

SEA-FLOOR SPREADING

By the early 1960s it was clear that continental drift occurred - the question was how?

The answers came from work being done in the 1950s and 1960s from on the geology of the sea floor. During this time, precision depths, using echo-sounding to measure the travel time to the bottom of the ocean, allowed the seafloor to be mapped.

Prior to this time, it had been known that there were underwater mountain ranges called "midocean ridges", and very deep regions called trenches, but the overall pattern was unclear.

Once a major portion of the ocean floors had been mapped - some striking patterns were clear. (NVE - 47)

- 1) The midocean ridges often form long continuous mountain chains extending for tens of thousands of kilometers.
- 2) The trenches often do the same. The trenches occur at the edges of continents (like W. South America) or near island chains.

Two other important discoveries were made

- 3) using the newly established world wide network of seismometers, the distribution of earthquakes was mapped. The vast majority were found to occur along the midocean ridges and at the trenches (NVE - 54)
- 4) Heat flow at the midocean ridges was much higher than in the ocean basins (NVE - 55)

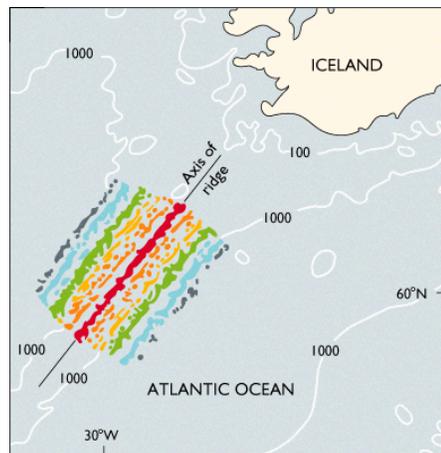
The key to this puzzle was the analysis of the magnetization of the sea floor. Marine geophysicists had been measuring this since the first magnetometers suitable for use at sea were developed in the 1950s. They discovered systematic variations in the amplitude of magnetic anomaly - difference in the earth's field due to the magnetized seafloor. Magnetization could be correlated over large regions: NVE - 60

The basic idea - which we'll discuss in detail, is the root of modern theories of *plate tectonics*. The upper layers of the earth are composed of *plates* of *lithosphere* - a strong material above a weaker *asthenosphere*. The lithosphere "slides over" the asthenosphere

proof - **Vine and Matthews (1963)** used this idea to explain the magnetic anomalies due to seafloor. As the seafloor is formed at the midocean ridge it cools and acquires the magnetization parallel to and proportional to the earth's field at the time. When the *field reverses* material formed then acquires the new field, but previously formed seafloor retains its field. The seafloor is functioning as a tape.

During the time these discoveries were being made, geologists were doing lots of thinking about what they meant.

Hess (1962) in a famous paper called "The History of the Ocean Basins", which he called "an essay of geopoetry" proposed the idea of *seafloor spreading* - the ocean floor acts like a conveyor belt.



The ocean floor is formed at ridges and destroyed at trenches. Therefore, although the rocks of continents may be 4 billion years old, the age of the seafloor is never older than 200 million years since it is being destroyed.

The midocean ridges - SPREADING CENTERS
Trenches - SUBDUCTION ZONES

Why aren't continents subducted - they're less dense than ocean floor and won't sink (granite vs. basalt).
So the ocean floor and continents act as recorders!

Paleomagnetists had established the history of the earth's field - a reversal time scale showing when the field had the present (normal) polarity and when it was reversed. (this was done using volcanic rocks on land and radiometric age dating) NVE - 4-14 (117)

Given the time scale - it was possible to determine how fast the seafloor had spread.

To see this (NVE-33) compare an observed magnetic anomaly profile to one calculated using a computer model of the spreading process: treating the magnetized seafloor as magnetized blocks whose sizes are given by the reversal sequence and spreading rate.

Notice that given a profile over the ridge the spreading rate is approximately symmetric - this is shown by the matched peaks on either side.

The anomaly sequence is known worldwide and anomalies are numbered and assigned ages according to a standard timescale: NVE 117

Notice: anomaly 3 ~5 Ma
5 ~9 Ma
6 ~20 Ma
10 ~30 Ma
20 ~46 Ma
34 ~80 Ma

WARNING:

1) the field reverses at irregular interval so the anomaly numbers aren't linear with age.

2) numbered anomalies indicate recognizable peaks - not all reversals correspond to individual numbered anomalies.

The same anomalies can be recognized in different oceans NVE - 80. Note that different oceans have different spreading rates and that these rates change with time.

The magnetic anomalies allow the age of the seafloor to be found - this has also been tested by the Deep Sea Drilling Project (NVE-85) which drills into the seafloor. The age of the sediment which has been deposited on top of the seafloor can be established from fossils - ages determined this way also increase with distance from the ridge according to the spreading rate. (NVE - 87)