

Rock Strata Check-Up: Twelve Items and a Synthesis

Learning target: I can apply the laws of superposition, original horizontality, lateral continuity, cross-cutting relationships and fossil succession, calculate ages from half-lives, and explain how geologists combine relative and absolute dating to organize Earth's history.

Retrieval and mastery check

About 40 min

Individual

MS-ESS1-4 · practice

MS-ESS2-2 · supports

independent practice

writing

Standards connections

MS-ESS1-4 (practice, the evidence-from-rock-strata half and the time-scale idea): MS-ESS1-4 is placed in California Grade 8; this Grade 7 lesson previews it. The items check the reasoning from rock strata and the half-life arithmetic that the PE's explanation uses; no period or epoch names are asked, in keeping with the assessment boundary.

MS-ESS2-2 (supports): Several items name deposition, tilting, erosion and faulting as separate events acting over different time spans, which is background for this Grade 7 PE on surface-changing processes.

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

Answers with reasoning

Quarry wall for items 1 to 5, top to bottom

1 Gravel, flat	top
2 Sandstone with leaf fossils, flat	
3 Limestone with shell fossils, tilted 25 degrees	
4 Shale, tilted 25 degrees	
5 Sandstone, tilted 25 degrees	bottom

Use this figure for items 1 to 5. A dike of igneous rock cuts layers 2, 3, 4 and 5 but not layer 1. A fault offsets layers 3, 4 and 5 and stops at the flat surface under layer 2. The surface between layers 3 and 2 is flat and cuts across the tilted tops of 3, 4 and 5.

Part A: Retrieval items

1. Which layer in the figure is the oldest? 2 pts

Answer: C. Layer 5, because it is at the bottom of an unbroken, right-side-up sequence.

Why: Superposition with its condition stated: the tilted layers are not overturned (25 degrees), so the lowest is oldest. Option A reverses the rule; B uses fossils as a count; D confuses 'flat' with 'first'.

Also acceptable: None.

2. Which rule tells you that layers 3, 4 and 5 were tilted after they formed? 2 pts

Answer: B. Principle of original horizontality.

Why: Sediment settles flat or nearly flat; a 25-degree tilt shared by three layers records a later event.

Also acceptable: None.

3. True or false: the dike is older than layer 2 because the dike is below layer 1. 3 pts

Answer: False. The dike cuts layer 2, so by the law of cross-cutting relationships it is younger than layer 2. Being below layer 1 only shows the dike is older than layer 1 (which it does not cut).

Why: Depth is not age for a cutting feature; what it cuts decides.

Also acceptable: Accept 'the dike is younger than 2 and older than 1'.

- False
- Dike cuts layer 2, so younger than 2
- Dike does not cut layer 1, so older than 1

4. Which is older, the fault or the dike, and how do you know? 2 pts

Answer: A. The fault, because it stops under layer 2 while the dike cuts layer 2.

Why: The fault moved before layer 2 was deposited (layer 2 is unbroken); the dike came after layer 2 (it cuts it). Option B is a false general rule; C uses size; D ignores layer 2.

Also acceptable: None.

5. What does the flat surface between layer 3 and layer 2 represent, and what does it tell you about the rock record at this quarry? 3 pts

Answer: It is a surface where the tilted layers were worn down (eroded) flat before layer 2 was deposited on top. It tells you that time is missing from the record here: whatever was deposited after layer 3 and before layer 2 was removed, and the tilting and erosion themselves took time that left no layers behind.

Why: The surface is an unconformity (students do not need the word). Full credit requires both the erosion idea and the missing-time idea.

Also acceptable: Accept 'a gap in the story' for missing time.

- Worn-down (eroded) surface formed after the tilt and before layer 2
- Time is missing from the record

6. Uranium-235 has a half-life of 704 million years. A zircon crystal has gone through 3 half-lives. How old is it, and what percent of its original uranium-235 remains? Show both calculations. 3 pts

Answer: Age: $3 \times 704 = 2,112$ million years. Remaining: $100\% \rightarrow 50\% \rightarrow 25\% \rightarrow 12.5\%$, so 12.5% remains.

Why: Count of half-lives times the half-life; halve three times.

Also acceptable: Accept 2.112 billion years and 1/8.

7. A fossil useful for matching layers in distant places should be easy to _____, found over a _____ area, and come from a species that lived for a _____ span of time. Such a fossil is called an _____ fossil. 3 pts

Answer: Easy to **recognize** (identify); found over a **wide** (large) area; lived for a **short** span of time; an **index** fossil.

Why: The three requirements plus the term.

Also acceptable: Accept 'spot' or 'identify' for recognize and 'widespread' for wide.

8. Explain why a lab cannot give the age of sandstone layer 5 in years by measuring its sand grains, and name one thing in the figure the lab could date in years. 3 pts

Answer: The sand grains were weathered out of older rocks; each grain's radioactive clock started when that older rock formed, not when the sand was deposited, so a date on the grains would be older than the layer. The lab could date the dike, because it is igneous rock whose clock started when the magma cooled.

Why: Sedimentary rock is made of recycled pieces; only the dike (igneous) in this figure can be dated directly.

Also acceptable: A student who says the grain dates give a maximum age for layer 5 is extending correctly.

- Grains carry older clocks from their source rocks
- Names the dike as datable

9. A canyon separates two cliffs. The left cliff shows, from the top, a white layer over a red layer over a gray layer; the right cliff shows the same three layers in the same order and thickness. What can you conclude, and by which rule? 2 pts

Answer: B. The layers were once continuous and the canyon is younger than all of them, by lateral continuity and cross-cutting.

Why: Matching layers across a gap were one layer; the gap cuts them, so it is younger. A reverses the logic; C assumes separation means different times; D misuses original horizontality.

Also acceptable: None.

10. A volcanic ash layer's zircon has 6.25% of its uranium-235 left. How many half-lives have passed, and how old is the ash? A shale layer lies directly on top of the ash; write one sentence about the shale's age. 3 pts

Answer: 6.25% is $100 \rightarrow 50 \rightarrow 25 \rightarrow 12.5 \rightarrow 6.25$, so 4 half-lives. Age: $4 \times 704 = 2,816$ million years. The shale on top is younger than 2,816 million years (superposition), but its exact age is unknown.

Why: Halving count, multiplication, and a one-sided bracket for the shale.

Also acceptable: Accept 2.816 billion years.

- 4 half-lives
- 2,816 million years
- Shale younger than that age

11. Draw a side view of three flat layers. Add a dike that cuts only the bottom two layers and stops below the top layer. Number the four features (three layers and the dike) from 1 = oldest to 4 = youngest, and write beside the drawing the rule that fixes the dike's number.

3 pts

Answer: Three horizontal bands; a vertical band (the dike) rising through the bottom two layers and stopping at the base of the top layer. Numbers: bottom layer 1, middle layer 2, dike 3, top layer 4. Rule written beside: the law of cross-cutting relationships (the dike is younger than the two layers it cuts and older than the layer that covers it unbroken).

Why: The dike must be placed between the middle and top layers; superposition fixes the layers.

Also acceptable: Numbering the top layer 4 and the dike 3 with the words 'the dike is covered, not cut' is the key idea in any wording.

- Dike cuts only the bottom two layers
- Order 1 bottom, 2 middle, 3 dike, 4 top
- Cross-cutting named for the dike

12. Two geologists describe the same basalt layer. One says 'it is younger than the limestone below it.' The other says 'it is 31 million years old.' Name the kind of dating each one used and explain why both statements are needed to tell the layer's story.

3 pts

Answer: The first used relative dating (an order from position: superposition). The second used absolute dating (an age in years from radioactive atoms in the igneous basalt). Both are needed because the order alone gives no years, and the number alone says nothing about what came before or after; together they place the basalt at 31 million years ago and tell you the limestone below is older than that.

Why: Students should name both methods and explain that each supplies what the other lacks, ideally noting that the dated basalt now gives the limestone a minimum age.

Also acceptable: Accept 'radiometric dating' for the second.

- Relative and absolute named correctly
- Order needs years; years need order
- Optionally: the limestone is older than 31 million years

Part B: Synthesis

13. Explain how geologists use rock strata to organize Earth's history. Your paragraph must (a) describe how at least three rules put events in order, using the quarry figure for examples, (b) explain how absolute dating of igneous rock attaches years to that order, and (c) state one thing the rock record cannot tell us and why. Use at least four vocabulary terms correctly and underline them.

8 pts

Answer: A full-credit paragraph: Geologists read the order of events from rock strata using a few rules. By the law of superposition, in an undisturbed stack the bottom layer is oldest, so in the quarry layer 5 formed before 4 and 3. By the principle of original horizontality, sediment settles flat, so the 25-degree tilt of layers 3 to 5 happened after they formed. By the law of cross-cutting relationships, the fault that breaks layers 3 to 5 is younger than them and older than layer 2, which lies across it, and the dike that cuts layers 2 to 5 is younger still; the flat worn surface under layer 2 is also a cutting feature and marks missing time. Fossils in the same order everywhere (fossil succession) let geologists match layers between distant places. Relative dating gives only order, so geologists use absolute dating on igneous rock, such as the dike: its radioactive atoms decay at a steady rate, and counting half-lives gives an age in years, which then puts limits on the layers it cuts (all older than the dike). The rock record cannot tell everything: eroded surfaces remove layers, so time is missing, and sedimentary layers get only age ranges, not exact years.

Why: Score (a) three rules with quarry examples, (b) absolute dating on igneous rock attaching years and bracketing, (c) a stated limit with a reason, and four underlined terms used correctly.

Also acceptable: Lateral continuity may replace one of the quarry rules if the student invents a canyon example. A limit such as 'overturned folds can hide the order' is acceptable with a reason.

- At least three rules, each with a quarry example
- Absolute dating of igneous rock explained with half-lives and used to bracket layers
- One limit of the record (missing time, only ranges for sedimentary layers, no names in years for fossils) with a reason
- At least four vocabulary terms underlined and correct

Teacher notes

Points: q1 2, q2 2, q3 3, q4 2, q5 3, q6 3, q7 3, q8 3, q9 2, q10 3, q11 3, q12 3, q13 8; total 40. Items 3, 4 and 11 target the cross-cutting rule, which the textbook's p. 101 Key Science Concept callout states backward; the lesson's pp. 96-97 and 103 are correct. Item 1 states the 'unbroken, right-side-up' condition that the p. 103 summary drops. Item 5's surface is an angular unconformity; the term is not required. Half-life items use the textbook's 704-million-year value for uranium-235 (p. 102, PDF 138). No item asks for the name of a geologic period or epoch, in keeping with the MS-ESS1-4 assessment boundary. The extension closes the loop with Worksheet 1's first explanation.

Scaffold offered to students: Three questions before every item

Before answering an item about the figure, ask: Is this stack undisturbed and right-side up where I am looking? What cuts what? Is the item asking for an order (relative) or a number of years (absolute)? For the half-life items, write a halving table (100, 50, 25, 12.5, 6.25) and count the steps; each step is 704 million years. For the synthesis, write one sentence per rule, then one sentence about years, then one about limits.

Extension: Revise your first story

Take out your answer to q7 on Worksheet 1 (the Pelican Point cliff story). Rewrite it using the rules and vocabulary of this chapter, with each event supported by a named rule. Then write two sentences about which of your original guesses turned out to be right and which the chapter changed, and why.