

Four Regions, Five Resources: A Resource Detective Jigsaw

Learning target: I can work with a team to use clues about a region's rocks, climate and plate history to predict which natural resources it has, and explain each prediction with the process that forms the resource.

Collaborative investigation

About 50 min

Jigsaw

MS-ESS3-1 · practice

collaboration

discussion

writing

Standards connections

MS-ESS3-1 (practice): Teams reason from geologic and climate evidence to the resources a region should have, which is the evidence-to-explanation move the PE requires; the individual section then asks each student to write one such explanation alone.

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

Answers with reasoning

Twelve evidence cards (four invented regions, three cards each)

1 Card 1: Cinder Range, the rocks

A chain of steep volcanoes, two of them active, runs through the region. Between the volcanoes, old granite is exposed, laced with quartz veins that carry green and blue copper stains. Soils on the slopes are thin and stony. Hot springs bubble up along a line of cracks in the rock.

2 Card 2: Cinder Range, climate and water

Rain and snow total about 1,200 mm a year. Streams run all year, fed by snowmelt. Shallow aquifers in the valley gravel refill every spring; a well drilled in 1995 shows the same water level today as when it was drilled. Water from one spring comes out at 96 °C.

3 Card 3: Cinder Range, plates and history

An oceanic plate sinks beneath the region today, 150 km to the west, and has done so for about 40 million years. Earthquakes are frequent. Magma sits 5 to 8 km below the volcanoes. The region has never been under the sea in the last 100 million years.

4 Card 4: Saltmarsh Flats, the rocks

Flat land underlain by thick layers of limestone and shale. The limestone is full of fossil clams and corals. Below 2 km, drillers pass through a dense shale that bends into a broad arch, then a porous sandstone, then a dark shale that smells of oil. No volcanic rock anywhere.

5 Card 5: Saltmarsh Flats, climate and water

Rain totals about 200 mm a year; it is a semi-desert. The only aquifer is 300 m down in old sandstone; its water, when tested, last fell as rain roughly 12,000 years ago. The water level in the region's wells has dropped 15 m in the last 30 years.

6 Card 6: Saltmarsh Flats, plates and history

The region sits in the middle of a plate, 1,500 km from the nearest boundary. About 150 million years ago it lay under a warm, shallow sea for tens of millions of years. Later it was buried under new sediment and gently folded. No volcano has erupted here in 300 million years.

7 Card 7: Riverbend Lowlands, the rocks

A wide valley floor of silt and clay dropped by a large river's floods, layer on layer. The dark topsoil is 1 to 2 m thick and rich in decayed plant matter. Below the silt is 50 m of sand and gravel, then hard, ancient bedrock with no fossils. No ore minerals have ever been found.

8 Card 8: Riverbend Lowlands, climate and water

Rain totals about 1,100 mm a year, spread through the year. The river floods most springs. Wells in the sand and gravel refill within weeks after pumping, and water levels have been steady for 60 years. Forests of fast-growing trees cover the hills on either side of the valley.

9 Card 9: Riverbend Lowlands, plates and history

The region is deep inside a continent, far from any plate boundary. The bedrock is about 2 billion years old and has been worn flat; it was once part of a mountain range that eroded away long before the valley formed. The region has not been under the sea for more than 400 million years.

10 Card 10: Old Shield Plateau, the rocks

A high, flat plateau of ancient granite and gneiss, worn smooth. No layered sedimentary rock, no fossils, no volcanic rock younger than a billion years. Soils are a few centimeters thick or absent. A few old quartz veins carry traces of copper, too thin to mine.

11 Card 11: Old Shield Plateau, climate and water

Rain totals about 150 mm a year. There are no permanent streams. The only aquifer is in cracks in the granite 200 m down; its water last fell as rain about 20,000 years ago, when the climate was wetter. The one town's wells have dropped 25 m in 40 years.

12 Card 12: Old Shield Plateau, plates and history

The region is in the stable interior of a plate; the last subduction zone here shut down more than a billion years ago, and the mountains it built eroded away. There has been no magma near the surface since then, and no sea for at least 500 million years.

Part A: Expert round (one region per person)

1. Your region: _____. From your three cards, list the clues that point *toward* a resource and the clues that point *against* one. Name at least two resources your region should have and one it should not, with the card number for each.

Answer: Region 1 (Cinder Range): toward geothermal (hot springs, 96 °C spring, magma 5-8 km down: cards 1-3), toward copper ore (copper-stained quartz veins in granite above an active subduction zone: cards 1, 3), toward renewable surface and shallow groundwater, used sustainably (1,200 mm rain, aquifers refill each spring, steady well: card 2); against petroleum (never under the sea in 100 million years, volcanic rock: card 3) and against fertile soil (thin stony soils: card 1). Region 2 (Saltmarsh Flats): toward petroleum (ancient shallow sea, fossil limestone, oil-smelling shale, porous sandstone, arched sealing shale: cards 4, 6); against copper and geothermal (no volcanic rock, mid-plate, no magma for 300 million years: cards 4, 6); groundwater present but nonrenewable (12,000-year-old water in a semi-desert) and used unsustainably (down 15 m in 30 years) (card 5); fertile soil unlikely (semi-desert: card 5). Region 3 (Riverbend Lowlands): toward fertile soil (1-2 m dark topsoil from river silt: card 7), renewable groundwater, used sustainably (1,100 mm rain, wells refill in weeks, steady 60 years: card 8), wood (fast-growing forests: card 8); against petroleum (no sea for 400 million years, bedrock with no fossils: cards 7, 9), copper (no ore minerals, boundary long gone: cards 7, 9) and geothermal (no magma, stable interior: card 9). Region 4 (Old Shield Plateau): against petroleum (no sedimentary rock, no sea for 500 million years: cards 10, 12), copper (traces only; subduction ended a billion years ago: cards 10, 12), geothermal (no magma for a billion years: card 12), fertile soil (centimeters thick: card 10); the only resource is fossil groundwater 20,000 years old: nonrenewable, and used unsustainably (down 25 m in 40 years) (card 11).

Why: Each region's three cards were written to make two or three resources likely and the rest unlikely, with at least one card giving the decisive clue for each.

Also acceptable: Accept 'wood' as a resource for Riverbend and 'surface water' for Cinder Range; both are supported by the cards.

- Names the region
- At least two resources the region should have, with card numbers
- At least one resource it should not have, with a card number

Part B: Home group task

1. Each expert teaches their region in two minutes: the rocks, the water, the plate history, and what resources the clues point to.
2. As a group, fill in the prediction table. In each cell write 'likely', 'unlikely' or 'small amounts', and the card number that is your best evidence.
3. For groundwater, do not just write likely or unlikely. Write two things, using the card evidence: is the water renewable (does nature refill it within about a human lifetime?), and is today's pumping sustainable (is it no faster than the refill?).
4. Below the table, write the one process that explains each 'likely'. For example, a 'likely' for copper must name magma from a subduction zone.
5. Prepare one challenge for the neighboring group's table: pick a cell you think they got wrong and the card that proves it.
6. Make sure every member can defend every cell. The challenge round can be aimed at anyone.

Group prediction table (fill in)

Region	Petroleum	Copper ore	Geothermal energy	Groundwater: renewable? Current use sustainable?	Fertile soil
Cinder Range					
Saltmarsh Flats					
Riverbend Lowlands					
Old Shield Plateau					

2. Group answer: Which region is richest in resources and which is poorest? For the poorest, explain using its plate history why it has so little, and name the one resource it does have and why that resource is in trouble.

Answer: Richest: Cinder Range (geothermal, copper ore, renewable water) or Riverbend Lowlands (fertile soil, renewable groundwater, wood); either is defensible. Poorest: Old Shield Plateau. Its plate history explains why: the subduction zone that could have made copper shut down over a billion years ago and the mountains it built eroded away; there has been no magma near the surface since, so no geothermal heat is shallow; it has not been under the sea for 500 million years, so there is no source rock for petroleum; and the thin soil cannot build up in a desert on bare granite. Its one resource is groundwater in cracks 200 m down, but that water fell as rain 20,000 years ago when the climate was wetter, hardly any new water enters today (150 mm of rain), and the wells have dropped 25 m in 40 years: it is being used far faster than it is replenished.

Why: The poorest region is the one whose past processes stopped longest ago and whose present climate replenishes almost nothing.

Also acceptable: Accept either Cinder Range or Riverbend as richest with reasons.

- Identifies Old Shield Plateau as poorest
- Explains the absence of resources from its plate history (ancient, no magma, no sea)
- Names fossil groundwater as the one resource and explains why it is in trouble using card 11

3. Group answer: Record the challenge the neighboring group made to your table (which cell, which card) and how you answered it. If you changed a cell, say which one and why.

Answer: Any recorded challenge with a card citation and a reply, for example: 'You marked Cinder Range groundwater as nonrenewable; card 2 says the aquifers refill every spring, so the water is renewable, and the well level unchanged since 1995 shows that today's pumping is sustainable.' Or: 'You marked copper likely for Old Shield Plateau; card 10 says the veins are too thin to mine, so it is small amounts, not ore.' Or: 'You marked fertile soil unlikely for Cinder Range; card 1 says thin and stony, so we agree, but the valley gravel might hold some farmland.' Credit depends on the citation and the quality of the reply.

Why: The record should show evidence-based challenge and response; changing a cell with a reason is a positive sign, not a penalty.

Also acceptable: Any reasonable challenge and evidence-based reply earns credit.

- Names the cell and the card
- Records the reply with evidence
- States whether a cell changed and why

Part C: Individual accountability (complete alone)

4. Cinder Range and Saltmarsh Flats both have copper clues on their cards? Check again. Which one has copper, and which card and which process explain why the other does not?

Answer: Only Cinder Range has copper ore. Its card 1 shows copper-stained quartz veins in granite and card 3 shows an active subduction zone with magma a few kilometers down, the process that releases copper-bearing fluids into cracks. Saltmarsh Flats has no copper clues at all: card 4 says no volcanic rock anywhere and card 6 says it is mid-plate with no magma for 300 million years, so the fluids that concentrate copper never formed there. (The question's first sentence is a trap; Old Shield Plateau has copper traces, but Saltmarsh does not.)

Why: This checks that students did not transfer a resource across regions and that they tie copper to subduction-zone magma.

Also acceptable: A student who notes that Old Shield's traces came from a subduction zone that died a billion years ago is reading the cards closely.

- Cinder Range identified as the copper region
- Saltmarsh's absence explained by no magma or no subduction (cards 4 or 6)
- Process named: fluids from magma above a subduction zone

5. Saltmarsh Flats and Old Shield Plateau both have deep, old groundwater that is dropping. Riverbend's groundwater is steady. Using the climate and rock cards, explain what makes the difference.

Answer: The difference is the recharge rate. Riverbend gets 1,100 mm of rain through the year and its aquifer is loose sand and gravel near the surface that refills within weeks, so pumping is balanced by replenishment and the level has stayed steady for 60 years (card 8). Saltmarsh gets 200 mm and Old Shield 150 mm, their aquifers are deep (300 m in old sandstone; 200 m in granite cracks), and the water in them fell as rain 12,000 and 20,000 years ago, in wetter climates; almost nothing refills them today, so every year of pumping lowers the level (cards 5 and 11). Same resource, different climate and rock: renewable in one place and nonrenewable in the others, and the falling well levels show that the dry regions are also pumping far faster than any recharge.

Why: The accurate version of 'groundwater is nonrenewable': the label depends on how fast present-day recharge can refill each aquifer, and falling levels show pumping outrunning that recharge, and old water in dry regions is the classic nonrenewable case (like the Great Artesian Basin and the aquifers under the Sahara).

Also acceptable: Accept an answer that uses only rainfall and water age if the refill-time idea is explicit.

- Names rainfall difference
- Names aquifer depth or rock type difference
- Uses the water-age or refill-time evidence
- Concludes that each aquifer's refill time decides the label, and that the falling levels show unsustainable pumping

6. Choose one region and one resource it is likely to have. Write a short scientific explanation (claim, evidence from at least two cards, reasoning) for why that resource is there and not in a region that lacks it. Name the past or present Earth process in your reasoning.

Answer: Model (Cinder Range, geothermal): Claim: Cinder Range has usable geothermal energy and Saltmarsh Flats does not. Evidence: card 1 reports hot springs along cracks; card 2 reports a spring at 96 °C and 1,200 mm of rain to supply groundwater; card 3 reports magma 5 to 8 km below the volcanoes above an active subduction zone. Saltmarsh's card 6 says no volcano in 300 million years and card 4 says no volcanic rock. Reasoning: Geothermal energy is usable where hot rock or magma is close enough to the surface to heat groundwater; above a subduction zone, the sinking plate causes melting and magma rises into the crust, so rock a few kilometers down is hot enough to produce 96 °C springs, and the heavy rain keeps the rock supplied with water to heat. Saltmarsh sits mid-plate with no magma, so its rock warms only at the slow ordinary rate with depth and nothing is hot near the surface. Other accepted choices: Saltmarsh petroleum (cards 4, 6: ancient sea, fossil limestone, oil-smelling shale, porous sandstone, arched seal); Riverbend fertile soil (cards 7, 8: river silt, decayed plant matter, year-round rain); Cinder Range copper (cards 1, 3).

Why: The individual explanation must have the three CER parts, evidence from two cards, a contrast region, and a named Earth process.

Also acceptable: Any region-resource pair supported by the cards is acceptable; the Old Shield's fossil groundwater is acceptable if the student explains it as a resource formed by a past wetter climate.

- Claim names a region, a resource and a contrasting region
- Evidence cites at least two cards with specifics
- Reasoning names the process (subduction-zone magma, ancient sea and burial, river deposition and decay, recharge)
- Explains why the contrasting region lacks the resource

7. A company wants to build a geothermal power plant in Riverbend Lowlands because it has plenty of water. Using the cards, write the two-sentence reply a geologist would give.

Answer: Model: 'Water is not the limiting factor for geothermal power; heat is. Riverbend sits on 2-billion-year-old bedrock deep inside a plate with no magma anywhere near the surface (card 9), so its groundwater is cool, and no amount of water can spin a turbine without hot rock to heat it.'

Why: This corrects the idea that a resource is available wherever one ingredient is plentiful; geothermal distribution follows the heat, which follows the plate setting.

Also acceptable: Accept a reply that recommends Cinder Range instead, if the reason is given.

- States that shallow heat, not water, is what Riverbend lacks
- Cites card 9 (or card 7's ancient bedrock)

Scoring rubric

Criterion	4 • Exemplary	3 • Proficient	2 • Developing	1 • Beginning
Expert teaching (Part A and Step 1)	Explains the region's clues accurately in two minutes, names at least two resources it has and one it lacks, and cites the card for each.	Accurate on the resources but cites cards for only some claims, or misses one resource the cards support.	Lists card contents without connecting them to resources, or assigns a resource the cards do not support.	Unable to explain the region, or teaches another region's clues.

Prediction table	All twenty cells filled correctly with a card number; the groundwater column states both whether the water is renewable and whether current pumping is sustainable, with evidence; each 'likely' has its forming process written below.	At most two cells wrong or missing evidence; processes written for most 'likely' cells.	Several cells wrong, or predictions made without card numbers, or processes missing.	Table mostly blank or filled by guessing.
Challenge and defense	Makes a specific challenge with a card citation, answers the neighboring group's challenge with evidence, and records whether a cell changed and why.	Challenge and reply recorded, but one of them lacks a card citation.	A challenge is recorded without evidence, or the reply restates the cell without reasons.	No challenge or reply recorded.
Individual accountability (Part C)	All four Part C answers are accurate, cite cards, and the q6 explanation has claim, evidence from two cards, a named process and a contrast region.	Three of four accurate with evidence; q6 missing one element.	Two accurate; q6 restates the group table without the process.	Part C mostly blank or inaccurate.

Teacher notes

Print and cut the twelve cards; hand each home group a full deck and have members draw regions so that expertise is spread. The intended table: Cinder Range: petroleum unlikely, copper likely, geothermal likely, groundwater renewable and used sustainably (refills every spring; steady well since 1995), fertile soil unlikely (thin). Saltmarsh Flats: petroleum likely, copper unlikely, geothermal unlikely, groundwater present but nonrenewable and used unsustainably (12,000-year-old water, dropping 15 m), fertile soil unlikely. Riverbend Lowlands: petroleum unlikely, copper unlikely, geothermal unlikely, groundwater renewable and used sustainably (refills in weeks, steady 60 years), fertile soil likely. Old Shield Plateau: petroleum unlikely, copper small amounts (traces, not ore), geothermal unlikely, groundwater nonrenewable and used unsustainably (20,000-year-old water, dropping 25 m), fertile soil unlikely. The regions are invented, but the clue types are real: water ages come from isotope dating, and 'fossil' groundwater from wetter past climates is the real situation under the Sahara and central Australia. Q4's first sentence is a deliberate trap; tell students in advance that one Part C question tests whether they check the cards instead of trusting the question.

Scaffold offered to students: Resource-by-resource checklist

Use this checklist for every cell in the table. Petroleum: was the region under a sea long ago, and is there layered rock with fossils, a dark shale, a porous layer and a sealing layer? Copper ore: is there, or was there ever, magma from a subduction zone nearby, and are there copper-stained veins? Geothermal: is hot rock or magma close to the surface today (hot springs, active volcanoes)? Groundwater: how much rain falls, how fast do the wells refill, and how old is the water? Fertile soil: is there thick, dark topsoil built from fine sediment and decayed plants? If a region fails the first question for a resource, the answer is 'unlikely' no matter what else it has.

Extension: Region 5: write the cards

Invent a fifth region and write its three cards (rocks; climate and water; plates and history) so that it has exactly two of the five resources and is missing the other three, with every clue consistent with how those resources form. Trade cards with a partner and see whether they can predict your two resources from the clues alone. Then rewrite any clue that was too obvious or too vague, and explain in two sentences what made a clue 'fair.'