

Six Seconds and Sixty Years: A Glacier's Two Clocks

Learning target: I can record what I notice about a glacier that changes its valley in seconds and in centuries, connect it to what I already know, and write a first explanation of how one process can work on two very different time scales.

Phenomenon exploration

About 25 min

Individual

MS-ESS2-2 · supports

discussion

writing

Standards connections

MS-ESS2-2 (supports): This sheet surfaces the chapter's puzzle: the same geoscience process (moving ice) produces a change that takes seconds and a change that takes centuries. Students only observe, question and offer a first explanation; the evidence-based explanation the PE asks for is built in later worksheets.

Purpose: activate · **Time:** about 25 minutes · **Format:** individual

Answers with reasoning

Field notebook: one day at Marrow Glacier

Ms. Alvarez's class is standing on a rocky ridge above the front of Marrow Glacier, a river of ice that flows out of the mountains and ends in a fjord. For most of the morning nothing seems to happen. Then there is a crack like a gunshot. A slab of ice about 40 meters tall, the height of a twelve-story building, leans away from the glacier and crashes into the water. From the first crack to the splash takes about six seconds. The wave it makes rocks the boats in the fjord for several minutes. Then the glacier looks as still as it did before.

Afterward the class looks around. A survey stake that a ranger hammered into the ice yesterday has moved about 0.5 meters toward the fjord in 24 hours. Beside the glacier, the bare bedrock is covered with long, straight scratches a few millimeters deep and many meters long, all pointing down the valley. A boulder 3 meters across sits alone on the ridge; it is made of a dark rock that does not match the pale rock under it, and the nearest cliff of that dark rock is 12 kilometers up the valley. The whole valley is shaped like the letter U, about 1.5 kilometers from rim to rim. The stream that pours out from under the ice is milky gray, as if someone had stirred flour into it.

Same glacier, two clocks

The ice slab that fell (what we watched)	The valley around us (what we found)
About 40 m tall	U-shaped valley 1.5 km wide
Fell in about 6 seconds	Scratches on bedrock, mm deep, m long
Wave lasted a few minutes	Boulder 3 m across, 12 km from its source rock
Happened once while we watched	Stake moved 0.5 m in one day

Teaching scenario: Marrow Glacier and every number on this page are invented to be realistic, not measured at a real glacier.

Measured changes from the notebook (teaching dataset)

Simulated teaching dataset: the numbers are invented to be realistic, not measured.

What changed	How big	How long it took
Ice slab broke off the front	about 40 m tall	about 6 seconds
Survey stake on the ice moved toward the fjord	0.5 m	24 hours
Scratches cut into bedrock beside the ice	a few mm deep, many m long	unknown
Dark boulder carried from its source cliff	3 m across, moved 12 km	unknown
Valley carved into a U shape	1.5 km wide	unknown

Simulated values for a classroom scenario; they are realistic for a valley glacier that ends in the sea.

Part A: Notice and wonder

1. List three things you **notice** in the notebook, the figure or the table. Use only facts that were observed or given, not explanations. Number them 1, 2, 3.

Answer: Any three given facts, for example: the slab was about 40 m tall and fell in about 6 seconds; the stake moved 0.5 m in 24 hours; the scratches are a few mm deep, many m long and all point down the valley; the boulder is 3 m across and its matching rock is 12 km up the valley; the valley is U-shaped and 1.5 km wide; the stream is milky gray.

Why: Observations only. A statement such as 'the glacier carved the valley' is an explanation, not a notice, and should be moved to Part C.

Also acceptable: Accept 'the glacier looked still again afterward' as an observation.

- Three distinct facts from the page
- No explanations mixed in

2. Write two questions you **wonder** about. At least one must be a question that could be answered by measuring something at the glacier.

Answer: Examples: How often do slabs fall off, and does it depend on the season? Does the ice move the same distance every day, or faster in summer? How deep do the scratches go under the ice? How did a 3 m boulder get 12 km from its source? Is the whole glacier moving, or only the front?

Why: At least one question must be answerable by a measurement (stake position over many days, counting calving events, dating the boulder's surface).

Also acceptable: A question about the gray stream (what is in it?) is measurable by filtering a sample and counts.

- Two genuine questions
- At least one is measurable at the glacier

Part B: What you already know and what you think now

3. Write two things you already know or believe about ice, glaciers or how rock gets broken and moved. It is fine if you are not sure; label anything you are unsure about with a question mark.

Answer: Any honest prior ideas, for example: ice is solid but glaciers flow very slowly; water freezing in cracks can split rock; rivers carry sand and gravel; glaciers existed over much of North America during ice ages.

Why: This item records prior knowledge for later comparison; do not grade for accuracy. Note common ideas to revisit: 'ice cannot move' or 'only water can carve valleys.'

Also acceptable: Accept personal experiences (seeing a glacier, frost heaving a sidewalk).

- Two statements about ice, glaciers or rock breaking and moving
- Uncertain statements marked

4. The stake moved 0.5 m in one day. If the ice kept moving at that rate, how far would it move in one year (365 days)? Then estimate how many years it would take ice to travel the 12 km from the dark cliff to the ridge where the boulder sits. Show your work with units.

Answer: $0.5 \text{ m per day} \times 365 \text{ days} = 182.5 \text{ m per year}$ (about 180 m per year). $12 \text{ km} = 12,000 \text{ m}$; $12,000 \text{ m} \div 182.5 \text{ m per year} \approx 65.8 \text{ years}$, about 66 years.

Why: The first step converts a daily rate to a yearly distance; the second divides a distance by a rate to get a time. Ice higher up a glacier usually moves more slowly than the front, so the real trip would take longer; the point is that even at the measured rate the boulder's trip is far longer than a school year but shorter than a human life.

Also acceptable: Accept 180 m per year and 65-67 years, or 'about 70 years' if the student rounded to 180 m per year ($12,000 \div 180 = 66.7$). If a student uses 360 days, 180 m per year and 66.7 years are fine.

5. Which explanation for the straight scratches on the bedrock fits the facts on this page best? Circle one, then write one fact from the page that supports your choice.

Answer: B. Rock fragments frozen into the bottom of the ice were dragged across the bedrock as the ice moved. Supporting fact: the scratches are straight, run for many meters and all point down the valley, the direction the stake shows the ice is moving.

Why: Ice alone is softer than most rock, so the scratching tool must be rock carried in the ice; the gray 'rock flour' in the stream is the powder from that grinding. Rain does not cut parallel straight grooves, and scratches older than the glacier would not all line up with its flow.

Also acceptable: A student who picks B and cites the gray stream water (ground-up rock) has also used the page correctly.

Part C: Your first explanation

6. The slab fell in six seconds. The U-shaped valley, the scratches and the far-traveled boulder look like the work of the same glacier, but none of them happened while the class watched. Write your first explanation of how one glacier can be responsible for a change that takes seconds and a change that takes far longer than a human life. Use at least two numbers from the page.

Answer: A strong first explanation: the slab fell quickly because the front of the glacier is pushed out over the water until it is unsupported, so once it cracks, gravity does the rest in seconds. The valley and scratches took much longer because the ice moves only about 0.5 m a day (about 180 m a year), and it grinds rock a little at a time with the fragments frozen into its base. Small daily grinding, repeated for thousands of years, could cut a valley 1.5 km wide; carrying a 3 m boulder 12 km would take about 66 years at the measured rate. Both changes come from the same moving ice; the difference is how much time each one has had.

Why: Students have not yet studied the lesson. Credit the two key moves: (1) the fast event is the end of a slow build-up (ice pushed out until it breaks) and (2) small, repeated changes add up over long times. Numbers are required.

Also acceptable: An explanation that says the valley was carved mainly by the stream and the glacier only polished it is a reasonable first idea; credit it if it uses the numbers and is revisited after Worksheet 4.

- Explains the fast event in terms of what the slow movement set up
- Explains the valley or boulder as many small changes repeated over a long time
- Uses at least two numbers from the page

7. **Predict.** Suppose the climate warms and the front of Marrow Glacier melts back 60 m every year for the next ten years. Describe two things you expect to find on the newly uncovered valley floor, and say why.

Answer: Expected finds (any two with reasons): bare, scratched and polished bedrock, because the ice had been grinding it; piles of unsorted rock, gravel and mud dropped where the ice melted, because melting ice cannot carry its load; boulders of rock types from up the valley; a lake or wet hollow where the ice had pressed the floor down; a milky stream still flowing from the new front.

Why: The prediction should follow from the page: the ice carries and grinds rock, so uncovered ground will show scratches and dumped rock. Accept any sensible pair with a stated reason.

Also acceptable: A prediction of a bare rock floor with no deposits is partly right (scratched bedrock) and should prompt a question about where the carried rock goes.

- Two specific predictions
- Each tied to something the glacier does

8. Write one question you would want answered before you could be sure that the valley was carved by ice and not by the stream. Say what measurement or observation would answer it.

Answer: Examples: 'Do the scratches continue under the ice, or only beside the stream?' (answered by looking at freshly uncovered rock); 'Are the valley sides straight and steep like a U or sloping like a V?' (measured from a cross-section; streams cut V shapes); 'Does the stream carry boulders this size today?' (observed during high flow).

Why: The question must target the ice-versus-stream choice and name an observation that would settle it.

Also acceptable: Accept 'How old is the surface of the boulder?' if the student explains that a dating method would show when it was dropped.

- Question distinguishes ice from running water
- Names a measurement or observation that would answer it

Teacher notes

Marow Glacier is fictional; the numbers are chosen to be realistic for a tidewater valley glacier (fronts of such glaciers commonly move from tens of centimeters to a few meters per day, and calving slabs of tens of meters fall within seconds). Collect first explanations on the board without correcting them; the lesson's vocabulary (weathering, erosion, deposition, uplift) is introduced in Worksheet 2 and the time-and-space chart in Worksheet 4. Listen for two ideas to revisit: 'the valley must have formed as fast as the slab fell' (size and speed are being confused) and 'ice cannot move.' In q4 the 66-year figure is deliberately simplified; ice up-glacier moves more slowly, so say the real trip is longer and ask why the measured rate near the front might not apply everywhere. Striations are made by rock held in the ice, not by the ice itself; the gray stream is rock flour from that grinding.

Scaffold offered to students: Sentence starters for Part C

If you are not sure how to begin q6, try: 'The slab falling was fast because _____. The valley took much longer because _____. Both are caused by the glacier because _____.' For q4, write the multiplication on one line and the division on the next so you can check each step: $0.5 \text{ m per day} \times 365 \text{ days} = \text{_____ m per year}$; $12,000 \text{ m} \div \text{_____ m per year} = \text{_____ years}$.

Extension: Two more clocks

The notebook lists three changes with 'unknown' for how long they took. For each one, propose a way a scientist could put a number on the time: what would they measure, and what would they have to assume about the past to turn the measurement into an age? Then rank the three from the easiest to the hardest to date and explain your ranking in two or three sentences.