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:-

1. Fix to a flat surface a large piece of white cardboard to represent the Earth's surface flattened out. Mark the modern magnetic North Pole, as illustrated in Step 1 on the diagram opposite and as shown in the completed exercise on page 2.

2. Pin one of the small pieces of coloured card, (a continent), on to the large piece. Mark with red dots any two places on this continent where it has been decided that Cambrian rocks outcrop.

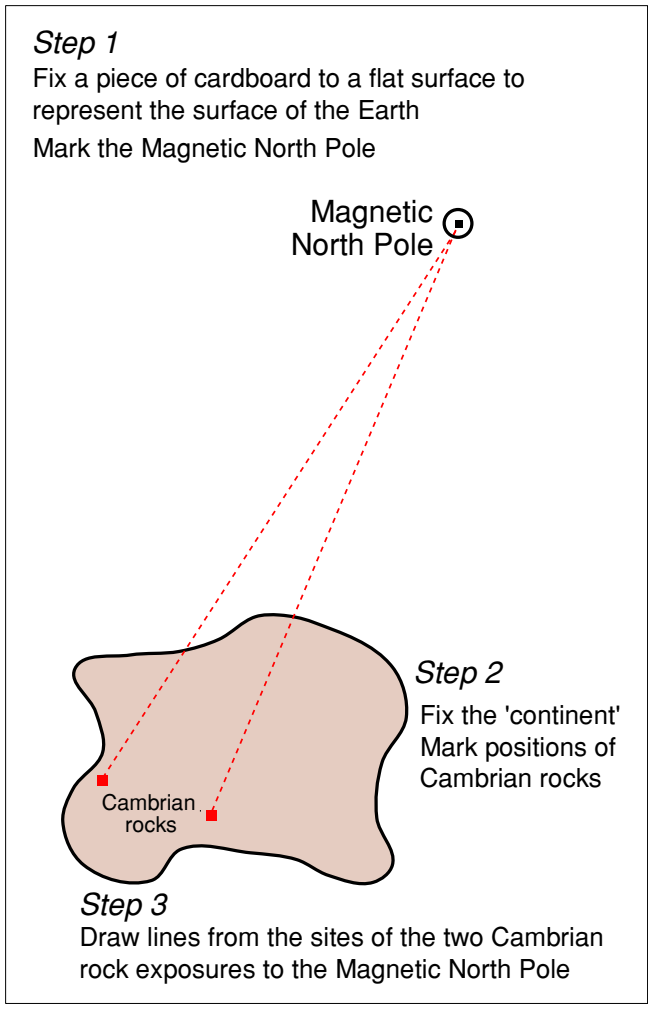
3. Draw two lines from the two red dots, i.e. from the Cambrian rocks on the continent to the magnetic North Pole. This step shows the position of the continent during the Cambrian period, c. 500 million years ago with respect to the Magnetic North Pole. The magnetic field of the Earth was recorded in the magnetic minerals in the rocks that formed at this time. When igneous rocks containing magnetic minerals cool down, their magnetism becomes aligned to the magnetism of the Earth's magnetic field at the time - so most measurements of palaeomagnetism are made on these rocks. The orientation of the continent at the time of the formation of these rocks with magnetic minerals is known from this 'frozen' or remanent magnetisation. Steps 2 and 3 are shown on the illustration opposite.

4. Move the continent to a new location to simulate its plate tectonic movement. Let us suppose that this shows the position of the continent in Cretaceous times, about 100 million years ago. Mark with blue dots any two places on this continent where it has been decided that Cretaceous rocks outcrop. Draw another two lines, in a different colour, from the continent to the magnetic North Pole. This is Step 4 as illustrated in the diagram on page 2.

5. Repeat Step 4 using a third colour, and suppose that this is where the continent is today. Fix the continent here.

6. Now extend the 'Cambrian' lines from the continent until they meet and mark the spot 'Cambrian' magnetic North Pole. Do the same with the Cretaceous lines and mark the spot 'Cretaceous' magnetic North Pole.

7. Connect the points of the Cambrian, Cretaceous and Magnetic North Poles and the pupils have drawn an apparent polar wandering curve.



The apparent polar wandering curve shows how the magnetic pole has appeared to move, based on the remanent magnetisation of the rocks. At one time it could not be decided 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.

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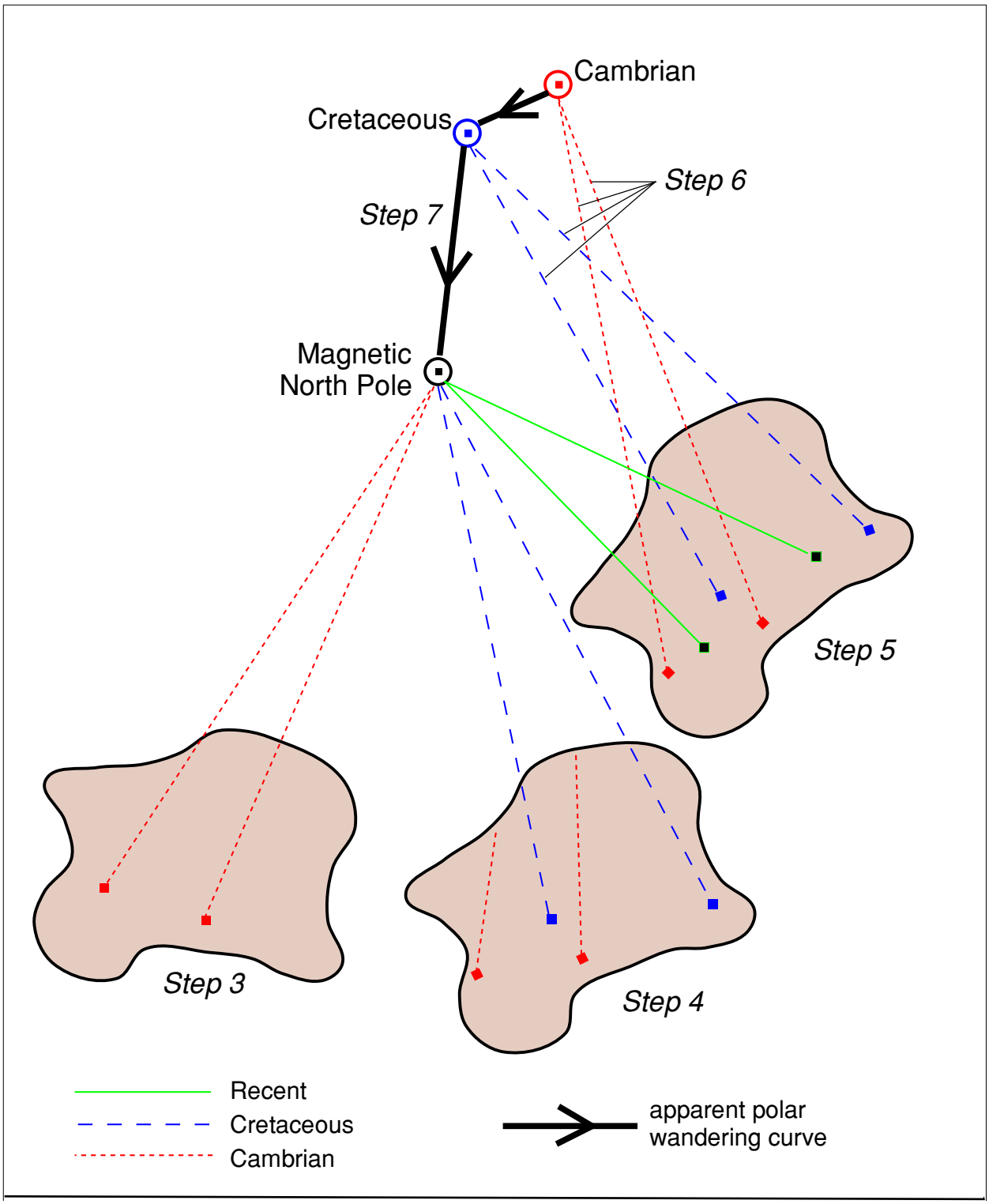
The back up:

Title: 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: 14 - 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;
- by recording this remanent magnetisation, it is possible to construct apparent polar wandering curves for each continent;
- realise that the magnetic pole has not wandered but the apparent curve can be used to determine the position of the continents at the time of the formation of the rocks with the magnetic minerals;
- the apparent polar wandering curves give good evidence for continental drift.

Context: Pupils often ask how scientists know that the continents have moved. This activity about the apparent wandering of the North Pole provides good evidence 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.

Underlying principles:
- When igneous rocks containing magnetic minerals cool down, their magnetism becomes aligned to the magnetism of the Earth's magnetic field at the time - so most measurements of palaeomagnetism are made on these rocks.
- The orientation of the continent at the time of the formation of these rocks with magnetic minerals is known from this 'frozen' or remanent magnetisation
- Many rocks can retain this remanent magnetisation to the present day.
- Using this recorded remanent magnetisation, it is possible to construct apparent polar wandering curves for each continent.
- The apparent polar wandering curves can be used to determine the position of the continents at the time of the formation of the rocks with the magnetic minerals.
- The apparent polar wandering curve shows how the magnetic pole has appeared to move, based on the remanent magnetisation of the rocks. In fact, plate tectonic theory shows that the continents have moved and not the poles. Polar wandering curves are, therefore, excellent evidence for plate tectonic movement.
- The curvature of the Earth has been ignored for the purposes of this activity. When dealing with the real world, either a globe or a suitable map projection must be used.

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:
- large piece of white cardboard c. 30 x 60cm
- 2 or 3 smaller pieces of pale-coloured card, c. 8 x 10cm cut to represent a continent
- coloured pencils or pens
- ruler
- scissors
- drawing pins.

Useful links:
Earthlearningideas:-
http://www.earthlearningidea.com
'Frozen magnetism'
'Magnetic Earth'
'Magnetic stripes'

Source: Adapted by Elizabeth Devon from an article by V.Radhakrishnan, 'Polar wandering on a desk top' Teaching Earth Sciences: vol19, pt.4 (1994).