

California Hazard Briefing: A Twelve-Card Jigsaw

Learning target: I can teach my group one kind of hazard evidence, combine it with my classmates' evidence to explain which California hazards can be forecast and how, and help my group justify mitigation choices.

Collaborative investigation

About 55 min

Jigsaw

MS-ESS3-2 · practice

MS-ESS2-2 · supports

MS-ESS2-3 · supports

collaboration

discussion

reading

Name _____

Date _____

Period _____

Directions

Your teacher will put you in a home group of four and give each of you one expert set (A, B, C or D). First, meet with the other students who have your set, read your three cards together and plan how to teach them (Part A). Then return to your home group and teach your cards in two minutes or less. Together, complete the briefing table and the county decision (Part B). Finally, complete Part C on your own. Every fact on the cards is real.

You will need: Printed and cut card sets (one set of three per expert), This worksheet, Pencil, Timer

Twelve evidence cards (four expert sets of three)

1 A1. Lassen Peak, 1914 to 1917

Lassen Peak, at the southern end of the Cascade volcanoes in northern California, began a long series of steam explosions in May 1914. On May 22, 1915, it erupted explosively: an eruption column rose more than 9 km above the vent, and over those days a pyroclastic flow and fast mudflows swept the northeast slope, still called the Devastated Area. Ash fell hundreds of kilometers east, in Nevada. The area was thinly settled and no one died. Today the USGS California Volcano Observatory monitors Lassen with seismometers, GPS stations and gas measurements.

2 A2. Long Valley Caldera: decades of unrest

Long Valley Caldera near Mammoth Lakes is an oval hollow about 30 km long, left by a huge eruption about 760,000 years ago. In May 1980, four earthquakes of about magnitude 6 shook the area. Since then the caldera has had swarms of small quakes and periods when its center rose. Around 1990, carbon dioxide from magma deep below began seeping into the soil on Mammoth Mountain and killed patches of trees. More than 40 years of unrest have not led to an eruption. Unrest raises the chance of an eruption; it does not guarantee one.

3 A3. Sharing the warning: volcano alert levels

The U.S. Geological Survey uses four alert levels for volcanoes. Normal: typical background activity. Advisory: unrest above the volcano's usual background. Watch: heightened or escalating unrest with an increased chance of eruption, but uncertain timing (or a minor eruption under way). Warning: a hazardous eruption is about to happen, is happening, or is suspected. Levels are set from monitoring data, such as earthquake counts, ground swelling and gas. A volcano can stay at Advisory or Watch for months or years; the level describes its current state, not a countdown.

4 B1. Stick, slip and creep

Most sections of the San Andreas Fault are locked: friction holds them while the plates keep moving, and stress builds for decades or centuries until the rock slips in a large earthquake. A section in central California, roughly between San Juan Bautista and Parkfield, behaves differently. It creeps, sliding slowly and almost steadily a few centimeters a year. In nearby Hollister, curbs and walls that cross a creeping fault are slowly bent out of line. Creeping sections release stress gradually and produce many small earthquakes, but not great ones.

5 B2. The Bay Area's real forecast

USGS forecast for the San Francisco Bay region, 2014 to 2043, chance of at least one earthquake: magnitude 6.0 or larger, 98 percent; 6.7 or larger, 72 percent; 7.0 or larger, 51 percent; 7.5 or larger, 20 percent. The most likely single source of a magnitude 6.7 or larger is the Hayward-Rodgers Creek Fault (33 percent), not the more famous San Andreas (22 percent). The forecast combines fault maps, how fast each fault is loading with stress (measured with GPS) and the history of past earthquakes. It names no dates.

6 B3. A foreshock and an alarm

On July 4, 2019, a magnitude 6.4 earthquake struck near Ridgecrest in the Mojave Desert. About 34 hours later, a magnitude 7.1 struck the same area. Only after the second quake could scientists call the first one a foreshock; most moderate quakes are not followed by a larger one. Since 2019, ShakeAlert has sent earthquake alerts to phones in California. It does not predict quakes: sensors detect the first, mild waves of a quake that has already started, and alerts can arrive seconds before strong shaking. People very close to the start may get no warning.

7 C1. The San Andreas: a transform boundary

The San Andreas Fault runs more than 1,000 km through California, from Cape Mendocino to the Salton Sea area. Land west of it, including Los Angeles, moves northwest relative to land east of it; across the whole plate boundary, the motion is about 5 cm per year. Its earthquakes are shallow, mostly in the top 15 to 20 km of the crust, and no volcanoes line it. Great earthquakes ruptured hundreds of kilometers of it in 1857 (Fort Tejon, about magnitude 7.9) and 1906 (San Francisco, magnitude 7.9).

8 C2. Cascadia: a subduction zone

For about 1,000 km, from Cape Mendocino in northern California to Vancouver Island in Canada, the Juan de Fuca Plate and the smaller Gorda Plate sink beneath North America. Water released by the sinking plate helps mantle rock melt, feeding the Cascade volcanoes, including Mount Shasta and Lassen Peak. The locked boundary last broke on January 26, 1700, in an earthquake of about magnitude 9. No one in the region wrote it down, but its tsunami was recorded in Japan, and drowned coastal forests in Oregon and Washington died that same winter.

9 C3. Exceptions to the pattern

The Hawaiian volcanoes sit more than 3,000 km from the nearest plate boundary. They are fed by a hot spot: a plume of unusually hot rock rising from deep in the mantle, which partly melts as it nears the surface. In the central United States, far from any plate boundary, the New Madrid seismic zone produced three earthquakes of about magnitude 7 or larger in 1811 and 1812, along old faults inside the North American Plate. Most hazards follow plate boundaries, but not all.

10 D1. Rules that came after disasters

On March 10, 1933, a magnitude 6.4 earthquake near Long Beach damaged or destroyed many school buildings; it struck after school hours. A month later, California passed the Field Act, which requires public schools to be built to stronger standards. In 1971, the magnitude 6.6 San Fernando earthquake collapsed parts of two hospitals. California then passed a 1972 law keeping most new homes and offices off the traces of active faults and a 1973 law requiring new hospitals to be built to keep working after an earthquake.

11 D2. Making structures stronger

Engineers retrofit (strengthen) older structures: steel jackets wrapped around concrete freeway columns, bolts that tie houses to their foundations, and braces inside walls. Base isolators, thick pads of rubber and steel set under a building, let the ground move beneath it while the building moves less; San Francisco City Hall was fitted with them after it was damaged in 1989. The new eastern span of the Bay Bridge, opened in 2013, was designed to reopen quickly after the strongest shaking expected in about 1,500 years.

12 D3. How strong is strong enough?

Making every structure survive the strongest possible shaking with no damage would cost far more than any community can pay, so engineers set targets by importance. An ordinary farm-road bridge only needs to stay standing in rare, strong shaking, even if it must close afterward. A main-road bridge should still carry emergency vehicles. A lifeline, such as the only bridge on the route to a hospital, must stay open with only minor damage. Each higher target means more steel, more concrete, more design work and more money.

Part A: Expert round

1. Your expert set: _____. Write the single most important idea from each of your three cards in your own words (one sentence each). Then write one question your home group is likely to ask and your answer to it. 3 pts

Part B: Home group task

1. Each expert teaches the three cards in two minutes or less, in the order A, B, C, D. Listeners may ask one question each.
2. Fill in the briefing table together. Every cell must name at least one card number as evidence.
3. Read the county decision, discuss for five minutes, and agree on three projects. Record the reasons and the card numbers that support them.
4. Check that every member can explain one row of the table without looking at the cards. Your teacher may call on anyone.

2. Group answer: complete the hazard briefing.

6 pts

Plate setting and why the hazard happens there (cards)	Can it be forecast days to weeks ahead? Evidence (cards)	What a long-term forecast is based on (cards)	Best-matched mitigation (cards)
Eruption at a California volcano (Lassen, Shasta or Long Valley)			
Large earthquake on the San Andreas or Hayward Fault			
Great Cascadia earthquake			

3. Group answer: The fictional Sierra Coast County lies near an active fault and a restless volcano. This year it can pay for only **three** of these six projects, which cost about the same: (a) retrofit three older public school buildings; (b) add GPS and gas sensors to the volcano; (c) strengthen the only bridge on the hospital route to the lifeline target; (d) strengthen all 40 farm-road bridges to the lifeline target; (e) a campaign to sign residents up for ShakeAlert phone alerts; (f) a map that keeps new homes off active fault traces. Choose three, give a reason and a card number for each, and explain why your group rejected project (d).

5 pts

Part C: Individual accountability (complete alone)

4. Explain why scientists can often forecast an eruption weeks ahead but cannot forecast the day of a San Andreas earthquake. Cite one card from set A and one from set B.

3 pts

5. Long Valley Caldera has been restless for more than 40 years without erupting (card A2). Does that mean its monitoring has failed? Explain using card A3.

2 pts

6. Use card B1 to explain why the creeping section of the San Andreas produces many small earthquakes but not great ones. 2 pts

7. Card B2 gives a 98 percent chance for magnitude 6.0 or larger but only 20 percent for 7.5 or larger. Explain the pattern using what you know about the frequency of small and large earthquakes. 2 pts

8. Nobody in the Pacific Northwest wrote down the 1700 earthquake (card C2). How do scientists know its date and size, and why do records like these matter for forecasting the next one? 2 pts

Teaching your cards in two minutes

Use this plan for each card: 'This card is about _____. The key fact is _____. It matters for our briefing because it shows _____.' Point to the column of the briefing table your card helps with. If you are listening, write the card number next to any fact you will use, so you can cite it later.

Write the county's public notice

Write a 150-word public notice for Sierra Coast County explaining the three projects your group chose. Readers are residents, not scientists. Explain what the county can and cannot know about each hazard, use the words *forecast* and *mitigate* correctly, and avoid any statement that sounds like a prediction of a date. Then trade notices with another group and mark any sentence that overstates what science can tell.