

Two Geologists, Two Clocks: Hutton's Slow Time and Bretz's Fast Flood

Learning target: I can explain, with evidence from a passage, how scientists learned to read both slow and sudden change in landscapes, and what uniformitarianism does and does not claim.

Reading with evidence

About 40 min

Individual

MS-ESS2-2 · practice

reading

writing

Standards connections

MS-ESS2-2 (practice): The passage shows two scientists constructing explanations from landscape evidence at very different time scales. Students practice citing evidence for how processes changed Earth's surface, which is the reasoning the PE asks them to do themselves.

Purpose: build · **Time:** about 40 minutes · **Format:** individual

Answers with reasoning

Two Geologists, Two Clocks

[1] Earth's surface keeps two kinds of time. One is so slow that nothing seems to happen in a human lifetime. The other is so fast that a landscape can change before lunch. Scientists took a long while to accept that both clocks are real. That story involves two stubborn geologists, a rocky point in Scotland and a dry, scarred plateau in Washington.

[2] In 1788 James Hutton, a Scottish farmer and doctor, rowed along the coast near Edinburgh with two friends, John Playfair and James Hall. At Siccar Point they found gray rock layers standing almost on end, like books on a shelf, with nearly flat layers of red sandstone resting on their broken edges. Hutton reasoned from what he could watch happening on any beach. Sand and mud settle in flat layers, so the gray layers had once been flat. They had hardened into rock, been tipped upright, been worn down to a flat surface, and then been buried under new sand that also hardened into rock. Each step, he argued, had to be done by processes he could see at work today: rivers carrying sand, waves wearing at cliffs, layers slowly turning to stone. Those processes are slow. Playfair later wrote that looking at the point made him feel dizzy, as if he were staring into a bottomless well of time.

[3] Hutton's idea was later named uniformitarianism: the processes we observe today also shaped the past. In 1830 Charles Lyell began publishing *Principles of Geology*, which spread the idea across the world; a young Charles Darwin took the first volume aboard the *Beagle* in 1831. The principle gave geologists a powerful tool. If you measure how fast a river deepens its channel today, you can estimate how long it took to cut a canyon. But the idea also hardened into a habit. For the next hundred years many geologists treated anything sudden or enormous with suspicion, because sudden and enormous sounded like the old stories of worldwide floods that Hutton had replaced.

[4] That habit ran straight into J Harlen Bretz. In the 1920s Bretz spent his summers mapping a strange region of eastern Washington he called the Channeled Scablands. It was crossed by huge dry canyons, some with dry waterfalls hundreds of feet high, and dotted with gravel hills far too large for any

river that flows there now. In 1923 he published his conclusion: the whole landscape had been carved by a gigantic flood in a matter of days. Other geologists rejected the idea. A flood that size seemed to break the rule that landscapes are built slowly, and Bretz could not say where so much water had come from.

[5] The answer lay in Montana. During the last ice age a lobe of the northern ice sheet dammed a river valley and backed up a lake, now called glacial Lake Missoula, holding roughly 2,000 cubic kilometers of water. When the ice dam failed, the lake emptied within about two days, and the water tore across Washington toward the Pacific. In 1940 geologist Joseph Pardee described ripples on the old lake floor that were up to about 10 meters high, a thousand times taller than the finger-high ripples a creek leaves in sand. Later air photographs showed the same giant ripples on the Scablands. The floods had happened not once but dozens of times, as the ice dam re-formed and broke again. In 1979, when Bretz was in his nineties, the Geological Society of America gave him its highest award.

[6] Hutton and Bretz were not really enemies. Both read a landscape by asking what process could produce what they saw, and both trusted processes that can be observed today. Ripples in a creek and ripples 10 meters tall are made the same way by moving water; one is simply larger and faster. What Bretz added to Hutton is now part of the modern principle: the same processes and the same natural laws have always been at work, but their rates can vary, and a sudden event is as real as a slow one. A hoodoo's pillar thins for thousands of years, and its cap falls in a second. Both clocks are telling the truth.

Questions: cite the passage

1. According to paragraph 2, what sequence of events did Hutton infer had happened to the gray rock layers at Siccar Point? List the steps in order.

Answer: The gray layers (1) settled flat as sand and mud, (2) hardened into rock, (3) were tipped nearly upright, (4) were worn down to a flat surface, and (5) were buried under new sand that also hardened into rock (the red sandstone).

Why: All five steps are listed in paragraph 2 in order; the tilting and the wearing down are the two steps students most often skip.

Also acceptable: Accept four steps if the hardening and tilting are combined, as long as the order is right.

- Steps in the correct order
- Includes tilting and wearing down
- Ends with burial by the new layer

2. Paragraph 2 says Hutton reasoned 'from what he could watch happening on any beach.' Explain why that way of reasoning led him to conclude that Siccar Point recorded an enormous amount of time.

Answer: He insisted that only processes he could watch today (rivers carrying sand, waves wearing cliffs, layers slowly turning to stone) could have done the work, and those processes are slow. Several slow steps had to happen one after another, so the total time had to be enormous, which is why Playfair felt dizzy looking into 'a bottomless well of time.'

Why: The link is slow observed rates plus many sequential steps equals vast time.

Also acceptable: A student who quotes Playfair's dizziness as the conclusion must still state the slow-rate reasoning.

- Names present-day, observable processes as the only ones allowed
- Connects slow rates (and several steps) to a huge total time

3. Paragraph 3 describes uniformitarianism as 'a powerful tool' and also as 'a habit.' Using the paragraph, explain the difference between the tool and the habit.

Answer: The tool: measuring how fast a process works today (such as a river deepening its channel) lets you estimate how long a past change took. The habit: geologists began to distrust anything sudden or enormous because it sounded like the old flood stories, so they rejected real sudden events before looking at the evidence.

Why: Paragraph 3 gives both; the question checks that students see the principle as useful and also see how it was over-applied.

Also acceptable: Accept 'the habit was assuming everything is slow.'

- Describes the rate-to-time tool
- Describes the habit of rejecting sudden or large events

4. Give two reasons from paragraph 4 that other geologists rejected Bretz's flood. Quote or closely paraphrase the passage for at least one of them.

Answer: (1) A flood that size 'seemed to break the rule that landscapes are built slowly.' (2) Bretz 'could not say where so much water had come from.'

Why: Both reasons are in paragraph 4; at least one must be quoted or closely paraphrased.

Also acceptable: Accept 'it sounded like the old catastrophe stories' for reason 1.

- Two reasons
- At least one quoted or closely paraphrased with the paragraph number

5. Paragraph 5 says the lake held roughly 2,000 cubic kilometers of water and emptied in about two days. Calculate the average volume of water that left the lake per hour. Show your work.

Answer: Two days = $2 \times 24 \text{ h} = 48 \text{ h}$. $2,000 \text{ km}^3 \div 48 \text{ h} \approx 41.7 \text{ km}^3$ per hour, about 42 cubic kilometers of water every hour.

Why: A simple rate: volume divided by time. The number itself is rough (the passage says 'roughly' and 'about'), which students can note.

Also acceptable: Accept 41.7, 41.67 or 'about 40 km³ per hour.' If a student uses 2 days = 48 hours but writes 1,000 km³ per day as an intermediate step, that is correct too.

6. What two pieces of evidence in paragraph 5 finally supported Bretz? For each, say what it showed.

Answer: (1) Joseph Pardee's 1940 description of ripples up to about 10 m high on the old floor of Lake Missoula, which showed that a huge body of fast water had drained from the lake. (2) Air photographs that showed the same giant ripples on the Scablands, which showed the flood water had crossed Washington just as Bretz said. (Also acceptable: the discovery of the lake itself, which answered where the water came from.)

Why: The two named pieces of evidence are the giant ripples in Montana and the giant ripples seen from the air in Washington; the lake answers the missing-water objection.

Also acceptable: The lake as a water source may replace one of the ripple items.

- Two pieces of evidence from paragraph 5
- States what each showed

7. Paragraph 6 says Hutton and Bretz 'were not really enemies.' Using evidence from at least two different paragraphs, explain what the two scientists had in common and what Bretz added to Hutton's idea.

Answer: In common: both read a landscape by asking what process could produce the features they saw (paragraph 6), and both trusted processes that can be observed today: Hutton used beaches and rivers (paragraph 2), and Bretz's flood ripples are creek ripples 'made the same way by moving water,' only larger (paragraph 6). What Bretz added: the same processes can run at very different rates, so a sudden event like a flood that emptied a lake in two days (paragraph 5) is as real as slow change; the modern principle keeps the same processes and laws but allows rates to vary (paragraph 6).

Why: Full credit requires evidence from at least two paragraphs, the shared method, and the rate-can-vary addition.

Also acceptable: A student may argue that Bretz 'corrected' rather than 'added to' Hutton; accept if the evidence is accurate.

- Names the shared method (observable present-day processes)
- Names what Bretz added (rates vary; sudden events are real)
- Cites at least two different paragraphs

8. The last paragraph ends with a hoodoo. Using the modern version of uniformitarianism described in paragraph 6, explain how a scientist today would use **both clocks** to explain the hoodoo's pillar and its fallen cap, and what evidence from the present they would rely on.

Answer: Slow clock: the scientist would measure how fast weathering and erosion thin rock today (for example, how much a soft rock surface loses per year to frost and rain) and use that rate to estimate the thousands of years the pillar took to narrow. Fast clock: the cap falls in a second once the pillar can no longer hold it, just as a rock falls today when its support is removed, so the collapse is explained by gravity acting on a pillar that had been thinning for a long time. Evidence from the present: measured weathering rates, fresh rockfalls seen at other hoodoos, the unweathered scar where the cap broke off, and the cap lying at the base.

Why: The answer must use both time scales for one landform and ground each in something observable now, which is the modern principle in action.

Also acceptable: A student who adds that the cap is harder rock that protected the pillar is drawing on the lesson and should be credited.

- Slow clock explained with a present-day rate
- Fast clock explained as the end of the slow build-up
- Names at least one kind of present-day evidence

Teacher notes

The passage is about 695 words. Historical facts are established: Hutton, Playfair and Hall visited Siccar Point by boat in 1788; Playfair's 'abyss of time' remark was published in 1805 (paraphrased here, not quoted); Lyell's Principles of Geology began publication in 1830; Darwin carried volume 1 on the Beagle, which sailed in late 1831; Bretz's first Scablands paper appeared in 1923; Pardee presented the giant current ripples of Camas Prairie, Montana, in 1940; Bretz received the Penrose Medal in 1979 at age 96. Glacial Lake Missoula held on the order of 2,000 km³ and drained in days; estimates of the number of floods range from dozens to about 90, so 'dozens' is deliberately conservative. The passage uses this history to teach the accurate version of uniformitarianism (same processes and laws; rates vary; catastrophes are part of the record), which corrects the textbook's 'in the same way' wording. The Grand Canyon figure in the extension (millions of years) matches the lesson's Key Science Concept spread.

Scaffold offered to students: Two columns before you write

On scrap paper make two columns headed 'Hutton (slow)' and 'Bretz (fast).' As you reread, write every date, place, number and piece of evidence in the matching column. Questions 1-2 use the Hutton column, 4-6 use the Bretz column, and 7-8 ask you to compare the two. For q5, remember that two days is 48 hours, and write the division as volume divided by hours.

Extension: Grand Canyon or Scablands?

The Grand Canyon is often described as the work of a river over millions of years; the Scablands were carved in days. Write a short paragraph explaining what evidence you would look for in a canyon to decide which clock carved it. Consider the shape of the channel, the size of the rocks the water moved, whether layers of flood deposits repeat, and whether the river flowing there today could do the work. Then explain why both answers are consistent with uniformitarianism.