THE TIME
600 MYA — PRESENT

PEOPLE TO KNOW
Earl Douglass
David Gillette
David Madsen

WORDS TO UNDERSTAND
compress
era
erosion
excavation
fault
fossil fuel
fracture
geologist
organic
quarry
remnant
sediment

One poet described Utah's Canyonlands this way:

Time trailing time,
Flooding shallow seas,
Iron-rich sandstone,
Fossil-laden limestone.
Uplift and erosion—
Canyonlands masterpiece.

Utah's Geologic History

A Timeline of Utah's Geologic History

SOURCE: *Utah Geological Survey*

Note: MYA means millions of years ago

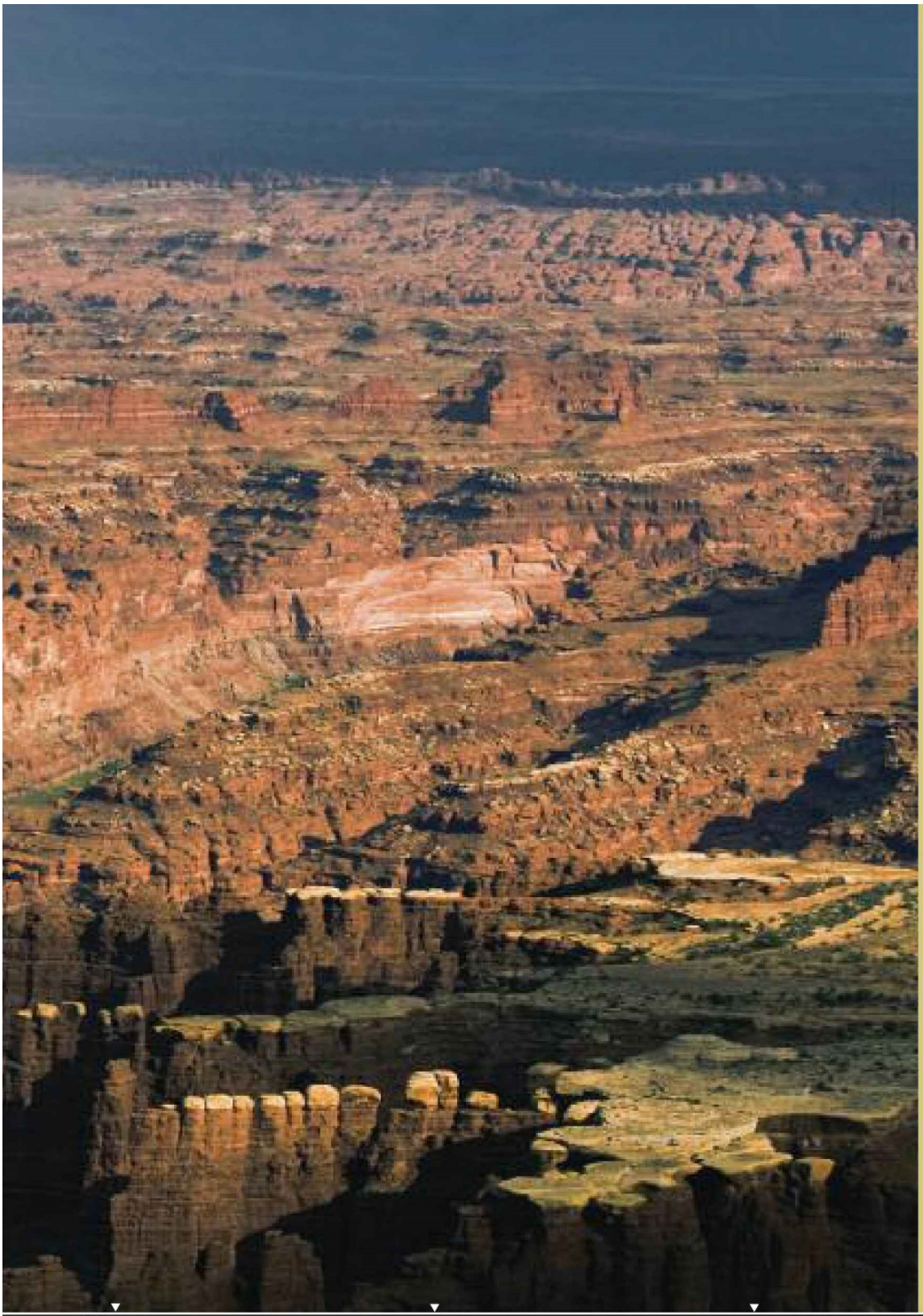
600 MYA | 500 MYA | 400 MYA

Precambrian Era

(85% of the earth's time period)

Paleozoic Era (570–240 MYA)

- Shallow seas cover Utah.
- Trilobites, amphibians, reptiles live in seas.
- Limestone, oil, gas, salt, potash, shale are in rock.



Chapter 2

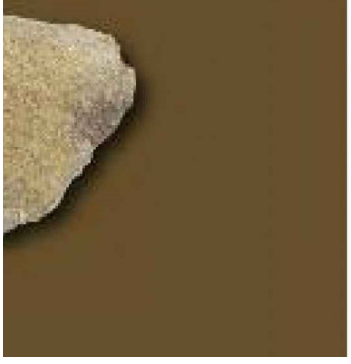
Setting the Stage

For millions of years Utah's land was covered by warm, shallow seas teeming with small shelled animals, fish, and then reptiles. The seas came and went over and over again. During this time our oil, gas, and coal were being formed.

The seas dried and sand covered the land. Dinosaurs lived here for millions of years. Then mammals came. Mountains and plateaus were formed. Volcanoes erupted, bringing up copper, gold, and silver from deep inside the earth. Then the shivering Ice Age once again changed the land.

Today, Utah's land reads like a book of geologic history. Everywhere you look you can see evidence of the earth's changes through time.

300 MYA | 200 MYA | 100 MYA | PRESENT



Mesozoic Era (240–65 MYA)

- Dinosaurs and primitive mammals appear.
- Shallow seas, then sandy deserts cover the land.
- Sedimentary rock of Utah's national parks is formed.
- River system exists.
- Dinosaurs disappear.
- Rocky Mountains begin forming.

Cenozoic Era
(65 MYA to present)

- Mammals live here.
- Mountains are formed.
- Plateaus rise. Volcanoes erupt.
- Copper and other minerals occur in rock.
- Carving of Canyonlands begin.
- Ice Age glaciers blanket northern Utah mountains.
- Lake Bonneville covers much of Utah, then declines.
- Great Salt Lake gets saltier.
- Humans appear.

A Matter of Time

It is hard to comprehend the long time periods of geology. One geologist explained how to measure time:

Hold your arms wide apart from your sides. If the beginning of earth time is your left fingertip, then animal life would begin near your left elbow. The Paleozoic clams would be at home from the middle of your right forearm to the beginning of your right index finger. The dinosaurs would cavort along your finger to the last joint. The end of your finger, from last joint to tip, would be the mammal years. And our species? The time people have lived on the earth can be measured by the snip of a fingernail.

—G. William Fiero

Shaping the Land

Geologists are scientists who learn about the history of the earth by studying rocks and land formations. They try to determine how rocks and the physical features of the land were formed. In the canyons of Utah you can see many layers of rock that give clues as to the history of the mountains and plateaus. Wind, water, earthquakes, floods, and even cold and heat have worked together to cause changes over very long periods of time. These changes are still going on.

The colors and shapes of Goblin Valley whisper the story of Utah's rocks.

Geologic Eras

From studying rock formations, geologists have divided the earth's long life into several major divisions of time called ***eras***. Study the timeline of these eras on the opening pages of this chapter. Eras are based largely on events that changed the earth's crust, such as the formation of mountain ranges. Eras are also based on the kinds of plants and animals that lived at the time.

The earliest known era, the **Precambrian,** is when the oldest rocks of the continents were formed. Precambrian rock can be found on Antelope Island in the Great Salt Lake.

The **Paleozoic** era means "ancient life." It is a time that fascinates mining engineers today. This era produced the beginnings of the ***fossil fuels*** we know as coal, oil, and natural gas. The fuels were formed from the remains of decaying plants and animals. Utah has many deposits of these fuels in Carbon County, the Uinta Basin, and other places.

The **Mesozoic** era is the time of the dinosaurs. These large creatures roamed the land in many places on the continent. Also during this era, the Rocky Mountains were just beginning to take shape.

In the last era, the **Cenozoic,** giant mammals replaced the dinosaurs. It became colder, and much of the earth's surface was covered with large sheets of ice. Utah was not covered with Ice Age glaciers, but many small glaciers formed in the tops of our mountains.

Utah's limestone is composed of the shells of ancient sea animals. The formations inside Timpanogos Cave are made by water dripping from the limestone and other rock.

After the ancient seas dried up, Utah had a period of dryness that had never been seen before or since. Today, Little Sahara Sand Dunes remind us of that time long ago.

Ancient Seas and Sandstorms

During many geologic eras, shallow seas took turns covering much of what is now North America, including Utah. ***Sediments*** made of loose sands, shells, and pebbles drifted to the bottom of the seas. In time, the sediments were forced together by heat and pressure into hard rock. As time passed, more layers of sediment were laid down. They hardened into layers of limestone and sandstone rock as thick as 1,000 feet in some places. These are important building stones today.

As the Utah region slowly began to lift above the surrounding land over time, the shallow seas washed away or evaporated. Utah then entered a period of dryness that had never been seen before or since. For thousands of years, sands from around the continent blew across the high basin that would become a part of Utah, especially in the Colorado Plateau Region. The desert sands ***compressed*** into mountains of sandstone thousands of feet high. These mountains can be found in Utah's five national parks and other areas.

Fossils

Dead plants and animals became fossils within rocks. Fossils are formed when minerals interchange with the ***organic*** matter of a living thing that has died. A fossil is also a trace or impression of a living thing, such as a footprint. Utah's oldest animal fossils are trilobites.

Dinosaurs

One of the most interesting geologic periods was when dinosaurs walked the earth. This was a time when there were no Rocky Mountains and no Colorado Plateau. They would not be formed for another 80 million years or so.

The different rock layers where many of Utah's dinosaur bones have been uncovered reflect the land at the time. Pebbly sandstone represents the channel of a river. It had a strong enough current to carry dead dinosaurs. Greater thicknesses of mudstones show that ancient rivers often flooded, spreading mud far over the low plains. Finally, rare limestone layers indicate that a few shallow lakes lay here and there. Overall, the land was a dry place, quite different from the swampy habitats associated with dinosaurs.

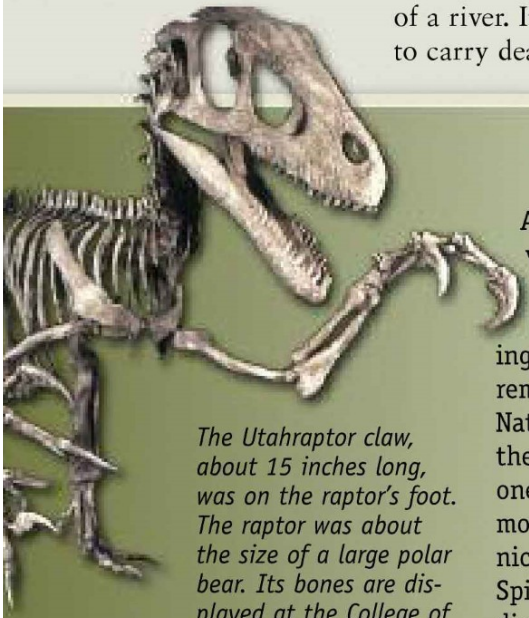
Our Dino Quarries

Some of the world's most complete dinosaur skeletons have been found in Utah. Ten new species have been discovered in the past few years. You can see the *quarries,* or digs, at Dinosaur National Monument near Vernal and at the Cleveland-Lloyd Dinosaur Quarry near Price.

The Cleveland-Lloyd Quarry has yielded over 40 allosaurs and over 12,000 other bones from its stony grip. You can see almost-complete skeletons of dinosaurs, an Ice Age mammoth, and a giant sloth at the CEU Prehistoric Museum in Price.

You can hike a trail in Mill Canyon, near Moab, and see dinosaur bones still in the ground. Rare tracks are in sandstone north of the Moab airport. The aptosaurus that once walked there had large hind feet about two feet in diameter, and smaller front feet.

Builders digging near St. George in 2000 uncovered dinosaur tracks. More than a thousand tracks have been found. They date back to 250 million years ago.



The Utahraptor claw, about 15 inches long, was on the raptor's foot. The raptor was about the size of a large polar bear. Its bones are displayed at the College of Eastern Utah in Price.

The Utahraptor

A newly discovered carnivore, called an "extraordinary killing machine" because of its huge slashing claws, was discovered in a remote region north of Arches National Park in 1992. Because the raptor closely resembles one of the dinosaurs in the movie "Jurassic Park," it is nicknamed the Utahraptor Spielbergi, after the movie's director, Steven Spielberg.

Douglass Discovers Dinosaurs

Earl Douglass was employed by the Carnegie Museum of Pittsburgh, Pennsylvania. He came to Utah's Uinta Basin to search for prehistoric mammals, not dinosaurs. He wrote in his journal in 1907:

May 31: *I want to go to Utah. . . . I wish I could go to collect fossil mammals. It is what I have wished to do for years.*

Douglass did move to Utah and began studying rock formations and looking for ancient bones. The next year the museum director came out and suggested they take a look at some older rocks in a different part of the basin. Mr. Andrew Carnegie, a very rich man in the East, had donated a lot of money to build a huge new exhibit hall at the museum in Pittsburgh. The story goes that Mr. Carnegie had said, "Fill that room with something big."

Douglass wrote in his journal about his first important dinosaur discovery:

August 12: *Went out prospecting again . . . . Found dinosaur bones but nothing good. . . .*

August 17: *At last in the top of the ledge . . . I saw eight of the tail bones of a Brontosaurus in exact position. It was a beautiful sight.*

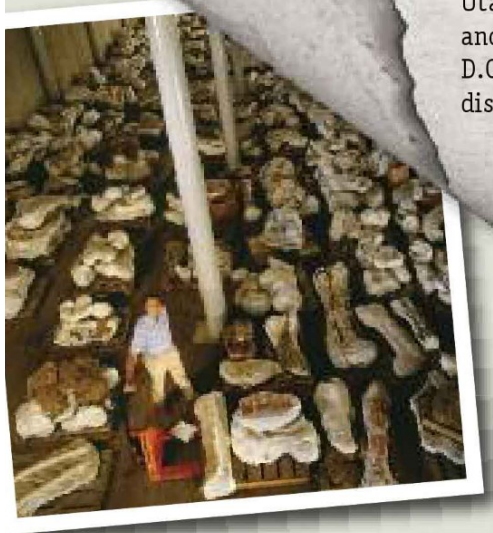
There were many problems, however, in getting the skeleton out of the ground and moving it:

August 19: *The construction of a road to the Dino does not seem so difficult . . . but that of getting out the Dino in good shape increases. It is going to be a tremendous job. But it will be one of the greatest specimens if it is all there. . . . Of all things I must not injure the specimen by carelessness or want of skill.*

Six years after Douglass first saw it embedded in the ground, the complete brontosaurus skeleton stood in the Carnegie Museum's exhibit hall in Pennsylvania. It was truly something big.

Later, when the Carnegie Museum ran out of room and out of money for more digging, Utah's dinosaur bones were taken by wagon and train to the Smithsonian in Washington, D.C., and some were returned to Utah and displayed at the University of Utah.

Earl Douglass



Where can scientists store thousands of dinosaur bones from Utah's quarries? Underneath the tall metal bleachers of Brigham Young University's football stadium, of course!

Utah Dinosaurs

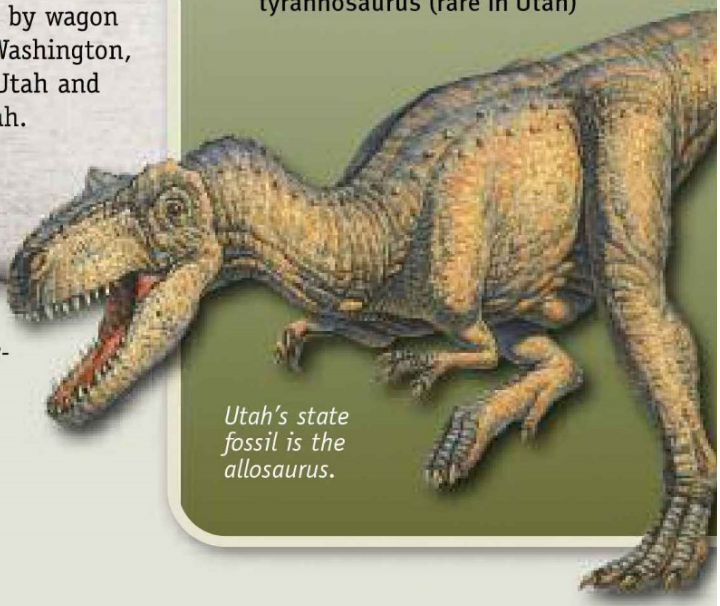
The huge creatures are divided into two groups by what they ate:

Herbivores (plant-eating)

aptosaurus
stegosaurus
camptosaurus
camarasaurus
diplodocus
triceratops (rare in Utah)

Carnivores (meat-eating)

allosaurus (most common)
Utahraptor (new find)
tyrannosaurus (rare in Utah)



Utah's state fossil is the allosaurus.

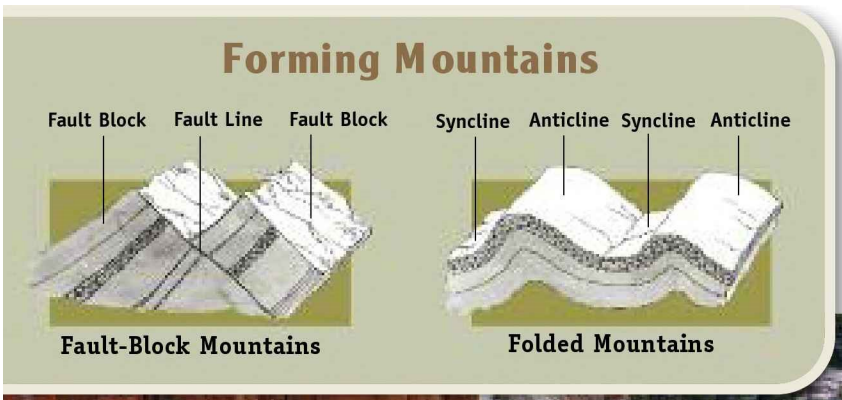
Natural Forces Shape Utah's Mountains and Plateaus

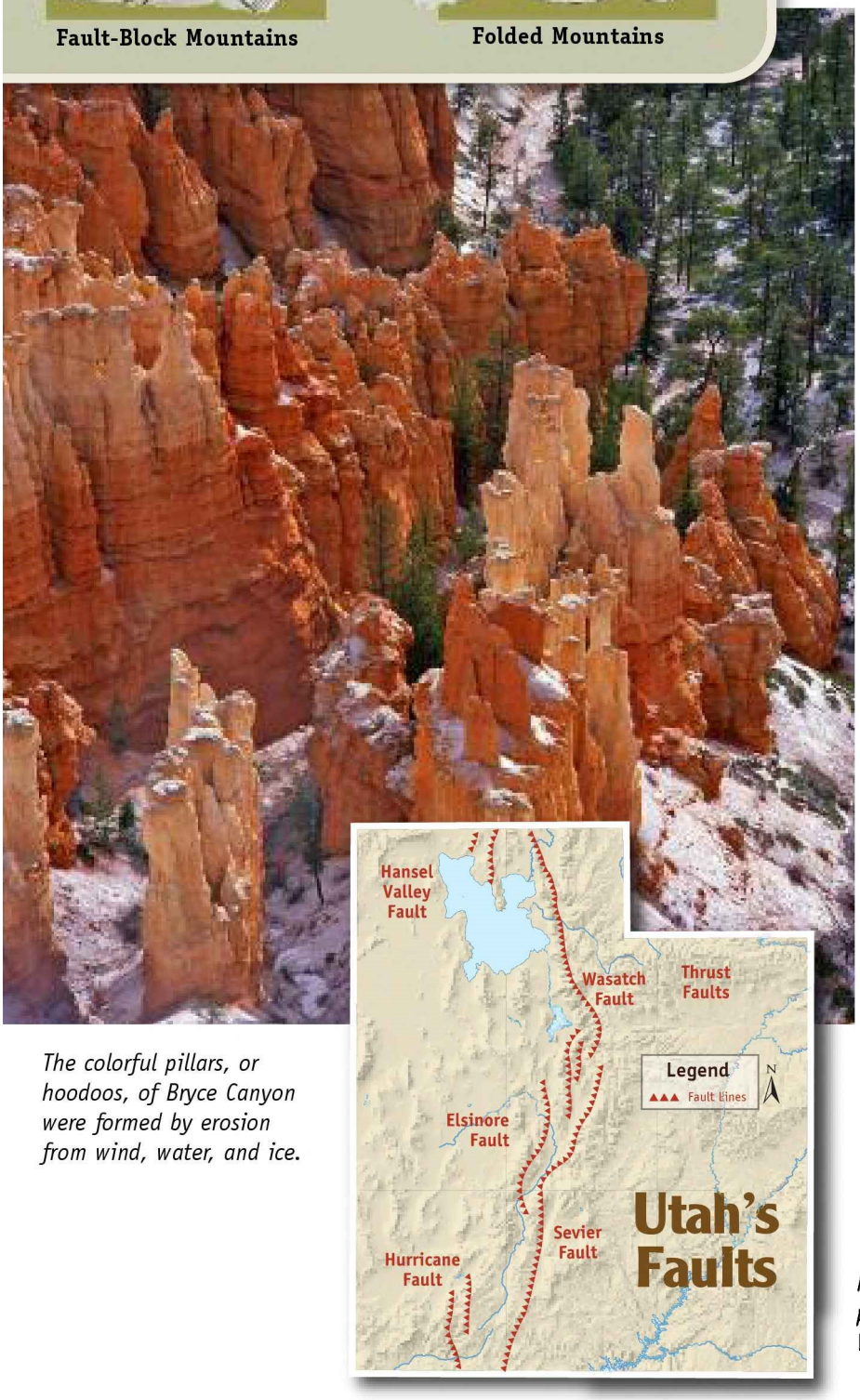
The Rocky Mountains, stretching from Alaska, through Canada, and south all the way to northern New Mexico, were slowly lifted by natural forces over thousands of years. How did this happen? The earth's surface was crunched together from faraway pressure of both the Pacific and Atlantic Ocean floors. The stress caused flat areas to buckle and rise in huge folds or cracks. Utah's land, like other parts of North America, were slowly lifted upward to make great peaks and cliffs.

Other parts of Utah's land were squeezed up into high plateaus as the mountains surrounding the area all pushed in on the region. Over time, water and wind caused ***erosion*** (wearing away) of the land and cut beautiful cliffs and canyons through the rock. As the canyons deepened, colored rock was exposed. This is how the great canyons of southern Utah were formed.

Faults

As a part of the uplift, ***faults,*** or cracks, began to form at weak spots in the earth's crust. One part of the earth was raised while the part next to it slipped downward. In time, mountain sediment washed down into the valleys.

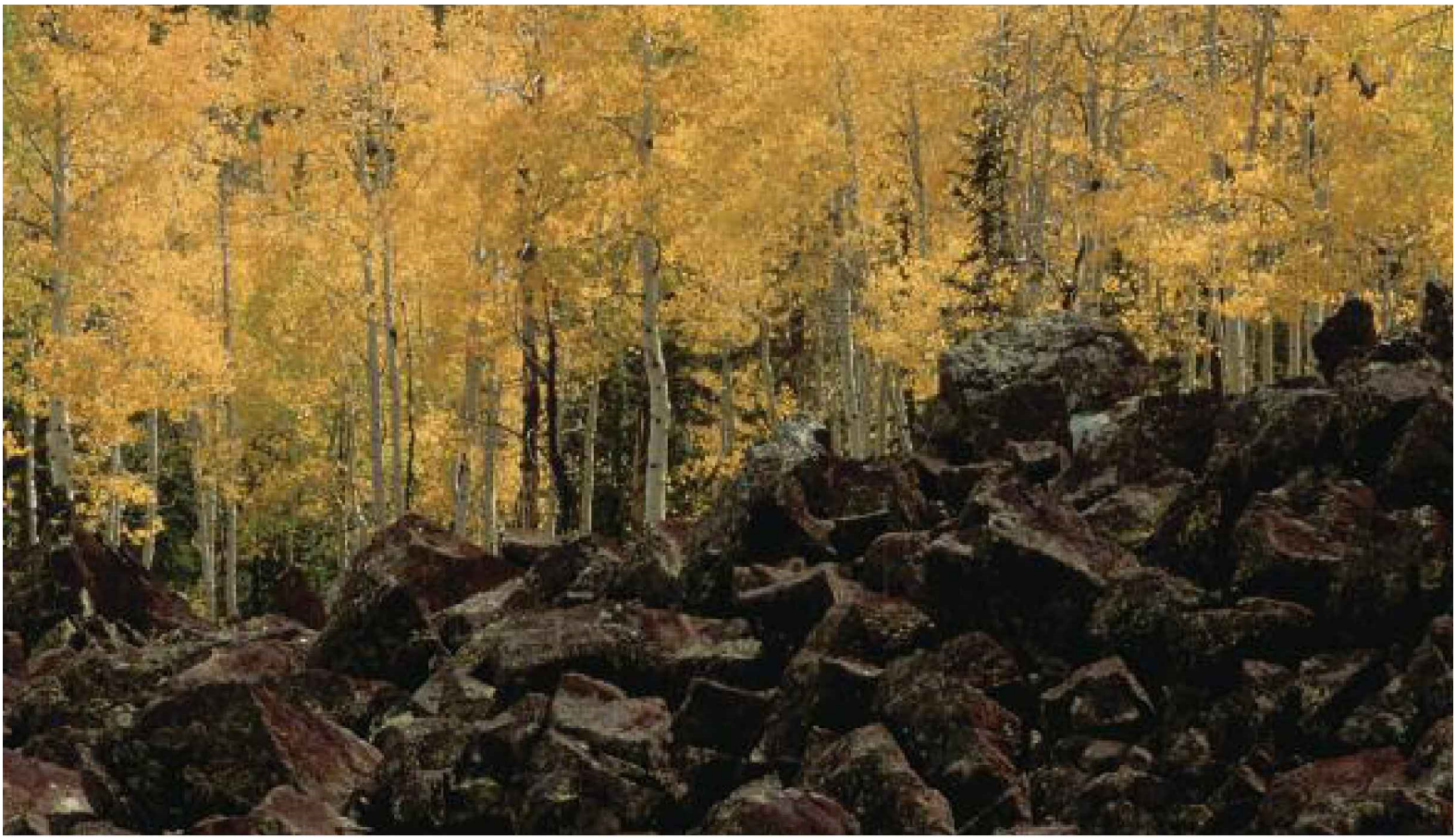




The colorful pillars, or hoodoos, of Bryce Canyon were formed by erosion from wind, water, and ice.

All three of the large universities along the Wasatch Front—Weber State University, the University of Utah, and Brigham Young University—are on fault lines. Utah State University in Logan is close to another fault line. Many of our large hospitals are also on fault lines.

Ninety percent of Utah's population live near the Wasatch Fault.



Lava once flowed over land we now call the Dixie National Forest near St. George.

Volcanoes Formed Mountains

In some areas, underground volcanic activity lifted large pieces of the earth's crust without breaking through the surface, causing isolated regions of scattered mountains. Examples of these are the La Sal, Abajo, and Henry Mountains of southeastern Utah.

Volcanoes Made Rock and Brought up Minerals

Igneous rock comes from deep inside the earth. Molten, or melted, rock is constantly being formed. Sometimes this rock pushes up through the earth's crust as lava. For hundreds of years, Utah was covered by active volcanoes that spread layers of ash and lava in many directions. Today all of Utah's volcanoes are extinct, or dead. But their craters and hardened lava flows can be seen in many parts of central and southern Utah.

Utah also has a rich store of metals and minerals. Some of them were deposited by volcanic action. That is how the copper, gold, silver, and molybdenum came to be in the Kennecott Utah Copper mine and in other places in Utah.

How did it happen? The oldest rock found at Kennecott's mine is sandstone. It was originally deposited as sediment in shallow seas. Extensive folding and faulting of the layered rock created the Oquirrh Mountains where the mine is located. Millions of years later, molten rock deep within the earth's crust pushed toward the surface and cooled. It was accompanied by hot mineral solutions that were forced into ***fractured*** sedimentary rock.

"Utah will yet become the treasure house of the nation."

—Abraham Lincoln, in a speech about mining wealth, 1800s

A squirrel perches on a volcanic rock. How can you tell the rock is volcanic?

Utah State Symbols

Rock: coal

Gem: topaz

Mineral: copper

Utah's Rock and Mineral Resources

Utah is rich in fossil fuels such as oil, natural gas, and coal. They were formed by the bodies of many, many plants and animals and much heat and pressure over millions of years. Today, these minerals heat our homes and run our cars.

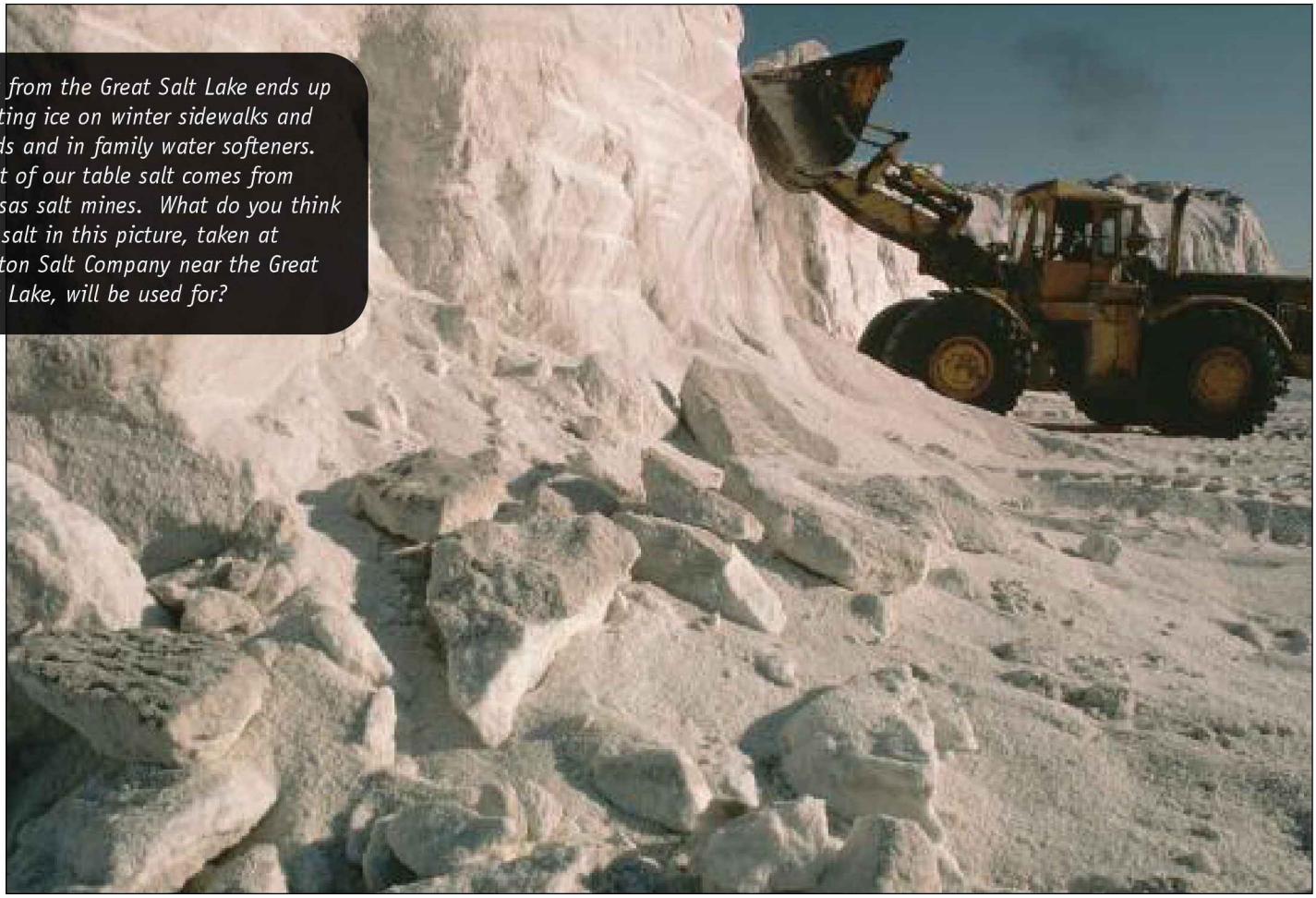
Utah has enough salt to satisfy the world's needs for a thousand years. Most of it is used for water softeners and icy roads. Other mineral salts are used as fertilizers and in explosives. Salt for food comes from other states. Large evaporation ponds allow many kinds of minerals to be taken from the shores of the Great Salt Lake.

Utah's geologic history has given us a tremendous supply of building stones. Large beds of sandstone, limestone, and quartz have been used for buildings. A type of pure marble is found near Fillmore. The Utah State Capitol Building is made from this granite.

Great amounts of sand and gravel were left by Lake Bonneville. They are used today in concrete, landscaping, and in highways.

What do you think

- What are some environmental issues associated with mining and refining of minerals? What are some ways these problems can be solved?
- Think about the mineral resources that provide fuel for your daily activities. Which ones would be the hardest to give up?



Salt from the Great Salt Lake ends up melting ice on winter sidewalks and roads and in family water softeners. Most of our table salt comes from Kansas salt mines. What do you think the salt in this picture, taken at Morton Salt Company near the Great Salt Lake, will be used for?

From Coal to Electricity

Large coal fields were discovered in Carbon County in the early 1880s. The coal fields are still important. Most of Rocky Mountain Power's electricity is generated by steam plants. How do they heat the water to make the steam? By burning coal!

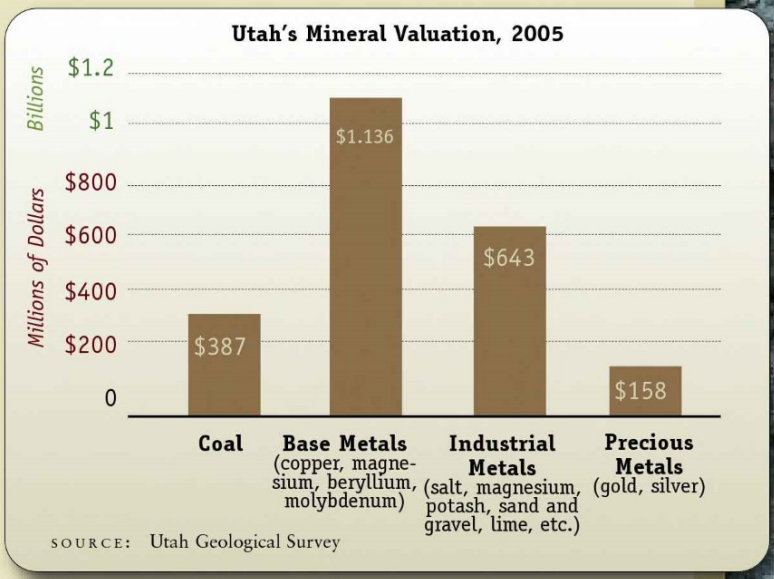
The electricity is sold to Utahns, other western states, and even to foreign countries such as Canada and Japan.

Using one form of natural energy to produce another, the Huntington power plant south of Price is one of five Utah power plants that burns coal to produce electricity.

Activity | Utah's Minerals

This graph shows the dollar value of the minerals that were mined in Utah in 2005. Remember, this is the dollar value, not the quantity. A small amount of gold or silver, for instance, might be worth much more than a larger quantity of coal.

1. Which category had the most value?
2. Which category had the least value?
3. What Utah mineral resources that produce energy are not shown on the graph?



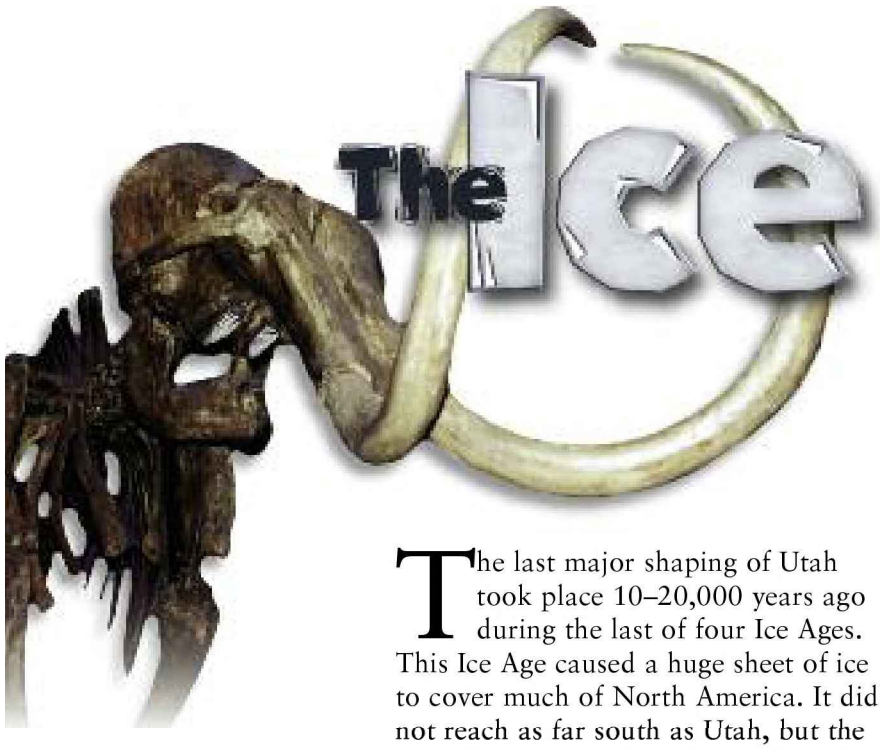
Choose one of the following activities:

A. Uses of Minerals

Choose a mineral from one of the mineral categories on the graph and do some research to learn how and where the mineral is used. Present your information in a written report, a poem, a poster, or a model.

B. Minerals in Your Life

Compose a story, poem, or song about how minerals are used in your life. You could include what your life would be like if Utah's minerals were not available.

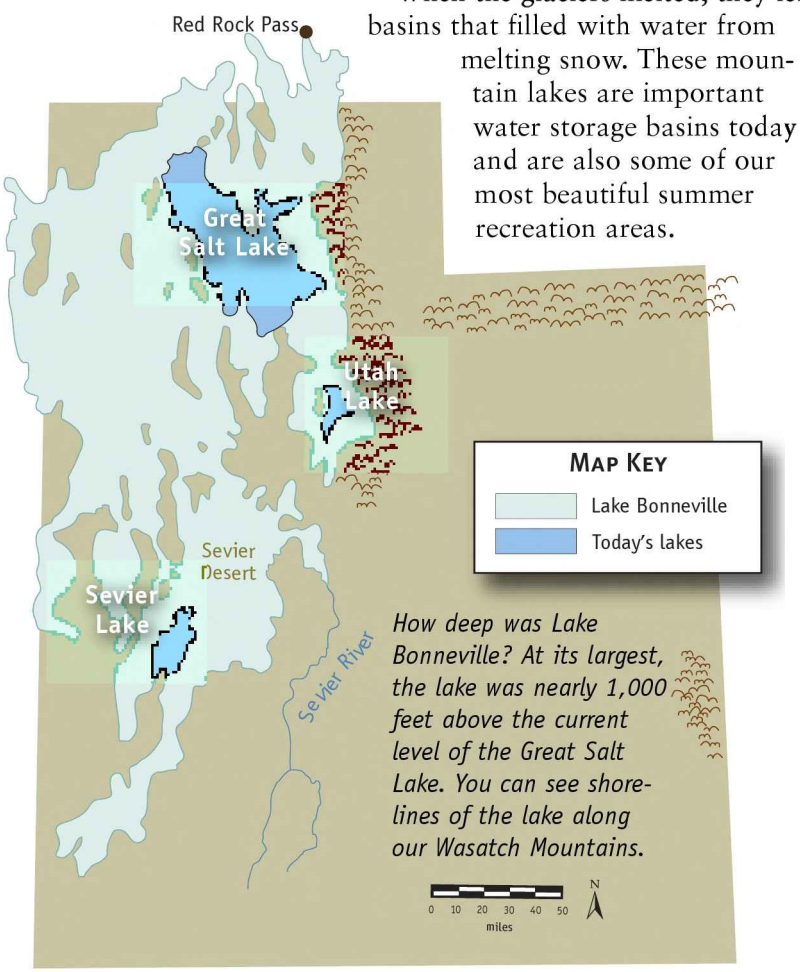


The Ice Age

The last major shaping of Utah took place 10–20,000 years ago during the last of four Ice Ages. This Ice Age caused a huge sheet of ice to cover much of North America. It did not reach as far south as Utah, but the cold climate caused glaciers to form in the Wasatch and Uinta Mountains.

Thousands of small glacial lakes can still be seen in the higher elevations of the mountains.

When the glaciers melted, they left basins that filled with water from melting snow. These mountain lakes are important water storage basins today and are also some of our most beautiful summer recreation areas.



How deep was Lake Bonneville? At its largest, the lake was nearly 1,000 feet above the current level of the Great Salt Lake. You can see shorelines of the lake along our Wasatch Mountains.

Lake Bonneville Was Utah's Ice Age Lake

Over many years, Ice Age temperatures became warmer and the ice slowly melted. The water formed a huge freshwater lake that spread over the flat land of the Great Basin. It covered much of Utah, spreading through canyons and mountain valleys.

Finally, the water overflowed and broke through Red Rock pass in Idaho. It rolled to the Pacific Ocean through the Snake and Columbia Rivers. This lowered the level of the lake. The waves of Lake Bonneville washed against the sides of the Wasatch Mountains until a flat bench, or terrace, was formed.

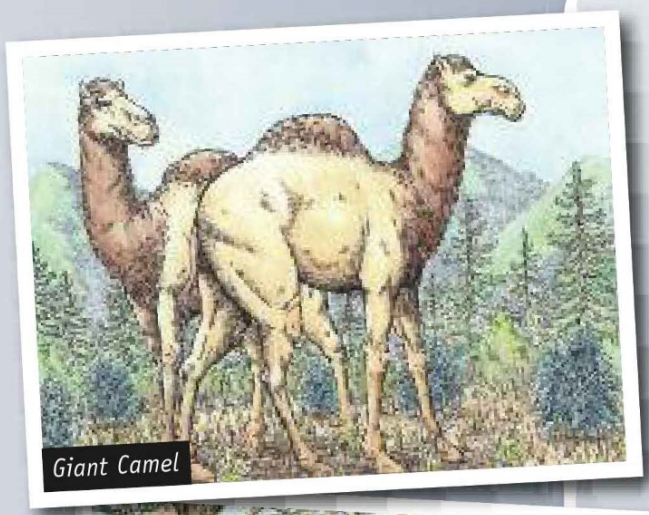
Mountain streams flowed down to the smaller lake, carrying loads of sediment. As the streams entered the lake waters, their speed slowed down and they spread out over the land, dropping much of the rich mountain soil and small rocks they carried. These sediments formed wide areas of loose soil, gravel, and sand and are now some of the best soil and gravel deposits in the state.

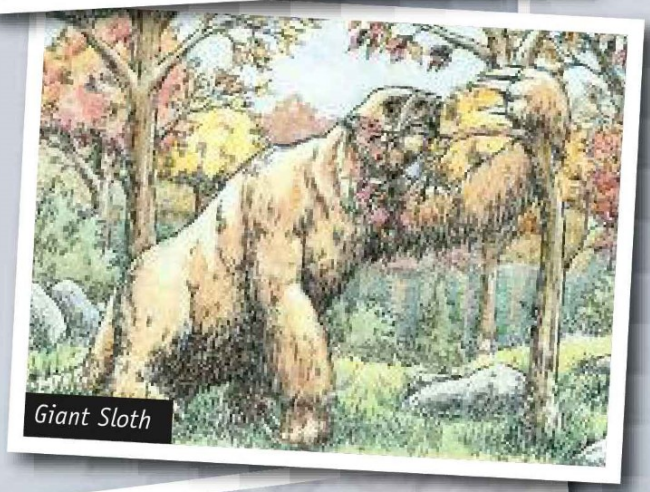
The major ***remnants*** of Lake Bonneville are the Great Salt Lake, Utah Lake, and Sevier Lake.

Ice Age Animals

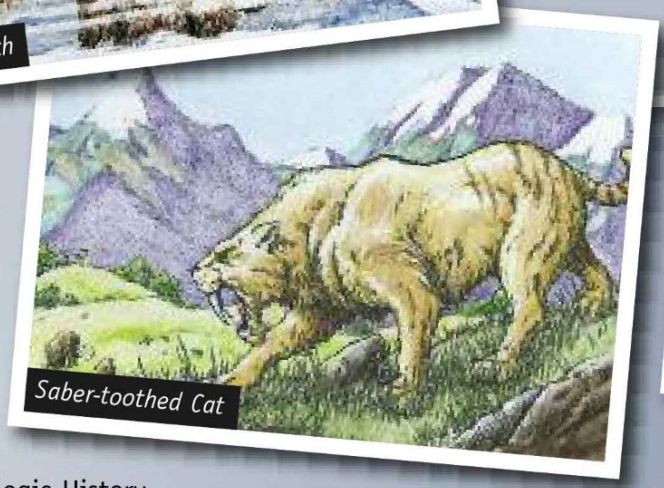
Millions of years after the dinosaurs became extinct, other animals adapted to the land. Now-extinct mammoths, ground sloths about as tall as the mammoths, ancient bison, musk ox, cave bears, saber-toothed cats and giant camels lived here.

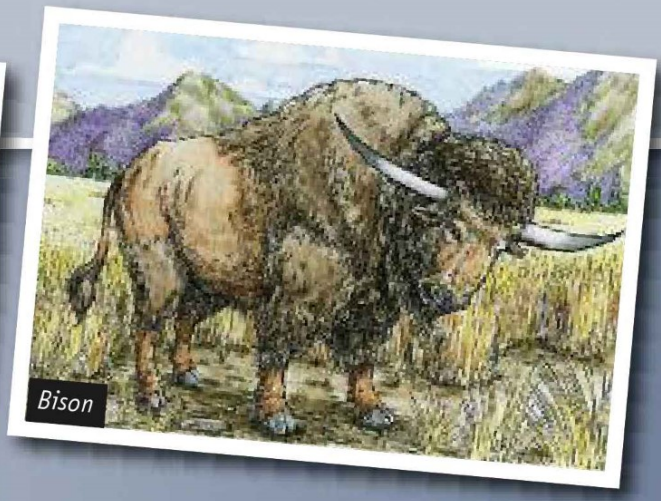
Bones of some of these animals have been found with spear points in them, showing that early people also lived at that time and hunted the animals.


Giant Camel


Giant Sloth

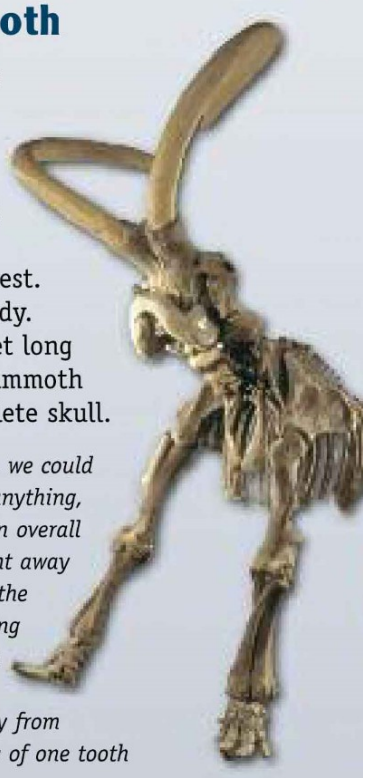

Mammoth


Saber-toothed Cat


Bison

The Huntington Mammoth

In 1988, a skeleton of a prehistoric mammoth was uncovered during reconstruction of Huntington Reservoir. State paleontologist David Gillette and state archaeologist David Madsen supervised the ***excavation*** high in the Manti-La Sal National Forest. Unfortunately, the site was very muddy. The first bone to be dug up was 4 feet long and 8 inches around. A section of mammoth tusk was dug up, and then the complete skull.



Once we identified where the bone was, we could feel down in the muck—we couldn't see anything, it was so black and so sloppy—and get an overall feel for the size of the skull. And so I went away that day after [several more swipes with the backhoe], each time striking bone, thinking that we probably had a complete skeleton of a mastodon.

The next day as I pulled the muck away from the . . . skull, I exposed a series of plates of one tooth that indicated it was a mammoth.

—David Gillette

The Huntington Mammoth is one of the most complete and well-preserved specimens ever recovered in the United States. The mammoth skeleton is on display at the College of Eastern Utah in Price.

Mammoths had high shoulders, a tall head with large curved tusks at least 10 feet long in mature bulls, and were about a foot taller than modern elephants. It was a large old bull, maybe 60 years old, that had died in the bog near a mountain glacier. It died somewhere between 9,500 to 10,000 years ago, at the end of the last Ice Age.

What is the difference between a mammoth and a mastodon? One of the differences is teeth! Mammoths have only one molar tooth in each side of each jaw, while mastodons have three. The shape of the teeth is also very different.

In 2004 the Utah State Capitol building was closed for renovation. Large shock absorbers were placed under the building to make it more stable in case of an earthquake. Construction was completed in 2008.

Natural Forces Affect the Environment Today

Changes on the surface of the land began almost as soon as the surface was formed. Wind, water, ice, heat, and cold are the main agents of erosion. They mount a constant, powerful force that even the hardest rocks cannot withstand.

Mud slides, rock slides, floods, and earthquakes are all reminders that the earth is still changing. Mud slides and floods currently cause the most damage in Utah.

Utah's earthquakes do cause limited damage from time to time, but no large-scale earthquake has occurred here since written history began. Utah has over 700 small earthquakes a year, but most of them are too small for us to feel. We also have about thirteen larger earthquakes a year, but they are usually not near towns. In 1934 the Hansel Valley Fault caused a 6.6 earthquake seven miles north of the Great Salt Lake, but did little damage because there were no towns nearby.

Activity | Natural Forces Shape the Environment

Choose one of these activities to learn more about Utah's changing land. Use the information in this chapter and other reference materials for information.

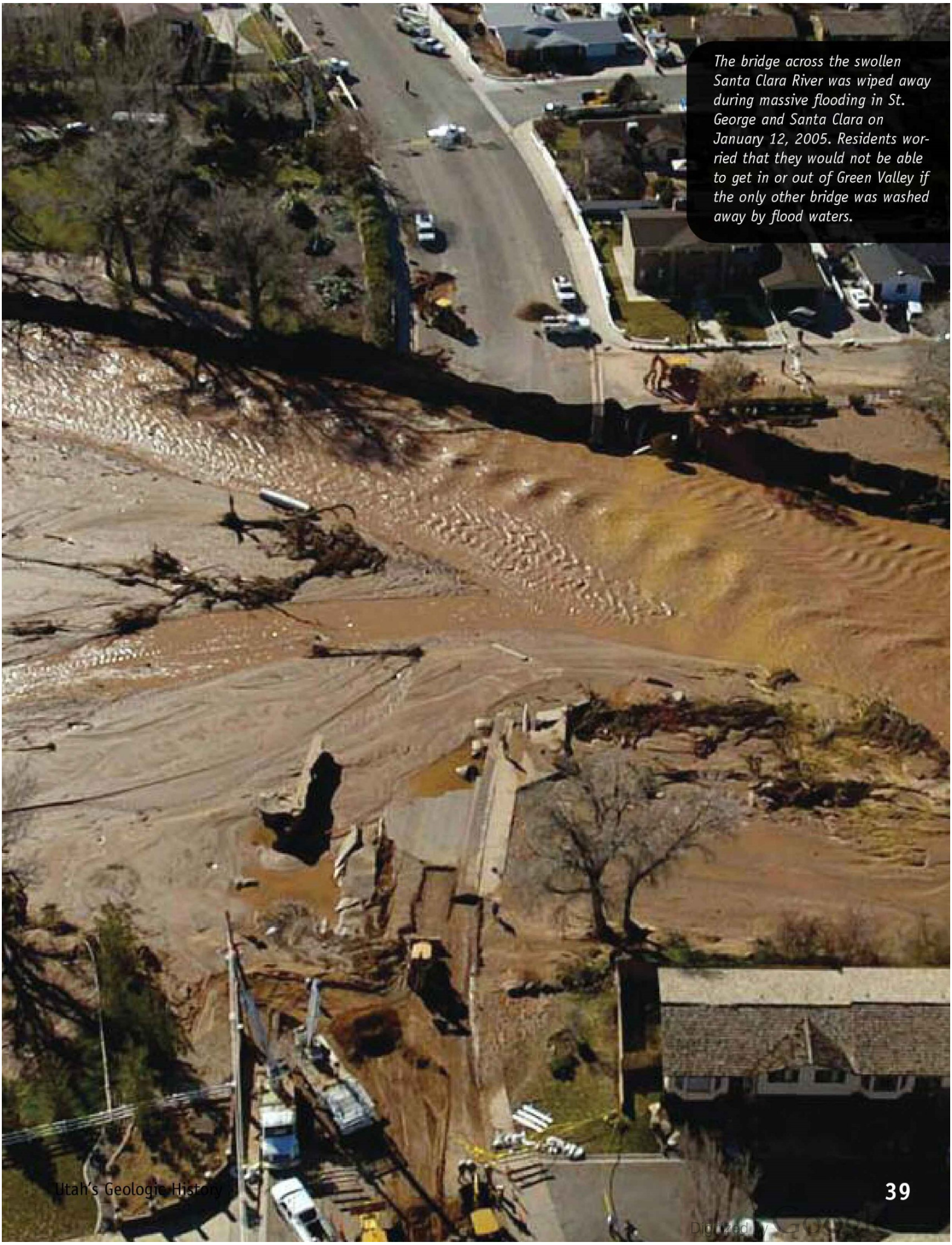
A. Utah's Geologic Development: Make a poster or chart showing the sequence of Utah's geologic development. Include shallow seas, formation of mountains and plateaus, eruption of volcanoes, the Ice Age, etc.

B. Recent Natural Disasters: Choose one of the natural disasters described in this chapter, or another Utah disaster, and learn more about what happened.

- How did it affect the land?
- How did it affect the people who lived in the region?
- How did it affect businesses and people's jobs?
- What has been done in the region to repair some of the damage?

Report what you learned in a written or verbal way, or present an art project about it.

In Farmington, a car lies sideways in a wall of mud that caused major damage to 30 homes in 1983. About 2,000 people were moved to safer ground.



The bridge across the swollen Santa Clara River was wiped away during massive flooding in St. George and Santa Clara on January 12, 2005. Residents worried that they would not be able to get in or out of Green Valley if the only other bridge was washed away by flood waters.

CHAPTER 2 REVIEW

Memory Master

1. How do geologists learn the history of the land?
2. Describe the sources of Utah's igneous rock, sandstone, and limestone.
3. What is Utah's oldest animal fossil?
4. Retell the main events of the discovery of Utah's first dinosaur bones near Vernal.
5. How were the Rocky Mountains formed?
6. What is a fault, and what happens when land slips along a fault?
7. Much of Utah's electricity is produced by burning _____ to produce steam.
8. Which of today's lakes are the remnants of the ancient Lake Bonneville?
9. What huge Ice Age animal bones were found at the Huntington Reservoir?
10. Describe some ways natural forces have changed the land during the last 50 years.

Activity | The Utah Geological Survey

Utah's state government operates many agencies. One is the Utah Geological Survey. By visiting their website you can find amazing information about the land outside your window and across the state.

Log onto **www.geology.utah.gov** and follow the menu links. See if you can answer these questions. Then choose one topic from the main menu to explore.

1. What are meteorites? Have meteorites and meteorite craters been found in Utah?
2. What kind of rock makes a good rock wall?
3. Can you find gold in Utah? If you find it, how do you stake a claim?
4. How do geologists know how old a rock is?
5. What are igneous, metamorphic, and sedimentary rocks?
6. Where can you find examples of the three rock types in Utah?
7. What kinds of dinosaurs lived in Utah, and where?
8. What kinds of energy does Utah produce, and where?
9. What is "liquefaction," and how can it be dangerous?
10. Where have the most recent earthquakes, landslides, and mudslides occurred?

Go to the Source

Analyze a Diary Account

Albert Jones lived near the Provo River in the late 1800s. His diary for 1872 reveals problems people faced along Utah's rivers.

May 29:
Water rising in the River on account of the excessive heat. Fears entertained for the safety of the crops.

June 4:
Provo River very high. Excitement on account of the probability of its coming into the city. The lower part of the field west of the city under water.

June 6:
Provo Cannon Bridge washed away by the flood in the afternoon.

June 17:
The meetinghouse bell rang to warn the citizens of the north . . . of Provo River Bridge being in danger of being washed away.

Compare what happened during two time periods.

1. What do the 2005 flood in St. George and Santa Clara (see page 39) and the 1872 Provo flood in Albert's diary have in common?
2. What are some differences?
3. In the first diary entry, Albert says the water was rising because of excessive heat. Why would heat cause flooding?