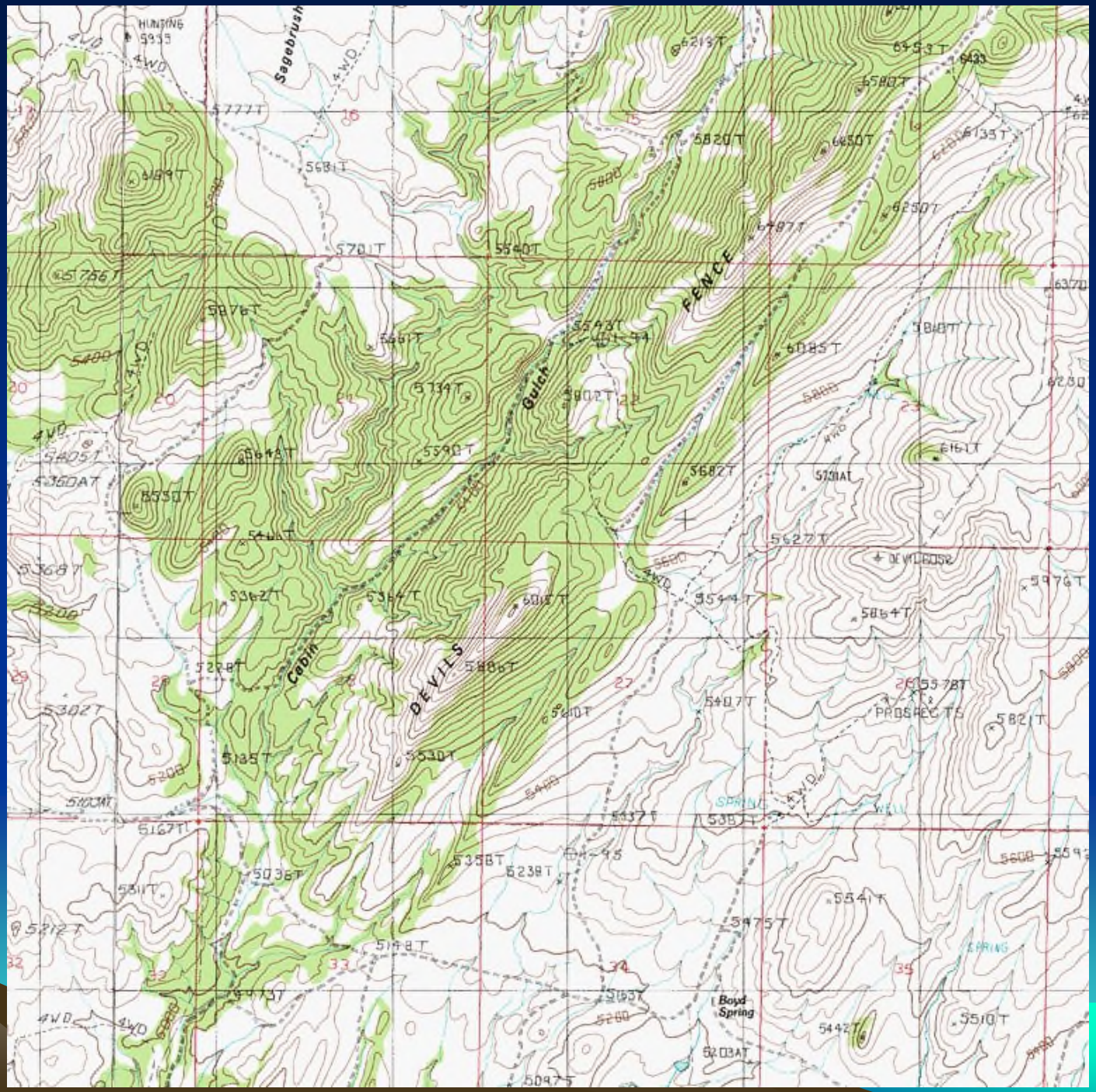


Topo Map of Devils Fence Quad, MT

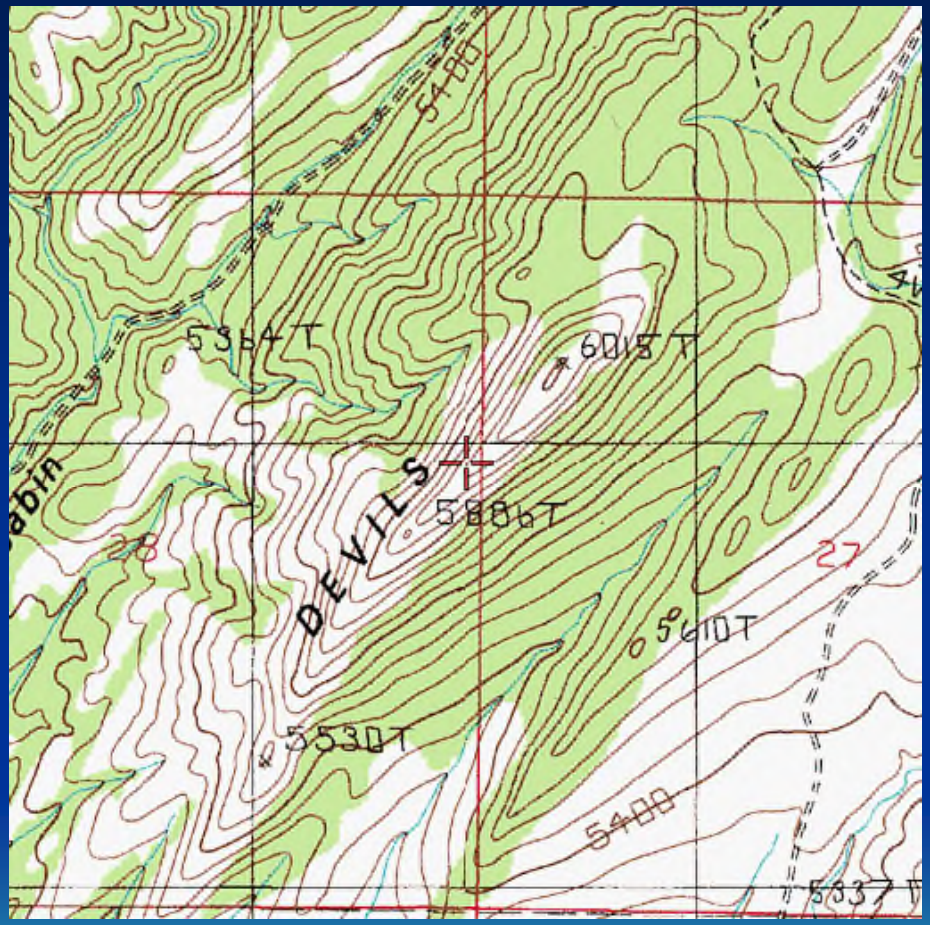


Devil's Fence Topographic Feature

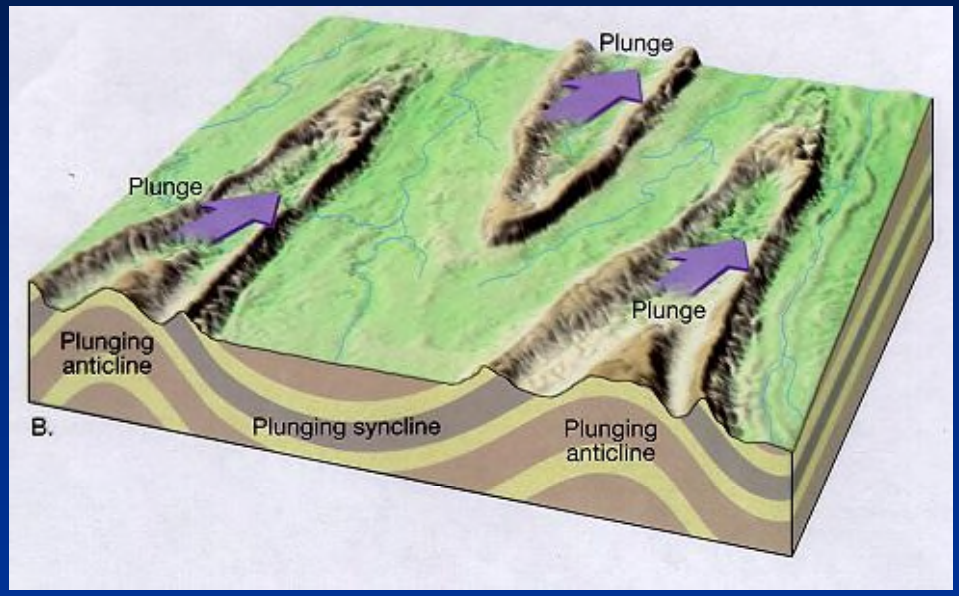
Devil's "Fence" Topo Feature

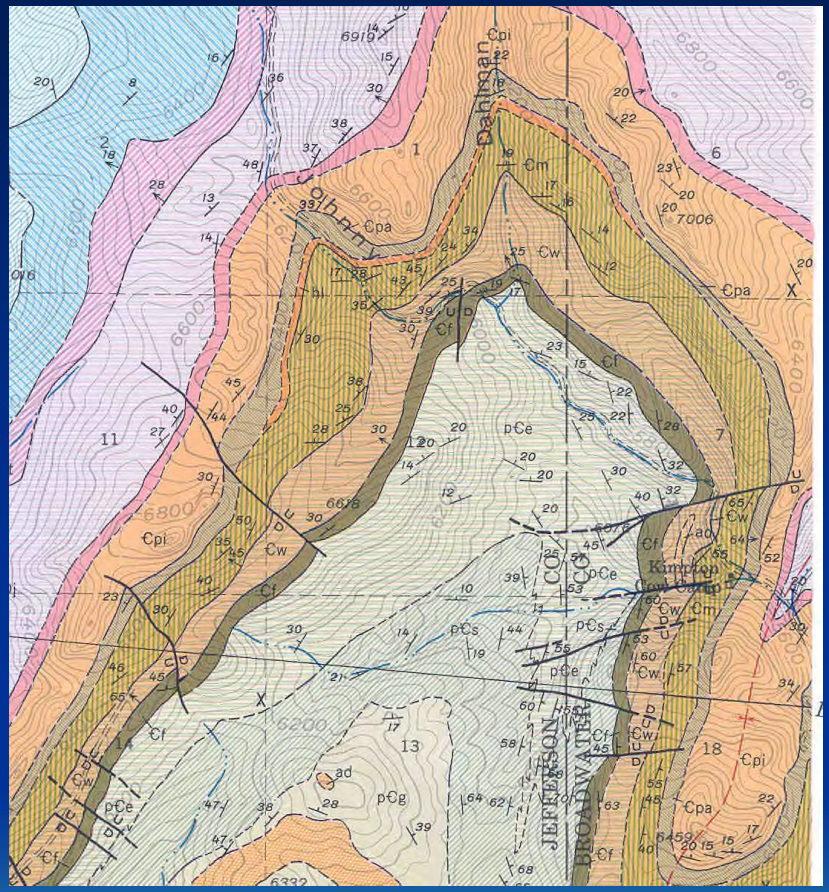


Devil's Fence Topography

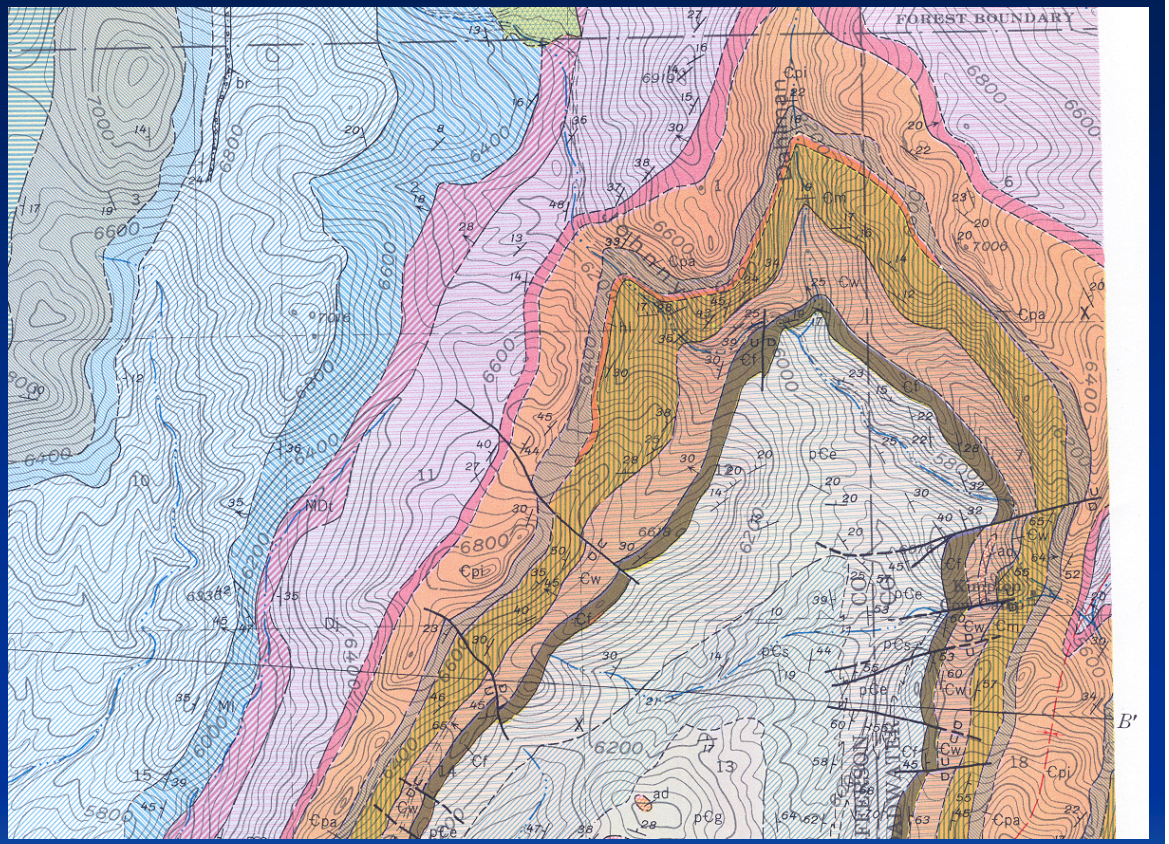


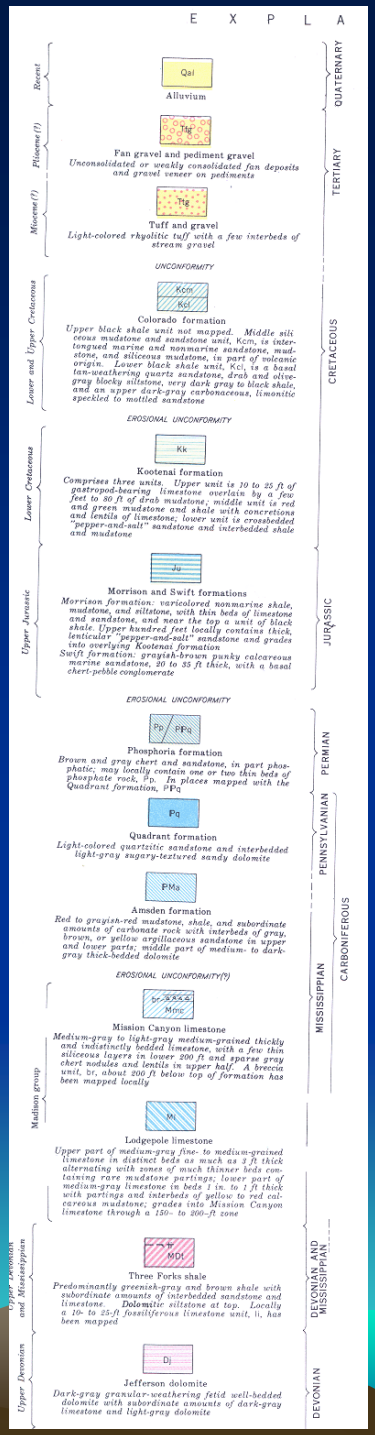
Devil's Fence Folds

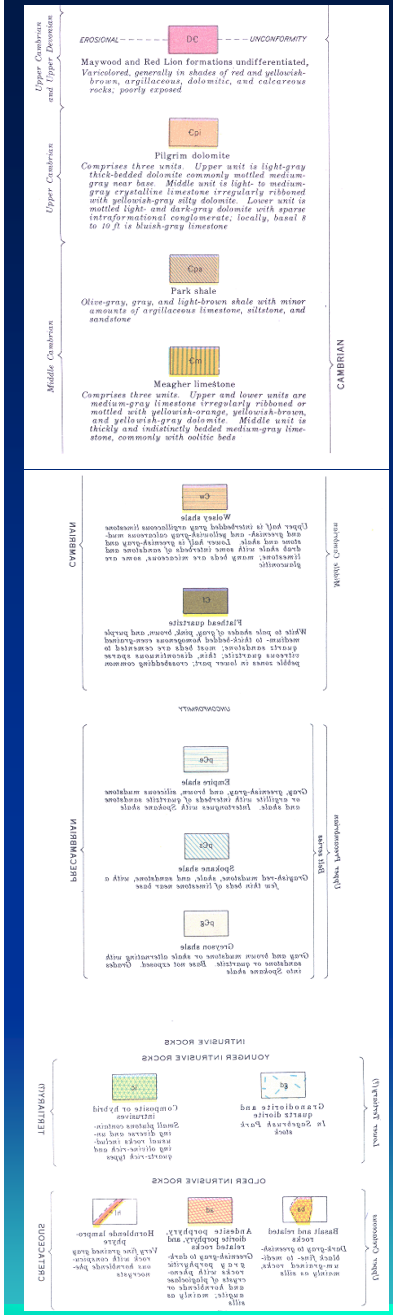




Devil's Fence Geology Map with Explanation







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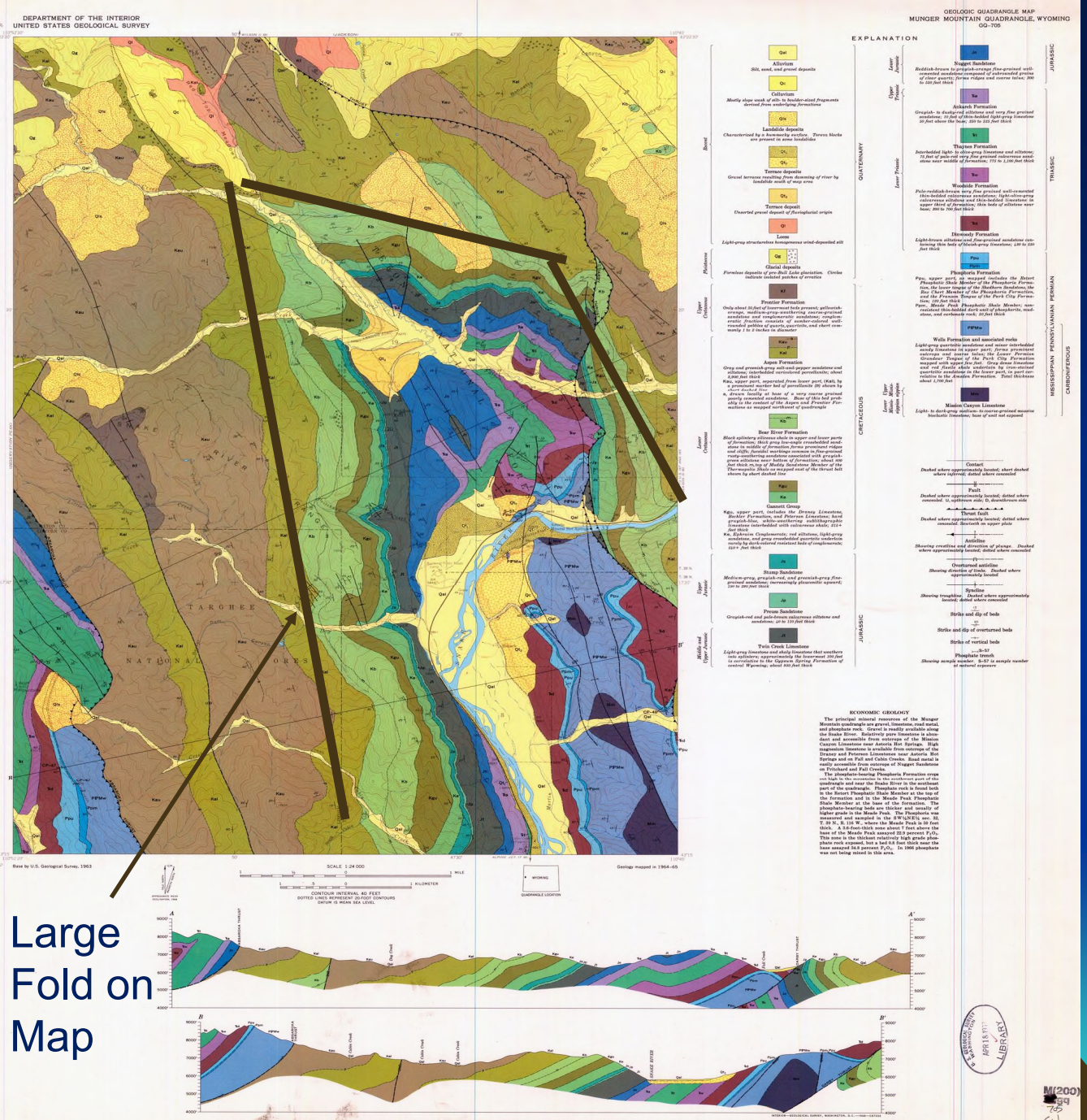
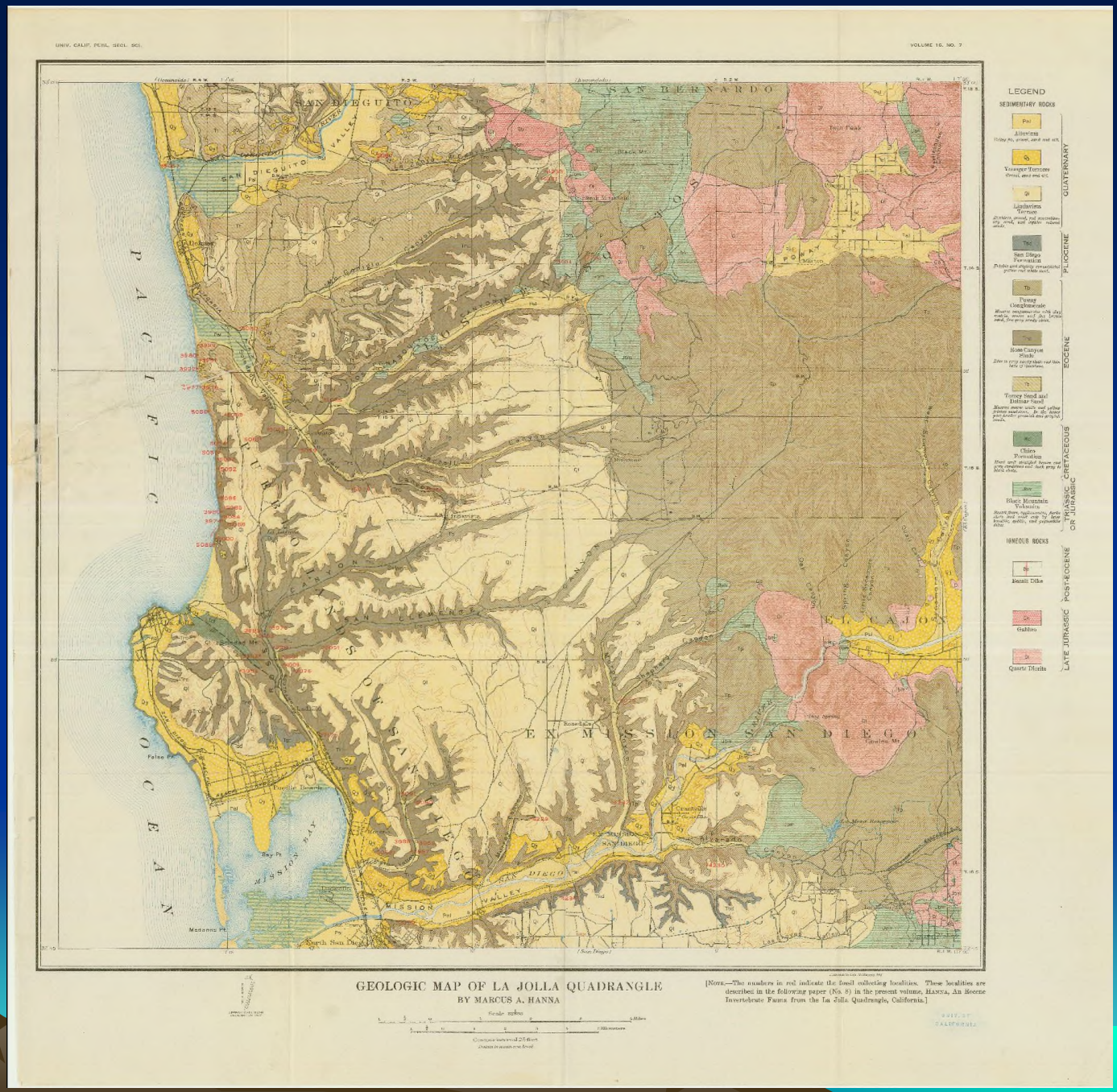
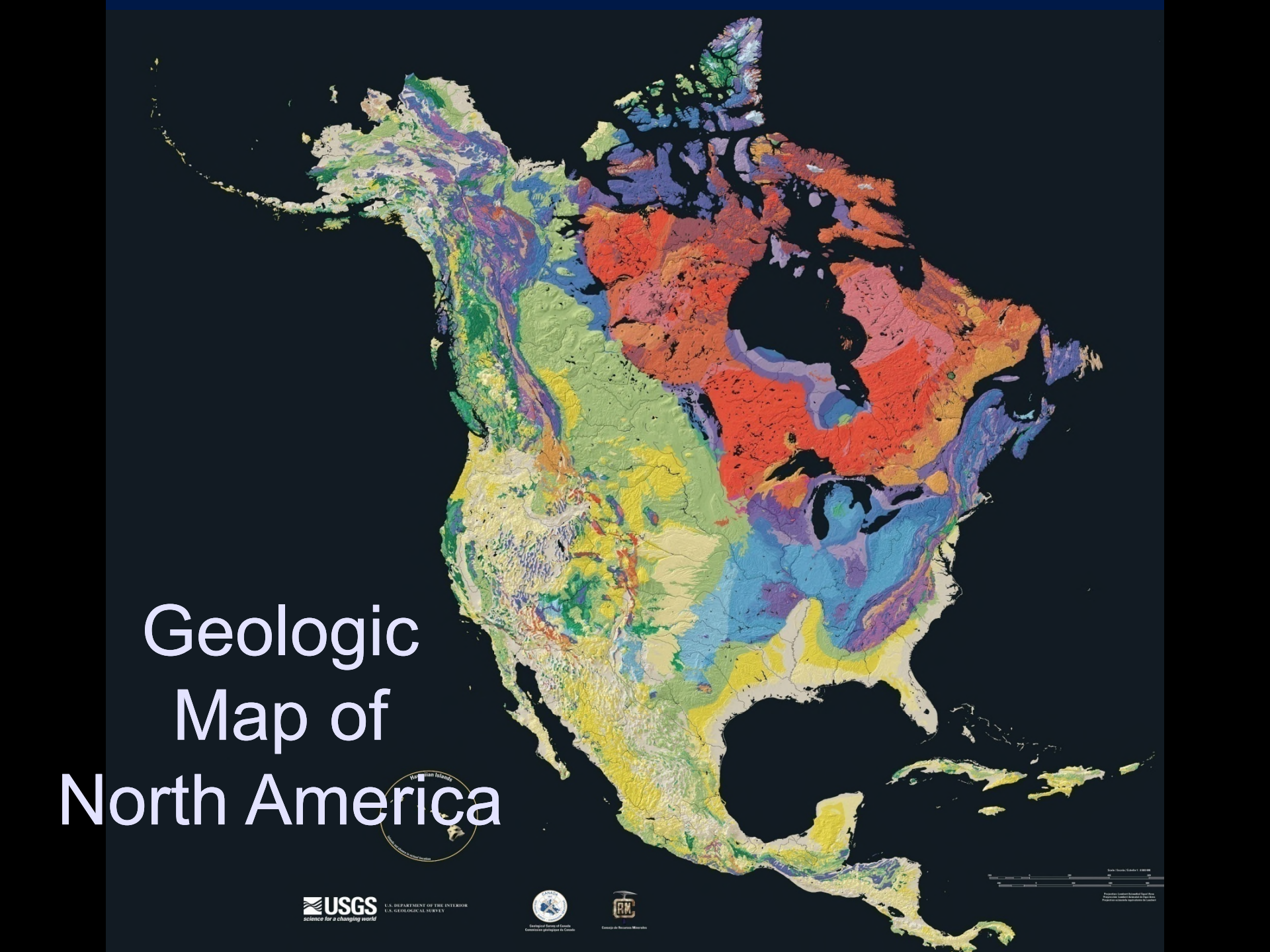


Mungar Mountain Geology Map

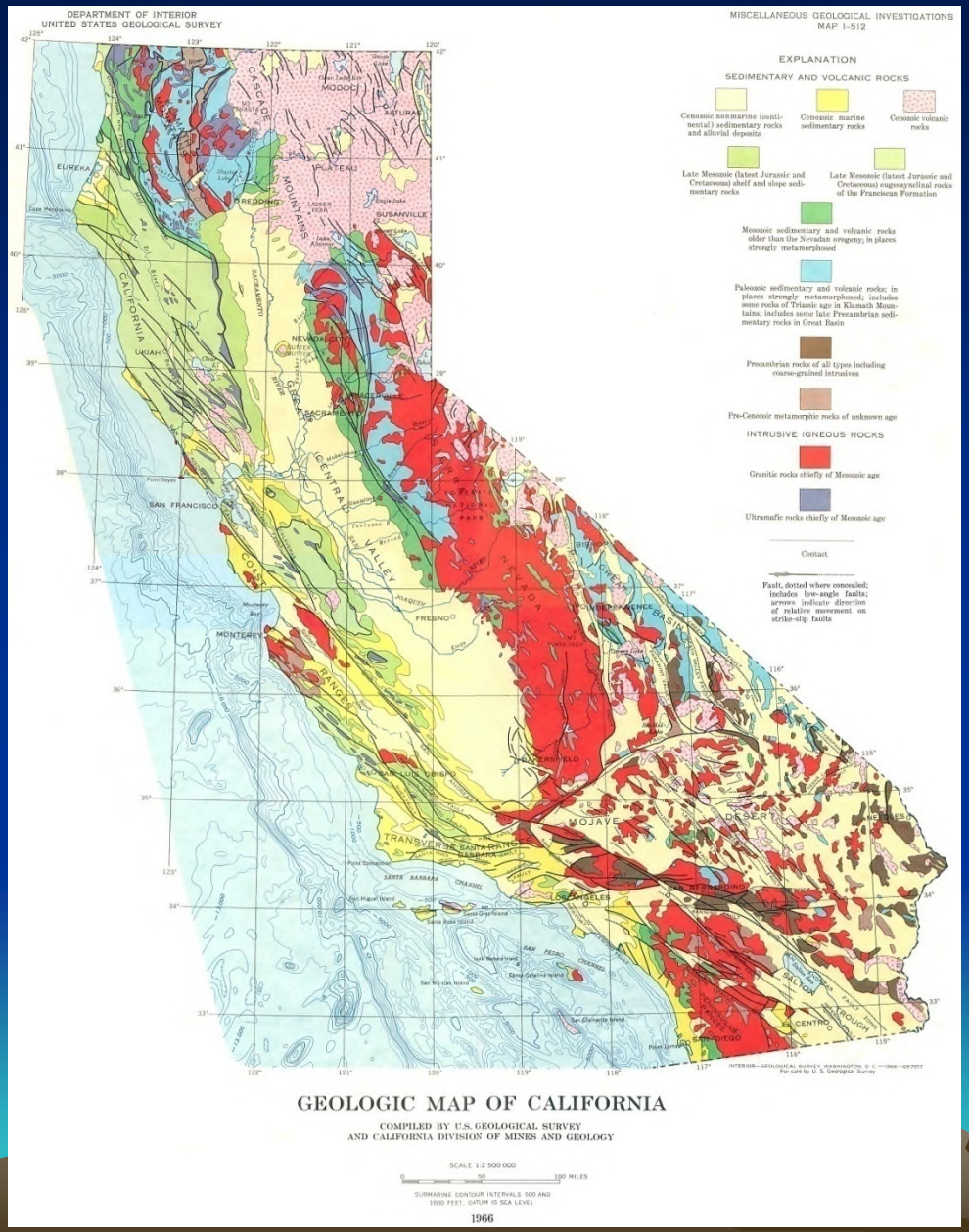
Large Fold on Map

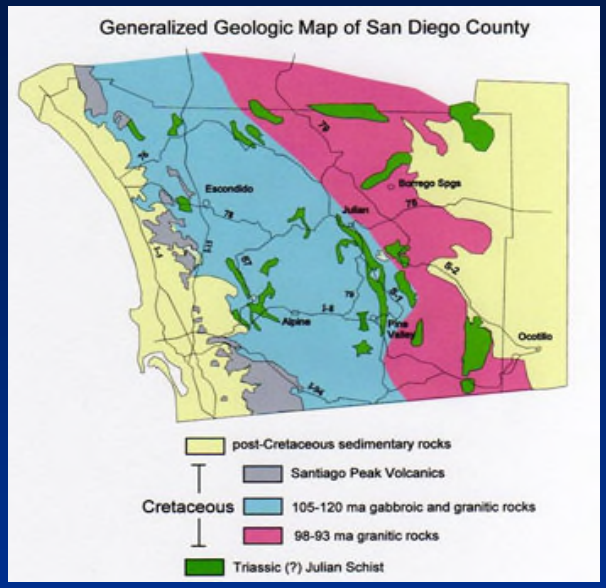
Geology Map La Jolla Quad

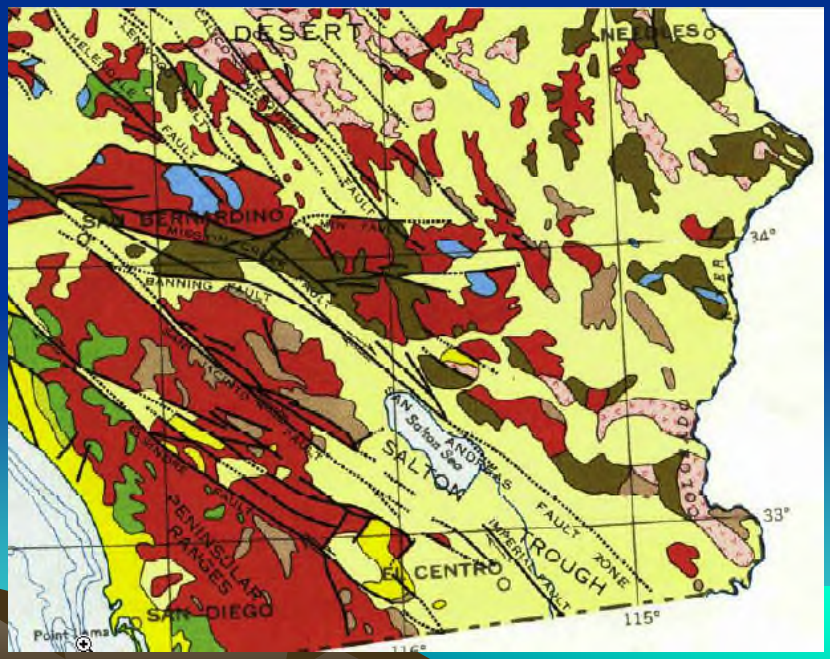



Geologic
Map of
North America
USGS
science for a changing world
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Geologic Maps of California







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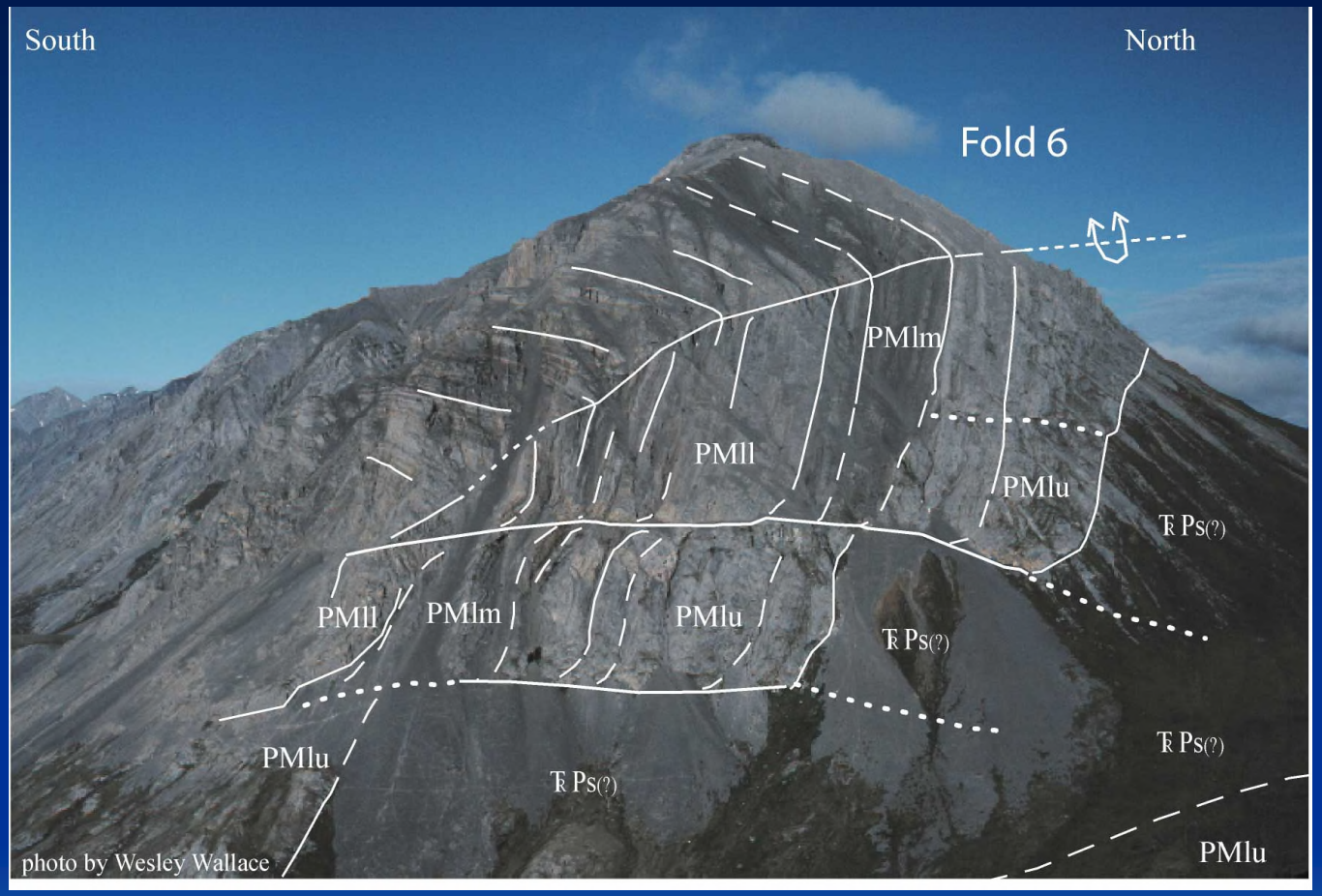
13) Slickenside grooves oriented vertical in fault scarp indicate dip-slip offset.

Structure Web References



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http://www.globalchange.umich.edu/Ben/ES/earthstructure.htm

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