

Plan the Drilling Voyage: Six Holes to Test a Spreading Ridge

Learning target: I can define the criteria and constraints of a seafloor-drilling expedition, choose drill sites that would test seafloor spreading, predict the ages the cores should show, and justify my plan.

Transfer and design

About 50 min

Pairs

MS-ETS1-1 · practice

MS-ESS2-3 · practice

engineering design

data analysis

writing

Name _____

Date _____

Period _____

Directions

You are the chief scientist planning a drilling voyage across an ocean we will call Ocean K. Your goal is to test whether the ridge in the middle of Ocean K is spreading, by drilling cores and dating the seafloor at several sites. Read the scenario, the rules, and the depth table. Sort the statements into criteria and constraints, work out how many sites you can afford and where you are allowed to drill, then choose your six sites, predict what each core should show, and justify your plan. Show every calculation with units.

You will need: This worksheet, Pencil, Calculator, Ruler for sketching the transect (optional)

The scenario

Ocean K is 2,400 km wide from the continental shelf on its west side to the shelf on its east side. Sonar shows a mid-ocean ridge running down the middle, 1,200 km from each shelf. Nobody has dated the seafloor of Ocean K. If the ridge is spreading at the rate suggested by satellite measurements of the two coasts, the seafloor should be moving away from the crest at about **3 cm per year on each side**. Your drill ship starts at the port on the west coast, must finish at the port on the east coast, and may drill at any site along the straight line between them.

Rules of the voyage — 1. You have **24 days** of ship time in total. 2. Drilling, coring and dating one site takes **3 days**. 3. The ship moves at most **400 km per day** when it is not drilling. 4. The drill pipe can reach the seafloor only where the water is **no deeper than 4,600 m**. 5. A core counts only if it reaches the volcanic rock under the sediment; the age of the oldest sediment resting on that rock is the age of the seafloor. 6. The crossing itself (2,400 km) must be paid for out of the 24 days.

Water depth and sediment thickness in Ocean K (teaching dataset)

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

Distance from ridge crest (km)	Water depth (m)	Sediment thickness (m)
0	2600	0
200	3200	80
400	3700	160
600	4100	250
800	4500	340
1000	4800	430
1200	5100	520

Simulated for teaching. The trends are real: seafloor sinks deeper as it cools and ages, and sediment piles up the longer the seafloor has existed. The numbers are invented and the same on both sides of the ridge.

Part A: Criteria or constraint?

A **criterion** is something the plan must achieve to count as a success. A **constraint** is a limit the plan cannot break. Sort these eight statements.

1. Label each statement a criterion or a constraint and give a short reason.

Criterion or constraint?	Why (five words or fewer)
a. Cores must come from both sides of the ridge.	
b. The voyage has 24 days of ship time.	
c. Every core must reach the volcanic rock under the sediment.	
d. The drill cannot reach the seafloor where water is deeper than 4,600 m.	
e. Sites should be spaced so the ages can be graphed as a line.	
f. The ship moves no faster than 400 km per day.	
g. At least one site must be near the ridge crest to anchor the youngest age.	
h. The ship must start at the west port and end at the east port.	

2. Write **one more** criterion and **one more** constraint of your own for this voyage. Each must be something not already in the list.

Part B: What the rules allow

3. How many days does the 2,400 km crossing use at 400 km per day? How many days are left for drilling? How many sites can you drill at 3 days each? Show each step.
- _____
- _____
- _____
4. Using the depth table, how far from the ridge crest, on each side, is the farthest point where the drill can still reach the seafloor? Explain how you decided.
- _____
- _____
- _____
5. Convert the expected one-side rate of 3 cm per year into kilometers per million years. Show every step. Then write the formula you will use to predict the age of seafloor at any distance from the crest.
- _____
- _____
- _____

Part C: Your plan

6. Choose your six sites. Use distances that appear in the depth table (0, 200, 400, 600 or 800 km) so you can read the depth directly. Fill in every column and show one age calculation below the table.

Side (west/east/crest)	Distance from crest (km)	Water depth from table (m)	Allowed? (depth ≤ 4,600 m)	Predicted age (millions of years)
Site 1				
Site 2				
Site 3				
Site 4				
Site 5				
Site 6				

7. Justify your plan. Explain how your six sites satisfy every criterion in Part A, stay inside every constraint, and will let you draw an age-versus-distance graph for both sides of the ridge. Say which site you would drop first if the voyage lost three days to a storm, and why.

8. Describe the result that would **support** seafloor spreading at Ocean K's ridge and the result that would **reject** it. Be specific about the ages and the two sides.

9. A teammate proposes drilling all six sites on the east side, 100 km apart, starting at the crest, 'to get a really detailed line.' Using the criteria, explain what that plan would gain and what it would lose.

10. Rule 5 says a core counts only if it reaches the volcanic rock. Using the sediment column of the table, explain why the sites far from the ridge are the slowest to drill and why that matters when you plan the order of your stops.

A plan that always works

If you are stuck choosing sites, start from symmetry. Put one site at the crest (0 km). Then choose the same two distances on both sides, using only distances that appear in the depth table, for example 400 km and 800 km. That gives crest, west 400, west 800, east 400, east 800, and one site left over; put it at 200 km on either side to fill in the line. Check each site against the 4,600 m rule, then compute each age as distance divided by 30 km per million years.

The budget is cut to 15 days

The funding agency cuts the voyage to 15 days. Recalculate how many sites you can afford, choose them, and write a two-paragraph memo to the agency explaining which criterion you had to weaken and why your reduced plan can still test seafloor spreading. Then propose one change to the ship (for example a faster transit speed or a shorter drilling time per site) and calculate exactly how many extra sites it would buy.