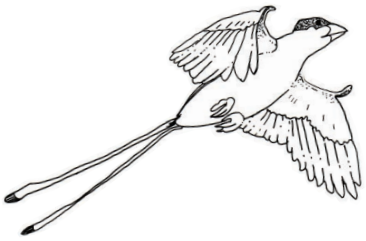
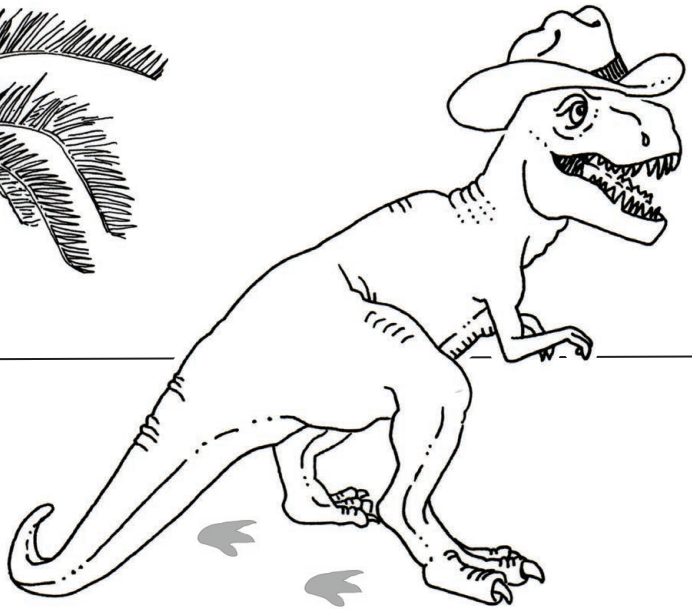
Exploring EARTH SCIENCE

in TEXAS





QAe8688
12/2020

Bureau of Economic Geology
Scott W. Tinker, Director

About this book

The *Exploring Earth Science in Texas Coloring Book* was developed as public outreach to school children. The content includes many of the topics that are required for middle school students and is intended to reinforce classroom lessons in Earth Science.

Acknowledgments
Linda Ruiz McCall (content development); Francine M. Mastrangelo (graphic design and illustration); Charles M. Woodruff, Jr., and Jeffrey G. Paine (reviewers); Amanda R. Masterson (editing)

Exploring Earth Science in Texas
Linda Ruiz McCall and Francine M. Mastrangelo

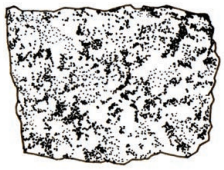
Contents

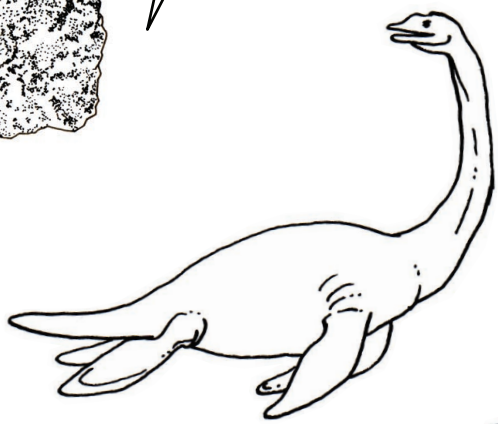
Bureau of Economic Geology

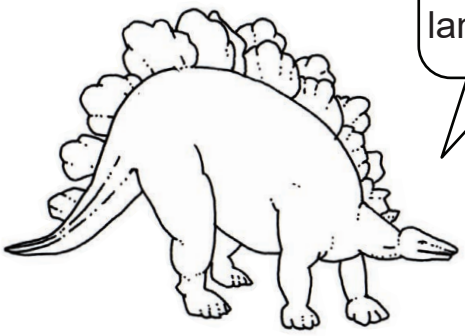
About Your Guides

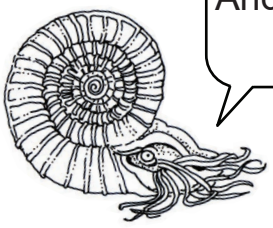
The Earth is a complex system of interacting rock, water, air, and life. Earth Science helps us understand these systems.

Let our guides take you through this book as we go exploring!





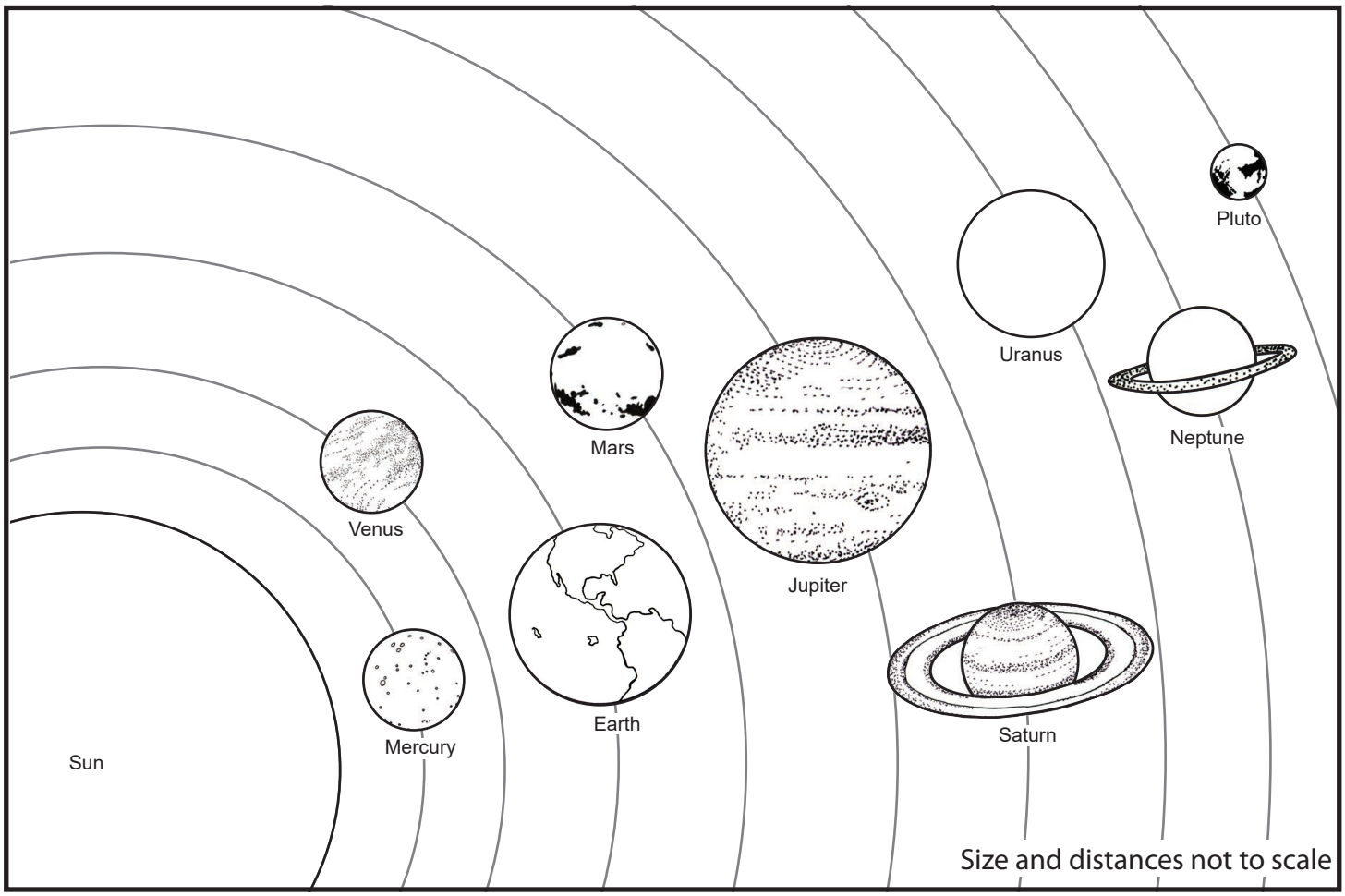




Bureau of Economic Geology

Our Solar System

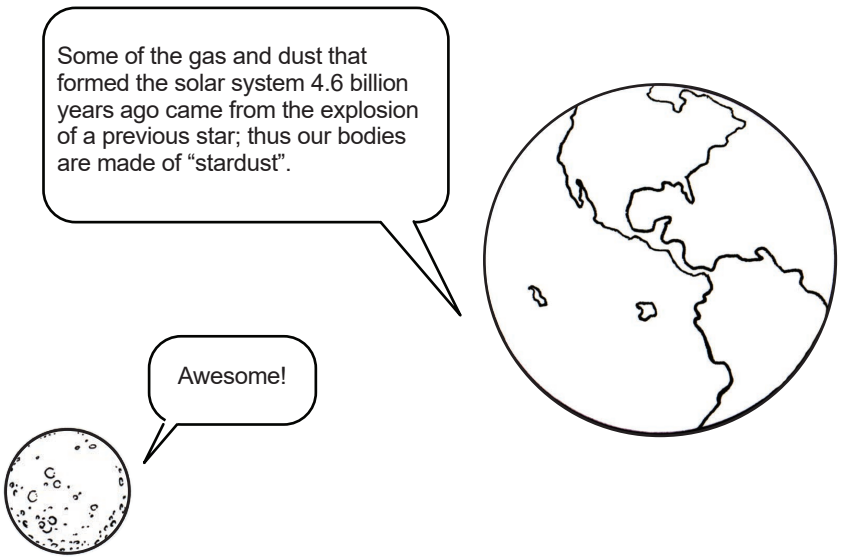
Our Solar System formed from a vast cloud of gas and dust 4.6 billion years ago. This age of 4.6 billion years is well established from the decay rates of radioactive elements found in meteorites and rocks from the moon. Studying other objects in the solar system helps us learn Earth's history. Active geologic processes such as plate tectonics and erosion have destroyed or altered most of Earth's early rock record. Many aspects of Earth's early history are revealed by objects in the solar system that have not changed as much as Earth has.*



QAe8797

Color each planet using this color key:

	Planet	Color
	Sun	yellow/orange
These planets are made of rock	Mercury	gray
	Venus	light gray
	Earth	blue/green
	Mars	red/brown
These planets are made of gases	Jupiter	brown stripes
	Saturn	yellow
	Uranus	light blue
	Neptune	blue
	Pluto	white

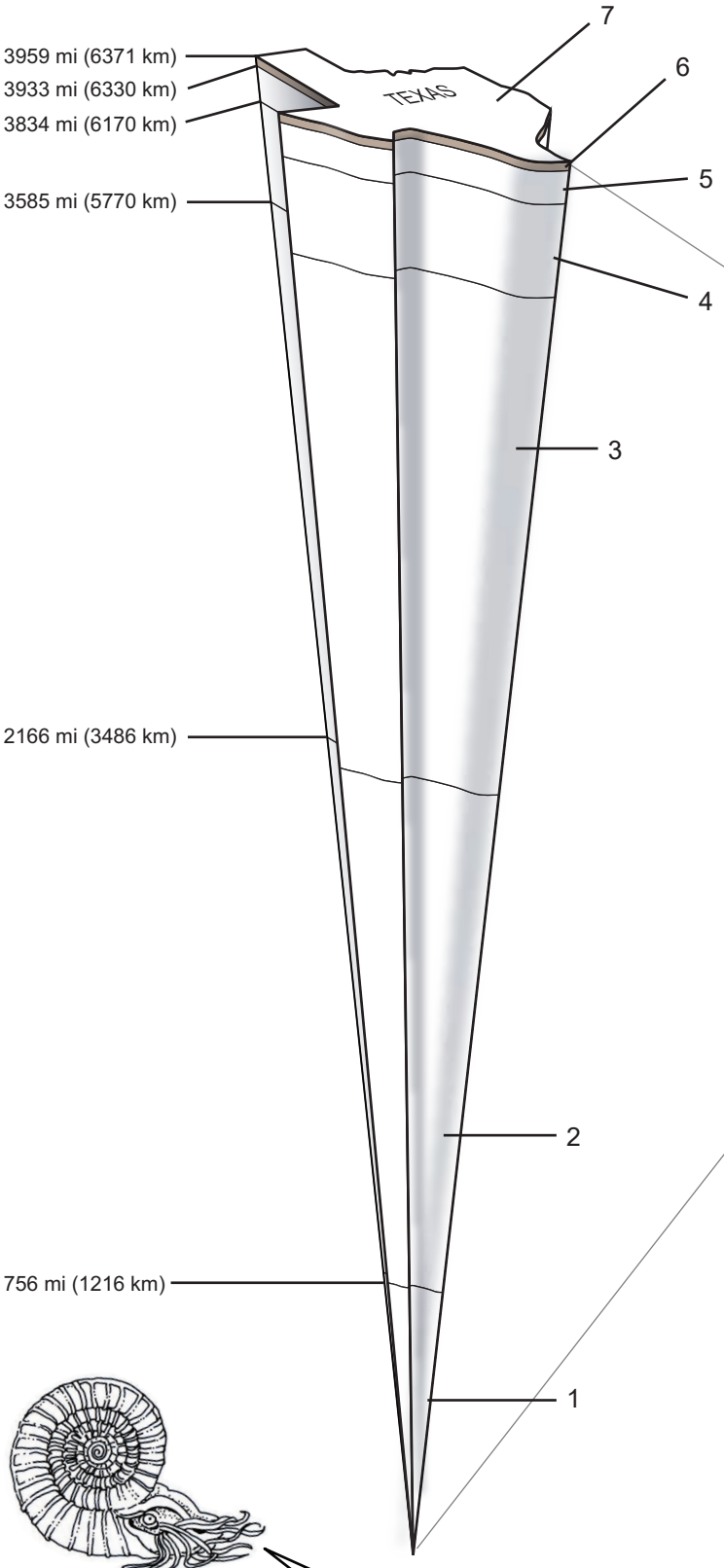


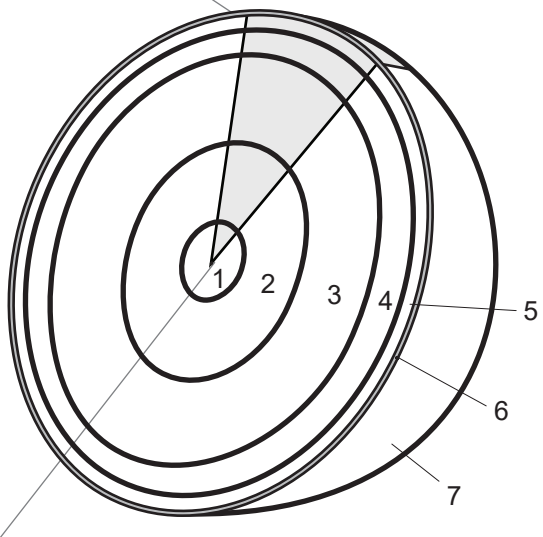
Bureau of Economic Geology

* Text modified from Earth Science Literacy Principles, www.earthscienceliteracy.org

Earth's Layers

Driven by gravity, Earth's metallic core formed as iron-nickel metal, and sank to the center. Rock surrounding the core was mostly molten early in Earth's history, and it slowly cooled to form Earth's mantle and crust. The atoms of different elements combined to make minerals, which combined to make rocks.*





EARTH

Did you know the inner core of Earth is made of solid iron-nickel metal?

Color each layer using this color key:

	Feature	Color
1	Inner core Solid iron–nickel metal	white
2	Outer core Liquid iron–nickel metal Rotation generates magnetic field	yellow
3	Lower mantle Solid iron–magnesium silicate Can flow slowly	orange
4	Asthenospheric mantle Solid iron–magnesium silicate Weak, flows more quickly	orange/red
5	Lithospheric mantle Solid iron–magnesium silicate, lower part of plate	red/brown
6	Crust Solid calcium–aluminum silicate, upper part of plate	gray
7	Surface	blue

QAe8798

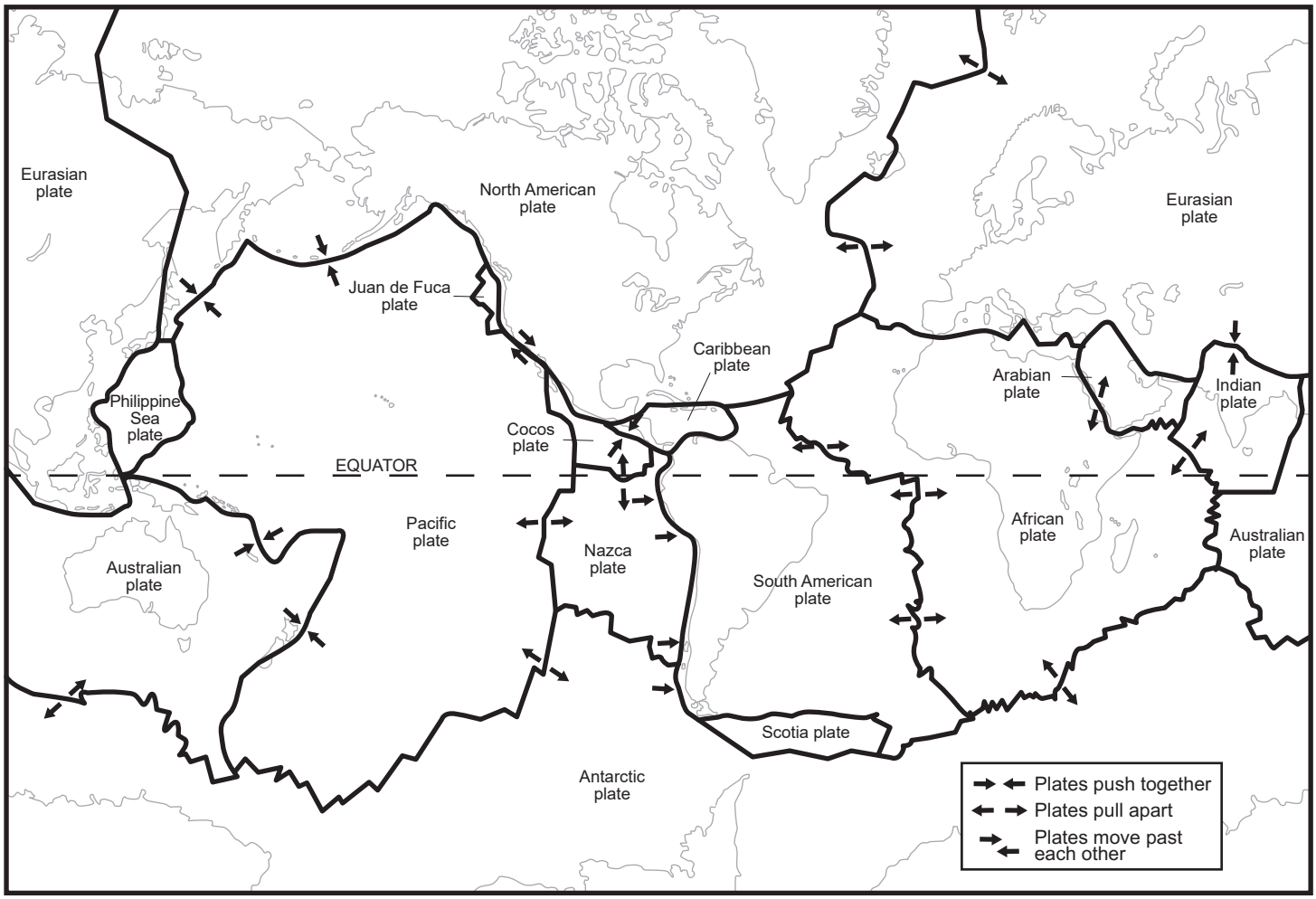
* Text modified from Earth Science Literacy Principles, www.earthscienceliteracy.org

Modified from Bureau of Economic Geology, Texas Through Time: Lone Star Geology, Landscapes and Resources, 2016

Bureau of Economic Geology

Earth's Tectonic Plates

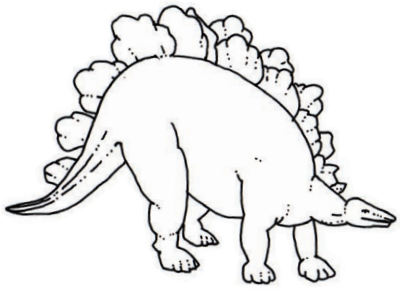
Earth's tectonic plates consist of the rocky crust and uppermost rigid mantle (Lithosphere), and move slowly with respect to one another. New oceanic plate continuously forms at mid-ocean ridges and other spreading centers, sinking back into the mantle at ocean trenches. Tectonic plates move steadily at rates of up to 10 centimeters per year.*



QAe8844

Color each tectonic plate using the color key.

Tectonic plate	Color
African plate	orange/red
Antarctic plate	blue
Arabian plate	yellow
Australian plate	orange
Caribbean plate	pink
Cocos plate	blue
Eurasian plate	green
Philippine Sea plate	dark pink
Indian plate	red
Juan de Fuca plate	blue
Nazca plate	light blue
North American plate	brown
Pacific plate	gray
South American plate	purple
Scotia plate	light blue



Tectonic plates move steadily at an average rate of up to 10 centimeters (3.9 inches) per year.

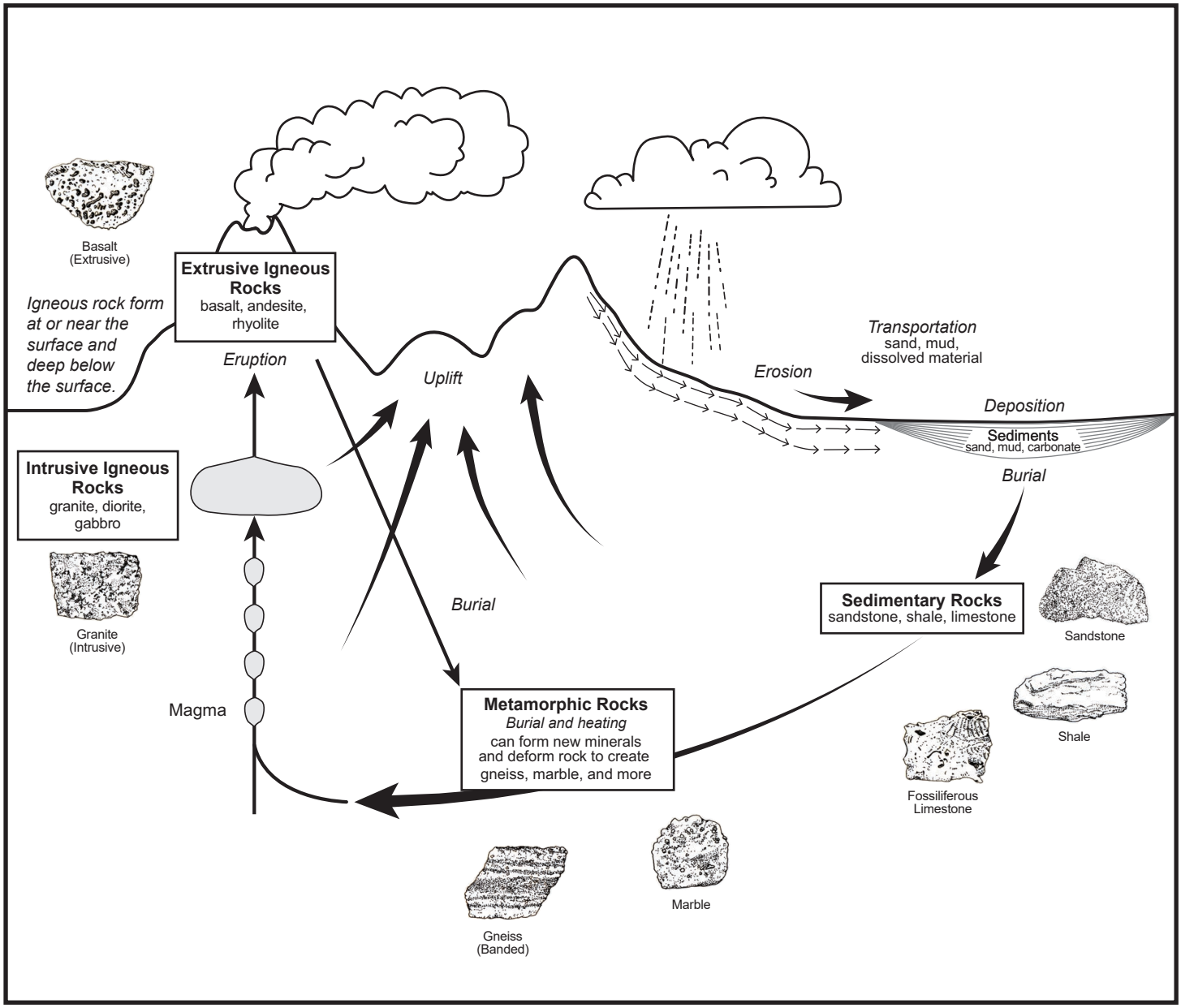
Plate boundaries are where most earthquakes and volcanoes occur.

Bureau of Economic Geology

* Text from Earth Science Literacy Principles, www.earthscienceliteracy.org
Modified from https://earthquake.usgs.gov/learn/glossary/images/plate_tectonics.gif

The Rock Cycle

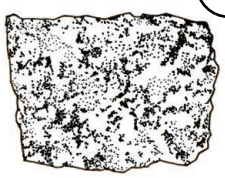
Rocks form from the cooling of magma, the accumulation and consolidation of sediments, and the alteration of older rocks by heat, pressure, and fluids. These three processes form igneous, sedimentary, and metamorphic rocks.*



QAe8799

Color each rock type using this color key:

Rock Type	Color
Sedimentary	yellow
Metamorphic	purple
Igneous	red



List the rock names for each rock type in the picture above.

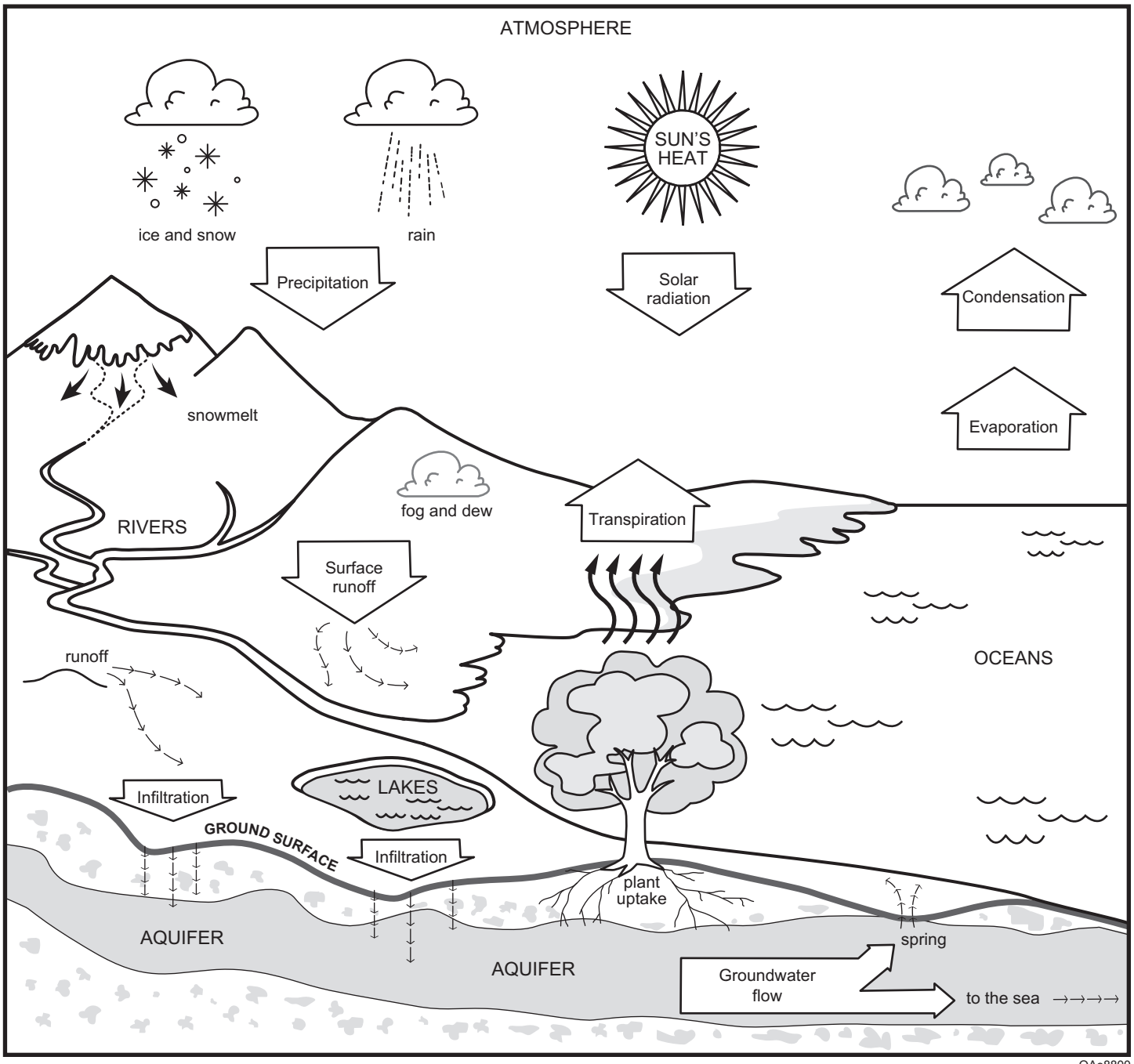
Rock Type	Rock names
Sedimentary	
Metamorphic	
Igneous	

* Text modified from Earth Science Literacy Principles, www.earthscienceliteracy.org
Modified from Bureau of Economic Geology, Texas Through Time: Lone Star Geology, Landscapes and Resources, 2016

Bureau of Economic Geology

The Water Cycle

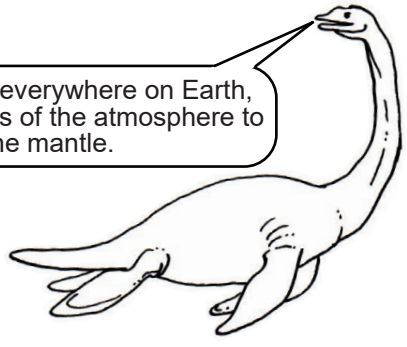
Earth is unique in our Solar System in that water has coexisted at Earth's surface in three phases (solid, liquid, and gas) for billions of years, allowing the development and continuous evolution of life. Water's combination of physical and chemical properties includes the manner in which water absorbs and releases heat, reflects sunlight, expands upon freezing, and dissolves other materials.*



QAe8800

Find the words listed below in the picture above and color them blue.

Solar radiation	Surface runoff
Evaporation	Infiltration
Condensation	Transpiration
Precipitation	Groundwater flow

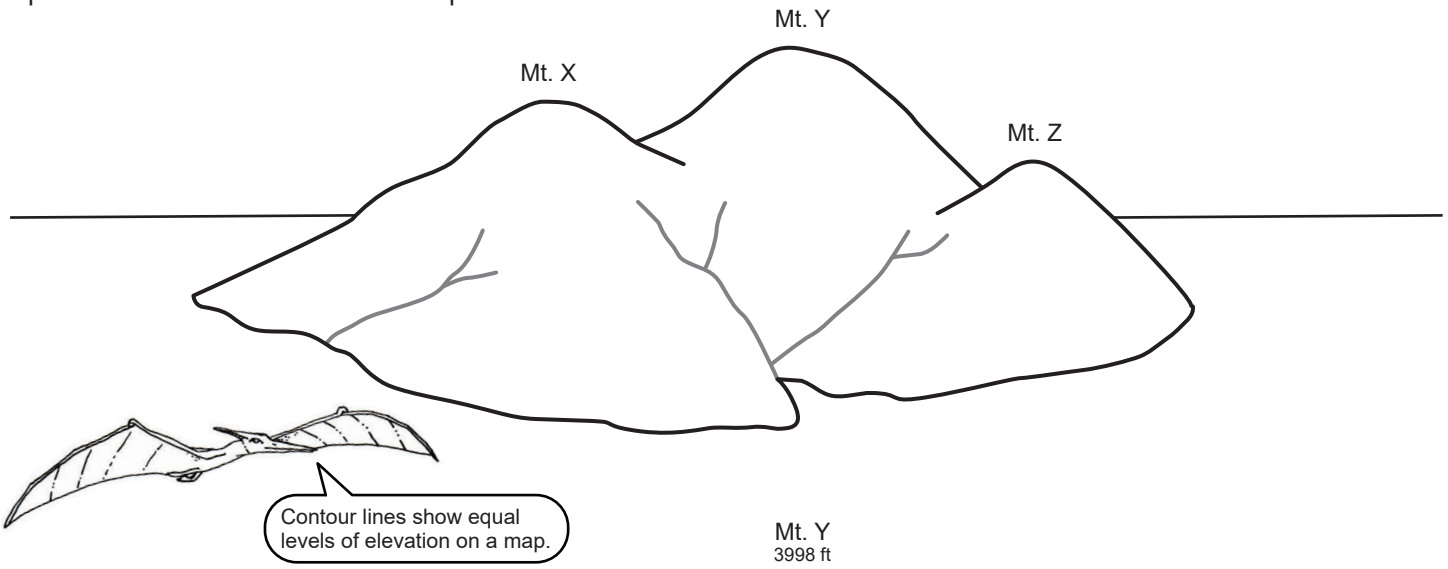


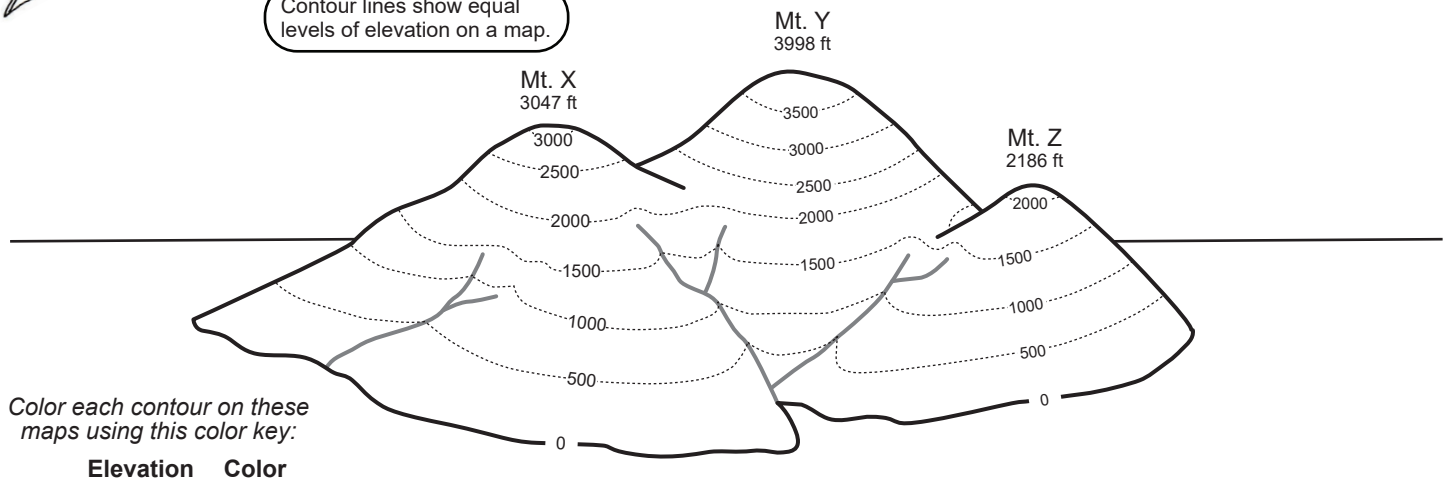
Bureau of Economic Geology

* Text modified from Earth Science Literacy Principles, www.earthscienceliteracy.org
Modified from https://water.usgs.gov/edu/activity-watercyclebegin.html

Topographic Maps

Topographic maps represent the three-dimensional surface of the earth in a two-dimensional format using contour lines to show changes in the elevation above sea level. The three-dimensional perspective views at the top of this page are represented as a two-dimensional map view at the bottom.

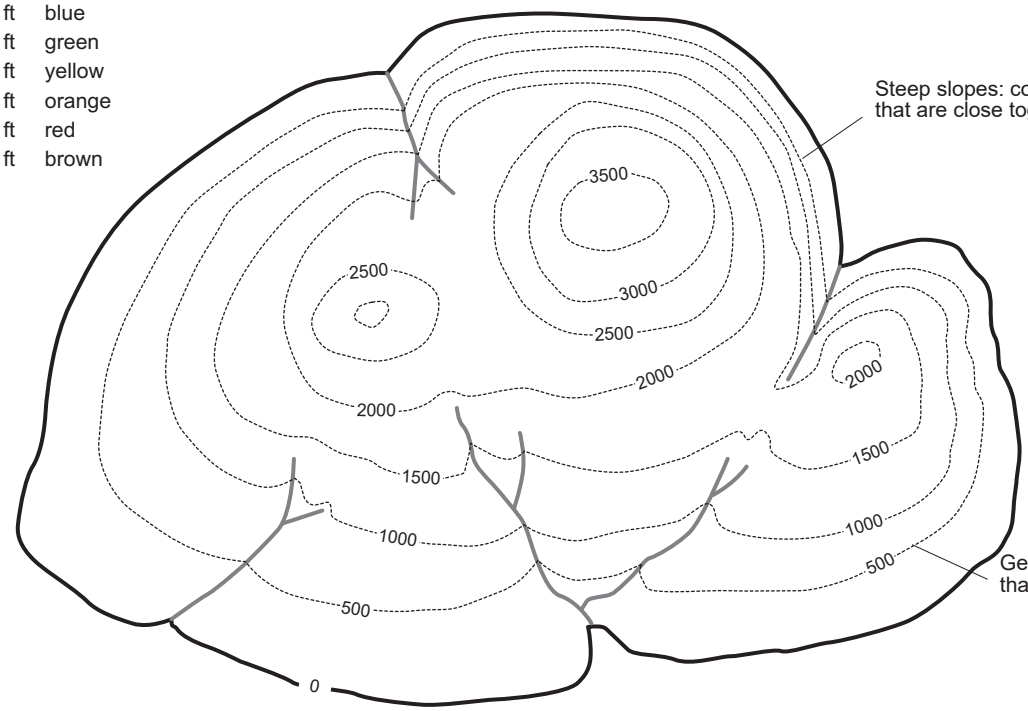




Color each contour on these maps using this color key:

Elevation	Color
less than 500 ft	white
500 ft – 1000 ft	purple
1000 ft – 1500 ft	blue
1500 ft – 2000 ft	green
2000 ft – 2500 ft	yellow
2500 ft – 3000 ft	orange
3000 ft – 3500 ft	red
greater than 3500 ft	brown

Map View



Steep slopes: contour lines that are close together.

Gentle slopes: contour lines that are farther apart.

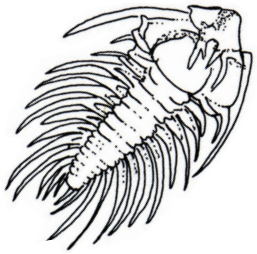
QAe8801

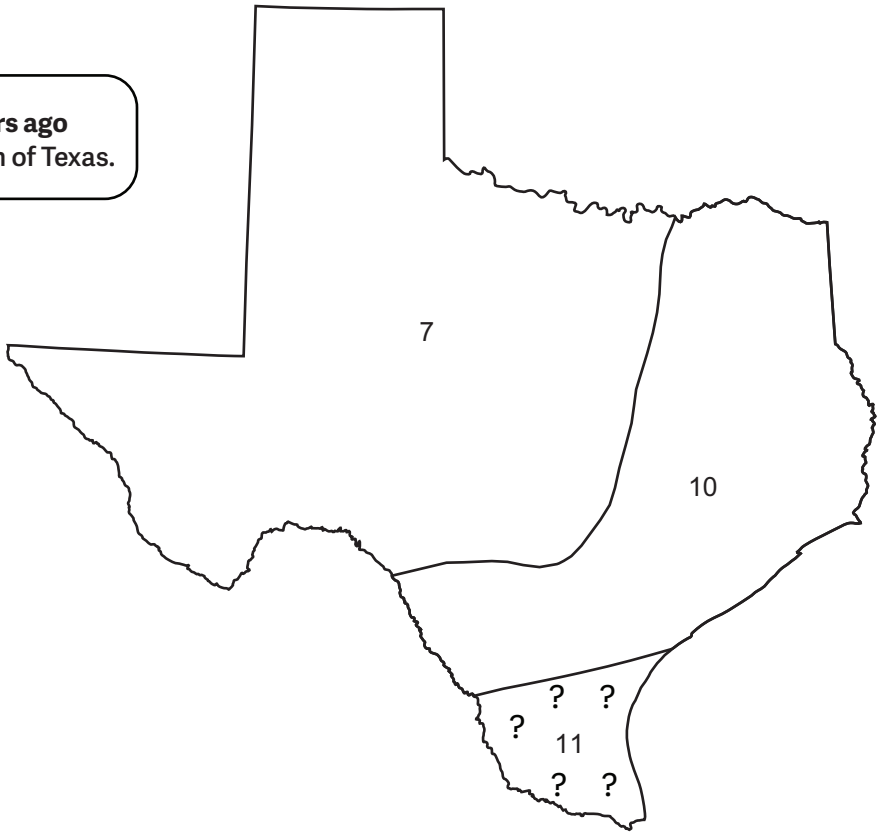
Modified from Bureau of Economic Geology, Introduction to Topographic Maps, 2019

Bureau of Economic Geology

Texas Through Time

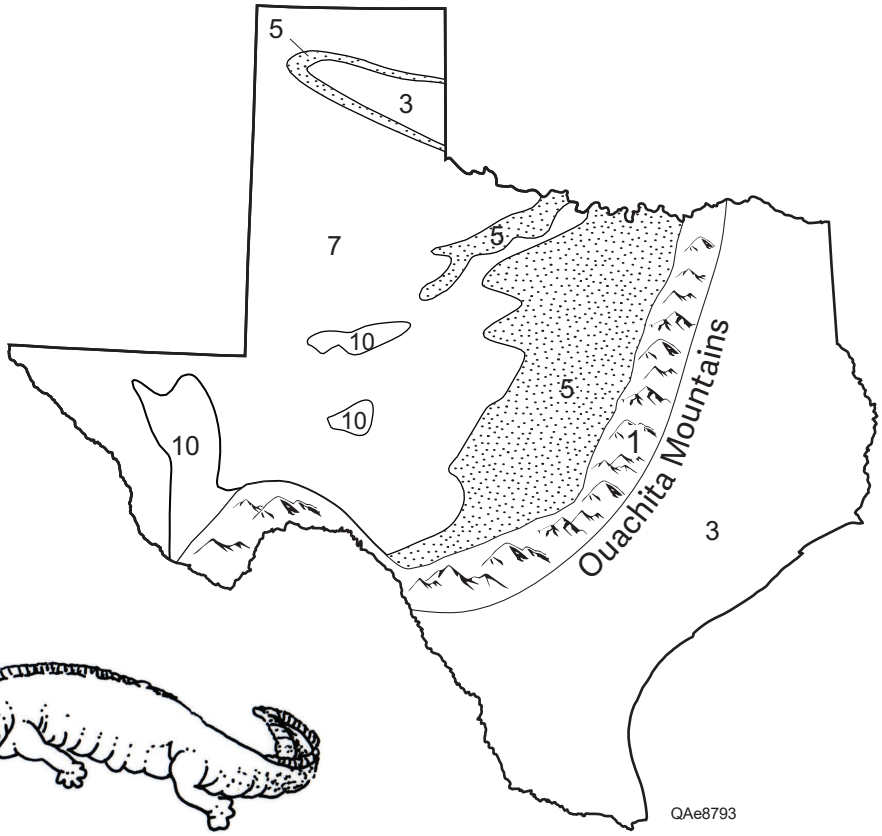
485 million years ago
Seas covered much of Texas.



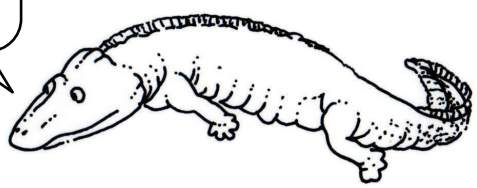


Color each feature using this color key:

	Feature	Color
1	Mountains	purple
2	Highlands	light purple
3	Land	light green
4	Volcanoes	red
5	Rivers, deltas, and shores	pink
6	Tidal flats, evaporating sea	grid lines
7	Shallowest sea	light blue
8	Reef	light blue/shells
9	Shallow sea	blue
10	Deep sea	blue/green
? 11 ?	Unknown	question marks



300 million years ago
The Ouachita Mountains stood tall throughout Central Texas.

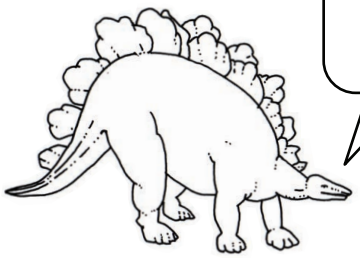


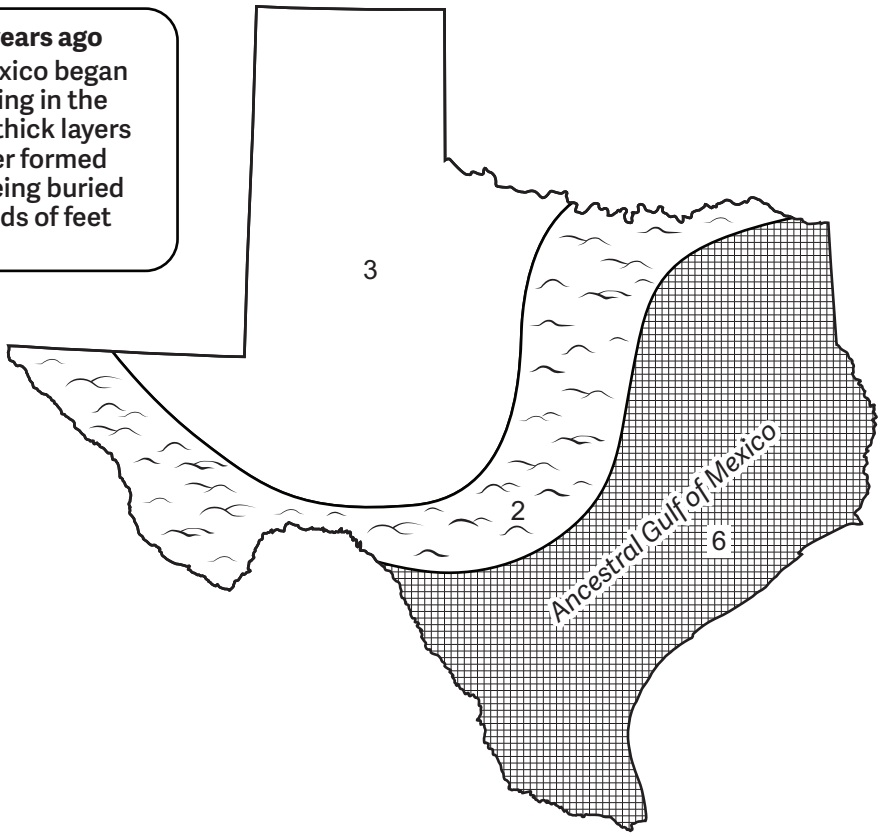
QAe8793

Bureau of Economic Geology

Texas Through Time

165 million years ago
The Gulf of Mexico began to open, resulting in the deposition of thick layers of salt that later formed domes after being buried under thousands of feet of sediment.

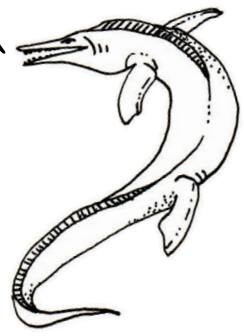


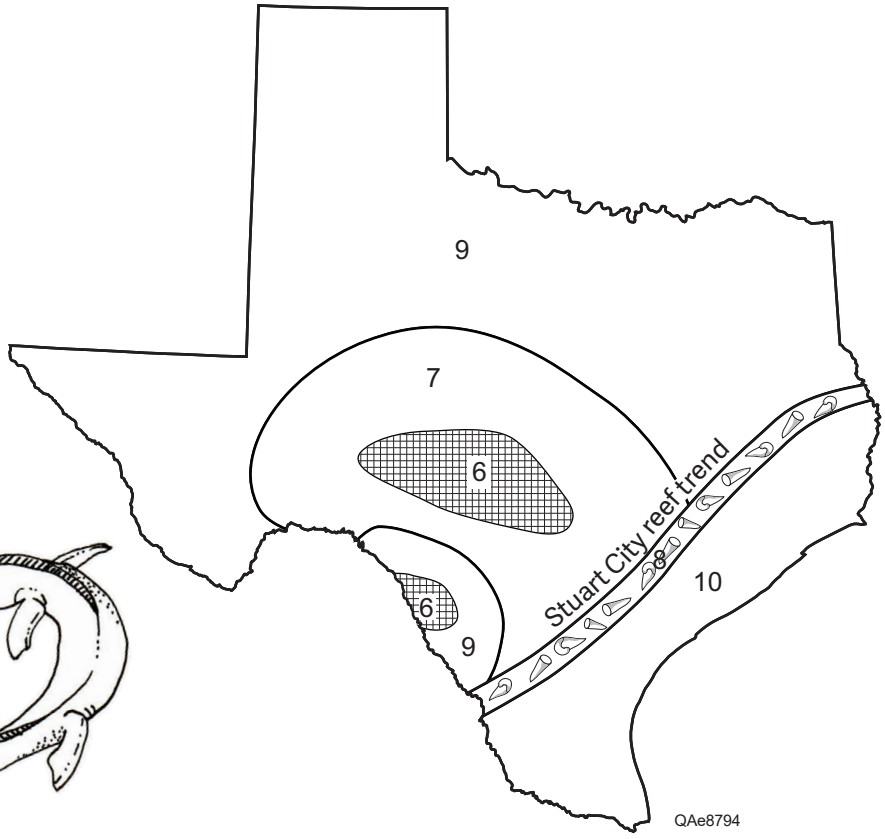


Color each feature using this color key:

	Feature	Color
1	Mountains	purple
2	Highlands	light purple
3	Land	light green
4	Volcanoes	red
5	Rivers, deltas, and shores	pink
6	Tidal flats, evaporating sea	grid lines
7	Shallowest sea	light blue
8	Reef	light blue/shells
9	Shallow sea	blue
10	Deep sea	blue/green
? 11 ?	Unknown	question marks

100 million years ago
Sea levels rose and covered the land again.

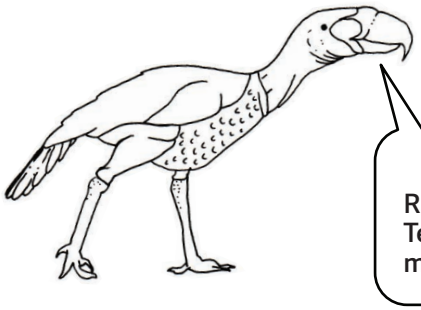




Modified from Bureau of Economic Geology, Great Places to View Texas Geology, 2019

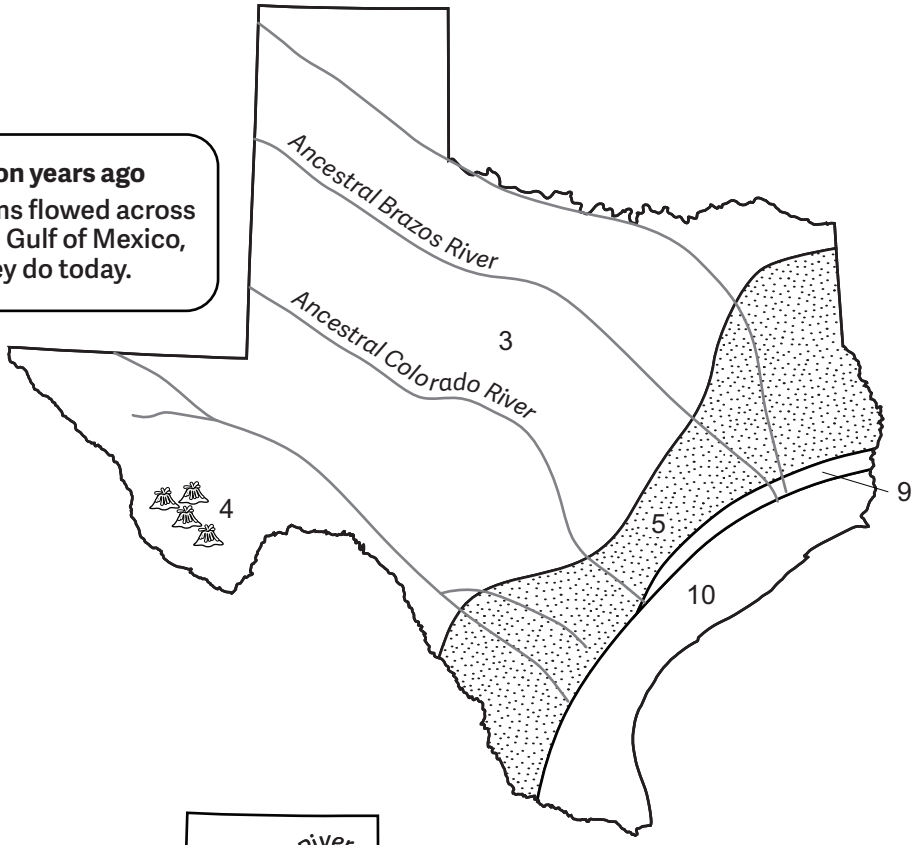
Bureau of Economic Geology

Texas Through Time



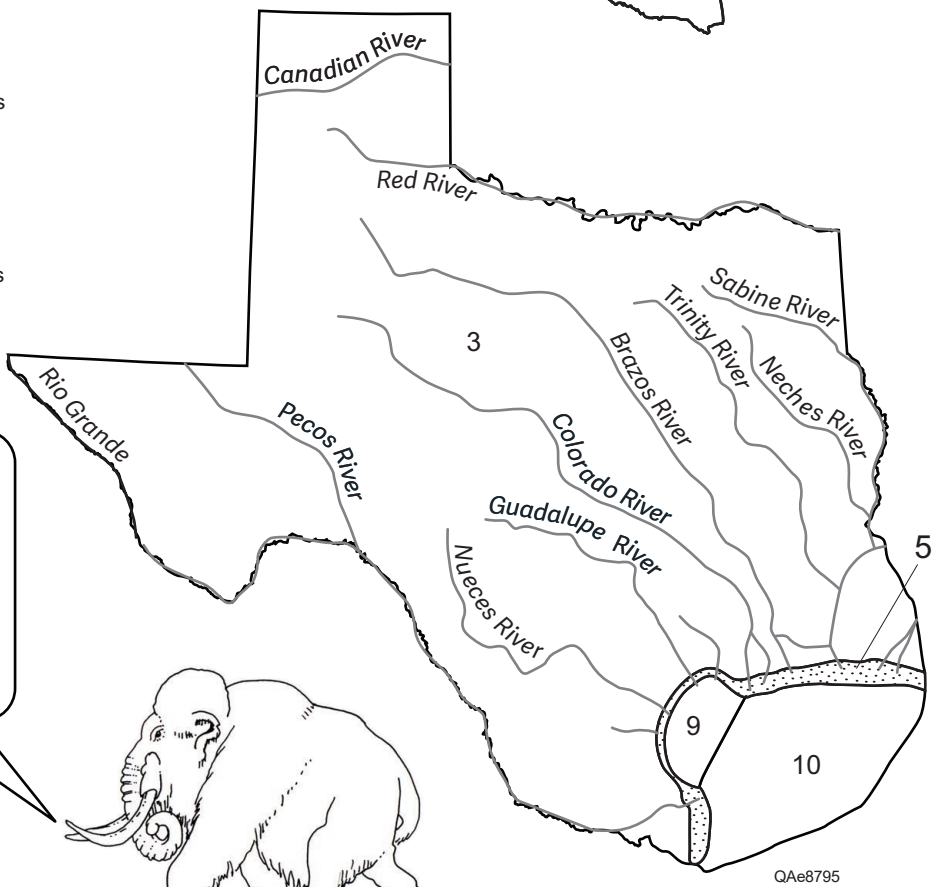
50 million years ago

River systems flowed across Texas to the Gulf of Mexico, much as they do today.



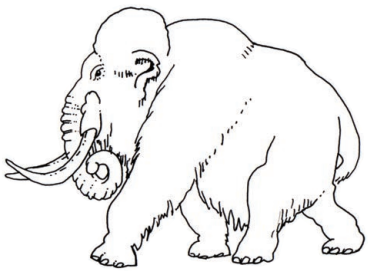
Color each feature using this color key.

	Feature	Color
1	Mountains	purple
2	Highlands	light purple
3	Land	light green
4	Volcanoes	red
5	Rivers, deltas, and shores	pink
6	Tidal flats, evaporating sea	grid lines
7	Shallowest sea	light blue
8	Reef	light blue/shells
9	Shallow sea	blue
10	Deep sea	blue/green
? 11 ?	Unknown	question marks



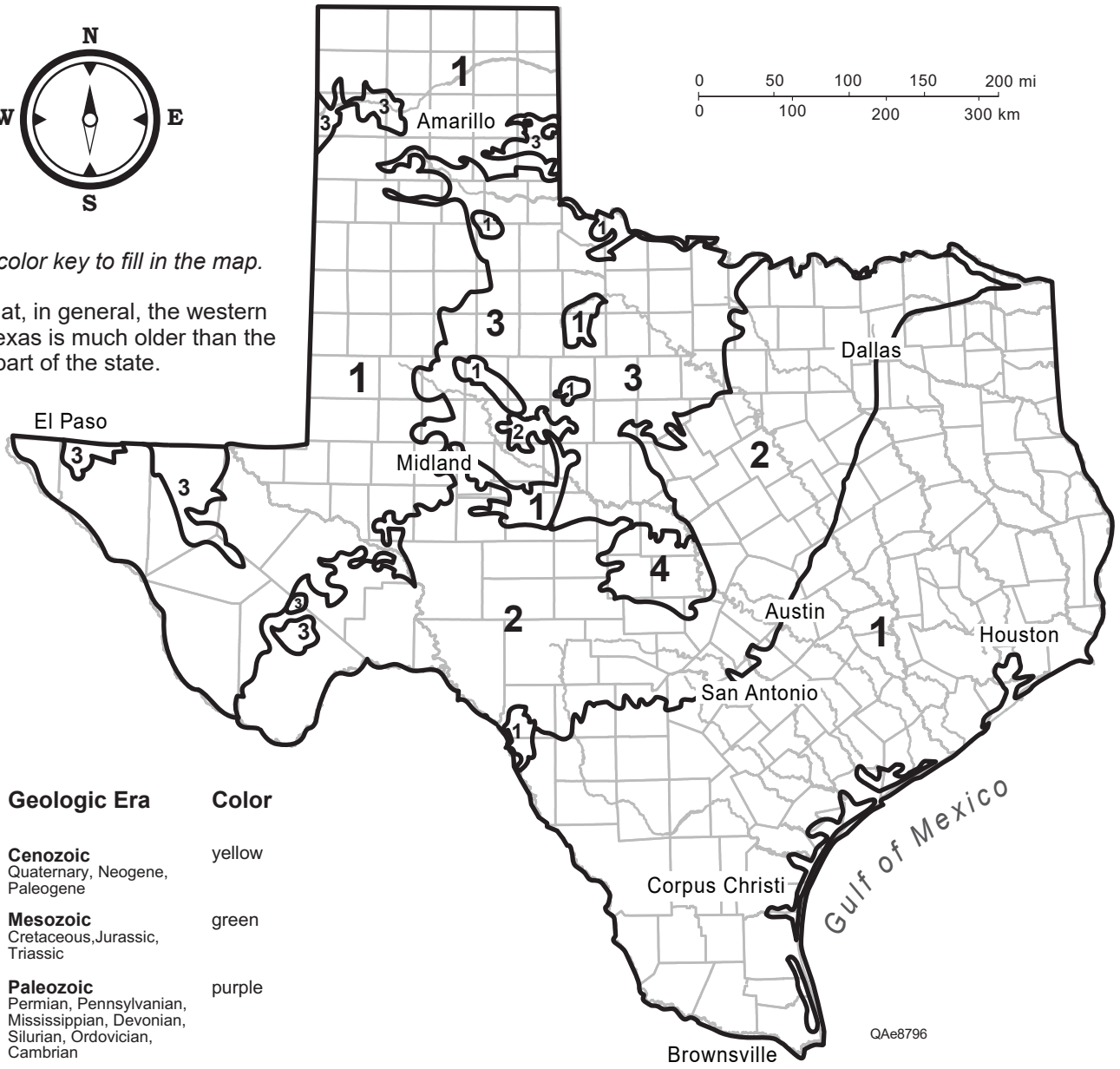
20 thousand years ago

The rock record shows that water stored in ice sheets and glaciers during the last ice age caused sea levels to be hundreds of feet lower than they are now. Many bays in Texas are drowned river valleys.



Bureau of Economic Geology

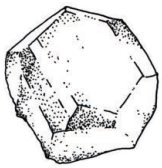
Texas Geologic Map
(Age of Rocks at Land Surface)



Use the color key to fill in the map.

Notice that, in general, the western part of Texas is much older than the eastern part of the state.

	Geologic Era	Color
1	**Cenozoic** Quaternary, Neogene, Paleogene	yellow
2	**Mesozoic** Cretaceous,Jurassic, Triassic	green
3	**Paleozoic** Permian, Pennsylvanian, Mississippian, Devonian, Silurian, Ordovician, Cambrian	purple
4	**Precambrian**	pink

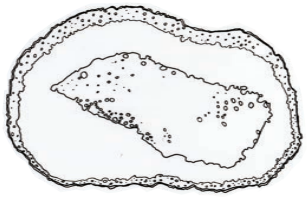


Texas Blue Topaz

Texas Blue Topaz is the state gem of Texas. Color me light blue.

The oldest rocks found at the Texas surface are about 1.35 billion years old.

Petrified palmwood, the state stone of Texas, came from palm trees, about 20 - 40 million years ago. Color me light brown.

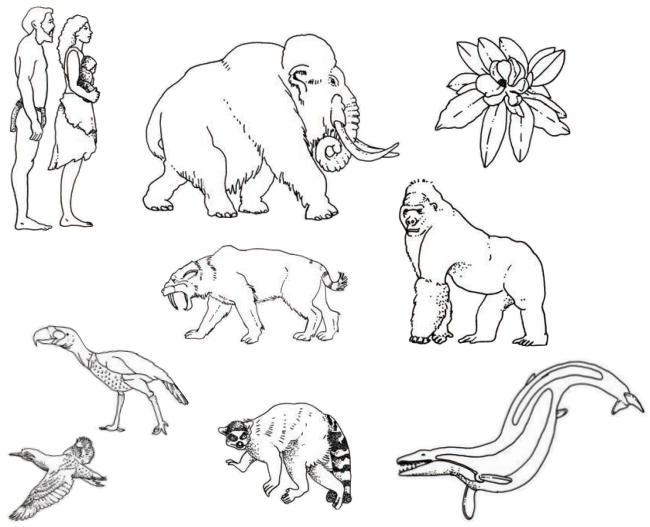
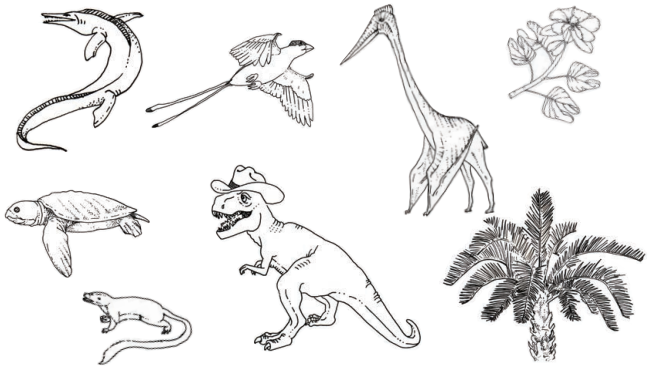
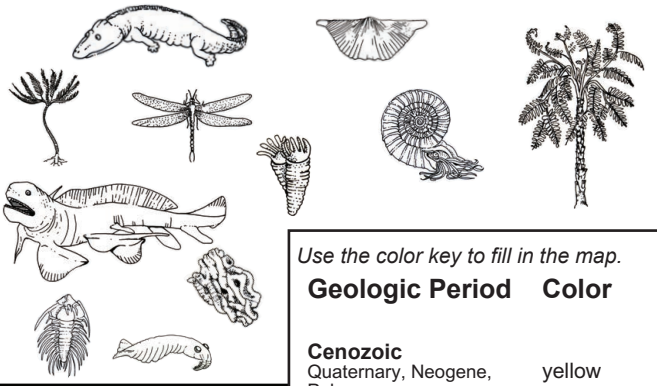


Petrified Palmwood

Bureau of Economic Geology

Geologic Time Scale

Earth is 4.6 billion years old. Earth scientists use the structure, sequence, and properties of rocks, sediments, and fossils to reconstruct events in Earth's history. Decay rates of radioactive elements are the primary means of obtaining numerical ages of rocks and organic remains. The geologic time scale illustrates the relationship between the age of the rocks and the life forms that existed during that time.*

Era	Period	Age in years (estimated)	Characteristic Life
CENOZOIC "Recent Life"	Younger Quaternary	~100,000	
	Older Quaternary	2,600,000	
	Neogene	23,000,000	
	Paleogene	66,000,000	
MESOZOIC "Middle Life"	Upper Cretaceous	~100,000,000	
	Lower Cretaceous	145,000,000	
	Jurassic Triassic	252,000,000	
PALEOZOIC "Ancient Life"	Permian	299,000,000	
	Pennsylvanian	323,000,000	
	Mississippian Devonian Silurian Ordovician Cambrian	541,000,000	
PRECAMBRIAN	*Timeline not to scale.*	4,600,000,000	

Younger ↑ Older

Use the color key to fill in the map.

Geologic Period	Color
Cenozoic Quaternary, Neogene, Paleogene	yellow
Mesozoic Cretaceous,Jurassic, Triassic	green
Paleozoic Permian, Pennsylvanian, Mississippian, Devonian, Silurian, Ordovician, Cambrian	purple
Precambrian	pink

QAe8792

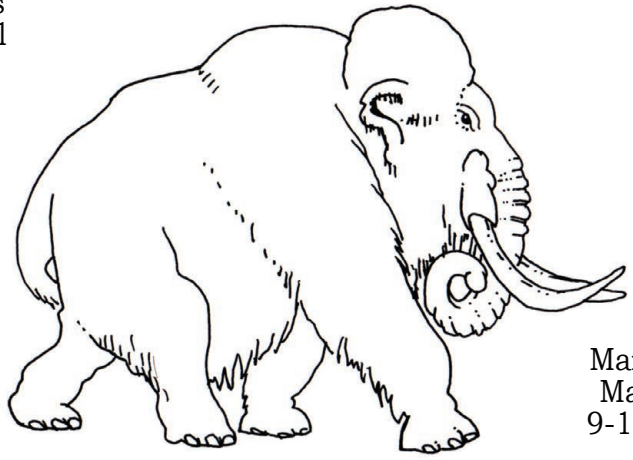
Bureau of Economic Geology

* Text modified from Earth Science Literacy Principles, www.earthscienceliteracy.org
Modified from Bureau of Economic Geology, Pecos County Texas GeoSign

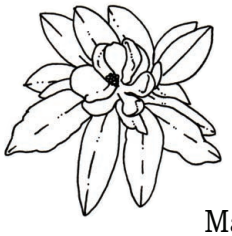
Featured Creatures from the Cenozoic Era

Cenozoic means “recent life.” The Cenozoic Era is from 66 million years ago to present time and is known for the increase in number of mammals, flowering plants, insects, fish, and birds. Note that mammals and birds are a type of vertebrate animal.

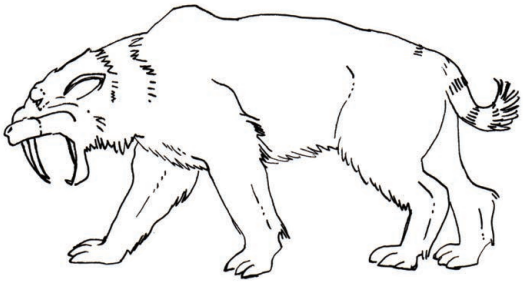
Humans
Mammal



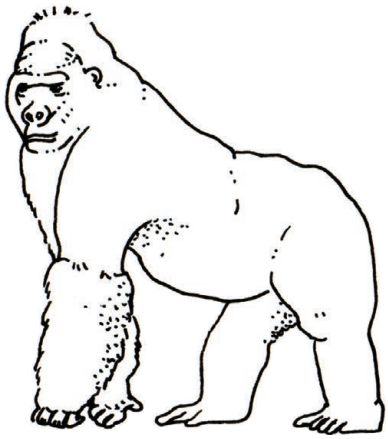
Mammoth
Mammal
9-11 ft tall



Magnolia
Flowering Plant

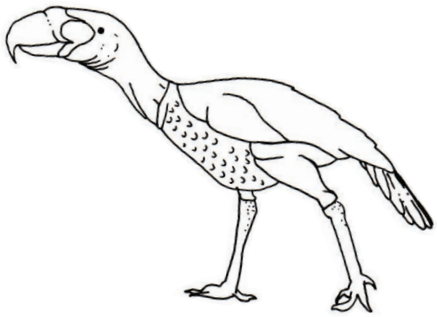


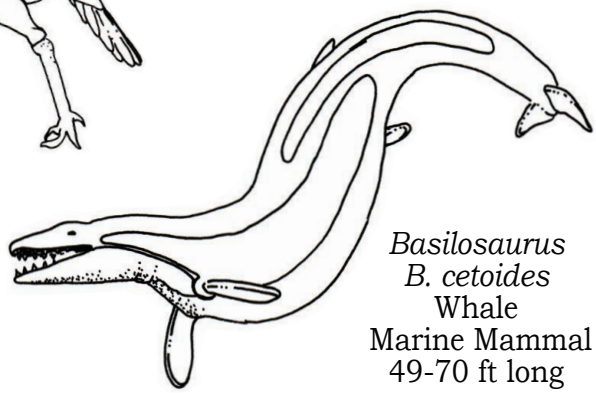
Smilodon
S. populator
Saber-tooth tiger
Mammal
6 ft long, 4 ft tall



Gorilla
Mammal
5 ft tall

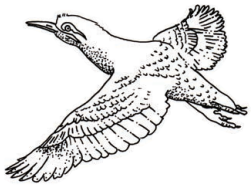
Gastornis
G. giganteus
Bird
6 ft tall





Basilosaurus
B. cetoides
Whale
Marine Mammal
49-70 ft long

Lithornis
L. celetius
Bird
1-2 ft

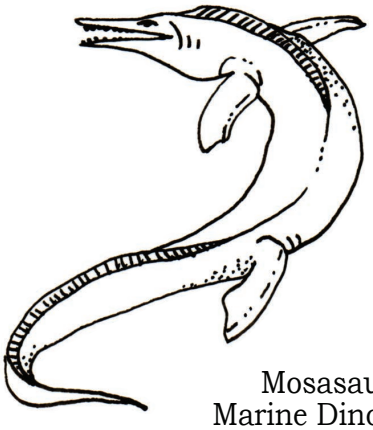


Lemur
Mammal
2-3 ft

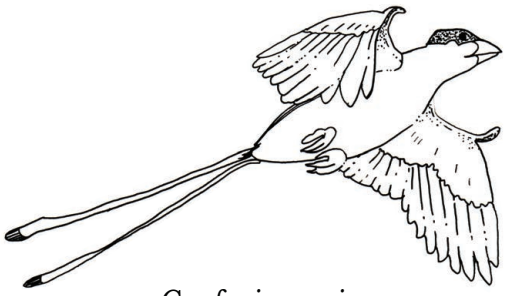
Bureau of Economic Geology

Featured Creatures from the Mesozoic Era

Mesozoic means “middle life.” The Mesozoic Era was from 252 to 66 million years ago and is known as the age of the dinosaurs. Reptiles were the dominant life form during this time. The Mesozoic ended with a mass extinction due to a meteorite impact that killed off all the dinosaurs except for those that could fly. Mammals also appeared during this time period, but they did not flourish until after the dinosaurs became extinct. Note that dinosaurs are a type of reptile.



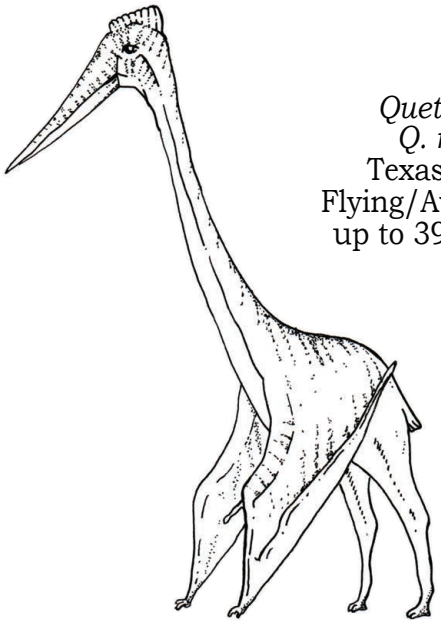
Mosasaur
Marine Dinosaur
33-60 ft long



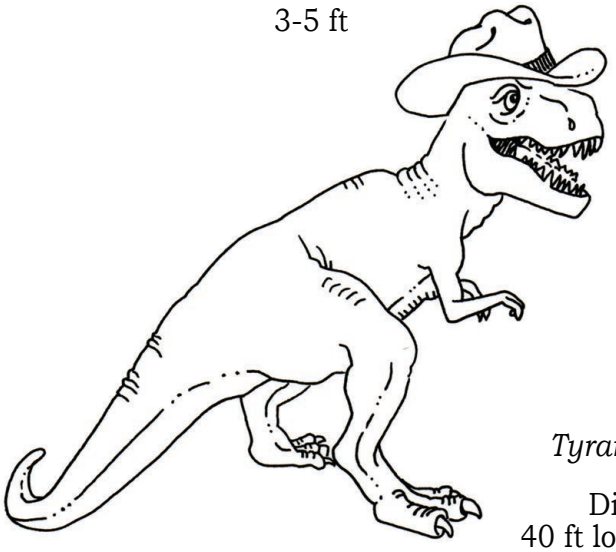
Confuciusornis
C. sanctus
Flying/AvianDinosaur
2-3 ft Wingspan

Archaeanthus
A. linnenbergeri
Flowering plant

Cycad
Plant
3-5 ft



Quetzalcoatlus
Q. northropi
Texas pterosaur
Flying/Avian Dinosaur
up to 39 ft Wingspan



Tyrannosaurus
T. rex
Dinosaur
40 ft long, 13 ft tall

Shrew
Mammal
6 inches

Bureau of Economic Geology

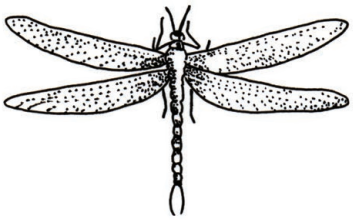
* Text modified from Earth Science Literacy Principles, www.earthscienceliteracy.org
Modified from Bureau of Economic Geology, Pecos County, Texas GeoSign

Featured Creatures from the Paleozoic Era

Paleozoic means “ancient life”. The Paleozoic Era was from 541 to 252 million years ago and began with the first abundant multicellular life forms. It ended with a worldwide extinction known as “The Great Dying.”

Eryops
E. megacephalus
Amphibian
Animal
5 ft long

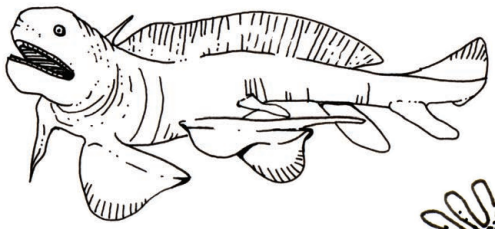
Brachiopod
Marine Invertebrate
Animal
1-15 inches

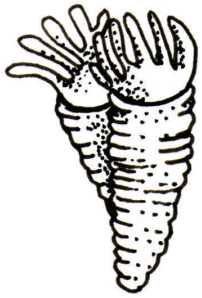


Meganeura
M. brongniart
Insect
25 inches

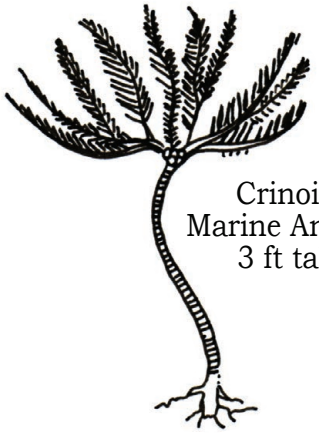
Medullosales
Seed Fern
Plant
23 ft tall

Orthacanthus
O. texensis
Bony Fish
10 ft long





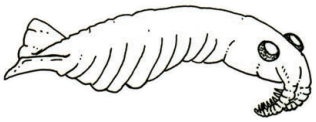
Rugosa
Coral
Marine Invertebrate
Animal
3.5 inches

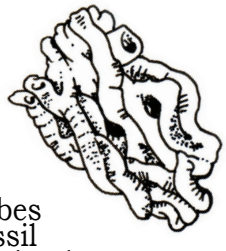


Crinoid
Marine Animal
3 ft tall

Trilobite
Marine Animal
up to 18 inches

Anomalocaris
A. canadensis
Marine Animal
3 ft long





Worm Tubes
Trace Fossil
of Marine Animal
Size varies

Bureau of Economic Geology

Vocabulary

Aquifer — A porous body of rock or sediment that holds and yields underground water

Asthenosphere — The upper part of the Earth's mantle made of partially molten rock that is less rigid than overlying crust and underlying mantle and thus deforms readily

Basalt — A dense, dark-colored, fine-grained, extrusive igneous rock

Carbonate — Mineral or rock composed of carbon and oxygen that is a main ingredient of limestone

Chert — A hard, fine-grained sedimentary rock made of microscopic crystals of quartz

Clay — Very fine-grained class of minerals–that include the main ingredient of claystone or shale

Condensation — The process of changing matter from a gas to a liquid

Contour lines — A line on a map that joins points of equal elevation

Convection — Heat transfer resulting from bulk movement of matter that occurs in the atmosphere, the oceans, and the interior of the Earth

Crust — The outermost major layer of the Earth, ranging in thickness from about 3 miles beneath oceans to roughly 40 miles beneath continents

Crystalline — The property of a solid material whose atoms are arranged in a highly ordered microscopic array

Deposition — The process where sediment, soil or rock material are laid down by various transporting agents, such as water, air, or glacial ice

Erosion — Process whereby soil or rock material is detached and carried away by water, wind, or ice

Evaporation — The process of changing matter from a liquid or solid state to a gas

Extrusive — Igneous rock that solidifies at the surface of the Earth

Fault — A break in the Earth across which movement has occurred

Fossil — Remains or trace of a plant or animal that has been preserved in rock or sediment

Geologic map — A map that shows three-dimensional geologic features such as rock type, faults, and folds

Gneiss — A coarse-grained, banded metamorphic rock

Granite — A coarse-grained, light-colored igneous rock composed of abundant quartz and other minerals

Igneous — Class of rocks solidified from a molten state

Infiltration — The process where water on the ground surface enters the soil or underlying substrate

Inner Core — The solid iron-nickel center of the Earth

Intrusive — Igneous rock that solidifies in the interior of the Earth

Lava — Hot, molten rock on the Earth's surface

Limestone — A sedimentary rock composed mainly of calcium carbonate

Lithosphere — The Earth's crust and the rigid upper-most layer of the mantle

Magma — Molten material that forms igneous rocks when cooled

Magnetic field (of the Earth) — The field of force generated by rotation of the Earth's inner and outer core

Mantle — Thick layer of dense rock below the crust and above the outer core of the Earth; approximately 84 percent of Earth's total volume

Marble — A metamorphosed limestone or other carbonate rock

Metamorphic rock — Class of rocks altered by high temperatures, and pressures, or mineralized fluids

Outcrop — Rock exposed at Earth's surface

Outer Core — The molten iron-nickel layer of the Earth between the inner core and the mantle

Precipitation — Any liquid or solid water that forms in the atmosphere and falls to Earth

Quartz — Hard, light-colored mineral composed of oxygen and silicon; one of the most common minerals in the Earth's crust

Sandstone — Any rock composed mainly of cemented grains of sand (commonly quartz)

Sedimentary rock — Class of rocks formed by the deposition of chemical precipitates, rock fragments, or organic material

Shale — Very fine grained sedimentary rock composed of layers of mud

Silica — An oxide of the chemical element silicon, most commonly seen as quartz

Silicate — Rocks or minerals composed of silicon, oxygen, and, commonly, other elements

Solar radiation — Energy radiated from the sun in the form of particles and waves; visible light is one type of this radiation

Solar system — The sun and objects that orbit it

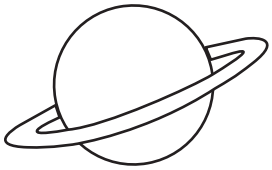
Surface runoff — Water that flows over the land surface

Tectonic forces — Geologic forces that move or deform the Earth's plates

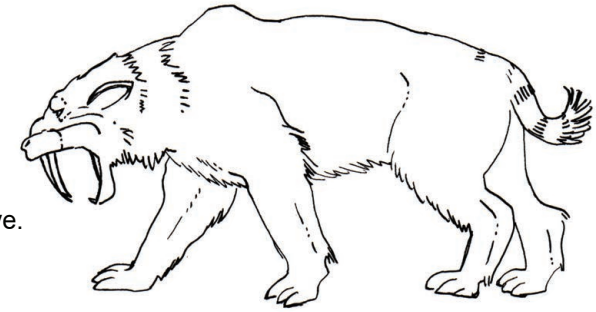
Tectonic plate — One of several mobile slabs of Earth's crust and upper mantle (lithosphere) that have large areal extent compared to thickness; these slabs move with respect to one another at typical rates of inches per year

Topographic map — A two-dimensional representation of part of Earth's three-dimensional landscape

Transpiration — Release of water vapor through the leaves of plants



Established in 1909, the Bureau of Economic Geology is the oldest research unit at The University of Texas at Austin. The Bureau is the State Geological Survey of Texas and has been an integral part of the development of the state's economic success through the years. Our mission is to serve society by conducting objective, impactful, and integrated geoscience research on relevant energy, environmental, and economic issues. Our vision is to be a trusted scientific voice to academia, industry, government, and the public, all of whom we serve.



Free digital copies of this document may be obtained at https://store.beg.utexas.edu/.

Bureau of Economic Geology