Indian Institute of Technology, Kanpur

Department of Earth Sciences

ES0213A: Fundamentals of Earth Sciences

Lecture 09. Concept of Plate Tectonics - II

Santanu Misra
Department of Earth Sciences
Indian Institute of Technology, Kanpur
smisra@iitk.ac.in ● *http://home.iitk.ac.in/~smisra/*

IITK Experimental Rock Deformation Laboratory

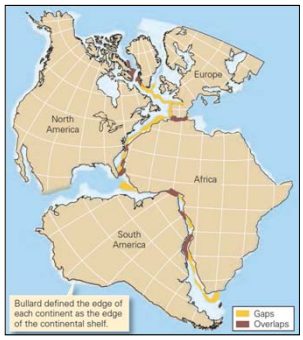
Aims of this lecture

- Palaeo-magnetism & Magnetic Inclinations as an evidence of Continental Drift
- Sea-Floor Spreading
- Scientific evidences of Plate Tectonics

Reference: Chapter 3, Marshak's Book

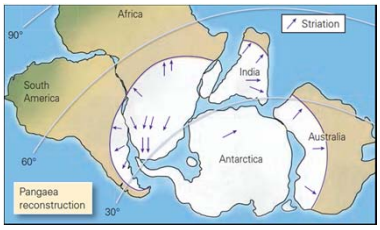
A Quick Review

Wegener Proposed the model of CONTINENTAL DRIFT; suggested a number of convincing evidences, but failed to provide the mechanism of continental drift.

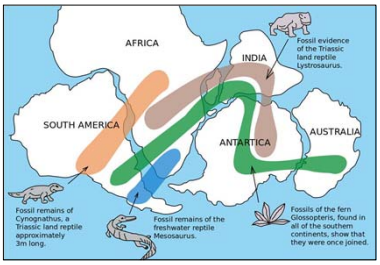


Matching boundaries of the continents

Similar Climatic Zones



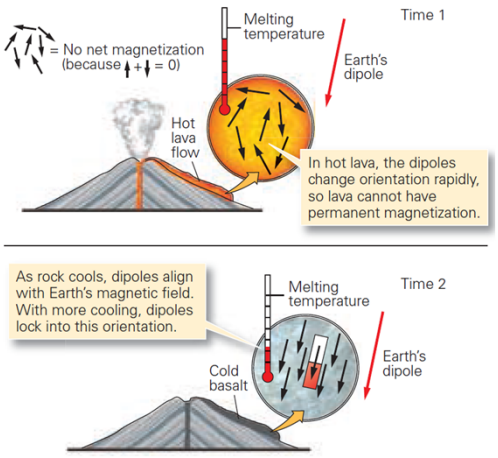
Similar Glacier Deposits



Similar Fossil records

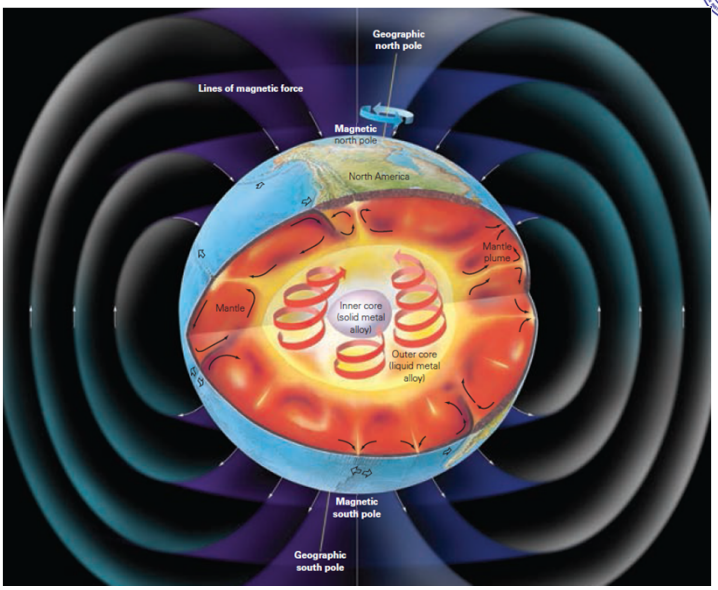
Palaeomagnetism - Introduction

- A few rocks in the Earth contain magnetic minerals (e.g., magnetite). They behave like magnets (strong/weak).
- These magnetic minerals, when crystallize from melt or deposit as sediments, align themselves along the Earth's magnetic field.
- The study of such magnetic behaviour led to the realization that rocks preserve **paleomagnetism**, a record of Earth's magnetic field in the past.
- The understanding of paleomagnetism provided proof of continental drift and, contributed to the development of plate tectonics theory.



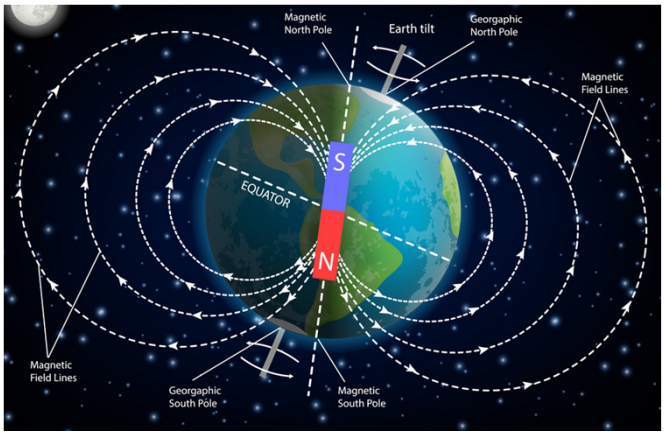
Earth's Magnetic Field

- The circulating liquid outer core (Fe-alloy) is responsible for the Earth's Magnetic field.
- Earth's magnetic field is similar like a bar magnet, which has two ends of opposite polarity – Magnetic dipole.



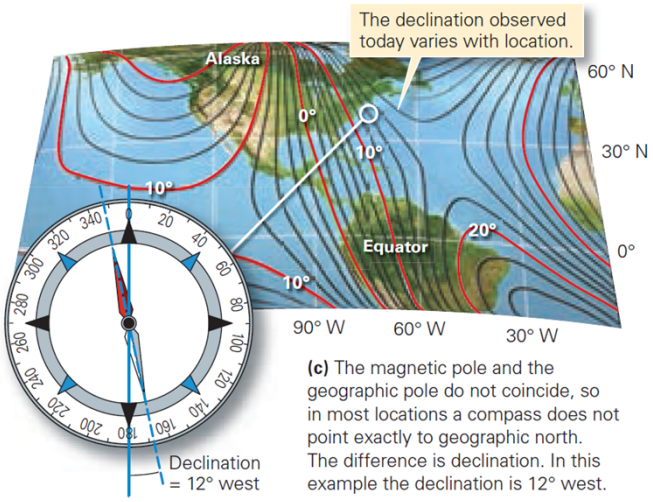
Earth's Magnetic Field

- Earth's dipole intersects the surface of the planet at two points, known as the **magnetic poles**.
- By convention, the north magnetic pole lies at the end of the Earth nearest the north geographic pole (the point where the northern end of the spin axis intersects the surface), so that the north-seeking (red) end of a compass needle points to the north magnetic pole.



Earth's Magnetic Field

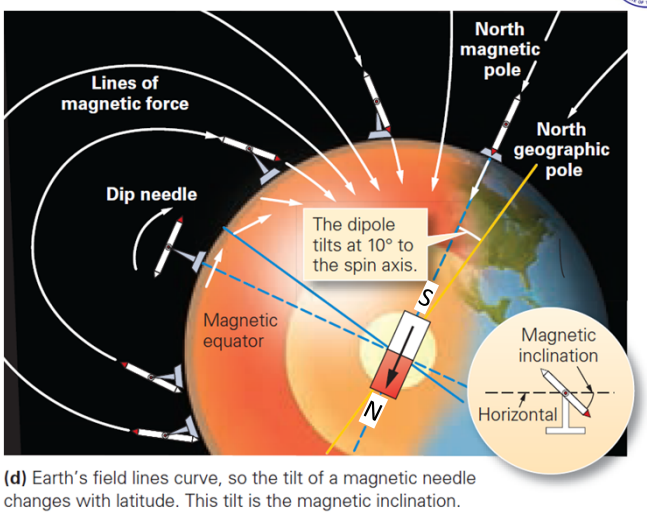
- As the geographic and Magnetic North directions do not coincide, the compass does not point exactly to geographic north. The angle between the direction that a compass needle points and a line of longitude at a given location is the **magnetic declination.** [the magnitude is not constant in time]



(c) The magnetic pole and the geographic pole do not coincide, so in most locations a compass does not point exactly to geographic north. The difference is declination. In this example the declination is 12° west.

Earth's Magnetic Field

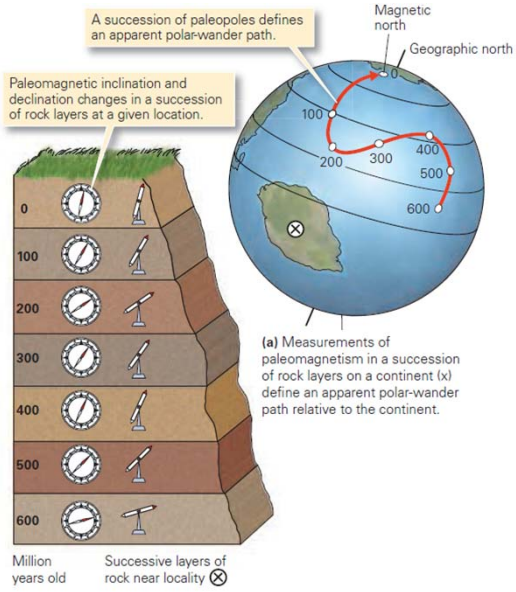
- Magnetic field lines curve through space between the magnetic poles. In a cross-sectional view,
  - Lines lie parallel (horizontal) to the surface of the Earth at the equator,
  - Lines tilt at an angle (inclined) to the surface in mid-latitudes,
  - Lines plunge perpendicular to the surface at the magnetic poles.
- The angle between a magnetic field line and the surface of the Earth, at a given location, is called the **magnetic inclination**.



(d) Earth's field lines curve, so the tilt of a magnetic needle changes with latitude. This tilt is the magnetic inclination.

Palaeomagnetism

- Earth's magnetic field is recorded and permanently stored by the magnetic minerals in rocks
- Geologists found that the paleomagnetic dipole in older rocks doesn't match always with the present day magnetic field. They concluded that the orientation of the Earth's magnetic dipole in the past was much different than it is today and thus that the magnetic poles were not necessarily close to the geographic poles (**Palaeopoles**).
- Geologists measured paleomagnetism in a succession of rocks of different ages from the same general location on a continent, and they plotted the location of the associated succession of paleopole positions on a map. The successive positions of dated paleopoles trace out a curving line that came to be known as an **apparent polar-wander path**.

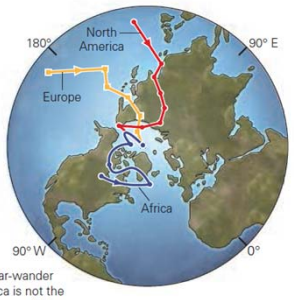


(a) Measurements of paleomagnetism in a succession of rock layers on a continent (x) define an apparent polar-wander path relative to the continent.

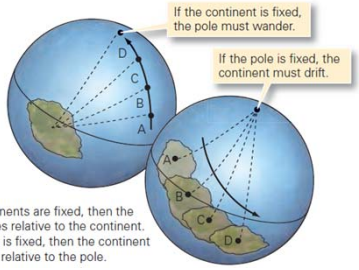
Palaeomagnetism

- Interestingly, it was found the apparent polar wander paths of different continents of same age are different.
  --This challenged the concept of fixed continents
- It's not the pole that moves relative to fixed continents but rather the continents that move relative to a fixed pole.
- Each continent has its own unique polar-wander path, the continents must also be moving relative to one another.

Alfred Wegener was right !! However, the mechanism of the drift was still unknown.



(b) The apparent polar-wander path of North America is not the same as that of Europe or Africa.



(c) If continents are fixed, then the pole moves relative to the continent. If the pole is fixed, then the continent must drift relative to the pole.

Next Lecture

Sea-floor Spreading
and
Plate Tectonics