

Fixing Dev's Field Report: Six Errors About Rock Layers

Learning target: I can find the errors in a student's report about a quarry wall, explain which rule each error breaks or misuses, and rewrite each statement correctly.

Error analysis About 40 min Individual MS-ESS1-4 · practice writing independent practice discussion

Standards connections

MS-ESS1-4 (practice, the evidence-from-rock-strata half): MS-ESS1-4 is placed in California Grade 8 and this Grade 7 lesson previews it. Diagnosing wrong uses of superposition, cross-cutting, fossil matching and half-lives sharpens the reasoning the PE's explanations depend on.

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

Answers with reasoning

The quarry wall

Hawk Ridge quarry wall, top to bottom

D Gray limestone (1 m), not cut by the fault, cut by the dike	top
C Tan sandstone (4 m), the thickest layer; cut by the dike and the fault	
B Black shale with fossil K (1.5 m); cut by the dike and the fault	
A Red siltstone (2 m); cut by the dike and the fault; bottom not exposed	bottom

Layers A to D are flat and unbroken except where the dike and the fault cut them. Clues: the dike cuts A, B, C and D. The fault offsets A, B and C by 1 m and stops at the base of D. In a corner of the quarry, layers A and B are bent into a tight fold; at the top of the fold, B lies underneath A. A sand grain from layer C was tested by a lab and found to have 25% of its uranium-235 left (half-life 704 million years). Fossil K, a ribbed clam whose species existed for about 150 million years, is found in layer B here and in a layer in Nevada.

Dev's report (seven statements) — 1. Layer C is the thickest, so it is the oldest; a thick layer takes the longest time to pile up. 2. The fault goes deeper than any layer I can see, so it is the oldest feature in the quarry. 3. The dike is younger than layers A, B, C and D because it cuts through all of them. 4. In the folded corner, B is under A, and the law of superposition says the bottom layer is always oldest, so in that corner B is older than A and the rule still works. 5. Layer B here and the layer in Nevada both have fossil K, so they formed at exactly the same time. 6. The sand grain from layer C has 25% of its uranium-235 left, so layer C is 1,408 million years old. 7. After two half-lives, 50% plus 50% of the uranium has decayed, so none of it is left.

Part A: Diagnose

1. For each statement write 'correct' or 'error'. For each error, name the rule or idea it misuses (choose from: superposition, cross-cutting relationships, index fossil / fossil succession, absolute dating, half-life, original horizontality). 7 pts

Answer: 1: error, superposition (thickness is not time). 2: error, cross-cutting relationships. 3: correct. 4: error, superposition (condition 'undisturbed' not met). 5: error, index fossil / fossil succession. 6: error, absolute dating. 7: error, half-life.

Why: Statement 3 is the decoy; it applies cross-cutting correctly. Accept 'original horizontality' as an extra note on statement 4 since the fold shows the layers were deformed.

Also acceptable: For statement 6, 'half-life' is a weaker but acceptable label if the student's Part B shows they understand the grain problem.

- Statement 3 marked correct
- All six errors marked
- A reasonable rule named for each error

Part B: Explain and rewrite

For each wrong statement, write two or three sentences: first what Dev got wrong and why, then the statement rewritten so that it is true for Hawk Ridge.

2. Statement 1 (the thick layer). 2 pts

Answer: Wrong because thickness tells how much sediment piled up, not when; a thick layer can form fast (a big flood or a sand dune) and a thin one slowly. Order comes from position, not size. Rewrite: 'Layer A is the oldest exposed layer because it is at the bottom of the undisturbed stack; C is thick, but it is the second youngest.'

Why: The error confuses amount with age. The rewrite must use position.

Also acceptable: Accept 'C is thick because a lot of sand was deposited, which says nothing about its age.'

- Thickness is not a clock
- Rewrite names A as oldest by position

3. Statement 2 (the deep fault).

2 pts

Answer: Wrong because a fault is a break in rock that already existed; it cannot be older than the rock it cuts, no matter how deep it goes. Depth is not age for a cutting feature. Rewrite: 'The fault is younger than A, B and C, which it offsets, and older than D, which lies across it unbroken.'

Why: Cross-cutting: the feature doing the cutting is the younger one. The 'stops at D' clue gives the upper limit.

Also acceptable: A rewrite that says only 'younger than A, B and C' earns most of the credit.

- A fault must be younger than what it cuts
- Rewrite places the fault between C and D

4. Statement 4 (the folded corner).

2 pts

Answer: Wrong because superposition applies only to undisturbed layers. In the fold, the layers have been bent so tightly that part of the stack is upside down; B lying under A there does not mean B is older. The rest of the quarry, where the layers are flat and unbroken, shows A under B, so A is older. Rewrite: 'In the folded corner the layers are overturned, so superposition cannot be read straight up there; using the undisturbed part of the wall, A is older than B.'

Why: This is the 'undisturbed' condition. Students may also note original horizontality: the fold itself proves a later deformation.

Also acceptable: Accept 'the fold flipped the order' as the core idea.

- Names the undisturbed condition
- Uses the flat part of the wall to fix A as older
- Rewrite says the fold is overturned

5. Statement 5 (fossil K in Nevada).

2 pts

Answer: Wrong on two counts. Fossil K's species lived for about 150 million years, so finding it in both places only shows both layers formed somewhere in that 150-million-year window; it is not an index fossil. And even a good index fossil gives 'about the same age', never 'exactly', because a species lives for some span of time. Rewrite: 'Layer B and the Nevada layer both formed during the 150 million years that fossil K existed; a short-lived, widespread fossil would be needed to match them more closely.'

Why: Both the long lifespan and the word 'exactly' are errors.

Also acceptable: A student who addresses only the 'exactly' problem earns partial credit.

- K's long lifespan makes the match loose
- 'Exactly' is wrong even for good index fossils
- Rewrite gives a window, not a moment

6. Statement 6 (the sand grain).

2 pts

Answer: Wrong because the sand grain's clock started when the grain crystallized inside some older igneous rock; that rock was later broken down and the grain was washed into the sand that became layer C. So 1,408 million years (25% left = 2 half-lives $\times$ 704) is the grain's age and a maximum for layer C, not the layer's age. Sedimentary rock cannot be dated directly this way. Rewrite: 'A grain in layer C is 1,408 million years old, so layer C is younger than that; to narrow its age we would need dated igneous layers above and below it, or a date on the dike, which is younger than C.'

Why: The grain-recycling idea is the heart of why absolute dating applies to igneous rock. The calculation itself is correct.

Also acceptable: Accept 'the grain is older than the sandstone it is in' as the key idea.

- Grain's clock started in an older rock
- 1,408 million years is a maximum for C, not its age
- Rewrite uses 'younger than'

7. Statement 7 (two half-lives).

2 pts

Answer: Wrong because each half-life removes half of what remains, not half of the original amount. After one half-life 50% is left; after the second, half of that 50%, which is 25%, is left. The percentages do not add. Rewrite: 'After two half-lives, 25% of the uranium-235 remains and 75% has decayed to lead.'

Why: The additive error is the most common half-life misconception.

Also acceptable: Accept a halving table (100, 50, 25) as the explanation.

- Half of what remains, not half of the original
- Rewrite says 25% remains after two half-lives

Part C: A note to Dev

8. Several of Dev's errors come from the same habit: using a rule without checking the condition it needs, or using a number without asking what it measures. Write Dev a short note (four to six sentences) that names this habit, gives two examples from his report, and tells him one question to ask himself before he writes a conclusion.

4 pts

Answer: Example note: 'Dev, most of your errors come from using a rule without checking the condition it needs, or using a number without asking what it measures. Superposition only works in an undisturbed stack, and the folded corner is not undisturbed (statement 4). The grain's 1,408 million years measures when the grain formed, not when the sand was laid down (statement 6). Fossil K only works as a time marker if its species lived a short time, and it lived 150 million years (statement 5). Before you write a conclusion, ask: what does this rule or number actually require, and does this quarry meet it?'

Why: Full credit needs the habit named, two correct examples from the report, and a usable self-check question.

Also acceptable: Students may frame the habit as 'jumping to conclusions' if the examples show the condition idea; accept 'thickness is not time' as one of the two examples.

- Names the habit (rule without condition, or number without meaning)
- Two examples drawn from the report
- One self-check question Dev can ask

Teacher notes

Each error targets a documented misconception: thickness equals time (1), depth equals age for cutting features (2), superposition without the 'undisturbed' condition (4; the textbook's p. 103 summary itself drops this condition, so expect students to defend Dev), fossils give exact ages (5; the textbook's pp. 98 and 103 say 'the same age' without a qualifier), sedimentary rock can be dated directly (6), and additive half-lives (7). Statement 3 is the correct decoy; students who mark it wrong are usually reading the p. 101 Key Science Concept callout, which states the cross-cutting rule backward. The quarry is invented. Pages: Sections 2, 4, 5, 6 and 7 (printed 93, 95-99, 102; PDF 129, 131-135, 138).

Scaffold offered to students: Test each statement against its rule

For every statement, find the rule Dev is using and write its full version, including any condition: 'In an UNDISTURBED stack, bottom is oldest.' 'A feature that CUTS rock is YOUNGER than that rock.' 'Same SHORT-LIVED fossil means ABOUT the same age.' 'Absolute dating works on IGNEOUS rock whose clock started when it formed.' 'Each half-life removes HALF OF WHAT IS LEFT.' Then ask whether the quarry meets the condition. If it does not, you have found the error.

Extension: Write statement 8

Dev did not notice that the fault stops at the base of layer D. Write a correct statement 8 that uses this clue to place the fault in the quarry's history relative to layers C and D and relative to the dike. Then explain why the fault and the dike cannot be the same age, and what you would look for at the spot where the dike crosses the fault to prove which came first.