University of Anbar

College of Science

Department of Applied Geology

Tectonics

Title of the lecture

Earth´s magnetic field

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Earth´s magnetic field

The earth has a magnetic field, which deflects the solar wind and traps cosmic rays. The geologists have hypothesized that the field results from the circulation of liquid iron alloy, an electronic conductor, in the earth´s outer core – in other words, the outer core behaves like an electromagnetic. We can image the earth as giant bar magnet, with a north magnetic pole and a south magnetic pole Fig. 1.

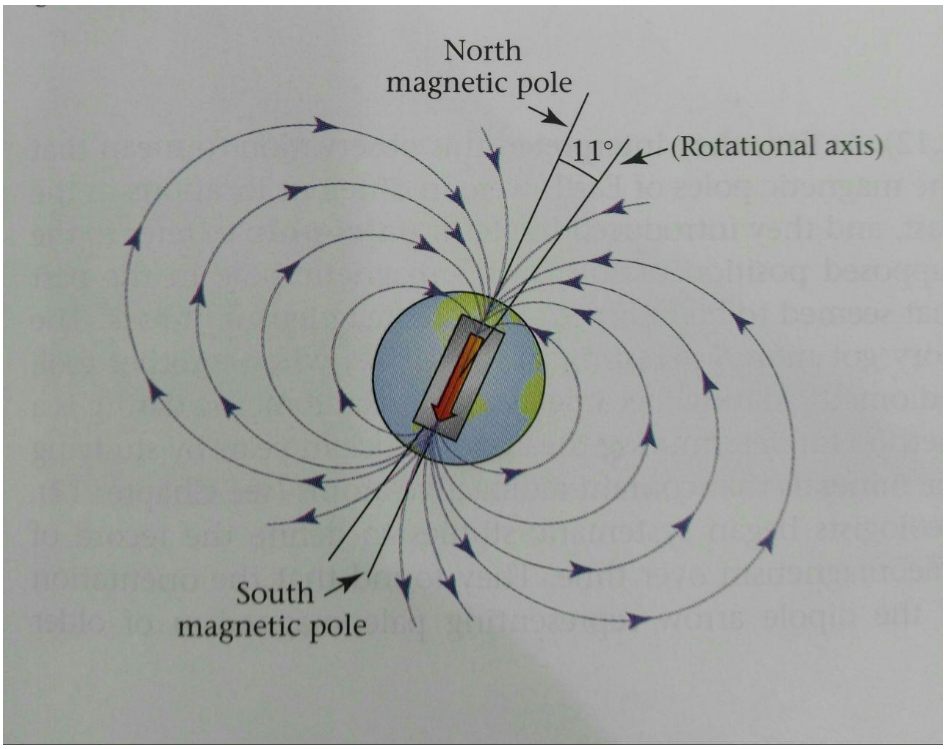

Fig. 1. We can picture earth´ magnetism by imagining that it contains a giant bar magnet. The dipole of this magnet points presently from the north magnetic pole to the south magnetic pole, and it pierces the earth at the magnetic poles. Today, the magnetic poles do not coincide exactly with earth´s geographic poles.

The north – seeking end of the compass points to toward magnetic pole while the south – seeking end points toward the south magnetic pole. We define the dipole of the earth as an imaginary arrow that points from the north magnetic pole to the south magnetic pole, and pass through the planet´s center.

Presently, earth´s dipole tilts at about 11° to the planet´s rotational axis (the imaginary line through the center of the earth around it earth spins). Therefore, the geographical poles of the planet (the places where the rotational axis intersects the earth´s surface) do not coincide exactly with the magnetic poles. For example, the north magnetic pole currently lies in arctic Canada. The compass needle in New York points about 14° west of true north. The angle between the direction that the compass needle points at a given location and the direction to true (geographical) north is called the magnetic declination Fig. 2.

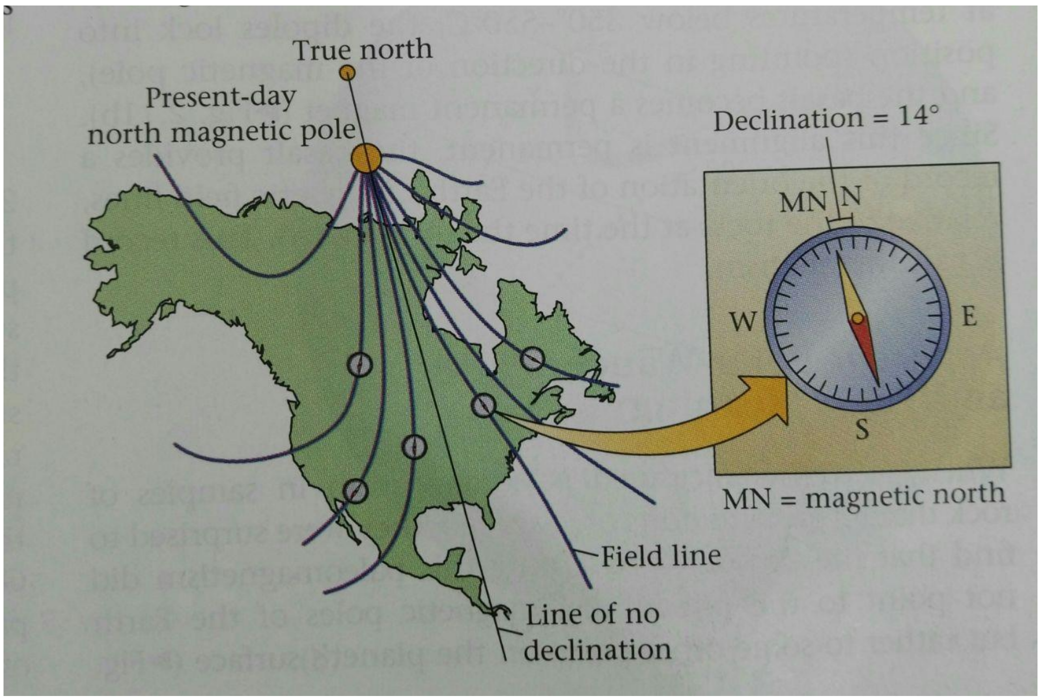

Fig. 2. The projection of magnetic field lines in North America. The lines of the longitudes run north – south, so in most places a compass needle will not parallel longitudes. Note that along circumference that pass through both magnetic north and geographic north, the magnetic declination = 0.

Fig. 3.- shows the magnetic field lines in space around the earth. At the equator the lines parallel earth´s surface; at mid – latitudes the lines tilt at an angle to the surface; and at the magnetic pole the lines are perpendicular to the surface. The compass needle in equator is horizontal, while it tilts at an angle at mid – latitudes whereas at the magnetic poles the needle becomes straight down. The needle´s angle of tilt is called the magnetic inclination.

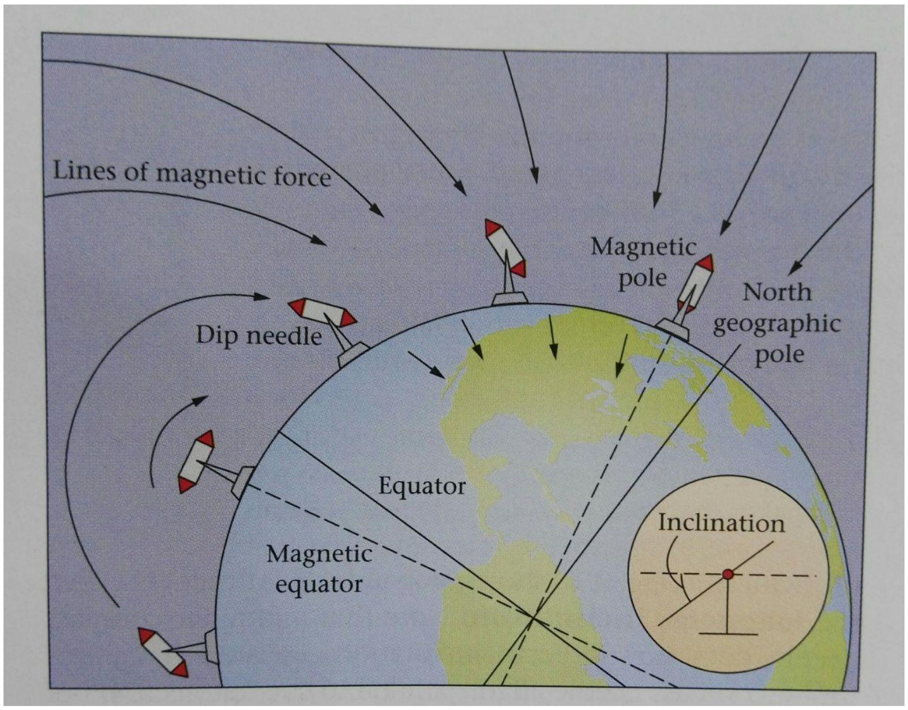

Fig. 3. An illustration of magnetic inclination. A magnetic needle that is free to rotate around a horizontal axis align with magnetic field lines. The angle of tilt depends on the latitude.

How do rocks develop paleomagnetism?

To see how magnetic rocks preserve a record of earth´s past magnetic field, let´s examine one kind of rocks, basalt. Basalt is a magnetite -containing igneous rock forms when lava, flowing out of a volcano, cools and solidifies. When lava first comes out of a volcano, it is very hot (up to about 1200°C), and thermal energy make its atoms wobble and tumble randomly. When this happens, the magnetic force exerted by one atom cancels out the force of another, so the lava as a whole not magnetic Fig. 4(a). However, as the temperature of the lava decreases, basalt rock starts to solidify. As the magnetic crystals in the basalt form and cool (that is, as thermal energy decreases), their iron atoms stop wobbling. The dipoles of all the atoms gradually become parallel with each other and with the magnetic field lines at the location where the basalt cools. Finally, at temperatures below 350° - 550°C, the dipoles lock into position (pointing in the direction of the magnetic pole), and the basalt becomes a permanent magnet Fig. 4(b). since this alignment is permanent, the basalt provides a record of the orientation of the earths magnetic field lines, relative to the rock, at that time the rock cooled. This record is paleomagnetism.

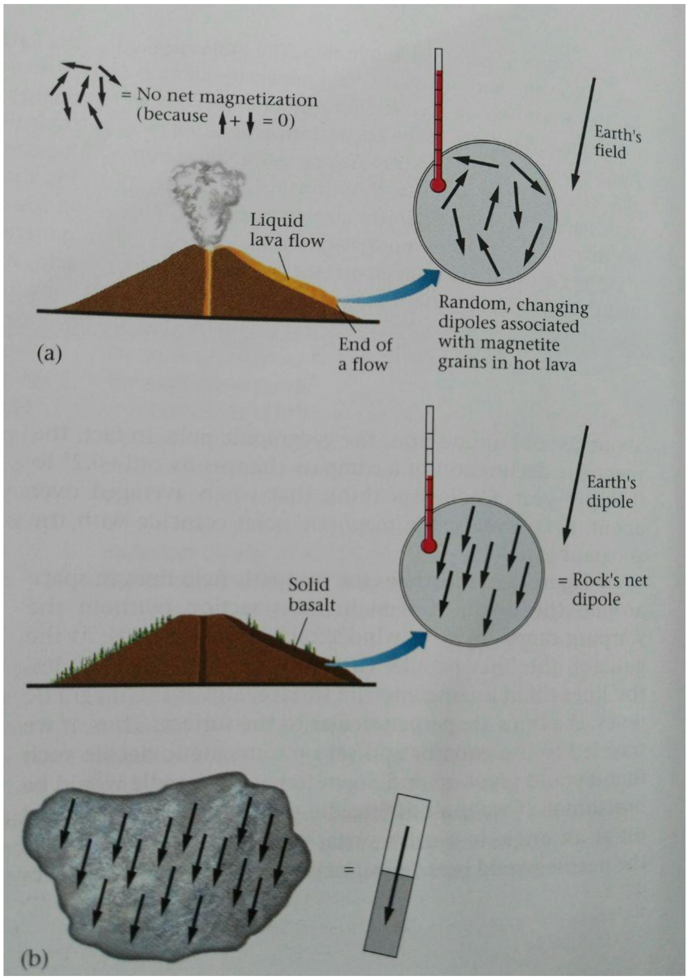

Fig. 4. The formation of paleomagnetism. (a) at high temperatures (greater than 350° - 550°C). (b) as the sample cools below 350° - 550°C.

Sea–floor bathymetry

Since sound waves travel at a known velocity, the time between the sound emission and the detection of the echo defines the distance between the ship and the sea floor (distance = velocity x time). As the ship moves, echo sounding permits observers to obtain a continuous record to the depth of the see floor; the resulting cross section showing depth plotted against location is called a bathymetric profile Fig. 5. By cruising back and front across the ocean many times, investigators obtained a series of bathymetric profiles and from these construction maps of the sea floor. Bathymetric maps revealed several important features of the oceanic floor.

1. Mid – oceanic ridges.
2. Deep oceanic trenches.
3. Seamount chains
4. Fracture zones

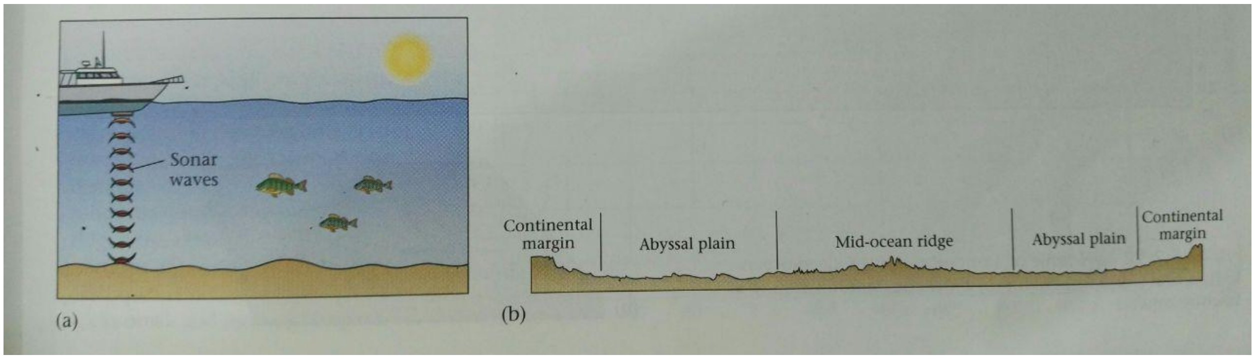

Fig. 5. (a) to make a bathymetric profile, researchers use sonar. (b) an east – west bathymetric profile of the Atlantic Ocean.

The reference

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