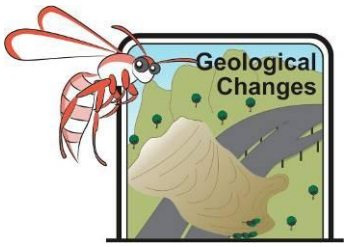
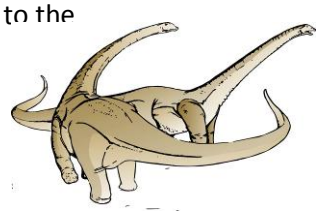


Making a tilt-o-meter & clinometer – Teacher Notes

It is difficult to predict when a volcano will erupt. Statistical probabilities can be calculated if there is an historical record of prior eruptions.

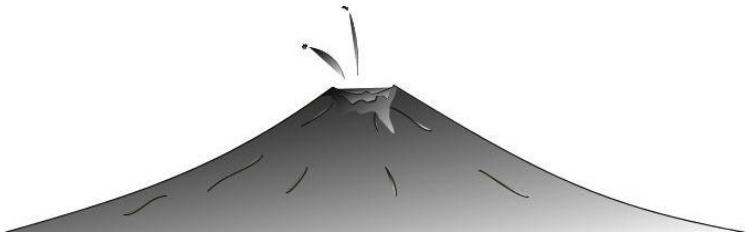
Historical eruptions

Massive volcanic eruptions have been major forcing factors in mass extinction events in the geological past. Earth's most devastating extinction, the "Great Dying" occurred between the Permian and Triassic eras and resulted in the death of over 95% of species on this planet. The major cause of deaths was not a result of hot lava or fires but was caused by volcanic ash and dust and by increased levels of carbon dioxide that outgassed from the volcanoes. Dust obscured the Sun causing a volcanic winter that lasted for up to five years. Plants did not have sufficient light to photosynthesise and many perished. Large animals that depended on plants for food were the first to die. Carbon dioxide induced global warming of 8°C, which lasted thousands of years, followed this. Most importantly, on this occasion, marine species were affected. It took over 10 million years for life on Earth to recover. Similar massive outpourings also contributed to the later and less lethal extinction at the end of the Cretaceous period that resulted in the death of the dinosaurs amongst other species. Massive volcanic eruptions such as these are geologically rare.



Supervolcanic events are used to describe shorter explosive events such as when specific vents eject magma and dust over a wide geographic area. The eruption of Mt Toba in Sumatra 74,000 years ago was the largest recent super volcanic event. An amazing 2,800 cubic kilometres of magma was extruded causing a volcanic winter as ash circulated around the globe and excluded sunlight. The movement of great ice sheets during the Pleistocene had pushed animals, including humans, south into African savannah. Some scientist think that gas and ash from Mt Toba further stressed human population numbers at this time reducing them to about 20,000 breeding pairs.

Vulcanologists have suggested that it takes about 600,000 years for the magma chamber below a supervolcano to refill after an eruption, the explosive release of gas and steam will occur more frequently. The gassy fumaroles and geysers at Yellowstone National Park are monitored to gain information to help predict overdue predicted eruptions.



"Active" volcanoes have erupted in the last 10,000 years.
"Dormant" volcanoes haven't erupted in the last 10,000 years but may still erupt.
"Extinct" volcanoes are never expected to erupt again.

There distinctions are often contradicted by surprise eruptions from "extinct" volcanoes.
Ordinary **active volcanoes** vent frequently. Before an eruption the pressure from gas and magma from below causes the ground to rise and swell. Increasing stress on ground rock is demonstrated as an increasing frequency of geyser discharge and earthquakes as the ground releases pressure. Measuring earthquake frequency, increased rates of geyser discharge and changes of tilt of the walls of volcanic vents can be used to estimate possible eruptions.

Making a tilt-o-meter & clinometer – Teacher Notes

I have included two methods of measuring inclination, the tilt-o-meter and the clinometer. You may wish to use either, however it can be interesting if your groups make one instrument and the other half make the other. Then their effectiveness can be compared and contrasted.

You may wish to demonstrate that "Water always finds its own level" to students before the tilt-o-meter activity.

Water finds its own level - Teacher demonstration

Materials

- Water
- Food dye (optional)
- A funnel (you can use a plastic sandwich bag as a funnel).
- Transparent tube (aquarium hose is perfect).

Method

1. Demonstrate this over a sink, bucket or outside over the grass.
2. Hold the plastic tube in an u-shape.
3. Mix colour into the water and pour through the funnel into the u-tube or alternatively cut a corner of the water filled plastic bag and use this to pour water into the tube.
4. Hold the tube with both open ends at the same height.
5. Alternately raise and lower each end to demonstrate that water will flow from the higher level to the lower level until a single level is obtained.

Observation

What did you observe? Water seeks its own level.

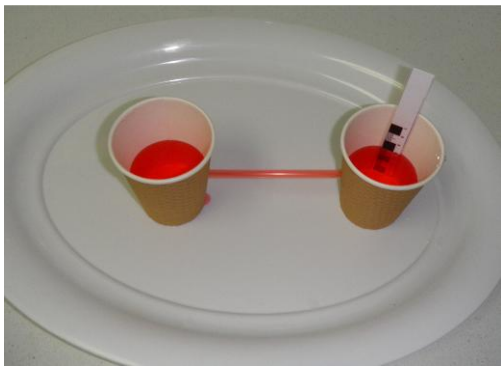
Making a tilt-o-meter

The Romans noticed bulging sides to volcanic vents usually preceded an eruption. They tried to monitor the degree of tilt by filling clay vessels to the top with water. The amount of water lost due to tilting could be measured.

Why was this not a very good idea?

If there was warm weather water would be lost into the atmosphere through evaporation. If it rained the vessels would fill with rain. Also animals may come and drink the water.

Materials



- Two paper cups
- Coloured water
- A plastic ruler or piece of cardboard with millimeters marked on it.
- A drinking straw (clear plastic if possible
- A nail or old ball point pen to drill a hole in the cups
- A little Blu-tack, plasticine or modeling clay
- A plastic plate or the empty tray from under a student's desk
- Text books, blocks, bricks or other objects with which to progressively raise one end of the tray or plate

Making a tilt-o-meter & clinometer – Teacher Notes

Method

1. Drill a hole into the side of each paper cup near the base. They should be at the same level and be small enough for the straw to fit snugly into it.
2. Place straw into holes between the cups as demonstrated above.
3. Test for leakage by pouring a little water into both cups.
4. Seal off leaks using Blu-tack, tape or plasticine.
5. Place depth measurer into one cup.
6. Read the depth measurement.
7. Place the first object under the opposite end and read the depth.
8. Repeat the last step four more times.

Observations

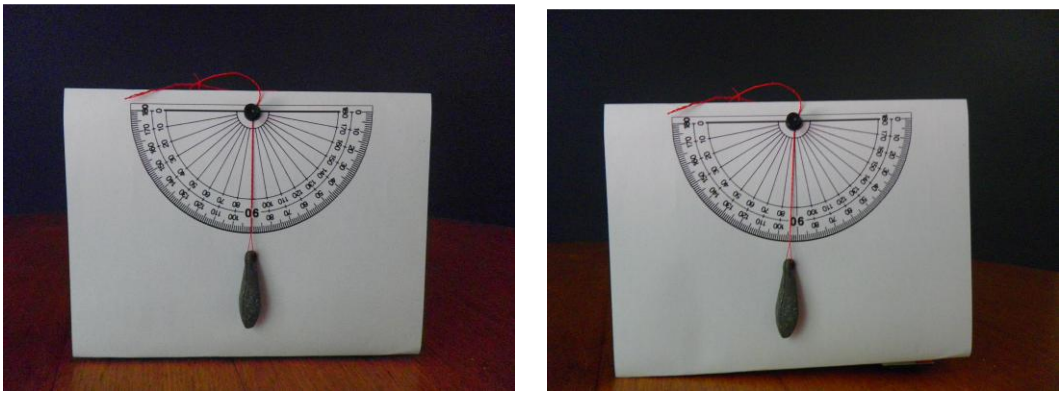
First decide how precise you wish to make readings of the depth. In this case reading to 1mm is sufficiently precise.

	Reading
Horizontal (flat)	
First rise	
Second rise	
Third rise	
Fourth rise	
Fifth rise	

Conclusion

Can you use a tilt-o-meter to measure changes in the slope of a volcano? Yes.

Making a clinometer



Paper clinometer on horizontal surface (left) and with one end raised (right).

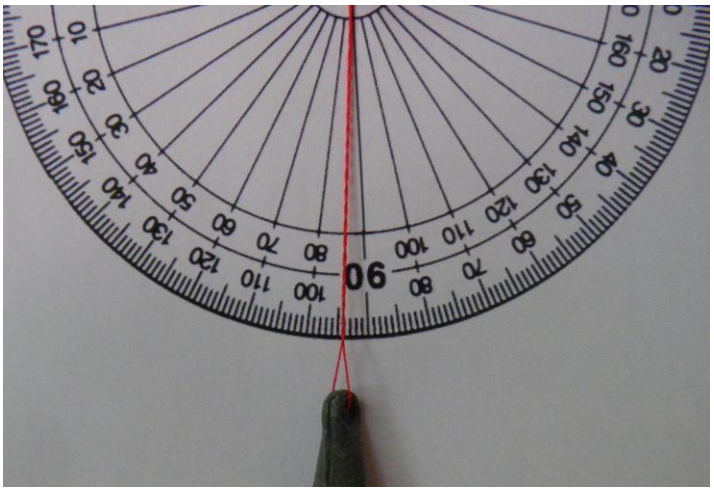
Making a tilt-o-meter & clinometer – Teacher Notes

Materials

- A cardboard box or empty milk carton.
- A protractor with Blu-tack or tape.
- Thread or string with a weight attached. A fishing weight is perfect.
- A drawing pin
- Textbooks, blocks, bricks or other objects with which to progressively raise one end of the box.
- A simple alternative to using a protractor is to print the image of one on a sheet of paper and attach that to the box.

Method

1. Using a drawing pin, attach the top of the string to the box so that the weight hangs freely and is vertical.
2. Slip the protractor under the string and align the 90^{o} vertical line with the string.
3. Place the first object under one end of the box.
4. Read the inclination measurement on the protractor. In the example beside the land is inclining 4^{0} to the left.



Observations

First decide how precise you wish to make readings of the depth. In this case reading to 1 degree is sufficiently precise.

	Reading in degrees
Horizontal (flat)	
First rise	
Second rise	
Third rise	
Fourth rise	
Fifth rise	

Conclusion

Can you use a clinometer to measure changes in the slope of a volcano? Yes

Compare and contrast

When we compare things look for similarities

When we contrast things we look for differences

In what ways do the two apples compare? Fruit, food, contain apple seeds, colourful, sweet, similar shape, plants.

In what ways do the two apples contrast? Different colour, different size, one has a leaf and the other doesn't, one has dew and the other doesn't.

Compare and contrast the devices

In what ways do the two devices compare? Measure inclination, easy to make, inexpensive to make, light to carry and install.

In what ways do the two devices contrast? One measures inclination by the movement of a liquid, one measures inclination by movement of a pendulum weight.

Which device do you think is better to predict the possibility of a volcanic eruption? Explain your answer. Any reasonable answer

List five ways in which volcanic activity changes the surface of the Earth.
Conical stratovolcanoes, flat domed shield volcanoes, flat stepped flood basalt hills (traps), ash covered land, waterways diverted, crops and animals killed, volcanic islands appearing out of the sea.