A SPECIAL PLACE !

NEBRASKA
SEDGWICK
PHILLIPS
WELD
WASHINGTON
KIT CARSON
ALAMOSA
OKLAHOMA
NEW MEXICO

We are in a special place!

THEME :

This is a unique location where we can see more evidence of geologic time and geologic process than is possible almost anywhere else in North America or in the world.

Why is this so?

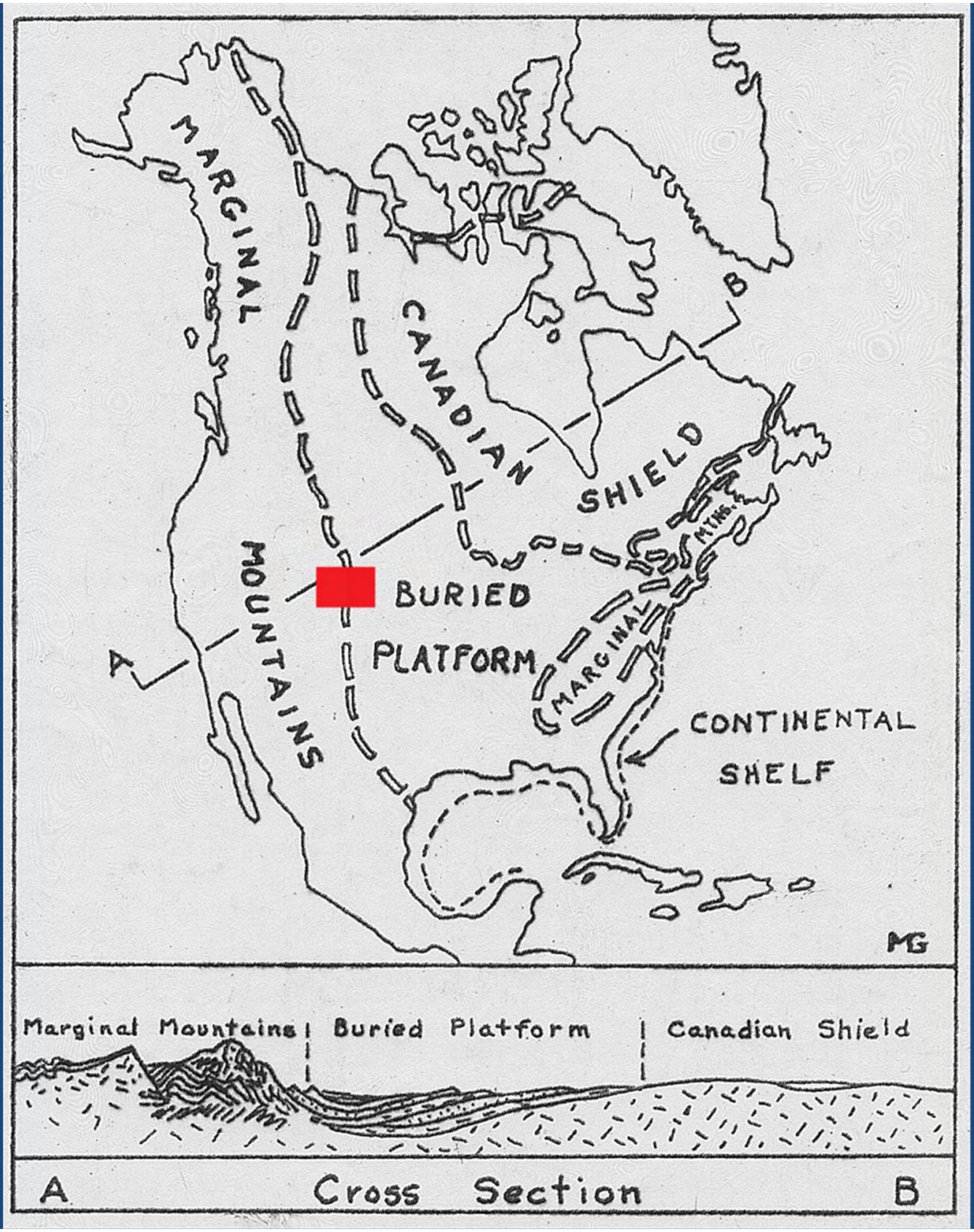
Living on the edge

We are at a significant boundary

— where plains and mountains meet.

— where a great variety of geologic processes are revealed in a short distance.

— where huge spans of geologic time are compressed in very short distance.



North America

Griffiths & Rubright, *Colorado*

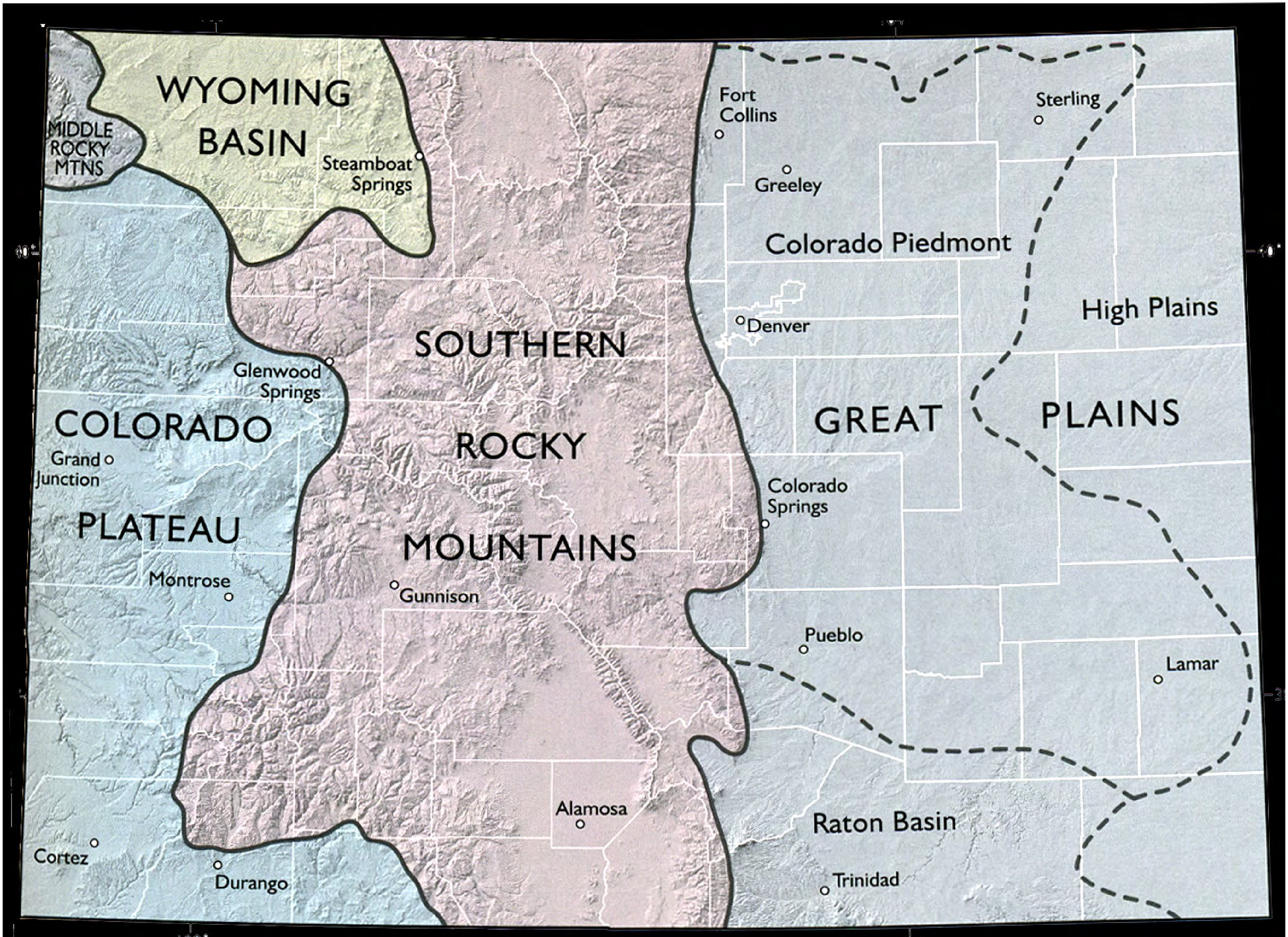
Other elements of the boundary

Biological

— where grasslands and forests meet.

Historical/cultural

— where mining and agriculture, urban and rural activities meet.



Matthews et al. *Messages in Stone*

How did this place get to be the way it is?

Dynamic Planet

1. Very dynamic planet — landforms are continually being created.
2. Continents are being moved around.
3. Landforms are being remodeled and demolished.

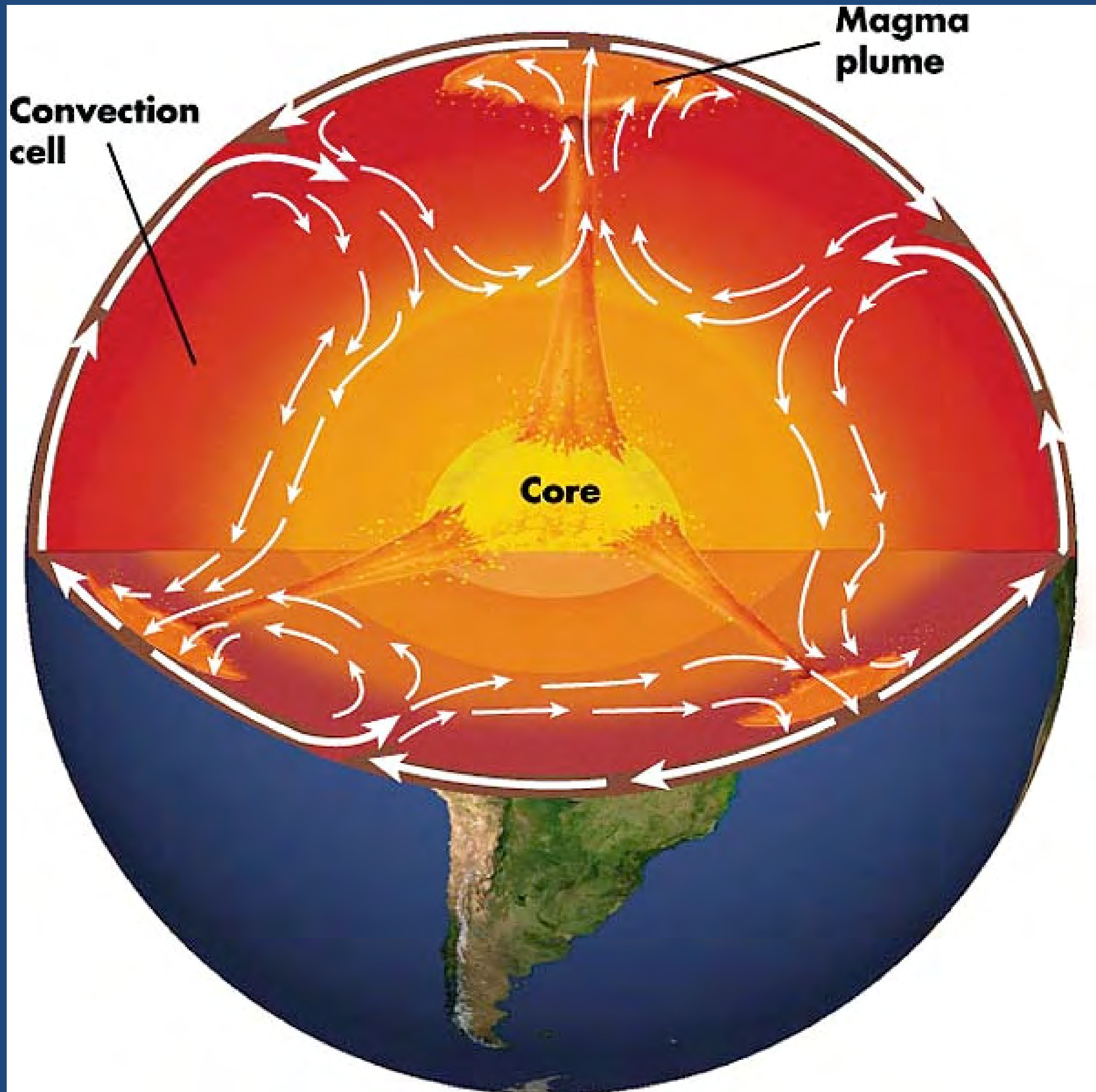
Floating Crust

—Planet has a molten interior.

—Crust can break in pieces and float horizontally as "plates."

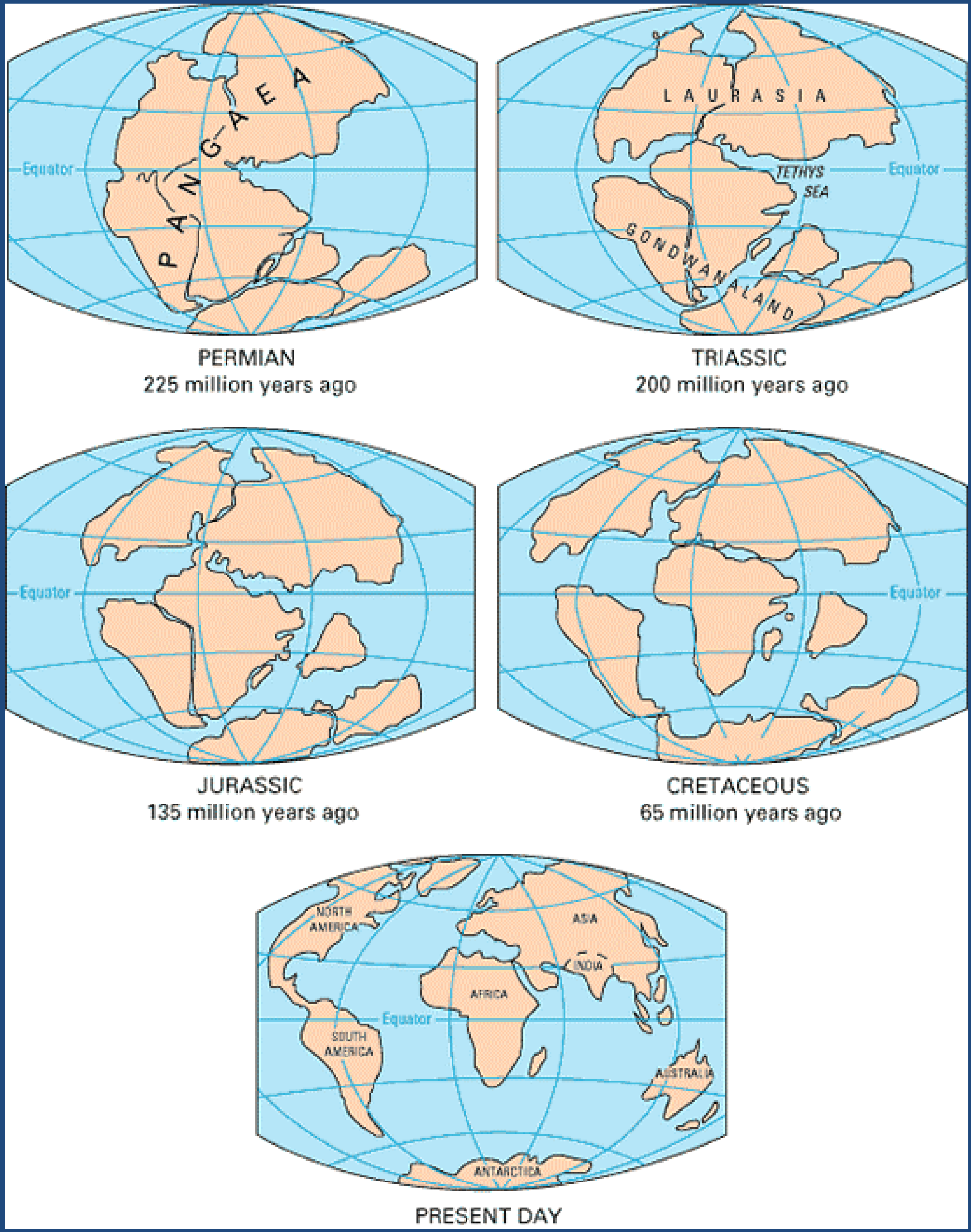
Plate tectonics

— moves up and down as well in small and large pieces.

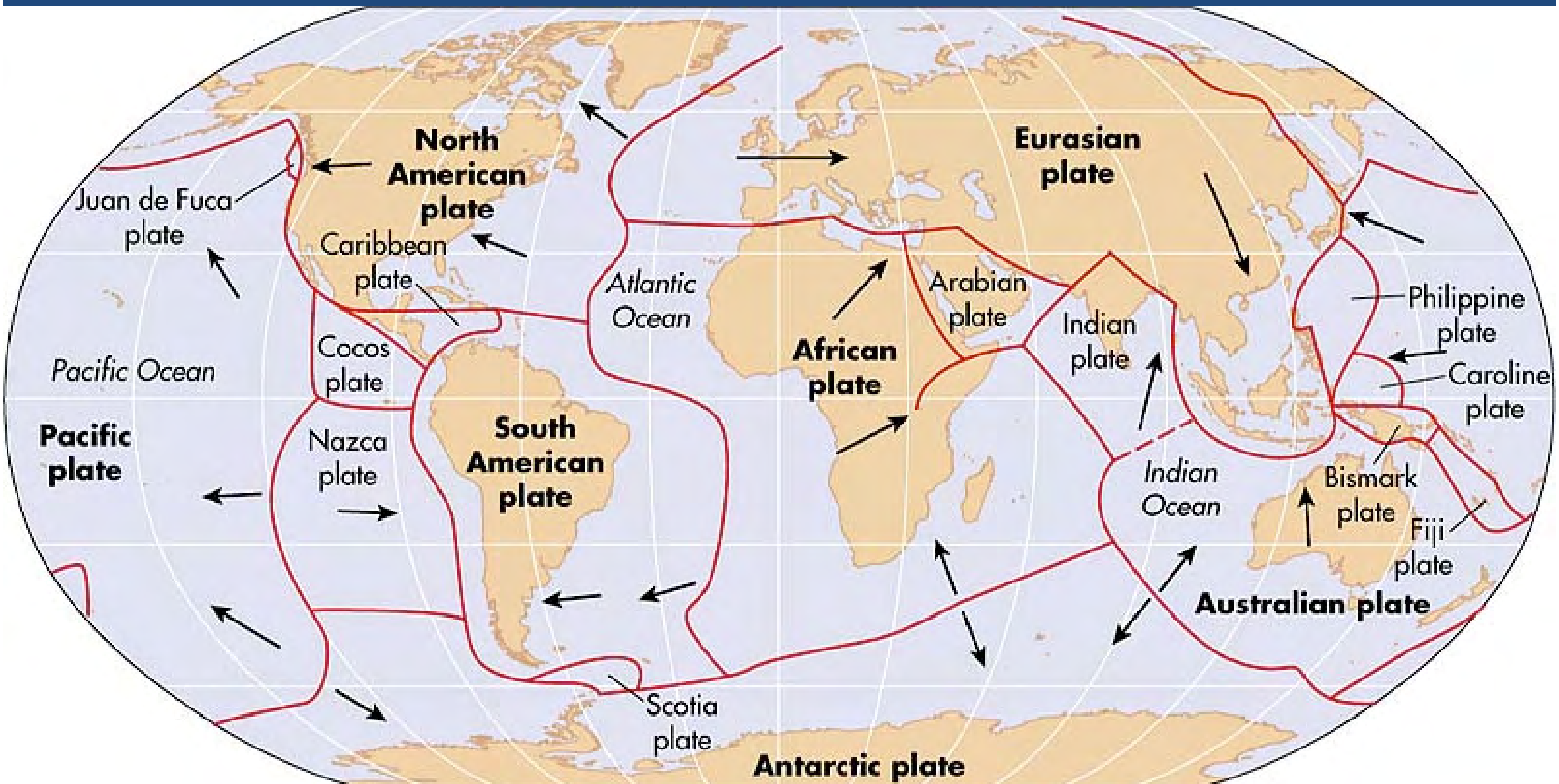


Arbogast, Discovering Physical Geography

Plate Tectonics



Modern Continental and Oceanic Plates



Colorado Landforms

During all this rafting around Colorado went up and down and sea levels went up and down.

We were sometimes dry land; sometimes under an ocean.

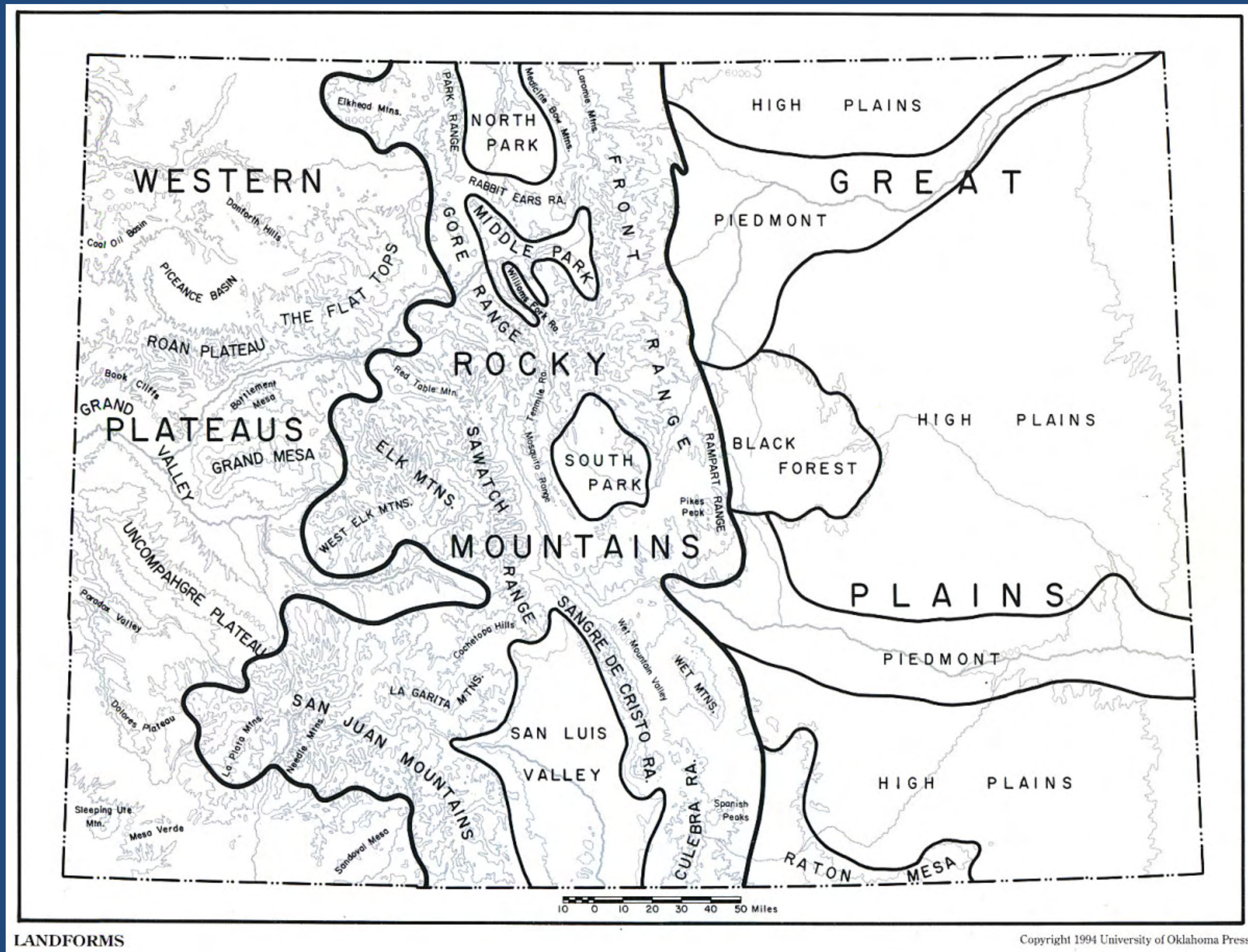
Landforms
Mountain side of boundary

Mountain side of the boundary

Rocky Mountains = N-S trending range from New Mexico into Canada

Front Range = eastern section of Rockies in Colorado

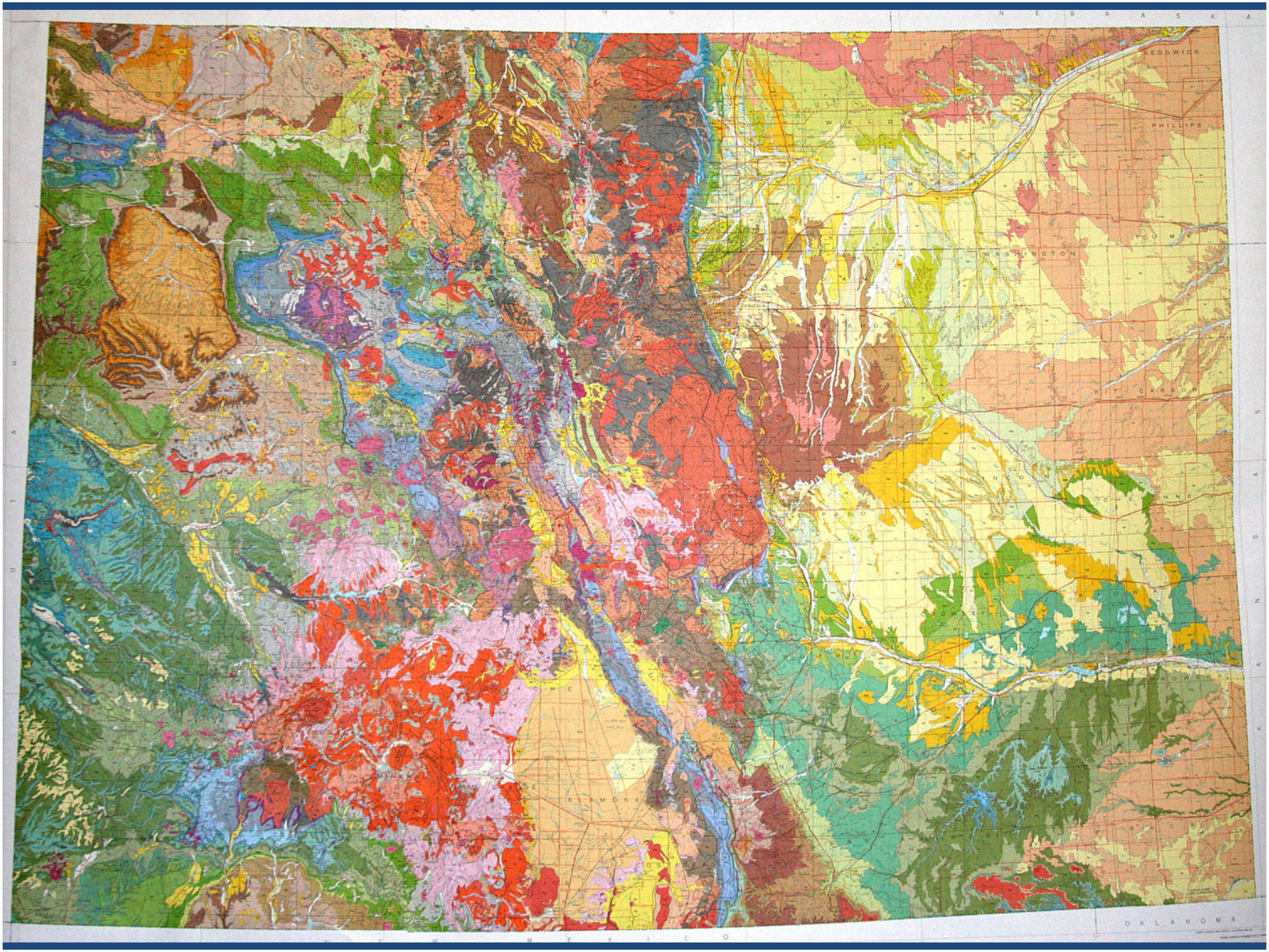
Colorado Physiographic Provinces



Noel et al *Historical Atlas of Colorado*

Front Range

ROCKS


N E B R A S K A
SEDGWICK
PHILLIPS
WASHINGTON
O K L A H O M A

Our Mountain Rocks

Rocks born of great heat, pressure, and movement:

1. <u>Igneous</u>
2. <u>Metamorphic</u>

Rock Types — Igneous

Igneous rocks = formed from molten source deep within mantle

Two Types of Igneous Rocks

Extrusive → lava

- flows out onto the surface

Intrusive

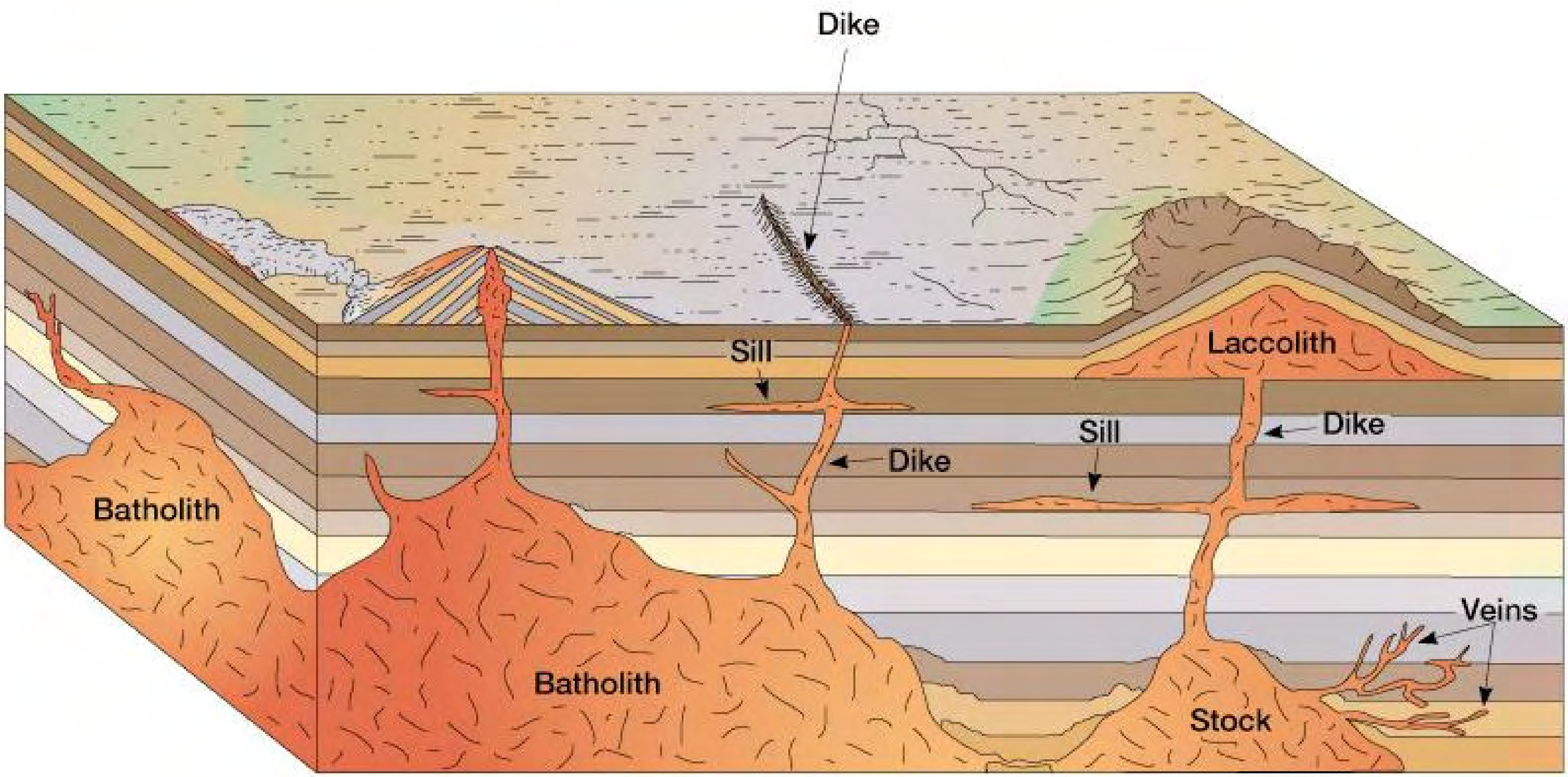
- cools and hardens slowly under-ground
- forms large crystals
- exposed by erosion

Igneous Rocks in Colorado

Extrusive – Golden, San Juans

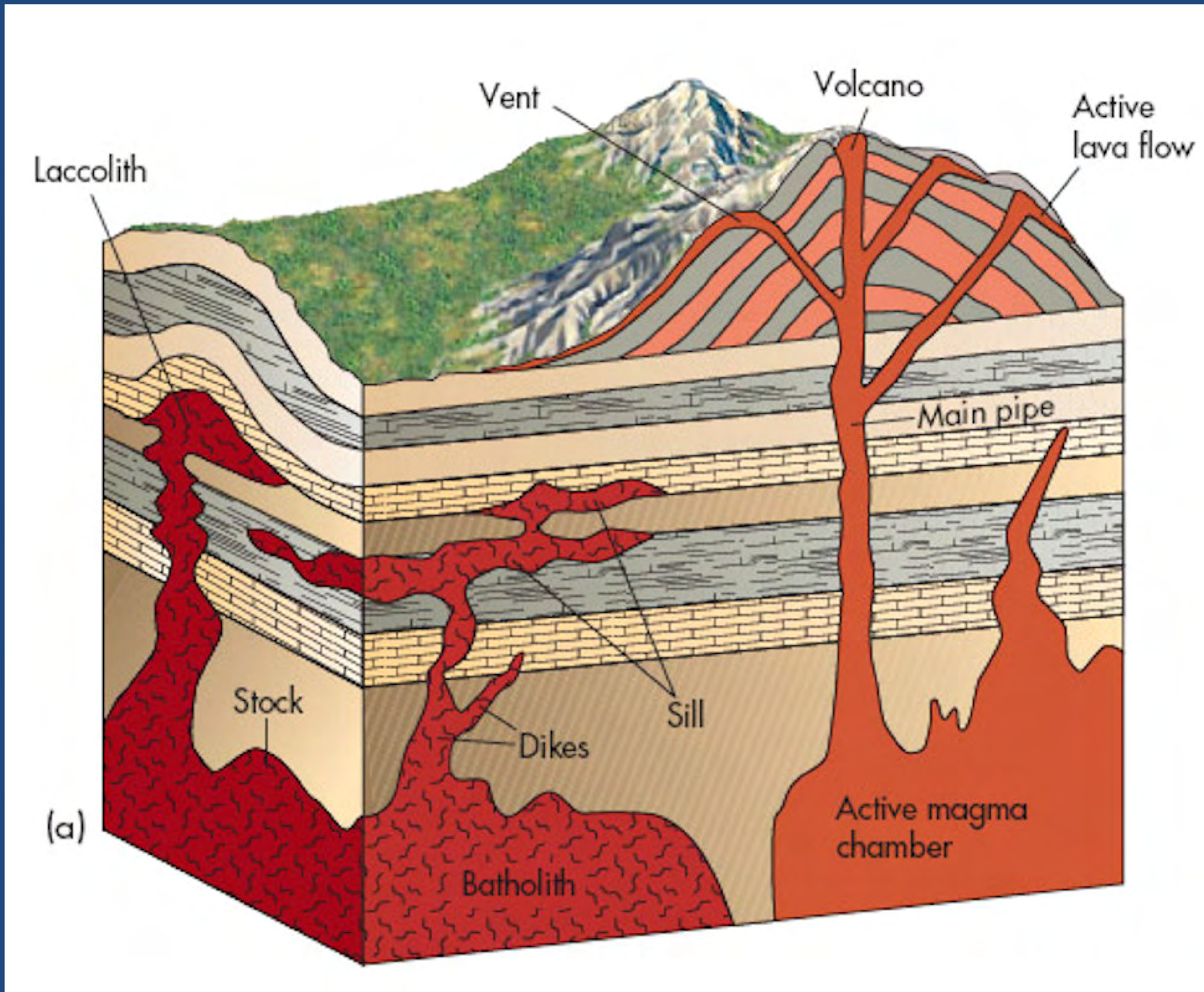
Intrusive – Front Range

Igneous Rocks



McKnight& Hess, *Physical Geography*

Igneous Rocks



Volcanic Activity

Northern Colorado has little extrusive igneous (lava). Lava flows in South and North Table Mountains near Golden.

The Brule Formation at Soapstone Prairie is from volcanic ash.

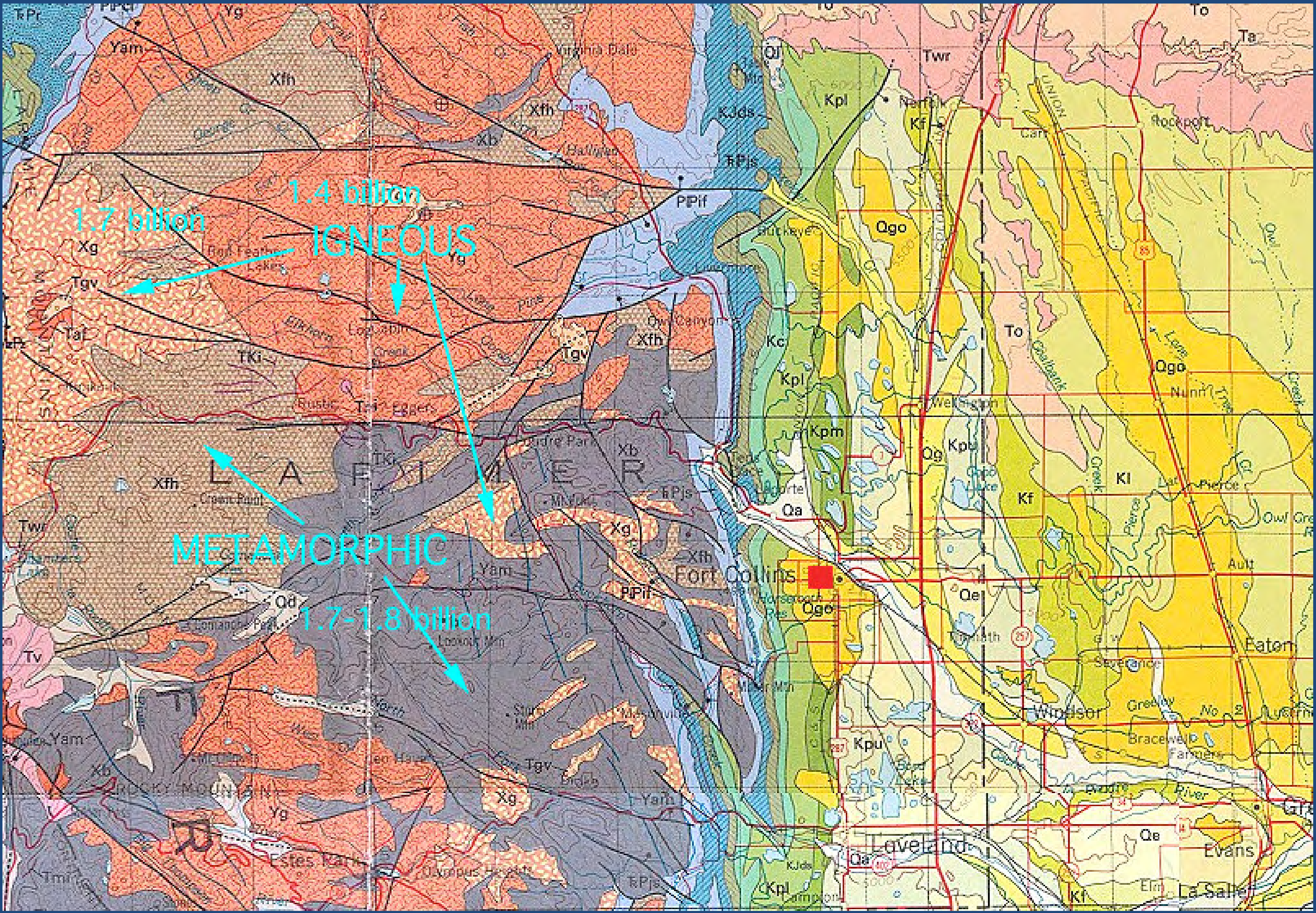
Landforms From Lava Flows

South Table Mountain

Intrusive Igneous

We have a great deal of
intrusive igneous rocks = granite

This is magma that did not reach surface and was later exposed by erosion.



1.4 billion
1.7 billion
IGNEOUS
METAMORPHIC
1.7-1.8 billion
L A R I M E R
Fort Collins
Loveland
Windsor
Eaton
Evans
La Salle
Estes Park
Xfh
Xg
Yg
Xb
Yam
Tgv
Kpl
Qgo
Qa
Qe
Kf
Kpu
To
Twr

Granite

most common intrusive igneous rock in our nearby mountains

Big crystals—cools slowly

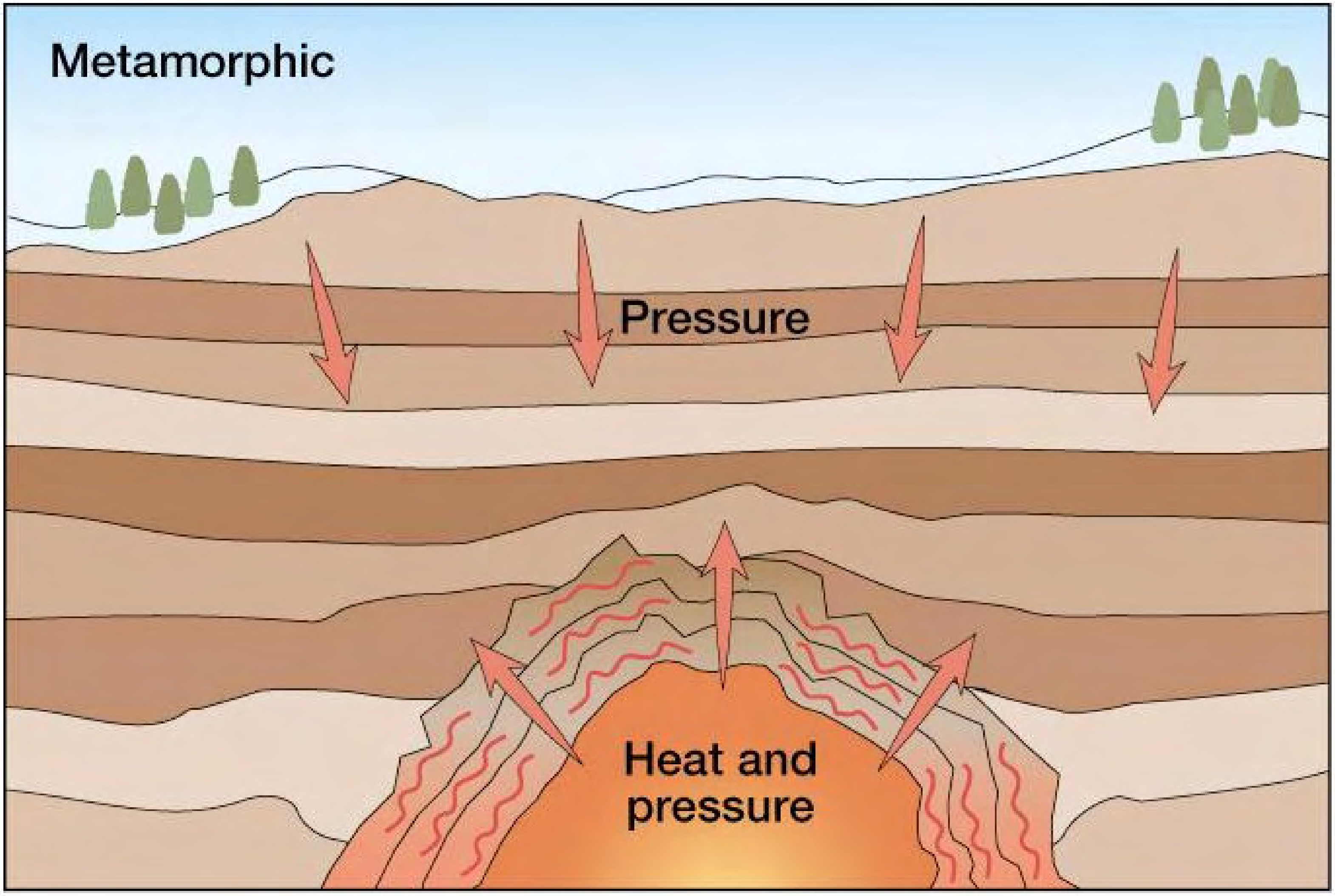
Fairly uniform

Metamorphic

Metamorphic rocks = any original type transformed by heat, pressure, or hot fluids.

Typical metamorphic = gneiss (granite transformed)

Metamorphic Rocks



McKnight & Hess, *Physical Geography*

Gneiss at Gateway

Mountain rocks closest to us

West of Fort Collins, the mountain rocks are mostly metamorphic—approximately 1.7 billion years old!

Identifying Metamorphic Rocks

Can be difficult because:

— often same composition as igneous;
they are simply altered versions
of the original rock.

—amount of alteration varies

Q: How do you tell the difference between igneous and metamorphic?

A: Metamorphic rocks often have:

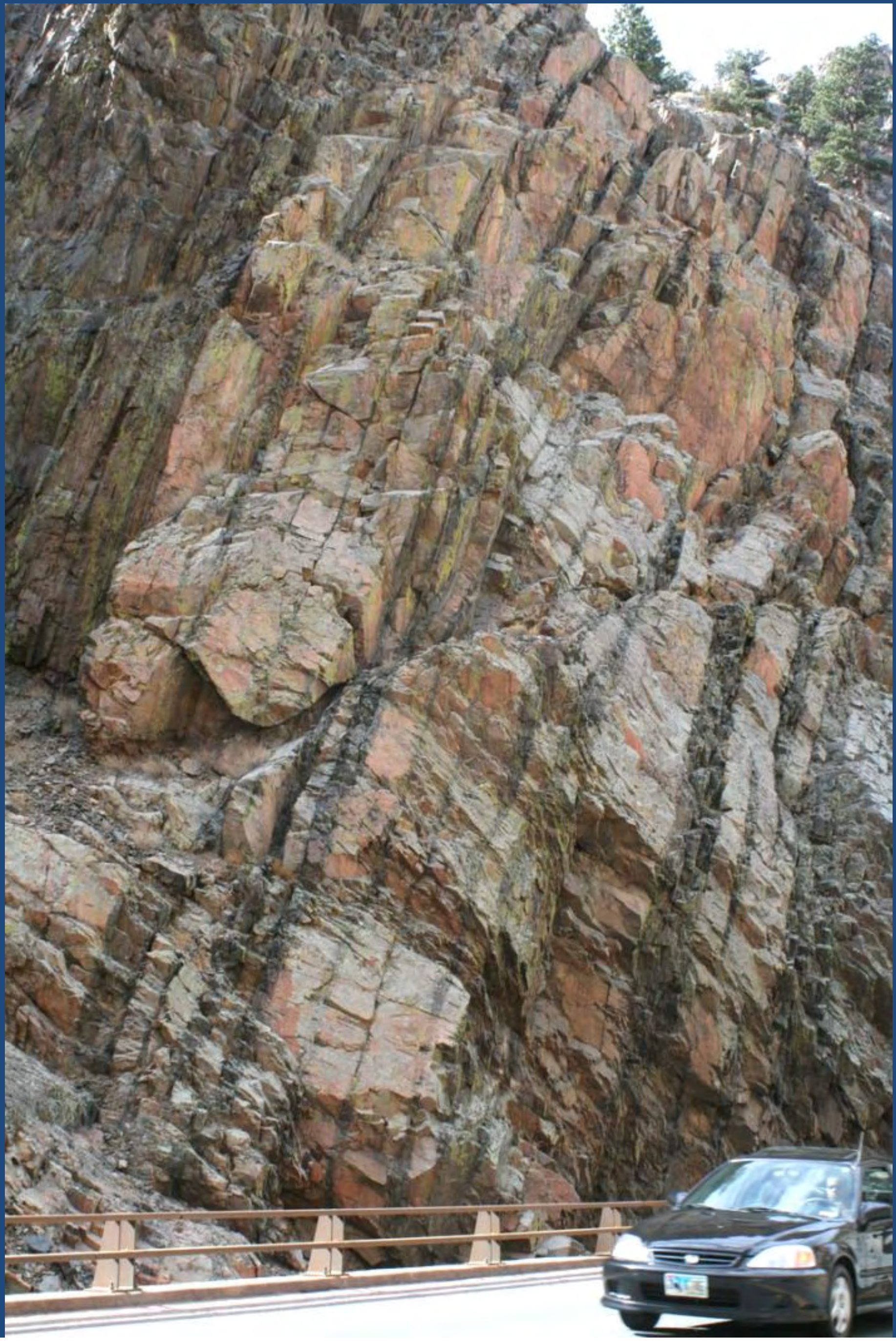
- smaller crystals
- minerals arranged in bands
- bands may be wavy
- often veins cutting across other types
- varying degrees of alteration

Banded Gneiss (migmatite)

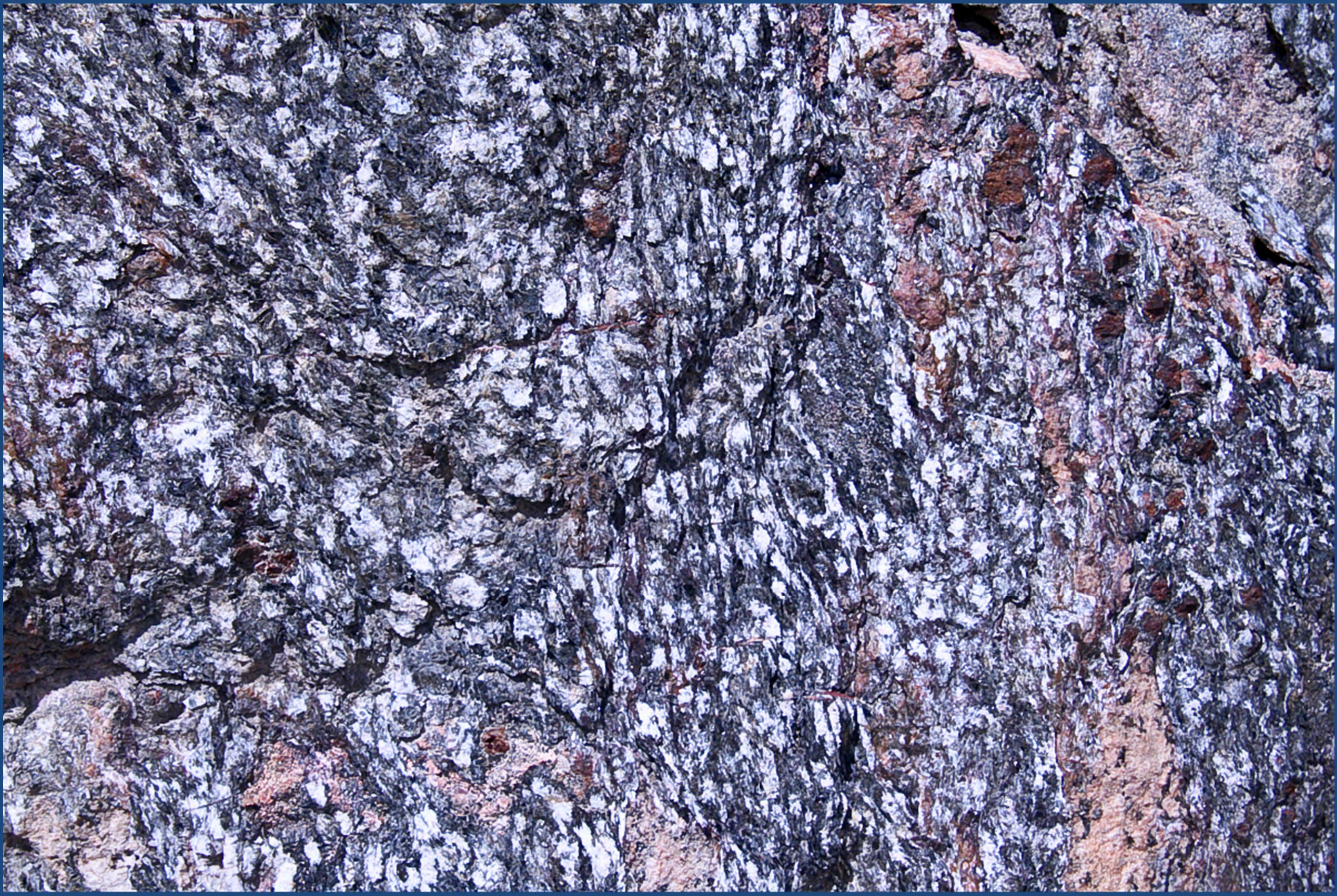
Foliated Metamorphic

Vein

Big Thompson Metamorphics



Gateway Augen Gneiss



Gateway vein

Granite

Gneiss

Plains side of boundary

East of the mountains, on the Plains side of the boundary, we have sedimentary rocks.

These are rocks produced by very quiet, gentle processes.

Migmatites

Many rocks in Front Range are migmatites = mix of metamorphic and igneous

Sedimentary Rocks

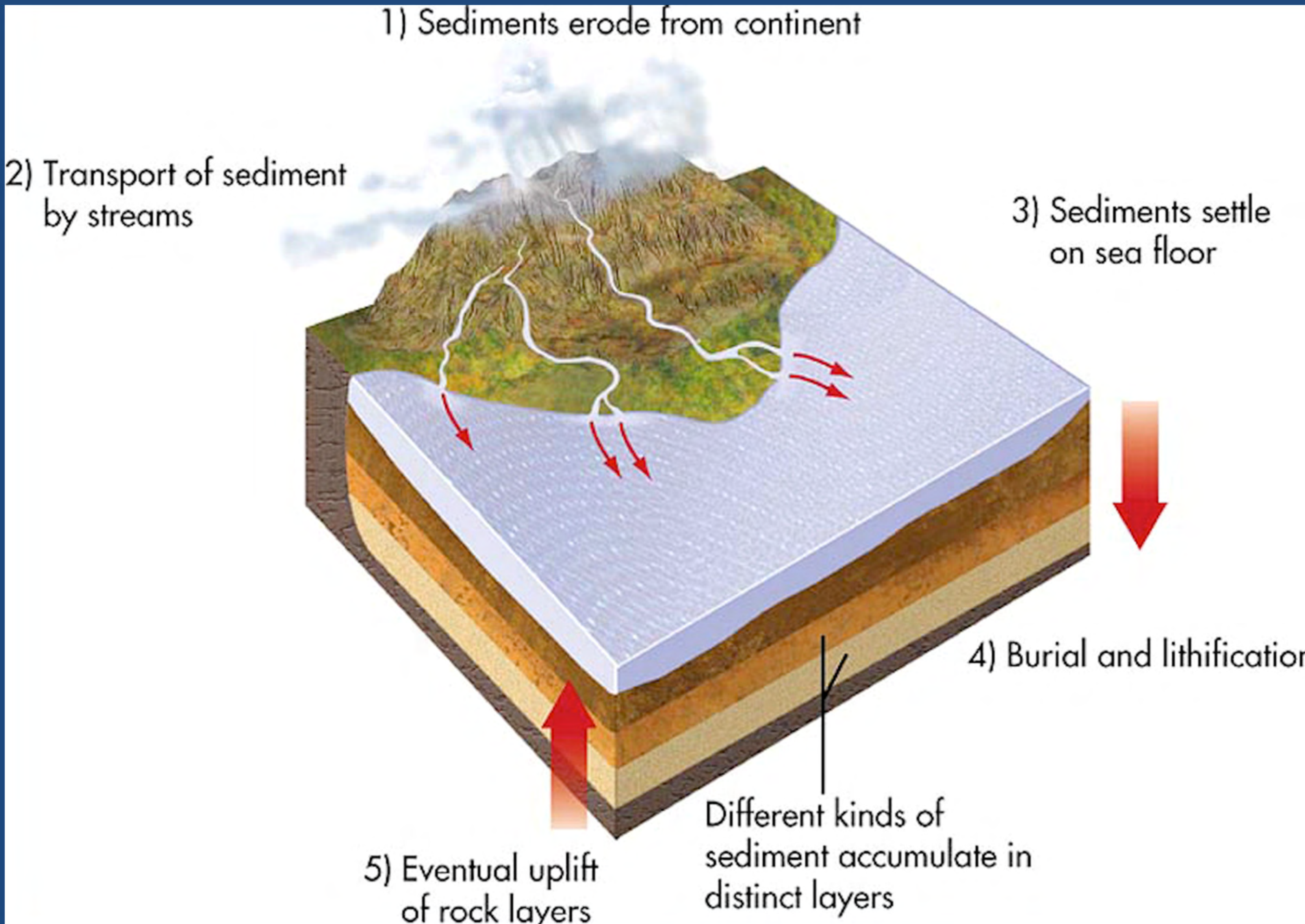
Material worn off somewhere else, then carried by water and wind and laid down in layers.

Layers cemented together = sedimentary rocks

Oldest on bottom – closest to mountains

Typical types here = sandstones, conglomerate, shales.

Sedimentation



Arbogast, Physical Geography

Sandstones – made from sand, in layers, sorted by size.

Conglomerates – sand and pebbles in a mix of sizes.

Shales – layers of mud; layers often thin.

Sandstone

Conglomerate

Shale

How to identify Sedimentary rocks

- Layers are parallel to each other.
- Usually breaks along these “bedding planes” —> “flagstones.”
- Often fine-grained.

GEOLOGIC HISTORY

Ancestral Rockies

Earlier set of Rocky Mountains rose above a sea about 300 million years ago about where the current mountains are. (These are fourth or so set of mountains).

As one of two large islands

- Frontrangia
- Uncompahgria

Ancestral Rocky Mountains

Johnson & Raynolds, A*ncient Denvers*

FOUNTAIN FORMATION

Ancestral Rockies shed material by
to form <u>Fountain Formation</u>

—about 280 million years ago

—thickness variable, average up to 800 feet

—mostly conglomerate

— varying resistance to erosion

— lying on metamorphic rocks
more than 1 billion years older

Ancestral Rocky Mountains

Johnson & Raynolds, *Ancient Denvers*

Boulder Flatirons

Red Rocks

Roxborough Park

Fountain Formation-Bobcat Ridge

LYONS FORMATION

About 260 million years ago

—climate very dry—in Pangaea

—sand dunes

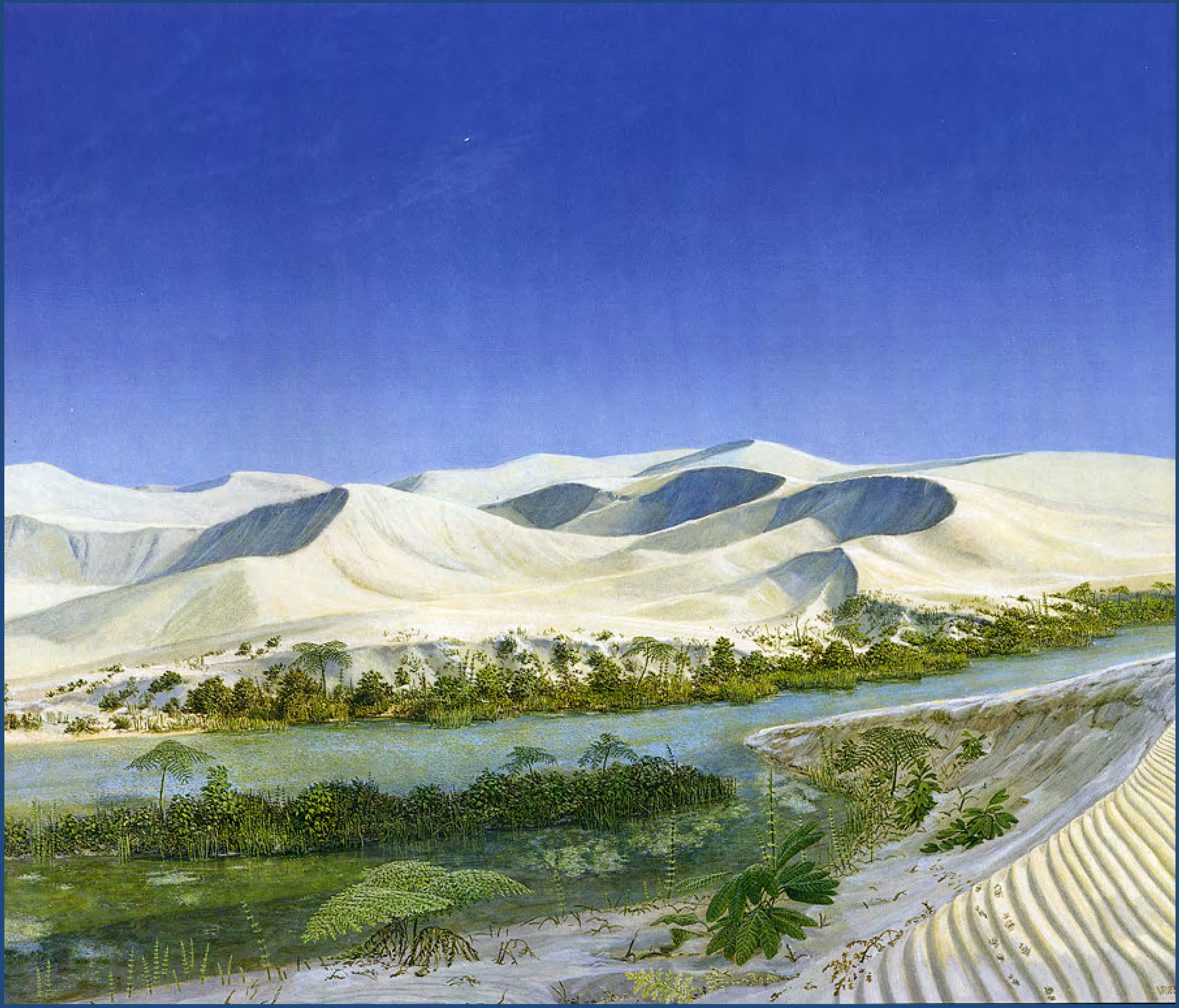
—fine grained sandstone

became well cemented and resistant to erosion

—economically important

Lyons Sandstone

ca. 260
million yrs bp



Johnson & Raynolds, A*ncient Denvers*

Lyons Sandstone

Lykins Formation

About 250 million years ago

—mountains eroded to low hills

—muddy, slimy, hot salt flats

—limestones and mudstone—easily eroded

—first reptiles

—followed by great Permian extinction

Lykins Formation

Johnson & Raynolds, A*ncient Denvers*

Morrison Formation

About 150 million years ago

—age of dinosaurs

—area very flat, mountains gone

— sediments ca. 400 feet thick

Morrison Formation

Johnson & Raynolds, A*ncient Denvers*

Dakota Group

About 100 million years ago

—sandy coast of Inland Seaway

beach sands, some thin muds

very resistant to erosion

—sediments from mountain in western Utah

stretch across Colorado, Utah, Kansas

—plant fossils and dinosaur prints

Dakota Group

ca 100 million yrs bp

Johnson & Raynolds, *Ancient Denvers*

“Dakota” near Red Rocks

Dakota/South Platte Formation

Ripples-South Platte (Dakota)

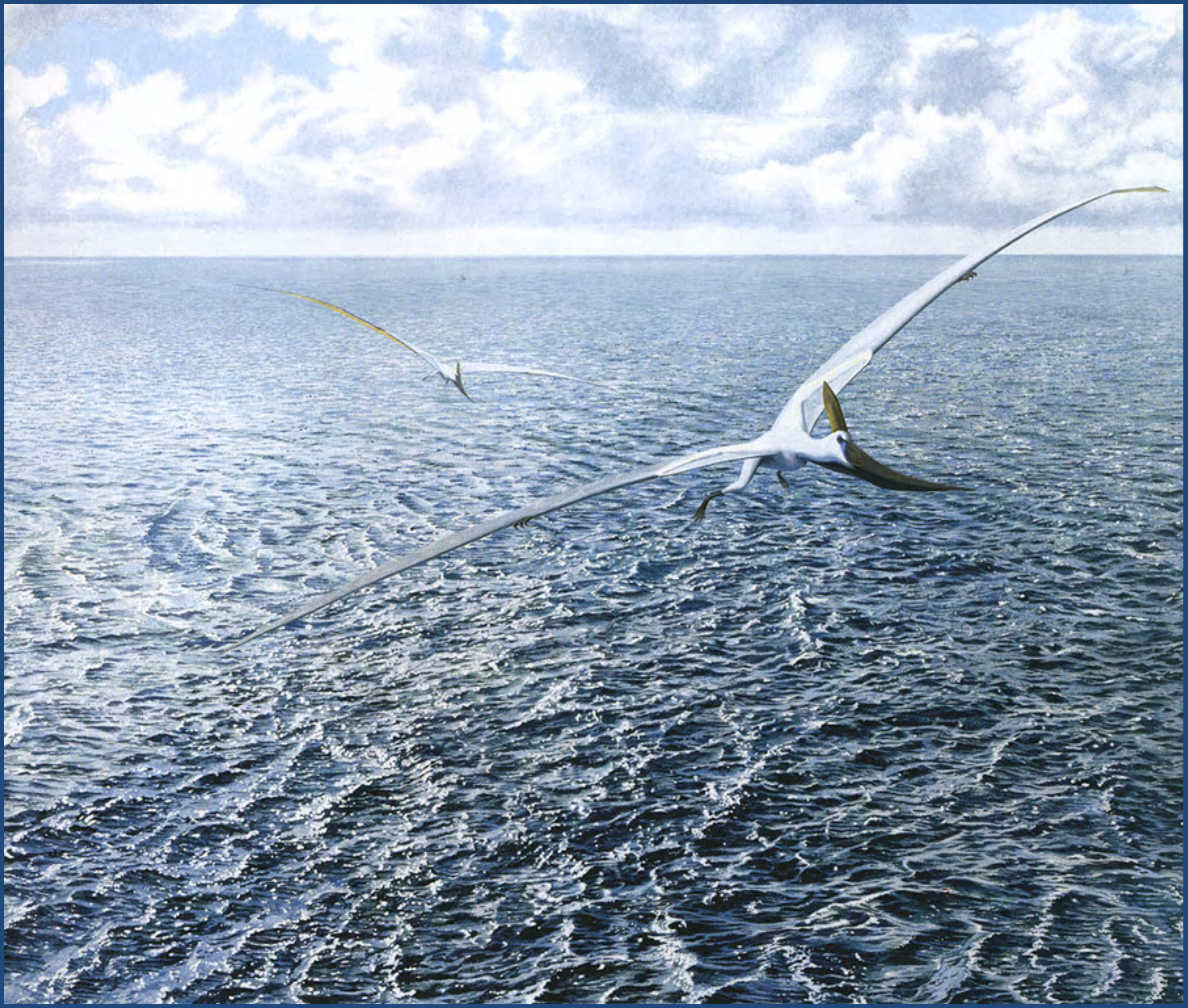
Pierre Formation

About 70 million yrs ago

—Colorado mostly covered by sea

—muddy sediments more than 1 mile thick

—this is the rock beneath Fort Collins rarely exposed



Pierre Formation

70 million
years bp

Johnson & Raynolds, A*ncient Denvers*

Pierre Shale

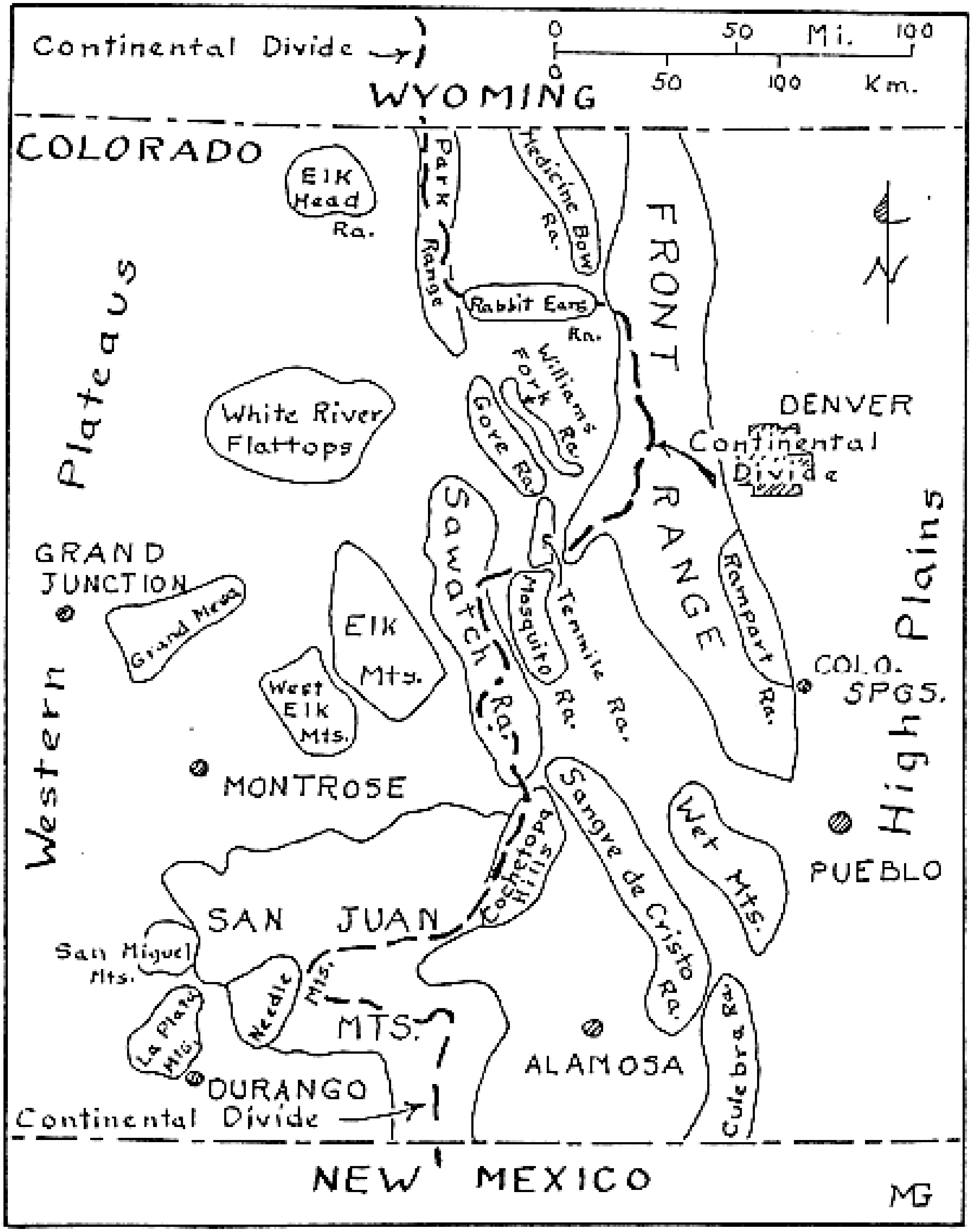
K/T Extinction

65 million years ago a meteorite hit near Yucatan and set off a world-wide fire storm that killed dinosaurs.

It left distinctive thin ash bed which was first recognized in Colorado.

CURRENT MOUNTAINS

Colorado Mountain Ranges



Griffiths & Rubright, *Colorado*

The current Rockies

Laramide Orogeny

between 70 and 40 million years ago

current Rockies rose in series of pulses.

They are still rising.

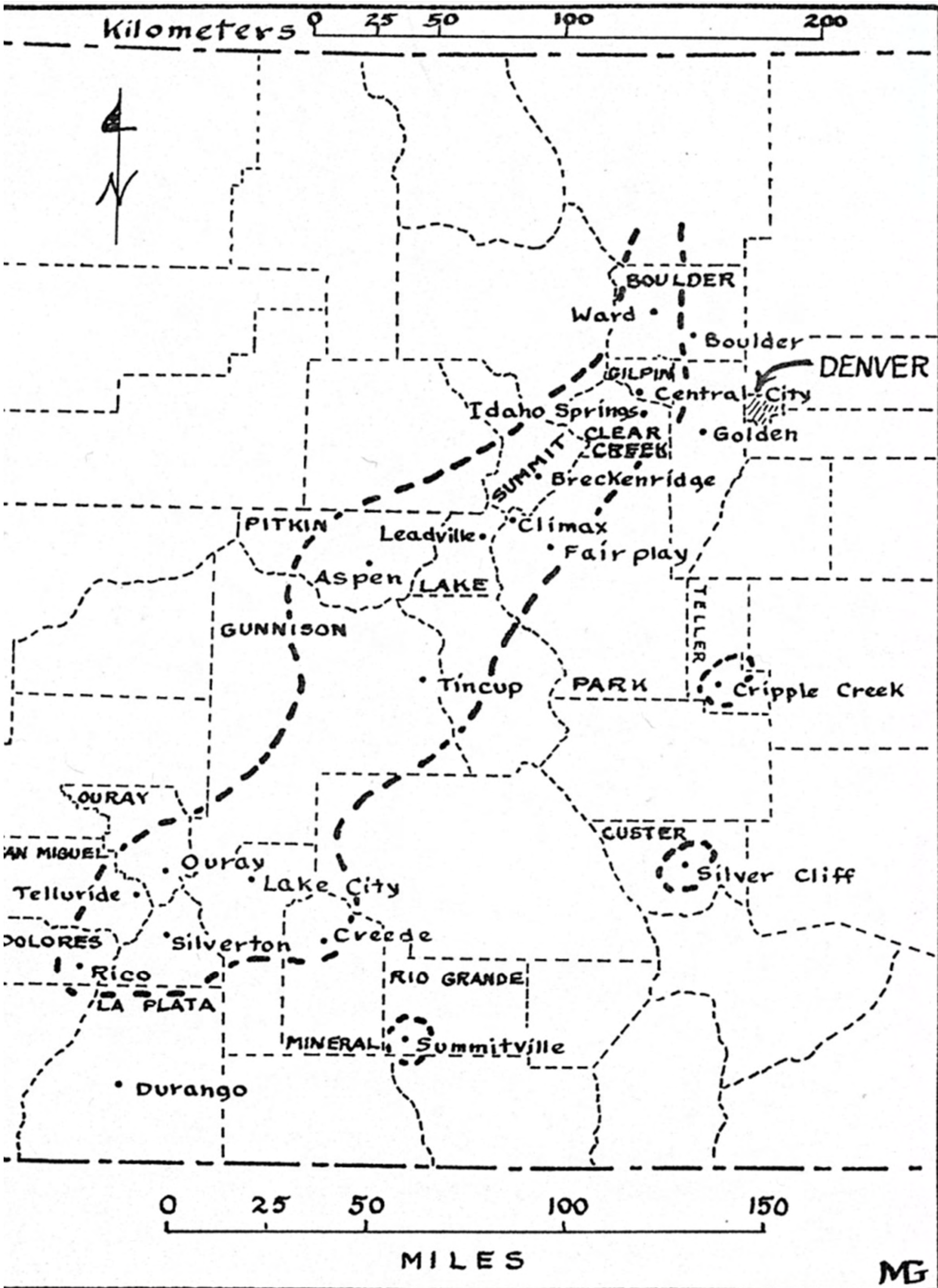
Laramide Orogeny

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



Colorado Mineral Belt

Griffiths & Rubright, *Colorado*

Vein

Laramide Orogeny

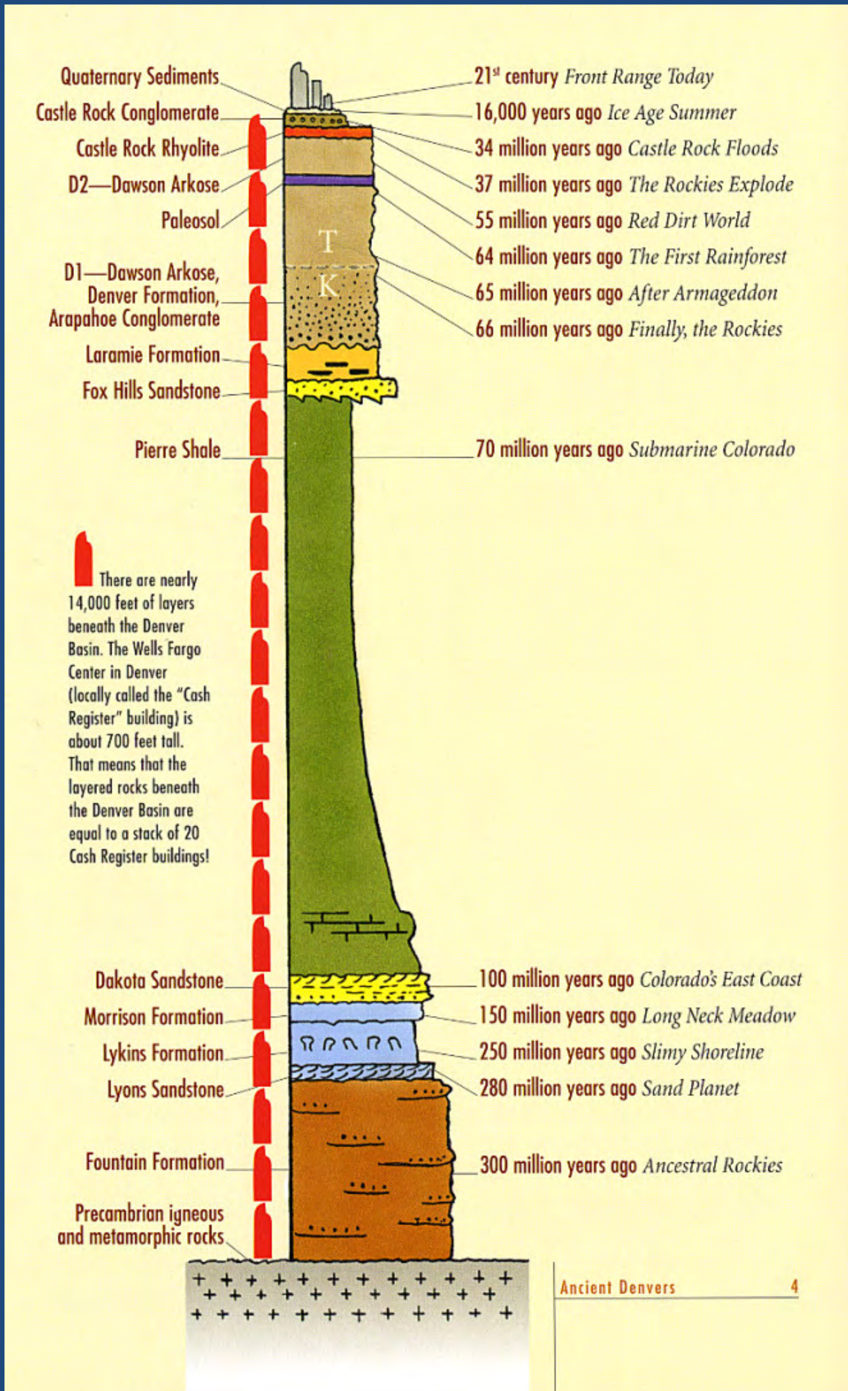
As mountains rose, they were also being worn away.

This produced a huge volume of sediments that became sedimentary rocks of Plains.

Sedimentary Rocks

There are 10,000-15,000 feet of these sediments east of the mountains

We live on those sediments here.



Relative Sediment Depths

(Total = ca 14,000 ft)

Johnson & Raynolds, *Ancient Denvers*

Laramide Orogeny

Forces that lifted Rockies up caused folding and faulting to sediments around mountains.

Folding and Faulting

Folding = bending rock layers

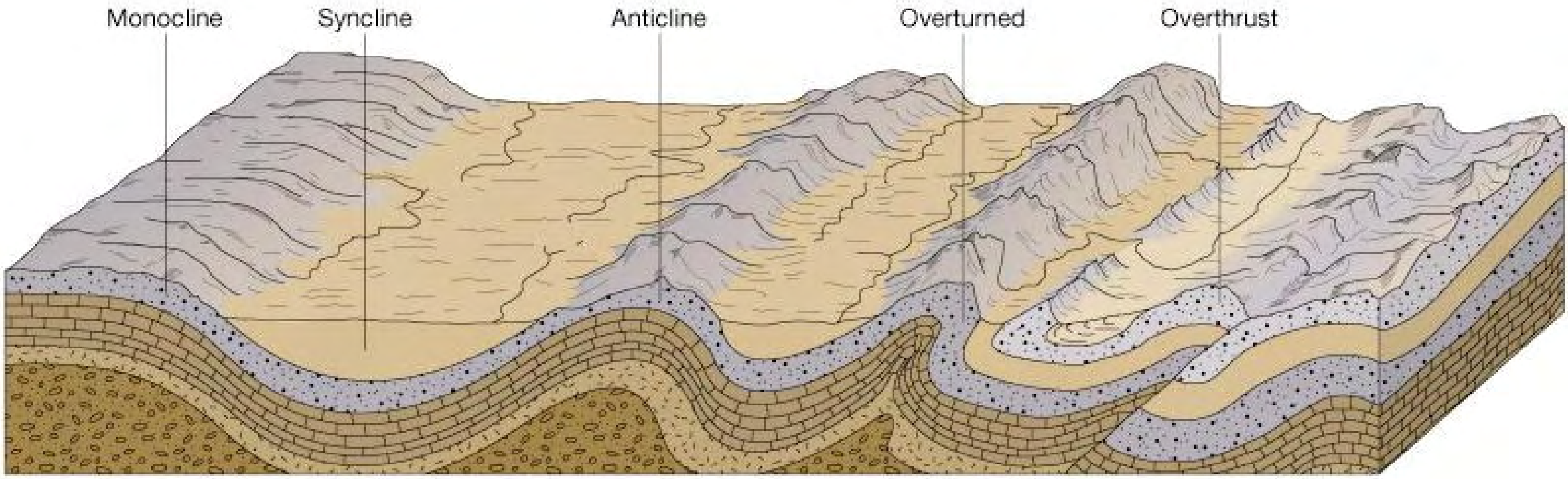
Faulting = breaking and moving rock layers

Anticlines and Synclines

Anticlines and Synclines are up and down folds

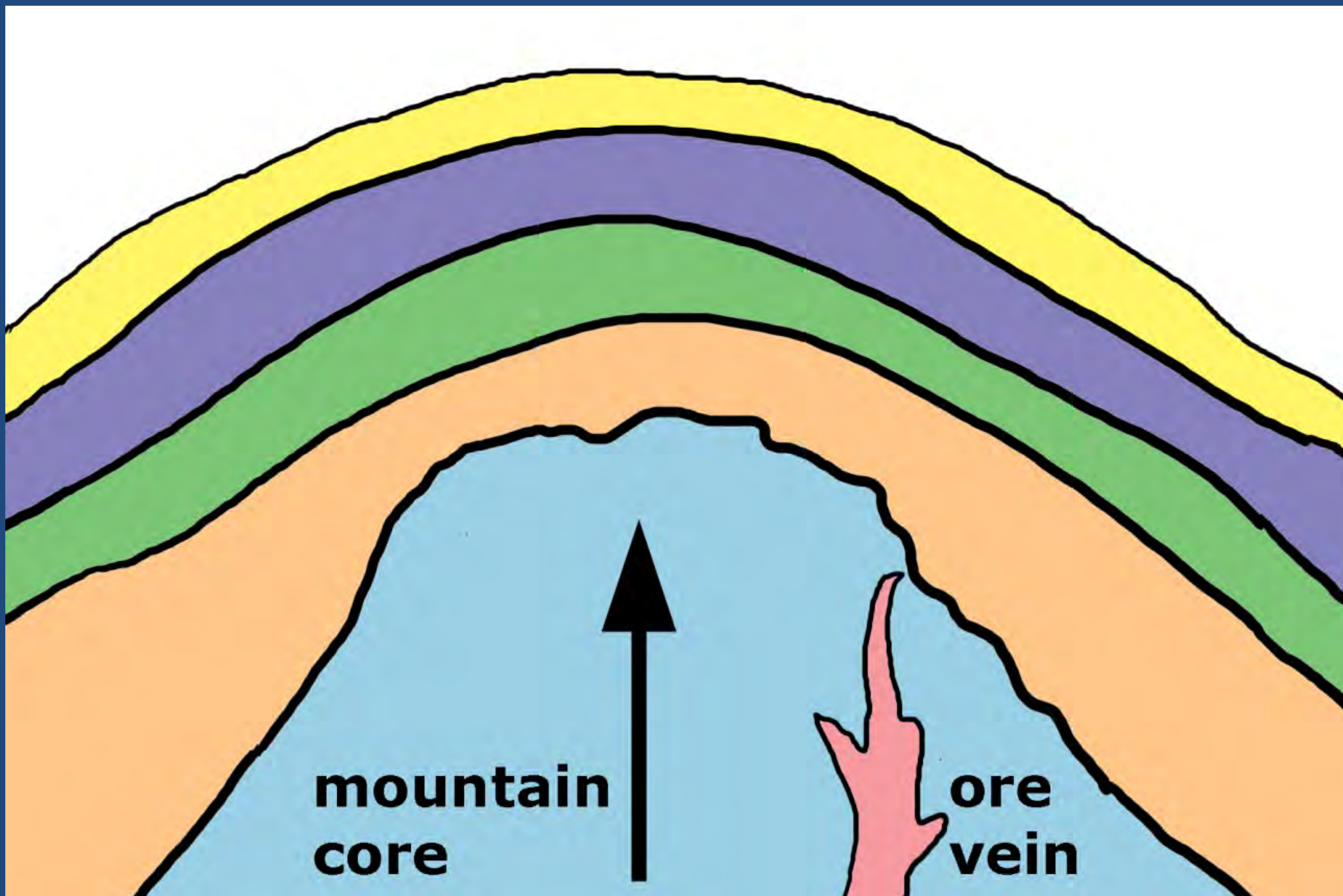
Normally produced by compressional forces

Types of Folds



McKnight and Hess, *Physical Geography*

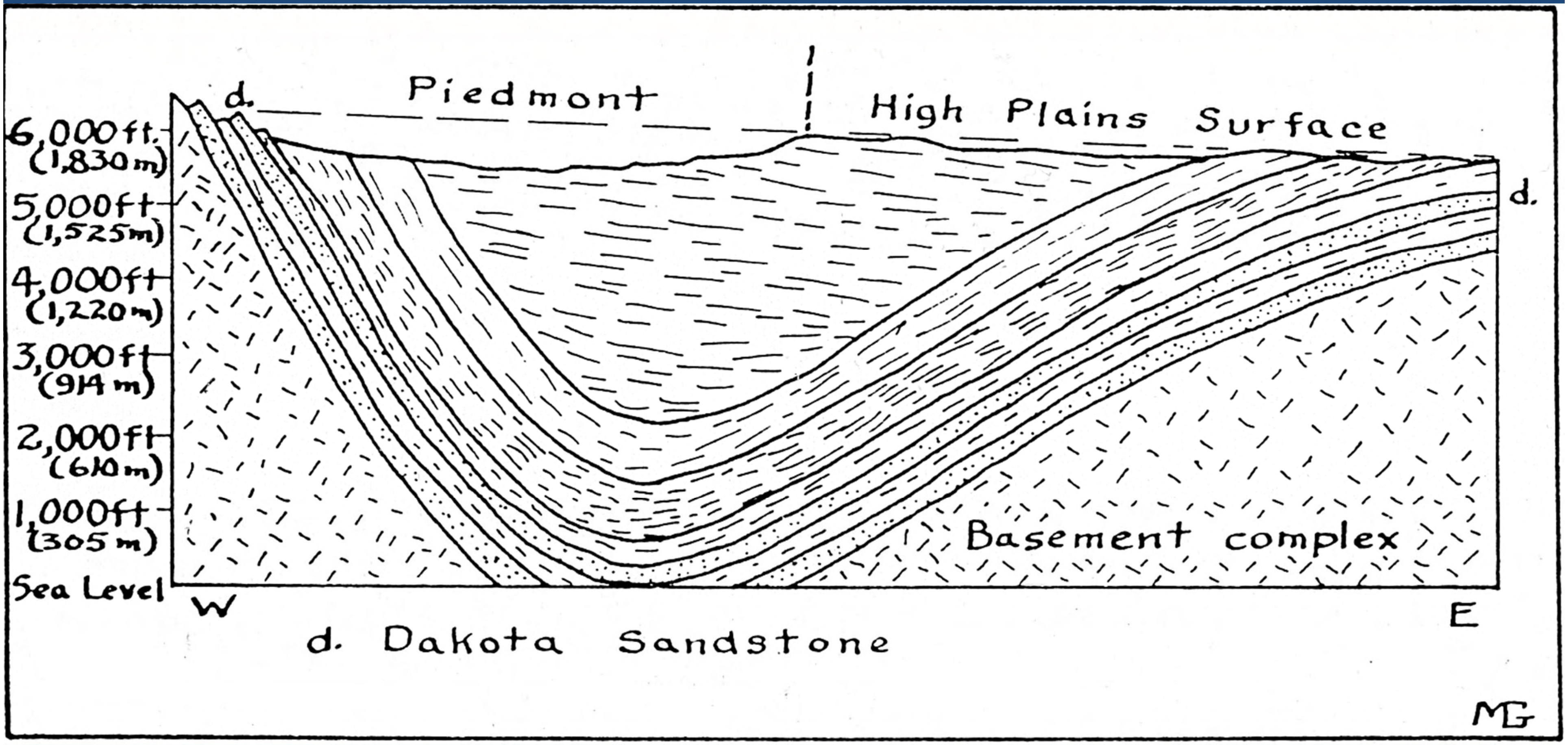
Anticline-like uplift



Basins

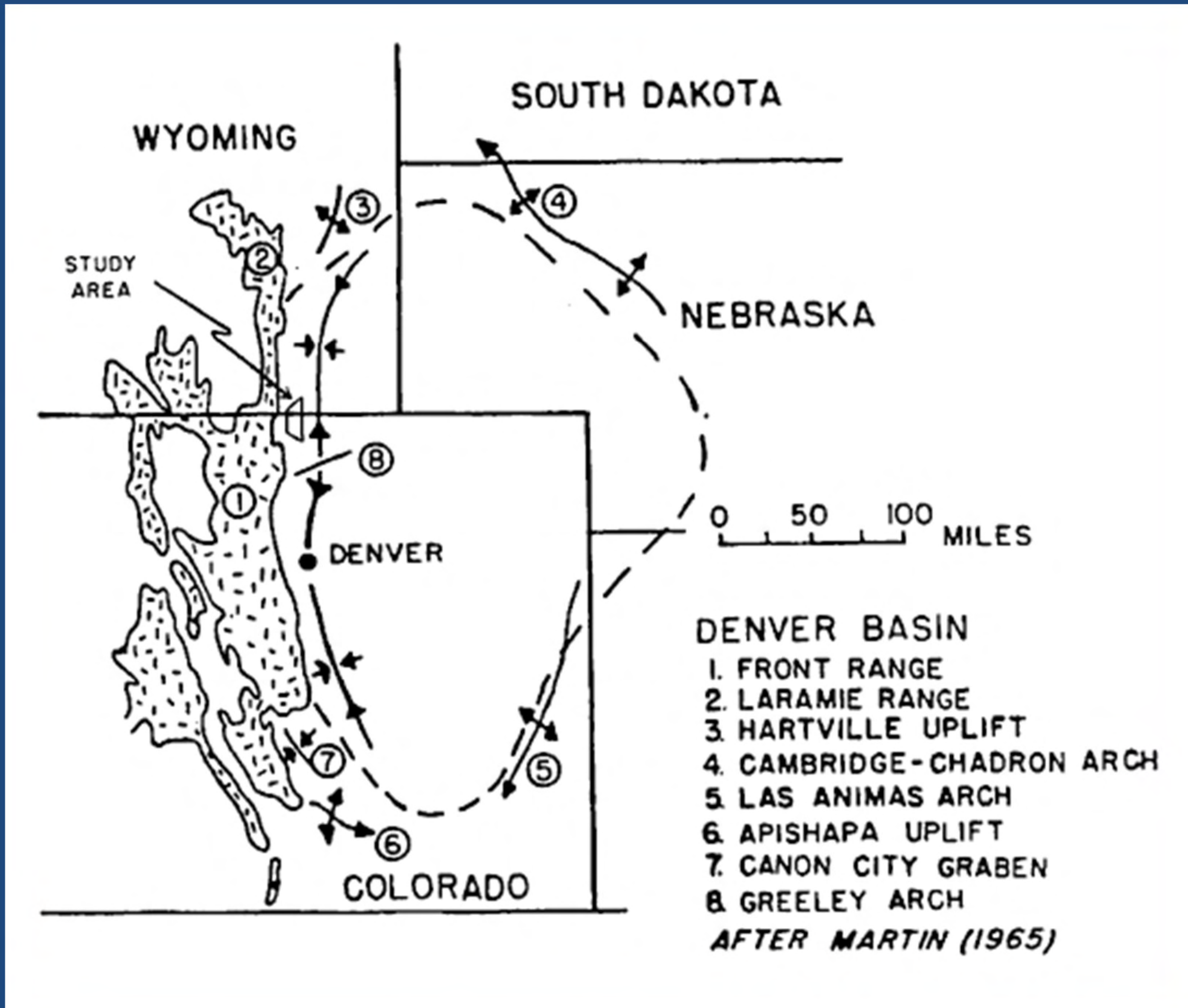
Not only did the sediments tilt up as mountains rose under them, basins also were warped down by same forces.

Syncline-Denver Basin



Griffiths & Rubright, *Colorado*

Denver Basin

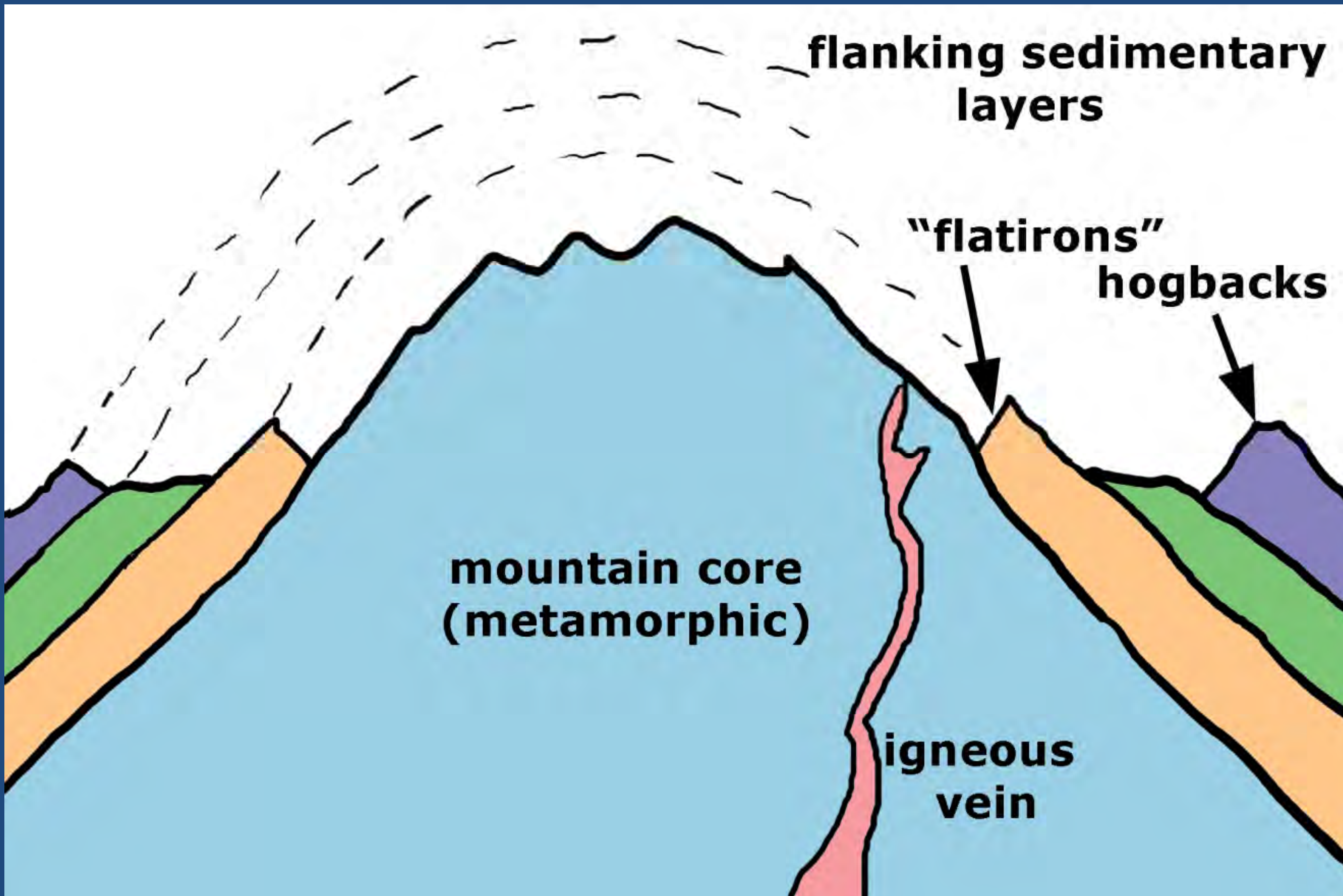


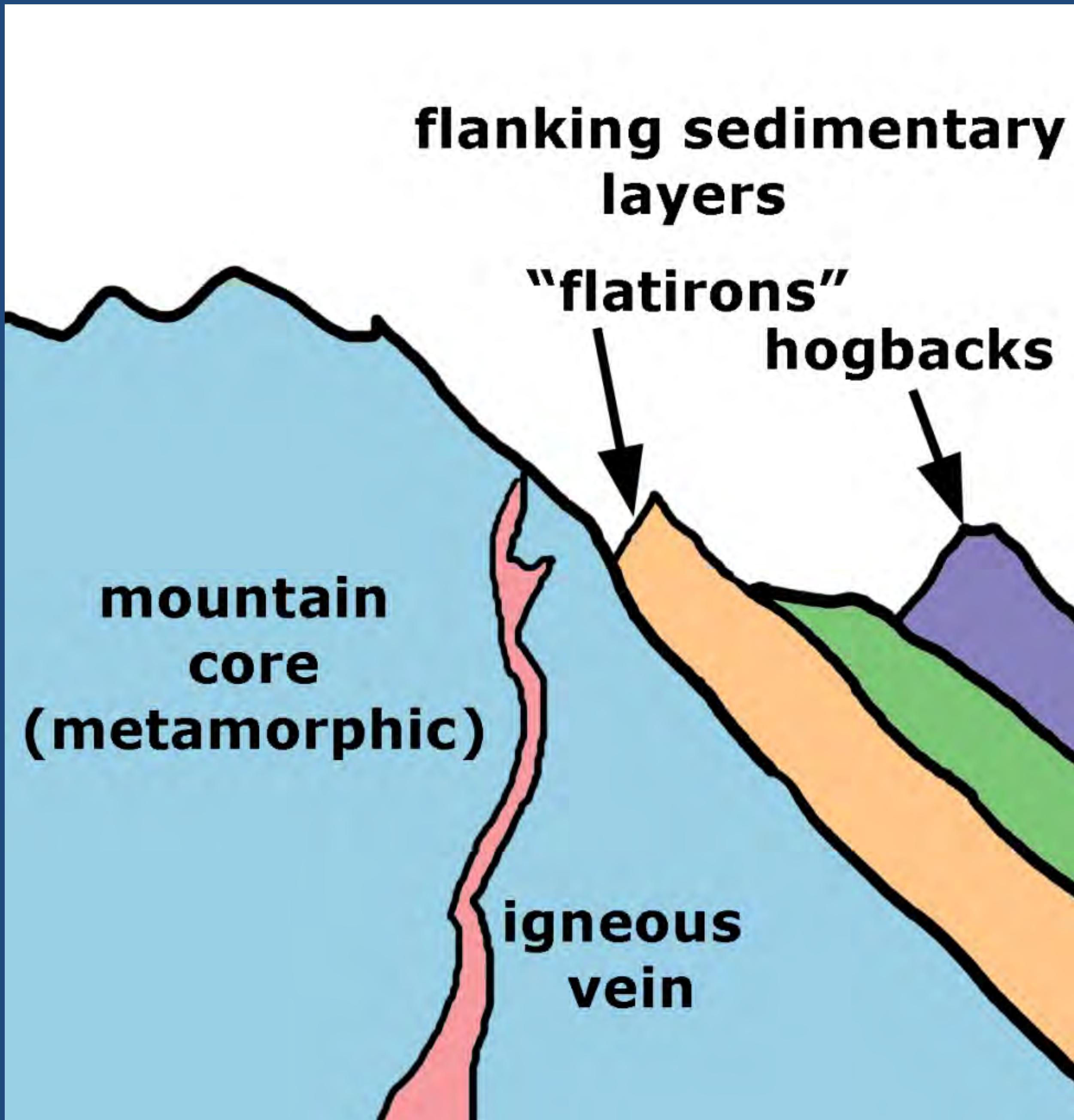
Grube, Dakota Group Stratigraphy,

Hogbacks

Uplift of Laramide Orogeny followed by erosion has left "hogbacks" (steeply tilted sedimentary layers).

Sediment eroded away

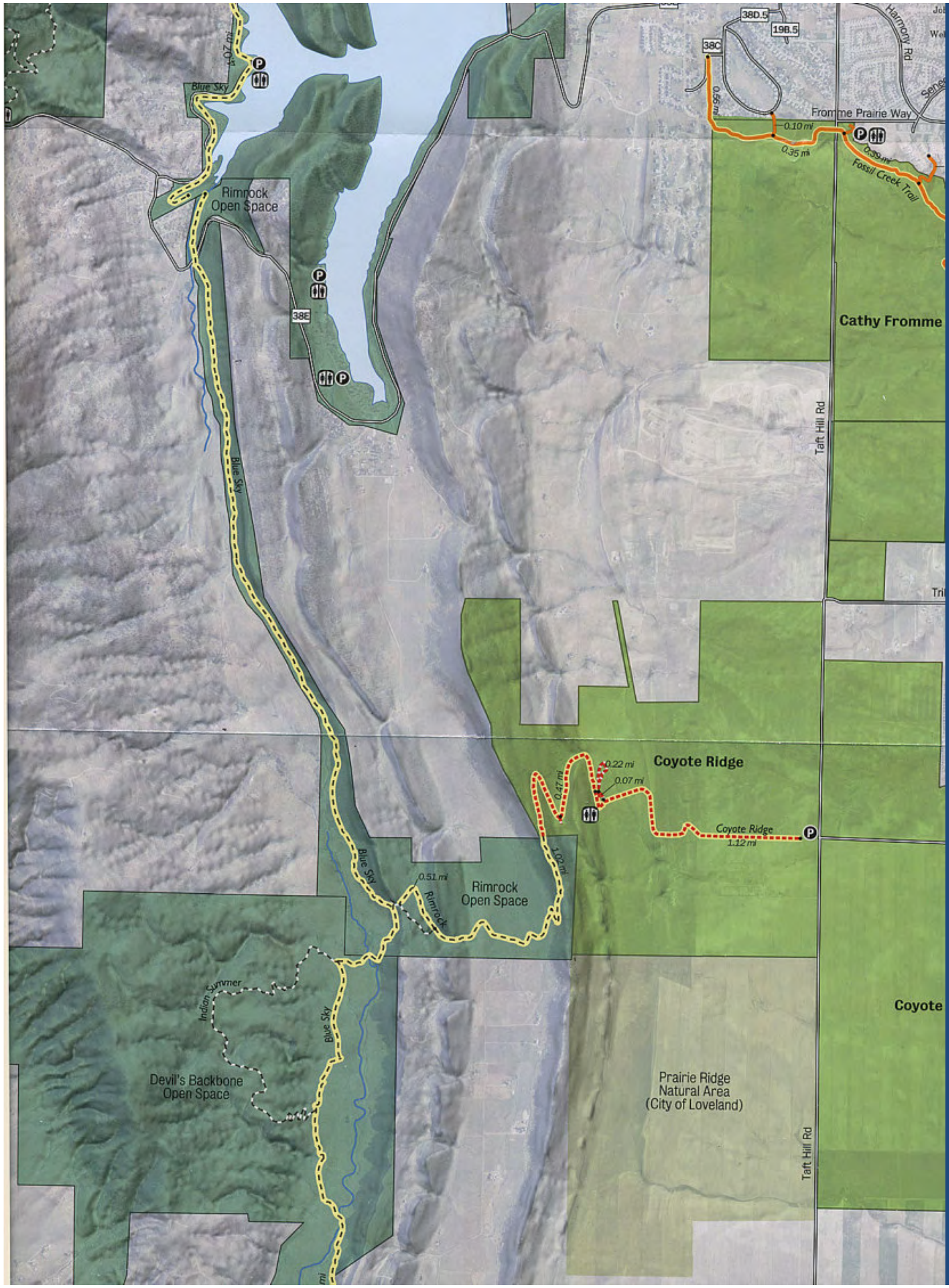



flanking sedimentary layers
"flatirons"
hogbacks
mountain core (metamorphic)
igneous vein

Hogbacks

Horsetooth Reservoir Lyons Formation

Hogback— Coyote Ridge



hogbacks

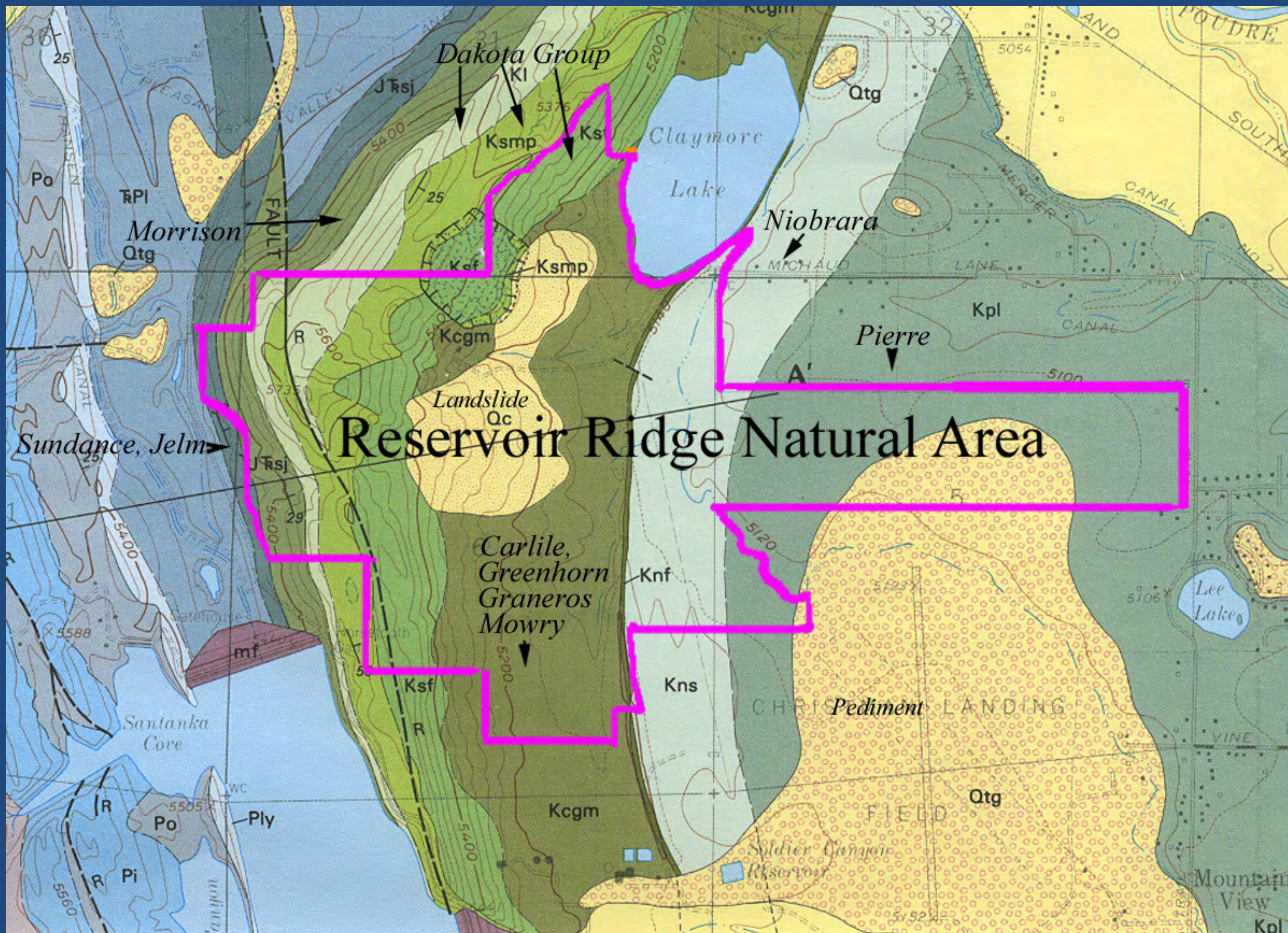
Fort Collins Natural Areas map

Exposing time

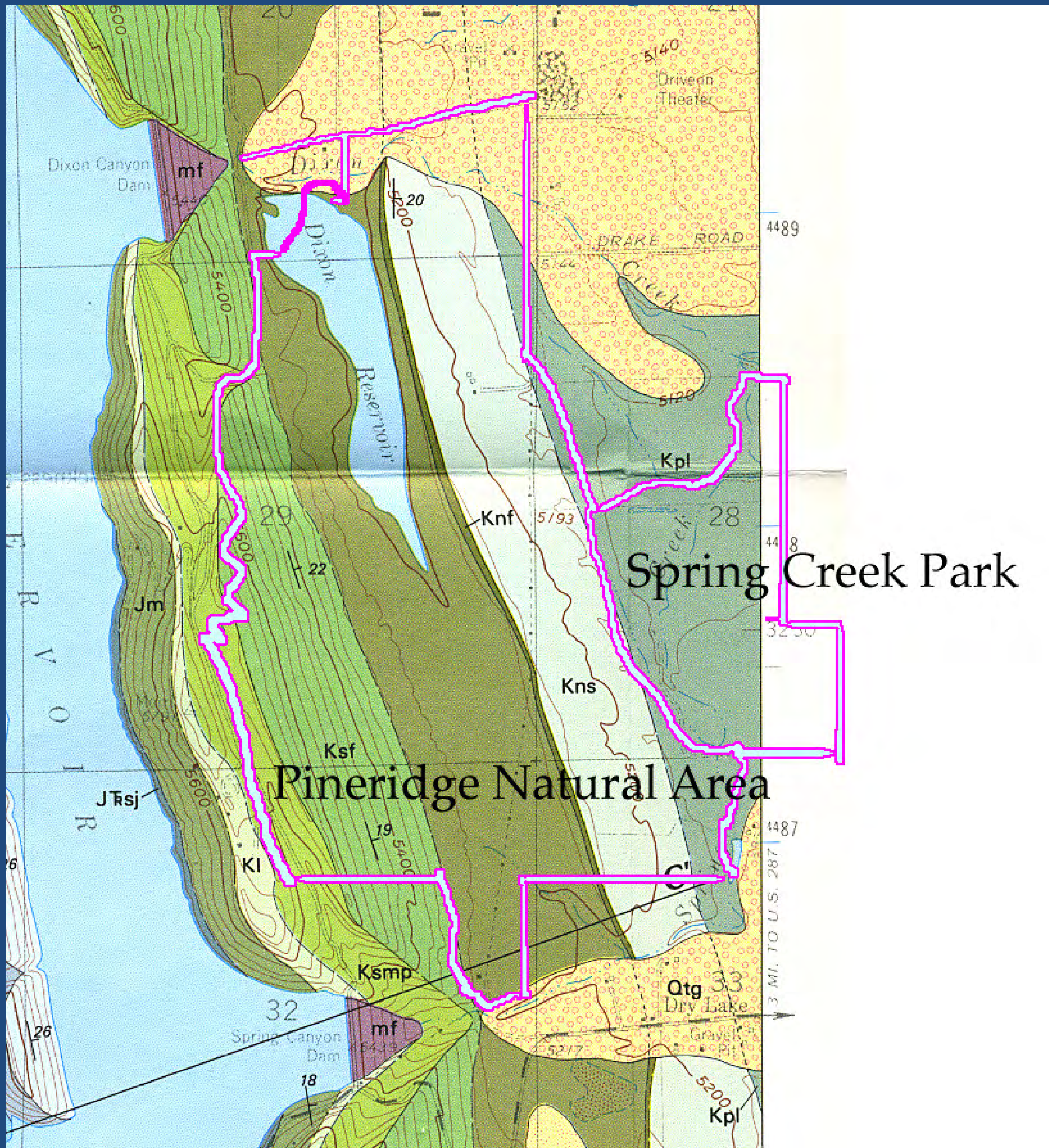
With the beds tilted up, the surface across them exposes hundreds of millions of years of time across a very short distance.

Photo by Louis Maher

Reservoir Ridge Natural Area



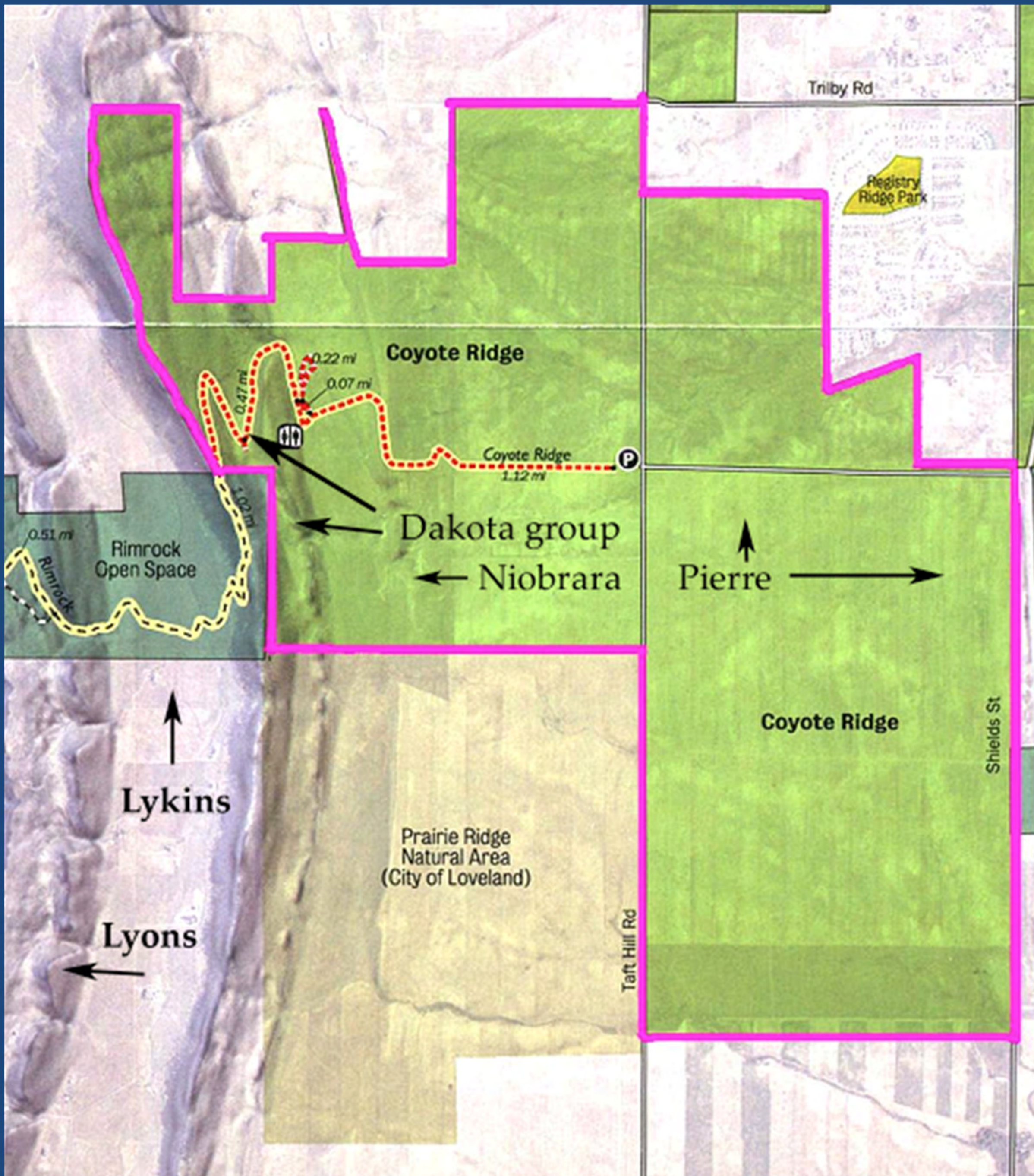
Adapted fromBraddock et. Al Geologic Map of the Horsetooth Quadrangle

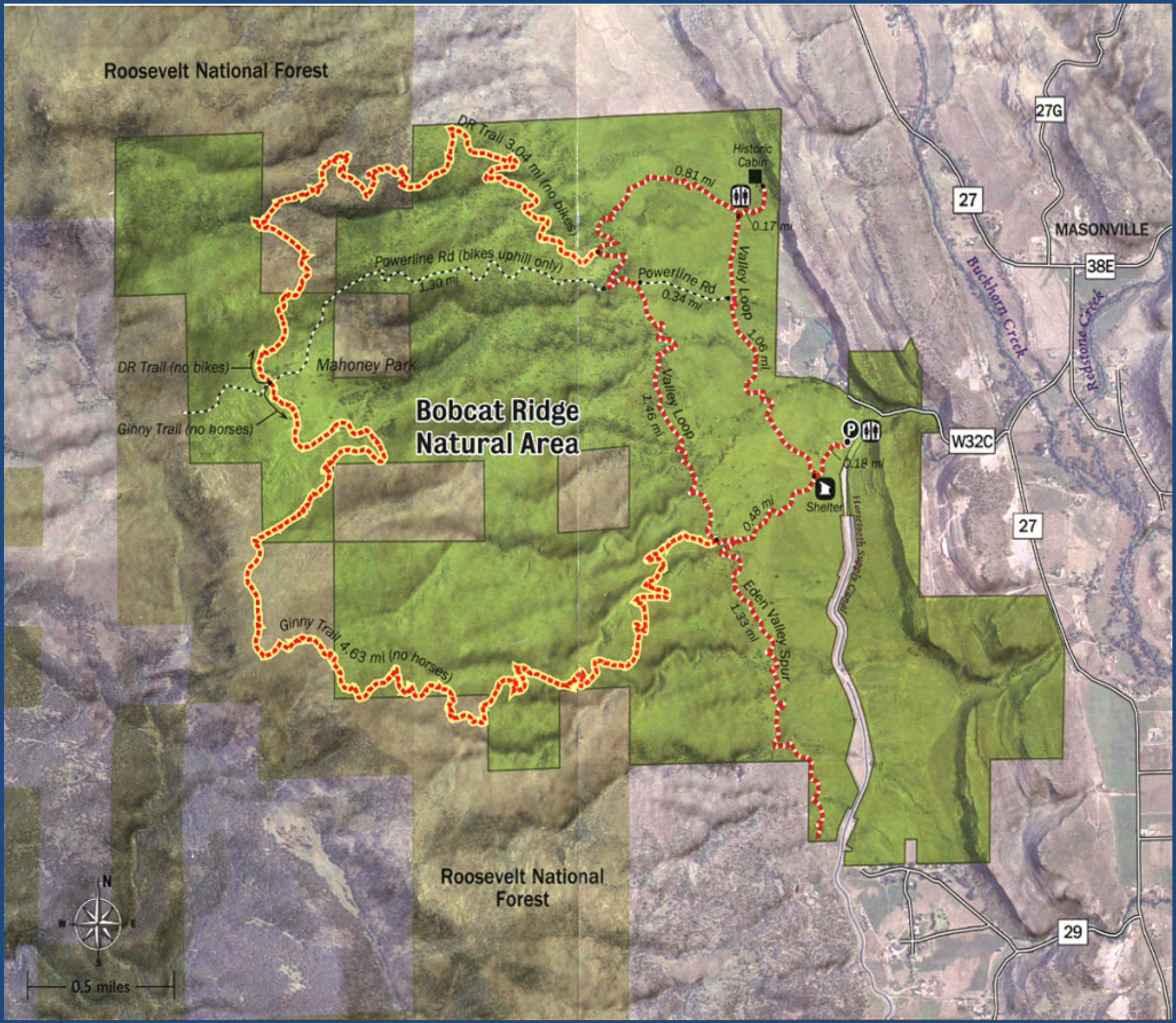


Pineridge Natural Area

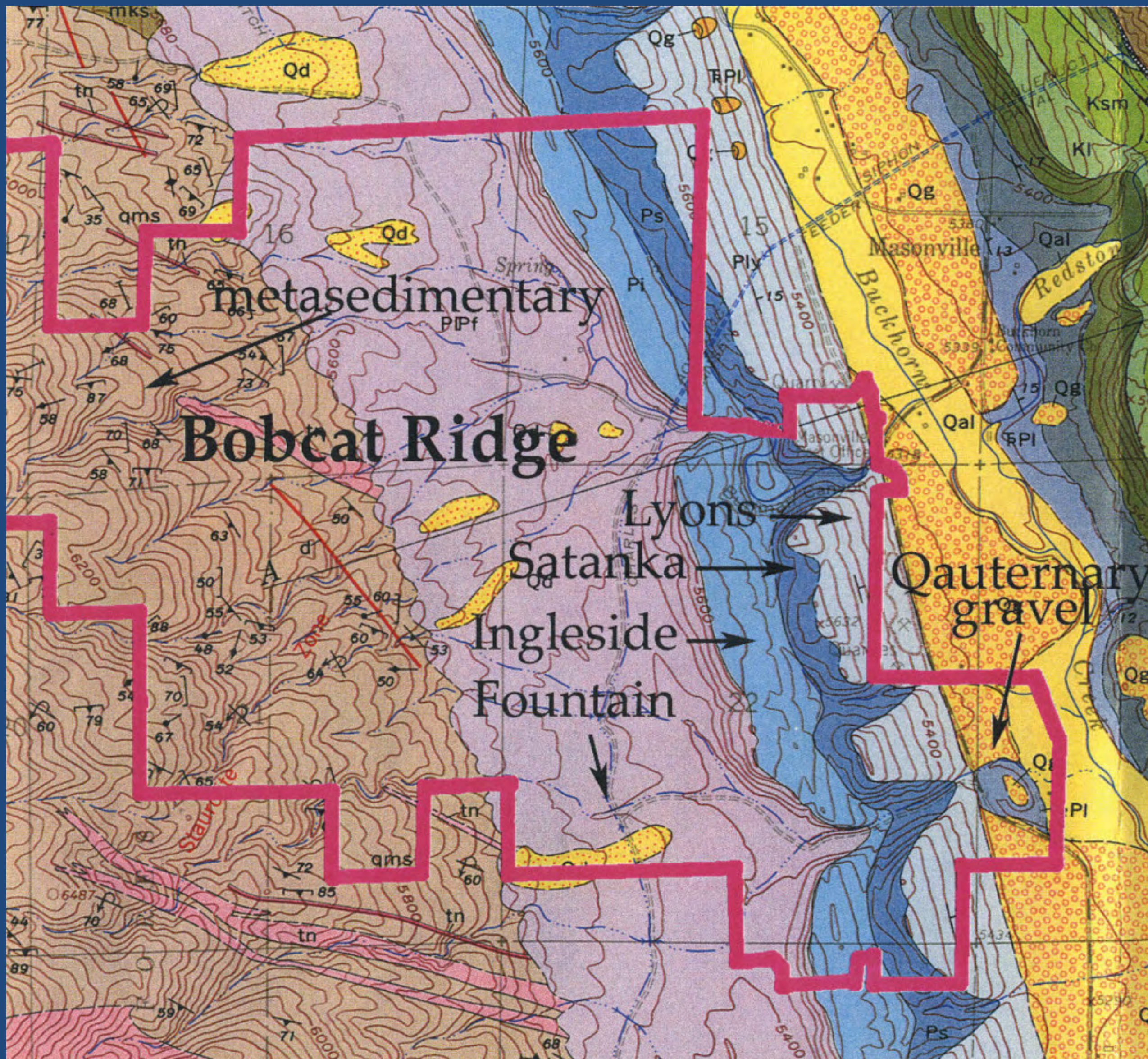
Adapted from Braddock et. al Geologic Map of the Horsetooth Quadrangle

Coyote Ridge

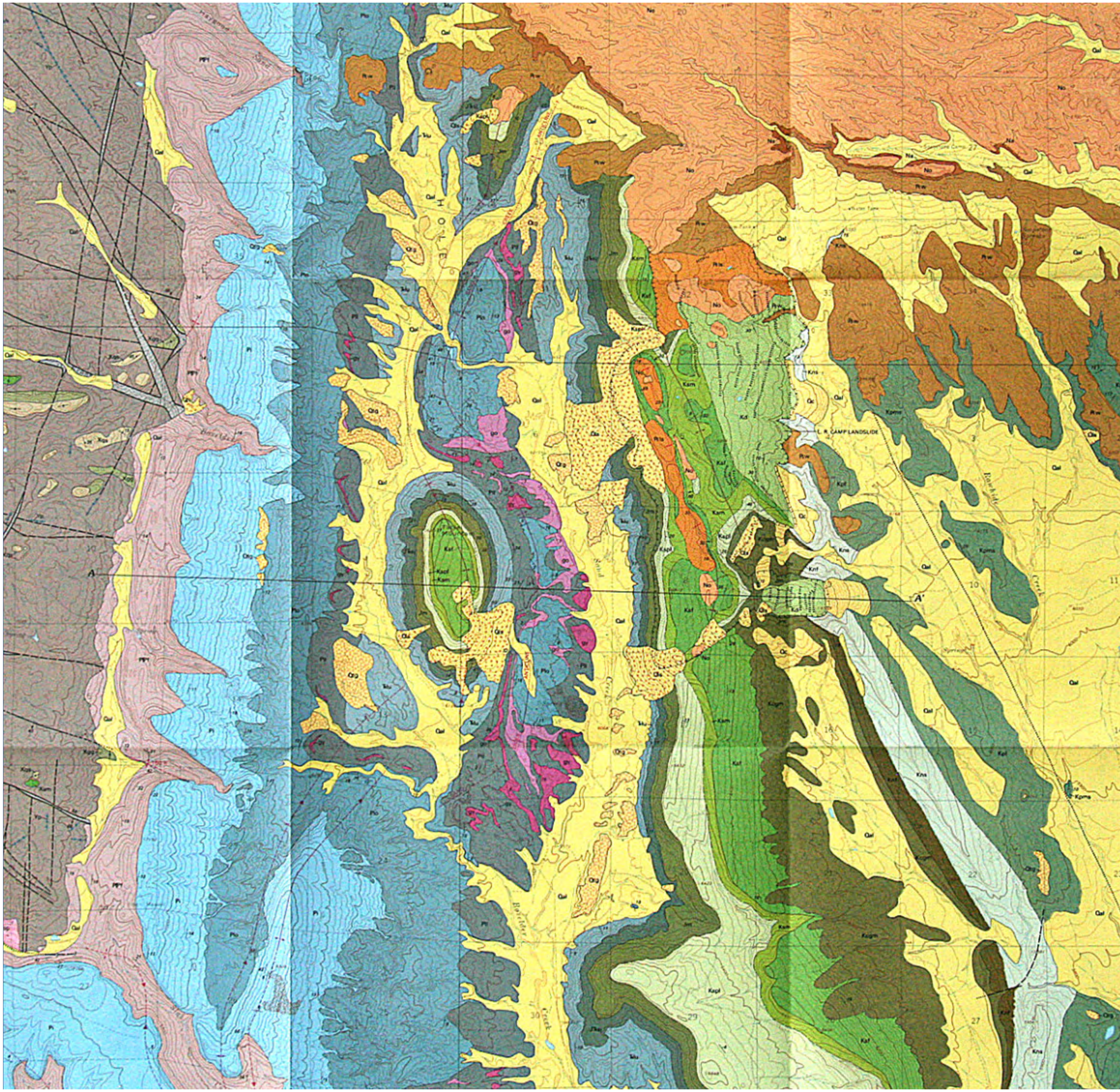




Bobcat Ridge

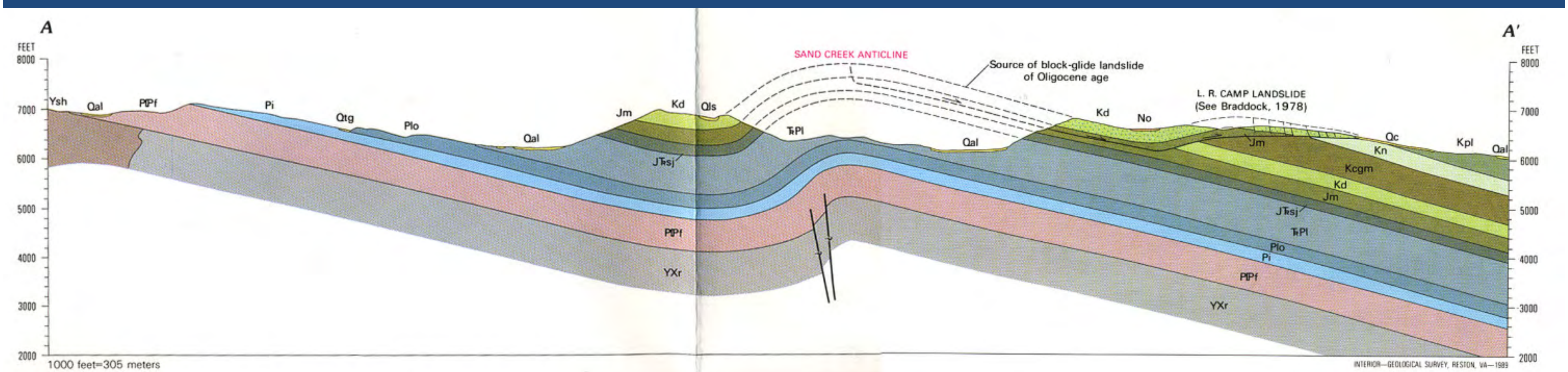


Bobcat Ridge



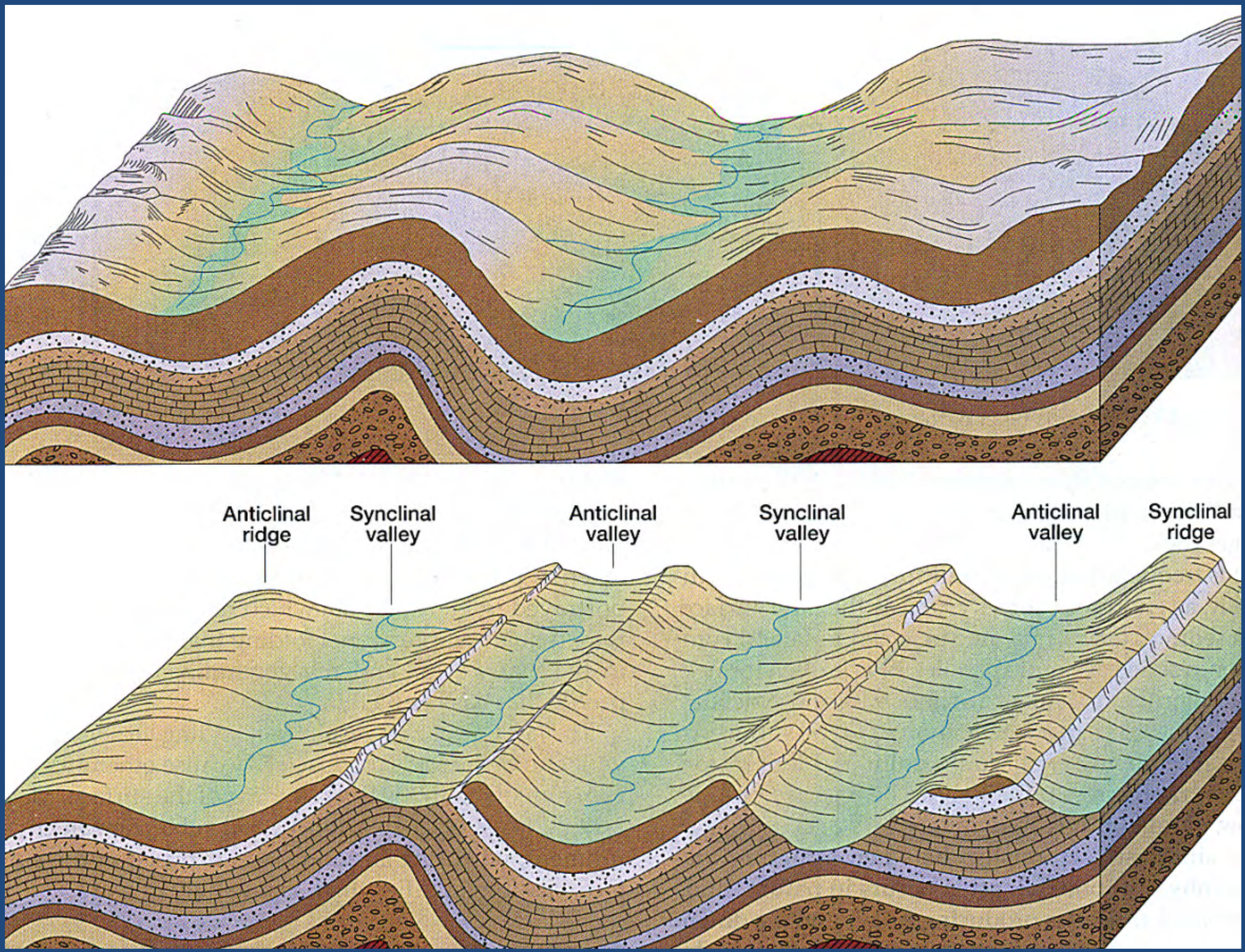
Red Mountain and Soapstone Prairie

Soapstone – Red Mt. Ranch



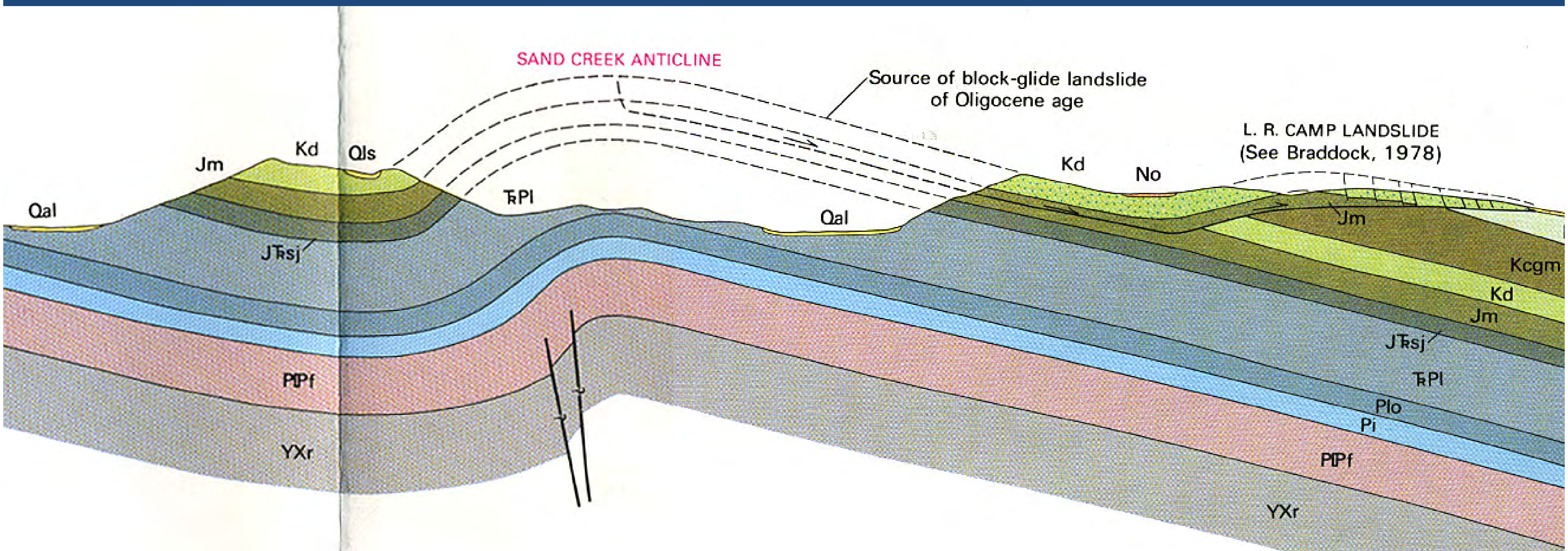
Courtright & Braddock, *Geologic Map of The Table Mountain Quadrangle*

Landscape reversal after time



McKnight and Hess, *Physical Geography*

Soapstone-Red Mountain Ranch



Courtright & Braddock, *Geologic Map of The Table Mountain Quadrangle*

Faulting

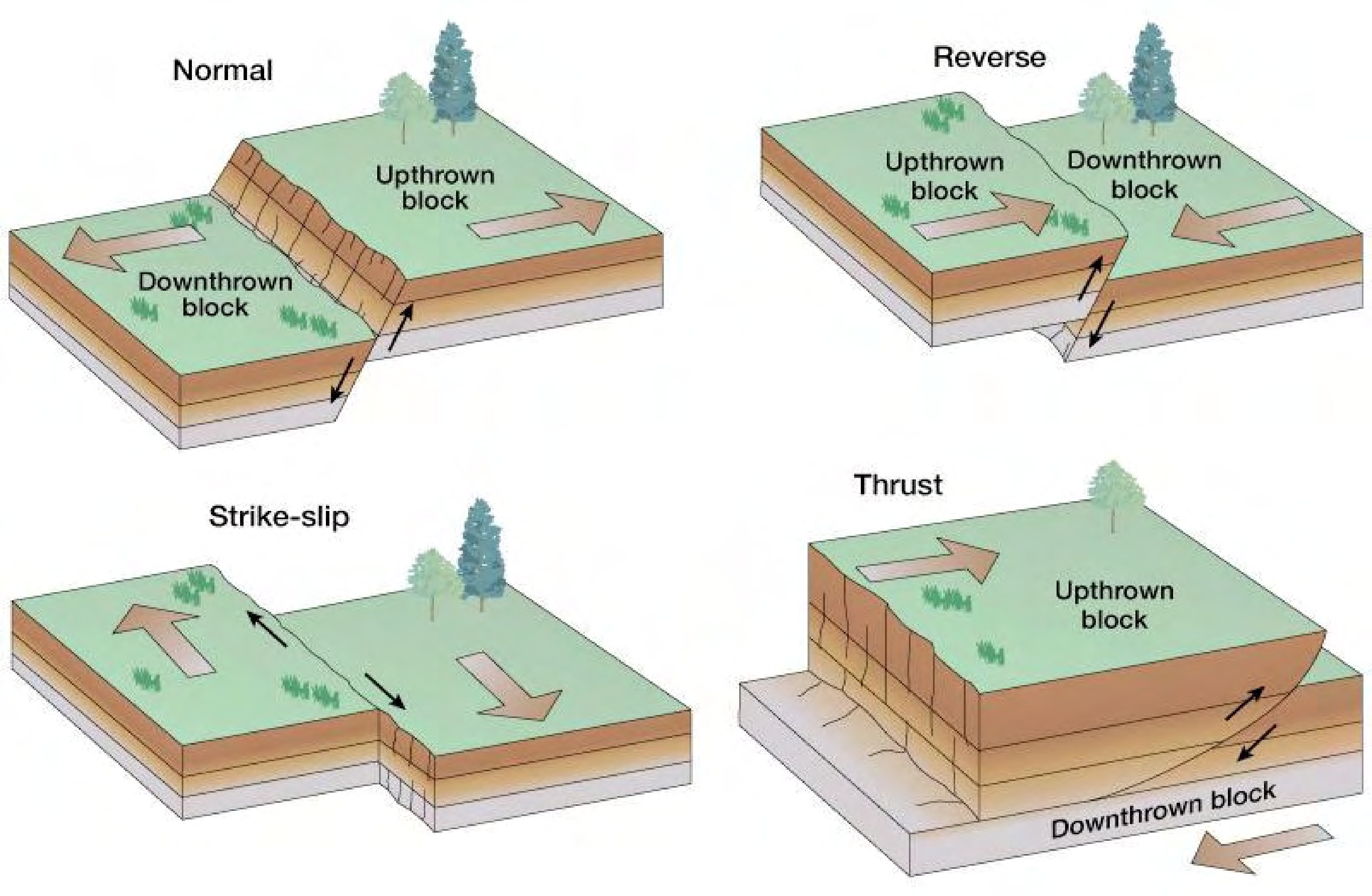
(breaking & moving)

Faults

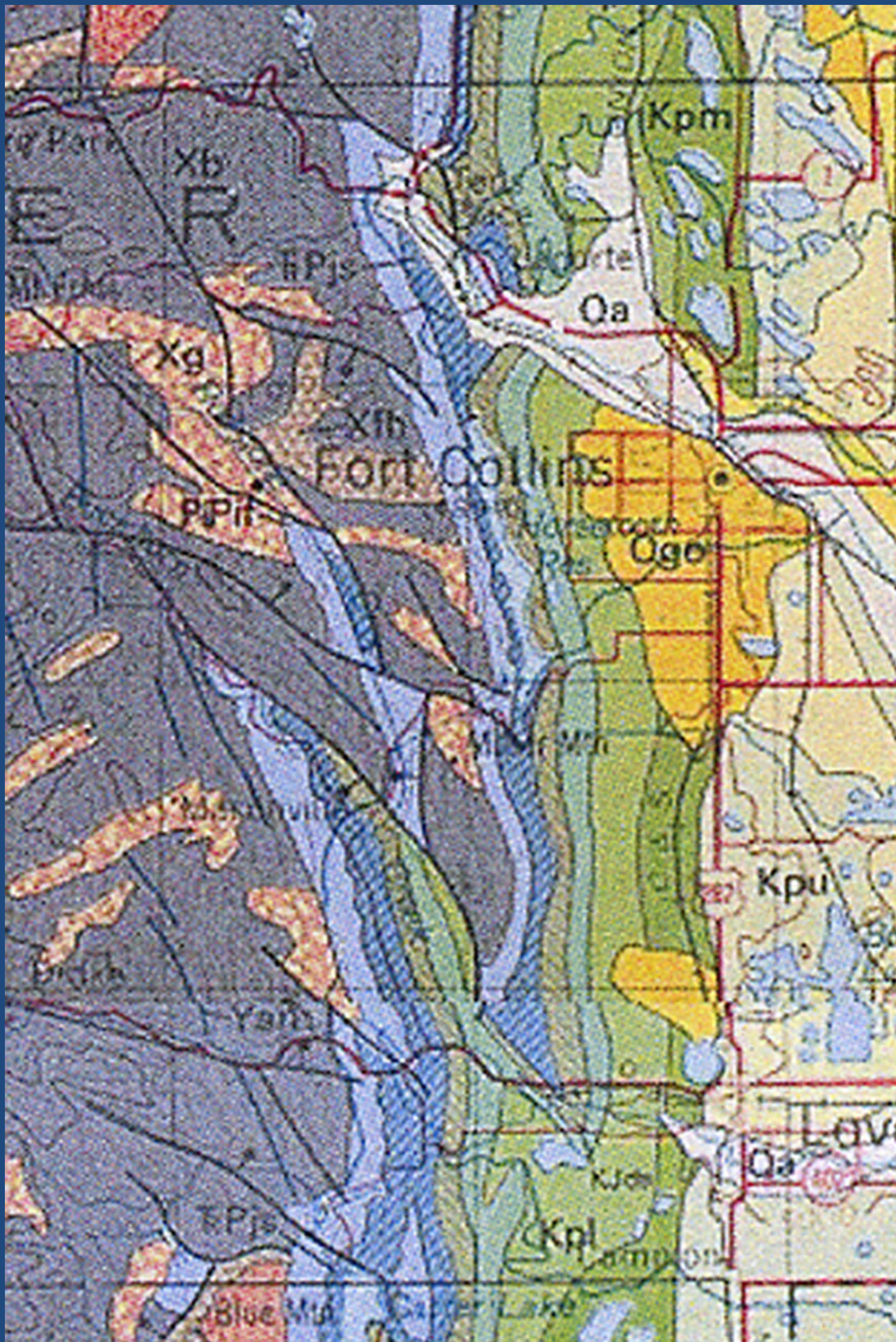
Faults are produced by:

1. Tensional forces —> Normal fault
2. Compressional forces —> Reverse fault
3. Shear forces —> Strike-slip and Transform faults

Types of Faults



McKnight and Hess, *Physical Geography*



Larimer County has its faults!

LANDFORMS SCULPTED BY WATER

Demolition

While landscapes are being created, they are also being worn away.

Demolition

Demolition has two components

1. weathering
2. erosion

Weathering = breaking up rocks

Before rocks can be removed they need to be broken up by weathering.

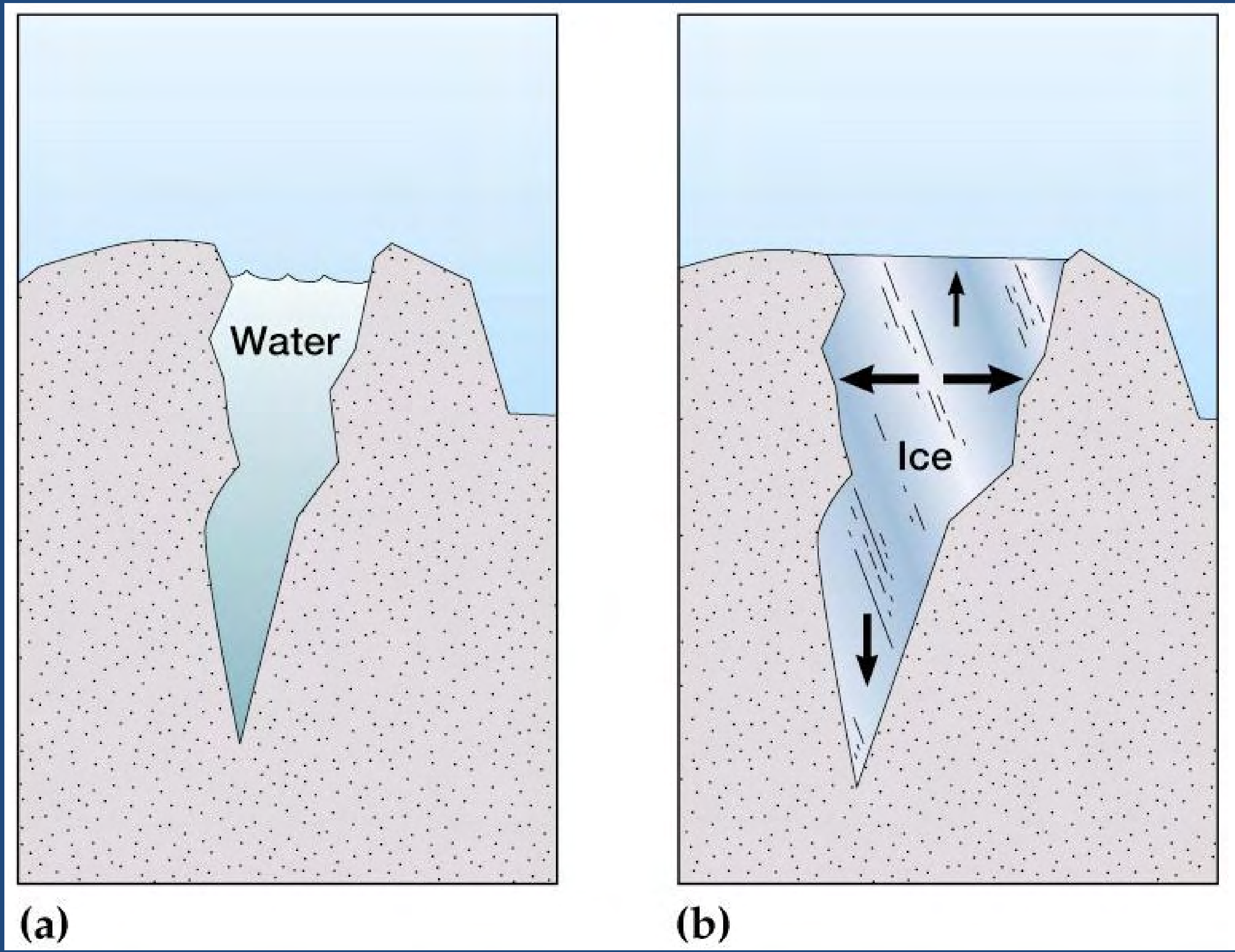
—mechanical

—chemical

Cracks in Granite

Highly Fractured Granite

Frost Wedging



McKnight & Hess, *Physical Geography*

Root Wedging

Unloading — Exfoliation

Chemical Weathering

Breaks down minerals within the rock

Spheroidal Weathering

Weathering of granite

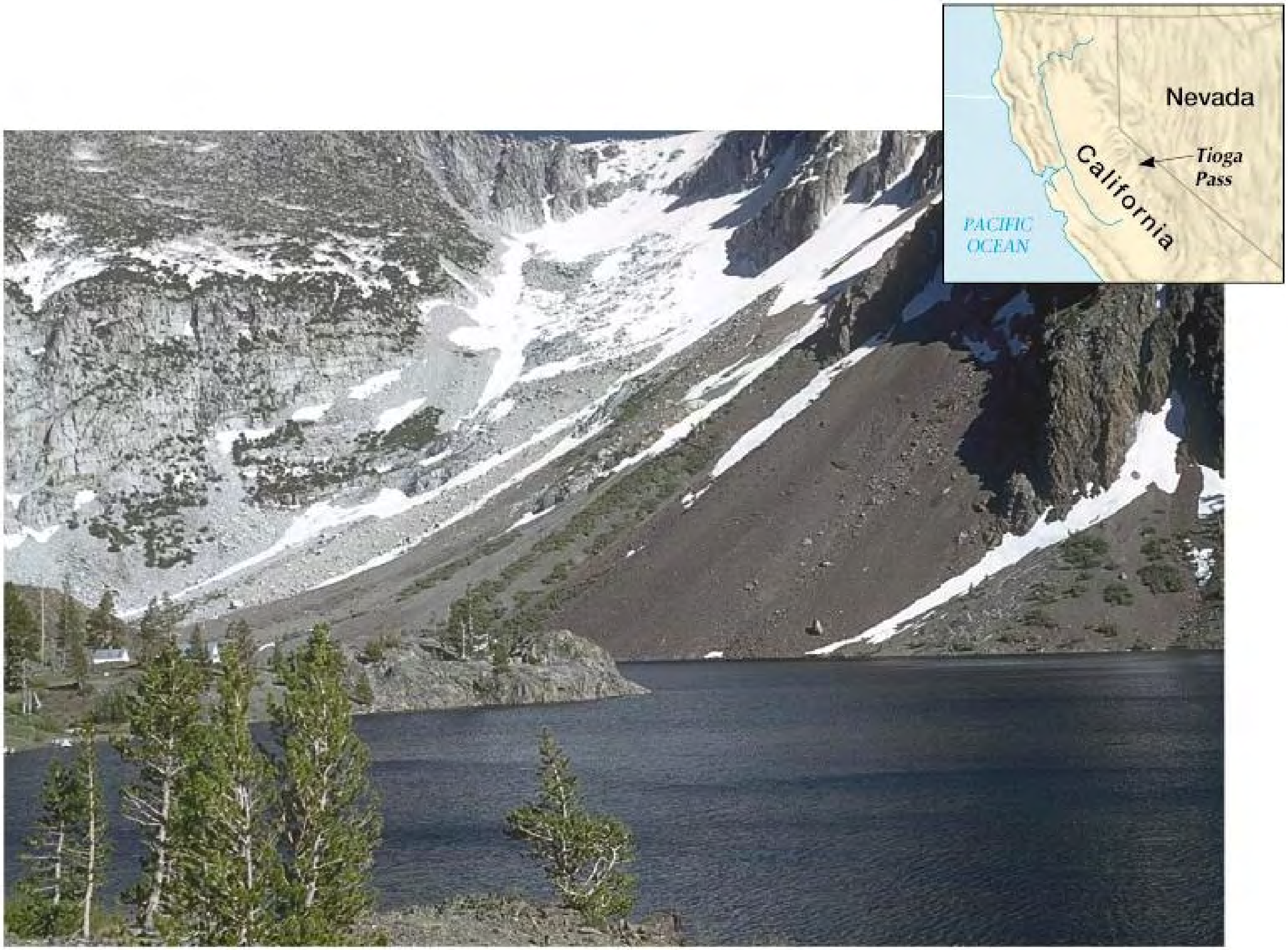
Gruss (weathered granite)

Elements of Erosion

Agents of removal

- mass wasting – gravity
- <u>flowing water</u>
- ice
- wind

Mass wasting —>talus



McKnight & Hess, *Physical Geography*

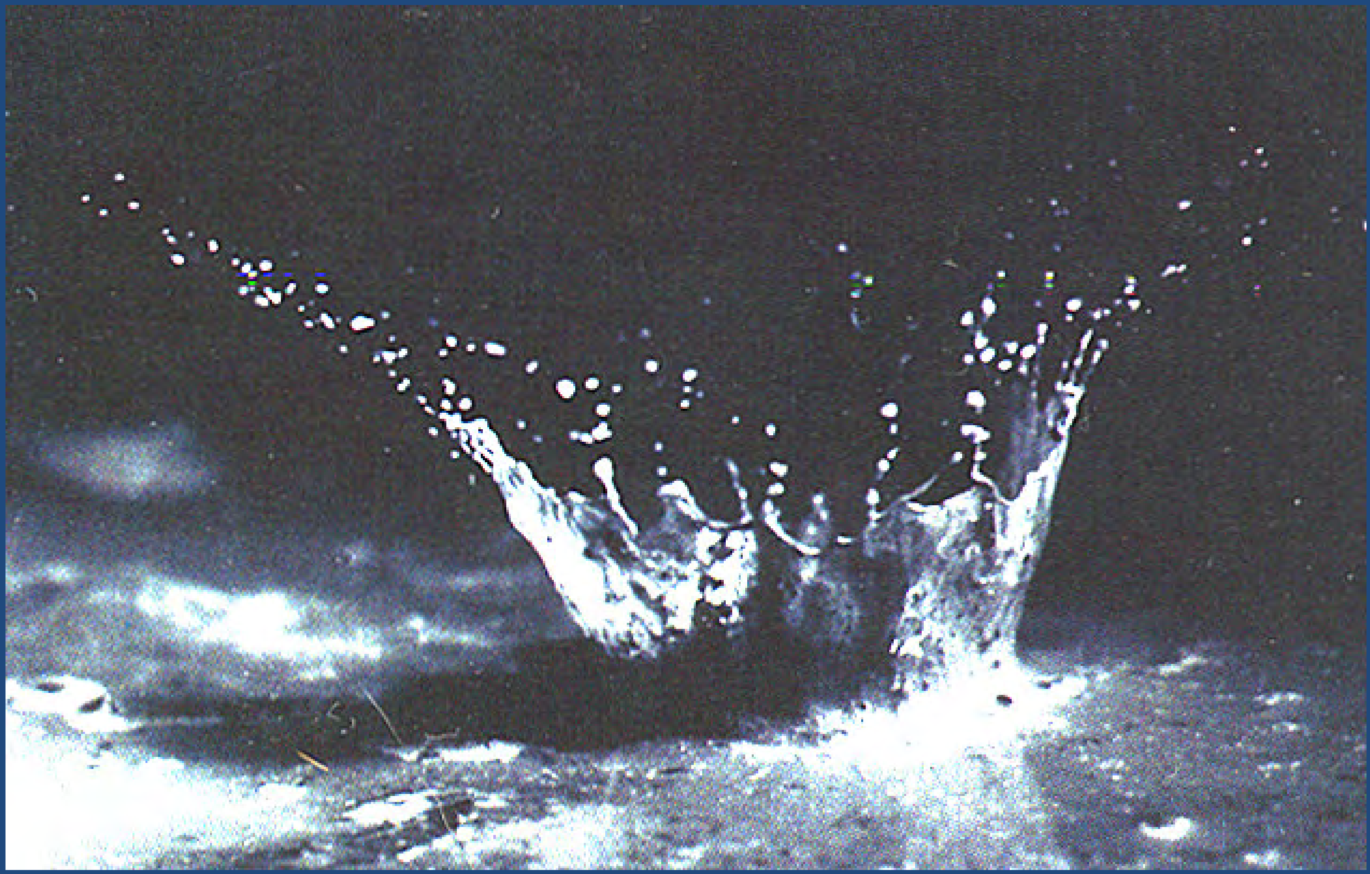
Water

—Flowing water is the greatest landscape remodeler.

—Flowing water's "passion" is to remove anything above sea level and carry it to the sea (base level).

—Streams are highly tuned and balanced systems using energy to move materials.

Erosion starts with raindrops



USDA

Work of streams

Ability of a stream to do work depends on:

—Volume (how much water)

—Velocity (how fast it is moving)

These quantities vary constantly.

Stream constantly adjusts its load to match its energy.

What work do streams do?

Streams do two things:

1. Remove material = Erosion
2. Deposit material = Deposition

Occurs in different parts of stream.

Occurs in same part at different times.

Stream erosion

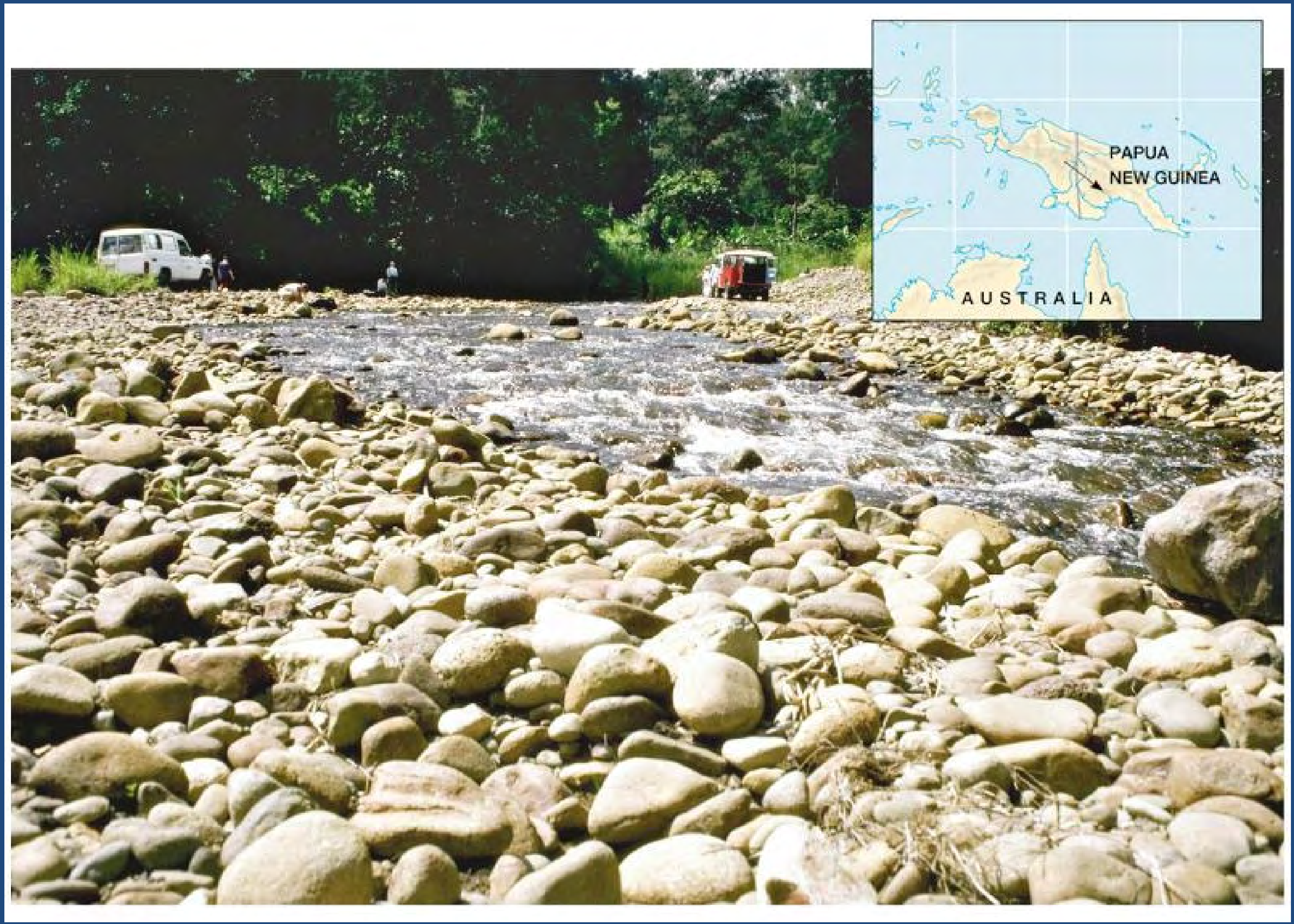
Streams remove materials in three ways

1. Power of water’s flow
2. Abrasion
3. Corrosion

Power of the current

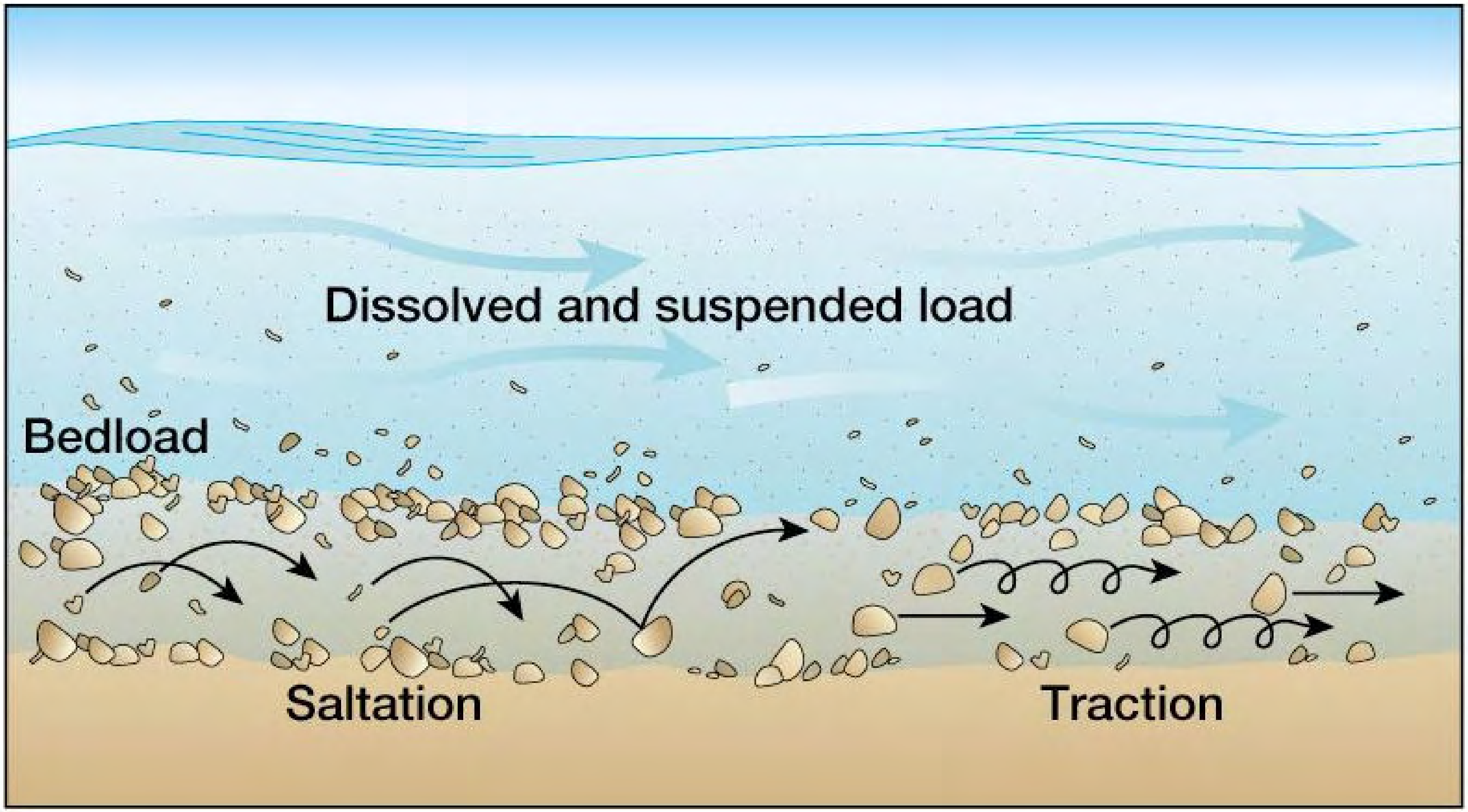
Lawn Lake Flood

Streambed Abrasion



McKnight & Hess, *Physical Geography*

How Streams move materials



Arbogast, *Discovering Physical Geography*

Stream Energy and Valley Shape

To see if a stream is eroding or depositing (net effect)look at its valley.

Valley Shape

Eroding

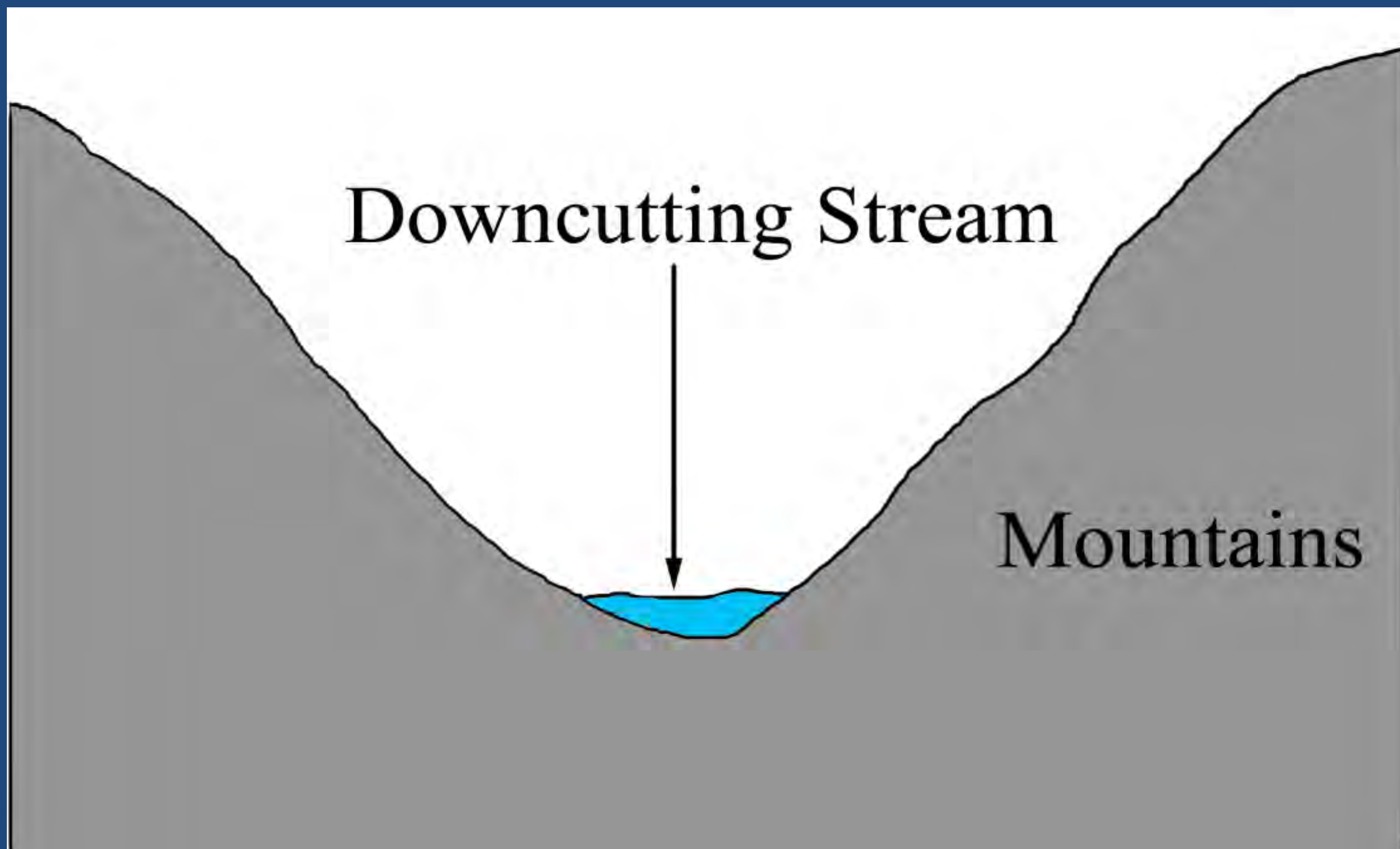
—High gradient (high energy) headwaters —> straight, steep valley sides

Depositing

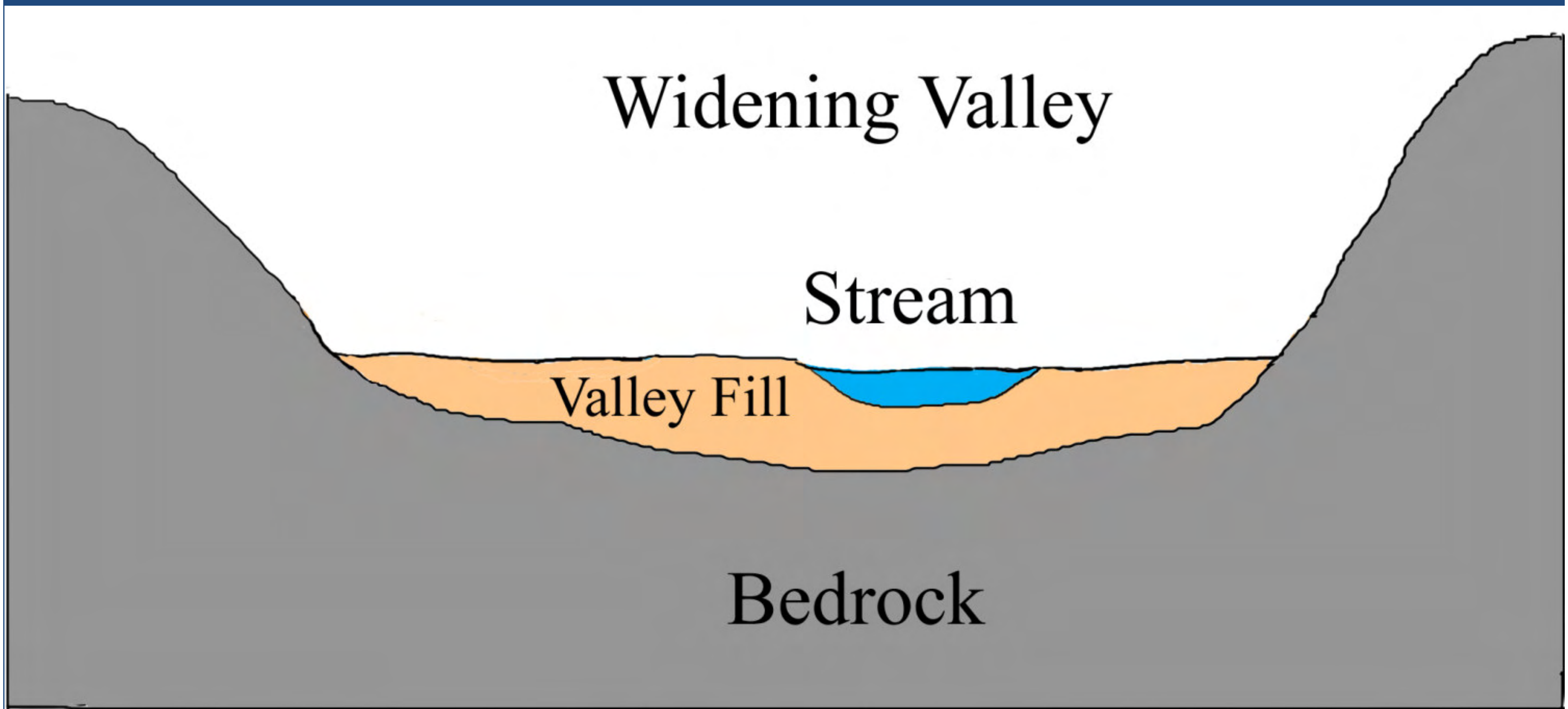
—Lower gradient and energy —> meandering, wider valley

Steep Gradient/High Energy

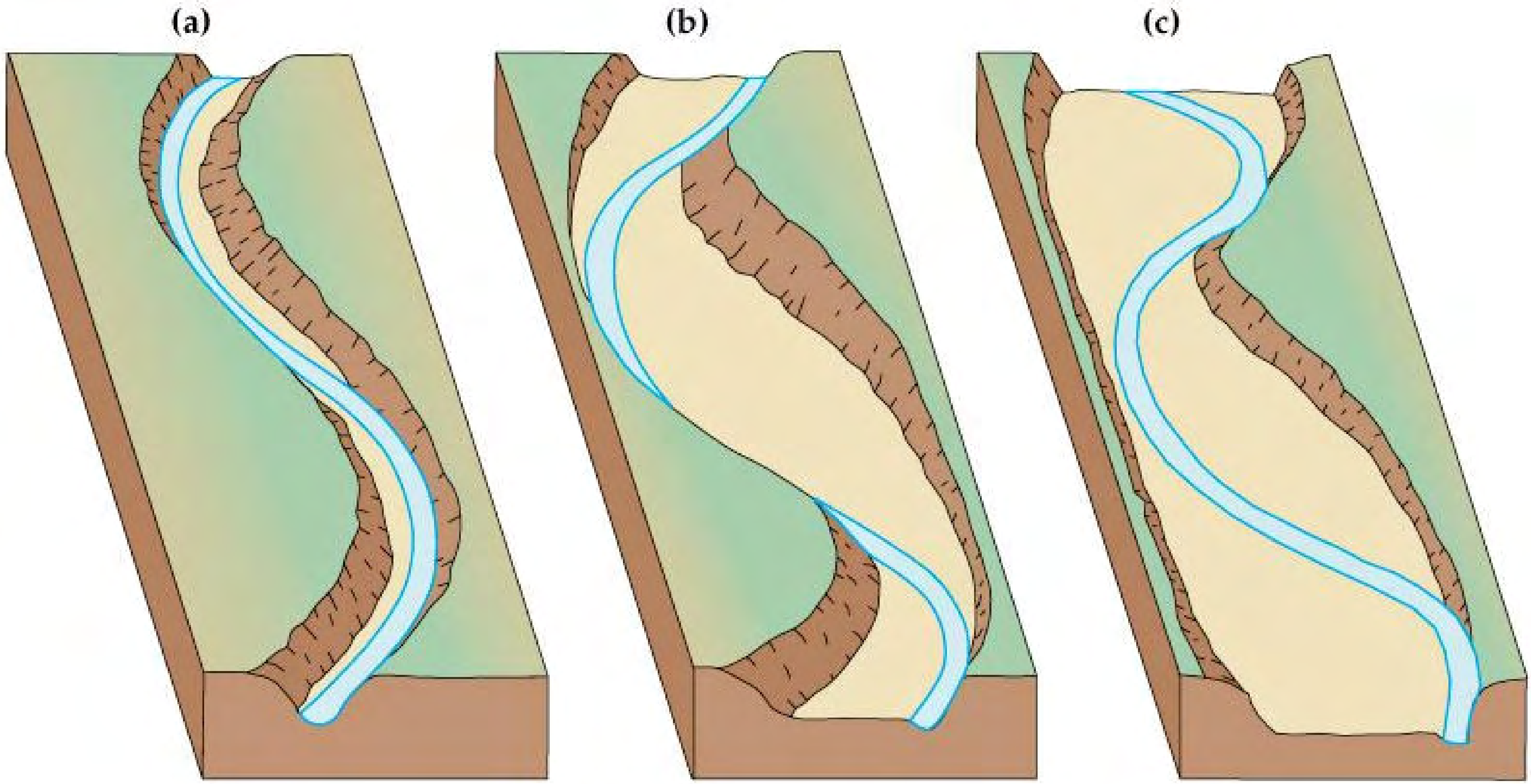
Headwaters



Lower Gradient/Less Energy

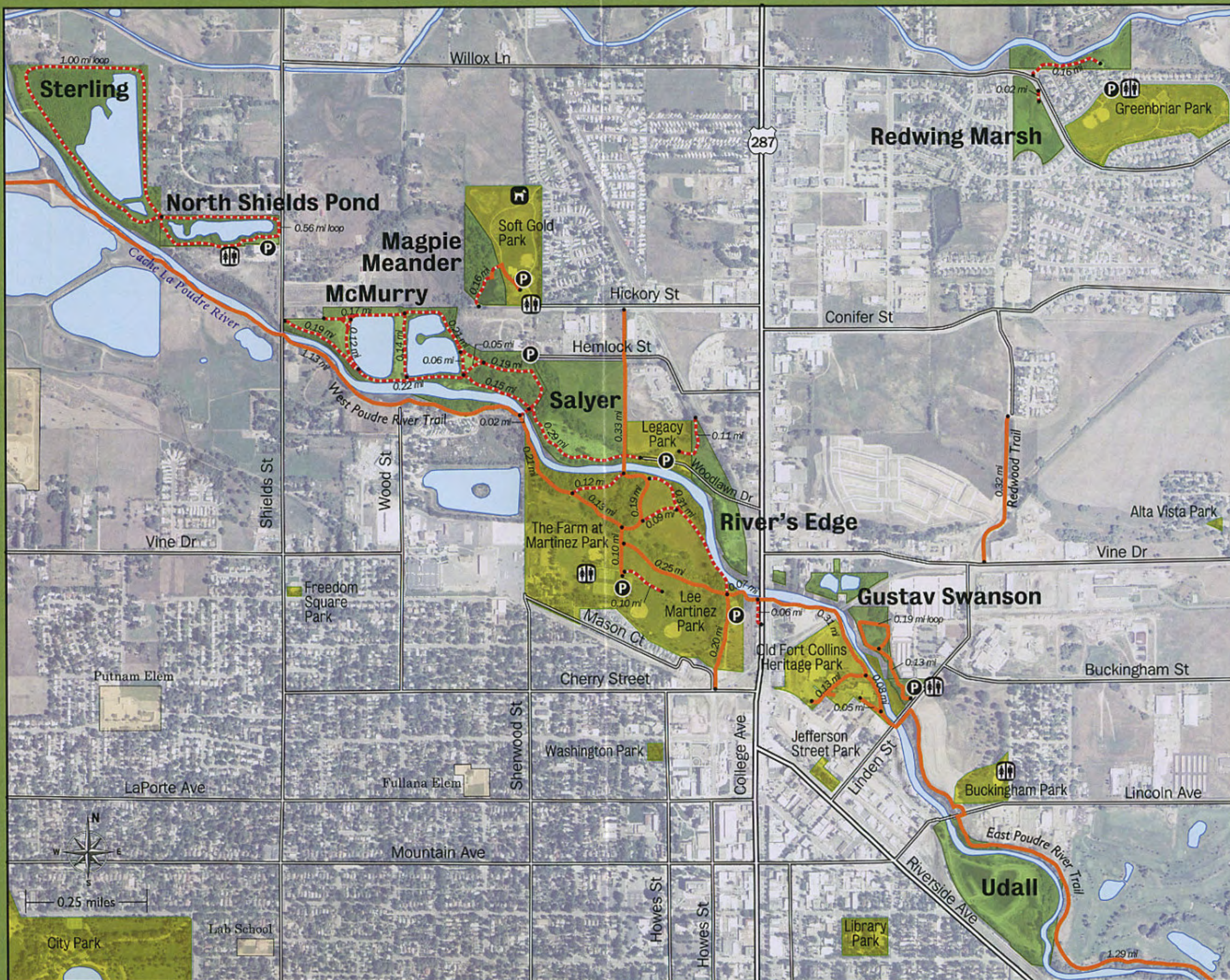


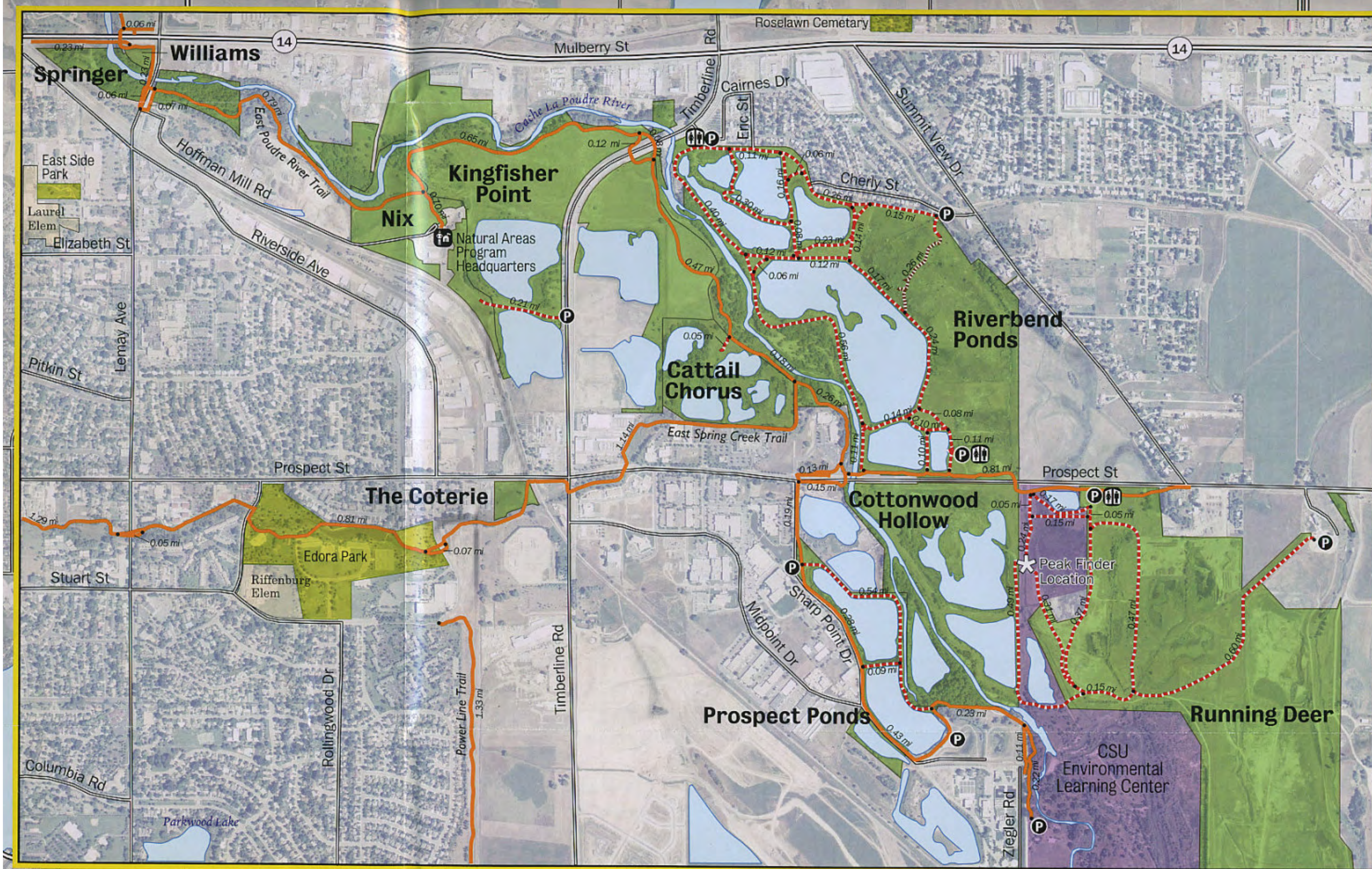
Valley Widening



McKnight & Hess, *Physical Geography*

Cache La Poudre River Corridor Natural Areas (north)

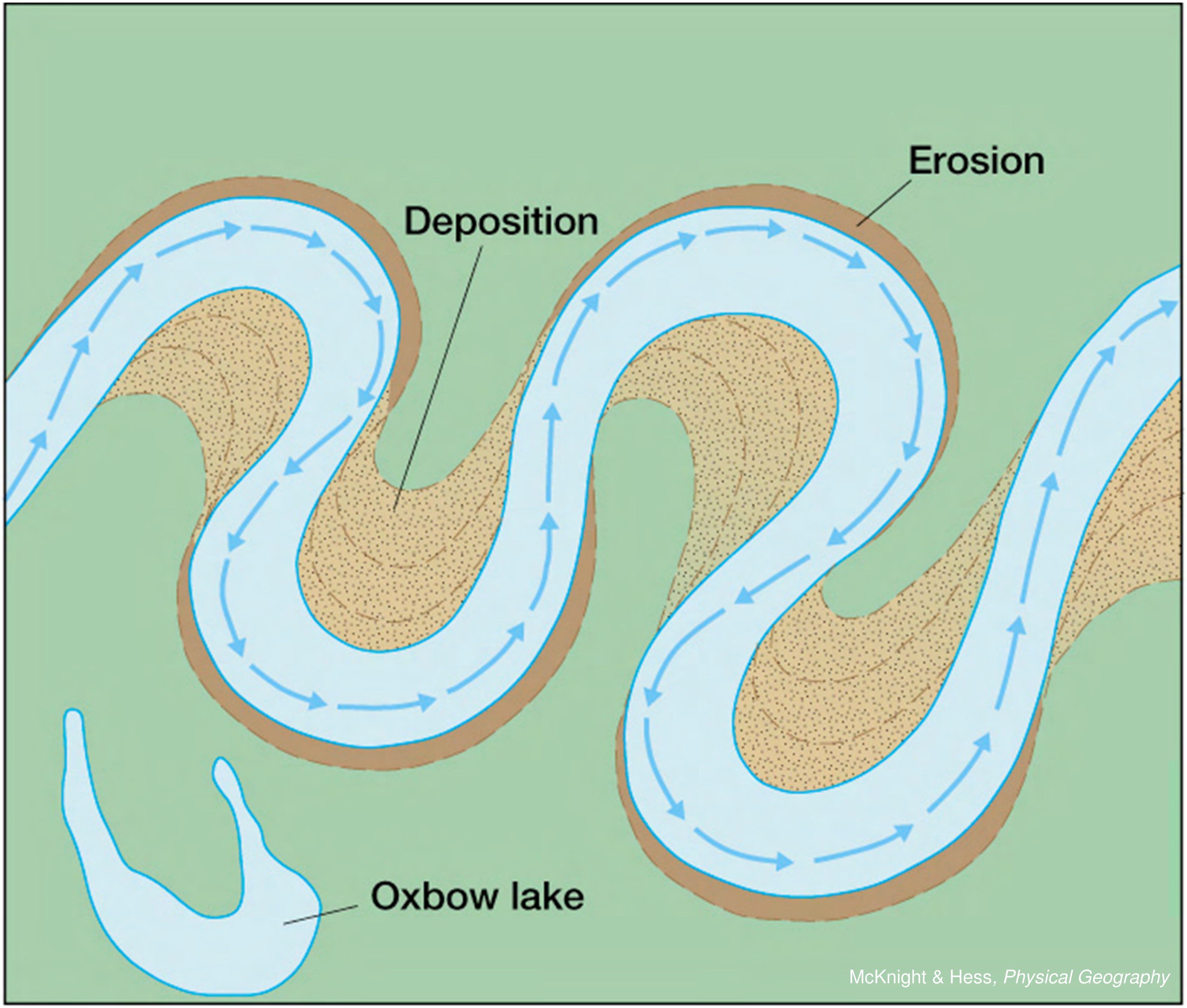




Roselawn Cemetery
Mulberry St
14
Williams
Springer
Timberline Rd
Cairnes Dr
Eric St
Summit View Dr
Cherly St
Cache La Poudre River
East Poudre River Trail
Hoffman Mill Rd
Riverside Ave
East Side Park
Laurel Elem
Elizabeth St
Kingfisher Point
Nix
Natural Areas Program Headquarters
Riverbend Ponds
Cattail Chorus
East Spring Creek Trail
Pitkin St
Lemay Ave
Prospect St
The Coterie
Cottonwood Hollow
Edora Park
Riffenburg Elem
Stuart St
Peak Finder Location
Midpoint Dr
Sharp Point Dr
Power Line Trail
Rollingwood Dr
Prospect Ponds
Running Deer
CSU Environmental Learning Center
Ziegler Rd
Columbia Rd
Parkwood Lake

Poudre Pointbar

Poudre sandbar


Erosion
Deposition
Oxbow lake
McKnight & Hess, *Physical Geography*

Amazon Meanders

Change in Stream Regime

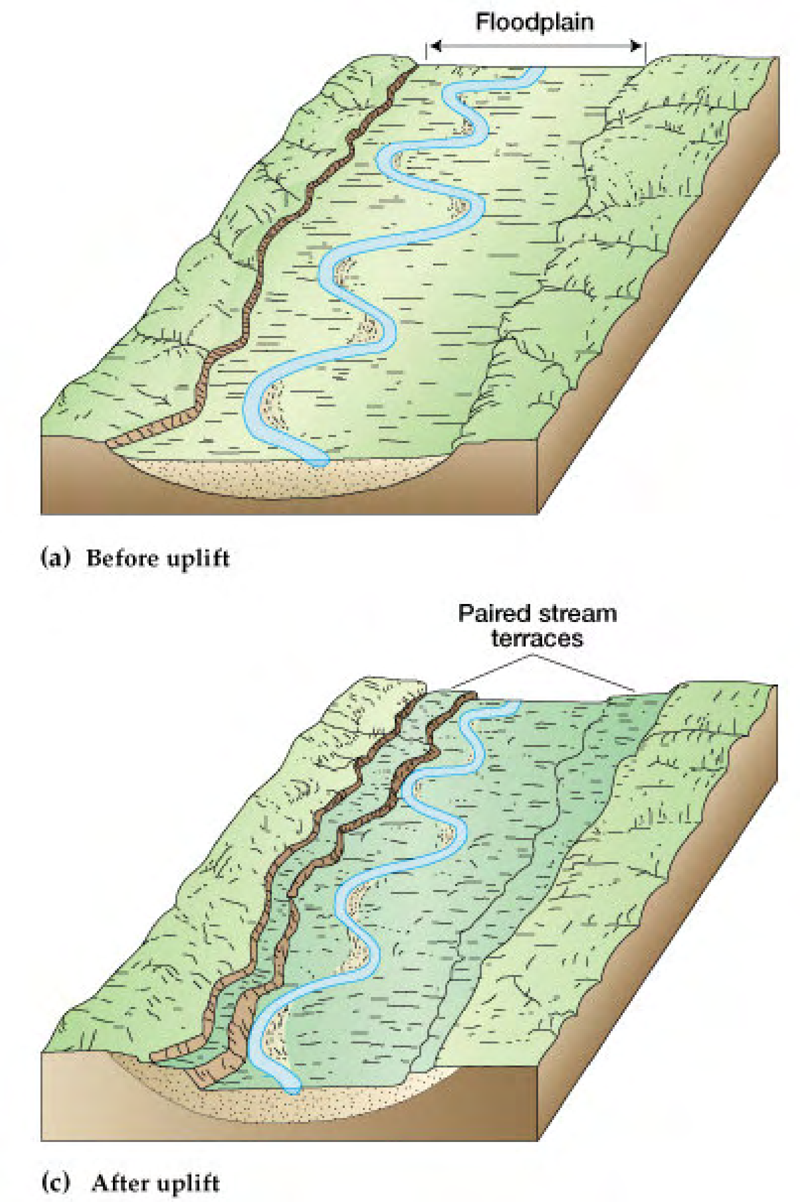
Streams can go from net eroding to net depositing or vice versa if

—the land rises or falls or

—the sea (base) level rises or falls

Rejuvenated streams —> terraces

Stream Rejuvenation



Stream Terraces

Stream Terraces

Caucasus Mountains

Gregory, The Lie of the Land

Historical Erosion

Erosion surfaces in mountains

pauses in mountain uplift —> streams cutting sideways —> flatter areas

Later rejuvenation = streams cut down again leaving mountain tops at same heights

Stream Rejuvenation

Long pauses in mountain uplift changed streams from downcutting to widening.

Renewed uplift changed streams back to downcutting again.

Erosional Surfaces

Stream Rejuvenation

Rapid uplift of mountains —> rapid downcutting by streams

- Big Thompson & Poudre Canyons
- Black Canyon of Gunnison
- Royal Gorge

Rejuvenated Stream-Big Thompson

Flooding

Floods are natural stream behavior.

Area flooded = floodplain

Floods are important because they:

— flush deposits downstream,

— bring in new soil,

—destroy and renew vegetation,

— damage man-made things

THE ROCK SOLID

END