University of Anbar

College of Science

Department of Applied Geology

Tectonics

Title of the lecture

Marine magnetic anomalies and magnetic reversals

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Marine magnetic anomalies and magnetic reversals

Two discoveries provided strong evidence for sea-floor spreading. The first discover was the measured strength of earth´s magnetic field is not the same everywhere in the oceanic basin; the variations are now called marine magnetic anomalies. The second was that earth´s dipole reverses direction every now and then; such sudden reversals of the earth´s polarity are now called magnetic reversals.

Marine magnetic anomalies

Geologist can measure the strength of the earth magnetic field with an instrument called a magnetometer. At any given location on the surface of the earth, the magnetic field that you are measure includes two parts: one that is created by the main dipole of the earth (dipole field) and the another that is created by the magnetism of near-surface rock.

A magnetic anomaly is the difference between the expected strength of the dipole field at a certain location and the actual measured strength of the magnetic field at that location. Places where the field strength is stronger than expected are positive anomalies, and places where the field strength is less than expected are negative anomalies. As a boat cruised along a single traverse, the magnetometer´s gauge would detect strong signals (a positive anomaly) and the weak signals (a negative anomaly) Fig. 1(a). When the data from many traverses was compiled on a map, these marine magnetic anomalies alternating bands. If we color positive anomalies black and negative anomalies white, the pattern made by anomalies resembles the stripes on a candy can Fig. 1(b).

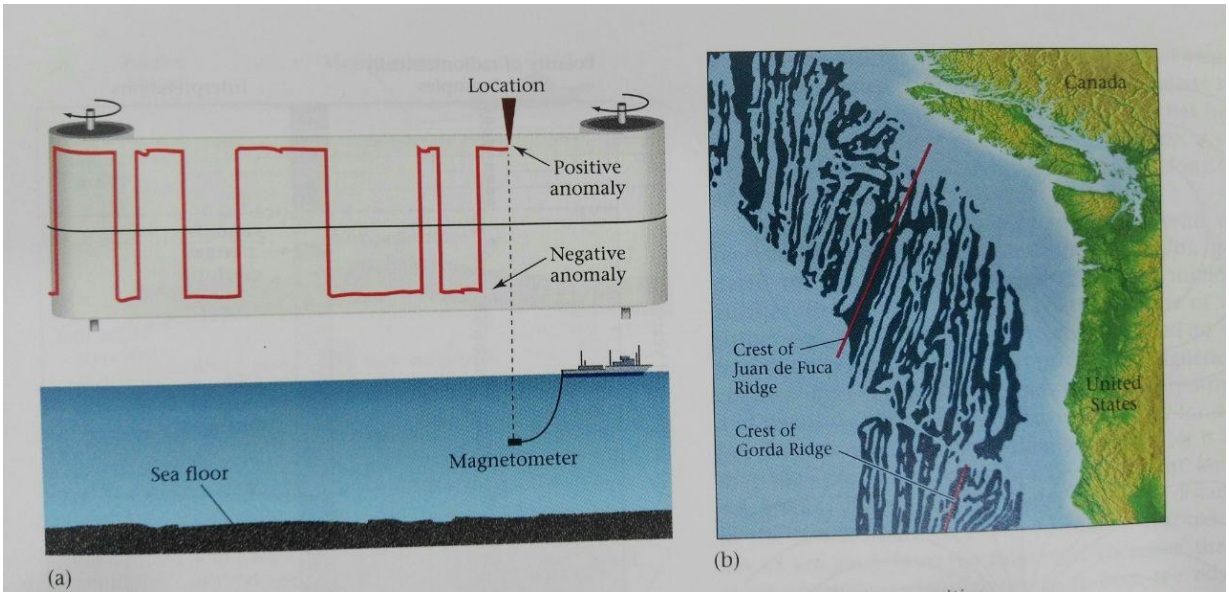

Fig. 1. (a) A ship sailing through the ocean dragging a magnetometer detects first a positive anomaly then a negative one and so on. (b) magnetic anomalies on the sea floor of the northwest coast of the United State

Magnetic reversals

Geologists decided to see if the magnetism of rocks changed as time passed. They measured the paleomagnetism of many successive basalt layers, cooled from lava, that had been erupted by a volcano over a long period of time. They found that the polarity (which end of a magnet points north and which end points south) of the paleomagnetic field of the same layers was the same as that of earth´s present magnetic field, while in other layers it was the opposite. Earth´s magnetic field can be represented by an arrow (dipole) that points from north to south; in some of the lava flows, the paleomagnetic dipole pointed south (these layers showed normal polarity), but in others the dipole pointed north (these layers showed reverse polarity) Fig. 2.

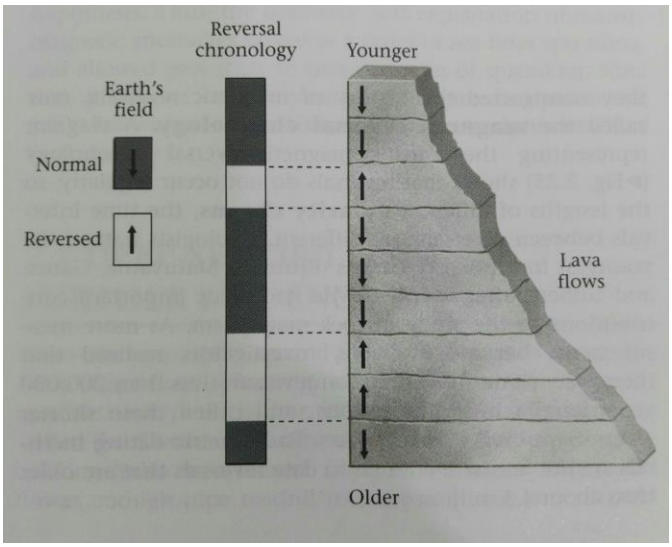

Fig. 2. In a succession of lava flow on land, different flows exhibit different polarity (indicated here by whether the arrow points up or down).

At various times during earth history, the polarity of earth´s magnetic field has suddenly reversed; in other words, sometimes the earth has normal polarity, as it does today, and sometime it has reversed polarity Fig. 3.

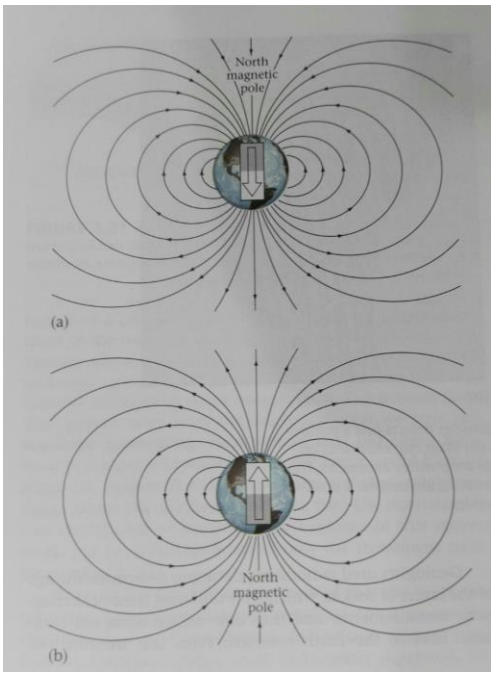

Fig. 3. The magnetic field of the earth has reversed polarity at various times during earth history. (a) if the dipole points from north to south, earth has normal polarity. (b) if the dipole points from south to north, earth has reversed polarity.

Times when the earth´s field flips from normal to reversed polarity, or vice versa, are called magnetic reversals. When the earth has reversed polarity, the south magnetic pole lies near the north geographic pole, and the north magnetic pole lies near the south geographic pole.

The interpretation of marine anomalies

The geologist, Fred Vine, discovered that a positive anomaly occurs over area of sea floor where basalt has normal polarity. In these areas, the magnetic force produced by the basalt adds to the force produced by earth´s dipole and created a stronger magnetic signal than expected, as measured by the magnetometer. A negative anomaly occurs over regions of sea floor where basalt has reversed polarity. Here, the magnetic force of the basalt subtracts from the force produced by the dipole and result in a weaker magnetic signal Fig. 4.

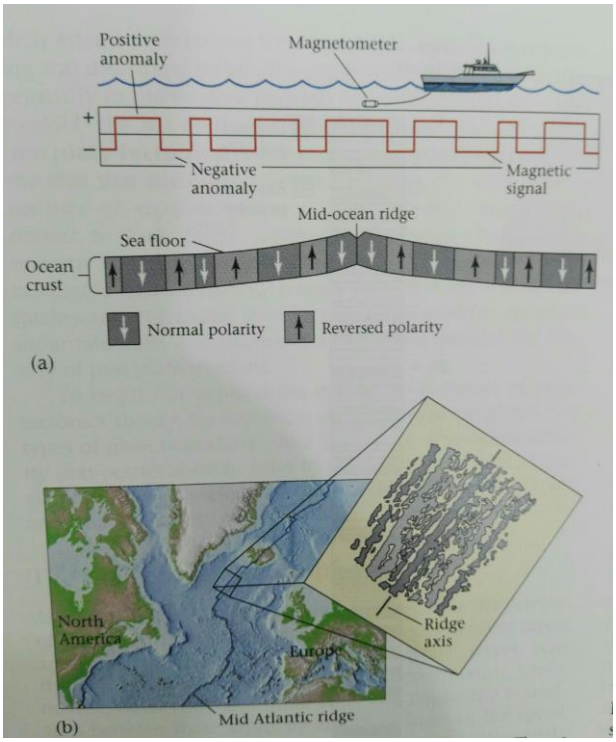

Fig. 4. (a) The explanation of marine anomalies. The sea floor beneath positive anomalies has the same polarity as earth´s field and therefore add to it. The sea floor beneath negative anomalies has reversed polarity and thus subtracts from earth´s field. (b) the symmetry of the magnetic anomalies measured across the mid-oceanic ridge south of Iceland.

Marine magnetic anomalies form as a consequence of sea floor spreading yielding positive anomalies form at times when the earth has normal polarity while sea floor yielding negative anomalies formed when the earth had reversed polarity. The pattern of anomalies is symmetric with respect to the axis of a mid-oceanic ridge Figs. 4 (b) and 5. The magnetic anomaly pattern on one side of a ridge was nearly a mirror image of the anomaly pattern on the other.

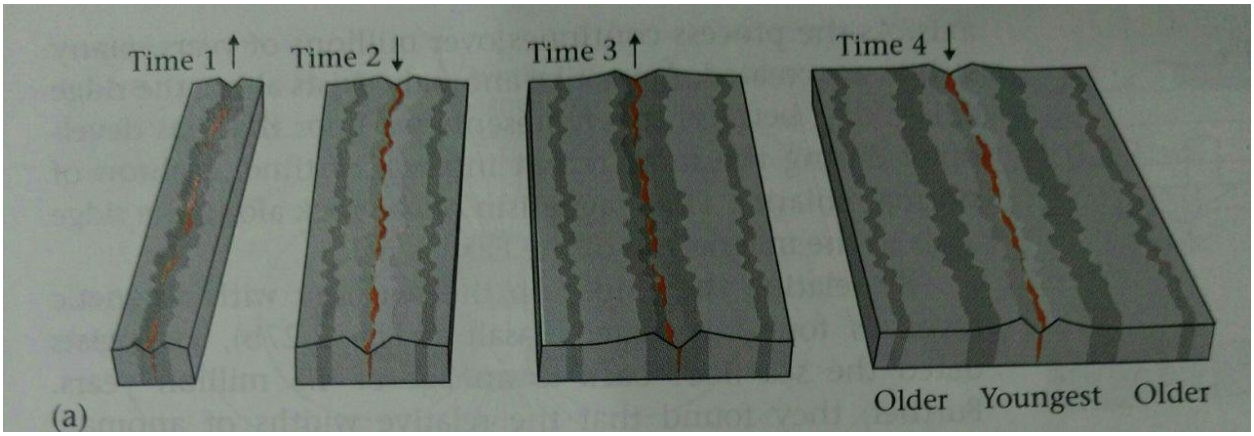

Fig. 5. Theprogressive development of stripes of alternation polarity in the ocean floor. Each time represents a successive stage of new sea floor forming at a mid-oceanic ridge, while earth´s field undergoes magnetic reversals.

The reference

Stephen, M., (2004) Essentials of geology, first edition, printed in United State of America, P 536.