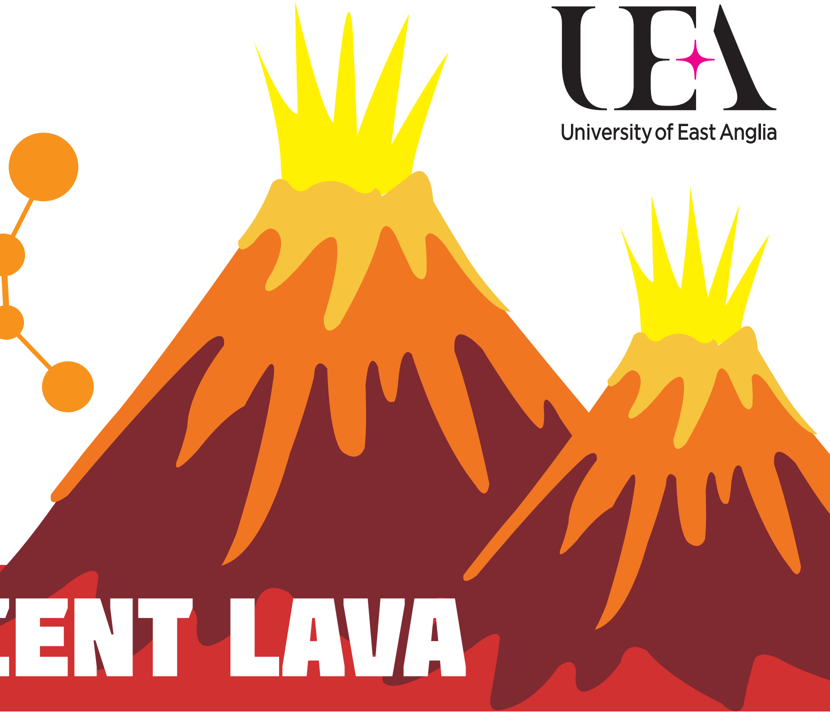
NORWICH SCIENCE FESTIVAL

At home



MAGMA-IFICENT LAVA

These activity sheets feature questions and tasks that you can use to find out a bit more about volcanoes and where they are found. They've been put together by UEA's volcano team, and include everything you need to answer the questions and find out more about volcanoes.

You can use these activity sheets over a few days – they are split into sections so you can do a little at a time. You should have room for all your answers on the sheet.

OFF YOU FLOW...

This activity sheet was produced as a collaboration between researchers at the University of East Anglia. Questions and tasks were conceived, designed and refined by Bridie V Davies, Jade Eyles, Jenni Barclay and Nicola C Taylor.

These activities can be found in our Volcanoes Top Trumps activity booklet, along with more fun activities designed to be completed using the information in a pack of Volcanoes Top Trumps.

Get some Volcanoes Top Trumps here: volcanoestoptrumps.org

Find the Volcanoes Top Trumps activity pack (plus more fun activities) here: volcanoutreach.uea.ac.uk

The Norwich Science Festival at Home activity sheets were brought to you by the University of East Anglia and the Norwich Research Park. For more information, visit norwichsciencefestival.co.uk.

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PLATE TECTONICS AND PLATE BOUNDARIES

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VOLCANOES SECTION 1

The Earth's surface is made up of a number of tectonic plates. The map in Section 4 shows them as they would be looking from above, but the illustration below shows a cross-section of the plates looking sideways into the interior of the Earth.

These plates are generally made up of oceanic lithosphere or continental lithosphere, depending on the type of crust that makes up the uppermost part of the plate.

Oceanic crust

Oceanic crust is typically thinner but denser, whereas continental crust can have more than 3x greater depth, but is less dense. The plates move very slowly around the planet due to heat coming from the Earth's core – they move at about the same rate your fingernails grow.

Plate boundaries

Although plate motion is very slow, over millions of years this motion can build and destroy continents, mountain ranges and deep oceans.

Now look at the diagram below. It shows you the different types of plate boundaries where volcanoes can form.

Where two plates meet, we call it a plate boundary. If the plates are moving apart it is called a divergent boundary – this could be a mid-ocean ridge, or a continental rift.

If the plates are moving towards each other it is a convergent boundary – a subduction zone.

At both types of plate boundary, hot liquid magma is created and can erupt at the surface forming volcanoes, because it is less dense than the tectonic plate above it.

Watch your fingernails really closely for one minute… can you see them growing?

Your fingernails grow very slowly… only about 2.5mm a month! So if you wanted to see them get longer you'd have to wait very patiently. The tectonic plates move at about the same rate. On average they move 3-5 cm per year. Some move faster and some move slower, but we still can't see it with our eyes. We use satellite measurements to track these very small movements of the plates. Although it is very slow, the movement of the plates can make big changes to the planet. For example, Scotland was positioned close to the equator around 400 million years ago!

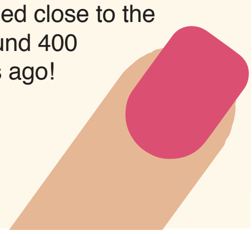
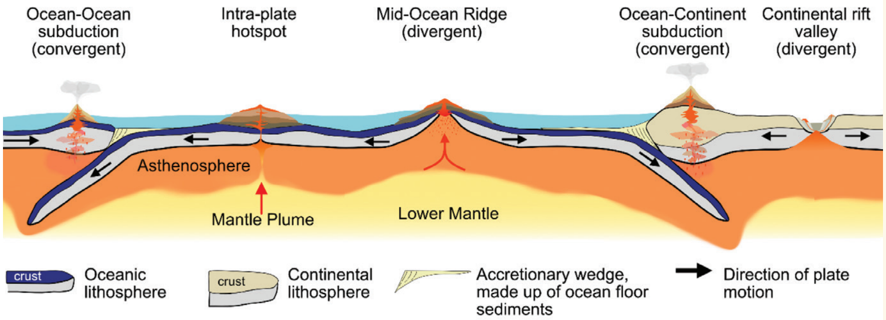


Diagram of a cross-section showing the different types of plate boundaries



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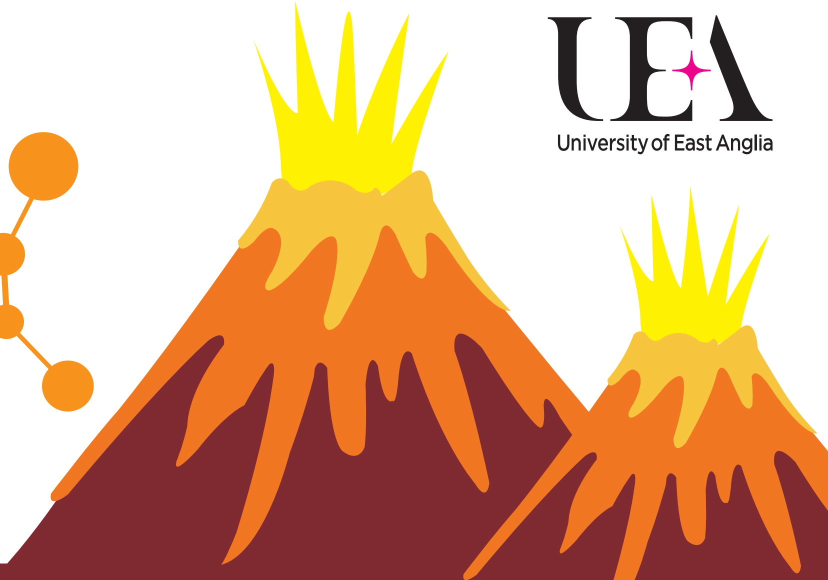

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PLATE BOUNDARIES, MAGMA PROPERTIES AND ERUPTIONS

VOLCANOES SECTION 2

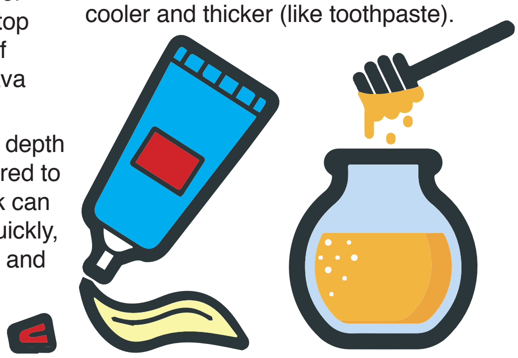
When tectonic plates have greater depth, magma can get stuck, crystallise a bit and change its composition. In turn, this changes how easy it is for magma to flow when it finally emerges. Depending on this, and how cooled it is, magma that erupts at the surface as lava can be runny (like honey) or thick (like toothpaste).

When runny lava erupts at the surface we usually see glowing lava flows or fire-fountains.

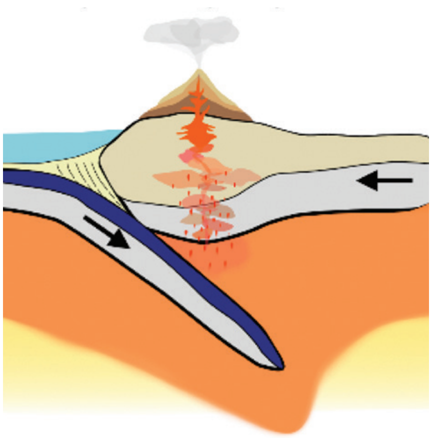
When thick lavas erupt they can create huge explosions of ash and rock, or they may just squeeze out of the top of the volcano making a big pile of hot rocks and lava. This type of lava doesn't flow very far.

As **oceanic lithosphere** has less depth and its crust is very dense compared to the rising magma, the molten rock can usually rise to the surface quite quickly, meaning it erupts while it is hotter and runnier (like honey).

Continental lithosphere has much greater depth and the crust is not as dense, so the rising magma can get trapped for longer, meaning by the time it reaches the surface it can be much cooler and thicker (like toothpaste).



Ocean-Continent subduction (convergent)



Experiment:

Find a jar of honey, syrup or a bottle of oil with the lid on, tip it and see how quickly the contents move. Now do the same for some ketchup or jam, or squeeze a little bit of toothpaste onto a plate and hold it at an angle. Does one move more quickly than the other, do some not move at all? Of the things you found, which one is thickest?

Write your observations in the table below:

Food item	How quickly does it move?

Answers: Oil and water will move much more quickly than honey, ketchup and syrup. But jam and toothpaste should move very slowly. This is because they are more viscous. If something is viscous it means it doesn't like to flow.

A good way to think about this is to consider the difference between walking through water compared to walking through air, and then imagine walking through a big pool of custard or thick toothpaste. It would be much more difficult because they are more viscous and they don't want to flow, so they resist your legs and arms as you move through them. (Just don't try filling your bath with custard at home!)

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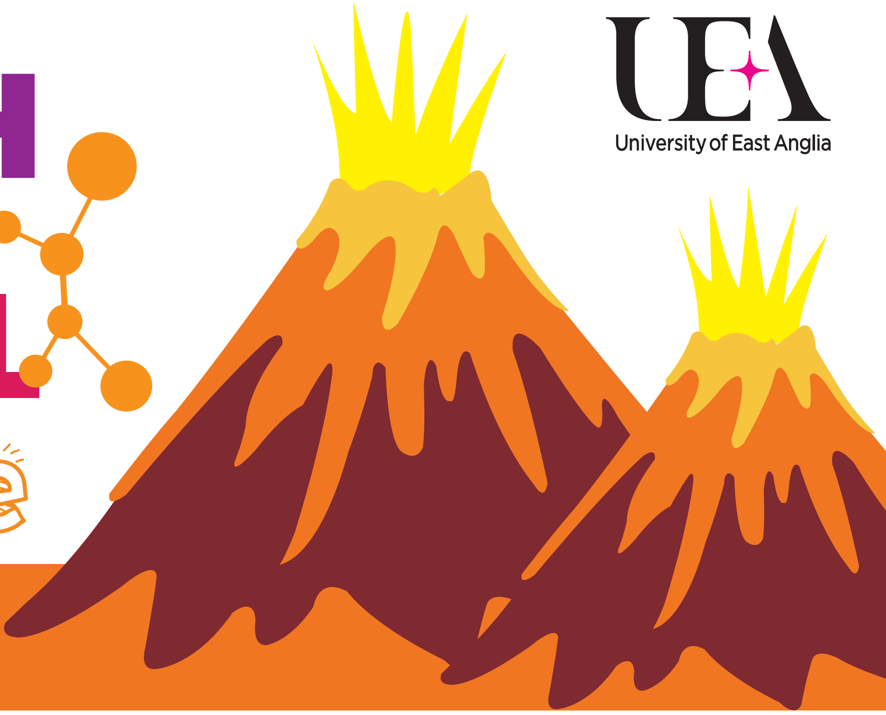
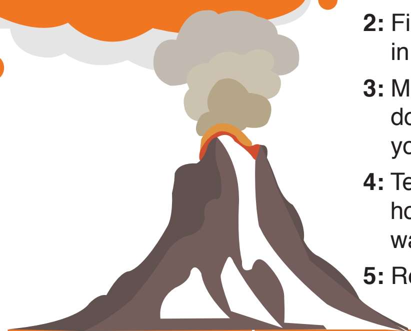
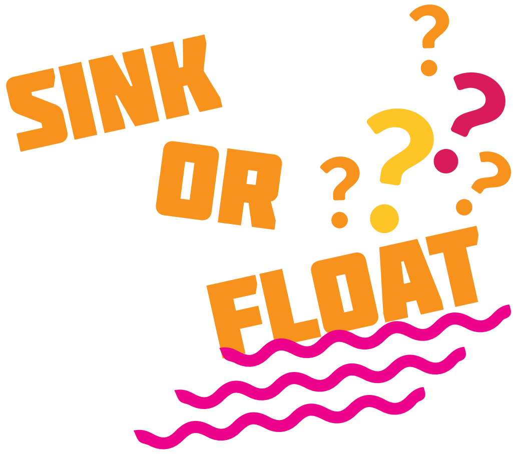


DENSITY

VOLCANOES SECTION 3





Experiment with density!

1: Fill a large bowl, sink or bath with water.

2: Find some objects made of the materials in the table below.

3: Make a hypothesis: which of your objects do you think will float, and why? Record your predictions in the table below.

4: Test your hypothesis – one at a time, hold each object at the bottom of the water, then let go.

5: Record your results in the table below.

Object	What is it made of?	Hypothesis	Does it float?
	wood		
	plastic, solid		
	plastic, hollow		
	stone		
	metal		

Was your hypothesis correct, or did some of your results surprise you? Check the 'Answers' at the bottom of this page to find out more about density.

Objects that rise to the surface and then float are less dense. The greater the difference in density between the object and the water, the easier it is for the object to rise to the surface.

Why is density important to volcanologists?

Sometimes, a plume of very hot material in the lower mantle rises up causing volcanic eruptions away from a plate boundary. We refer to this as a hotspot.

Have you ever heard the phrase 'hot air rises'? Hotter air is less dense than cooler air. The same goes for hotter water, and hotter magma!

Answers:

Water has a density of 1g/cm3, which means that 1 cubic centimetre of water weighs 1 gram.

Objects made from wood usually float because their density is lower, whereas stone and metal are likely to sink. This is because these materials are denser – the building blocks that make up materials like metal are packed much closer together, so they have more mass per cubic centimetre.

Did you get the results you expected? Try as many objects as you can, and see if you can work out which objects and materials are the densest.

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VOLCANOES SECTION 4

The locations of volcanoes

For this activity, you'll use the diagram below, which shows the locations of a selection of volcanoes worldwide.

1 How many of the volcanoes are near plate boundaries? How would you express that as a percentage? [ ] [ ] %

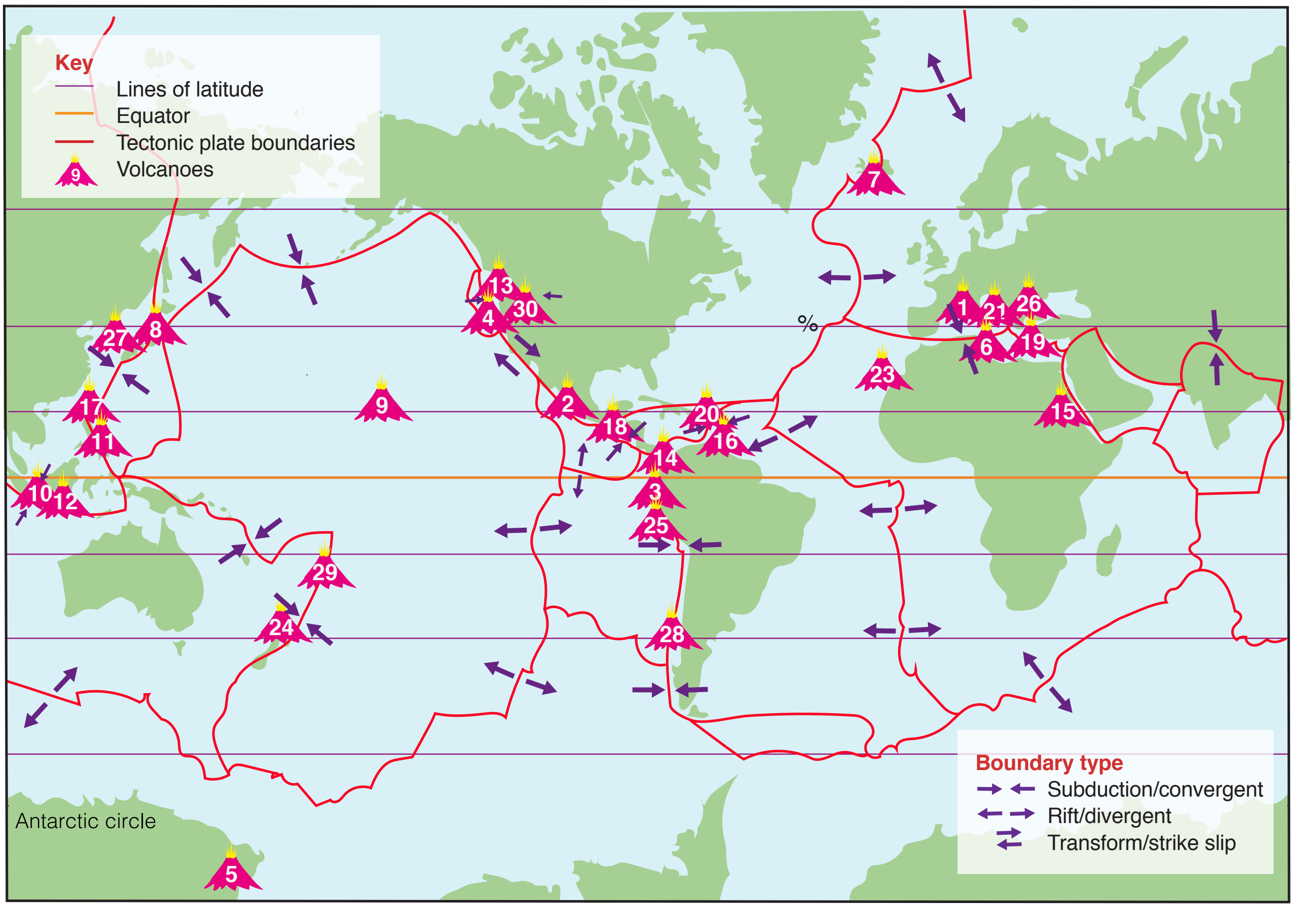
2 What percentage of the volcanoes are found near subduction zones? [ ] %

3 Globally, around 80% of historical eruptions have occurred near subduction zones. Is the proportion of volcanoes that are at subduction zones a good representation of this global proportion? Why?

[ ]

[ ]

Diagram of volcano locations worldwide



Answers:

1) The total number of volcanoes here is 30. Erebus, Kilauea and Teide are the volcanoes not obviously near a margin. This is 3 from 30.
The fraction is 3/30 = (simplify) = 1/10 = 0.1
Expressing this as a % means multiplying by 100 = 0.1 x 100 = 10%
If you included Nyiragongo, this would be 4/30 = 2/15 which, multiplied by 100 = 13.33%

2) There are 25 volcanoes near subduction zones (areas where plates are moving towards one another).
25/30 = 5/6 = 0.833 (rounded to three decimal places)
0.833 x 100 = 83.3%

3) With just 30 volcanoes here, 83.3% is not a bad representation of the correct proportion. 24 volcanoes would have been exactly 80% but since its only 'around' 80% our proportion is pretty good!

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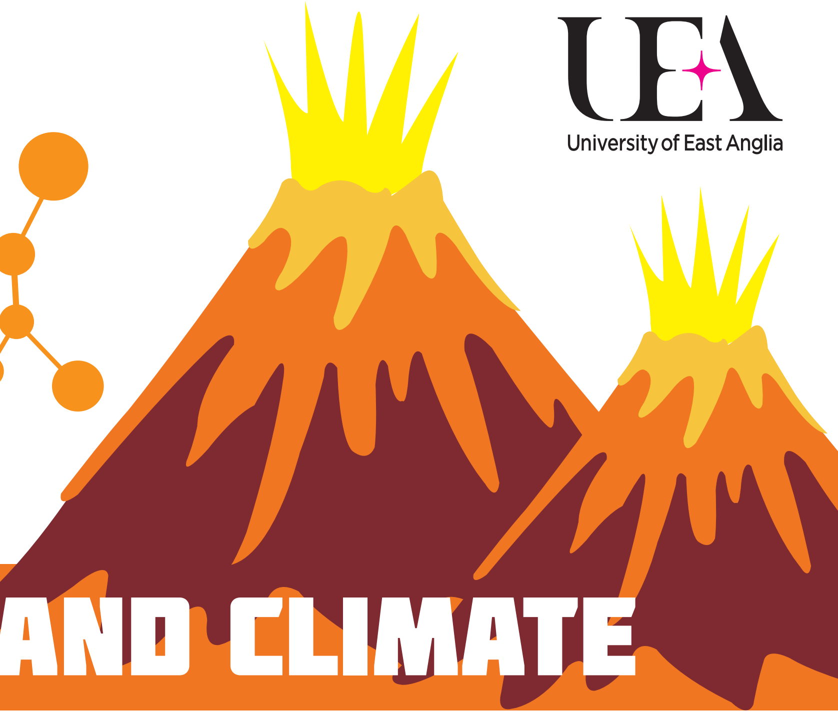

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VOLCANOES AND CLIMATE

VOLCANOES SECTION 5

Weather describes the day-to-day variation of the atmosphere (sun, rain, wind) but climate describes the average (mean) weather conditions over long periods of time.

Latitude = the angular distance of a place north or south of the Earth's equator, usually expressed in degrees and minutes

Climate is modified by latitude (see definition above) but is also affected by proximity to the sea, and the presence of mountains. These can affect both rainfall and temperature. Volcanoes are often mountains, so have a different climate at their peak, relative to sea level at that latitude.

Climate zones

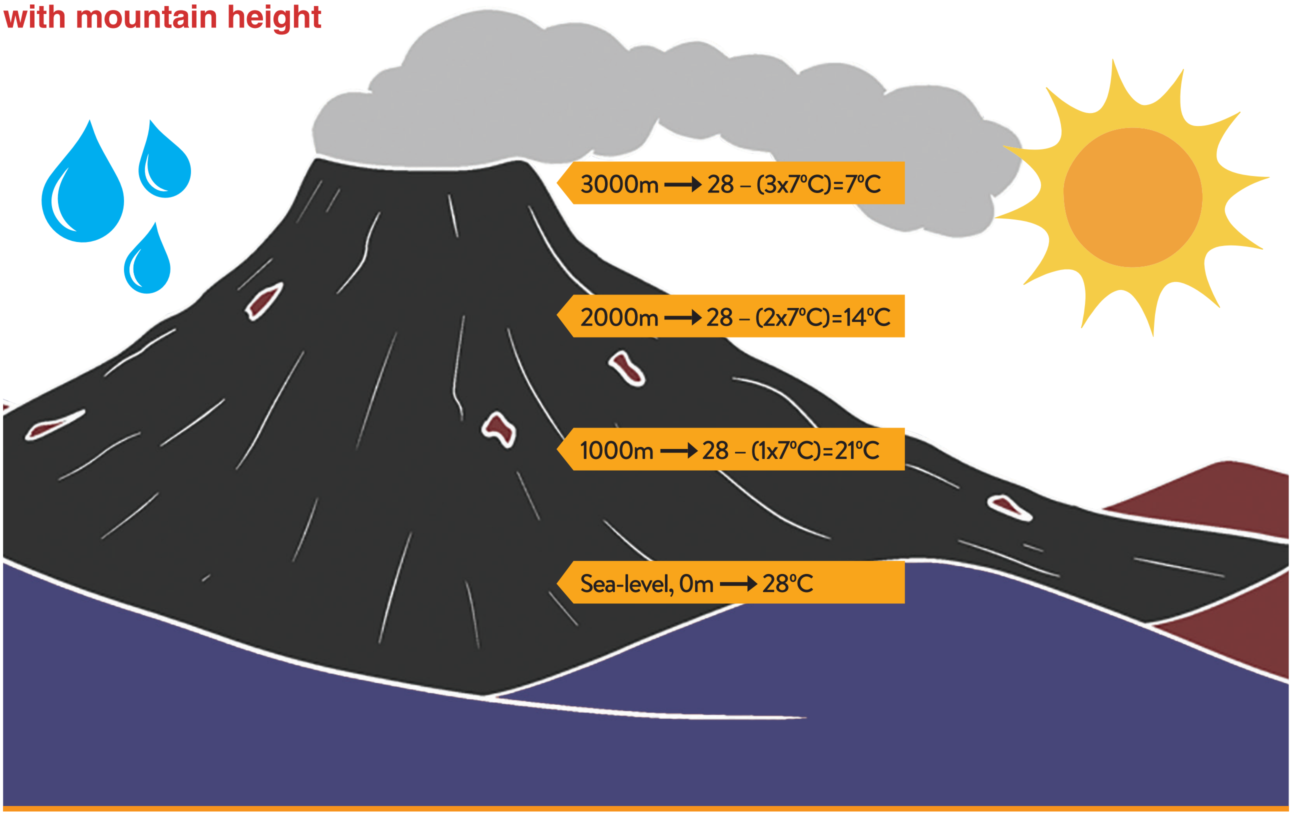
Broadly speaking, anywhere more than 66° north or south of the Equator has a **polar climate**.

The **temperate zone** is found between 23.5° and 66° north and south of the Equator.

The **tropical zone** extends for around 30° either side of the Equator.

Temperature is lowered by around 7° for every 1000m of extra height above sea level.

Change in temperature with mountain height



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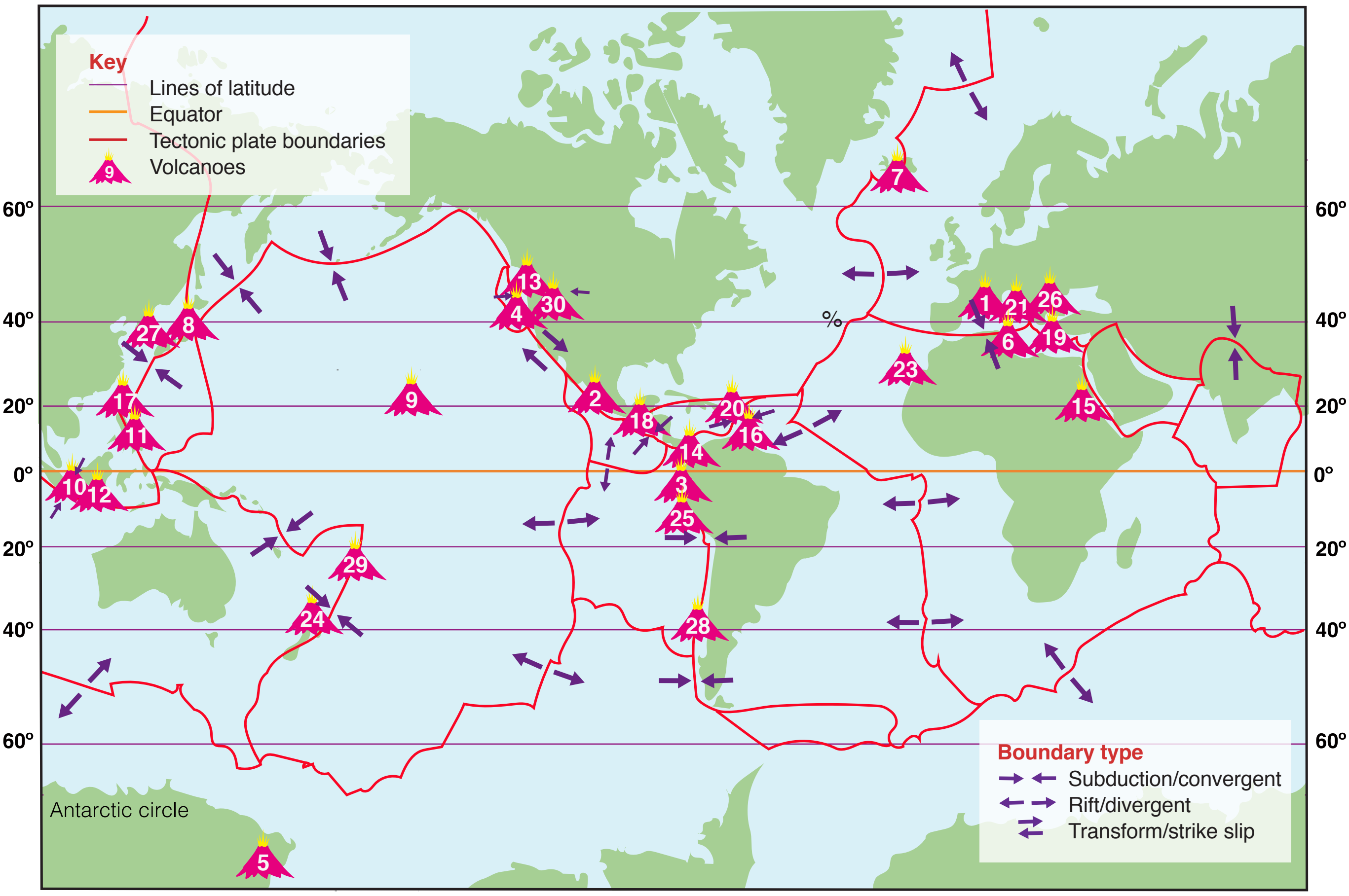
Over to you!

Use the information from the previous page and the map below to answer questions about climate and volcanoes.



Volcanoes

1 Campi Flegrei, Italy
2 Colima Mexico
3 Cotopaxi, Ecuador
4 Crater Lake, USA
5 Erebus, Antarctica
6 Etna, Italy
7 Eyjafallajökull, Iceland
8 Fuji, Japan
9 Kilauea, USA
10 Krakatau, Indonesia
11 Mayon, Philippines
12 Merapi, Indonesia
13 Mount St Helens, USA
14 Nevado Del Ruiz, Colombia
15 Nyiragongo, Democratic Republic Of The Congo
16 Mount Pelée, Martinique
17 Pinatubo, Philippines
18 Santa Maria, Guatemala
19 Santorini, Greece
20 Soufrière Hills, Montserrat
21 Stromboli, Italy
22 Tambora, Indonesia
23 Teide, Canary Isles
24 Tongariro, New Zealand
25 Tungurahua, Ecuador
26 Vesuvius, Italy
27 Unzen, Japan
28 Villarica, Chile
29 Yasur, Vanuatu
30 Yellowstone, USA

1 Cotopaxi, Erebus, Eyafjallajökull, Villarica, Fuji and Mount St Helens are often snow-covered, even though they are in different climate zones. Find and mark the locations of these volcanoes on the map using the numbered list provided.

2 Assume that the temperature at sea level in Ecuador is 30°C. What is the temperature at the top of Cotopaxi? (Hint: use the relationship between temperature and height above sea level. You can either make an equation from this relationship or take the approach shown in map above, but remember the last height will be a fraction of 1000 metres.)

3 Which climate zone has the most volcanoes? (Hint: use the map!) Why do you think this is?

4 Using your knowledge of magma and lava, what do you think will happen to the snow on top of a snow-covered volcano when it erupts?

Answers:

2) *Cotopaxi is 5,897 m. This means that there is 5897/1000 × 7°C change in temperature from sea-level. This is 41°C! This implies the temperature at the top of Cotopaxi is 30°C-41°C = -11°C! That is pretty cold!*

3) *The tropics have the most volcanoes. Looking at the tectonic plates, they are smaller in this region and so have more boundaries – which means more volcanoes!*

4) *The snow will be rapidly melted. Snow melts at 0°C, and typically volcanic material is erupted between 500°C and 1000°C – that is a lot of extra heat energy to melt the snow!*

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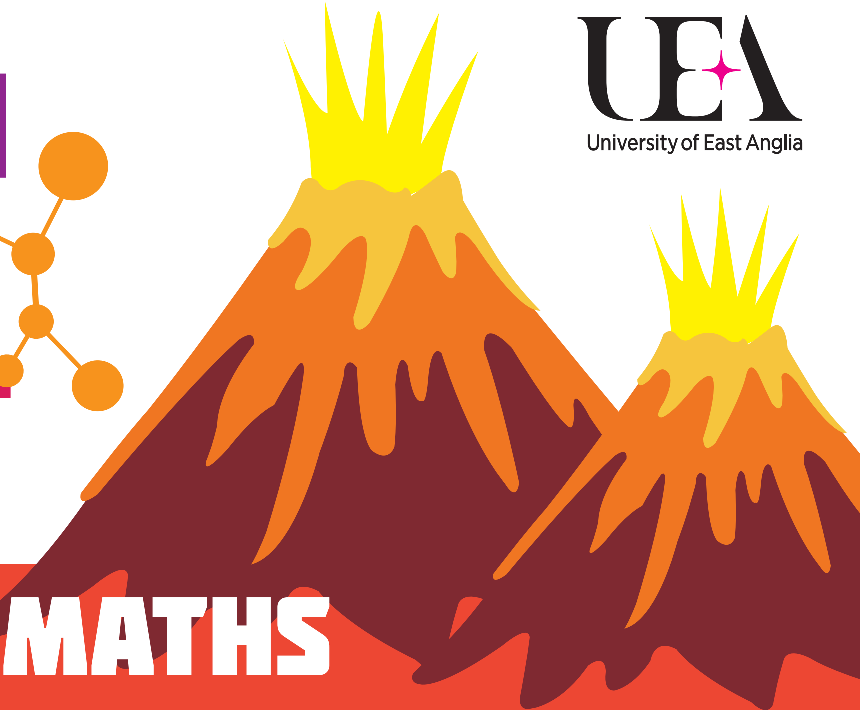
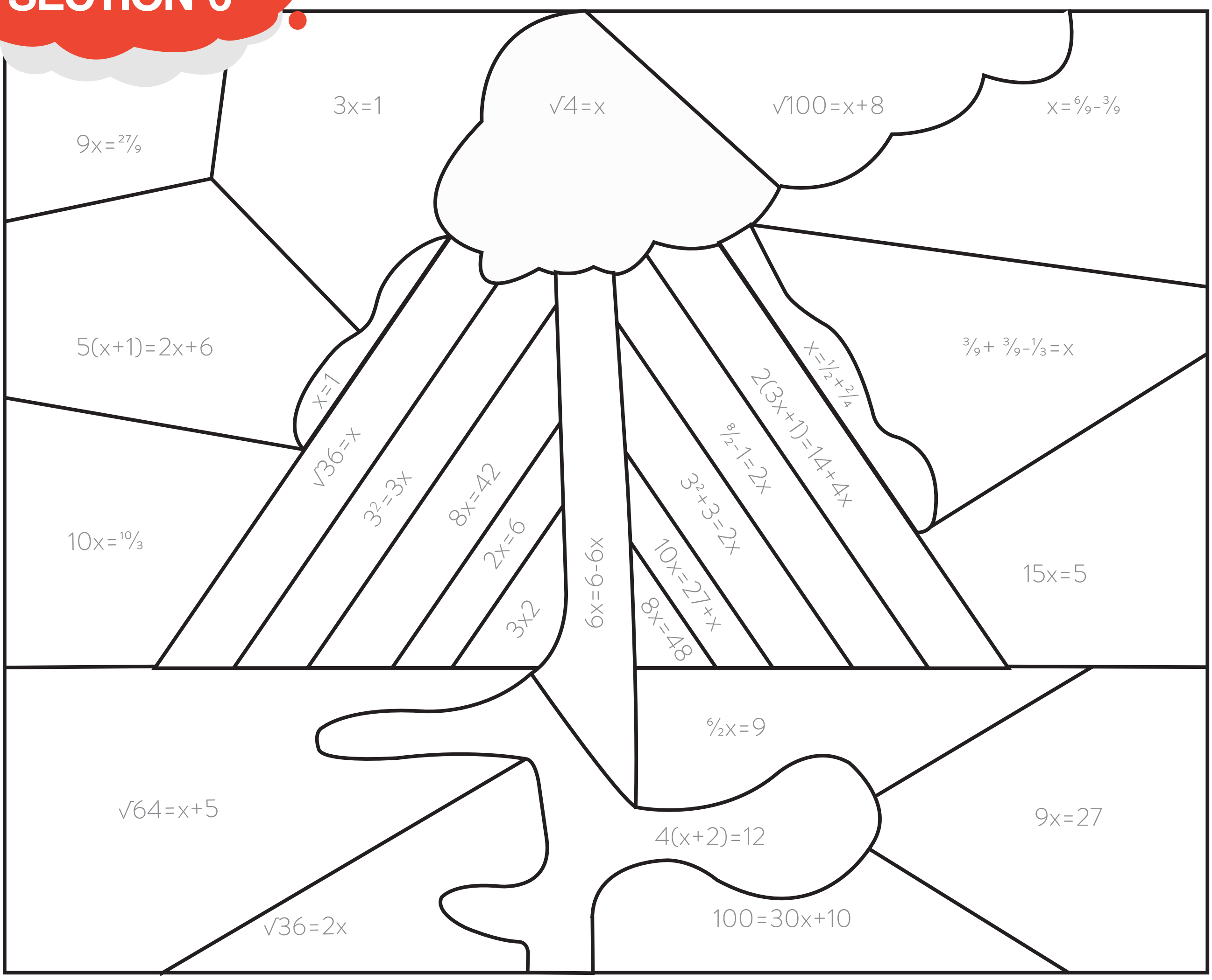


COLOURING MATHS

VOLCANOES SECTION 6

Another part of being a volcano scientist is solving problems!

Can you solve for x in each of these zones of our volcano drawing, and use that to colour the picture?



= 6 = 3 = 1 = ½ = ⅓ = 2