

Fix Mateo's Rock Cycle: Finding and Repairing Six Errors

Learning target: I can find the errors in another student's explanation of the rock cycle, explain the thinking behind each error, and rewrite each statement so that it is scientifically correct.

Error analysis

About 40 min

Individual

MS-ESS2-1 · practice

writing

independent practice

Standards connections

MS-ESS2-1 (practice): Repairing a flawed description and diagram of the cycle (fixed order, melting as metamorphism, the Sun melting rock, sand hardening by drying) targets the exact ideas a correct model must get right. Students critique a model rather than build their own, so this is practice toward the PE.

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

Answers with reasoning

Mateo's summary (numbered sentences)

What Mateo wrote — **S1.** Rocks move through the rock cycle in a fixed order: igneous rock becomes sedimentary rock, sedimentary rock becomes metamorphic rock, and metamorphic rock melts to make igneous rock again. **S2.** Igneous rock forms when magma or lava cools and its minerals crystallize. **S3.** Granite has big crystals because it cooled quickly at the surface, where there was plenty of room for the crystals to spread out. **S4.** Sand turns into sandstone when it dries out in the sun and hardens, the way mud dries into a crust. **S5.** Metamorphic rock forms when a rock gets so hot that it melts partway and then re-hardens with a new texture. **S6.** Weathering breaks rock down where it sits, and erosion carries the pieces away. **S7.** The Sun's heat is what melts rock deep underground into magma, because the Sun is Earth's main energy source. **S8.** Once a rock has become metamorphic, it has reached the end of the cycle and cannot change into anything else.

Mateo's diagram (described) — A single circle with three boxes spaced around it: Igneous rock, Sedimentary rock, Metamorphic rock. Three arrows run clockwise: Igneous to Sedimentary, labeled 'weathering'; Sedimentary to Metamorphic, labeled 'heat and pressure'; Metamorphic to Igneous, labeled 'melting'. There are no other boxes and no other arrows.

Part A: Find the errors

1. Write the numbers of the sentences that contain a science error: _____. (Two sentences are correct as written.)

Answer: S1, S3, S4, S5, S7 and S8 contain errors. S2 and S6 are correct.

Why: S2 correctly describes igneous formation; S6 correctly separates weathering (breaking down in place) from erosion (carrying away).

Also acceptable: None; all six must be listed for full credit, and S2 and S6 must not be listed.

Part B: Explain and repair

For each sentence below, write two things: (a) what Mateo was probably thinking, and why it seems reasonable but is wrong; (b) a corrected sentence.

2. **S1** (the fixed order).

Answer: (a) Mateo probably learned the cycle from a diagram drawn as a circle and assumed the arrows show a required order, the way the seasons follow one another. It seems reasonable because 'cycle' sounds like a loop. But the rock cycle is a set of possible routes, not a schedule. (b) Corrected: Rock can change along many routes in the rock cycle; any rock type can become any other, for example igneous rock can be changed straight into metamorphic rock by heat and pressure, and metamorphic rock can be weathered straight into sediment.

Why: The explanation must identify the loop-as-order assumption; the rewrite must state that any rock can become any other, ideally with a skip-a-step example.

Also acceptable: Accept 'rocks can also stay the same for millions of years' as an extra correction.

- Explains the loop/order assumption
- Rewrite says any rock can become any other
- Rewrite gives at least one example of a route that skips a step

3. **S3** (granite's big crystals).

Answer: (a) Mateo seems to think crystals need open space to grow large, so he put granite at the surface, where there is 'room'. It is reasonable to think space matters, but crystal size depends on time, not room: crystals grow for as long as the melt stays liquid. (b) Corrected: Granite has big crystals because its magma cooled very slowly deep underground, insulated by surrounding rock, which gave the crystals a long time to grow; rock that cools quickly at the surface has tiny crystals.

Why: The rewrite must reverse both the speed (slow) and the place (underground) and give time as the reason.

Also acceptable: Accept 'intrusive' for underground if explained.

- Explains the 'room to grow' assumption
- Rewrite says slow cooling underground
- Rewrite links crystal size to cooling time

4. **S4** (sand drying into sandstone).

Answer: (a) Mateo is using an everyday experience, mud drying into a crust, and assuming sandstone forms the same way. Dried mud is still loose material that crumbles when wet, so drying does not make rock. (b) Corrected: Sand turns into sandstone when it is buried under more and more layers of sediment; the weight of those layers squeezes the grains together (compaction), and minerals carried by water between the grains glue them to one another (cementation).

Why: Both compaction and cementation are needed, and burial rather than sunlight is the setting.

Also acceptable: Accept 'pressed and glued' for compaction and cementation if burial is mentioned.

- Identifies the drying-mud analogy as the source
- Rewrite names burial, compaction and cementation

5. **S5** (metamorphic rock melting partway).

Answer: (a) Mateo knows metamorphic rock involves heat and knows heat melts things, so he assumed the rock must melt at least a little. It is a natural link, but if the rock melts, the result is magma and then igneous rock, not metamorphic rock. (b) Corrected: Metamorphic rock forms when heat and pressure change the texture or minerals of a rock while it stays solid; its crystals can regrow, flatten and line up in bands, but the rock never melts.

Why: This is the chapter's central misconception. The rewrite must say the rock stays solid and that melting would lead to igneous rock instead.

Also acceptable: A student who adds that at extreme temperatures some rock can begin to melt and then leaves the metamorphic path is correct and should be credited.

- Explains the heat-means-melting assumption
- Rewrite states the rock stays solid
- Rewrite describes what heat and pressure do instead (regrow, flatten, align crystals)

6. **S7** (the Sun melting rock underground).

Answer: (a) Mateo knows the Sun is the energy source for most things on Earth's surface, so he extended it to underground melting. The Sun does power weather, rivers, wind and ice, but sunlight cannot reach kilometers underground; rock there is heated by Earth's own interior. (b) Corrected: Rock deep underground melts into magma because of heat from Earth's interior; the Sun's energy drives surface processes such as weathering, erosion and deposition, while Earth's interior drives melting, metamorphism and the tectonic forces that lift rock.

Why: The rewrite must assign the Sun to surface processes and the interior to deep processes.

Also acceptable: Accept gravity named as an additional surface-process source.

- Explains the overgeneralization of the Sun's role
- Rewrite assigns melting to Earth's interior
- Rewrite assigns surface processes to the Sun

7. **S8** (metamorphic rock as the end of the cycle).

Answer: (a) Mateo may think of metamorphic rock as the 'finished' or 'hardest' rock, perhaps because it is the last stop in his loop. But no rock is an end point. (b) Corrected: Metamorphic rock can keep changing: it can be weathered into sediment if uplifted to the surface, it can be changed again by more heat and pressure, or it can melt into magma; there is no end to the rock cycle.

Why: The rewrite should give at least two possible futures for a metamorphic rock.

Also acceptable: One future plus the statement 'there is no end' is acceptable.

- Explains the end-point assumption
- Rewrite gives at least two futures (sediment, more metamorphism, magma)

Part C: Repair the diagram and look back

8. Mateo's diagram has the same problem as S1, plus two missing boxes. Name the two boxes he should add, and list **three** arrows (with their process labels) that his diagram is missing.

Answer: Missing boxes: magma and sediment. Missing arrows, any three of: sedimentary rock to sediment (weathering and erosion); metamorphic rock to sediment (weathering and erosion); igneous rock to metamorphic rock (heat and pressure); sedimentary rock to magma (melting); igneous rock to magma (melting); magma to igneous rock (cooling and crystallization, which replaces his 'melting' arrow pointing directly to igneous rock); sediment to sedimentary rock (compaction and cementation). Also note that his 'weathering' arrow should go from igneous rock to sediment, not directly to sedimentary rock.

Why: The diagram repeats S1's single-loop error and skips the two in-between materials. Students should recognize that 'melting' cannot point straight at igneous rock because melting produces magma.

Also acceptable: Accept the observation that his existing arrows need re-routing through the new boxes as one of the three fixes.

- Names magma and sediment as missing boxes
- Lists three valid missing arrows with correct process labels

9. Which everyday experience most likely led Mateo to the error in S5?

Answer: A: Seeing ice melt and refreeze into a different shape, and assuming rock changes the same way.

Why: S5 treats a change in texture as requiring melting and re-hardening, which is how ice behaves. The other options relate to sediment, erosion or surface warming, none of which suggest melting as the way rock changes form.

Also acceptable: None.

10. Write a replacement summary for Mateo in four to six sentences that keeps his two correct sentences and fixes every error. It must say that any rock can become any other, and it must name the energy source behind surface processes and the energy source behind deep processes.

Answer: Model summary: Igneous rock forms when magma or lava cools and its minerals crystallize; slow cooling underground makes large crystals and fast cooling at the surface makes small ones. Weathering breaks rock down where it sits, and erosion carries the pieces away, until they are deposited as sediment and, after burial, compacted and cemented into sedimentary rock. Heat and pressure deep underground can change any rock into metamorphic rock while it stays solid, and enough heat can melt any rock into magma. These changes do not happen in a fixed order: any rock type can become any other, and a rock can also sit unchanged for millions of years. Surface processes run on energy from the Sun (and gravity), while melting, metamorphism and uplift run on heat from Earth's interior.

Why: Full credit requires the two correct sentences (S2 and S6 ideas) retained, all six errors absent, the any-to-any statement, and both energy sources matched to the right processes.

Also acceptable: Order and wording are free; a summary that is longer than six sentences but fully correct earns full credit.

- Keeps the ideas of S2 and S6
- No remaining errors from S1, S3, S4, S5, S7 or S8
- States that any rock can become any other
- Names the Sun for surface processes and Earth's interior for deep processes

Teacher notes

The six errors map to the chapter's main misconceptions: the loop as a required order (S1, diagram), big crystals from fast cooling (S3), sedimentary rock by drying (S4), metamorphism as partial melting (S5), the Sun as the source of interior heat (S7), and a rock type as an end point (S8). S5 is the one to spend time on in the debrief: emphasize that if a rock melts it has left the metamorphic path, and that at the very highest temperatures some rock does begin to melt, which is the boundary between the two processes. S2 and S6 are correct on purpose so that students must judge each sentence rather than assume everything is wrong. The q9 distractor D (a rock warm in the sun) also catches students who hold the S7 error; use it in discussion.

Scaffold offered to students: Three questions to test any sentence

Run each sentence through these tests. Test 1, order: does the sentence force rock to follow one path? Real rock can take any route. Test 2, melting: does the sentence say rock melts when the process does not involve melting? Only the route into magma involves melting; metamorphic change happens in solid rock. Test 3, energy: does the sentence put the Sun underground or Earth's interior at the surface? The Sun drives weathering, erosion and deposition at the surface; Earth's interior drives melting, metamorphism and uplift below it. Also check the crystal rule: slow cooling underground makes big crystals, fast cooling at the surface makes small ones.

Extension: Write the trap

Write your own eight-sentence rock-cycle summary that contains exactly three errors, each of a different kind (one about order, one about energy, one about a process). Make the errors sound reasonable, the way Mateo's do, by building each on a real everyday experience. Trade with a partner and see whether they can find and repair all three. Afterwards, write two sentences about which of your errors was hardest to spot and why that kind of error is easy for people to believe.