26. What is the Rio Grande Rift?

Description: Students will learn about the concept of a rift in general and about the Rio Grande Rift in particular. Two different diagrams of the rift can be used by different grade levels or can be used in sequence together for the same grade level. Students color the diagrams, analyze them, and answer in-depth questions about them.

Objectives: Students will:

- understand the geology of the Rio Grande Valley at Albuquerque;
- begin to understand the geological process of rifting and relate that process to the Rio Grande Rift;
- understand that the rock layers exposed in the Sandia Mountains to the east are the same ones over six miles (10 km) below the city; and
- understand that the Rio Grande exists because of the rift.

Materials: three Kleenex® boxes or three medium-sized wood blocks

DiagramA: "Development of the Rio Grande Rift in Three Time Snapshots" (one per student)

Diagram B: "Geologic Cross Section of the Rio Grande Rift at Albuquerque" (one per student)

colored pencils

a photograph of the Sandia Mountains with Rio Grande Valley (postcards work well)

Optional: samples of limestone and pink granite from the Sandia Mountains and a sample of volcanic basalt

Background: See overview explanation in this section, "Geologic History of the Rio Grande Rift."

26. What Is the Rio Grande Rift?

Grades: 3–8 and 6–12

Time: two class periods

Subject: science

Terms: *crystals, fault, granite, layer, magma, rift, sediment, slow-cooling/fast-cooling, strata, trough, volcano*

The Rio Grande Rift is one of only five young, active continental rifts in the world. The biodiversity and geodiversity of the Rio Grande Valley are related to the existence of the rift. Most river valleys are eroded or cut by the rivers that flow within them. However, the Rio Grande did not erode the broad flat valley through which it now flows; it simply took advantage of the presence of low areas along which to flow.

Diagram A, designed for Grades 3–8, presents simplified snapshots of the area around Albuquerque at different times in the geologic evolution of the landscape. Diagram B (more complete but still simplified), designed for Grades 6–12, is a cross-section drawn on the basis of many pieces of scientific information including drilled wells and geophysical measurements. It is as accurate as it can be at this scale.

Procedure:

1. Introduce the lesson by asking students to talk about the Sandia Mountains, and what they look like, either from their own experience or from viewing a photograph. Ask open-ended questions such as "Do you see different colors?" "Are there different kinds of rock?" "What color are the Sandias as the sun sets?" "Do the Sandias look different when viewed from Albuquerque and when viewed from the East Mountains?" Try to get students to relate as much of their own personal experience of viewing the mountain as possible.

2. Explain that the distinctive look of the Sandias is a result of their geology (both the result of rock type and the result of the way in which they were formed).

   Rock type: As you look at the western side of the Sandias, the bottom three-fourths of the mountain range is mostly made of very old granite. Granite is a rock that is composed of the minerals quartz, feldspar and mica. Granite forms from molten rock deep beneath the surface. The rock cools slowly underground, and the mineral crystals grow to be very big. The pink color at sunset and the eroded rounded appearance of the base of the mountains are both caused by the fact that the mountains here are made of granite. The layered rock at the top of the Sandias is a different kind of rock; it is sedimentary rock, mostly limestone with sandstone and shale. The limestone was formed as a mixture of sediment and fossils at the bottom of an ocean that covered New Mexico about 300 mya. Today the limestone forms the very distinctive layered cap at the top of Sandia Crest.

   In the middle of the rift, associated with the Albuquerque volcanoes, you can find a third type of rock that is very common in New Mexico: basalt. Basalt is a type of volcanic rock that

forms when molten rock deep beneath the surface is erupted onto the surface to form a lava flow. Basalt cools very quickly when it reaches the surface and, therefore, the minerals making up the rock are very small and almost invisible without a microscope.

As water and wind eroded the landscape of New Mexico, the river has carried rocks from many areas. If you look closely at the rounded eroded cobbles along today's river channel, which have been carried downstream by the river, you will find granite, limestone, basalt and other rocks from the mountains and volcanoes adjacent to the Rio Grande Rift.

Formation of the mountains: The mountains that form the margin of the rift have been brought up along faults and tilted back, almost like the opening of a trap door. You can see this if you look at the difference between the appearance of the west side and the east side of the Sandias.

3. Demonstrate how the Rio Grande Valley in New Mexico was formed. Place three Kleenex® boxes or blocks of wood together, side-by-side. Then lift all three by holding the two outer boxes—pressing together to raise the middle box as you lift. You have a piece of the Earth's crust with two fault lines (the faults are where the boxes touch each other). Release the tension holding them together, and allow the middle box to drop a few inches, to illustrate the crust dropping in a rift.

   Note: The Rio Grande Rift is not a boundary between two plates; it is a place within the North American plate where the Earth's crust has thinned and dropped downward. Water has followed the low areas of the rift in New Mexico, carrying sand, silt and rocks (products of erosion) along with it over millions of years as the rift formed. Eventually the low areas of the rift were filled with sediment. In the center of the Rio Grande Rift the crust is thin; this becomes the easiest location for magma to come to the surface, such as at the Albuquerque volcanoes.

   Of course, this is a simplified demonstration. In the real situation, the rift would be bounded by many faults on both sides and the rift itself would consist of a series of oval low areas or basins.

4. For younger students, or as an introduction to older students, distribute the time-sequence Diagram A, "Development of the Rio Grande Rift in Three Time Snapshots," and discuss what the area would have looked like if the students could have visited here in a time machine. Are there mountains? How big are they? Was there a river? What direction was it flowing from,

north or west? Where are the volcanoes? Ask students to find and point out these features. Ask students when they would have liked to have lived in the Albuquerque area (20 million years ago [mya], 10 mya, today) and why. Have students color three types of rocks with three different colors:

a. Sandia granite and other rock types around 1.5 bya (billion years ago);
b. the sandstones, shales, and limestones from before the age of dinosaurs and during the age of dinosaurs (350 mya to 65 mya); and
c. the recent sediments filling the rift valley (20 mya to today).

As a group discuss Questions #1, 4, 5, and 6 below.

5. For older or advanced students, introduce the cut-away Diagram B, "Geologic Cross-section of the Rio Grande Rift at Albuquerque" in the student activity pages. Compare the geologic layers to a slice of cake with the levels being different kinds of rock. Ask students to find and point out: 1) the Rio Grande; 2) Albuquerque volcanoes; 3) top of the Sandia Mountains; 4) the largest fault/place of most offset; 5) the magma route to the volcanoes.

   Explain that there are many different types of rocks in the Albuquerque area and that by coloring each layer differently, we will be able to see some of the geologic changes that have happened in this valley.

6. Have students color the diagram and answer the questions.

Questions:

1. Which layer forms the top of the Sandia Mountains and is also buried below the river?
   Pennsylvanian Limestone —300 million years old
2. How many feet/meters of vertical displacement between those two layers?
   40,000 feet/12,400 meters
3. How many feet/meters of vertical displacement are present between the top of the Sandias and the Rio Grande itself?
   5678 feet/1732 meters
4. What happened to the layers of rock that used to be on the top of the Sandias that are still present in the Rio Grande?
   Eroded as the mountains uplifted, the sediments filled in the valleys
5. Which layers have been eroded from the top of the Sandia Mountains?
   Probably all of the Mesozoic units (see overview and geologic time line for more information about Mesozoic)

6. Why are the volcanoes located in the center of the rift?
   Because at the center of the rift, the crust is thinner (again, see overview essay, "Geologic History of the Rio Grande Rift)

Discussion: The colored diagram shows how the layers of rock have dropped down and are off-set in the Middle Rio Grande Valley. Explain that one of the layers of rock in the Albuquerque area was laid down by an ocean that covered this part of North America 300 million years ago; geologists call this Pennsylvanian limestone. This name refers to the time the rock unit was deposited and comes from the state of Pennsylvania, where rocks of this time period were first described. The Pennsylvanian rocks have been faulted in the Rio Grande Rift and are now displaced a great distance. The Pennsylvanian limestone forms the top—horizontal lines seen from Albuquerque—on the crest of the Sandias. The base of the Sandia Mountains contain some of the oldest rock in New Mexico, Sandia granite, which is 1.5 billion years old. The rocks are very old but were pushed up by the rift faults only 5–10 million years ago. Note, the age of the mountains is not the same as the age of the rocks that make up the mountains. (Contrast this to volcanoes where the age of the rock and time of formation are the same.) The Albuquerque volcanoes are very young: about 150,000 years old.

The rift illustrated in the cross-section has dropped deeply on the east side and less on the west. In other areas of New Mexico, the west-side has dropped further. Generally, the rift has large parallel faults, but the center area tips to one side or the other—called a "trap-door" shape, rather than a straight drop down.

Extension/ Assessment: For Grades 3–8, use the techniques described above.

For more advanced middle school students, use the geologic cross-section but have the students color only the Precambrian rocks, Pennsylvania/Permian and the volcanoes. Then have them color the Mesozoic rocks (the age of dinosaurs) and ask them why these rocks are not on top of the Sandias but occur to the east of the Sandias.

Answer: *They either eroded away as the mountains formed or rocks of this age were never deposited in that area. This might happen if it was a high-standing area during this time period.*

Then ask them where the rest of the sediments filling the basin beneath Albuquerque came from.

Sediment that has been eroded off of highlands surrounding the rift or carried down the rift valley by the river.

A few questions for older students:

Find the largest boundary of 'missing time,' between layers. This is the called an unconformity. What might have happened to cause this?

Between the Precambrian and the Pennsylvanian/Permian, either the layers eroded away before 355 million years ago, or the area was high and no material was deposited there.

Look at the faults in the diagram. What type of faults are there? What does this indicate?

They are all normal faults; no thrust or reverse faults are found. This is a signature of a rift valley.

Extension/ Assessment Activity:

This activity is a fun evaluation for both younger and older grades. In small groups, students create a model of what they learned from the preceding activity.

Materials for small groups:
paper and pencils for planning
cross-section handouts, from this activity, for reference
plates, trays or pieces of cardboard for the groups to mount their models
paper for labels
markers
plastic knives
One of the following sets of ingredients:
a) cake and icing: un-iced sheet cakes, one per group; frosting containers, one per group, or containers of different colors to be shared by whole group
b) peanut butter, jelly and bread for each small group
c) Play-Doh® in different colors, one set of at least three colors per small group

Time: two hours

Procedure: 1. Divide class into small groups.

2. After reviewing the rift formation, ask each group to plan how they will show the Rio Grande Rift. They should include the river, layers of rock below the river and the mountains, as well as the steps to form them. Students must identify different parts of the formation with labels. They should refer to their cross-section handouts.

3. Review each group's plans before handing-out one of the above ingredient sets, knives, and labeling paper. Allow students an assembly time of at least 30 minutes to create and label their

models. Encourage groups to add details to them like tiny houses, roads, trees, etc.

4. Have groups describe their model to the class. After the group presentations, plan a time for eating, or, in the case of Playdoh®, baking in the oven for taking home.

Resources/ References:

An activity for Grades 6–12 is included in The Watercourse. 2001. Discover a Watershed: The Rio Grande/Rio Bravo. Bozeman, Montana: The Watercourse. "Which Came First the River or the Rift?" p. 195.

What Is the Rio Grande Rift?

Student Questions

1. Which layer forms the top of the Sandia Mountains and is also buried below the river?

2. How many feet/meters of vertical displacement between those two layers?

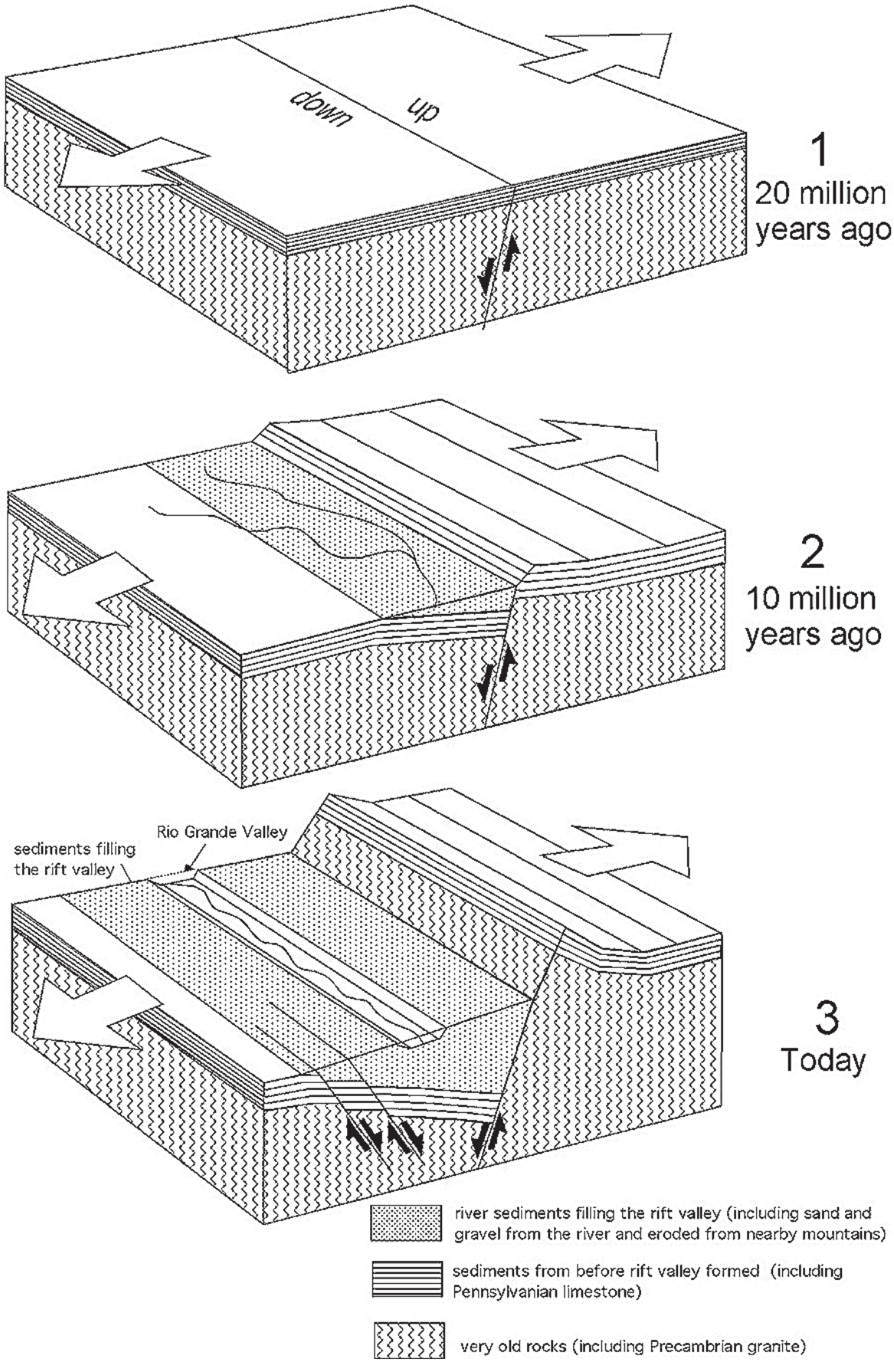
3. How many feet/meters of vertical displacement are present between the top of the Sandias and the Rio Grande?

4. What happened to the layers of rock that used to be on the top of the Sandias that are still present in the Rio Grande?

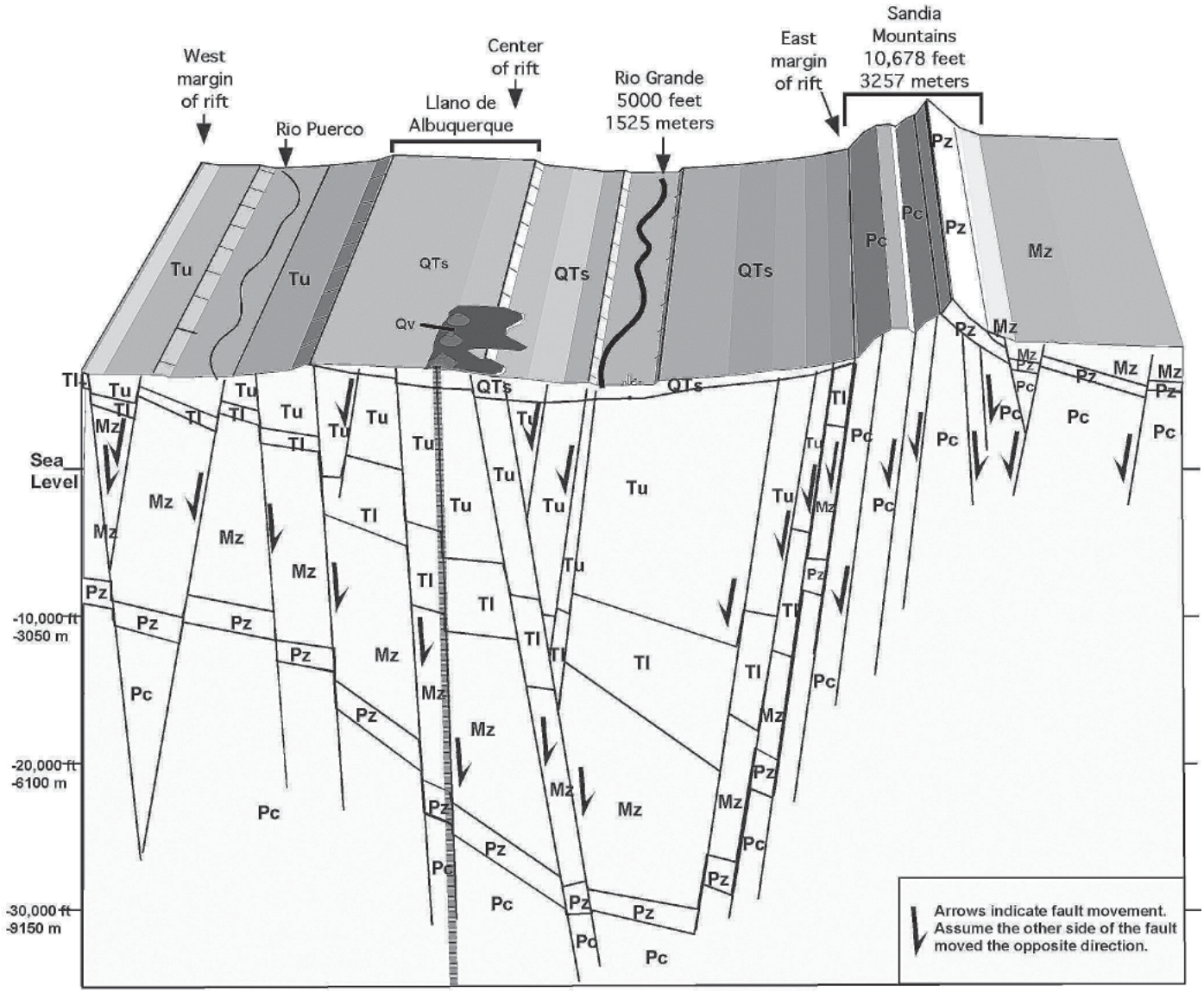
5. Which layers have been eroded from the top of the Sandia Mountains?

6. Why are the volcanoes located in the center of the rift?

A. Development of the Rio Grande Rift in Three Time Snapshots



B. Geologic Cross-section of the Rio Grande Rift at Albuquerque



rock types

Tu — young Tertiary sediments — 35 to 2 million years ago

QTs — Tertiary-Quaternary sediments — 2 million years ago to present

Qv — Quaternary volcanic rocks — 150,000 years ago

Pc — Precambrian rocks — older than 1.5 billion years ago

Pz — Pennsylvanian & Permian sedimentary rocks — 355-248 million years ago

Mz — Mesozoic sedimentary rocks — 248-65 million years ago

TL — older Tertiary sediments — 65-35 million years ago