

Were They Ever One? A Claim-Evidence-Reasoning Case for Two Continents

Learning target: I can use fossil, rock, shape and seafloor evidence to argue whether South America and Africa were once joined and are still moving apart, and explain why independent lines of evidence make the argument strong.

Claim, evidence, reasoning

About 45 min

Individual

MS-ESS2-3 · assesses

writing

data analysis

Standards connections

MS-ESS2-3 (assesses, interpreting fossil and rock distributions, continental shapes and seafloor data as evidence of past plate motion): Students interpret all four kinds of data named in the PE and construct an evidence-based argument that the plates carrying two continents have moved apart. The seafloor evidence uses drill-core ages and structures, not magnetic data, in line with the assessment boundary.

Purpose: assess · **Time:** about 45 minutes · **Format:** individual

Answers with reasoning

The evidence file

Evidence A: Fossils (real distributions). The table lists three organisms whose fossils occur in rocks of the same age on both continents.

Evidence A: Fossils found on both sides of the South Atlantic (real distributions)

Fossil	What it was	Where found	Could it cross 3,000 km of open ocean?
Mesosaurus	Reptile about 1 m long that lived in shallow coastal and inland waters, about 280 million years ago	Southern Brazil and Uruguay; South Africa and Namibia	No; built for shallow water, not open sea
Glossopteris	Extinct seed plant (a tree) with tongue-shaped leaves, 250 to 300 million years ago	South America, Africa, India, Australia, Antarctica	No; its seeds were too large and heavy to blow across an ocean
Cynognathus	Dog-sized land reptile with mammal-like teeth, about 240 million years ago	Argentina; South Africa	No; it lived on land and did not swim

Evidence B: Rocks (real). Belts of old rock on the two coasts match in type, age and the order of their layers. Rock layers in eastern Brazil and in Gabon, in West Africa, were laid down in the same kind of lakes at the same time, about 130 million years ago, and contain the same fish fossils. Both continents also hold deposits left by ice sheets about 300 million years ago, with scratches on the bedrock showing which way the ice moved. When the continents are placed side by side, the scratches point outward from one common center, as if a single ice sheet had covered the joined lands.

Evidence C: Shapes (real). The coastlines of the two continents fit roughly, but coastlines move whenever sea level changes. In 1965 a team at Cambridge University used a computer to fit the continents along the edge of the continental shelf, at a water depth of about 900 meters. That edge is the true rim of each landmass. The shelf edges of South America and Africa fit with only small gaps and overlaps along more than 5,000 kilometers.

Evidence D: Seafloor ages (simulated drill cores). A drilling ship took cores along a line from the Brazilian shelf to the West African shelf. The dataset gives the age of the oldest sediment resting on the volcanic rock at each site. These numbers are a teaching dataset; the pattern is the one real drilling found.

Evidence D: Seafloor age along a line from Brazil to West Africa (teaching dataset)

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

Site	Distance from ridge crest (km)	Side	Age of seafloor (Ma)
B1	1400	west (toward Brazil)	70
B2	1000	west	50
B3	600	west	30
B4	200	west	10
R0	0	ridge crest	0
A4	200	east (toward Africa)	10
A3	600	east	30
A2	1000	east	50
A1	1400	east	70

Simulated for teaching. Distances are measured from the crest of the Mid-Atlantic Ridge; the pattern matches real drilling results, the values are invented.

Evidence E: Seafloor structures (real). Sonar mapping shows a continuous mid-ocean ridge running down the middle of the South Atlantic, about halfway between the two continents, and its bends follow the bends of both coasts. A narrow valley runs along the ridge crest. Nearly all the earthquakes in the South Atlantic happen in a thin belt along that crest. Satellite measurements show the two continents moving apart today at about 3 to 4 centimeters a year.

Evidence F: Climate today (real). Both the Amazon basin in Brazil and the Congo basin in Africa have hot, wet climates and tropical rainforests today, and both lie near the equator.

Warm-up: organize the evidence

1. Which evidence item is **not** useful for deciding whether the continents were once joined? Explain why it does not help, even though it is true.

Answer: Evidence F. Both regions are hot and wet today because both sit near the equator today; the present climate tells you where the continents are now, not where they were 250 million years ago. It would be true whether or not the continents had ever been joined, so it cannot tell the two possibilities apart.

Why: Evidence that is expected either way does not discriminate between hypotheses. This is the key test students should apply to every item.

Also acceptable: Accept 'it is about the present, not the past.'

- Identifies F
- Explains that it is consistent with both possibilities and so cannot decide between them

2. Using Evidence D, calculate the spreading rate on one side of the ridge in km per million years, then convert it to cm per year. Show your work. Does the result agree with the satellite rate in Evidence E? (Remember that the satellite rate is for both sides together.)

Answer: Using B1 or A1: $1,400 \text{ km} \div 70 \text{ million years} = 20 \text{ km per million years on one side}$. Conversion: $20 \text{ km} \times 100,000 \text{ cm/km} = 2,000,000 \text{ cm per million years}$; $\div 1,000,000 \text{ years} = 2 \text{ cm per year on one side}$. Both sides together: 4 cm per year. Evidence E gives 3 to 4 cm per year for the two continents moving apart, so the drill-core rate agrees with the satellite rate.

Why: Any site gives 20 km per million years because the dataset is built on that half-rate. Agreement between a rate read from ages and a rate measured today is itself powerful evidence that the process has run steadily.

Also acceptable: Accept any site used; accept 2 cm/yr compared with 'half of 3 to 4', or 4 cm/yr compared with 3 to 4, as long as the student handles the one-side versus both-sides distinction.

3. Evidence A, B and C were all available to Wegener by 1915. Evidence D and E were not. For each of the three older items, write one other explanation someone in 1915 could have offered that does **not** require the continents to move. Then say which of the newer items (D or E) is hardest to explain without moving plates, and why.

Answer: Alternative explanations from 1915: (A) a land bridge once connected the continents and later sank into the ocean, letting animals and plants cross; (B) the same kinds of rock and glaciers could form in two separate places at the same time if the climate was similar everywhere; (C) the coastline fit could be a coincidence, since any two wiggly lines look a little alike. Hardest to explain without moving plates: Evidence D (or E). The ages increase symmetrically from zero at the ridge to 70 million years at the farthest sites, which means the seafloor between the continents was built strip by strip at the ridge over at least 70 million years; there is no way to get that pattern if the continents stayed put. Evidence E's direct measurement of present-day motion is also decisive.

Why: Students should see that the pre-1915 evidence allowed other stories (sunken land bridges were the standard rival) while the seafloor pattern does not. Either D or E is acceptable as 'hardest' with a correct reason.

Also acceptable: Accept 'the fossils floated across on logs' for A if the student notes the table says this is unlikely; accept 'the shelf fit of 1965 was only measured later, so in 1915 only the rough coastline fit was available' as context.

- One alternative for each of A, B and C
- Chooses D or E
- Explains why the seafloor pattern or direct measurement cannot be explained without motion

Your argument

Answer: Claim: South America and Africa were once a single landmass that split apart, and they are still moving apart today. Evidence: (1) Fossils of *Mesosaurus*, a 1-meter reptile of shallow water, and *Cynognathus*, a dog-sized land reptile, occur in rocks of the same age in Brazil, Uruguay and Argentina and in southern Africa, and neither could cross 3,000 km of ocean (Evidence A). (2) Rock layers from 130-million-year-old lakes in Brazil and Gabon match in type, age and fossils, and 300-million-year-old glacial scratches on both continents point outward from one common center when the continents are placed together (Evidence B). (3) The continental shelf edges, fitted by computer in 1965 at about 900 m depth, match along more than 5,000 km with only small gaps (Evidence C). (4) Drill-core ages rise symmetrically from 0 at the ridge crest to 70 million years at 1,400 km on both sides, giving 2 cm per year on each side (Evidence D). (5) A continuous ridge with a crest valley and a belt of earthquakes runs midway between the coasts, and satellites measure the continents separating at 3 to 4 cm per year today (Evidence E). Reasoning: If the two continents were joined, land animals and heavy-seeded plants could spread across the whole landmass, so the same species on both sides is exactly what we expect; if the continents never moved, a 3,000 km ocean would have blocked them. Matching lake rocks and a single glacial center are expected if the lands were one and are a strange coincidence otherwise. The shelf edges fit because they are the torn edges of one piece. The seafloor ages are the strongest line: the ocean floor was built strip by strip at the ridge over at least 70 million years, and the youngest floor is in the middle, which is impossible if the floor had always been there. The satellite rate (3 to 4 cm per year) matches the rate read from the ages (4 cm per year, both sides), so the process that opened the ocean is still running. Each line comes from a different kind of measurement made by different people, and all of them point to the same moving plates. One line could be a coincidence; five independent lines agreeing cannot be, which is why this explanation is a theory and not a guess.

Why: This is the solved model response. Full credit requires a two-part claim, at least three evidence items from at least two families with specific names or numbers, reasoning that gives the 'expected if moved / hard to explain if not' contrast for each, and an explicit statement about independent lines agreeing. Evidence F should not appear.

Also acceptable: A student who claims the continents were joined but is unsure whether they still move can earn full marks on evidence if they discuss D or E and explain their hesitation. A response that uses only fossils and rocks (one family) earns at most level 2 on Evidence.

- Claim states both that the continents were joined and that they are still moving apart
- At least three evidence items from at least two families, with names or numbers from the file
- For each item, explains why it is expected under motion and hard to explain otherwise
- Explains why independent lines agreeing strengthen the claim
- Does not use Evidence F

4. A member of your panel says, 'The fossils alone prove it; we do not need the seafloor data.' Explain why Wegener's experience shows that fossils alone were not enough, and name the one thing the seafloor evidence added that the fossils could not.

Answer: Wegener had the fossil evidence in 1912 and 1915, and most geologists still rejected drift, because fossils alone could be explained by a sunken land bridge and because no one could say what force moved a continent. The seafloor evidence added a mechanism and a tested prediction: the ridge is where new seafloor forms, the symmetric ages show the ocean opening at a measured rate, and the satellites show it is still opening. Fossils show the continents were once connected; the seafloor shows how they separated and that they are separating now.

Why: This item ties the CER to the historical lesson: evidence of connection is not the same as evidence of motion with a mechanism.

Also acceptable: Accept 'the seafloor showed the ocean floor was younger than the fossils, so the ocean opened after the animals lived' as the added point.

- States that the fossil evidence existed and was still rejected
- Names the mechanism or the tested age prediction as what the seafloor added

5. Describe one new measurement that could **weaken** your claim if it came out a certain way, and say what result would do the damage.

Answer: Examples: if new drill cores found the seafloor ages scattered randomly, or oldest at the ridge, the spreading argument would fail; if the satellites showed the two continents standing still or moving toward each other, the 'still moving apart' half of the claim would fail; if the matching fossils turned out to be of very different ages on the two continents, the fossil evidence would weaken.

Why: A claim worth making is one that evidence could overturn. Any specific measurement with a stated damaging result earns credit.

Also acceptable: Any logically connected measurement and result.

- Names a specific measurement
- States the result that would weaken the claim

Scoring rubric

Criterion	4 • Exemplary	3 • Proficient	2 • Developing	1 • Beginning
Claim	States clearly that the continents were once joined and are still moving apart; both parts present and consistent with the evidence.	States one part clearly; the other is missing or vague.	A claim is present but hedged or partly contradicts the evidence used.	No claim, or a claim unrelated to the evidence file.
Evidence	Three or more specific items from at least two families, each with names, numbers or distances from the file and a statement of what it shows; Evidence F not used.	Three items from two families, but one lacks specifics or does not say what it shows.	Only one family used, or only one or two items, or Evidence F included as evidence.	Evidence missing, invented or copied without connection to the claim.

Reasoning	For each item, explains why it is expected if the continents moved and hard to explain otherwise; explicitly argues that independent lines agreeing make the claim stronger.	Gives the expected-or-not contrast for most items; the independent-lines point is present but thin.	Restates the evidence without the contrast, or gives the contrast for only one item.	No reasoning, or reasoning that misreads the data (for example, oldest seafloor at the ridge).
Scientific accuracy and language	Uses ridge, seafloor spreading, continental shelf, plate and rate correctly; rates and units correct; no scientific errors.	Terms mostly correct; one slip (for example, mixing one-side and full spreading rates).	Several terms used loosely, or the mantle described as liquid, or a unit error in the rate.	Scientific language absent or consistently wrong.

Teacher notes

Evidence A, B, C, E and F are real; D is simulated and labeled. Real details behind them: Mesosaurus (Early Permian) is known from the Paraná basin of Brazil and Uruguay and the Karoo of South Africa and Namibia; its exact water type is debated, so the sheet says shallow coastal and inland waters. Cynognathus (Early to Middle Triassic) is known from Argentina and South Africa. The matching lake deposits are the Early Cretaceous rift-lake rocks of northeastern Brazil and Gabon. The glacial evidence is the Permo-Carboniferous glaciation of the southern continents. The 1965 fit is Bullard, Everett and Smith's computer fit at the 500-fathom (about 900 m) contour. Present-day separation across the South Atlantic is about 3 to 4 cm per year from satellite geodesy. The simulated D values use a 20 km per million year half-rate, so q2 gives 2 cm per year on each side and 4 cm per year in total; the real South Atlantic opened about 130 million years ago, so real margin ages are older than D's 70 Ma. Watch for responses that treat F as evidence; the warm-up is designed to catch this before the CER. Magnetic stripes are deliberately absent.

Scaffold offered to students: An expected-or-not table

Before writing, make a table on scrap paper with the evidence letters A to F down the side and two columns: 'Expected if the continents moved apart?' and 'Easy to explain if they never moved?' Fill each cell with yes or no and three or four words of reason. Every row with yes in the first column and no in the second is a piece of evidence you can use. The row with yes in both columns is the item to leave out. Your Reasoning section is simply those rows written as sentences.

Extension: Argue the other side, then answer it

Write the strongest case a careful scientist in 1926 could make against the claim using only Evidence A, B and C, including the mechanism problem. Then write a reply from a scientist in 1970 that uses Evidence D and E to answer each objection point by point. Finish with two sentences on what the exchange shows about why scientists ask for a mechanism and a testable prediction before accepting an idea.