

Two Road Cuts, One Story? A Claim-Evidence-Reasoning Case

Learning target: I can use fossils and an ash layer as evidence to claim which layers in two distant road cuts formed at about the same time, and explain my reasoning with the law of fossil succession and the idea of an index fossil.

Claim, evidence, reasoning

About 40 min

Individual

MS-ESS1-4 · practice

MS-LS4-1 · supports

writing

data analysis

Standards connections

MS-ESS1-4 (practice, constructing an explanation from fossils in rock strata): MS-ESS1-4 sits in California Grade 8; this Grade 7 lesson previews it. Writing a CER that matches layers across two sites by their fossils is exactly the kind of evidence-based explanation from rock strata the PE describes, at a smaller scale.

MS-LS4-1 (supports): MS-LS4-1 is a Grade 8 PE about patterns in the fossil record. The idea that species appear in a fixed order in rock layers is used here as a tool, not assessed; no species or era names are required.

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

Answers with reasoning

The scenario

A county is planning a bike path beside a highway. Two road cuts along the route, the North Cut and the South Cut, are three kilometers apart. The contractor, Mr. Alvarez, looked at both and said, 'These rocks are completely different colors and types. They have nothing to do with each other, so we do not need the geologist to look at both.' The county geologist, Dr. Okafor, disagrees. She thinks some layers in the two cuts formed at about the same time, and that knowing which ones would help predict what the path's builders will dig into between the cuts. Her field logs and fossil guide are below. (The places and fossils are invented for this worksheet.)

Dr. Okafor's layer logs (teaching data; layers listed from top to bottom)

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

North Cut	Rock and thickness	Fossils	South Cut	Rock and thickness	Fossils
N1	Yellow sandstone, 2 m	none	S1	Pebbly conglomerate, 1 m	none
N2	Gray limestone, 3 m	Fossil K	S2	Red sandstone, 2 m	Fossil R
N3	Brown mudstone, 1 m	Fossils R and K	S3	White ash, 0.3 m	none
N4	White ash, 0.2 m	none	S4	Gray limestone, 2 m	Fossils K and M
N5	Black shale, 2 m or more	Fossil M	S5	Black shale, 1.5 m or more	Fossil M

All layers in both cuts are flat and unbroken. Nothing in either log has been dated in years yet.

Fossil guide (teaching dataset)

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

Fossil	What it was	How long the species existed (million years)	Where it has been found
K	A ribbed clam	150	Five continents
R	A tightly coiled sea shell	2	Four continents
M	A small sea snail	6	Only in this region

Teaching dataset: the three fossil species are invented; their time spans and ranges were chosen to be realistic.

Warm-up: organize the evidence

- Which of the three fossils is the best index fossil? Use two columns of the fossil guide to justify your choice, and say why the other two are weaker. 2 pts

Answer: Fossil R. It existed for only about 2 million years (a short time span) and is found on four continents (widespread), which are the two requirements of an index fossil. K is widespread but lasted 150 million years, so it only narrows a layer's age to a huge window. M lasted 6 million years, which is fairly short, but it is found only in this region, so it cannot match layers across distant places (though it can help locally).

Why: Both guide columns (time span and distribution) must be used. M is the subtle case: it is useful here, within the region, but not an index fossil in the general sense.

Also acceptable: A student who notes that M still helps match N5 with S4/S5 within this county has a good point and should be credited.

- Chooses R
- Cites the short time span and the wide distribution
- Explains K's long span and M's limited range

2. Which layer in the South Cut most likely formed at about the same time as N3 in the North Cut? 2 pts
Give two separate reasons from the logs.

Answer: S2. Reason 1: N3 and S2 both contain fossil R, the short-lived species, so they formed within the same 2-million-year window. Reason 2: both sit directly on top of a white ash layer (N4 under N3; S3 under S2), which is the same position in the sequence.

Why: Two independent connections: the index fossil and the position above the ash.

Also acceptable: None; S4 shares K with N3 but K is long-lived and S4 is below the ash.

- Names S2
- Fossil R shared
- Same position above the ash

3. Mr. Alvarez says different rock types mean different times. Explain how a mudstone and a sandstone could form at the same time three kilometers apart. (Think about where mud settles and where sand settles along a shore.) 2 pts

Answer: Along a shore, sand drops out close to the beach where waves and currents are strong, while fine mud is carried farther out and settles in calmer, deeper water. So at the same moment, sand could be piling up at the South Cut's location and mud at the North Cut's location. Rock type records the environment, not the time.

Why: The key idea is that rock type reflects environment and environments differ from place to place at the same time.

Also acceptable: River delta versus floodplain, or beach versus lagoon, are acceptable environment pairs.

- Sand near shore, mud farther out (or any two environments side by side)
- Concludes that rock type shows place or environment, not age

Your argument

Answer: Claim: Dr. Okafor is right. N3 and S2 formed at about the same time, the ash layers N4 and S3 are most likely the same ash fall, and N5 and S4/S5 are also about the same age. Evidence: (1) N3 and S2 both contain fossil R, which existed for only about 2 million years and is found on four continents. (2) Both N3 and S2 lie directly above a white ash layer (N4, S3). (3) N5 and S4 and S5 contain fossil M, found only in this region and lasting 6 million years, and in both cuts the M-bearing shale is the bottom layer. (4) Fossil K appears in N2, N3 and S4, but K lasted 150 million years, so it only shows those layers are within a very wide window. Reasoning: By the law of fossil succession, species appear in the same order everywhere, so layers holding the same short-lived species formed within that species' lifetime. R is an index fossil (short-lived, widespread, easy to recognize), so the R match ties N3 and S2 to about the same age within about 2 million years; K is not an index fossil, so a K match proves little. The ash adds a second, independent tie: ash from one eruption settles over a region in days, so an ash layer marks one instant, and finding R just above the ash in both cuts means the same event sits in the same place in both sequences. Different rock types (mudstone versus sandstone) do not weaken the claim, because rock type records the environment where sediment settled, not when. 'About the same age' is correct because fossils and position give a time window, not a single year.

Why: Score with the rubric. Full credit needs a specific pair, three cited pieces of evidence with numbers, and reasoning that uses fossil succession, the index-fossil definition, the ash, and the environment point.

Also acceptable: A claim that also pairs N4 with S3 and N5 with S5 is stronger, not wrong. A claim that pairs N2 with S4 on the basis of K alone should be marked down in Reasoning for treating K as an index fossil.

- Claim names N3 and S2 (and may add N4/S3 and the M-bearing shales)
- At least three pieces of evidence with layer labels, fossil letters and numbers
- Reasoning uses fossil succession and the index-fossil definition, explains the ash, and explains why rock type does not matter
- Uses 'about the same age' and explains the window

Follow-up

4. Dr. Okafor can send both ash samples to a lab that compares the chemical 'fingerprint' of volcanic ash. What result would strengthen your claim, and what result would weaken it? Explain why an ash layer is such a useful time marker. 2 pts

Answer: Strengthen: the two ashes have the same chemical fingerprint, which would show they came from the same eruption and settled at the same moment in both places. Weaken: different fingerprints, which would mean two different eruptions, so the ash layers would no longer tie the sequences together (the fossil R match would still stand, but with less support). An ash layer is a useful marker because a single eruption spreads ash over a wide area within days, so wherever that ash is found it marks the same instant, and the ash's zircon crystals can also be dated in years.

Why: Students should see the ash as a potential 'same instant' marker and understand that fingerprint matching tests whether it really is the same ash.

Also acceptable: A student who says a different fingerprint would not destroy the claim because R still matches is reasoning carefully; credit it.

- Same fingerprint strengthens; different weakens
- Explains that one eruption's ash settles everywhere at essentially the same time
- Optionally notes that ash can be dated in years

Scoring rubric

Criterion	4 • Exemplary	3 • Proficient	2 • Developing	1 • Beginning
Claim	States that Dr. Okafor is right and names N3 and S2 as about the same age in one clear sentence; may add the ash pair and the M-bearing shales.	Names N3 and S2 but the statement is vague about 'about the same age' or does not take a side on Dr. Okafor.	Pairs layers on the basis of fossil K alone, or names a correct pair with contradictory statements.	No claim, or a claim unrelated to the evidence.
Evidence	Three or more specific pieces of evidence with layer labels, fossil letters and numbers from the guide, each stating what it rules in or out.	Three pieces of evidence, but one lacks a number or does not say what it shows.	One or two pieces of evidence, or evidence copied from the logs without connecting it to layers.	Evidence missing, invented, or contradicting the logs.
Reasoning	Uses the law of fossil succession and the index-fossil definition explicitly, explains why R beats K, explains what the ash adds, explains why rock type does not matter, and justifies 'about the same age'.	Uses fossil succession and the index-fossil idea and connects evidence to the claim, but omits one of: the ash, the rock-type point, or the 'about' justification.	Restates the evidence without a rule, or states the rule without linking it to the specific layers.	No reasoning, or reasoning that misuses the rules (for example, same rock type means same age).
Scientific language and accuracy	Uses index fossil, fossil succession, ash, layer and 'about the same age' correctly; no scientific errors.	Terms mostly correct; one minor slip (for example, 'exactly the same age') that does not change the claim.	Several terms misused, or one error that weakens the argument (treating K as an index fossil).	Terms absent or wrong throughout.

Teacher notes

The cuts and fossils are invented. The design has one strong tie (fossil R plus the ash), one weak tie (fossil K, long-lived), and one local tie (fossil M, short-lived but regional) so that students must weigh evidence rather than count matches. The textbook says layers with the same fossils are 'the same age' (pp. 98, 101, 103); the accurate statement, which this worksheet uses, is 'about the same age, within the species' lifetime', and the textbook's own p. 98 caption says 'approximately'. Ash-fingerprint matching (tephrochronology) is a real technique; students do not need the name. Pages used: Section 6 (printed 98-99, PDF 134-135) and the Key Science Concept spread (100-101, PDF 136-137).

Scaffold offered to students: Line up the logs

On scrap paper, write the North Cut layers in a column and the South Cut layers in a column beside it. Draw a line between any two layers that share a fossil, and a dashed line between the two ash layers. Then ask of each line: how long did that fossil species live? A short-lived species makes a tight connection; a long-lived species makes a loose one. The tightest connections are your strongest evidence.

Extension: A third cut

A new cut is opened ten kilometers away. From top to bottom it shows: gray limestone with fossil K; white ash; brown mudstone with fossils R and K; black shale with no fossils. Decide whether the ash in this cut is the same ash as N4 and S3, and explain your answer using fossil succession. Then explain what it would mean if the lab found that this ash has a different chemical fingerprint from the other two.