

Tinker Creek Canyon Jigsaw: Twelve Clues, One Timeline

Learning target: I can combine evidence held by different experts to reconstruct the order of events at a canyon, name the rule or method that fixes each event's place, and defend the timeline to another group.

Collaborative investigation

About 50 min

Jigsaw

MS-ESS1-4 · practice

MS-ESS2-2 · practice

collaboration

discussion

visual modeling

Standards connections

MS-ESS1-4 (practice, the evidence-from-rock-strata half): MS-ESS1-4 is a California Grade 8 performance expectation; this Grade 7 lesson previews it. Building a canyon's event timeline from layered, cut and dated evidence is the explanation-from-strata work the PE calls for, done collaboratively.

MS-ESS2-2 (practice): The timeline includes slow processes (deposition, tilting) and sudden ones (an ash fall, fault movement) at different scales, which is the varying-time-scales idea of this Grade 7 PE.

Purpose: practice · **Time:** about 50 minutes · **Format:** jigsaw

Answers with reasoning

The site

Tinker Creek Canyon (an invented place) is a 40-meter-deep canyon cut by a small creek. Its walls expose six layers, labeled A at the bottom through F at the rim, plus a dike (K) and a fault (Z). Each card below holds one observation made at the site or in a lab. No single card tells the whole story; the group's job is to put twelve clues together.

Twelve evidence cards (teaching data; cut apart before class)

1 Card 1: The stack

From the creek upward the wall shows: A, dark shale, 4 m; B, gray limestone, 3 m; C, red sandstone, 2 m; D, white volcanic ash, 0.3 m; E, gray mudstone, 2 m; F, loose brown gravel, 1 m, at the rim.

2 Card 2: Tilt and a flat surface

Layers A and B lean 30 degrees to the east. Layers C, D, E and F are nearly flat. The surface between B and C is flat, and the bottom 10 cm of C is packed with rounded pebbles of B's gray limestone.

3 Card 3: Both walls

The north wall and the south wall of the canyon show the same six layers in the same order and thicknesses. Every layer ends abruptly at the canyon wall, as if sliced.

4 Card 4: Dike K

A 1-meter-wide band of dark, fine-grained igneous rock rises from below A straight up through A, B, C, D and E. Its edges are baked. Its top is covered by layer F, which it does not enter.

5 Card 5: Fault Z

A nearly vertical break. West of it, layers A through E sit 3 m higher than east of it. Dike K is also offset by 3 m where the fault crosses it. Layer F runs across the fault unbroken.

6 Card 6: Ash D in the lab

Zircon crystals from ash layer D formed when the ash erupted. The lab measured their uranium and lead and reports an age of 93 million years, give or take 2 million.

7 Card 7: Fossils in A and B

Layer A holds shelled sea animal species S1 and never S2. Layer B holds species S2 and never S1. Both species lived in the sea.

8 Card 8: A quarry 300 km away

In a quarry 300 km north, a sandy layer with S1 lies beneath a sandy layer with S2. The rocks look nothing like A and B, but the fossil order is the same.

9 Card 9: Environments

Layer C has sloping internal stripes like those in desert sand dunes. Layer E holds leaf fossils and freshwater fish bones. So by the time C formed, this place was dry land, not sea floor.

10 Card 10: The lab says no

A sample of sandstone C sent for absolute dating came back untested with a note: 'The grains in this sandstone are pieces of older rocks. Their clocks started long before the sand was laid down, so a date on them would not be the layer's age.'

11 Card 11: Layer F

Layer F is loose gravel, not yet cemented into rock. It holds a bone from a land mammal. It rests on an uneven surface that cuts across the tops of E and dike K.

12 Card 12: Regional note

A mountain range 50 km east has layers tilted the same direction as A and B. Geologists there have shown the mountains rose when two plates collided, after B formed and before C formed.

Part A: Expert round (one set per person)

1. My expert set: _____ (A, B, C or D). For each of your three cards, write one sentence that says what the card proves and which rule or method it uses (superposition, original horizontality, lateral continuity, cross-cutting, fossil succession, absolute dating, or 'limit of the evidence'). 3 pts

Answer: Set A: card 1 gives the order of deposition A, B, C, D, E, F from the bottom up (superposition); card 2 shows A and B were deposited flat and tilted later, and that B was eroded before C was laid down (original horizontality; pebbles are a cross-cutting-type clue); card 3 shows the layers once continued across the canyon and the canyon is younger than all of them (lateral continuity and cross-cutting). Set B: card 4 shows the dike is younger than A-E and older than F (cross-cutting); card 5 shows the fault is younger than A-E and the dike, and older than F (cross-cutting); card 6 gives D an age of 93 million years (absolute dating). Set C: card 7 shows S1 appears before S2 (superposition); card 8 shows the same order 300 km away (fossil succession); card 9 shows the environment changed from sea to land after B (limit of the evidence: it dates nothing by itself). Set D: card 10 shows sedimentary rock cannot be dated directly (limit of the evidence); card 11 shows F is the youngest layer and sits on an erosion surface that cuts E and K (cross-cutting, superposition); card 12 ties the tilt to a mountain-building event between B and C (original horizontality plus outside evidence).

Why: Score the student's own set only. Each card needs a 'what it proves' sentence and a rule.

Also acceptable: Card 9 may be labeled 'environment clue' rather than 'limit'; card 2's pebbles may be called an inclusion clue or cross-cutting.

- Three sentences, one per card in the student's set
- Each sentence states an older/younger relationship or a limit
- Each names a rule or method

Part B: Home group task

1. Each expert teaches their three cards to the group in under two minutes each. Listeners may ask questions but not read the cards themselves.
2. Lay the cards on the desk. Start with the stack (cards 1 and 2): put the deposition of each layer in order, oldest first.
3. Insert each cutting or bending event (tilt, flat surface, dike, fault, canyon) just after the youngest thing it affects and just before the oldest thing it does not affect.
4. Attach the one age in years (card 6) to its event, and decide which other events it puts limits on.
5. Fill in the group record table. Every event needs at least one card number as evidence and one rule or method.
6. Swap tables with a neighboring group. Challenge one placement with a card number; answer their challenge with a card number. Record the exchange in q3.

Group record: Tinker Creek timeline (fill in; 1 = first event)

Order	Event	Evidence (card numbers)	Rule or method used
1			
2			
3			

Order	Event	Evidence (card numbers)	Rule or method used
4			
5			
6			
7			
8			
9			
10			
11			

2. Group answer: Which event was the hardest to place, and which two cards finally settled it?

2 pts

Answer: Most groups find the fault-versus-dike order or the placement of the tilt hardest. Fault versus dike is settled by card 5 (the dike is offset, so the fault is younger) and card 4 (the dike is younger than E, so both are after E). The tilt is settled by card 2 (A and B tilted, C flat, so the tilt is between B and C) and card 12 (the mountain-building between B and C).

Why: Any event is acceptable if the two cards named genuinely fix it.

Also acceptable: The canyon (cards 3 and 11) or the flat surface (cards 2 and 9) are also reasonable choices.

- Names an event
- Names two cards that fix its position
- The cards actually do fix it

3. Group answer: Write the strongest challenge the neighboring group made to your timeline and the card you used to answer it.

2 pts

Answer: Example: 'They said the dike must be younger than the fault because it reaches higher in the wall. We answered with card 5: the fault offsets the dike by 3 m, and a fault can only shift something that already exists, so the dike is older.'

Why: Credit any genuine challenge answered with a specific card and a rule.

Also acceptable: If the neighboring group's challenge was correct and the group changed its timeline, that is an excellent answer; credit it fully.

- A specific challenge recorded
- Answered with a card number and a rule

Part C: Individual accountability (complete alone)

4. Dike K and fault Z both cut the stack. Which is older? Name the card and explain the rule that proves it. 2 pts

Answer: Dike K is older. Card 5 says the fault offsets the dike by 3 m. By the law of cross-cutting relationships, a fault can only move rock that already exists, so the dike was there before the fault moved.

Why: This is the cleanest cross-cutting relationship on the sheet.

Also acceptable: None.

- Dike older
- Card 5 cited
- Cross-cutting explained (the fault shifts the dike, so the dike existed first)

5. What can you say about the age in years of layer E and of layer C? Which cards and which rule give you those limits? 2 pts

Answer: Layer E lies above ash D (card 1), so by superposition E is younger than 93 million years (card 6). Layer C lies below D, so C is older than 93 million years. Neither layer has a second limit from the cards: E is older than F, but F has no age; C is younger than B, but B has no age. Both are one-sided limits.

Why: Students should use the dated ash as a bracket in both directions and notice that each layer gets only one limit.

Also acceptable: Adding that the dike and fault are also younger than 93 million years (they cut D) is correct.

- E younger than 93 million years
- C older than 93 million years
- Cards 1 and 6 and superposition named
- Recognizes the limits are one-sided

6. Explain in your own words why the lab refused to date sandstone C (card 10), and name a layer in the canyon that the same lab could date directly. 2 pts

Answer: The grains in C came from older rocks that were broken down and washed here; each grain's radioactive clock started when the grain's original rock formed, long before the sand was deposited. Dating the grains would give the age of the source rock, not of layer C. The lab could date ash layer D directly, or dike K, because both are igneous and their clocks started when they cooled.

Why: Card 10's explanation in the student's own words, plus a correct igneous example.

Also acceptable: A student who says a date on C's grains would give a maximum age for C is extending correctly.

- Grains carry older clocks
- Names D or K as directly datable

7. When did the creek cut the canyon, compared with every other event? Use cards 3 and 11 and the rule that supports each. Then explain what the matching walls (card 3) tell you about the layers that used to be where the canyon is now. 3 pts

Answer: The canyon is the youngest event. Card 3: the layers end abruptly at both walls, so the canyon cuts all six layers (cross-cutting), including F, the youngest layer, and card 11 shows F is loose and uncemented, so it is very recent. Nothing lies across the canyon unbroken, so nothing is younger than it. Card 3's matching walls show, by the principle of lateral continuity, that the layers once ran continuously across the space where the canyon is now; the creek removed them, and the missing rock was carried away as sediment downstream.

Why: Students must place the canyon last and use lateral continuity to say what used to fill the gap.

Also acceptable: Noting that the erosion surface under F (card 11) is a separate, earlier erosion event is a strong extra.

- Canyon is last
- Cross-cutting from card 3 (layers cut by the canyon)
- Card 11 used to show F is young
- Lateral continuity: the layers once continued across the gap

8. Suppose fossil S2 turns up in a layer in another state. Using cards 7 and 8, what could you say about that layer's age, and what could you not say? 2 pts

Answer: You could say the layer formed during the time species S2 lived, and that it is younger than any layer holding only S1 and older than any layer that holds whatever species came after S2, because by the law of fossil succession species appear in the same order everywhere (cards 7 and 8). You could not say the layer's age in years, and you could not say it formed at exactly the same time as B here, only about the same time, within S2's lifetime, which the cards do not give.

Why: The answer should separate what fossil succession gives (order and an approximate match) from what it cannot give (years, exactness).

Also acceptable: A student who points out that the cards do not say how long S2 lived, so the match could be loose, has read card 7 carefully.

- About the same age as B, within S2's lifetime
- Younger than S1-only layers
- Cannot give years or an exact match

Scoring rubric

Criterion	4 • Exemplary	3 • Proficient	2 • Developing	1 • Beginning
Timeline order	All eleven events in a correct order: A, B deposited; tilt; erosion of B; C; D (93 million years); E; dike K; fault Z; erosion and F; canyon. The tilt may be placed anywhere between B and the erosion of B.	One event out of place (commonly the dike and fault swapped) but all layers and the canyon correct.	Layers in order but two or more cutting events misplaced, or the canyon not last.	Order based on position in the wall alone, with cutting events ignored.
Evidence and rules	Every event has at least one card number and a correct rule or method; the 93-million-year age is attached to D and its limits on neighbors are noted.	Every event has a card number; one or two rules missing or mislabeled.	Several events lack a card number, or rules are mostly missing.	No evidence recorded.

Expert teaching and defense	Each expert can state what each of their three cards proves and its rule; the group answers the neighbor's challenge with a specific card, and changes the timeline if the challenge is right.	Experts teach their cards; the challenge is answered without a card number or the exchange is not recorded.	One or two experts read their cards aloud without saying what they prove; no real exchange with the neighbor group.	Cards shared without teaching; no defense.
Individual accountability (Part C)	q4 to q8 answered with cards and rules; the one-sided limits in q5 and the 'about, not exactly' in q8 are stated.	q4 to q8 mostly correct; one limit or qualifier missing.	Two or more of q4 to q8 answered without cards or rules.	Part C incomplete or copied from the group table.

Teacher notes

Print and cut the twelve cards; give each home group one full deck and hand out the expert sets by number. The intended timeline (oldest first): 1 A deposited (sea, S1); 2 B deposited (sea, S2); 3 A and B tilted by the plate collision; 4 the tilted layers eroded flat (the surface with pebbles of B); 5 C deposited (desert dunes, dry land); 6 ash D falls, 93 million years ago; 7 E deposited (land: leaves, freshwater fish); 8 dike K intrudes through A-E; 9 fault Z moves, offsetting A-E and K; 10 an erosion surface cuts E and K, then gravel F is deposited across the fault; 11 the creek cuts the canyon through everything. The site is invented; the 93-million-year age was chosen so no real fossil groups are implied by the species letters. Cards 10 and 11 target the lesson's unexplained claim that absolute dating applies only to igneous rock. The textbook's p. 101 Key Science Concept callout states the cross-cutting rule backward; the lesson's pp. 96-97 and 103 have it right, and cards 4, 5 and 11 follow the correct version.

Scaffold offered to students: Three questions for every card

If a card is hard to teach, answer three questions about it on a sticky note: What does it describe (a layer, a cut, a fossil, a lab result)? What does it prove is older or younger than what? Which rule or method says so? For the timeline, remember that something must exist before it can be tilted, cut, eroded or dated, and that a layer lying unbroken across a feature is younger than that feature.

Extension: A thirteenth card

Write a thirteenth evidence card that would settle something the twelve cards cannot: for example, whether the tilting of A and B happened before or after fault Z moved, or how long ago layer F was deposited. Describe the observation or lab result on your card in the same style as the others, then explain exactly which placement in the timeline it would fix and why.