

Scale Sorters: Twelve Earth Events on Two Rulers

Learning target: I can work with a team to place Earth events on a time-and-space chart, find the patterns the chart reveals, and defend our placements with the numbers on the cards.

Collaborative investigation

About 50 min

Jigsaw

MS-ESS2-2 · practice

collaboration

discussion

data analysis

Standards connections

MS-ESS2-2 (practice): Sorting twelve events by spatial and time scale, then identifying that size and speed are independent and that sudden events have slow set-ups, builds the scale reasoning students need to explain surface change at varying scales. The group poster is a model, not yet a written explanation from evidence.

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

Answers with reasoning

Twelve event cards (sizes and times are teaching values, rounded to be realistic)

1 Card 1: Beetle on a dune

A beetle crosses a sand dune. Each step presses grains against each other and chips a few. Space: a few millimeters. Time: seconds. Agent: a living thing. The same tiny grinding happens every time anything walks on sand.

2 Card 2: Glacier carves a valley

A glacier flows down a mountain valley, dragging rock frozen into its base. It deepens the floor about 1 mm per year and over 100,000 years turns a V-shaped valley 20 km long into a U shape. Space: 20 km. Time: 100,000 years. Agents: ice carrying rock, and gravity.

3 Card 3: Lava buries a valley

A volcano erupts. Over three weeks, lava flows bury a valley 10 km long under new rock. Space: 10 km. Time: weeks. Setup: magma had been collecting beneath the volcano for centuries before the eruption.

4 Card 4: Hoodoo cap falls

A hoodoo's soft pillar has thinned for tens of thousands of years under its hard cap. One morning the 2 m cap tips and falls in about 3 seconds. Space: about 10 m. Time of the fall: seconds. Time of the setup: tens of thousands of years.

5 Card 5: Cave passage grows

Weakly acidic groundwater dissolves limestone along a crack, widening it by about 1 mm per year at most. A passage 2 m wide took at least 2,000 years; the whole cave system is about 500,000 years old. Space: a few km of passages. Time: hundreds of thousands of years. Agent: water (chemical weathering).

6 Card 6: Continent drifts

A continent rides its plate at about 2.5 cm per year. Over 100 million years that is 2,500 km. Space: thousands of km (global). Time: 100 million years. Driven by forces inside Earth.

7 Card 7: Flash flood

Heavy rain falls upstream. A wall of water scours 15 km of canyon floor in 6 hours, rolling boulders the size of cars. Space: 15 km. Time: hours. Agent: water. Setup: the canyon itself took far longer to form, and loose rock had collected on its floor for years.

8 Card 8: Mountain range rises

Forces beneath the crust raise a mountain range 500 km long at about 1 mm per year for 30 million years. Space: 500 km. Time: tens of millions of years. Erosion removes rock as the range rises, so the peaks never reach the full height the arithmetic gives.

9 Card 9: Frost splits a boulder

Water seeps into a crack in a 1 m boulder, freezes on winter nights and expands, prying the crack wider each year. After about 20 winters the boulder splits in two. Space: 1 m. Time: decades. Agent: ice.

10 Card 10: Dune migrates

Wind erodes sand from the back of a 100 m tall dune and deposits it on the front, so the whole dune creeps downwind about 1 m per year. Space: hundreds of m. Time to move 1 km: about 1,000 years. Agent: wind.

11 Card 11: Impact dust cools the planet

A large asteroid strikes Earth. Within days its dust spreads around the planet and blocks sunlight, cooling the whole surface for months to years. Space: global. Time: days to years. Setup: the asteroid had circled the Sun on the same path for billions of years until that path finally crossed Earth's.

12 Card 12: Landslide

After a week of heavy rain, a hillside 400 m across gives way and slides into the valley in about 90 seconds. Space: hundreds of m. Time: seconds to minutes. Setup: water soaked the slope for days, and a stream had steepened the slope's base over centuries.

Part A: Expert round (one set per person)

1. Your expert set: _____. For each of your three cards, write its space category (human: mm to m; local: 10s to 100s of m; regional: km to 100s of km; continental or global) and its time row (seconds to hours; days to decades; thousands to hundreds of thousands of years; millions of years or more), and one number from the card that justifies each choice.

Answer: Set A: Card 1 human, seconds to hours (a few mm, seconds); Card 2 regional, thousands to hundreds of thousands of years (20 km, 100,000 years); Card 3 regional, days to decades (10 km, three weeks). Set B: Card 4 local, seconds to hours (about 10 m, 3 seconds); Card 5 regional (a few km) or local, thousands to hundreds of thousands of years (500,000 years); Card 6 continental or global, millions of years or more (2,500 km, 100 million years). Set C: Card 7 regional, seconds to hours (15 km, 6 hours); Card 8 continental, millions of years or more (500 km, 30 million years); Card 9 human, days to decades (1 m, 20 winters). Set D: Card 10 local, thousands to hundreds of thousands of years (100 m dune, 1,000 years per km); Card 11 global, days to decades (global, days to years); Card 12 local, seconds to hours (400 m, 90 seconds).

Why: Each expert set mixes fast and slow, small and large on purpose so that every student handles both rulers. Card 5 may go in local or regional; Card 4 is placed by the fall, with the setup noted in the record.

Also acceptable: Accept Card 4 placed by its setup (local, thousands row) if the student explains the choice; the record table should then note the fall.

- Identifies the set
- Correct space and time for each of the three cards
- A number from each card cited

Part B: Home group task

1. On the poster paper, draw a chart with four columns (human, local, regional, continental or global) across the top and four rows (seconds to hours; days to decades; thousands to hundreds of thousands of years; millions of years or more) down the side. Label both rulers.
2. Each expert places their three cards in the cells they agreed on in the expert round and explains the numbers that justify each placement. The group may move a card only if it can point to a number on the card that was misread.
3. Fill in the group record table. In the last column, write whether a slow process had to happen first to make the event possible, and name it.
4. Look for patterns. Find two cards that prove that size and speed are independent. Find every sudden event and its slow setup. Find the cells with the most cards and the cells that are empty.
5. Prepare a two-minute defense: why each card is where it is, and the two patterns you found. Every member must be able to defend any card, not just their own.

Group record (fill in)

Card	Space category	Time row	Sudden or gradual?	Slow setup first? (name it)
1 Beetle				
2 Glacier valley				
3 Lava flow				
4 Hoodoo cap				
5 Cave passage				
6 Continent				
7 Flash flood				
8 Mountain range				
9 Frost and boulder				
10 Dune				
11 Impact dust				
12 Landslide				

2. Group answer: Which two cards did your group choose to prove that size and speed are independent, and what numbers on the cards make the case?

Answer: Strong pairs: Card 11 (global, days) versus Card 5 (a few km, 500,000 years) or Card 9 (1 m, decades): the biggest event is among the fastest and a small one is among the slowest. Or Card 7 (15 km in 6 hours) versus Card 2 (20 km over 100,000 years): similar size, wildly different time. Or Card 6 (2,500 km, 100 million years) versus Card 12 (400 m, 90 seconds): the largest is the slowest and a small one is nearly instant, so neither size nor speed predicts the other.

Why: Any pair that shows a large-fast event with a small-slow one, or a same-size pair with different times, proves independence.

Also acceptable: Any accurate pair.

- Two cards named
- Numbers cited from both
- Conclusion stated: size does not predict speed

3. Group answer: List every card your group marked 'sudden,' and beside each one write the slow setup that came first. What do these events have in common?

Answer: Sudden: Card 3 lava (magma collecting for centuries), Card 4 hoodoo cap (pillar thinning for tens of thousands of years), Card 7 flash flood (canyon formed long before; loose rock collected for years; rain upstream), Card 11 impact (asteroid in orbit for billions of years), Card 12 landslide (days of soaking rain; centuries of the stream steepening the slope). In common: each is fast once it starts, but each needed a slow process to set it up, so the sudden event is the last step of a gradual one.

Why: Five cards are sudden; each card states its setup. The pattern is the lesson's claim that catastrophic events are prepared by slow change.

Also acceptable: A group that lists Card 1 as sudden (it is fast) should be asked whether it is catastrophic; accept if they argue it is fast but tiny.

- All five sudden cards listed
- A setup named for each
- Pattern stated

4. Group answer: Write the strongest challenge the neighboring group made to one of your placements, and how you answered it using a number from the card.

Answer: Common challenges and good replies: 'Card 4 should be in the thousands row because the pillar took tens of thousands of years' (reply: the card describes the fall, 3 seconds; the setup is recorded in the last column, and a group may show both by drawing an arrow from the thousands row to the seconds row). 'Card 5 is local, not regional' (reply: one passage is 2 m, but the system is a few km, so the card fits the regional column at its smallest; either placement is defensible if the number is cited). 'Card 11 is not a surface change' (reply: the cooling affects the whole surface, and the card's space is stated as global).

Why: The quality of the record matters more than which challenge was raised; look for a specific challenge and a reply that cites a card number.

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

- Records a real challenge
- Reply uses a number from the card

Part C: Individual accountability (complete alone)

5. Card 8 says the range rises 1 mm per year for 30 million years. Calculate the total rise in kilometers, showing each unit step. Then explain in one sentence why no mountain on Earth is that tall.

Answer: 1 mm per year $\times$ 30,000,000 years = 30,000,000 mm. 30,000,000 mm $\div$ 1,000 = 30,000 m. 30,000 m $\div$ 1,000 = 30 km. No mountain is 30 km tall because weathering and erosion remove rock from the range the whole time it is rising, so the height is the rise minus what erosion has carried away (the tallest peaks on Earth are under 9 km).

Why: Two unit steps after the multiplication; the second part applies the card's own note about erosion.

Also acceptable: Accept 30 km with any correct conversion path; accept 'erosion wears it down as fast as it rises' for the explanation.

6. Card 10's dune creeps 1 m per year. How many years would it take to cross a 5 km wide valley? Then calculate how far Card 6's continent moves in that same number of years, in meters.

Answer: 5 km = 5,000 m; 5,000 m $\div$ 1 m per year = 5,000 years. The continent at 2.5 cm per year moves 2.5 cm $\times$ 5,000 = 12,500 cm = 125 m in the same time.

Why: Both are rate problems; the comparison shows that the 'slow' dune outpaces the continent by 40 times, yet over 100 million years the continent travels 2,500 km because it never stops.

Also acceptable: Accept 125 m or 0.125 km.

7. A friend says, 'Sudden events just happen; there is no way to see them coming.' Using two cards from the chart, explain why 'sudden' describes how fast an event happens, not whether it had a cause that built up over time.

Answer: Model answer: 'Sudden' tells you how long the event itself takes, not where it came from. The landslide (Card 12) took 90 seconds, but a week of rain had soaked the slope and a stream had been steepening its base for centuries; anyone measuring the soil water or the slope could have seen the risk growing. The hoodoo cap (Card 4) fell in 3 seconds after tens of thousands of years of thinning; a scientist measuring the pillar's width each year would know it was getting close. The events happened fast, but their causes built up slowly and could be measured.

Why: Full credit requires two cards, each with its slow setup, and the explicit distinction between speed and cause.

Also acceptable: Cards 3, 7 or 11 are equally good choices.

- Two sudden cards used
- Each setup described
- States that sudden means fast, not causeless

8. Which card gives the best example of using a process we can measure today to understand the past (uniformitarianism)? Explain what is measured today and what it lets us estimate about the past.

Answer: Best cases: Card 2 (glacier): the 1 mm per year deepening can be measured today, and multiplying it by time lets us estimate how long the U-shaped valley took (about 100,000 years for 100 m). Card 6 (continent): the 2.5 cm per year measured today lets us estimate how far continents have moved over millions of years. Card 5 (cave): the measured widening rate gives the age of a passage. In each case, a rate observed now is assumed to have applied in the past, which is what uniformitarianism allows.

Why: Any card with a present-day rate used to estimate a past duration is correct; the answer should name the measurement and what it lets us estimate.

Also acceptable: Card 10 (dune speed measured today, used to estimate how long a dune field took to form) is also correct.

- Names a card with a measured present-day rate
- Explains what the rate lets us estimate about the past

Scoring rubric

Criterion	4 • Exemplary	3 • Proficient	2 • Developing	1 • Beginning
Placement accuracy	All twelve cards in defensible cells, each justified by a number from the card; both rulers labeled.	Ten or eleven cards defensible; one placement justified by feeling rather than a number.	Several cards placed by how 'big' or 'slow' the event sounds rather than by its numbers.	Cards placed at random or a ruler missing.
Patterns found	States that size and speed are independent with a cited pair, lists all five sudden events with their setups, and names crowded and empty cells.	Both main patterns stated; one sudden event's setup missing or the pair's numbers not cited.	One pattern stated, or patterns stated without card evidence.	No patterns identified.
Group process and defense	Every member can defend any card and answer a challenge with a number; expert knowledge was taught, not just announced.	Defense given by most members; one challenge answered without a number.	One or two members did the placing and defending.	No defense, or placements changed under challenge without evidence.
Individual accountability (Part C)	Both calculations correct with units; q7 uses two cards and separates speed from cause; q8 names a measured rate and its use.	Three of four items accurate; one calculation has a unit slip or q7 uses one card.	Two items accurate; others restate the group result without reasoning.	Part C mostly blank or inaccurate.

Teacher notes

Print and cut the twelve cards; shuffle them before handing a deck to each home group so that the expert sets must be assembled by number. The sets (1-3, 4-6, 7-9, 10-12) each contain a mix of fast and slow, small and large on purpose. Card values are teaching values chosen to be realistic: valley glaciers erode on the order of millimeters per year; cave passages widen at up to about 1 mm per year (National Park Service); continents move a few centimeters per year (the textbook's 1-3 cm; some plates exceed 7 cm); uplift rates of about 1 mm per year are typical of active ranges; dune migration of about a meter per year is realistic for

large dunes. Card 4 is the designed argument: the fall is seconds, the setup is tens of thousands of years, and the group record's last column is where both belong. Expected cells: 1 human/seconds; 2 regional/thousands; 3 regional/days-decades; 4 local/seconds; 5 regional (or local)/thousands; 6 global/millions; 7 regional/seconds; 8 continental/millions; 9 human/days-decades; 10 local/thousands; 11 global/days-decades; 12 local/seconds. Empty cells will include human/millions and global/seconds, which is a good discussion.

Scaffold offered to students: Two questions per card

If your group is stuck on a card, ask only two questions in order. Size: would the change fit in your hand (human), on a sports field (local), across a city or county (regional), or across a continent (continental or global)? Time: did it happen while someone watched (seconds to hours), within a lifetime (days to decades), over many lifetimes (thousands to hundreds of thousands of years), or over a time no person could witness (millions of years or more)? Use the number on the card, not your feeling about how big or slow the event sounds.

Extension: Thirteenth and fourteenth cards

Write two new cards of your own, one for an empty cell on your group's chart and one for the most crowded cell. Each card needs a size with a unit, a time with a unit, an agent and, if the event is sudden, its slow setup. Trade cards with another group and place theirs on your chart without looking at their answer. Then write a paragraph on which cells of the chart are hardest to fill with real events and why.