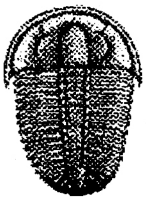
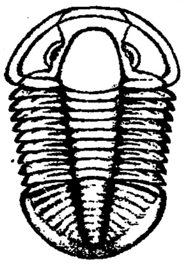
# Fossil Identification

## Most Common



Elrathia Kingi

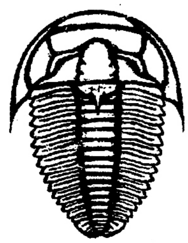


Asaphiscus Wheeleri

Peronopsis Interstricta (Agnostus)

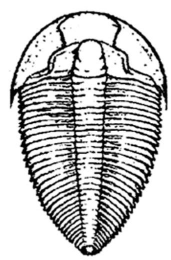
Brachiopod

## Less Common

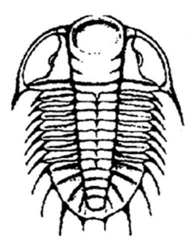


Bolaspidella Housensis

## Rare



Alokistocare Harrisi



Olenoides Nevadensis

Trilobites flourished from about 550 million years ago to about 250 million years ago. They swam, crawled, and floated in ancient seas and oceans. Trilobites and the materials that encase them provide evidence of dramatically changed conditions of Utah. Earth scientists deduce from trilobite, coral, and sponge fossils that what-is-now Utah was south of the Equator and resembled today's Bahamas.

What has happened since then? Note how the layers of bedrock that you hunt trilobites in today are tilted. That tilting is evidence of tectonics. During dinosaur time, compressional tectonics built mountain ranges across this region of Utah and those processes tilted the bedrock units. That was about 75 – 65 million years ago… long after the trilobites swam and died in the shallow seas.

Our present geologic environment is dominated (a) by extensional tectonics that has created the basins and ranges of the Great Basin over the past 20 million years and (b) by climate change that has changed scenery over the past 4 million years. The basins of the Basin and Range physiographic province are dry during global interglacial climate regimes, and have large lakes during global glacial times. Lake Bonneville is the most recent of the large lakes and dates from the Ice Ages of only about 30,000 – 13,000 years ago. So… don't confuse the seas of the trilobites with the lakes of the Ice Ages.

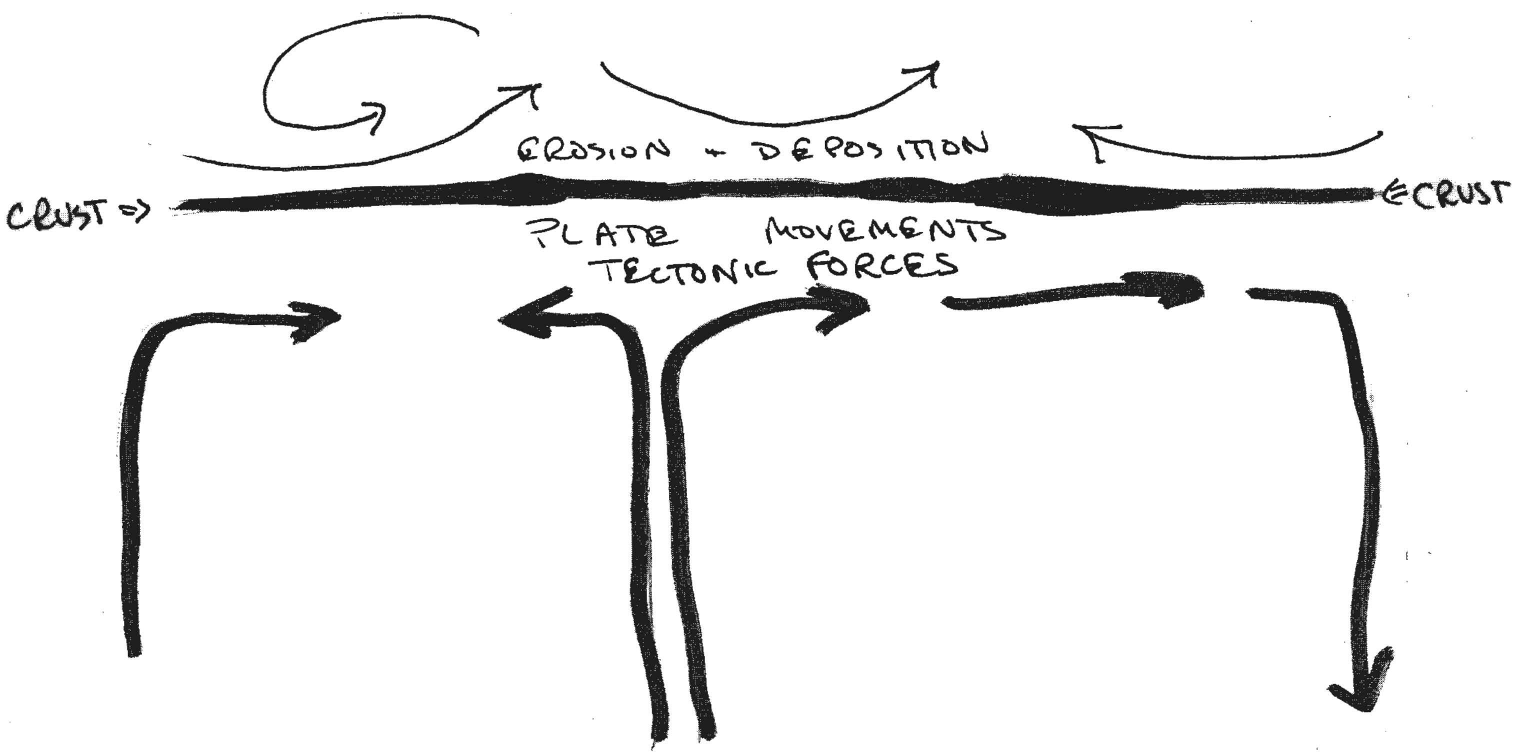
What a difference a half-billion years makes!

# BACKGROUND

How do we know the *geologic* history of Utah? The evidence is in the *rocks* and *landforms.* Before we begin the story, we want to introduce four fundamental geologic principles. Others will be introduced as they are needed.

*PRINCIPLE 1:* **The earth is dynamic and continually changes.**

Forces within the earth (*tectonic* forces) produce movements upward, downward, and laterally of portions of the Earth's *crust.* Forces acting on the surface of the Earth, modify the surface of the earth by *erosion* and *deposition.*

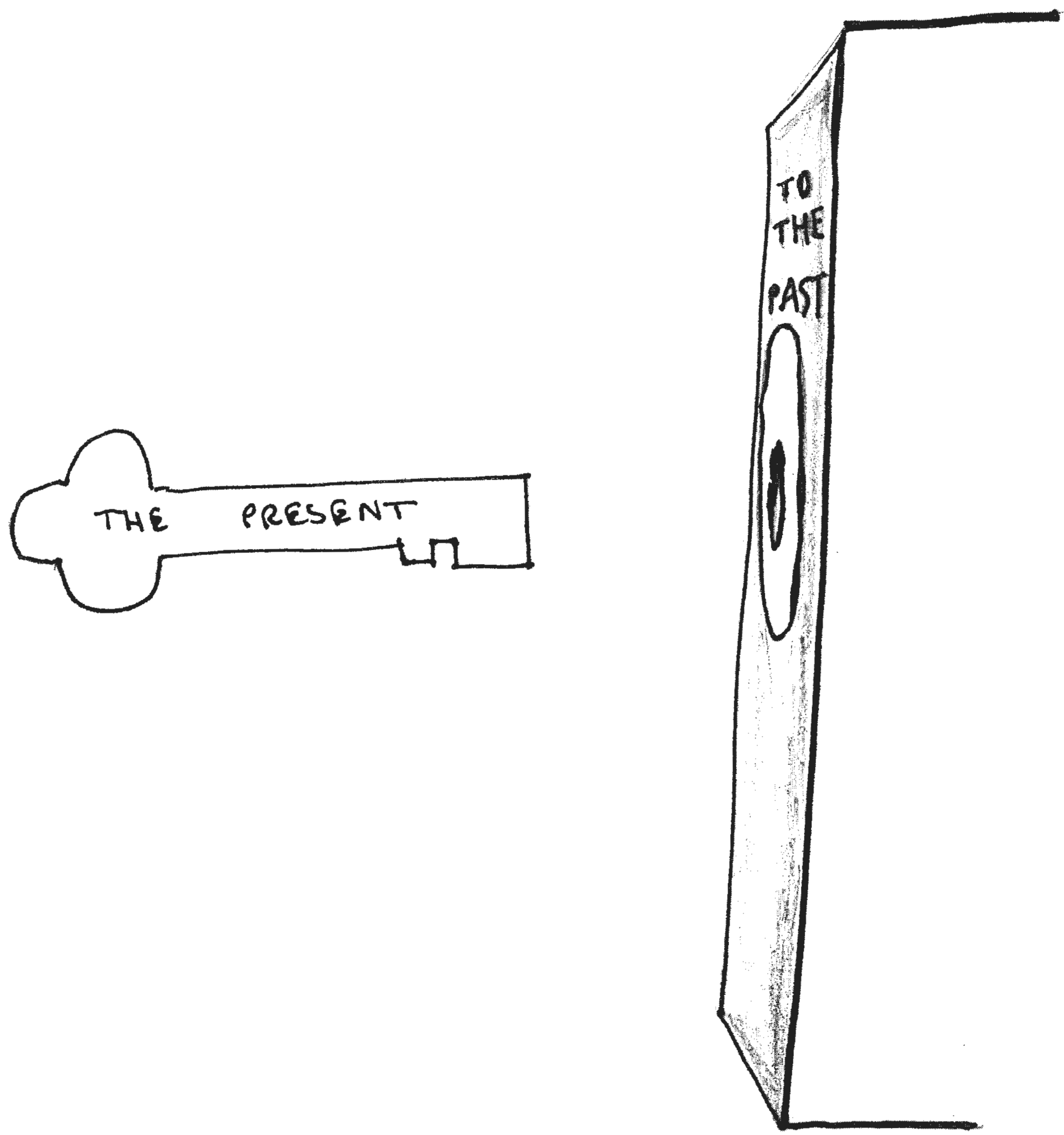





TEACHER FEEDBACK:

## *PRINCIPLE 2:* **The present is the key to the past.**

The same processes we observe today that form and modify rocks and landforms have been operating unchanged, though at different rates, throughout the history of the earth. This is the *Principle of Uniformitananism.* Somewhere on or in the Earth, rocks like most of Utah's rocks are in the process of forming today. Studying the conditions that produce these rocks today tells us about the conditions that existed when Utah's rocks were forming.





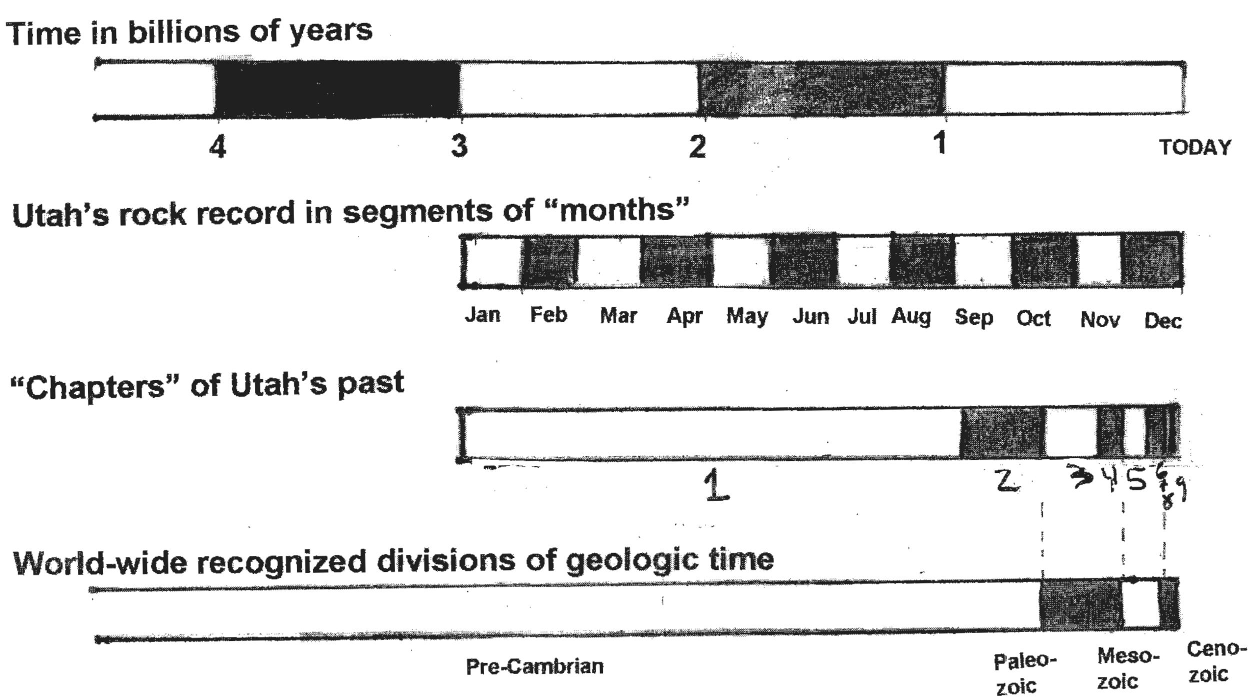

TEACHER FEEDBACK:

## *PRINCIPLE 3:* The vast length of *geologic time* is difficult for even earthscientists to comprehend.

When we think of historic time we think in such units of time as the 150 years since the Mormon pioneers settled in Utah, the 500 years since Columbus sailed to America, the nearly 5000 years since the pyramids were built in Egypt, and the 10,000 to 15,000 years that human beings have inhabited the Great Basin.

In this book we want to relate the three billion years geologic history that Utah rocks record to a comprehensible time frame. If the three billion years of geologic history recorded by Utah rocks equaled one "year" then the time since the pyramids were built would be three-quarters of a minute; the time since Columbus five seconds, and the time since the pioneers arrived in Utah two seconds. Throughout this book we will relate geologic time to this one year time scale.

Some of Utah's rocks are among the older rocks studied by earth scientists, but even Utah's rocks do not record all of Earth's approximately 4.5 billion year history.



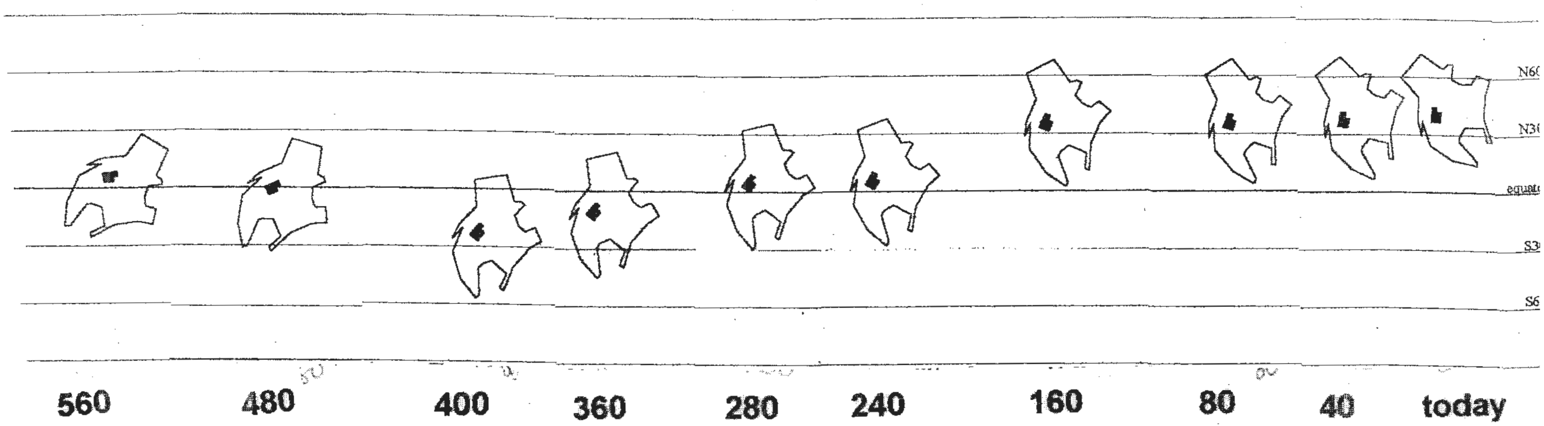



TEACHER FEEDBACK:

## *PRINCIPLE 4:* When we discuss "Utah" in the geologic past we are referring to what would become the State of Utah.

Surveyors have marked Utah's borders. Every place in the state is referenced to geographic coordinates (latitude and longitude for example). However, every year Utah's borders change, however imperceptibly. Tectonic forces move masses as large as continents and as local as individual landforms. Forces acting within the earth and on Earth's surface alter well known land features in spite of the legislation that makes those features political boundaries.

The geographic coordinates that define Utah today have little meaning in describing events that occurred millions or billions of years ago. The North American continent has wandered north and south of the equator. Utah's land surface has been contracted and stretched. Most of today's familiar landmarks simply weren't here 20 million years ago. Thus when we describe a condition that existed "in Utah" in the geologic past, we are describing the condition that existed where the rocks of that age, now in Utah, were at that time. Even this is sometimes difficult, because rocks that are now juxtaposed in the same area may have been far apart when they were formed.




Adapted from Hintze 1988.

**Location of Utah with respect to the equator.**

**Utah's temperate present contrasts with its mostly tropical past.**

**Numbers refer to millions of years. Note how this diagram shows only the last half billion years. In the time scale of one year equaling Utah's 3.5 billion year rock record, the time represented is only October 21 to December 31st.**

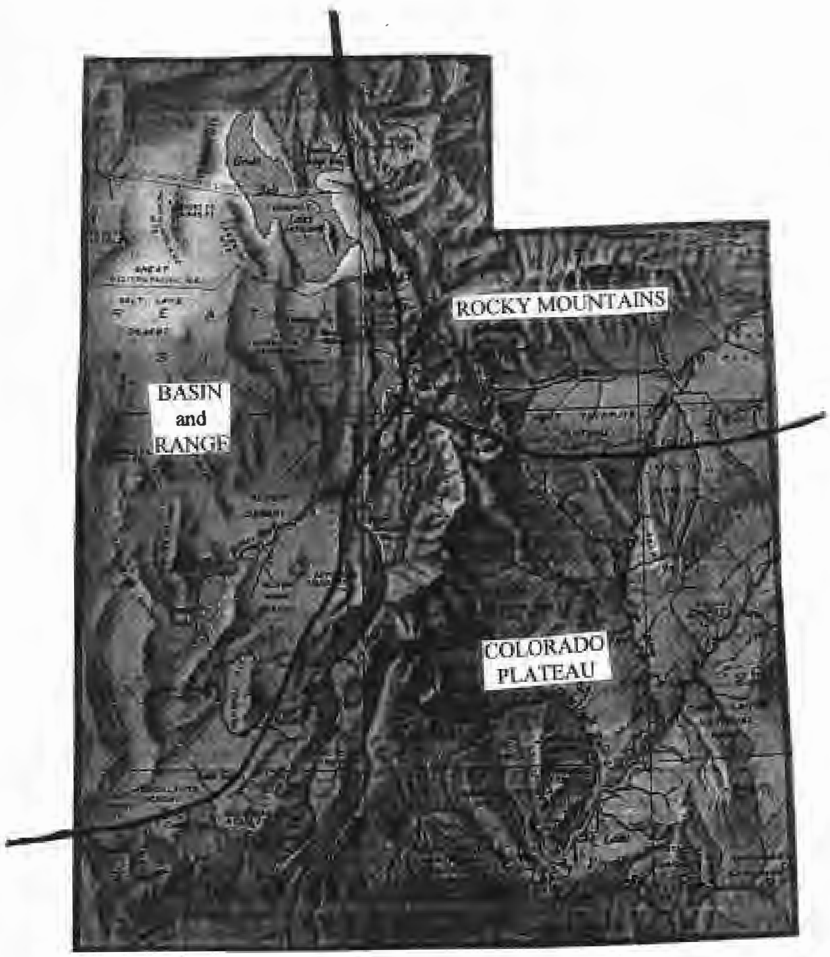
**North America is outlined only for perspective... the North American continent has changed significantly during this time.**



TEACHER FEEDBACK:

# UTAH TODAY

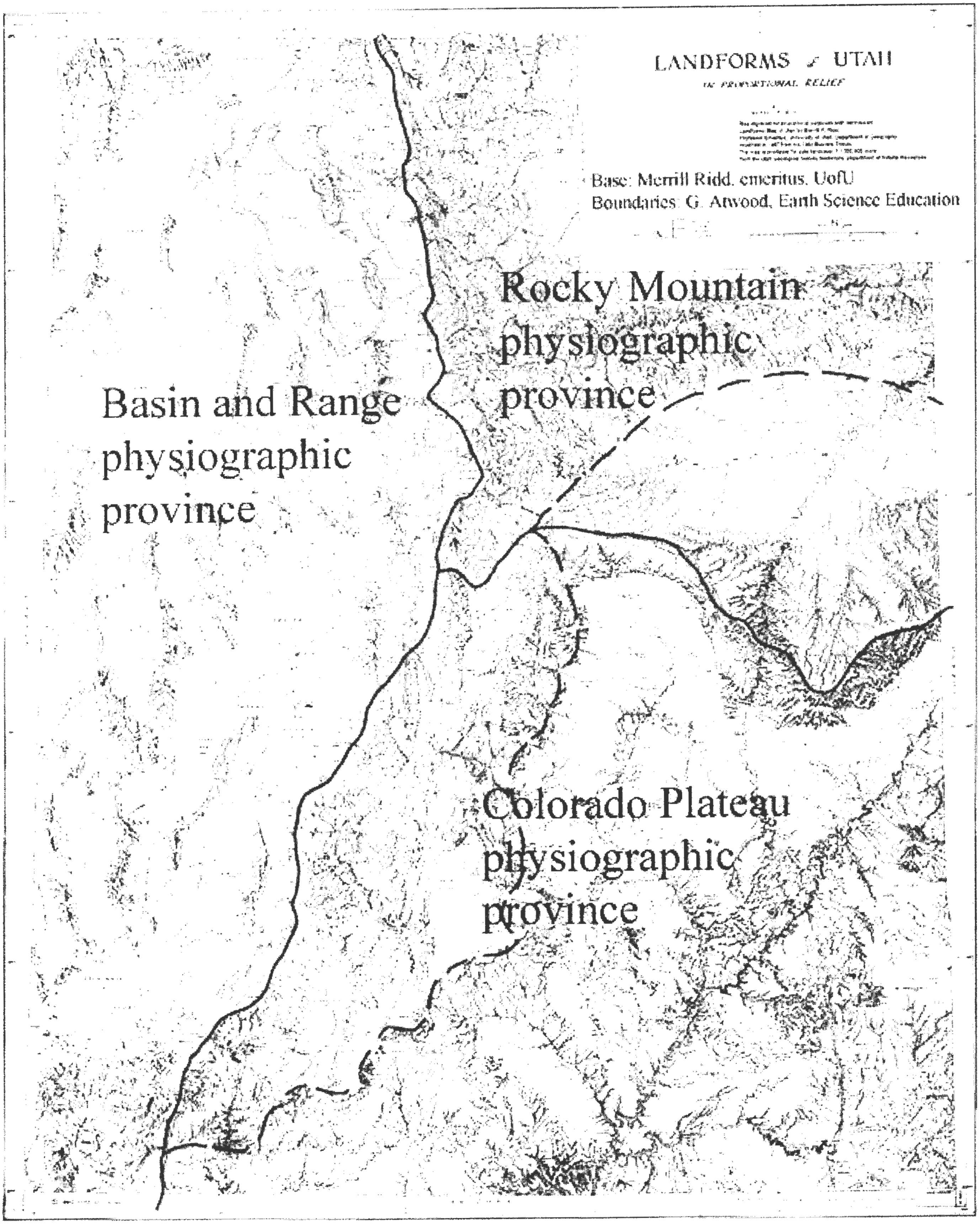
The present features of the landscapes of Canyonlands, Antelope Island, and the Uinta Mountains look different. Geographers divide Utah into three areas called *physiographic provinces* based on significant differences in the present features of Utah's land surface. These regions are: Basin and Range, Rocky Mountains, and Colorado Plateau. Only a portion of each of these provinces lies within the state's boundaries. Why do the regions look so different? Because they have different geologic histories.

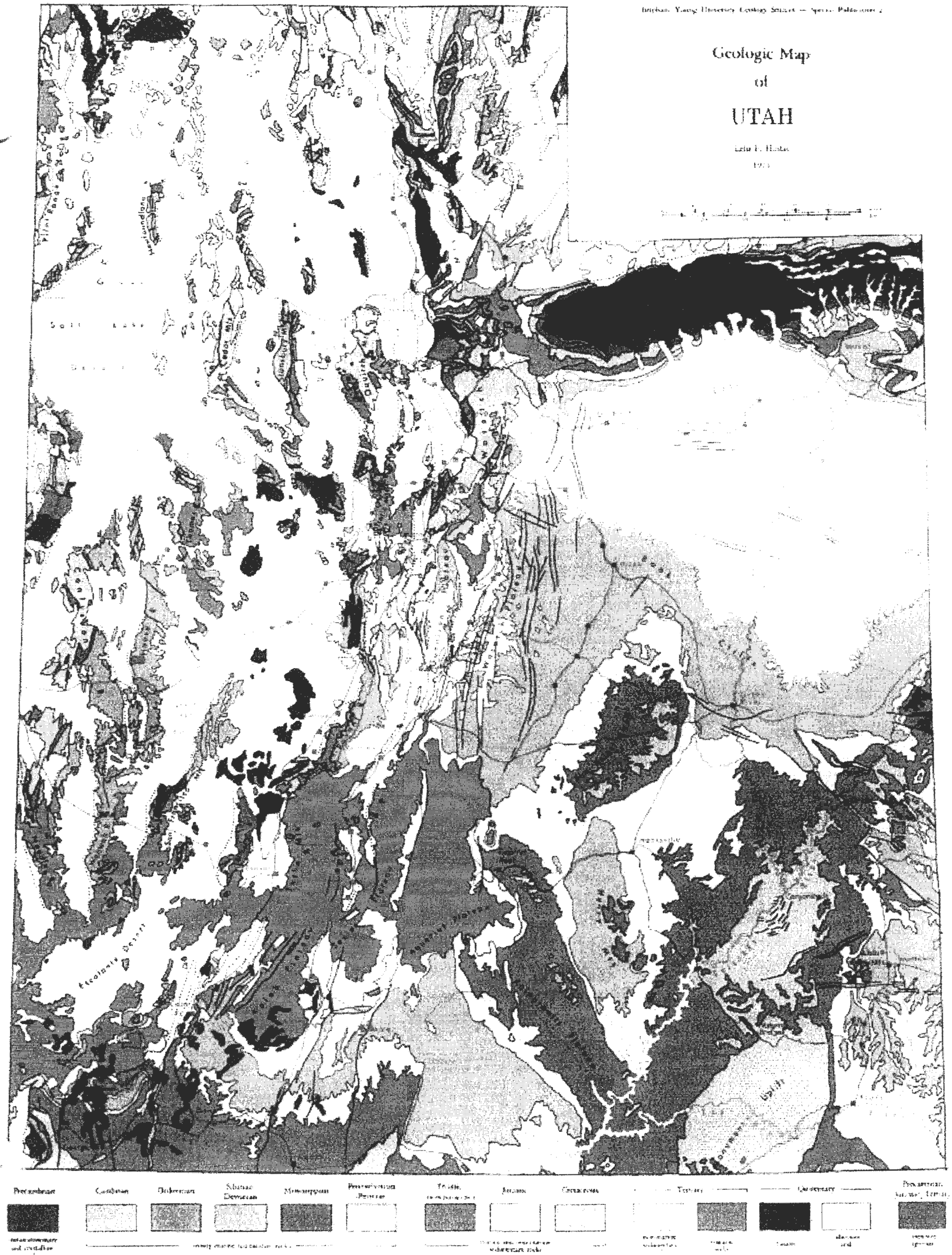



**PHYSIOGRAPHIC PROVINCES**



**TEACHER FEEDBACK:**


LANDFORMS of UTAH
IN PROPORTIONAL RELIEF
Base: Merrill Ridd, emeritus, UofU
Boundaries: G. Atwood, Earth Science Education
Rocky Mountain physiographic province
Basin and Range physiographic province
Colorado Plateau physiographic province

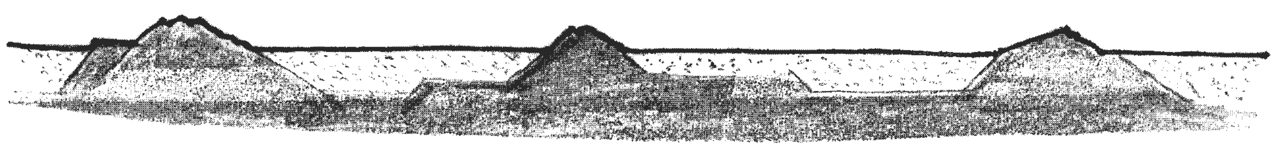

Geologic Map
of
UTAH
Precambrian
Cambrian
Ordovician
Silurian
Devonian
Mississippian
Pennsylvanian
Permian
Triassic
Jurassic
Cretaceous
Tertiary
Quaternary

## Basin and Range province:

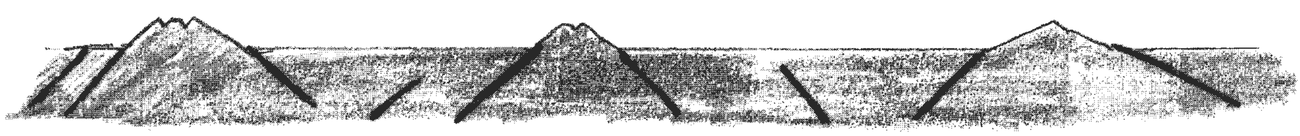
Most of the western part of Utah is in the Basin and Range province. As the name describes, this is a region of alternating *mountain ranges and basins,* usually called *valleys.* The basin and range topography results from very active geologic processes that continue today as the crust of the earth in this region is stretched and broken into blocks along fractures called faults. Some blocks stay high and make the ranges. Alternating blocks drop down along the faults to form valleys. When movements occur on the faults, earthquakes jolt the region. Because the stretching of the earth's crust is east - west, the tears along the faults run north - south, and so the mountains and valleys trend north - south. From a satellite the mountains of the Basin and Range look like a swarm of caterpillars heading north to Canada.

**Profile of Basin and Range scenery**


**Cross-section of Basin and Range showing bedrock crust (gray) and sediments eroded from bedrock (stippled).**



**Cross-section highlighting Basin and Range faults that bound the mountain blocks.**



Erosion wears down the mountain blocks. Streams carry rock materials eroded from the mountains into the valleys and deposited them as sand, gravel, and clay. These deposits *of sand, gravel, and clay* are over two miles thick in some of the valleys.

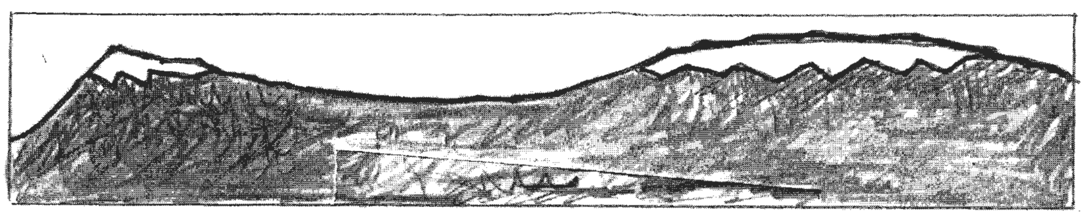
**Cross-section highlighting the basin fill.**

A portion of the Basin and Range province is called the *Great Basin,* an area where all of the water and sediments flow into the valley bottoms and none escapes to rivers that flow to the oceans. *Lakes,* such as Great Salt Lake, have formed in some of the lower valleys.

## The Rocky Mountains province:

The northeast part of Utah lies within the Rocky Mountains province. This province includes the state's two largest mountain ranges, the Uinta Mountains and the Wasatch Range. The largest rivers that originate in Utah start in this province where the high mountains receive more rain and snow than the rest of the state. The topography of the Rocky Mountains province has been developing over a longer period of time than the Basin and Range. The Uinta Mountains and the Uinta Basin differ markedly from the mountain ranges and valleys of the Basin and Range province. That they are much larger and trend east-west rather than north-south is obvious. Not so obvious is their different geologic story. Very different forces created Kings Peak and Antelope Island.

Along the boundary of the Basin and Range and the Rocky Mountains provinces, the Wasatch Range, which looks mostly like a Rocky Mountains mountain, shares some characteristics of Basin and Range province mountains. Why is that? Because its geologic story is not quite like that of the Uinta Mountains. Most of its history is similar to the Rocky Mountains province but the range is younger and a Basin and Range fault bounds it to the west, slicing its abrupt mountain face into triangle-shaped facets.



**ROCKY MOUNTAINS**

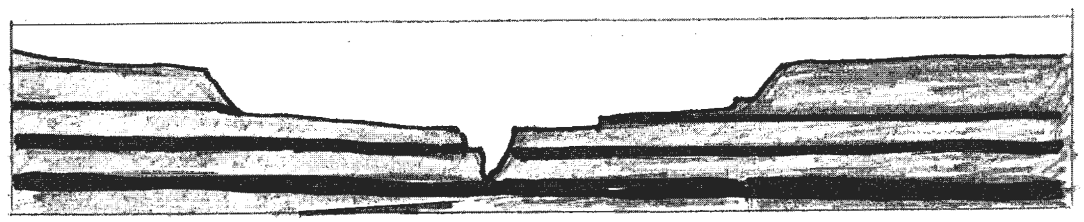


**TEACHER FEEDBACK:**

## Colorado Plateau province:

In the southeast is the Colorado Plateau province, a land of generally flat-lying, layered rocks exposed in *cliffs, mesas* and deep *canyons.* The Colorado Plateau's generally high elevation, low rainfall and active erosion expose bright red and maroon, layered, nearly flat-lying rock layers. The Colorado River carries most of the debris eroded from the rock layers toward the Pacific Ocean.

The Colorado Plateau portion of Utah has been geologically more stable than has the rest of Utah. The rock layers are generally so horizontal, that *folds* of the rock layers form prominent topographic features: Waterpocket Fold, Combs Ridge, San Rafael Reef. It should be no surprise to you that its four mountain masses, the Henry, La Sal and Abajo Mountains and Navajo Mountain, differ from Rocky Mountain mountains or Basin and Range ranges because different geological process formed them.



**COLORADO PLATEAU**



**TEACHER FEEDBACK:**

The exact boundaries between these provinces is arbitrary, but earth scientists agree on the general divisions. The three physiographic province differ because they have different geologic histories. Telling the geologic history that explains how they developed into their present form is the story of this book.

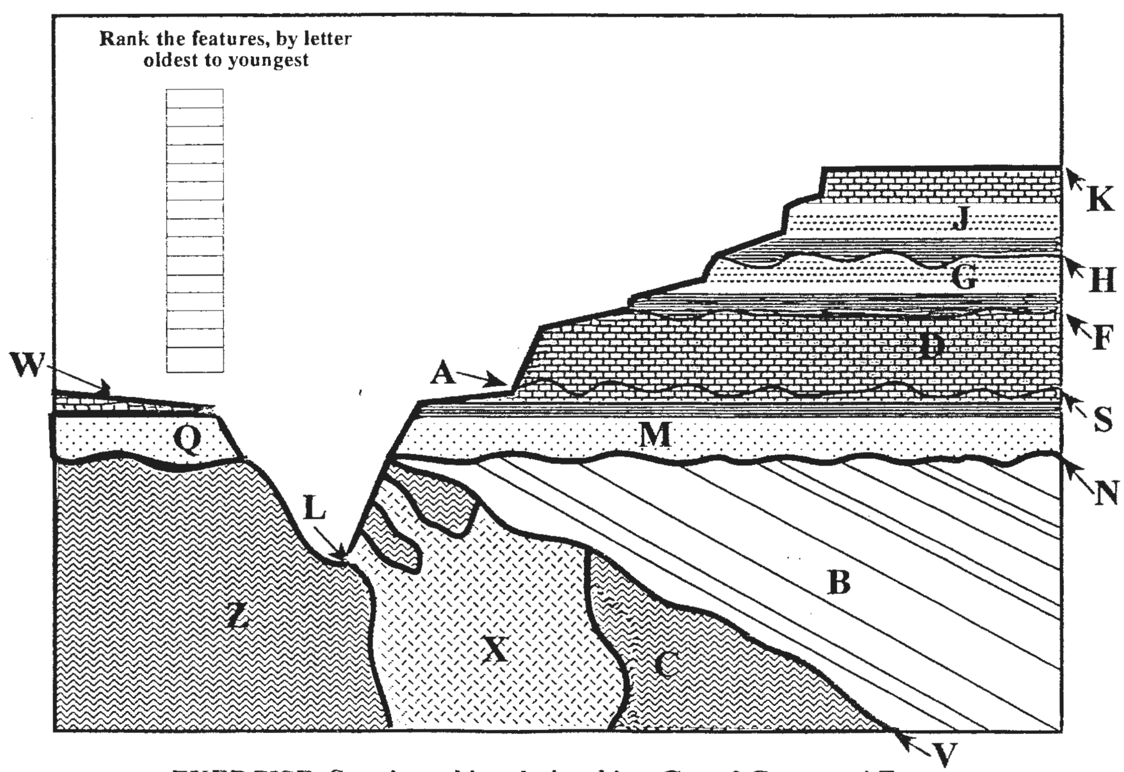
**From: Intermountain Health Care brochure.**
**Note... how areas of Utah look different.**
**Where would you draw the boundaries of th three physiographic provinces?**
**Note... how the hospitals are not randomly dispersed. Utah's physical geography has determined the location of its population centers.**

**TEACHER FEEDBACK:**

# THE STORY IN THE <u>LAYERED</u> ROCKS

Most of the rocks exposed to our view in Utah today are *sedimentary rocks. Sediments,* eroded bedrock, deposited in approximately horizontal layers, when buried by additional younger sediments, become *sedimentary rock* by rock-forming processes. Most of our knowledge of the geology of Utah comes from studying these rocks because sedimentary rocks are historians. The size, shape, and composition of sediments and the fossils trapped in them record when they were deposited and the environment where they were deposited and buried. Most of Utah's sedimentary rocks tell stories of shallow ocean environments and land environments within a few hundred feet above sea level.

For example, some of these sedimentary rocks tell stories of tropical conditions near the equator. A tropical climate in Utah? "Utah" hasn't always been at mid-latitudes. Tectonic forces move our plate of the earth's crust sometimes inches a year. Those sedimentary rocks record times when Utah was near and even south of the equator. The climate was warmer. Layers of sediments were laid down layer upon layer and became layers of sedimentary rocks as they were buried deeper under more layers of sediments. Eventually thousands of feet of these layered rocks covered our portion the earth's surface. Now, hundreds of millions of years later, they are exposed at the earth's surface in Utah's mountains.



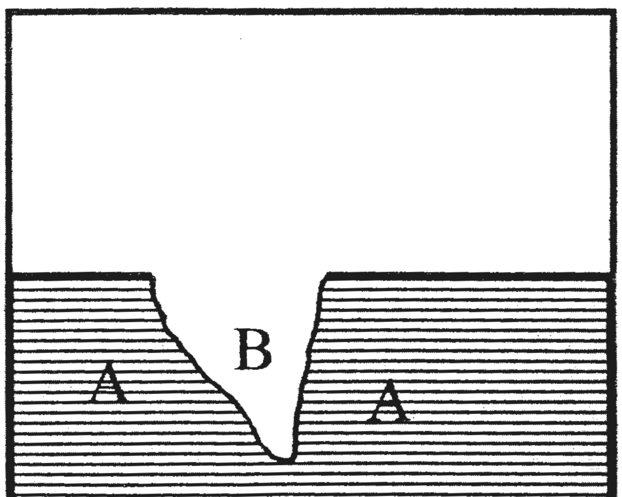

**EXERCISE: Stratigraphic relationships, Grand Canyon, AZ**



**TEACHER FEEDBACK:**

*PRINCIPLE 5:* **The rocks in a landform are usually older than the landform.**

For example the solid bedrock that forms the Uinta Mountains is much older than the mountains. The rock had to be there before they were bent and faulted and then eroded into the mountains we see today. (An exception to this principle is a *volcano* and its *lava* where the landform and the rocks form at the same time.) Utah's bedrock is much older than the mountains, cliffs and canyons made of them. We learn most about Utah's geologic past from rocks that record what happened back then. We learn many details about the last 50 million years from the shapes and components of landforms. Landforms tell geologic stories, but they don't reach into the past as far as the rocks they're made of.




CANYON B DISSECTING
PLATEAU A

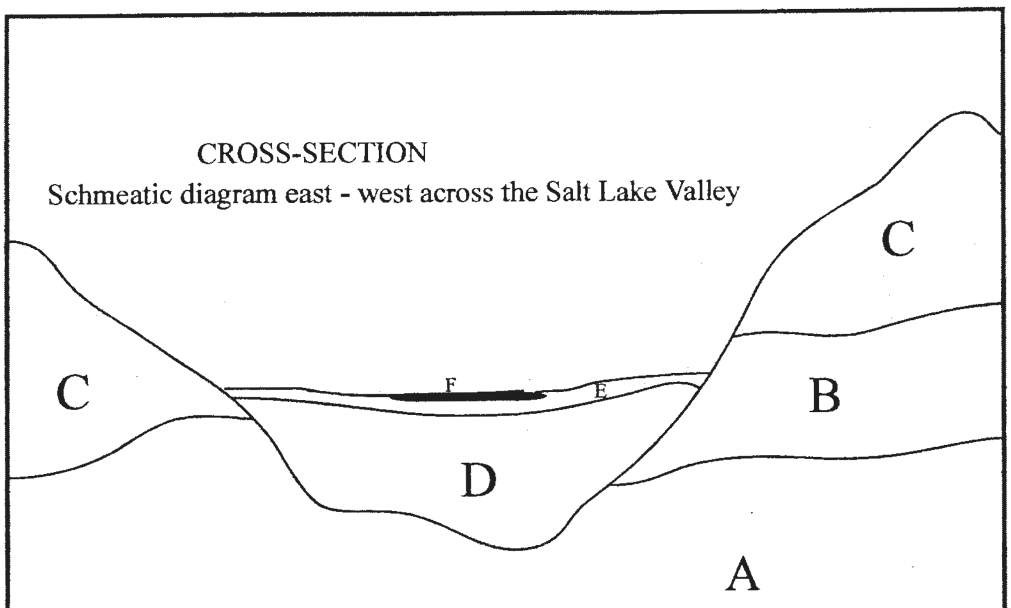


**TEACHER FEEDBACK:**

*PRINCIPLE 6:* **In a sequence of sedimentary rock layers the bottom layer was deposited first and is thus the oldest.**

It's called the Law of Superposition... younger sediments are deposited on older sediments. The relative ages of many sedimentary rock sequences can be figured out just using this simple law.

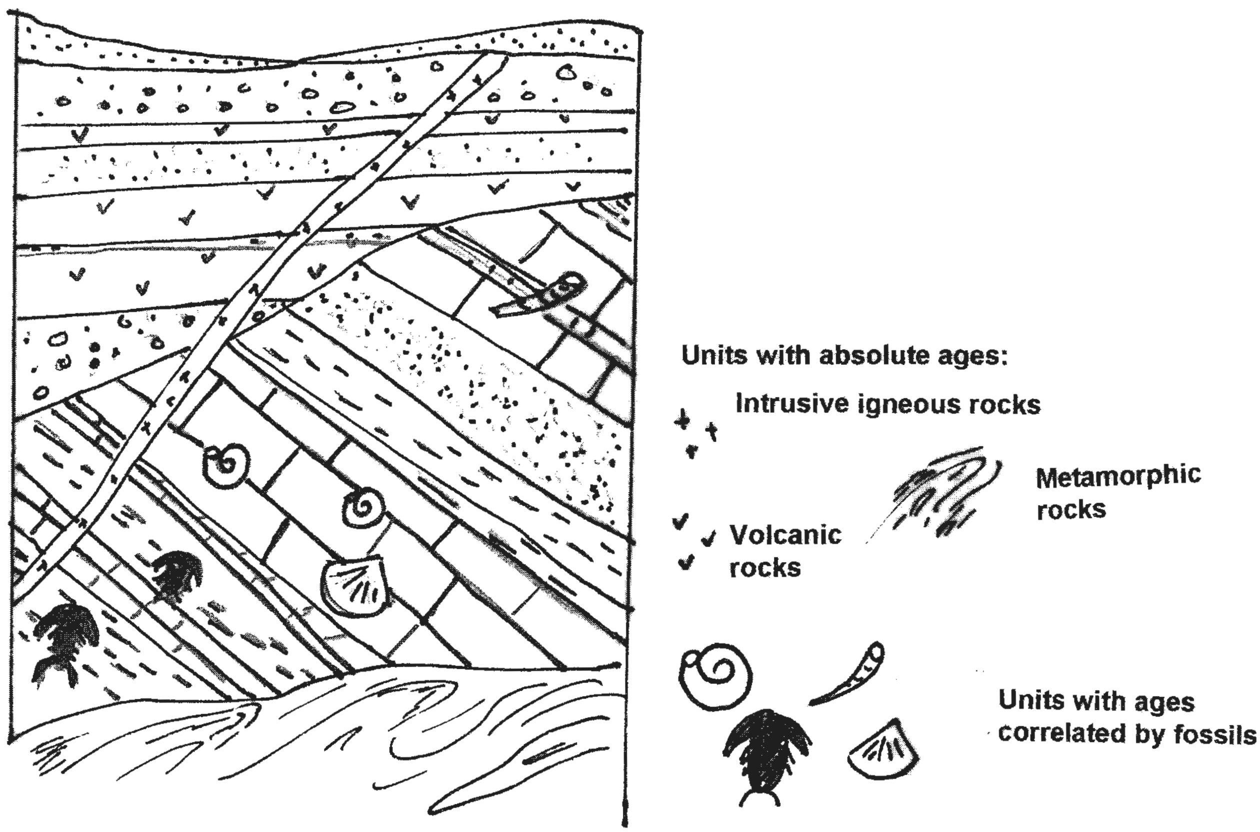
Until about fifty years ago the best evidence we had about the age of sedimentary rocks was from the *fossils* they contained. Fossils are the *petrified* remains of plants and animals that lived and were buried in sediments. When *paleontologists* examined fossils in stacks of sedimentary rock layers, they discovered systematic differences among older and younger rock sequences. By studying the fossils in many stacks of layered rocks all over the world, paleontologists pieced together a fairly complete record of how living things whose remains eventually became fossils changed with time. Using this record they determined the relative age of rocks that contained fossils. They could not determine the age in years.




Superposition...
younger on older

Now the age in years of *minerals* containing *radioactive elements,* such as uranium, can be determined by measuring how much of the radioactive decay of the element has occurred since the mineral formed. In some rocks the age of the minerals is also the age of the rock.

The approximate age in years of most rocks can be determined by combining the ages determined by radioactivity analysis with the fossil record. Not every rock layer has been dated with radioactive minerals or even with fossils. The Law of Superposition is still a very useful tool in figuring out the relative age of rock layers. Then when you know an absolute date of one rock layer in years, you can work forwards and backwards in time from that age.





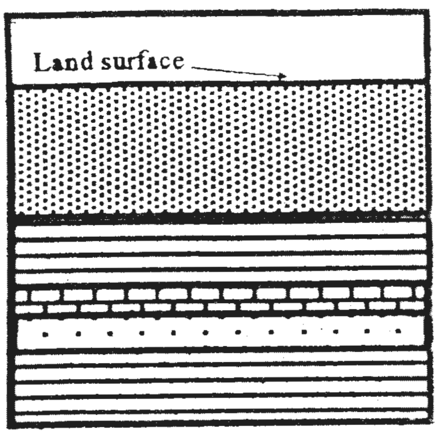

TEACHER FEEDBACK:

*PRINCIPLE 7:* **The layering of rocks formed from sediments deposited in water starts out nearly horizontal.**

Think about the bottom of the ocean, or a lake, or even a lazy stream's bed. Sediments deposited layer by layer on these relatively horizontal surfaces start out relatively horizontal. Thus, millions of years later when we see these rocks layers tilted or contorted, we know they have been deformed from their original, nearly horizontal, configuration.

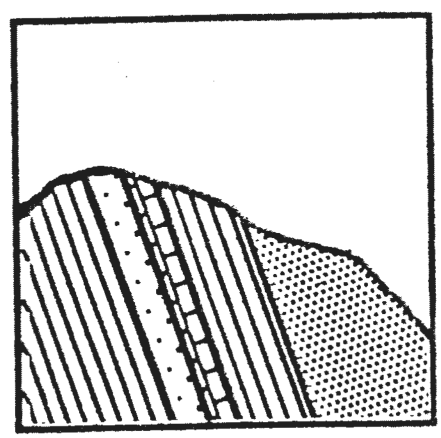
By studying how sedimentary rocks have been deformed we can learn what has happened to them, what forces were responsible, and when the action took place.

BEFORE TILTING




Cross-section View
(from the side)

AFTER TILTING



Cross-section View
(from the side)



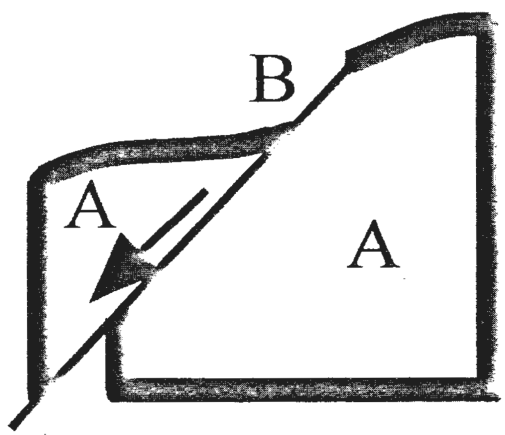
TEACHER FEEDBACK:

*PRINCIPLE 8:* **Cross cutting relationships indicate the relative age of geological features.**

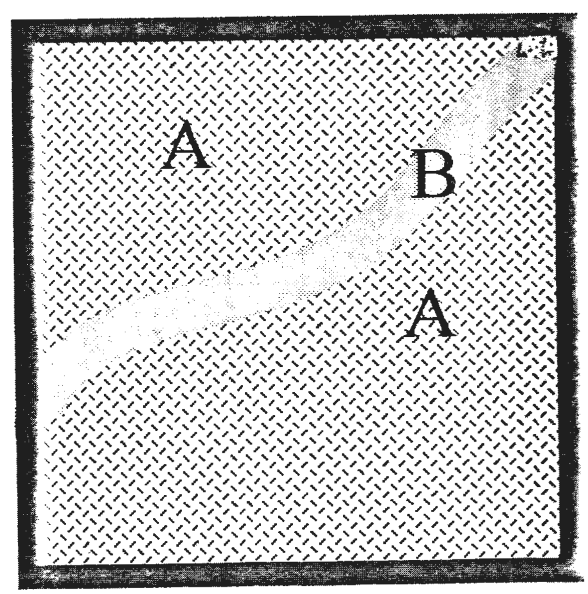
A geologic feature that cuts across or terminates another feature must be younger than the feature it cuts or terminates.

For example, if a fault offsets one rock layer but does not offset an overlying layer, the fault must be younger than the broken layer and older than the overlying layer that is not cut.

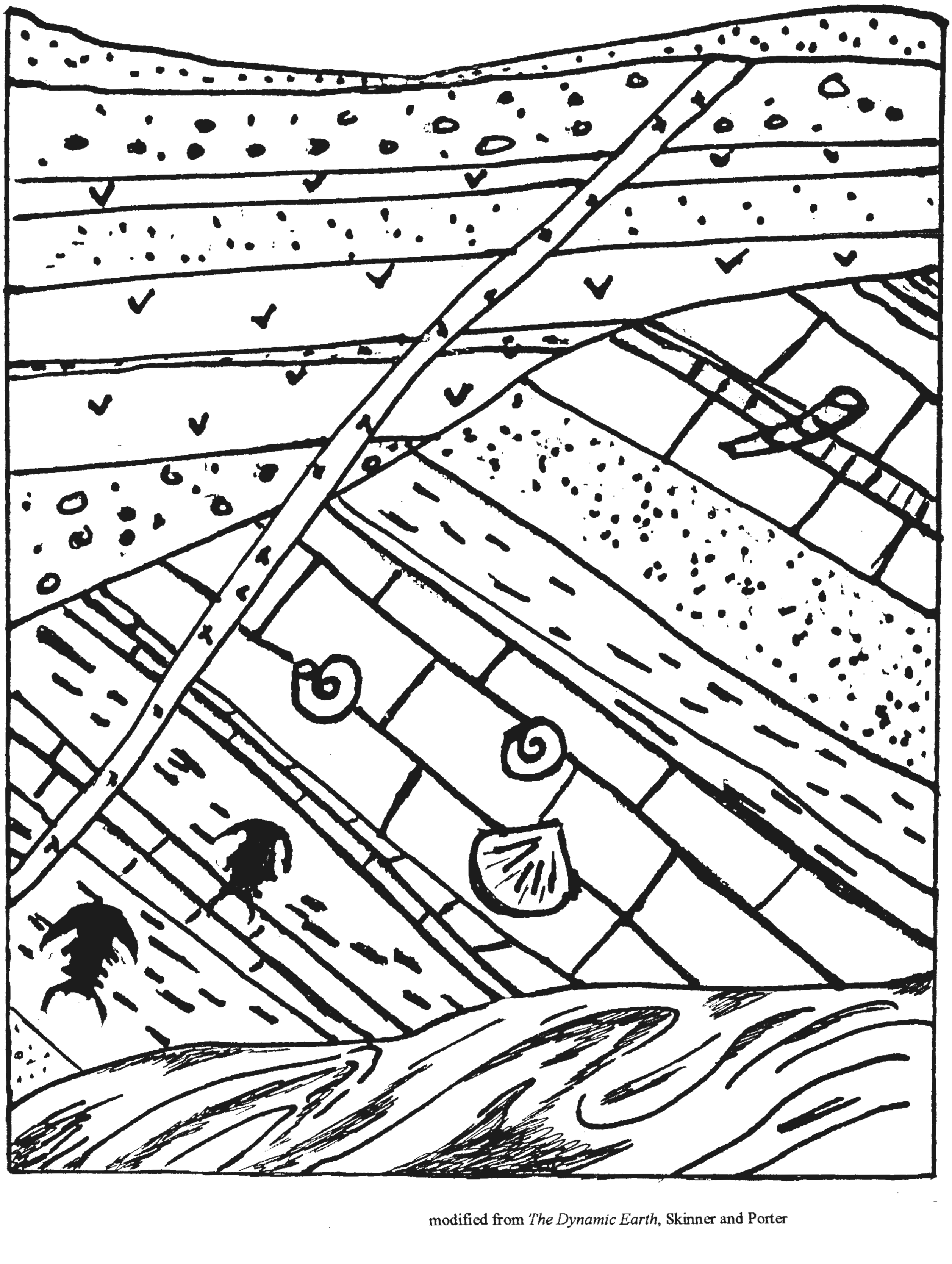
If a mass of *intrusive igneous* rock cuts across rocks or a fault, the igneous rock must be younger than the rock it cuts across.



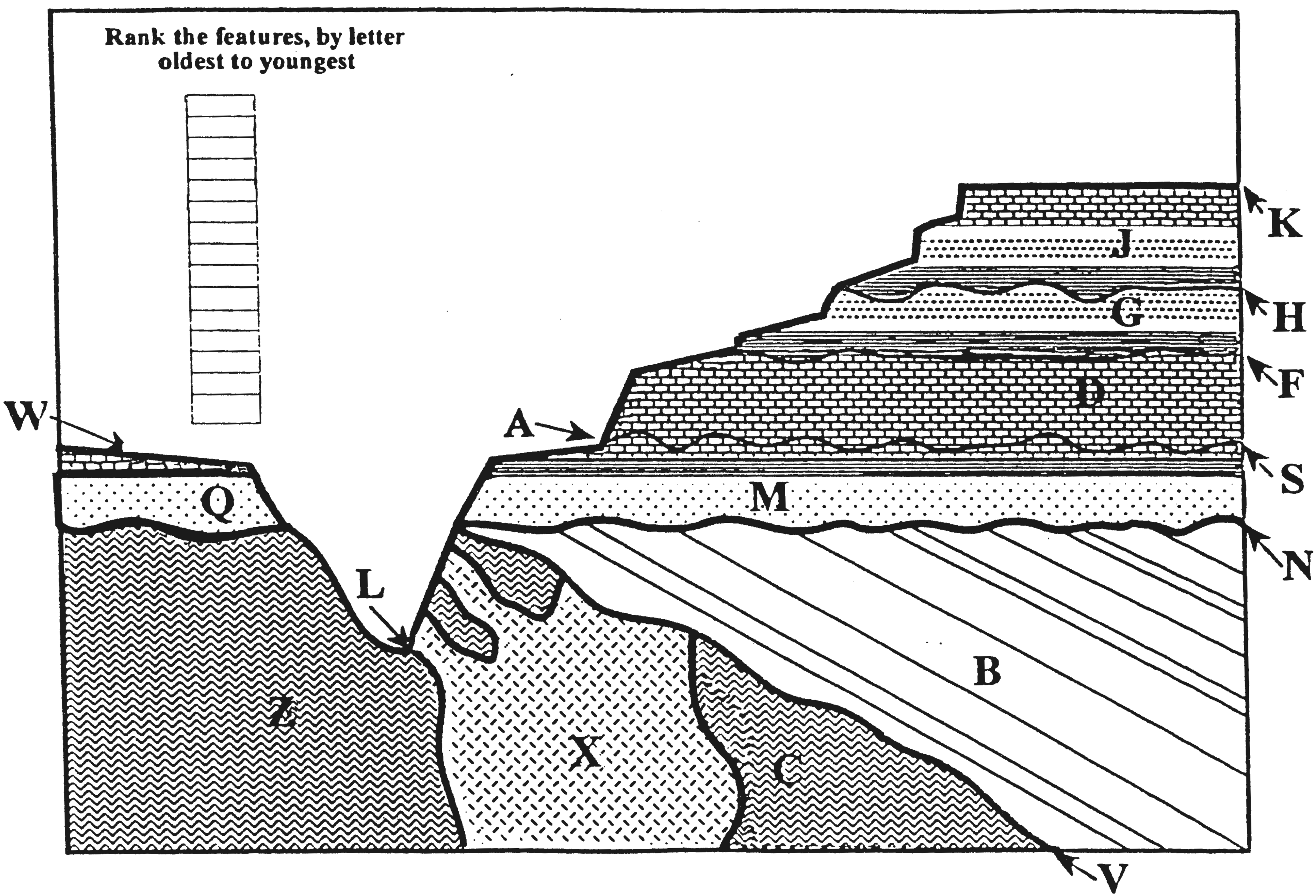

FAULT B CUTS BLOCK A



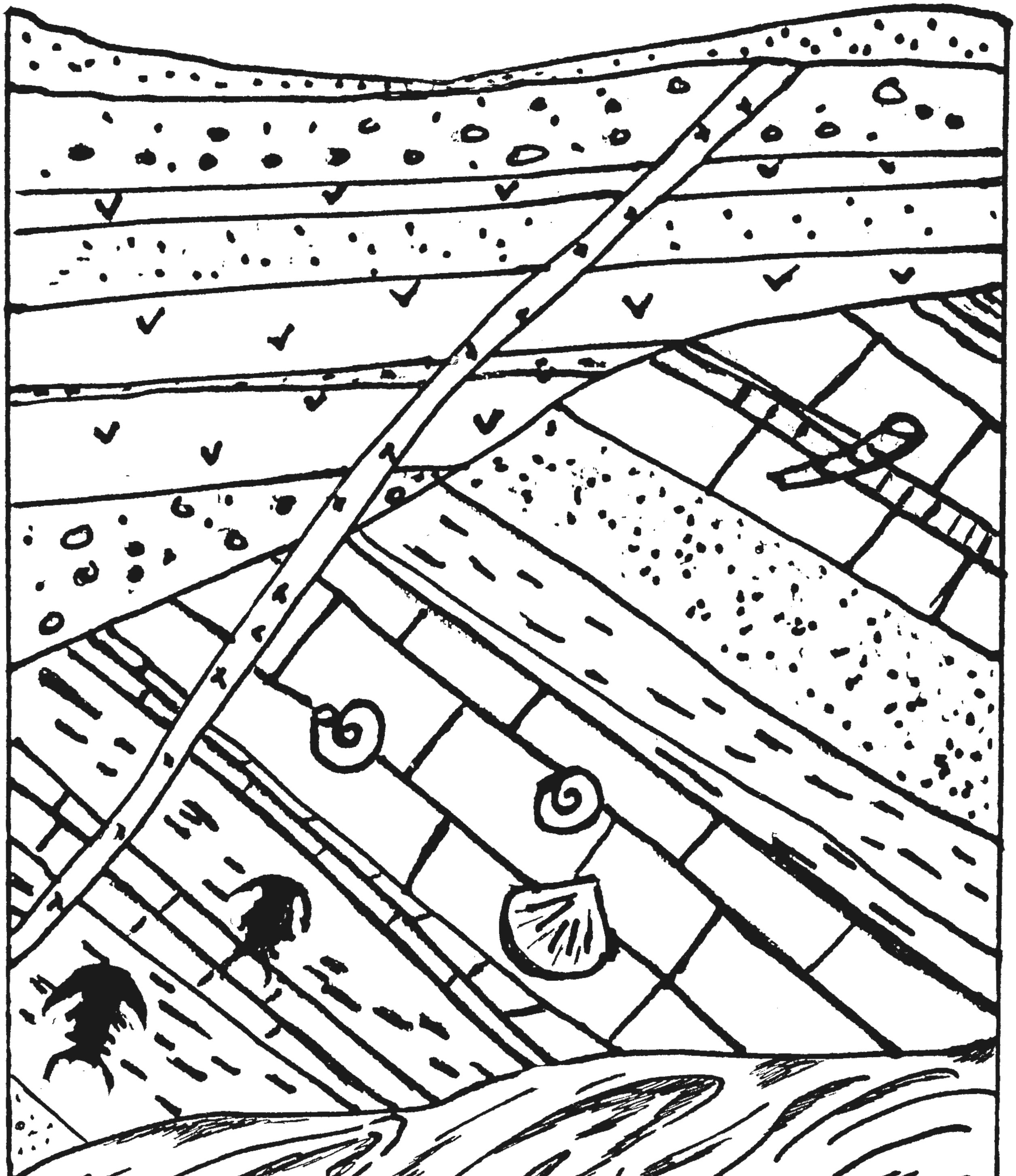

ROCK B CUTS A



modified from *The Dynamic Earth*, Skinner and Porter




**EXERCISE: Stratigraphic relationships, Grand Canyon, AZ**



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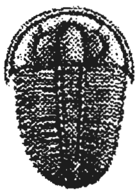

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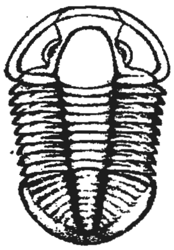

Asaphiscus Wheeleri

Peronopsis Interstricta (Agnostus)

Brachiopod

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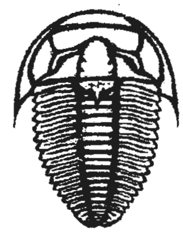
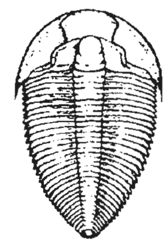
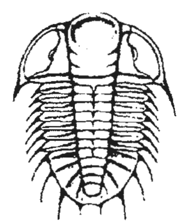


Bolaspidella Housensis

## Rare



Alokistocare Harrisi



Olenoides Nevadensis

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Our present geologic environment is dominated (a) by extensional tectonics that has created the basins and ranges of the Great Basin over the past 20 million years and (b) by climate change that has changed scenery over the past 4 million years. The basins of the Basin and Range physiographic province are dry during global interglacial climate regimes, and have large lakes during global glacial times. Lake Bonneville is the most recent of the large lakes and dates from the Ice Ages of only about 30,000 – 13,000 years ago. So… don't confuse the seas of the trilobites with the lakes of the Ice Ages.

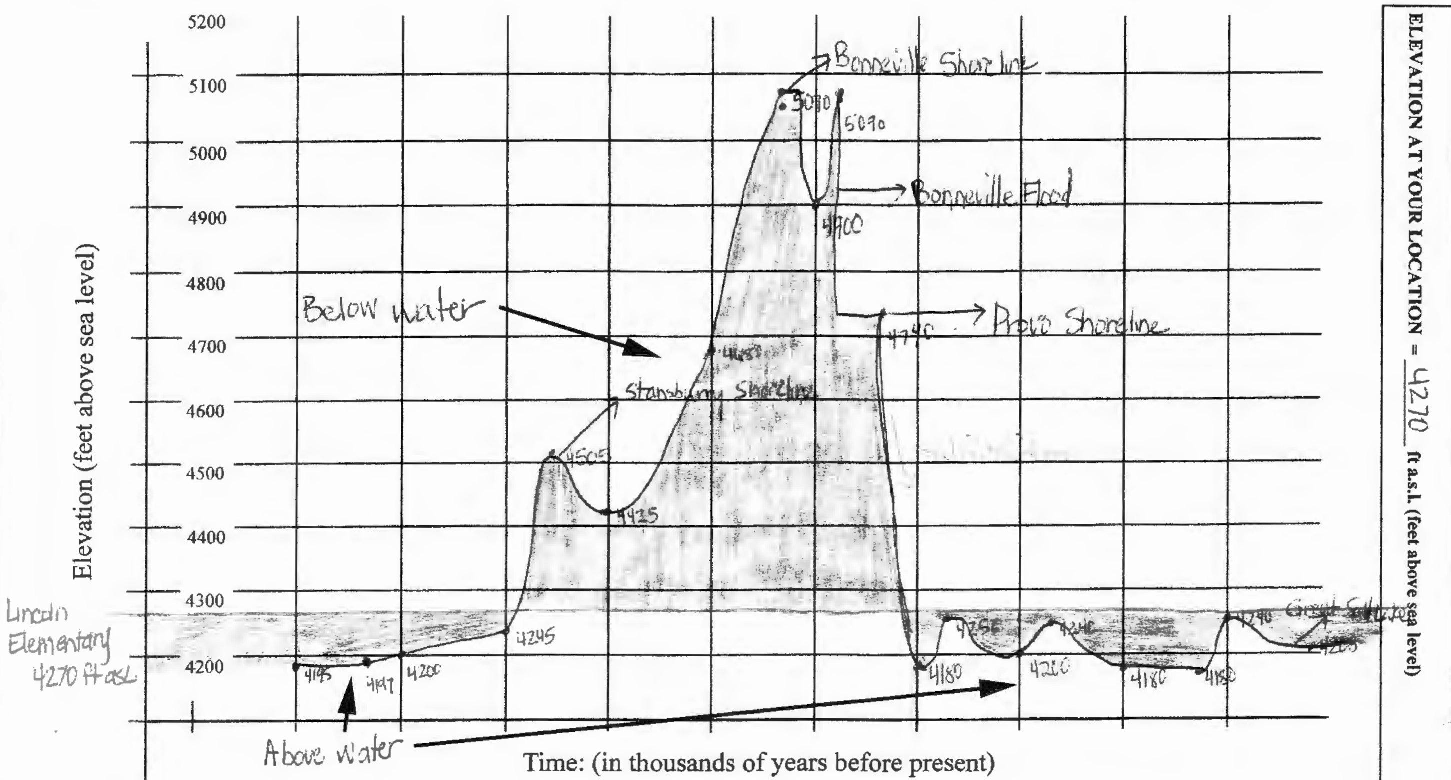
What a difference a half-billion years makes!

# REVIEW: hydrographs

**Describe climate change and the Lake Bonneville story for your location: LOCATION is** Lincoln Elem., 450 E. 3700 S.

**Step 1: Determine the elevation of your location. Step 2: Draw a horizontal line at that elevation on this chart. Step 3: Sketch the rise and fall of the lake based on Map 73. Step 4: Indicate with colors or labeling when your site was above and below water on the time line and describe the sediment record (erosional, depositional (shorelines = sand and gravel; deltas = silts and sands; off shore = clays). Step 5: Then summarize conditions and evidence for various times (backside of sheet).**

CAUTION: The more we learn about climate change and our lakes, the more complex the story gets. Map 73, Major Levels of Great Salt Lake and Lake Bonneville, tells the general story well. It is outdated in its details. Use it anyway. Tell the basic story, clearly and simply. As you learn more, you'll tell a more elaborate story.

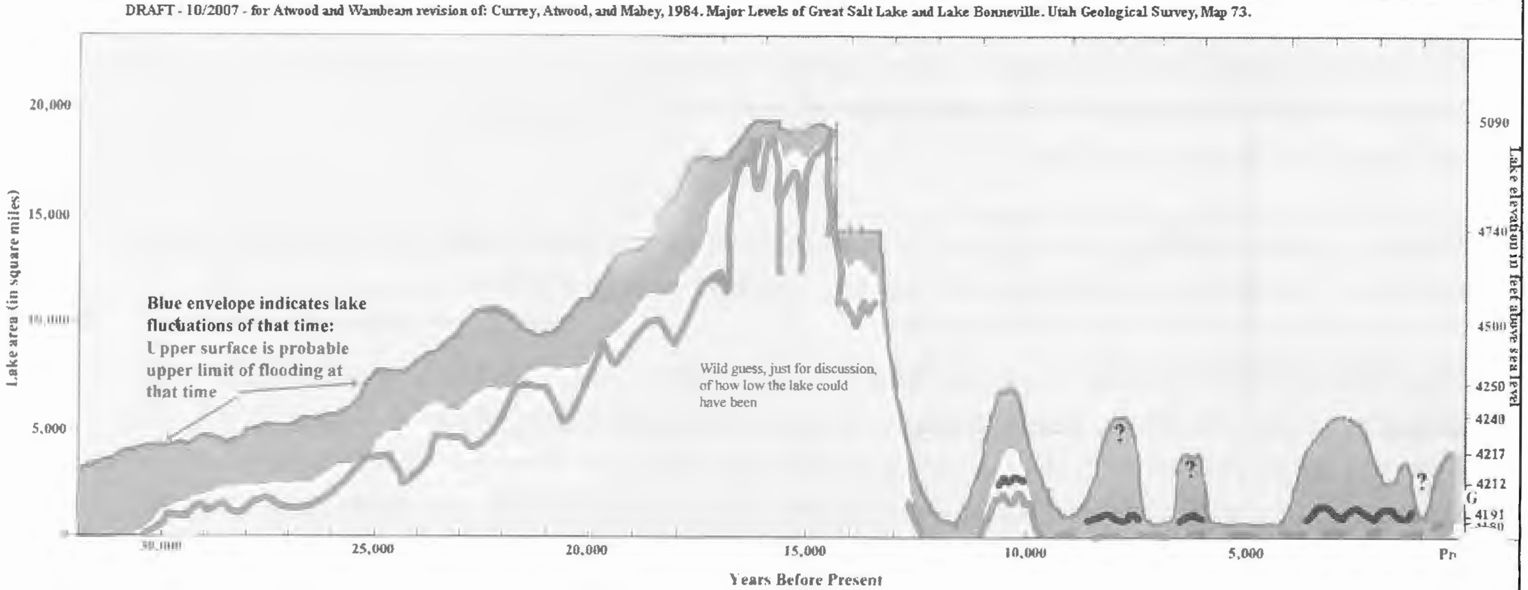



**ELEVATION AT YOUR LOCATION =** 4270 **ft a.s.l. (feet above sea level)**

TIME LINE — 33 — 30 — 27 — 24 — 21 — 18 — 15 — 12 — 9 — 6 — 3 — 0 —

SEDIMENT RECORD: **Erosional - no sediments** | **Sand and gravel** | **Clay, clay, clay, clay,** | **Sand and gravel** | **Erosion -- no lake sediments as record... perhaps wind or**

**DRAFT - 10/2007 - for Atwood and Wambeam revision of: Currey, Atwood, and Mabey, 1984. Major Levels of Great Salt Lake and Lake Bonneville. Utah Geological Survey, Map 73.**




⟵ **Lake Bonneville** ⟶

**Ice Age climate - colder and wetter than today's climate**

⟵ **Great Salt Lake** ⟶

**Hot, dry climate similar to today's with some major climate excrusions both wetter and drier**

**REVIEW --A few important concepts:**

**Great Salt Lake is the "global interglacial" lake of present relatively hot, dry conditions.**
**Great Salt Lake is a closed-basin lake, meaning, no outlet.**
**Water balance: the volume of Great Salt Lake INCREASES when in-flows (precipitation, surface water, and ground water) EXCEEDS out-go (evaporation and pumping) and the lake rises. Conversely, the volume of Great Salt Lake decreases and lake level drops when outgoes exceed inflows.**
**Great Salt Lake is highly responsive to changes in climate.**

**Lake Bonneville is the global-glacial lake of the Ice Ages of about 30,000- 3,000 years ago.**
**Lake Bonneville began as a closed-basin lake, rose due to climate change, and overflowed the rim of the Great Basin near Red Rock Pass in Idaho about 16,000 years ago.**
**Lake Bonneville did NOT fill due to melting of glaciers. Cold, wet climate caused the growth of mountain glaciers and the rise of Lake Bonneville.**
**Lake Bonneville, at the Bonneville level, was about 1000 ft deep and extended into eastern Nevada and southern Idaho. Lake Bonneville dropped from the Bonneville level of Lake Bonneville to the level of Great Salt Lake by two processes: (a) dam failure (the lake's outlet into the Columbia River basin eroded catastrophically 14,500 years ago and lake surface dropped about 350 - 400 ft. This event is called the Bonneville Flood. Conditions continued to be global glacial); (b) climate changed from global-glacial to global-interglacial. Warmer - drier conditions resulted in the succeeding 700 ft drop of lake level, and the beginning of Great Salt Lake. This change in climate, end of Lake Bonneville, and start of Great Salt Lake is called the Salinity Crisis.**

**EVIDENCE: Recognize materials, landforms, and processes.**
**Along the shore: waves erode and deposit sediments including sand and gravel. Tufa is a great marker for shorezones because it requires sunlight, wave action, and calcium carbonate saturated water.**
**On the lake bed, far from shore: lakes deposit clays.**
**Where rivers come into lakes: deltas form made of silt and sand.**
**On land: the terrain erodes.**

**Shore processes shape coastal landforms including sea cliffs, lagoons, beaches, and mudflats. In deep water, lakebeds tend to be flat, nearly-horizontal, and smooth.**

**MAJOR LEVELS - can be recognizable landmarks ... and foster a sense of place. In order of decreasing elevation, the five major levels of Lake Bonneville and Great Salt Lake are: the Bonneville level of Lake Bonneville (about 5200 ft a.s.l.); the Provo level of Lake Bonneville (about 4800 ft a.s.l.); the Stansbury level of Lake Bonneville (about 4400 - 4500 ft a.s.l); the Gilbert level of Great Salt Lake (about 4240 - 4270 ft a.s.l.); and historic levels of Great Salt Lake (4191 - 2412 ft a.s.l.). Earth processes including isostasy and faulting have modified the elevation of evidence of major levels. This can be an invitation to teach science, but expect some classroom frustration.**

TEACHER TRILOBITE DAY – WORKSHEET – COMPLETE MOST OF THIS IN TODAY.
CONSULT me (Genevieve) or one of the volunteers and we'll check off completed.

DURING LUNCH, after the LECTURE -- In your own words … what does each term mean and give an example with respect to your STRATIGRAPHIC SANDWICH.

**(a) SUPERPOSITION** means: ________________________________________________
An example of this with respect to my sandwich is:

DRAW it!!

**(b) CROSS-CUTTING RELATIONSHIP** means:____________________________________
EXAMPLE #1 of this with respect to my sandwich is:

DRAW it!!

EXAMPLE #2 of this with respect to my sandwich is:

DRAW it!!

**THEREFORE: From most recent:**
**To what happened before**

**To what happened before that**

**To what happened before that**

**To what happened before that**

**Are relationships of my STRATIGRAPIC SANDWICH.**

**LOOK AROUND the scenery surrounding UDig Quarry.**

**OBSERVE at least three relationships of SUPERPOSITION:**

**(a) I see that ________________________ is literally on top of _____________________**
**SKETCH (and if you want to take a photo for your own memories, do so.**

**(b) I see that ________________________ is literally on top of _____________________**
**SKETCH (and if you want to take a photo for your own memories, do so.**

**(c) I see that ________________________ is literally on top of _____________________**
**SKETCH (and if you want to take a photo for your own memories, do so.**

I find this
____ nifty;
____ exciting because… :
____ a whole new way to look at landscape… or…

COULD YOU DO THIS OUTSIDE AT YOUR SCHOOL OR ELSEWHERE?
___ YES
___ Perhaps for a few parts of the landscape
___ No, it does not make sense (ask for a bit of coaching from workshop volunteers) and don't make this difficult. The goal is for you to be able to teach the obvious, but recognizing the obvious is not… hmmm obvious.

**PART TWO: OBSERVE at least two relationships of CROSS-CUTTING RELATIONSHIPS:**

**(a) I see that ___________________________ cuts across ________________________**
**SKETCH (and if you want to take a photo for your own memories, do so.**

**(b) I see that ___________________________ cuts across ________________________**
**SKETCH (and if you want to take a photo for your own memories, do so.**

**THIRD: ____ OBSERVE tilted layers of bedrock units. Come to me and do the Geologists' Salute so I know you see what I want you to see.**
**Which happened first… and then… and then. Are these in correct order… ___YES; __No**
**(1) the laying down of the sediments**
**(2) that became the gray bedrock layers**
**(3) their tilting**

I find this
____ nifty;
____ exciting because… :
____ a whole new way to look at landscape… or…

COULD YOU DO THIS OUTSIDE AT YOUR SCHOOL OR ELSEWHERE?
___ YES
___ Perhaps for a few parts of the landscape
___ No, it does not make sense (ask for a bit of coaching from workshop volunteers) and don't make this difficult. The goal is for you to be able to teach the obvious, but recognizing the obvious is not… hmmm obvious.

**HISTORY OF MAJOR GEOLOGIC EVENTS AT U-DIG. From youngest to oldest.**
Note, many of the chapters of Utah's geologic past are missing here. OBSERVE the EVIDENCE of the three chapters of Utah's geologic past that are well-represented here (Chapters NINE—Now, Stretch; CHAPTER 6 – Scrunch and Swamps; and CHAPTER 3 – Shallow Seas).
Only Salt Lake County has evidence of all nine chapters in one county.

**CHECK next to the evidence (observation) when you see it.**

**CHAPTER NINE – of Utah's Geologic Past. The Present meaning the past few million years.**
**___ Observe CROSS-CUTTING by erosion of the mountains.**
**___ Observe SUPERPOSITION way south of the sediments of Sevier dry Lake and Lake Bonneville sediments.**
**State the obvious: are the sediments off in the distance younger than, or older than the gray bedrock at UDig? _________________**

**Chapter Nine of Utah's geologic past is the formation of the basins and ranges of the Basin and Range by extensional tectonics, erosion of ranges, and deposition of those sediments in basins.**

CHAPTER EIGHT – Impressive igneous… Evidence near here (for example, Drum Mountains), but I don't think we can observe evidence here.
CHAPTER SEVEN – Seven-Up… the region rises about a mile. Don't expect yourself to see the evidence here.

**CHAPTER SIX – Scrunch and Swamps. Evidence of this chapter includes folding and faulting of bedrock.**
**____ Observe TILT of gray bedrock layers.**
**Which came first, the gray bedrock or its tilting? __________________________**

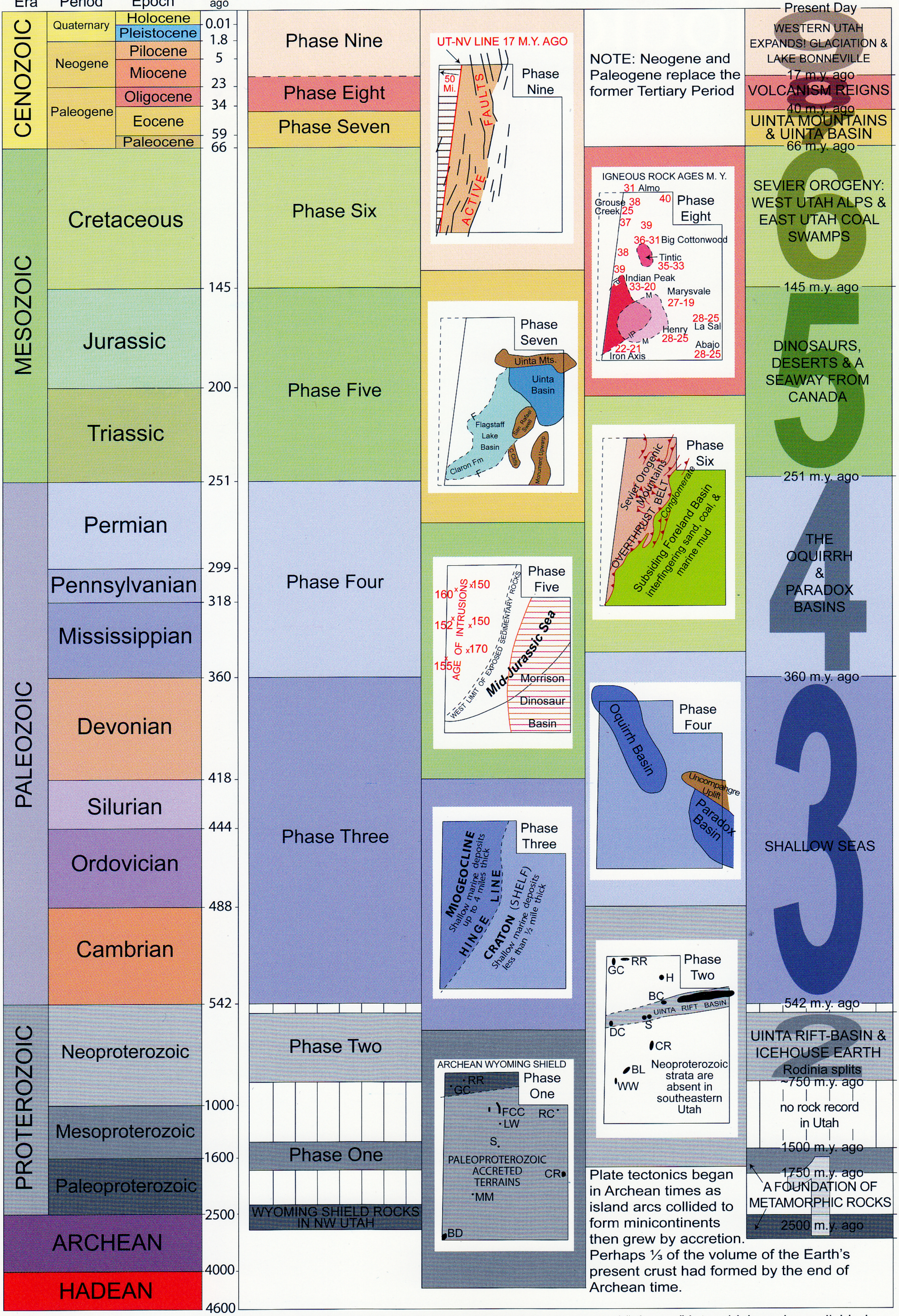
CHAPTER FIVE – Deserts and Dinosaurs. Evidence of this chapter is missing.
CHAPTER FOUR – Broad Basins. Evidence of this chapter was never here.

**CHAPTER THREE – Shallow Seas … seas come in and seas come out.**
**Sea floor sediments become gray bedrock. Fossils of this time frame include TRILOBITES!**
**___ Observe LAYERS that contain trilobites.**
**___ Observe LAYERS that underlie the layers with trilobites in them**
**___ Observe LAYERS that overlie the layers with trilobite in them.**
**If you wanted to locate another place, nearby, with trilobites, how would you go about finding it? ______________________________**

CHAPTER TWO – Metamorphic Lite. Present in many areas of Utah. No evidence here.
CHAPTER ONE – Metamorphic Basement
Underneath it all. This bedrock dates from so long ago that the rocks are difficult to decipher and come from a history that is poorly understood. This bedrock underlies the region but we do not see evidence of it here.

# Nine Phases of Utah's Geologic History

Read upward from Phase One for continuity




This chart shows the relationship between standard geologic time names and the numbered "phases" into which we have divided Utah's geologic history. Each place on Earth has its own geologic history as recorded in its rocks. Utah, because of the wide range of ages represented and number of tectonic events involved, has more phases in its geologic history book than most places on Earth.

**L.F.Hintze and B.J.Kowallis, 2009. Geologic History of Utah**