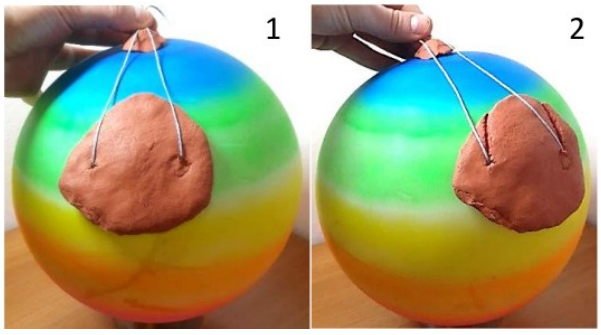
Extension
Did the continents move for you?
Plotting the movement of continents using apparent polar wandering curves.

After a brief discussion about continental drift and plate tectonic theory, ask the pupils to follow these steps (Pupils can work in pairs to make modelling easier).

1. Take a ball (for example, a football) and fix a piece of Plasticine™ on the hole that is used to inflate it. This point will be the magnetic North Pole.
2. Take a piece of Plasticine™ and model it on the sphere as if it is a continent. On this continent mark two deep points with a black pen and at each point, fix a piece of string.
3. Now stretch each string until you reach the "magnetic North pole" and press the string into the Plasticine™. With a red pen, colour-in the groove that is formed by the string in the Plasticine™. The two points, marked in black deep in the Plasticine™, represent Cambrian magnetic rocks and the red lines represent their magnetic orientation.
4. Move the continent on the sphere.
5. Repeat number 3 above, colouring in the grooves with a different colour (e.g. green) and pressing the string, not as hard as before, into the Plasticine™. The two points, not as deep as earlier in the Plasticine™, represent younger magnetic rocks of Cretaceous age and the green lines represent their magnetic orientation.
6. Move the continent on the sphere.
7. Repeat number 3 again without pressing into the Plasticine™ and draw lines on the surface with a different colour (e.g. blue).

The magnetic field of the Earth, represented by the two strings, is recorded in the magnetic minerals in the rocks that are formed at different times. When igneous rocks containing magnetic minerals cool down, their magnetisation becomes aligned to the direction of the Earth's magnetic field at the time (represented by the coloured grooves). Each step is shown in the photos below.



Figures 1 and 2 - steps 1 to 3

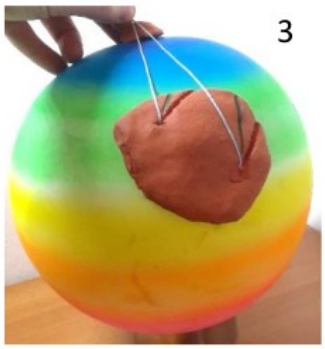
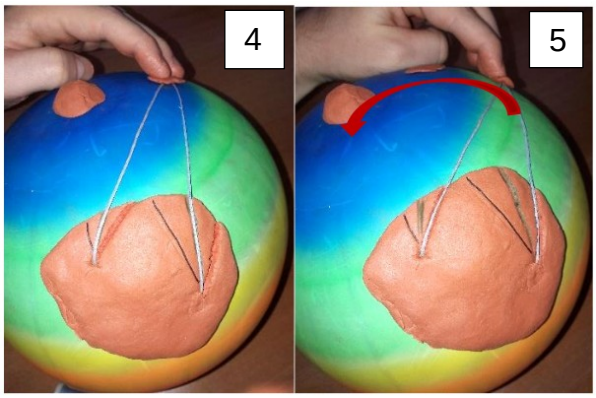


Figure 3 - step 5

Once the pupils have reached step 7, ask them to leave the Plasticine™ in position and to follow the red lines, using strings from the continent until they meet each other. Mark the spot with red painted Plasticine™. This is apparently the 'Cambrian' magnetic North Pole. Do the same with the green lines and mark the spot with green painted Plasticine™. This is apparently the 'Cretaceous' magnetic North Pole.



Figures 4 and 5 - marking the apparent polar wandering curve

Connecting the three Plasticine™ poles, pupils can observe an apparent polar wandering curve. This curve shows how the magnetic pole has appeared to move, based on the remanent magnetisation of the rocks. At one time scientists could not decide whether it was the poles that had moved, or the continent. As more data were gathered from different continents, it became clear that the poles had never moved more than a few hundred kilometres from the geographic poles, and it was the continents which had moved across the surface of the globe. Apparent polar wandering curves are now regarded as excellent evidence for plate tectonic movement. Point out to the pupils that each group has different polar wandering curves depending upon where they placed their continent.

The back up:

Title: Extension activity for 'Did the continents move for you?'

Subtitle: Plotting the movement of continents using apparent polar wandering curves.

Topic: This exercise can be used in any science or geography lesson about plate tectonic theory and the movement of the continents.

Age range of pupils: 16 - 18 years.

Time needed to complete activity: 30 minutes.

Pupil learning outcomes: Pupils can:

- appreciate that magnetic minerals become magnetised in the direction of the Earth's magnetic field;
- construct apparent polar wandering curves for each continent by recording the remanent magnetisation in rocks.
- realise that the magnetic pole has not wandered but the apparent curve can be used to determine the positions of the continents at the time of the formation of the rocks with the magnetic minerals;
- understand that the apparent polar wandering curves give good evidence for continental drift.
- see that magnetised rocks are not all found on the same level. Older rocks are often found more deeply and they indicate events further back in the past;
- learn to work on a sphere.

Context:

Pupils often ask how scientists know that the continents have moved. This activity about the apparent wandering of the Magnetic North Pole shows how magnetic evidence can be used to demonstrate that the continents do indeed move.

Following up the activity:

Although the model becomes complicated, it is possible to split a continent within its journey, e.g. start with Pangaea and then split it into South America and Africa. Using remanent magnetisation, it is possible to work out when the split occurred. It is also possible to use different Plasticine™ colours to represent parts of the crust with the same characteristics (e.g. the same fossils). This will add further elements to the understanding of the theory of plate tectonics.

Underlying principles:

- Most measurements of palaeomagnetism are made on igneous rocks, since they acquire and retain a stronger magnetisation than most sedimentary and metamorphic rocks.
- The latitude of the continent at the time of the formation of these rocks with magnetic minerals is known from this 'frozen' or remanent magnetisation.
- Using this recorded remanent magnetisation, it is possible to construct apparent polar wandering curves for each continent.
- The apparent polar wandering curve shows how the magnetic pole has appeared to move, based on the remanent magnetisation of the rocks. Plate tectonic theory shows that the continents have moved and not the poles. Polar wandering curves are, therefore, excellent evidence for plate tectonic movement.

Thinking skill development:

Pupils can recognise a pattern as they repeat the lines leading to the eventual wandering curve. Cognitive conflict is caused when it is realised that the continents have moved, not the magnetic pole. Metacognition occurs through discussion about what is happening; applying the model to the real situation involves bridging skills.

Resource list:

- Plasticine™
- football
- 2 strings
- coloured pencils or pens

Source:

Devised and translated into English by Simone Tagliati, Institute of Geosciences, University of Campinas (Unicamp), Brazil, with reference to the Earthlearningidea 'Did the continents move for you'.
http://www.earthlearningidea.com/PDF/216_Polar_wandering.pdf