Geo-magnetic Pole Reversal
or
Those Flipping Poles!

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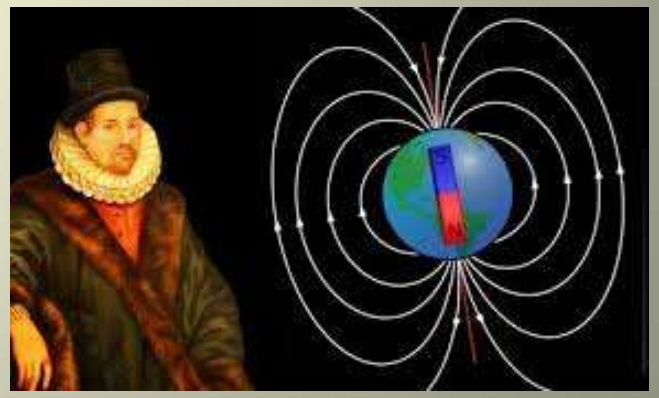
For Halesworth U3A Science Group

Discovering Geo-magnetism
Early Discoveries

- George Hartmann d.1564
  - German engineer and instrument maker
- Robert Norman 1581
  - English mariner and compass maker
  - Wrote pamphlet entitled Newe Attractive, describing the lodestone as a magnet and measured magnetic dip
- William Gilbert 1600
  - First to recognise that earth is magnetic and centre of earth is iron



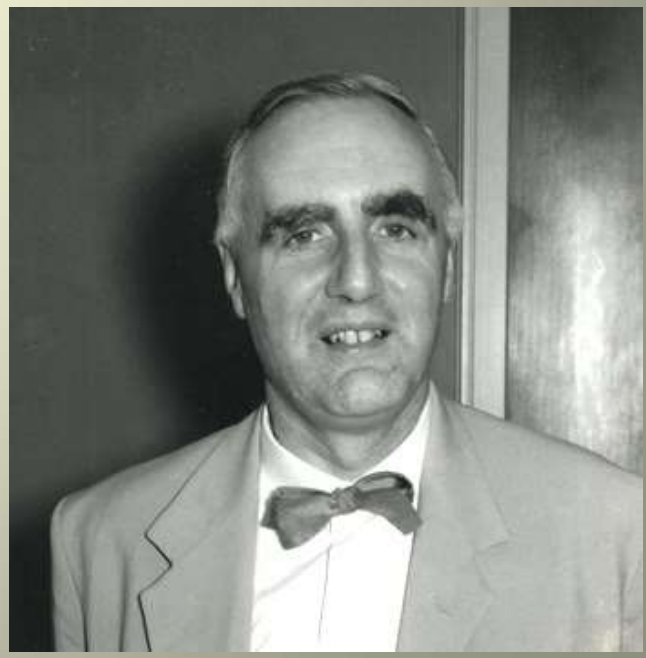
Discovering Geo-magnetism 19th & Early 20th C

- Carl Freidrich Gauss 1831
  - Using first electro magnetic telegraph worked out how to measure earth's magnetic field
- Bernard Bruhnes 1906
  - French geo-physicist wanted to trace differences in strength of earth's magnetic field
  - Known for work on Paleo-magnetism

  First to discover geo-magnetic reversal

Discovering Geo-magnetism 20th C

- Motonari Matuyama 1920s
  - Japanese geologist – followed up Brunhes work
  - First to conduct a disciplined study of the hypothesis that earth's magnetism had reversed
  - Collected basalt specimens
  - Studying marine gravity in submarine, using pendulum
- Edward Bullard 1960s
  - Developed a method for explaining earth's magnetic field
  - Developed method of dating rocks using radio-active decay
  - Thus proving Matuyama's theory



Discovering Geo-magnetism mid 20th C

- Harry Hess and Fred Vine (1960s)
  - Served in navy in WW2 – became fascinated by rocks on sea floor
  - Using echo sounders, discovered mid ocean ridges
  - Measured ages of rocks and their magnetism
  - Joined forces with Vine at Cambridge University – who analysed the data
  - Developed theory of 'sea floor spread'

So, what did these men teach us about the earth and its magnetism?

- Structure of the earth
- What creates the magnetism
- How magnetism protects the earth
- How the continents move around

BUT

What causes the poles to flip?

Structure of the Earth

Formation of Earth

- 4.5 billion years ago – uniform ball of hot rock
- 500 mya earth heated beyond melting point of iron – Iron Catastrophe
- Formed Outer Core, Inner Core and recently discovered Inner Inner Core
- Convection currents in fluid Outer Core are source of earth's magnetic field

Chemical Composition of Earth

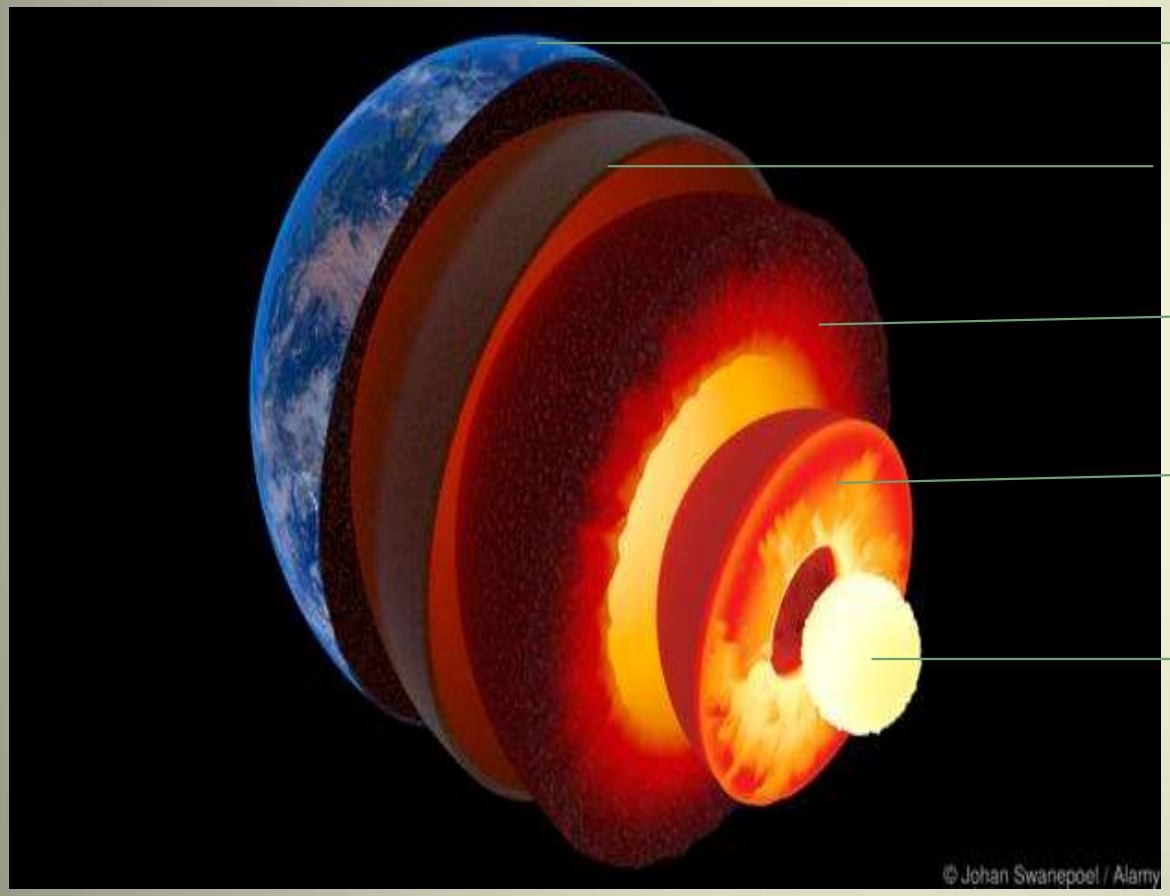
Lighter metals and minerals in mantle:

- Magnesium, aluminium, silicon, oxygen
- Calcium, sodium

Metals in the core:

- Elements dissolved in iron called siderophiles – gold, platinum and cobalt
- Iron and Nickle (NiFe)
- Sulphur – 90% found in earth's core

How is Magnetism Created ?



Crust or Lithosphere

Outer mantle or Athenosphere

Inner mantle

Liquid core – nickel iron

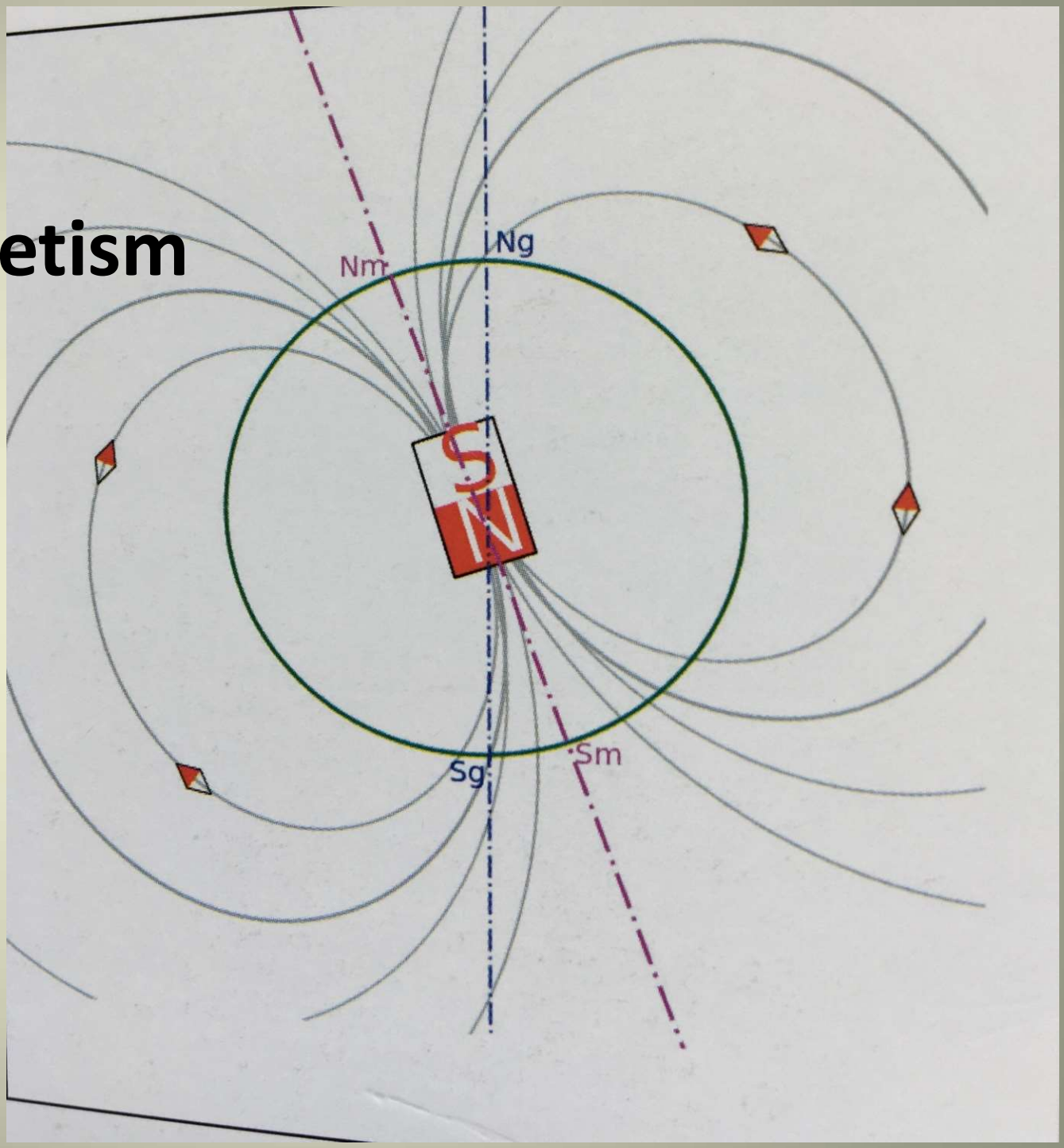
Solid iron core

Glatzmaier and Roberts (1995)– used computer modelling to speed up movement inside centre of earth to represent 500,000 years

Earth's magnetism

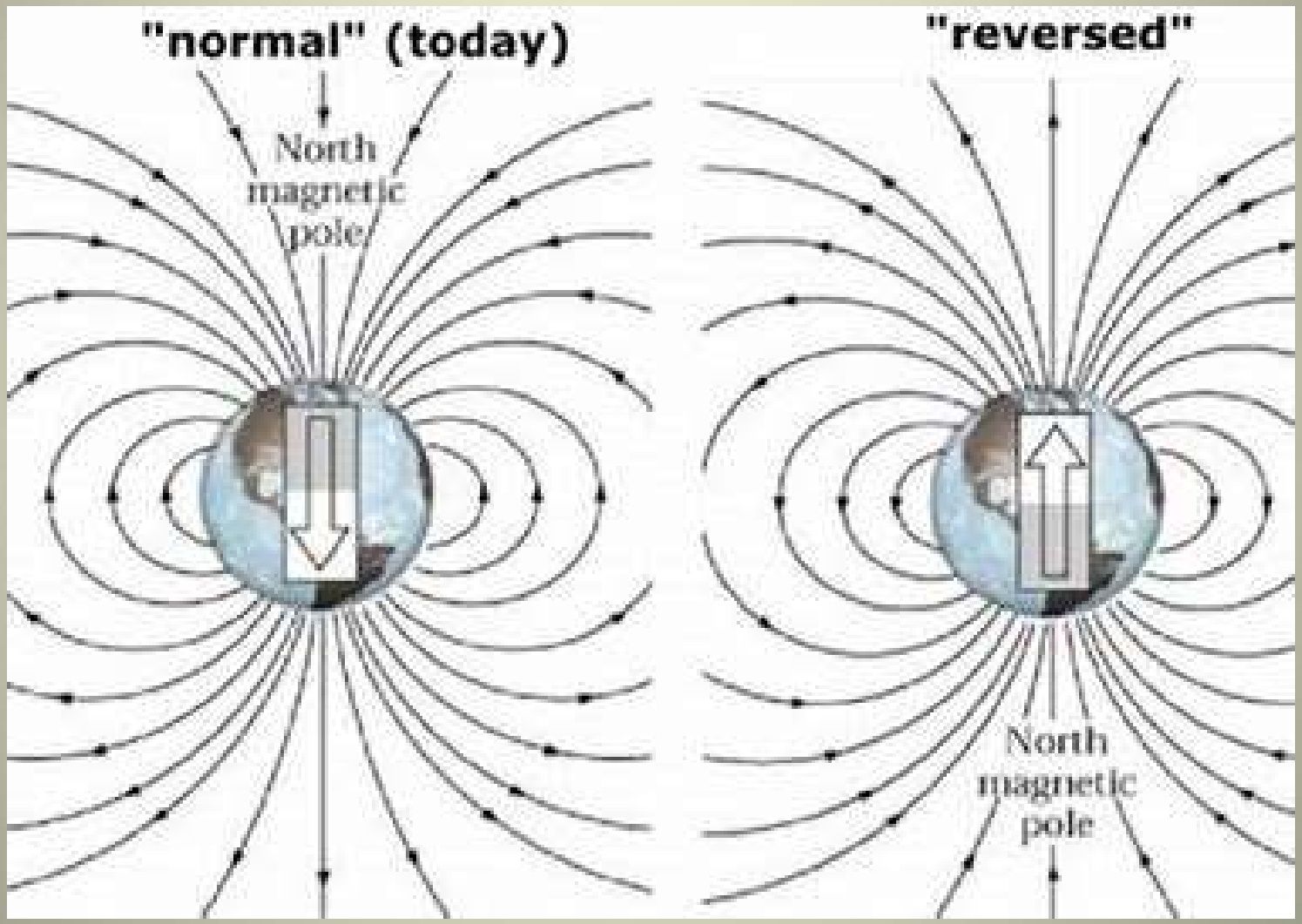
Geographic N / S poles form the axis of rotation. Whereas magnetic N / S poles are variable

Earth is a bar magnet with 2 poles
Note behaviour of Magnetism:
North pole at southern end of magnet,
ions drawn into northern end

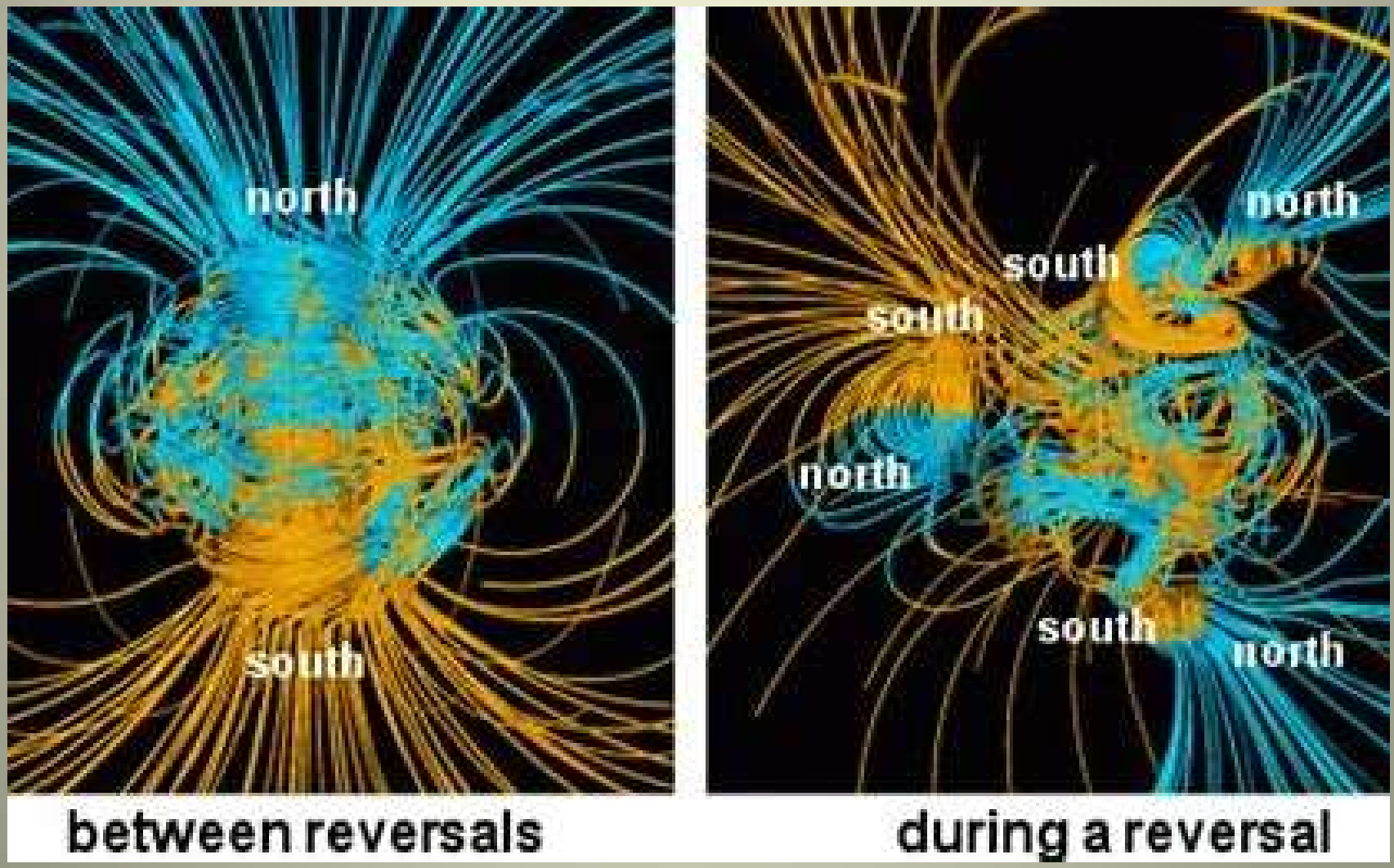


Source: Planet Earth Manual p94

Earth's magnetic fields



Convolutions of magnetic fields as Poles reverse



How the Continents are moved

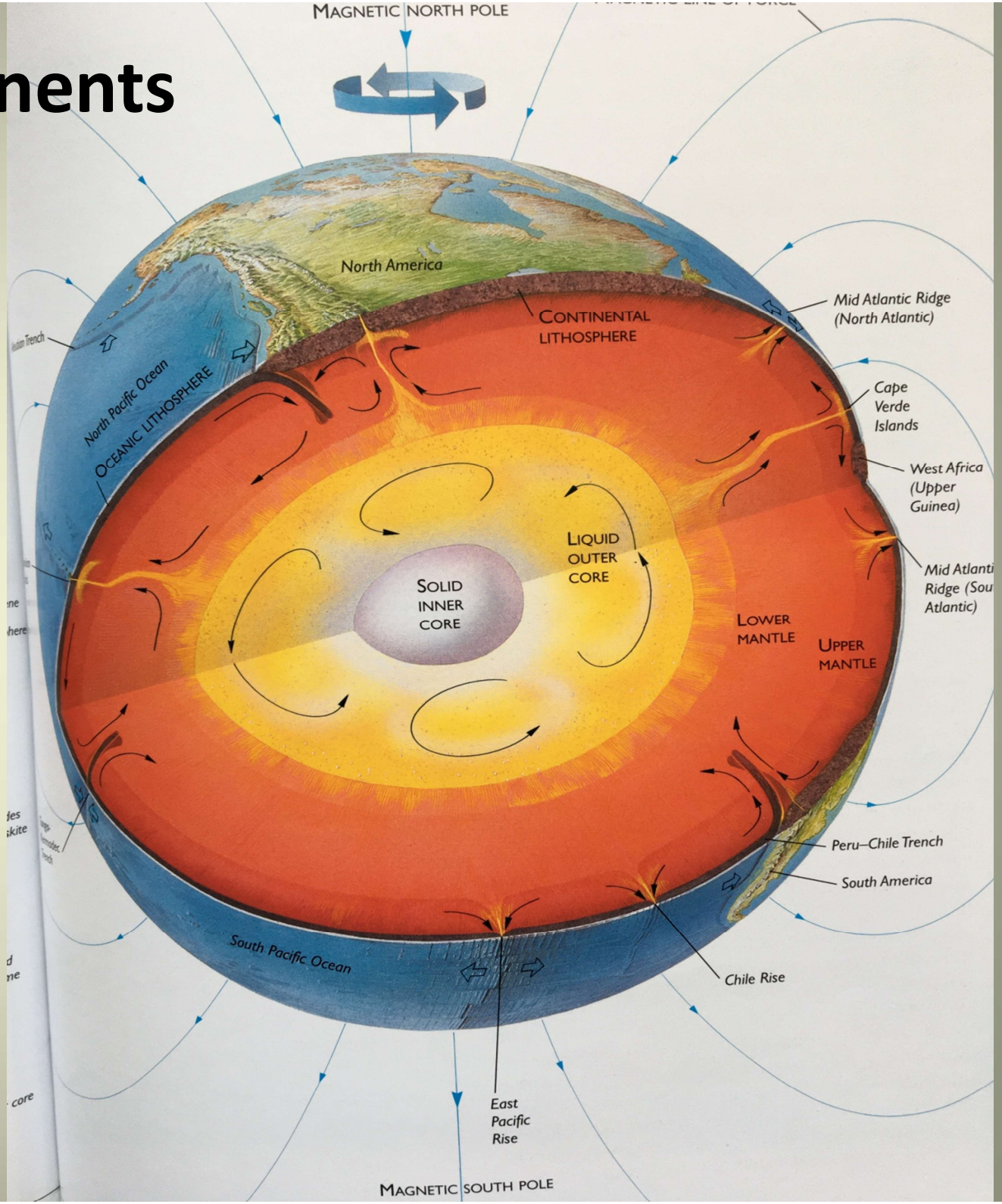
Turbulence within the outer core

Convection currents create turbulence and generate electrical impulses which result in magnetism

Sea floor spread

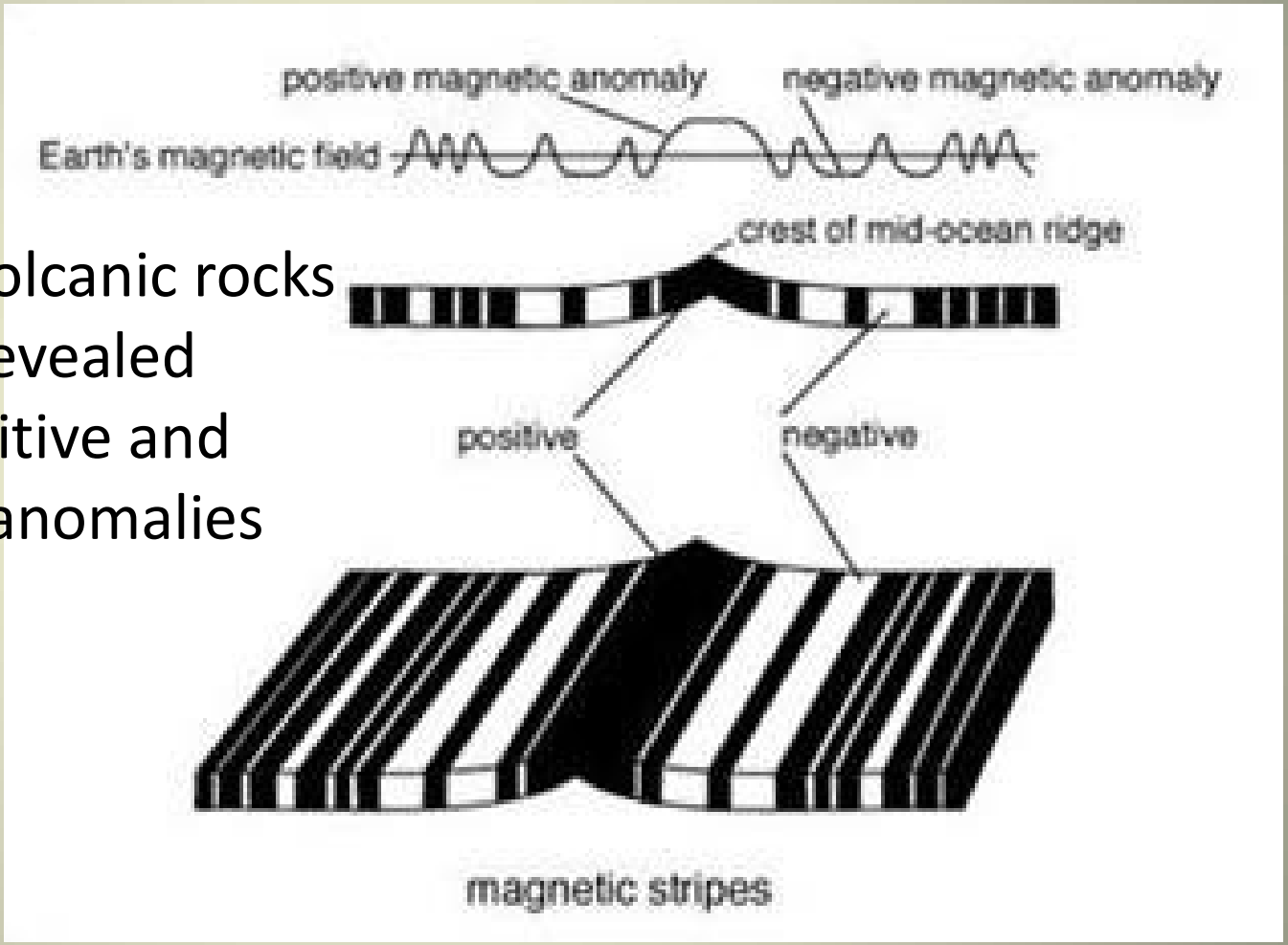
By mid ocean eruptions:
Iceland and Hawaii
And continental subduction zones:
Peru – Chile trench
Tonga – Kermadec trench

Earth Story p97



Discovering concrete evidence that the poles have flipped

Hess's surveys of volcanic rocks on the ocean bed revealed parallel lines of positive and negative magnetic anomalies



How frequently have they flipped?

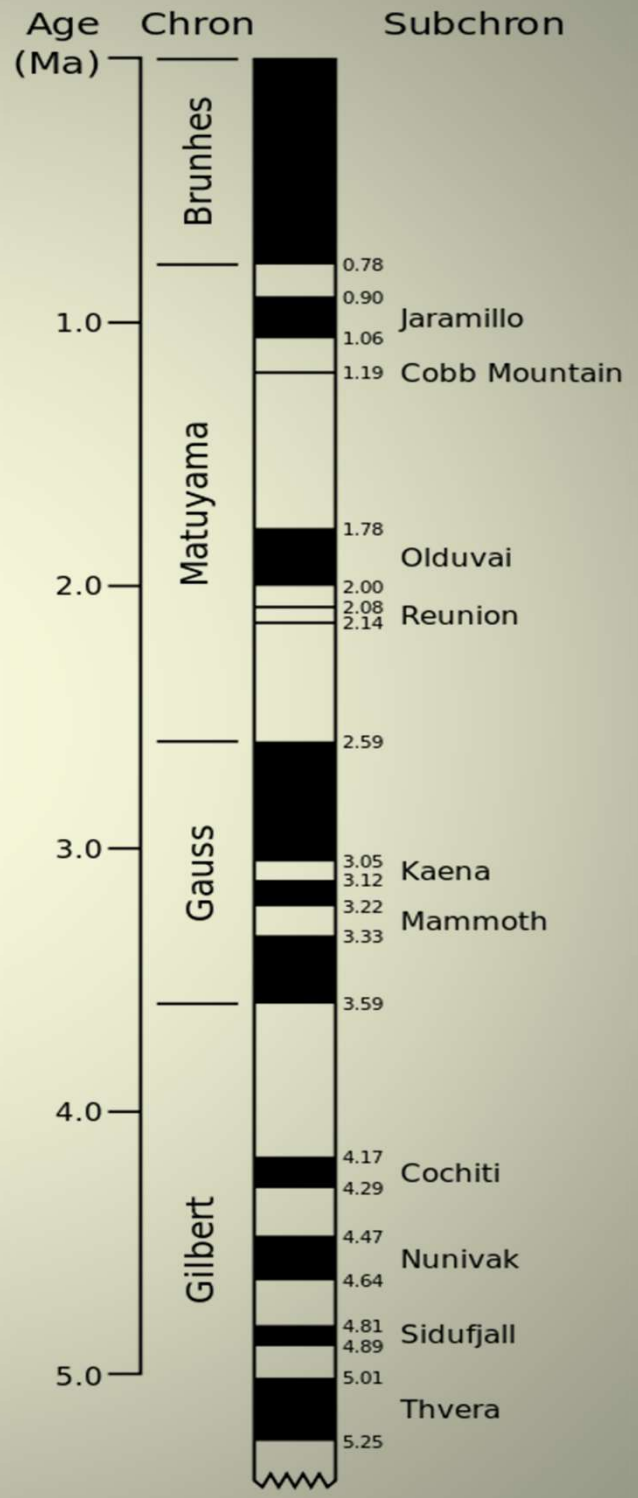
- First thoughts – every million years
- Now – random
  - Last reversal 780k ya; average 450 k
- Chrons , Superchrons and Subchrons
- Excursions
  - Magnetism in outer core changes while inner core remains the same
  - Occur when changes in magnetism occur for shorter periods of time

Chrons, Superchrons and Subchrons

Chron is the period of time when earth's polarity is stable ie. Between one switch and the next.
Superchron is a period of time when there is no change in polarity for more than 10m years
Subchron is a short period of reversal of less than 0.1 m years

Geomagnetic polarity during the last 5 million years (Pliocene and Quaternary, late Cenozoic Era).
Frequency of changes has slowly increased

United States Geological Survey



Periodicity of Reversals

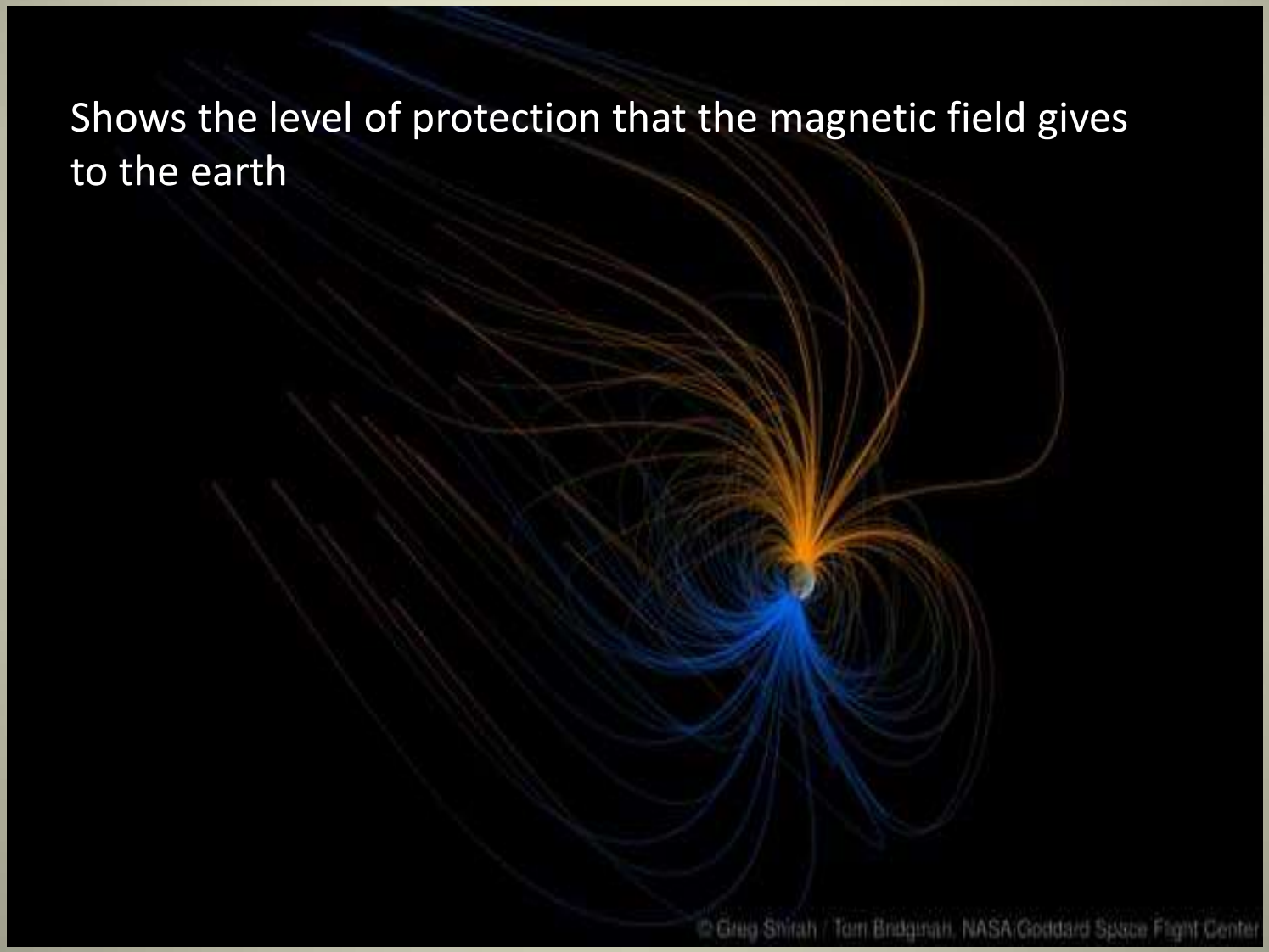
Million years ago	Geological period	Period of time	Number of reversals
54 Ma	Eocene	4m years	10
42 Ma	Oligocene	3m years	17
24 Ma	Miocene	3m years	13
15 Ma	Miocene	12m years	51

Periodic Excursions and minor movements in polarity

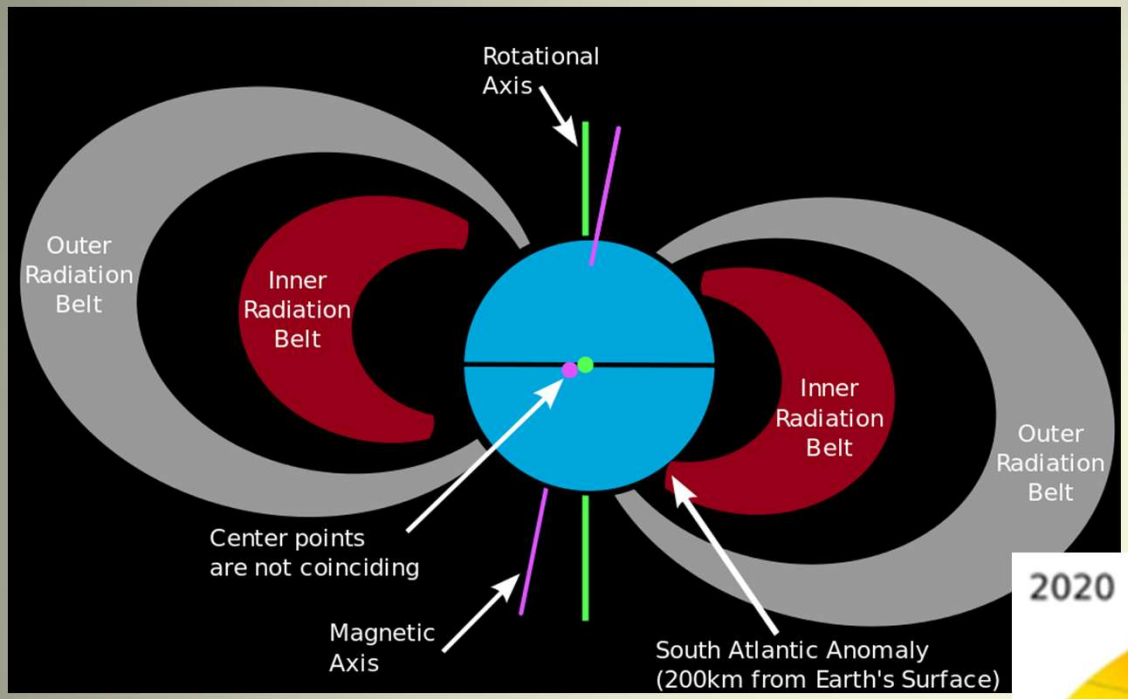
- Occur when magnetism begins to change, but stops
  - Caused by Outer Core reversing its magnetism while Inner Core remains the same
- Variations in declination between true north and magnetic north in recent history
  - 1580 – 11 degrees E of N
  - 1660 – due N
  - 1820 – 24 degrees W of N
  - 1970 – 7 degrees W of N
  - 2019 – due N
  - Currently moving at 40 miles per year

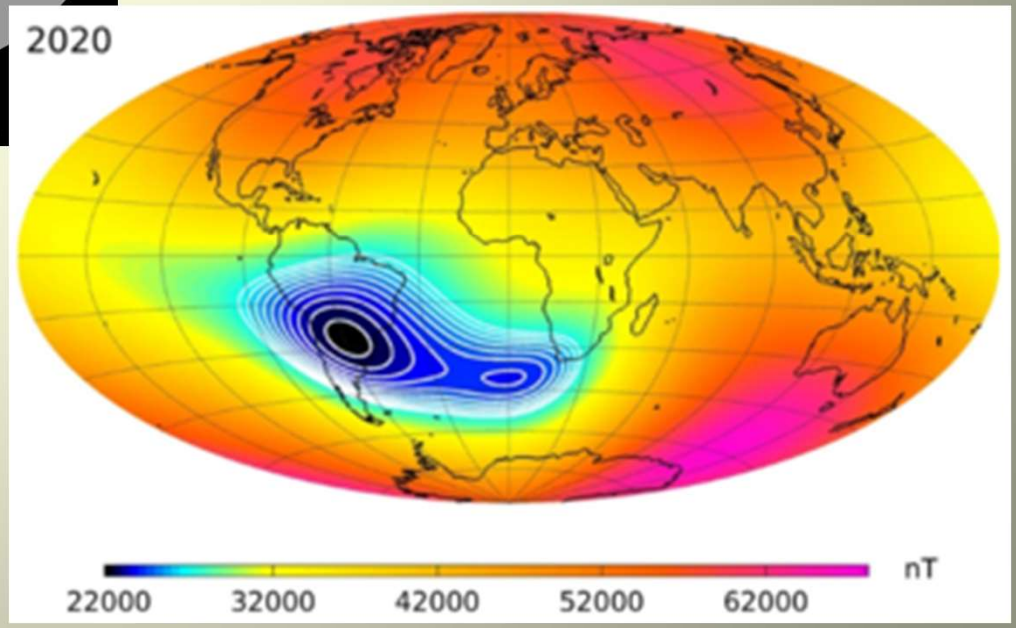
Earth’s magnetosphere

Shows the level of protection that the magnetic field gives to the earth



Van Allen belts and South Atlantic Anomaly





Are there links between polar flips and extinctions?

- Several research projects investigating this possibility
- Laschamps Excursion 42 – 40 k ya: time of demise of Neandertals
  - Study of carbon dating of ancient kauri trees in NZ
  - Solar activity at a minimum
  - Evidence in cave art indicate an increase in cave dwelling
  - Increase in red ochre handprints – can be used as sunscreen

NZ Kauri trees

What could be the impact on the modern world ?

- https://www.businessinsider.com/earth-north-south-poles-flip-magnetic-field-2018-4?r=US&IR=T