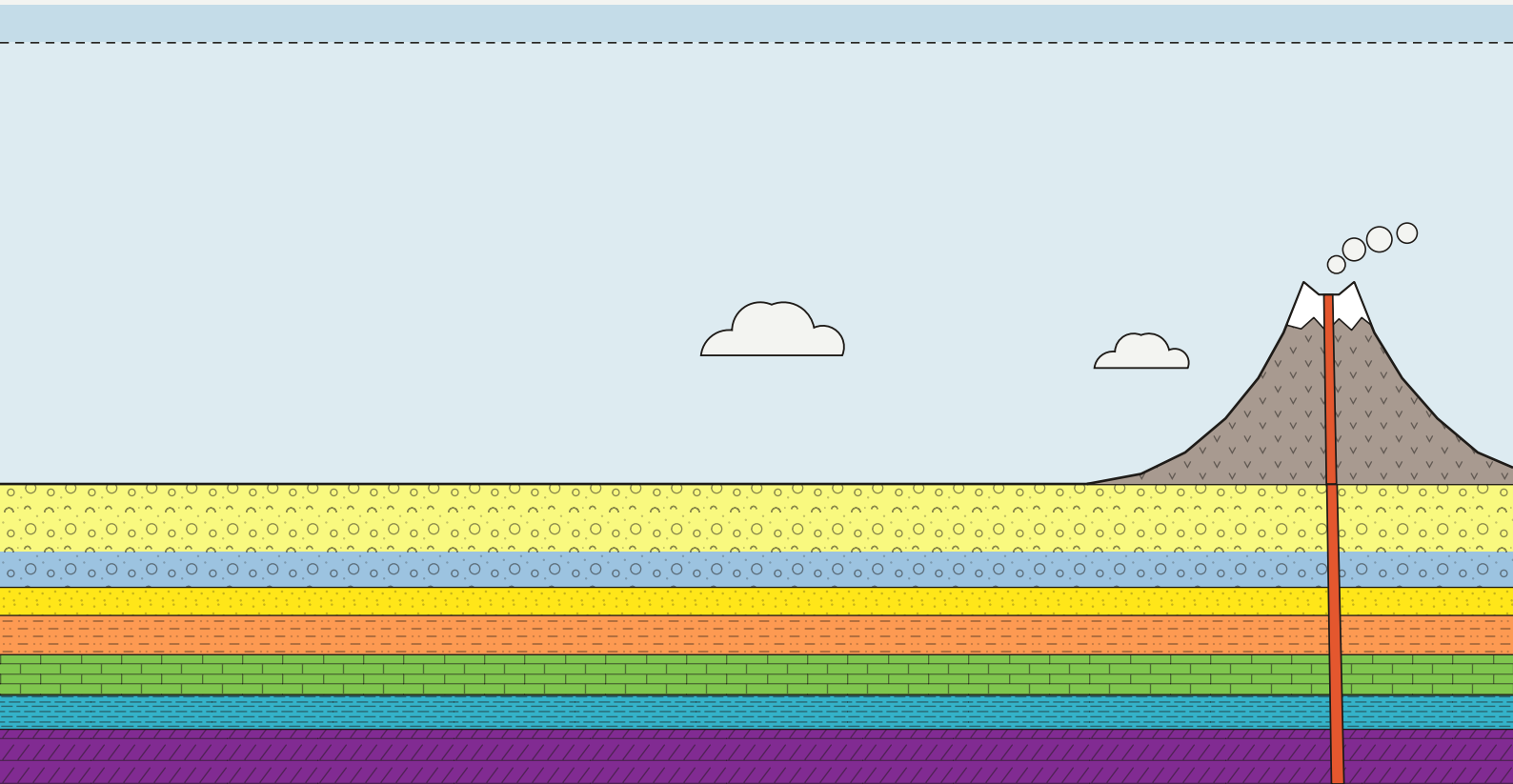
INTERNATIONAL EARTH SCIENCE COMPETITION

Qualification Round

Edition of 2027 • intesc.org



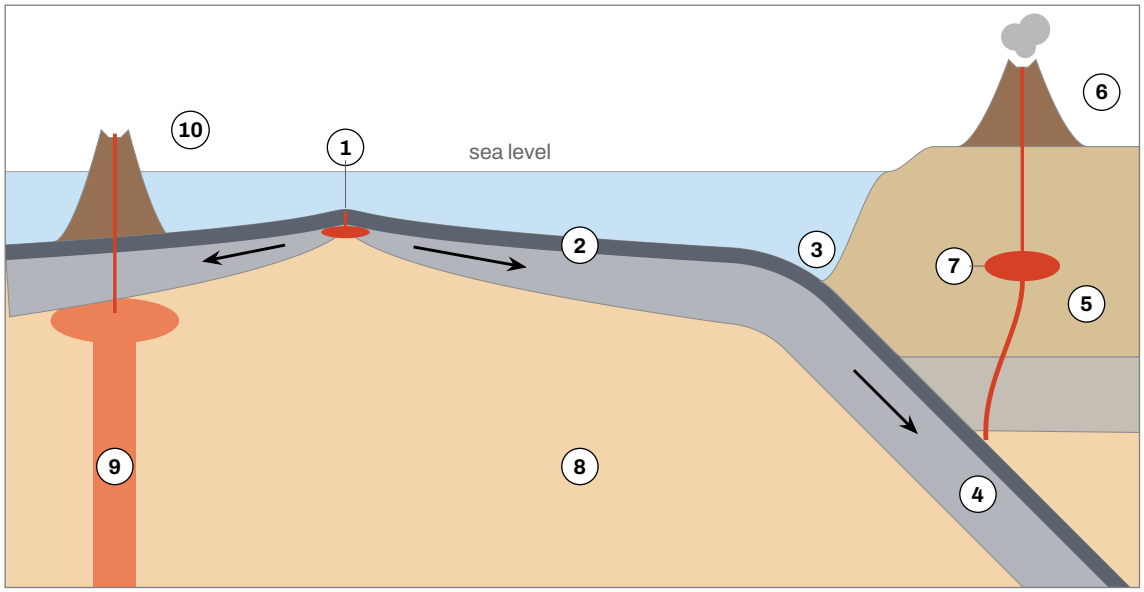
Problem A: Where Plates Meet

The outer shell of the Earth is broken into large plates that move by a few centimetres per year, about as fast as your fingernails grow. Where plates move apart, new ocean floor is born; where they move towards each other, one plate can sink deep into the mantle. Most of the world's earthquakes and volcanoes occur along these plate boundaries.

The cross-section shows a part of the Earth from a volcanic island in the ocean to a continent. The black arrows show the direction in which the plates move. The drawing is not to scale.

Task: Match each number 1 to 10 in the figure with the correct name from the list below. Each name is used exactly once.

Names: asthenosphere (hot, slowly flowing part of the mantle), continental crust, magma chamber, mantle plume, mid-ocean ridge, ocean trench, oceanic crust, subducting plate, volcanic island above a hotspot, volcano at a convergent plate boundary.



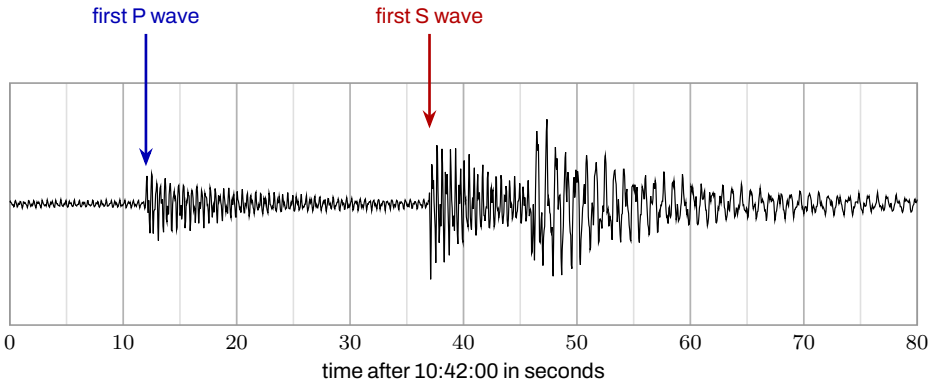
Problem B: How Far Away Was the Earthquake?

You may have counted the seconds between a flash of lightning and the thunder to find out how far away a thunderstorm is. Seismologists use the same idea to find out how far away an earthquake happened.

An earthquake sends two kinds of waves through the rock: the fast P waves (primary waves), which travel through the Earth's crust at about $v_P = 6.0\,\mathrm{km/s}$, and the slower S waves (secondary waves), which travel at about $v_S = 3.5\,\mathrm{km/s}$. The P waves always arrive first, and the longer the time Δt between the arrival of the P waves and of the S waves, the farther away the earthquake was. The distance d between the station and the earthquake is

$$d = \Delta t \cdot \frac{v_P\, v_S}{v_P - v_S}.$$

The figure shows the recording (seismogram) of a small earthquake at a seismic station.



(a) Read from the seismogram the arrival times of the first P wave and of the first S wave, and the time difference Δt between them.

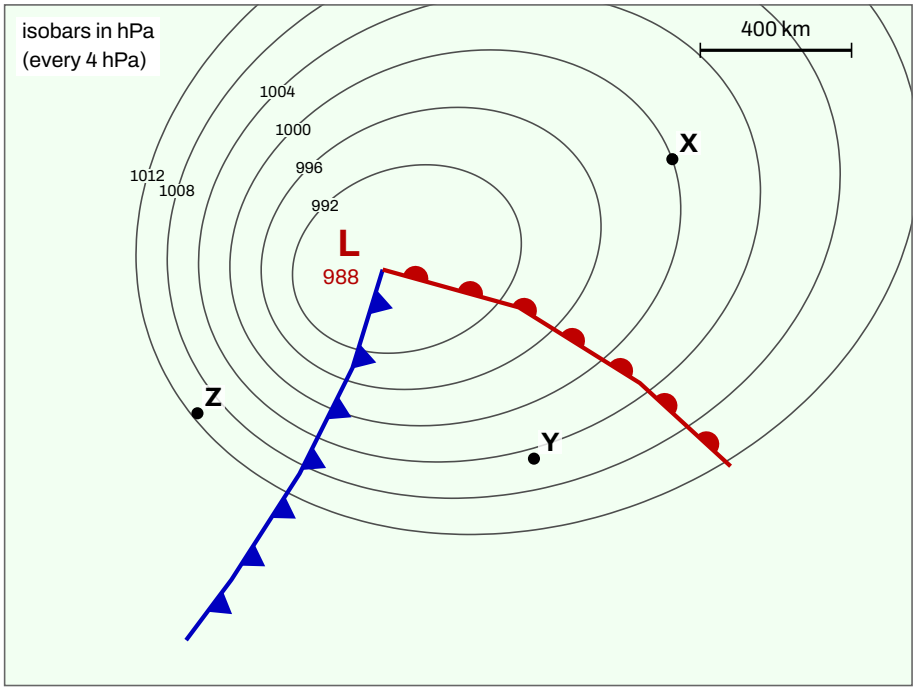
(b) Calculate the distance between the station and the earthquake. At what time did the earthquake happen?

(c) With one station, you only know how far away the earthquake was, but not in which direction. Explain how seismologists find the location of the earthquake (the epicentre) using several stations.

Problem C: Reading a Weather Map

Weather forecasters start their day with maps like the one below. It shows a low-pressure system (L) over the mid-latitudes of the Northern Hemisphere. The black lines are isobars: lines that connect places with the same air pressure at sea level, drawn every 4 hPa. Two fronts extend from the centre of the low: a warm front (line with semicircles) and a cold front (line with triangles). The symbols point in the direction in which the fronts move. The whole system moves towards the east.

Three weather stations X, Y and Z are marked on the map.



(a) What is the air pressure at station X? At which of the stations X and Z is the wind stronger? Give a reason.

(b) Station Y lies between the two fronts, in the warm air. Describe how the weather at Y will change when the cold front passes in the next hours (temperature, clouds and precipitation, wind, air pressure).

(c) Explain why a cold front usually brings short, heavy showers, while a warm front usually brings long-lasting, steady rain.

Problem D: The Oldest Crystals on Earth

In the Jack Hills of Western Australia, geologists found tiny crystals of the mineral zircon ($ZrSiO_4$), thinner than a hair, which are older than any known rock on Earth. When a zircon crystal forms, it takes uranium atoms into its structure, but almost no lead. Uranium-238 then slowly decays into lead-206, with a half-life of $t_{1/2} = 4.47$ billion years. The lead cannot escape from the crystal, so the amount of lead grows as the uranium decays, like the sand in an hourglass.

The number of uranium atoms decreases as $N_{\mathrm{U}} = N_0\, e^{-\lambda t}$, where N_0 is the number of uranium atoms when the crystal formed, t is the time since then, and $\lambda = \dfrac{\ln 2}{t_{1/2}}$ is the decay constant.

[Image: electron microscope image of a zircon crystal from the Jack Hills, about 0.2 mm long, with growth zones like tree rings.]

(a) Calculate the decay constant λ in units of 1/billion years. Show that the ratio of the number of lead-206 atoms to the number of uranium-238 atoms in the crystal is $\dfrac{N_{\mathrm{Pb}}}{N_{\mathrm{U}}} = e^{\lambda t} - 1$.

(b) In one crystal, the ratio is measured as $N_{\mathrm{Pb}}/N_{\mathrm{U}} = 0.979$. Calculate the age of the crystal, and compare it with the age of the Earth, about 4.54 billion years.

(c) The oxygen in these zircons shows that they formed from magma that contained material which had once been in contact with liquid water at the Earth's surface. Explain what this tells us about the early Earth, and why almost no rocks of this age have survived.

Problem E: The El Niño of 2026–2027

In 2026, a very strong El Niño developed in the Pacific Ocean: off the coast of Peru, the sea became more than $4\,^{\circ}\mathrm{C}$ warmer than normal. During an El Niño, the normally dry coast of Peru often gets heavy rain, while Indonesia and Australia get much less rain than usual.

The sketch compares a normal year with an El Niño year along the equator. The trade winds blow from east to west.

Task: Explain what changes in the Pacific Ocean during an El Niño, and why Peru then gets more rain while Australia and Indonesia get less.

