A SPECIAL PLACE!

We are in a special place!

THEME
This is a unique location where across very short distances there is evidence of:
- vast amounts of geologic time
- multiple geologic processes

How does this happen?
1. We are at a significant physical boundary
   — physiographic provinces
   — rock types
   — geologic history and processes
2. Mountain building has left us with unique physical features

North America

Physiographic Boundary
Mountains
Plains

[Map of North America showing physiographic boundaries]
Physiographic Boundaries

Rock type boundaries
Plains rocks (sedimentary) meet
Mountain rocks (igneous, metamorphic)

Other boundaries
Biological
— grasslands meet forests
Historical/Cultural
— mining meets farming
— urban meets rural

Natural Areas and boundaries
Mountain side—Gateway
Straddle—Bobcat, Pineridge, Coyote Ridge,
Plains—the rest
ROCKS

—Mountain rocks
—Plains rocks

Mountain Rock Types

Igneous rocks—from molten source deep within mantle
Metamorphic—any type changed by heat, pressure, fluids

Igneous Rocks

Extrusive = volcanos → lava, ash, pumice onto surface
Intrusive = batholiths, stocks cool & harden underground exposed on surface by erosion

Volcanos
Lava
Pahoehoe
Aa

Volcanic ash/pumice

Extrusive Igneous Rocks
Lava
Ash
S. Table Mt.
Soapstone

Intrusive Igneous
West of us are huge areas of intrusive igneous = granite
1.4 billion years old

Granite
cooled slowly underground
large crystals
Metamorphic rocks = any original transformed by heat, pressure, hot fluids
Typical metamorphic = gneiss (granite transformed)

Closest mountain rocks west of Fort Collins = mostly metamorphic
Approx. 1.7 billion years old

Identifying metamorphic
Can be difficult because:
— often same composition as igneous—they are just altered versions of original rock
Distinguishing metamorphic from igneous
Metamorphic rocks often have:
— minerals arranged in bands
— bands may be wavy
— often veins cutting across other types
— varying degrees of alteration

Granite

Gneiss

Banded Gneiss

Gateway Augen Gneiss

Foliated Metamorphic

Vein
Big Thompson
Metamorphics

Plains Rock Type
Sedimentary

Sedimentary Rocks
Material:
— worn off somewhere else,
— carried by water and wind,
— settles out in layers
— cemented together
Oldest on bottom = closest to mts.

Sedimentation

Sedimentary Rocks
Sandstones – sand, in layers
sorted by grain size
Conglomerates – sand and pebbles
mix of several sizes
Shales – layers of mud, layers often thin
very fine particles

Identifying Sedimentary rocks
— Layers parallel to each other
— Usually break along these bedding planes → (flagstones)
— Often fine grained
GEOLOGIC HISTORY

Ancestral Rockies
Rose above sea ca. 300 million ybp about where the current mountains are
One of two large islands
Frontrangia
Uncompahgria

Sandstone
Conglomerate
Shale
**FOUNTAIN FORMATION**

Ancstral Rockies shed materials
— 280 million ago
— average thickness 800 ft
— mostly conglomerate
— varying hardness
— lying on metamorphic rocks
more than 1 billion years older

**Ancestral Rockies**

**Fountain Conglomerate**

**Boulder Flatirons**

**Red Rocks**

**Roxborough Park**
Fountain Formation
Bobcat Ridge

LYONS FORMATION
260 million years ago
—climate very dry (Pangaea)
—sand dunes
—fine grained sandstone,
—well cemented, resistant
—economically important

Lyons Sandstone

LYKINS FORMATION
250 million years ago
—only low hills
—muddy, slimy, hot salt flats
—limestone and mudstone
—easily eroded (soil covered)
—first reptiles
—followed by Permian extinction

Lykins Formation
**MORRISON FORMATION**
150 million years ago
— age of dinosaurs
— area very flat (mountains gone)
— sediments ca. 400 ft. thick

**Morrison Formation**

**DAKOTA GROUP**
100 million years ago
— sandy coast of shallow sea
— sediments from mts in W. Utah
  beach sands, thin muds
— plant fossils & dinosaur prints
— very resistant to erosion

**Dakota Group**
ca 100 million yrs bp

**Dakota near Red Rocks**

**Dakota group**
Dakota (South Platte Formation)

Ripples-South Platte

Dakota (Lytle Formation) Devil’s Backbone

NIOBRARA FORMATION
85 million years ago
— marine origin
— shale and chalk
— abundant small fossils
— endemic plants (*Physaria bellii*)

Niobrara

PIERRE FORMATION
70 million yrs ago
— Colorado mostly under water
— muddy sediments more than 1 mile thick
— the rock beneath Fort Collins
— rarely exposed (soil covered)
Pierre Shale

PRESENT MOUNTAINS
Laramide Orogeny

Laramide Orogeny
70 to 40 million ago current Rockies rose in series of pulses (3rd or 4th set of mts here)
…. probably still rising

Plate push from west

Laramide Orogeny
During and after mountain building:
1. two major periods of volcanic activity
2. magmatic intrusions and metamorphism
3. faulting and folding
Colorado Mineral Belt

Magmatic intrusions created veins altered rocks and deposited ores

Mountain erosion

As mountains rose, they were being worn away → source of huge volume of sediments = sedimentary rocks of Plains

Sedimentary Rocks

10,000-15,000 thousand feet of sediments east of mountains

We are on those sediments here

Relative Sediment Depths

(Total = ca 14,000 ft)
Folding and Faulting

Forces that lifted Rockies caused surrounding sediments to bend and break.

Folding = bending rock layers
Faulting = breaking and moving rock layers

Folding anticlines and synclines
product of compressional forces

Types of Folds

Anticline — up
Syncline — down

Prior to orogeny

sedimentary deposition in shallow sea

mountain core
Anticlinal mountain uplift

Anticlinal uplift accompanied by synclinal downwarp east of mountains

Synclinal downwarp Denver Basin

Denver Basin

Hogbacks

Erosion has left “hogbacks” (steeply tilted sedimentary layers)
resistant beds → hogback ridges
less resistant → valleys between ridges

These are unique features

Sediment eroded away
Exposing time

By turning beds up, the surface across them exposes hundred’s of millions of years of time in a very short distance.
Adapted from Braddock et. al. Geologic Map of the Horsetooth Quadrangle

Pineridge

Coyote Ridge

Bobcat Ridge

Bobcat Ridge

Red Mountain Soapstone

Landscape reversal
Soapstone-Red Mountain Ranch

Faulting breaking & moving

Faults
1. Tensional forces
   Normal fault
2. Compressional forces
   Reverse fault

Faults produced by:
3. Shear forces
   Strike-slip fault

Looking down from above

Larimer County has its faults!
LANDFORMS SCULPTED BY WATER
Landform demolition

Demolition
Demolition can be concurrent with landform creation
Demolition has two components:
1. weathering
2. erosion

Weathering
Before rocks can be removed they need to be broken up by weathering
—mechanical
—chemical

Cracks in Granite

Frost Wedging

(a) (b)
Highly Fractured Granite

Root wedging

Unloading/Exfoliation

Chemical Weathering
Breaks down minerals within the rock

Spheroidal Weathering

Weathering of granite
Gruss

Erosion

Agents of erosion:
1. gravity = mass wasting
2. flowing water
3. ice = glaciers
4. wind

Water

— Flowing water = greatest landscape remodeler
— Streams are highly tuned and balanced systems using energy to move materials

Flowing water’s passion:
— Plane landscape off to sea level
— Carry everything off to sea

Mass wasting → talus

Erosion starts with raindrops
Raindrop impact

Work of streams
- Ability of a stream to remove depends on:
  — Volume  (how much water)
  — Velocity  (how fast it is moving)
- These vary constantly
- Stream constantly adjusts its load to match its energy

Streams both:
— Remove material = Erosion
— Deposit material = Deposition

These occur:
— In different parts of stream
— Same part at different times

Streams work by:
1. Power of current - push, roll
2. Abrasion - rub smooth
3. Corrosion - chemically dissolve

Power of the current

Lawn Lake Flood
Streambed Abrasion

Streams move things

Valley Shape reveals stream energy

down-cutting (high energy)  
depositing (low energy)

Valley Shape

Eroding stream = cutting down
—steep gradient
—“straight” course
—steep valley sides

‘V’ shaped valley

Steep Gradient/High Energy
**Deposition**

- lower gradient (less energy)
- cutting sideways and depositing
- meandering stream course
- low sides and broad valley

**Lower Gradient** (less energy)

- Widening Valley

**Valley Widening**
Change in Stream Regime

Streams can go from net eroding to net depositing or vice versa in hours and over millenia

Causes of change

—Land moves up or down
—Sea levels fall or rise
—Climate changes precipitation amounts

Stream Rejuvenation

Long pauses in mountain uplift changed streams from downcutting to widening
Renewed uplift changed streams to downcutting again
Stream Rejuvenation
— our streams have been rejuvenated
  ie. increased their downcutting
  several times
— rejuvenation often leaves
  - terraces
  - broad erosional surfaces

Stream Rejuvenation

Stream Terraces

McKnight & Hess, *Physical Geography*

Stream Terraces

Caucasus Mountains

Gregory, *The Lie of the Land*

Erosional Surfaces

Rejuvenated Big Thompson

Flooding
Floods = natural stream behavior
area flooded = floodplain
Flooding:
— flushes deposits downstream
— brings new soil
— may renew some vegetation
— damages man-made things
Floodplains and floods

Talk about them in intervals
eg. “100 yr floodplain” (made by
“100 yr flood”
does NOT mean will flood every 100 yrs, but the probability is of a flood
of that size once every 100 yrs

Power of water!

THE ROCK SOLID
END