HARTAI ÉVA,

GEOLOGY

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A Műszaki Földtudományi Alapszak tananyagainak kifejlesztése a TÁMOP 4.1.2-08/1/A-2009-0033 pályázat keretében valósult meg.

V. Seafloor spreading

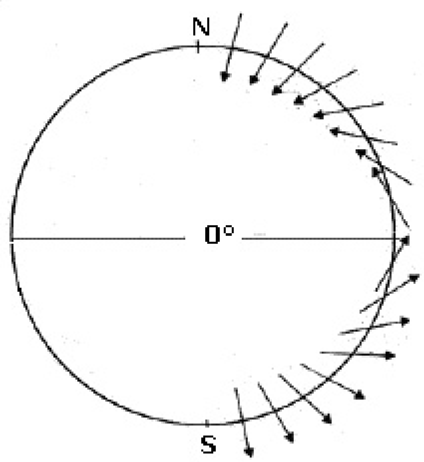
1. The paleomagnetic record

> Wegener died in 1931 and although debate on the theory of continental drift continued, its pace slowed down. A turning point came in the 1950s to the mid-1960s. During this period geophysicists made a number of remarkable discoveries.

It was **paleomagnetism** that brought significant discoveries through the study of the magnetic features of rocks. This method is based on the fact that certain igneous and sedimentary rocks can became weakly magnetized and therefore preserve a fossil record of the Earth's magnetic field at the time and place the rocks formed.

Three essential bits of information are contained in that fossil magnetic record:

- The first is the Earth's polarity – whether the magnetic field was normal or reversed at the time of formation.
- The second is the location of the magnetic poles at the time the rock formed. Just as a free-swinging magnet today will point toward today's magnetic poles, so too does paleomagnetism record the direction of the magnetic poles at the time of rock formation.

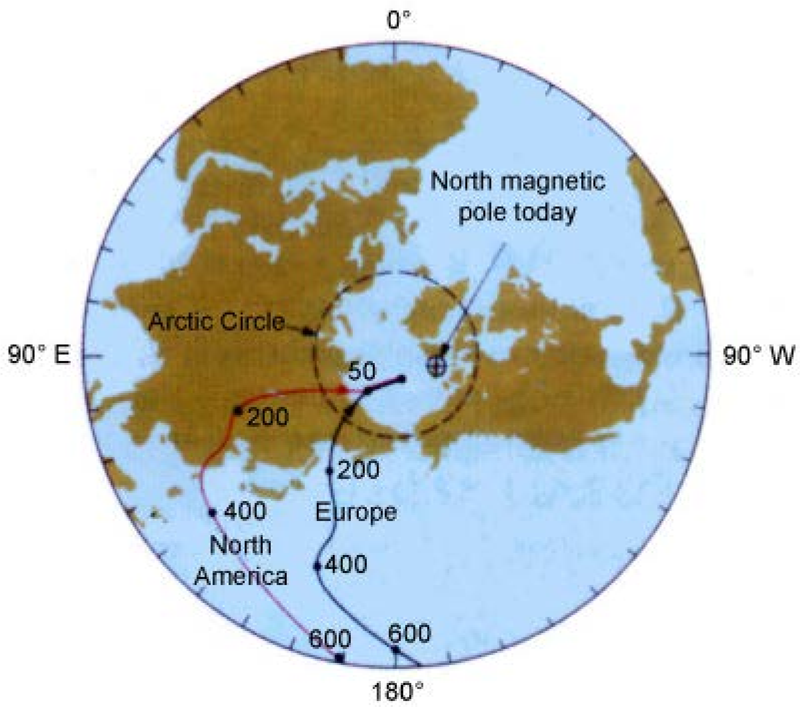


The magnetic inclination related to latitude
By measuring the magnetic inclination it is possible to determine the latitude (distance from equator) at the time of the formation of the magnetic rocks.

The third piece of information, and the one that provides the data needed to say how far from the point of rock formation the magnetic poles lay, is the **magnetic inclination**, which is the angle from the horizontal assumed by a freely swinging bar magnet. The magnetic inclination varies regularly with latitude, from zero at the magnetic equator to 90°at the magnetic pole. The paleomagnetic inclination is therefore a record of the place between the pole and the equator (that is, the magnetic latitude) where the rock was formed.

2. The revival of the theory of continental drift

In the 1950s geophysicists studying paleomagnetic pole positions found evidence that the poles wandered all over the globe. They referred to the strange plots of paleopole positions as **apparent polar wandering**. The geophysicists were puzzled by this evidence, because the Earth's magnetic poles and the poles of rotation are close together.



Results of paleomagnetic measurements in the 1950s
The curves trace the apparent path followed by the north magnetic pole through the past 600 million years. Numbers are millions of years before the present. The curve determined by paleomagnetic measurements in North America (red) differs from that determined in Europe (black). Wide-ranging movement of the pole is unlikely, therefore geologists conclude that it was the continents that moved, not the pole.

Determination of the magnetic latitude at any rock should therefore be a good indication of the geographic latitude at which the rock was formed. When it was discovered that the path of apparent polar wandering measured in North America differed from that in Europe geophysicists were even more puzzled. Somewhat reluctantly, they concluded that – because it is unlikely that the magnetic poles moved – the continents and the magnetized rocks in them must have moved.

In this way the *hypothesis of continental drift* revived, but a mechanism to explain how the movement occurred was still lacking.

3. Paleomagnetism and seafloor spreading

All the early debate about continental drift and even the data on apparent polar wandering had centred on evidence drawn from the continental crust. As the movement of continents started to be accepted, another idea arose – that the oceanic crust could also move.

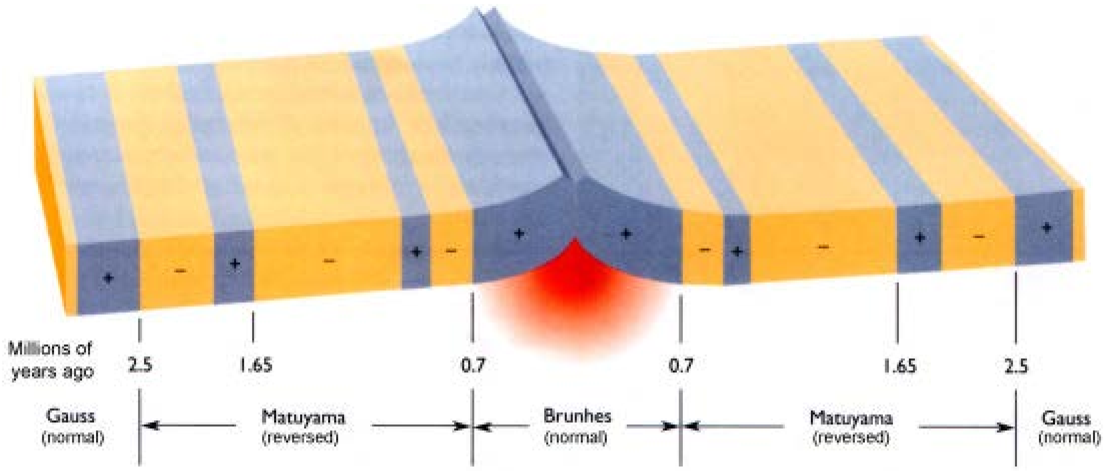
***Harry Hess**, Canadian geophysicist who formed the theory of seafloor spreading.*

In 1962 ***Harry Hess*** of Princeton University hypothesized that the topography of the seafloor could be explained if the seafloor moves sideways, away from the oceanic ridges. His theory came to be called the **theory of seafloor spreading** and was soon proved to be correct by the application of paleomagnetic measurements.

The formation of the oceanic crust

Hess postulated that magma rose from the interior of the Earth and formed new oceanic crust along the oceanic ridges. He could not explain what made the crust move away from the ridges, but he nevertheless proposed that it did and that as a consequence the oceanic crust far from any ridge was older than any crust nearer the ridge. Hess' theory was first confirmed by three Canadian scientists, who took basalt samples from the ocean bottom and found that the oldest rocks were indeed those furthest from the ridge.Spreading and magnetic polarity

When lava is extruded at any mid-ocean ridge, the rock it forms becomes magnetized and acquires the magnetic polarity that exists at the time the lava cools. If new lava is continuously making new oceanic crust and if the crust is continuously moving away from the oceanic ridge, then this crust should contain a continuous record of the Earth’s changing magnetic polarity. The oceanic crust is, in effect, a very slowly moving magnetic tape recorder. In fact, two oceanic tape recorders commence at each mid-ocean ridge, one on each side of the ridge, in which successive strips of oceanic crust are magnetized with *normal and reverse polarity*.



The magnetic polarity of the oceanic crust

Lava extruded along the oceanic ridge forms new oceanic crust. As the lava cools, it becomes magnetized with the polarity of the Earth’s magnetic field. Successive strips of the oceanic crust have alternate normal (blue) and reverse (yellow) polarity. The ages of the reversals are the same in the two sides of the ridge.

It was a straightforward matter to match the sort of magnetic pattern observed with a record of magnetic polarity reversals. The magnetic stripping allowed the age of any place on the seafloor to be determined.

Because the ages of magnetic polarity reversals had been carefully determined *magnetic stripping* also provided a means of estimating the speed with which the seafloor had moved. In some places such movement was found to be remarkably fast: as high as 10 cm/year.