

A scenic landscape photograph of a river winding through a valley. The river flows from the upper left towards the bottom right. The surrounding hills are covered in sparse, dry vegetation and scattered trees. A prominent, light-colored cliff face is visible on the right side of the river. The overall lighting suggests a bright, sunny day.

Earth's Natural Resources

Chapter 19 of 29 • Processes that Shape Earth

Lesson 19: Why are different resources found in different places, and what happens as we use them?

Angela's Wand • Bring Science Alive! 7th Grade Integrated

PHENOMENON

California's buried treasure map is lumpy

Stack four maps of California. Gold mines make a thin stripe along the Sierra foothills. Oil wells crowd into Kern County. Geothermal plants cluster in a few spots, mainly The Geysers north of San Francisco and the Imperial Valley. The biggest groundwater store is under the flat Central Valley. Nothing is spread evenly, and the patterns do not overlap. Why?

- Notice: what shape does each pattern make: stripe, cluster or sheet?
- Wonder: why does gold follow mountains while oil sits under a flat valley?
- Predict: which of these four could run out in your lifetime?





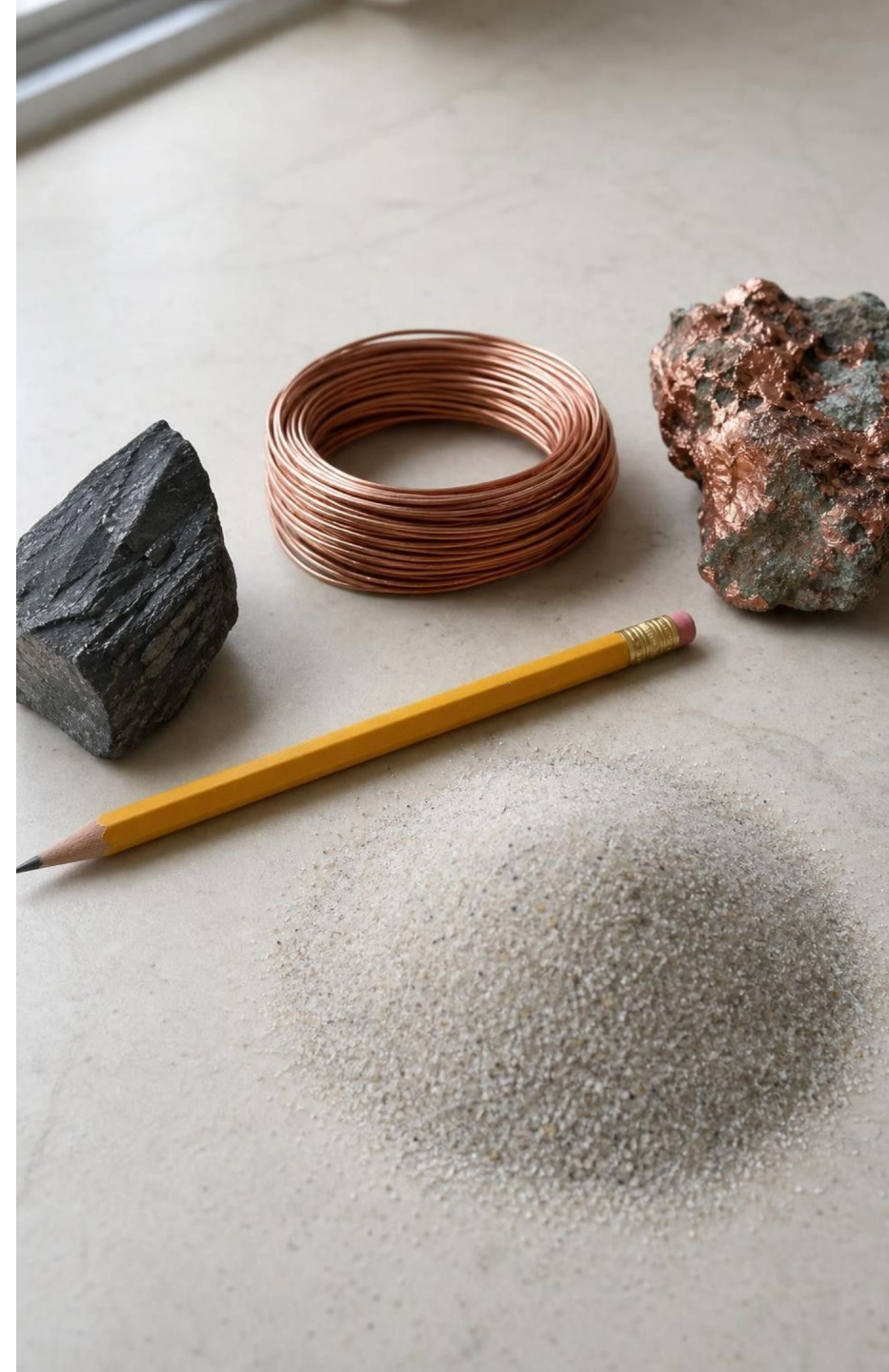
LEARNING TARGETS

What you will be able to do

- 1 Explain with evidence how past and present Earth processes put a resource in one place and not another.
- 2 Describe the recipe for an ore deposit, an oil reservoir, a geothermal field and an aquifer.
- 3 Sort resources as renewable or nonrenewable by nature's clock, and explain why renewable is not unlimited.
- 4 Use recharge and pumping data to decide whether a use of groundwater is sustainable.
- 5 Score competing designs against criteria and constraints, as the Hoover Dam team did.

Everything on your desk came from somewhere

- A natural resource is any material or energy source people take from nature and use.
- Pencil: wood from a forest, graphite from a mine, metal band from ore, rubber from a plant or oil.
- Phone: plastic from petroleum, copper and other metals from ore, glass from sand, and water to make it.
- Some come from the surface (wood, soil, river water); some from deep underground (oil, ore, hot water).
- This lesson follows six: fresh water, petroleum, geothermal heat, soil, copper ore and wood.



Nature's clock: renewable or nonrenewable?

Model: How long nature takes to make more, compared with a human lifetime

Renewable (replaced within about a lifetime)

Surface water: refilled by rain and snow every year

Heat flow from Earth's interior: continuous

Planted pine forest: ready to harvest in about 15 to 25 years

Shallow gravel aquifer in a rainy valley: refills in years

Nonrenewable (takes far longer than a lifetime)

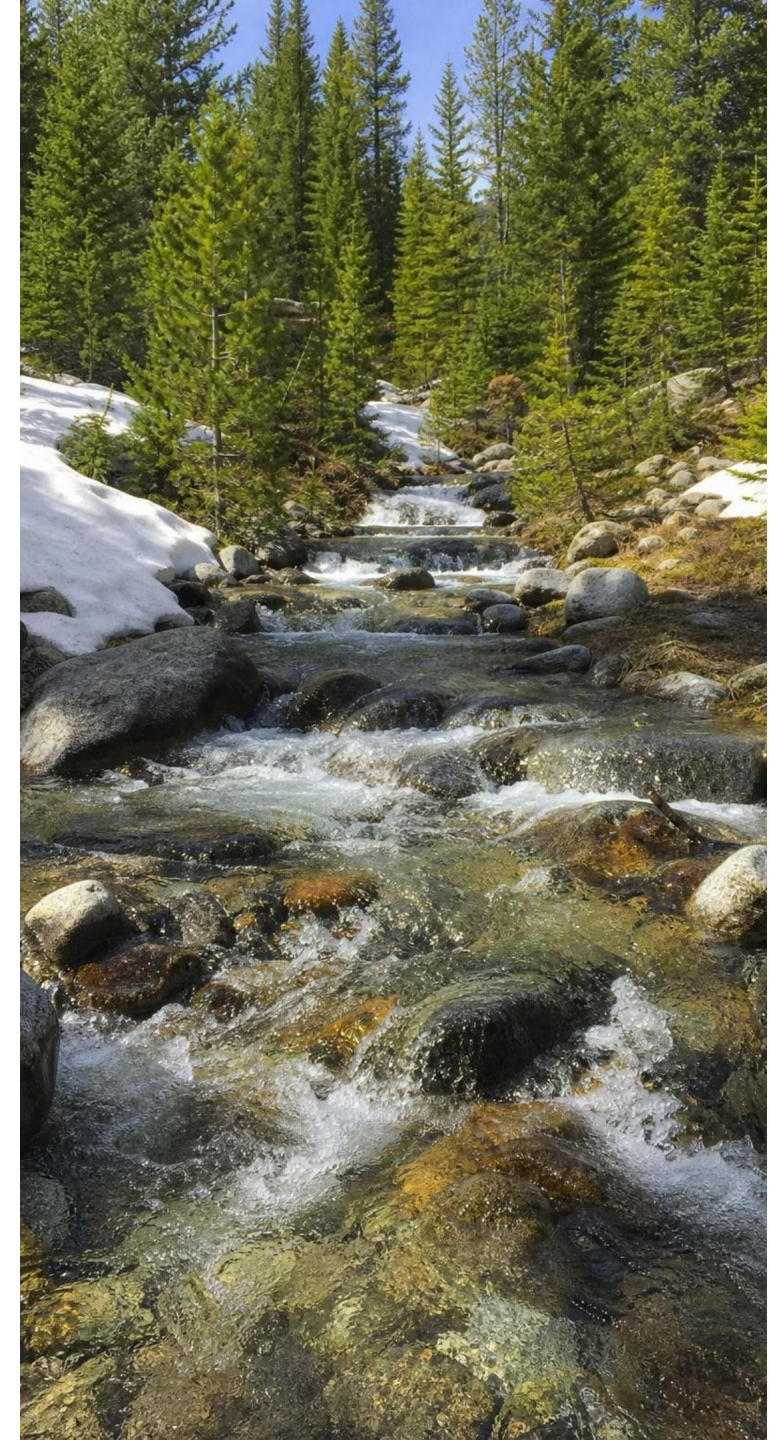
Petroleum: millions of years of burial and heating

Copper and gold ore: millions of years of magma and hot fluids

Thick fertile topsoil: centuries per centimeter

Deep desert aquifer: water that soaked in over a million years ago

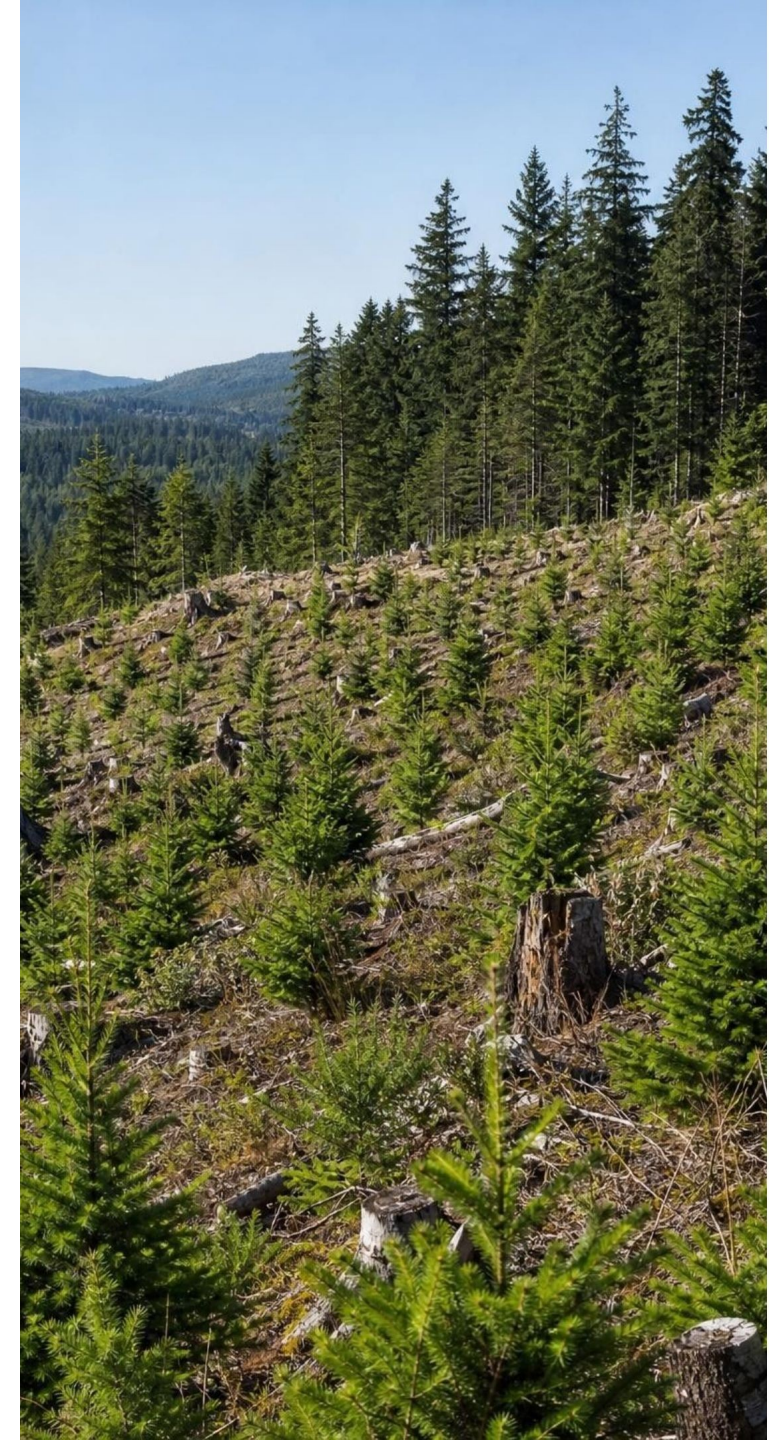
The label comes from nature's replacement time. Whether a use is sustainable is a second question: rate of use versus rate of replacement.



VOCABULARY IN CONTEXT

Four words to keep straight

- **renewable resource:** A resource nature replaces within about a human lifetime. *River water and a replanted forest are renewable; both can still run short if overused.*
- **nonrenewable resource:** A resource that takes far longer than a human lifetime to form, so using it shrinks the supply. *Copper ore formed over millions of years; a mined-out deposit is gone for any practical purpose.*
- **sustainable:** A way of using a resource that leaves enough for future generations: use no faster than it is replaced. *Pumping an aquifer is sustainable only when yearly pumping is no larger than yearly recharge.*





CHECK FOR UNDERSTANDING

Quick check: which is nonrenewable?

On a human timescale, which of these is nonrenewable?

A. Water in a river that is refilled by snowmelt every spring

B. Copper in an ore body that formed from hot fluids 30 million years ago

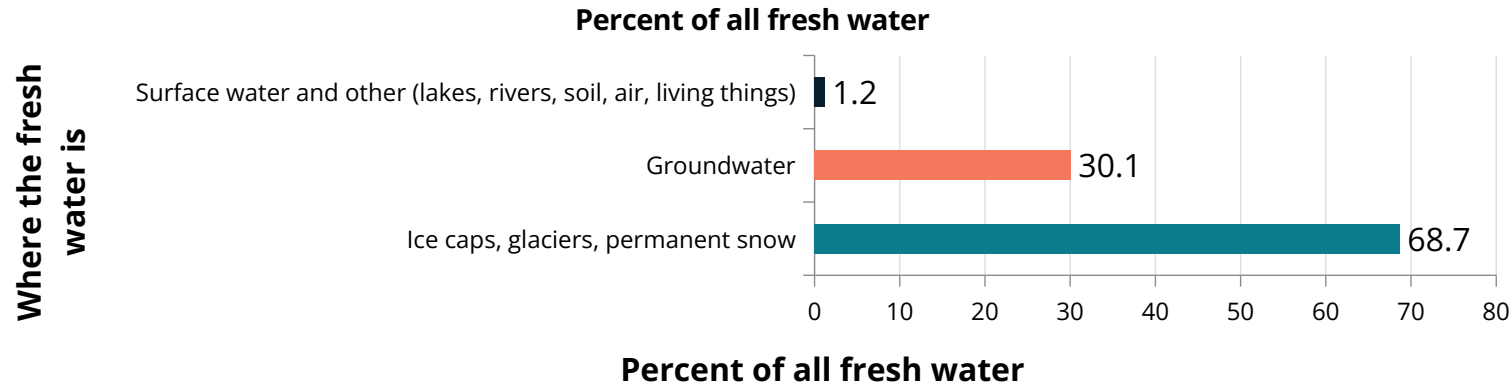
C. Heat flowing up from Earth's interior

D. Wood from a pine plantation replanted after each harvest

MODEL

Where Earth's fresh water is

Model: Share of Earth's fresh water by where it is stored (USGS estimate, rounded)



Fresh water is only about 2.5 percent of all water on Earth; the rest is salty. Of that small slice, most is frozen, and nearly all the rest is underground.



Inside an aquifer

Model: A cross-section of a valley aquifer system, top to bottom

Soil and plant roots: rain soaks in here (recharge)

Unconfined aquifer: river gravel and sand, pores full of water below the water table

Clay layer: tiny pores, water barely moves; seals the layer below

Confined aquifer: porous sandstone; water entered far away or long ago

Bedrock: granite with few cracks; stores almost no water

Water is stored in the pore spaces between grains. Gravel and sand have big connected pores; clay has many tiny pores that hold water but will not let it flow to a well.





Why groundwater is uneven, and why it can run out

- Rain and snow: wet regions recharge aquifers quickly; deserts recharge slowly or not at all.
- Rock and sediment: thick gravel and sandstone store and give water; clay and granite do not.
- Depth and age: deep aquifers under deserts may hold water that soaked in during wetter climates long ago.
- The test of a use: pump less than the recharge and the level holds; pump more and it falls.
- Pumping has already redrawn the map: some aquifers have dropped tens of meters in a century.

REAL-WORLD CONNECTION

California connection: the sinking Central Valley

Under the Central Valley lies California's largest groundwater store, in thick sediment washed down from the Sierra Nevada and Coast Ranges. In droughts, farms pump far more than recharge. As clay layers lose water, the ground compacts: parts of the San Joaquin Valley sank nearly 9 meters from the 1920s to 1970 and sank again in recent droughts. A 2014 law requires local agencies to balance pumping with recharge.



CHECK FOR UNDERSTANDING

Quick check: which well is the safest bet?

A town can drill one well. Which site will refill fastest after a wet winter?

A. Deep sandstone under a desert that gets 8 cm of rain a year

B. Thick river gravel in a valley that gets 80 cm of rain and snowmelt a year

C. A clay-rich layer in a valley that gets 80 cm of rain a year

D. Cracked granite on a mountain that gets 120 cm of rain a year





Think, pair, share

Discuss: is groundwater renewable?

- What is the recharge rate: rain, snow, rivers, and porous ground to let it in?
- How old is the water already there? Years, or a million years?
- How much is being pumped compared with the recharge?
- Does the answer change for the same aquifer in a wet decade and a dry decade?

The textbook says most groundwater is nonrenewable. A student says her family's well refills every spring. Who is right, and what would you need to know to decide for a particular aquifer?

How petroleum forms

Model: From plankton to an oil reservoir, over millions of years

- 01 Tiny marine organisms die and sink into oxygen-poor mud on a sea floor
- 02 (burial) Layers of sediment bury the mud deeper and deeper
- 03 (heating) Deeper rock is hotter: at roughly 60 to 120 °C the organic matter slowly changes into oil
- 04 (migration) Oil, lighter than water, migrates upward through porous rock
- 05 (trapping) A sealing layer (shale or salt) over a fold or fault stops it: a trap
- 06 (storage) Oil fills the pores of the reservoir rock beneath the seal

Every step must happen. Skip the low-oxygen mud, the right heating or the trap, and there is no oil field.



Why oil is here and not there

- The recipe is rare: source mud, long heating, porous reservoir rock and a sealed trap, all in one place.
- Giant fields such as Ghawar in Saudi Arabia lie where ancient seas left thick organic-rich sediment.
- Kern County's oil comes largely from the Monterey Formation, plankton-rich mud from deep offshore basins.
- Oil fuels most transportation; it supplies less than 1 percent of U.S. electricity.
- Drained fields drop off the map; companies move on, so human removal changes the pattern.





VOCABULARY IN CONTEXT

Words for finding oil and water underground

- **aquifer:** Porous rock or sediment that stores groundwater and lets it flow to a well. *River gravel under a valley floor is a typical aquifer; clay above it is not.*
- **recharge:** Water that soaks down into an aquifer; the recharge rate is how much arrives each year. *A wet winter raised the recharge, and the water table came up two meters.*
- **geologic trap:** A fold or fault where a sealing layer stops rising oil and holds it in a porous reservoir rock. *The sandstone arched upward beneath a shale cap, and oil collected in the top of the arch.*

Four ways Earth concentrates metal ore

MODEL

Model: Processes that turn ordinary rock into ore



Igneous settling: Dense metal-rich crystals sink and collect in layers at the bottom of a cooling magma chamber (chromium, platinum, nickel).



Hydrothermal veins and porphyries: Hot water from cooling magma dissolves metals, flows through cracks and drops them as it cools. Most copper and much gold; common above sinking plates.

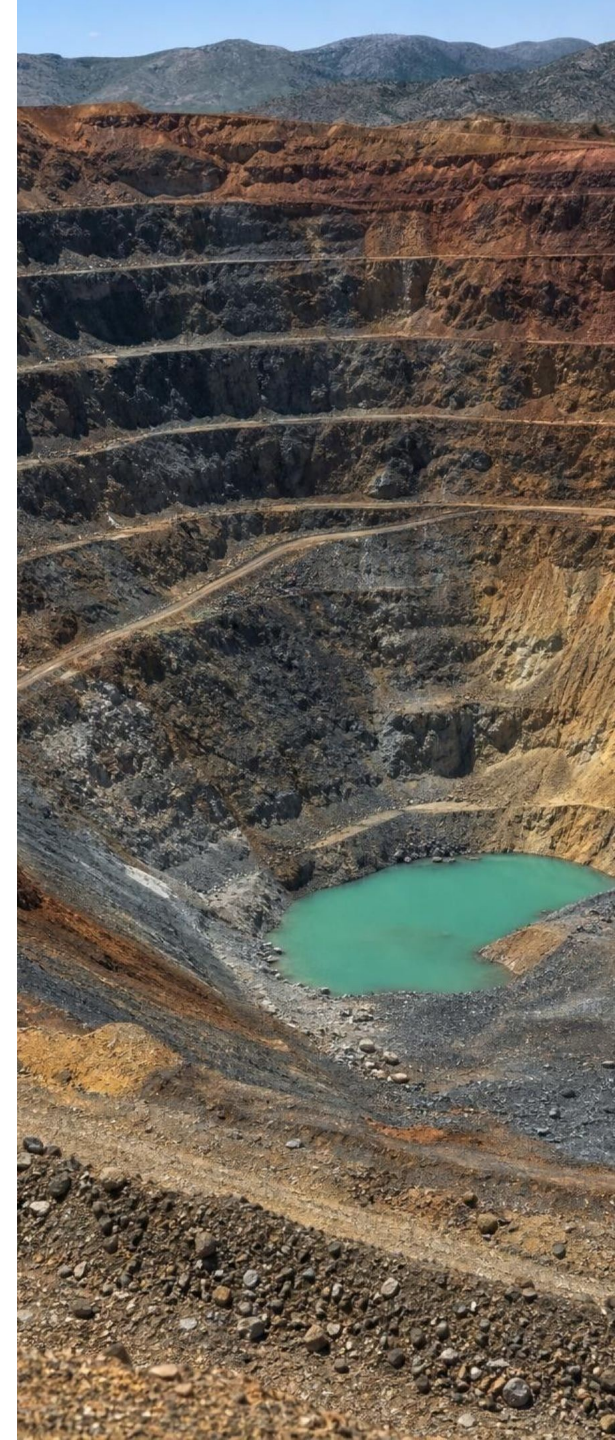


Sedimentary layering and placers: Iron settled out of ancient seas in thick layers; salt and gypsum formed as seas evaporated; dense gold flakes collected in river gravel.



Deep weathering: Long, hot, rainy weathering dissolves away everything else and leaves aluminum-rich bauxite or nickel-rich soil behind.

Ore is rock with enough metal to be worth mining. Each process concentrates a metal that is normally spread thinly through ordinary rock.





REAL-WORLD CONNECTION

California connection: why the gold is in the foothills

The Mother Lode is a belt of gold-bearing quartz veins in the western Sierra Nevada foothills. Between about 150 and 100 million years ago, while magma rising above a subduction zone was building the Sierra's granite, hot water carried dissolved gold up cracks and left it in quartz veins. Weathering later freed the gold; streams gathered the dense flakes in gravel. A find at Sutter's Mill in 1848 began the Gold Rush.

CHECK FOR UNDERSTANDING

Quick check: where would you look for copper?

A geologist wants a large copper deposit. Which setting is the best evidence?

A. A flat plain of young river mud with no bedrock exposed

B. A belt of old, eroded volcanoes with granite intrusions and quartz veins, above a former subduction zone

C. A salt flat where a shallow sea evaporated

D. A coral reef limestone with marine fossils



Geothermal energy: heat where the plates meet

- Earth is hot inside; heat escapes fastest where magma is near the surface, at plate boundaries and volcanoes.
- Groundwater that touches hot rock becomes hot water or steam, which can spin turbines or heat buildings.
- The Geysers north of San Francisco is the world's largest geothermal complex; the Imperial Valley is another.
- The heat flow is effectively endless, but a reservoir of hot water can be drawn down faster than it refills.
- At The Geysers, steam pressure fell in the 1980s; treated wastewater is now injected to sustain the field.





Soil and wood: resources that grow, slowly or fast

- Soil forms as weathered rock grains mix with organic matter; one centimeter of topsoil can take centuries.
- Rainy places weather rock faster, so soil may be thicker, but heavy rain also washes nutrients out.
- Overgrazing and bare fields let wind and water strip topsoil far faster than it forms.
- Forests grow where climate and soil allow; a planted pine stand regrows in decades, old growth in centuries.
- Whether wood is renewable depends on the forest and the harvest rate, not on the tree's name.

THINK, PAIR, SHARE

Discuss: are humans a geoscience process?

- A mined-out copper pit and a drained oil field are blanks on the map that were not blank before.
- The Central Valley sank as water was pumped; the ground itself changed.
- Geologic processes took millions of years; removal takes decades.
- Which of these changes could be reversed, and which cannot?

The standard says resource distribution results from past and current processes. Pumping, drilling, mining and logging are current processes. How are they like geologic processes, and how are they different?



Task: read the clues, predict the resource

Apply it *Simulated data for practice.*

Four fictional sites were mapped by a survey crew. For each, decide which resource (if any) the evidence points to, and name the process that put it there.



Site	Rock and landscape	History clues	Rain per year	Your prediction and process
P	Folded sandstone with shale on top; marine fossils; a tar seep	Was an ocean basin 20 million years ago; buried 3 km, then folded	25 cm	
Q	Eroded old volcanoes; granite; quartz veins with green copper stains	Above a plate that sank 40 million years ago	50 cm	
R	Wide valley floor of thick gravel and sand; river fed by snowmelt	Rivers have filled the valley for 2 million years	70 cm	
S	Flat limestone with reef fossils; layers not folded; no seal on top	Was a shallow sea; never buried deeper than 1 km	30 cm	

Engineering: how the Hoover Dam team chose a design

Model: Criteria the dam had to meet versus constraints it had to fit

Criteria (what success required)

Constraints (limits on the solution)

Store enough Colorado River water for a growing Southwest

Cost to build and maintain

Generate electricity

The shape of the canyon and its rock

Protect downstream communities from floods

Harm to the river and its ecosystems

The team scored each design against both lists. The arch-gravity dam won for this canyon: the curve steers part of the water's push into the canyon walls, and the wide base resists by weight.





MISCONCEPTION CHECK

True or false? Renewable means it cannot run out

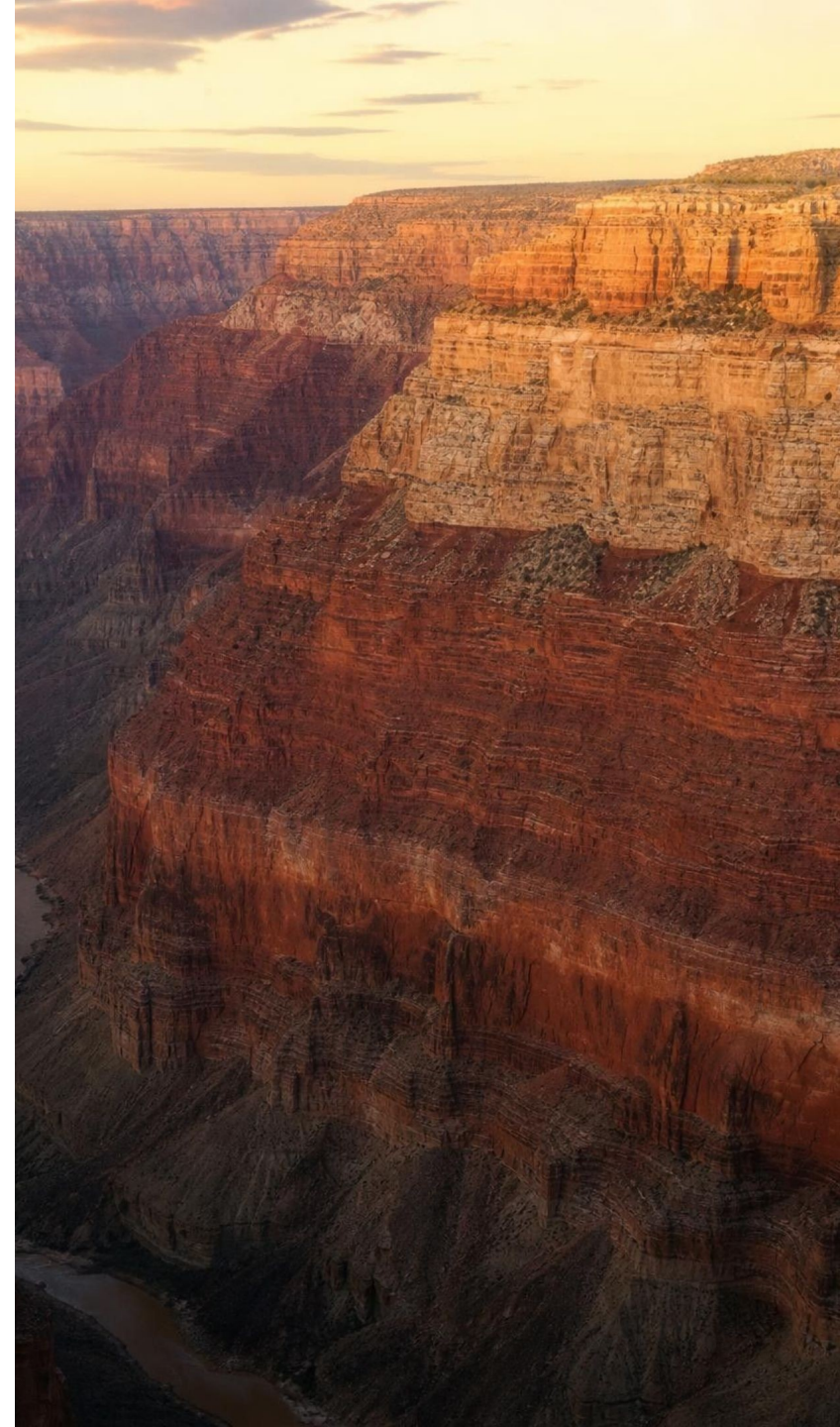
"Geothermal energy is renewable, so a geothermal power plant can take as much steam as it wants forever and the supply will never drop."

True or false? Explain your reasoning.

PUTTING IT TOGETHER

Putting it together

- A resource map is a map of Earth's history: each resource formed only where its recipe came together.
- Oil: buried plankton mud, long heating, porous reservoir rock and a sealed trap.
- Ore: crystals settling in magma, hot fluids, sedimentary layers or deep weathering.
- Geothermal heat: plate boundaries. Groundwater: porous rock plus recharge, now or in a wetter past.
- Renewable or not is nature's clock; sustainable or not is our rate against nature's rate.
- Pumping, drilling, mining and logging are current processes that are redrawing the map.





Exit ticket

Exit ticket

Name one surface clue a geologist uses to predict copper ore, and the process it points to.

A shallow aquifer refills in about 20 years; a town pumps 9 units/yr, recharge is 4. Renewable? Sustainable?

Why is there oil under Kern County but not under the Sierra Nevada? One sentence.

Give one way human use has changed where a resource is found.