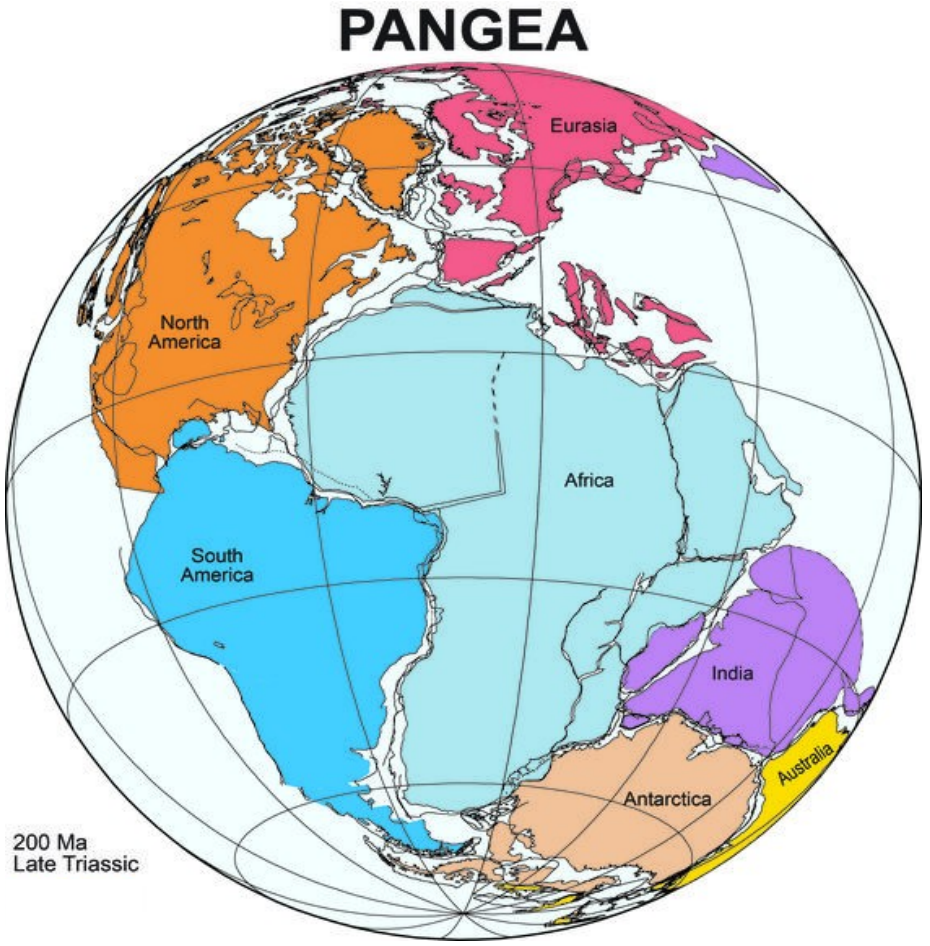
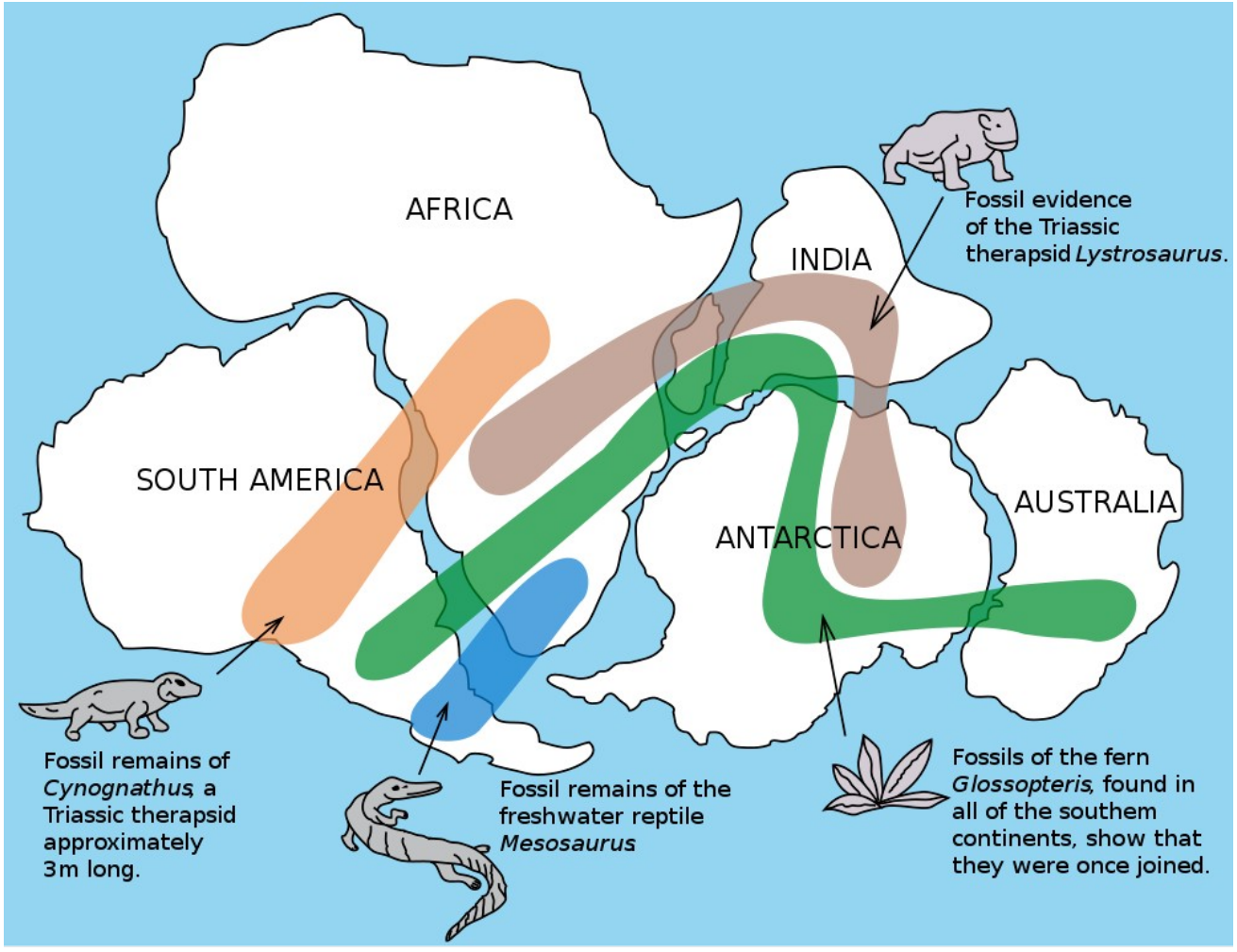
Break-up of Pangea

Rifting-drifting between NS & NW Africa (last 250 million years ago: Triassic-Present)

Hidden force of Magnetism

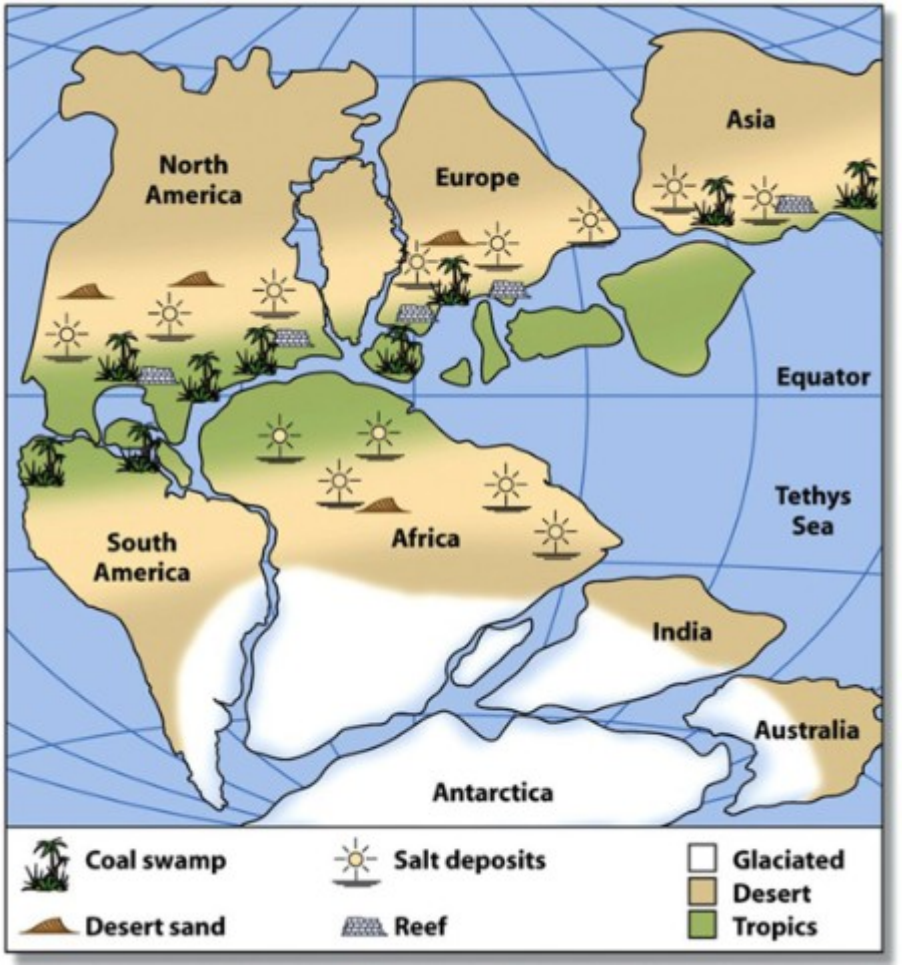


Pangea was initially reconstructed by closing the oceans using the conjugate geometry of their shared continental margins.
The discovery of magnetic stripes in the oceans in the 1950's provided an alternative, more accurate and age-controlled, method of closing the oceans.



Some land animals and plants have been found on continents now separated by oceans (coloured bars show such animals & plants that span Pangea)

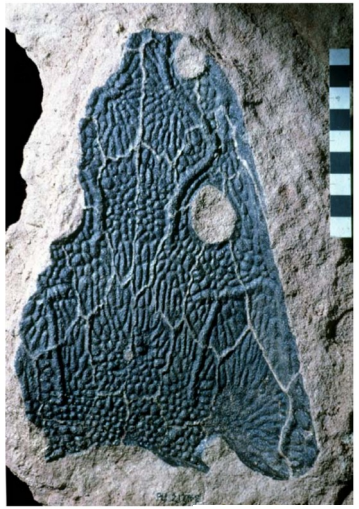
Public domain by Osvaldocangaspadilla in WikiCommons; derived from USGS

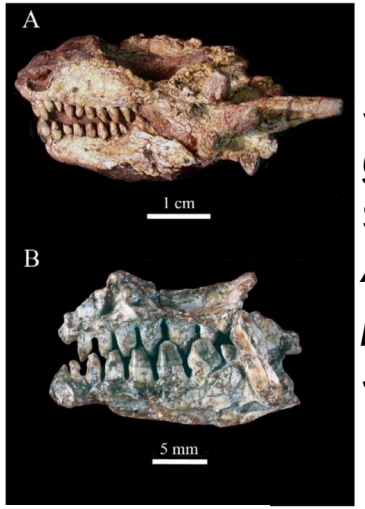


Latitudinal climactic belts, e.g. glacial (till), deserts (sand dunes), tropical (coal+reefs) plotted on Pangea reconstruction.

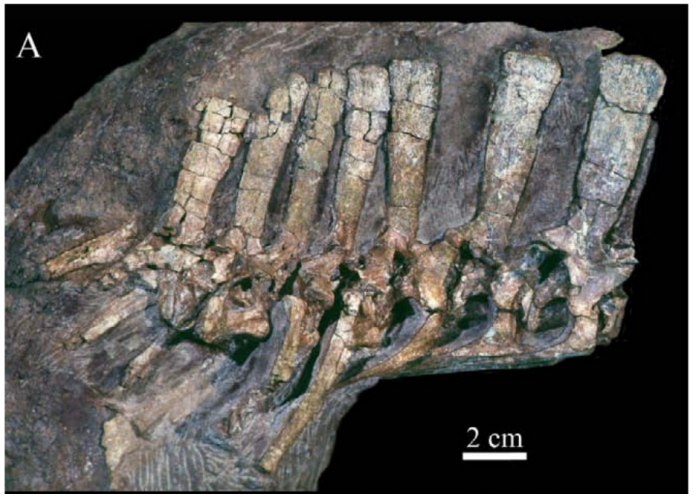
https://www.d11.org/site/handlers/filedownload.ashx?moduleinstanceid=21477&dataid=34024&FileName=Continental%20Drift%20and%20Plate%20Techtonics.pdf

Triassic fossils





Procolophonid Parareptiles: *Scoloparia glyphanodon* skull and *Acadiella psalidodon* Jaw Evangeline Beach Member Wolfville Formation



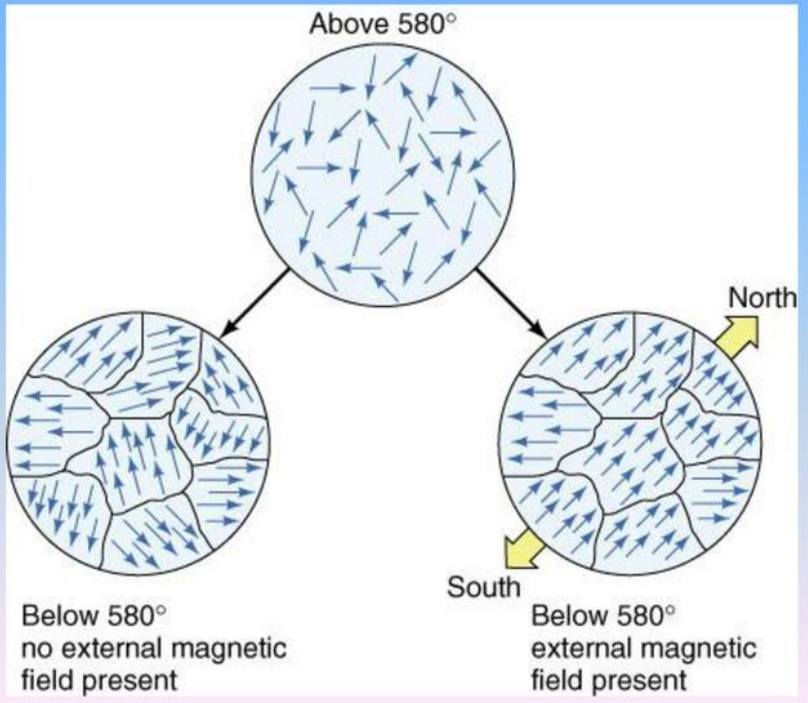
Pseudosuchian archosaur: Evangeline Beach Member of Wolfville Formation

Sues & Olsen 2015

Metoposaurus Bakeri: back surface of skull: Evangeline Beach Member Wolfville Formation

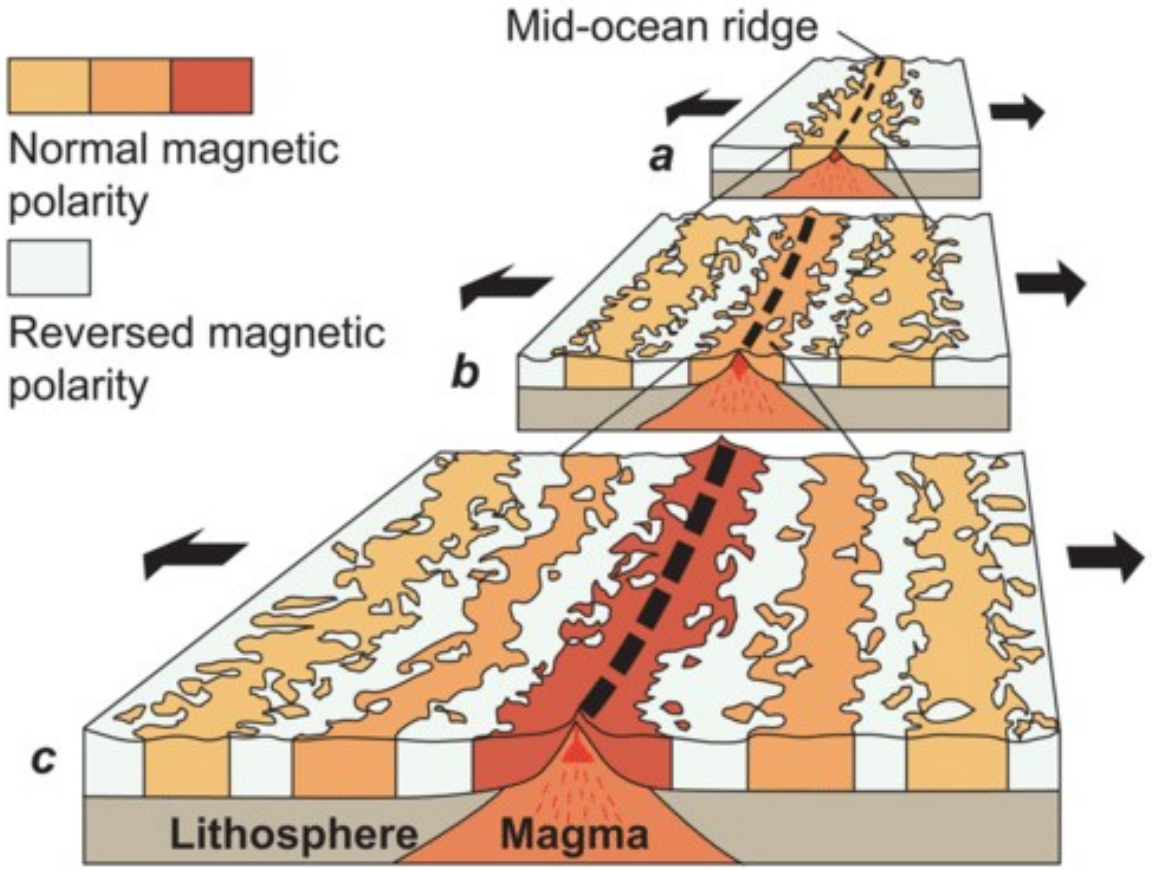
Dinosauromorph Footprint: Blomidon Formation

- As the lava hardens, the ***magnetic orientation*** is preserved and provides a record of the current Earth's magnetic field.



http://www.mrsciguy.com/EarthScience/magnet.html

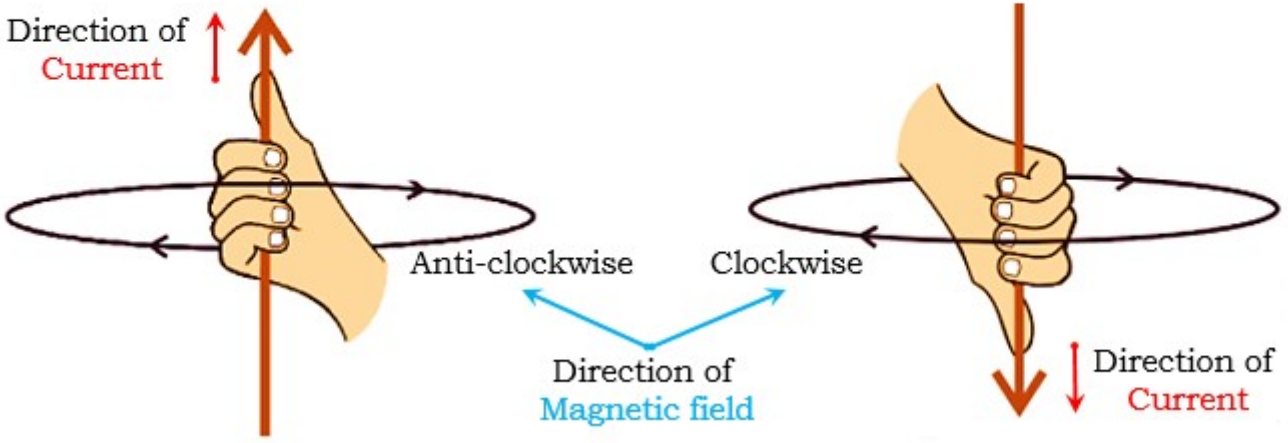
Magnetic bands in the ocean floor

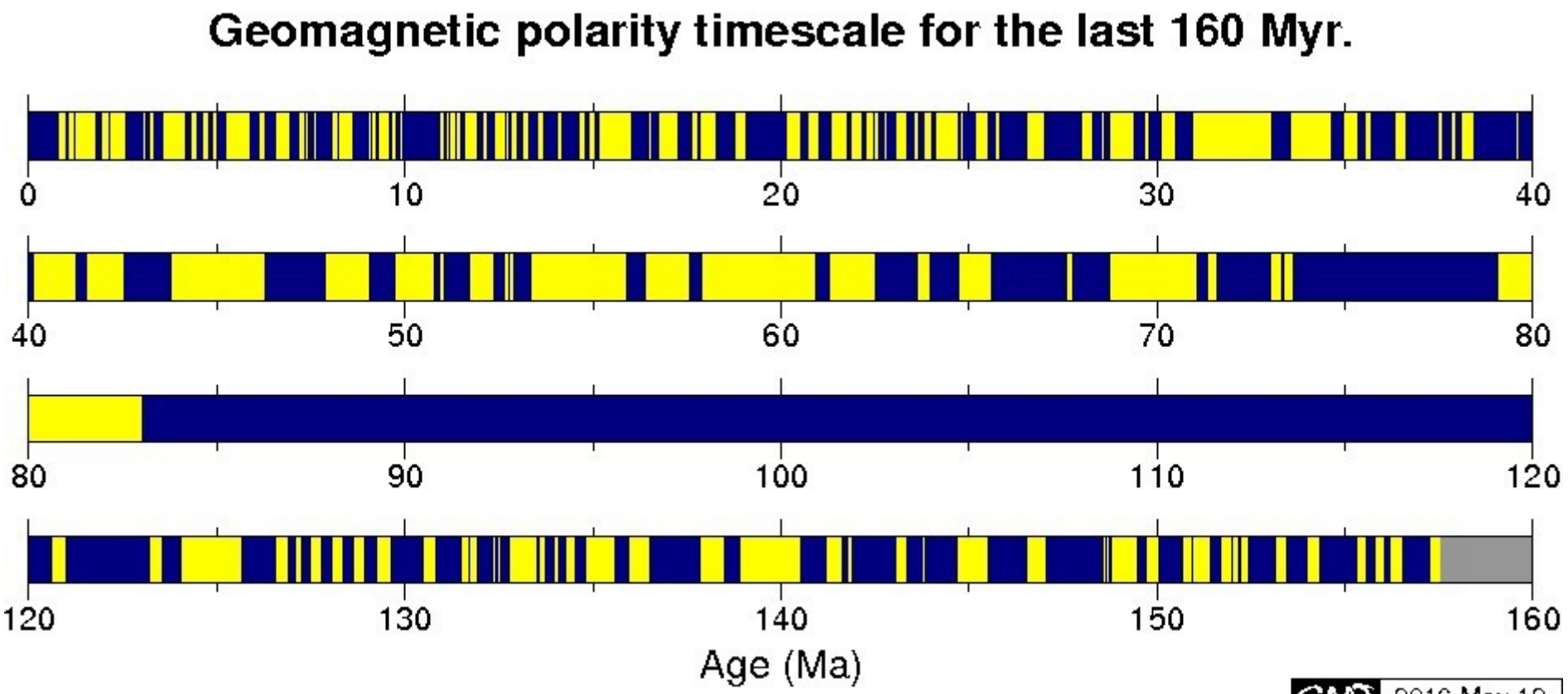


Magnetic polarity (pointing North) is normal at the Mid-Atlantic Ridge, which has a rift along it's axis. Normal and Reversed polarity alternate away from the ridge and are mirror images of one another.

https://www.ck12.org/book/ck-12-earth-science-for-high-school/section/6.3/

Maxwell Right Hand Thumb Rule





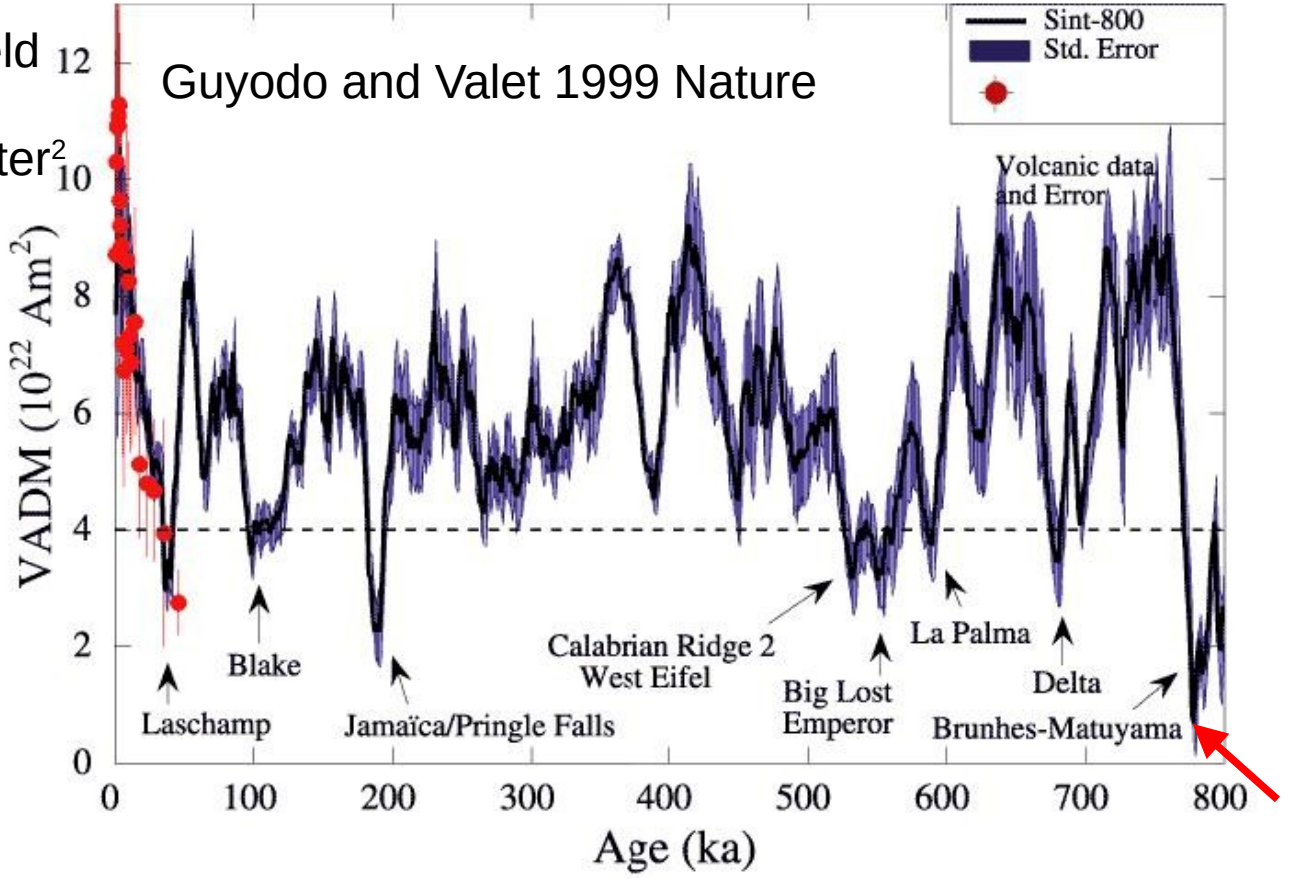
Graph shows the magnetic bands by age recorded in the oceans (blue – normal, yellow – reversed)

Frequency gradually decreases over Time and and then increases

https://www.slideshare.net/Qoochay/plate-tectonics-36818819

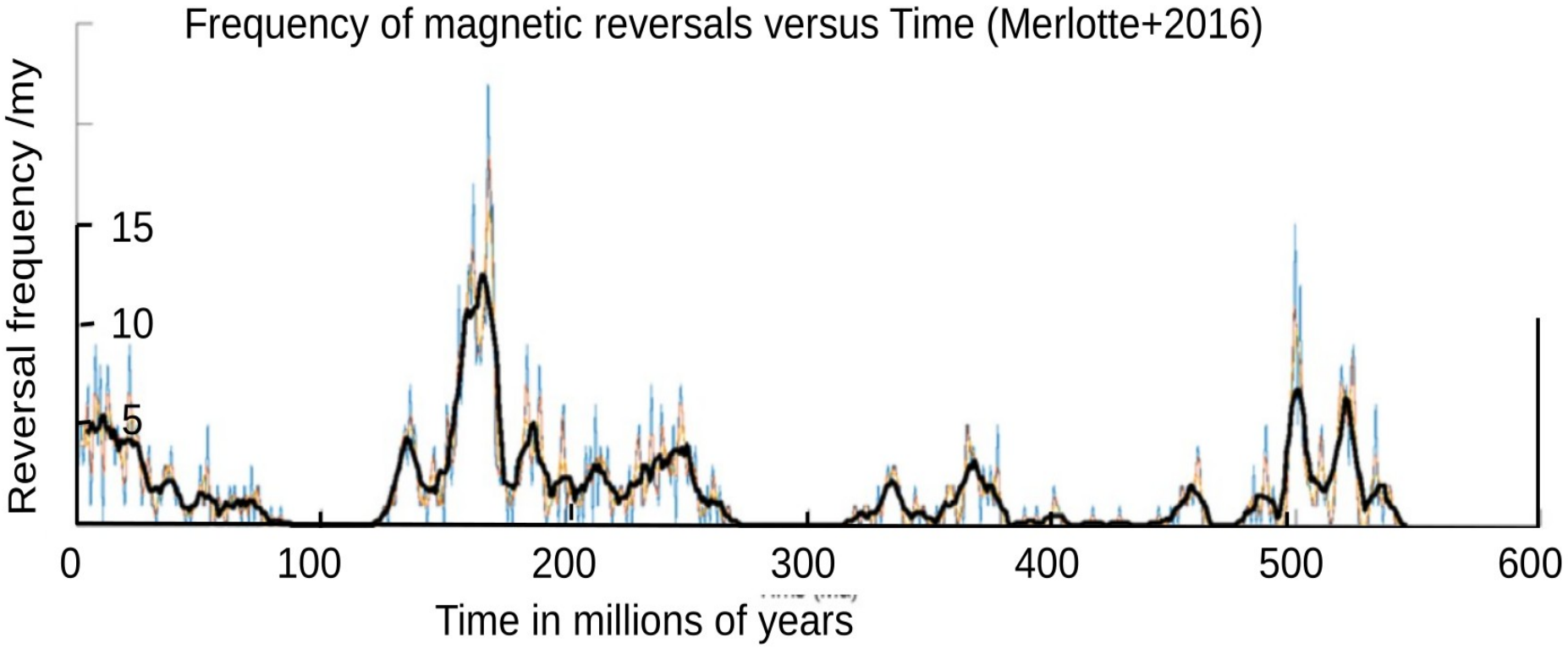
Magnetic field strength varies over time

Magnetic field Strength in Ampere-meter^2



Last reversal

Note the wave patterns display several orders of frequency
https://www.megakastro.gr/weather_agro/solar_modulation.htm

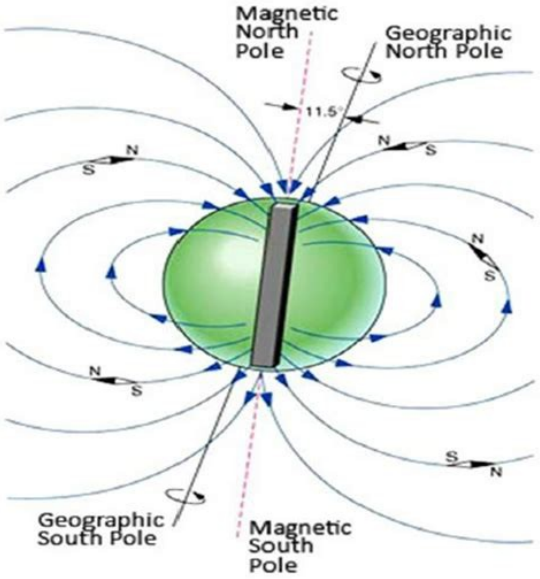


Note that there are several orders of frequency

Inferred origins of the earth's magnetic field

Bar magnet

Core temperature too high
make this model impossible



Edwards, S. (2015).
The Global Coherence Initiative

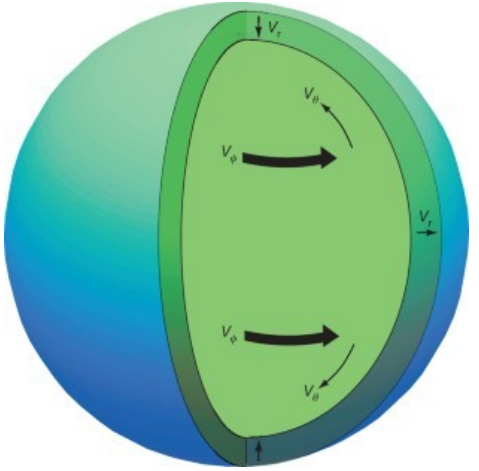
Spiral flow

Outer Core is a liquid with spiral flow
creating a magnetic field – model
not in accord with reality

https://www.geologyin.com/2017/07/
nickel-is-crucial-for-earths-magnetic.html

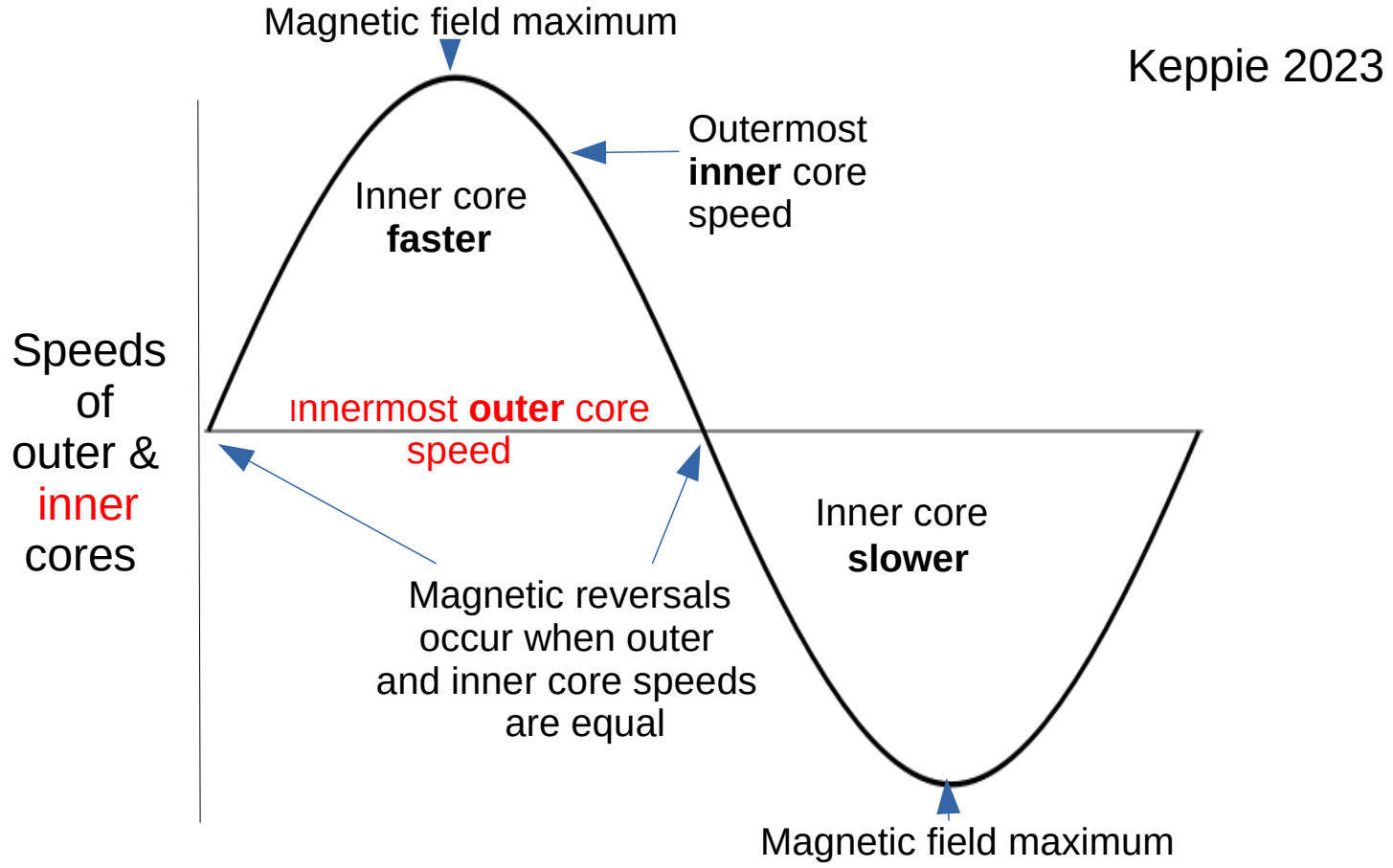
Toroidal flow

Liquid Outer Core is mainly toroidal
flow produced by Earth's rotation with
minor component towards poles

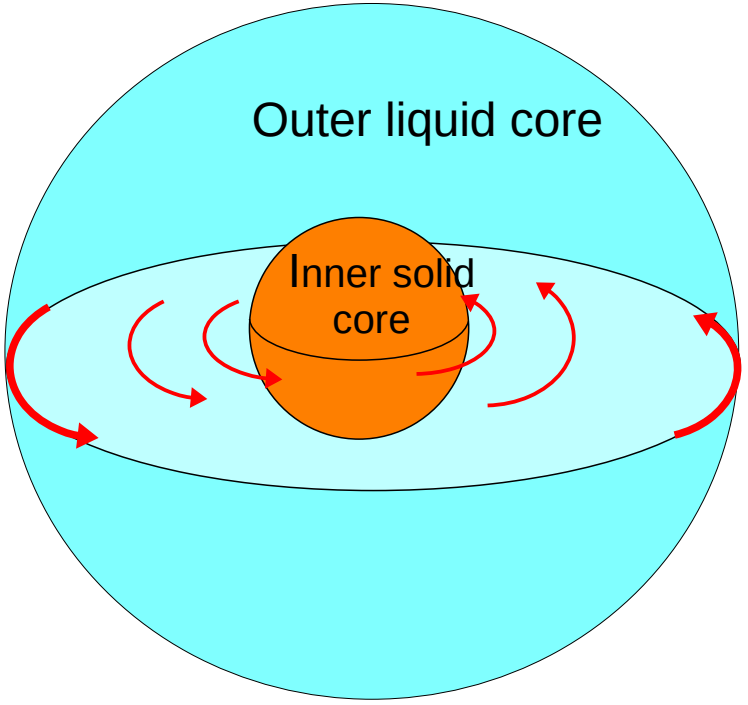


Buffett, 2017. Nature

Earth's rotation induces a torus flow in the viscoelastic mantle, liquid outer core and solid inner core. However, inertia of the solid inner core will affect the speed of the adjacent outer core flow, which will alternately rotate faster or slower producing magnetic field reversals that gradually change in intensity

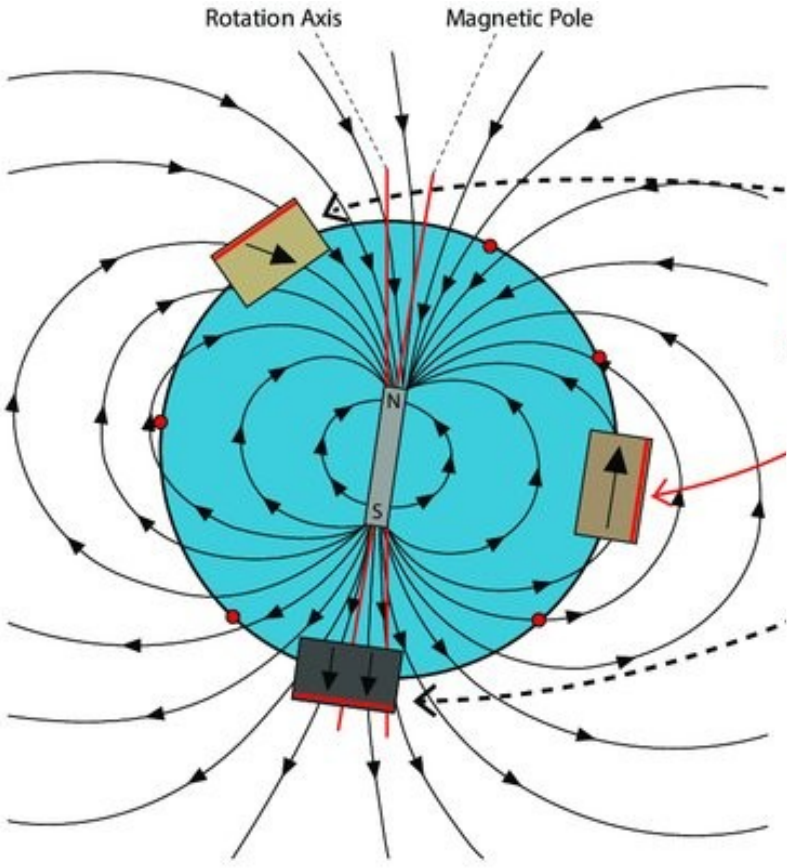


Origin of magnetic field and reversals (Keppie 2023)

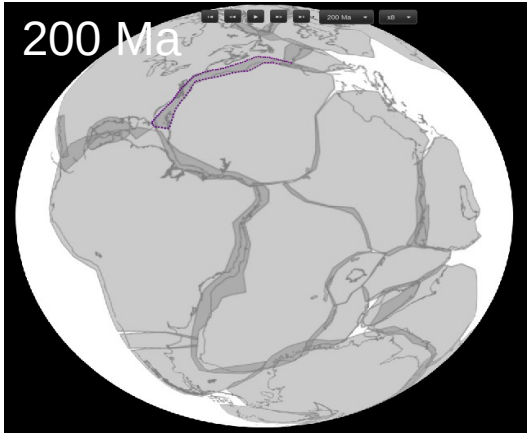


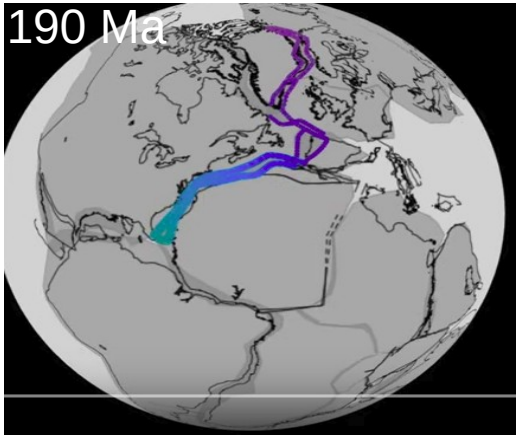
Earth spins at 15°/hour at the equator. Relative motion between outer and inner core produces a torodial magnetic field in the inner core. When the inner and outer cores reach the same speed the magnetic field stops, however the solid inner core has momentum that increases it's speed relative to the outer core which causes a reversal of the magnetic field . When the solid inner core stops accelerating, the magnetic field reaches a maximum, and then decreases. – this gives rise to a fluctuating frequency of magnetic stripes (2nd order). This alternation gradually slows down, stops and then rises again giving rise to a 1st order frequency..

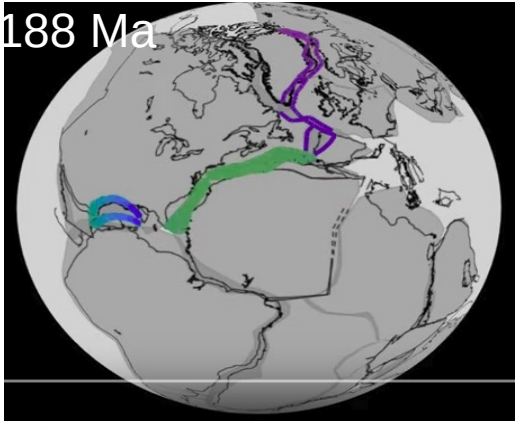
Magnetic field and measured inclination, which indicates the (paleo)latitude

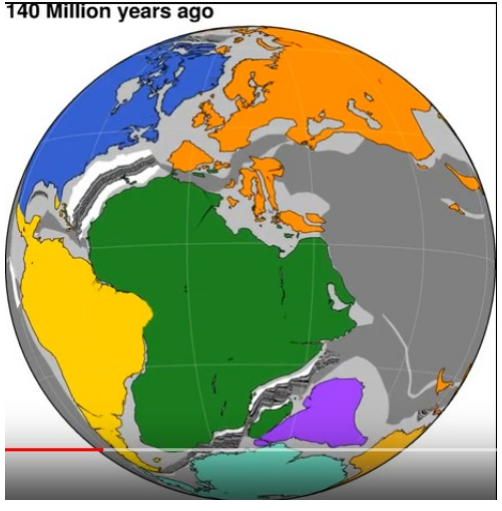


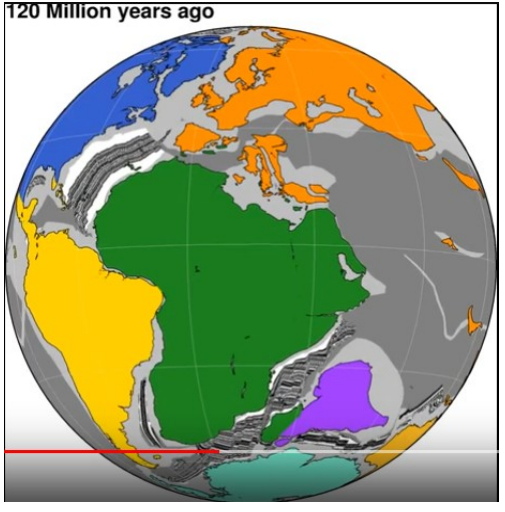
Breakup of Pangea and opening of the Atlantic Ocean at different times
(https://www.youtube.com/watch?v=BwBEPlH4t58

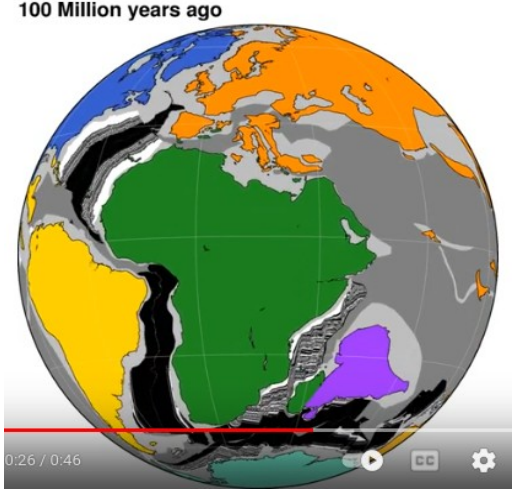




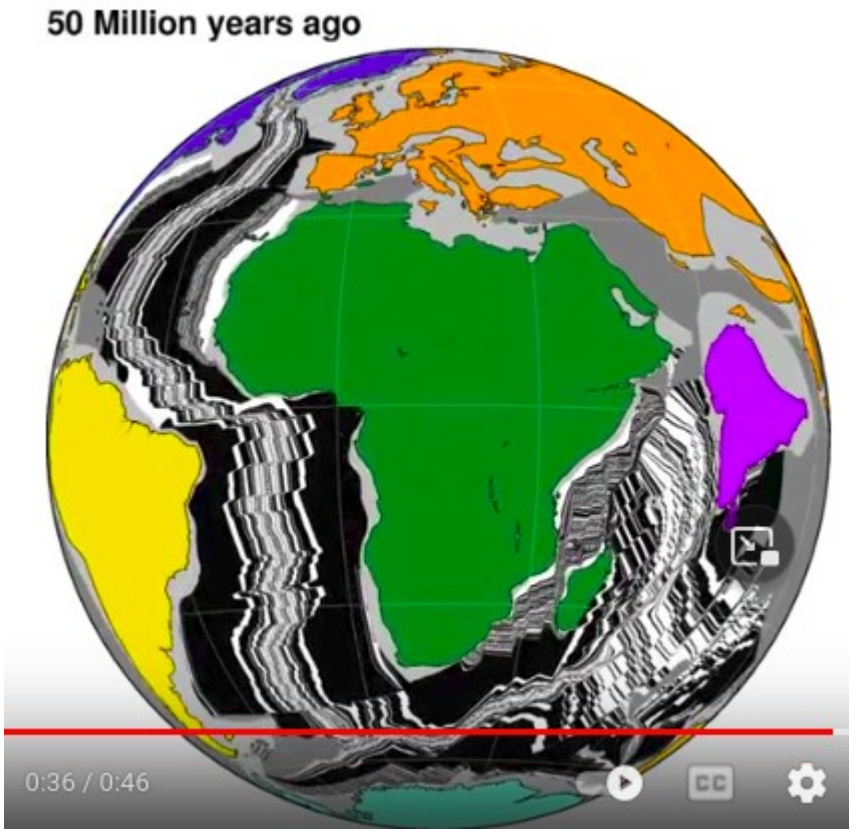


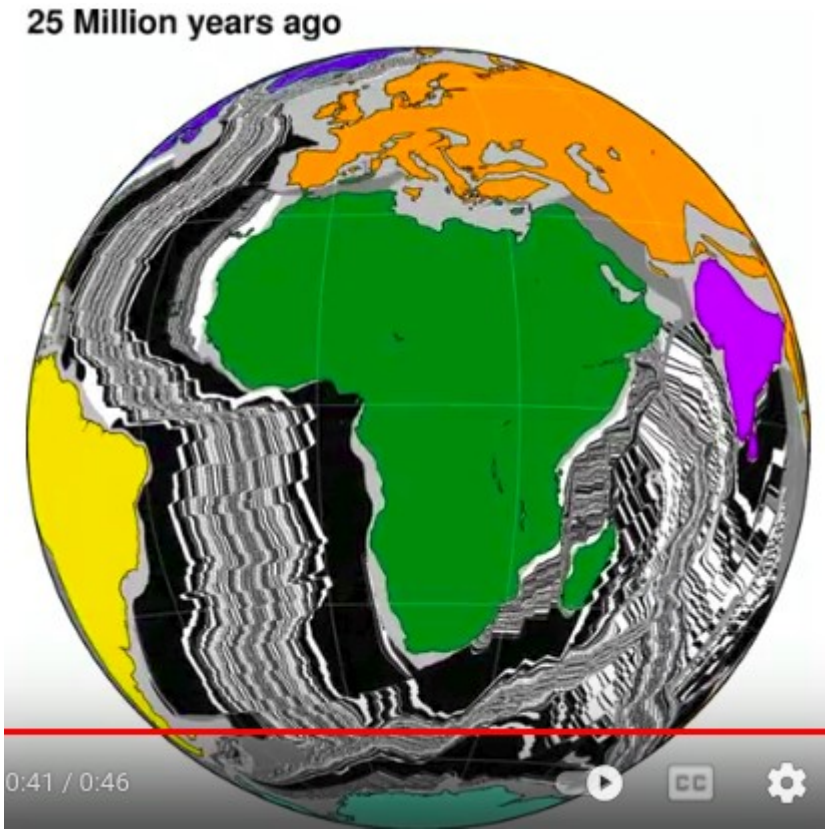






https://www.youtube.com/watch?v=BwBEPlH4t58



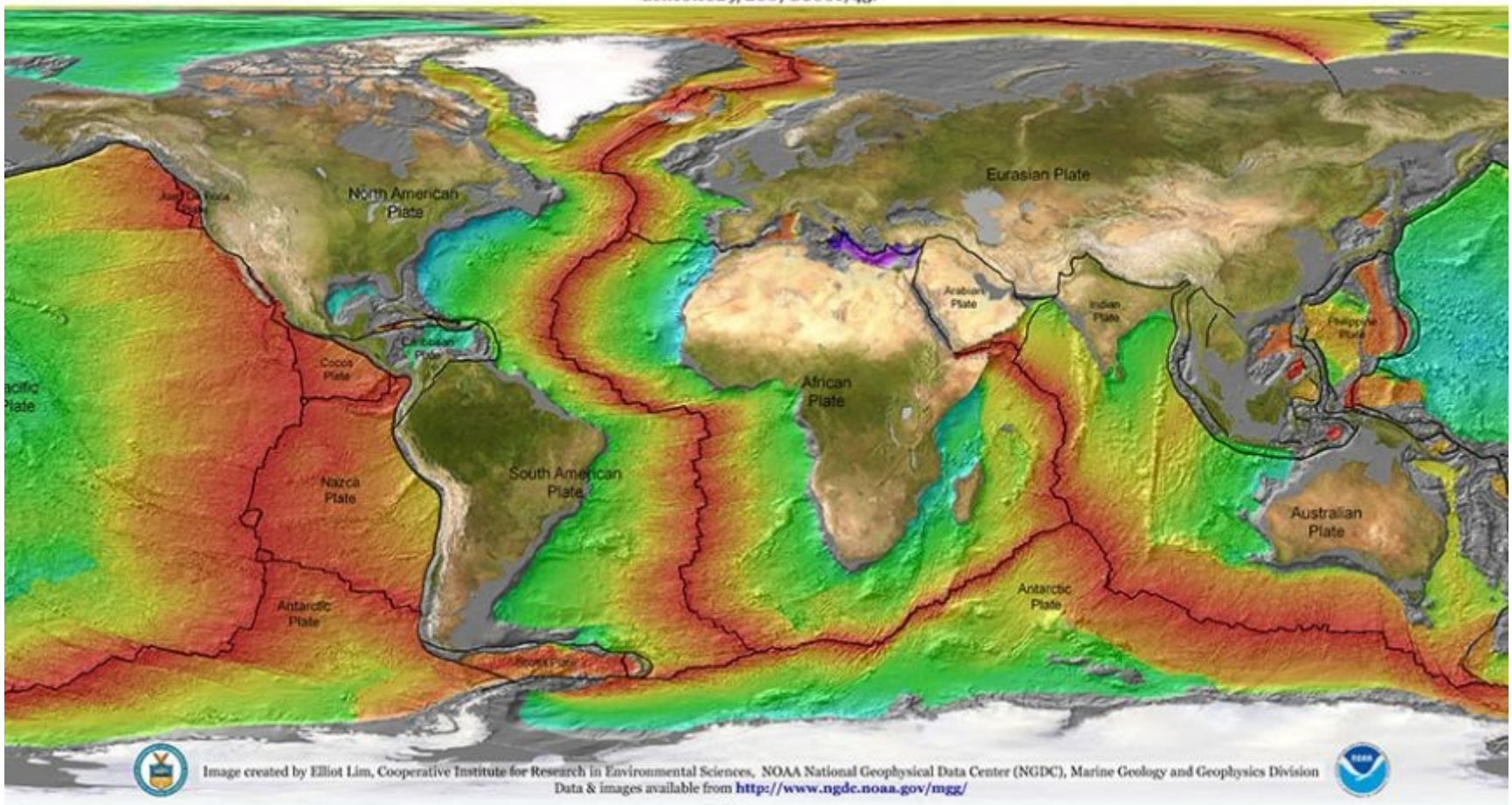


Future: https://www.youtube.com/watch?v=2It3ETk2MGA

Age of Oceanic Lithosphere (m.y.)

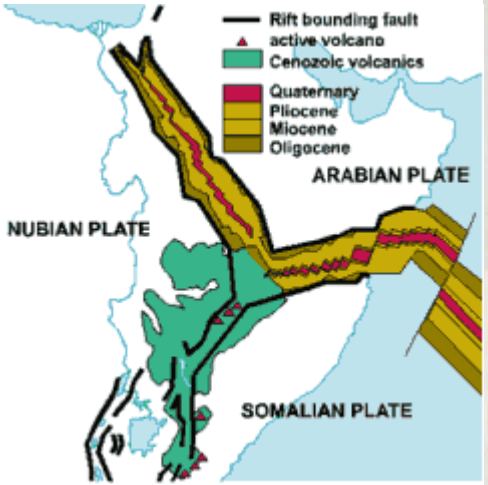
Data source:

Muller, R.D., M. Sdrolias, C. Gaina, and W.R. Roest 2008. Age, spreading rates and spreading symmetry of the world's ocean crust,Geochem. Geophys. Geosyst., 9, Q04006, doi:10.1029/2007GC001743.

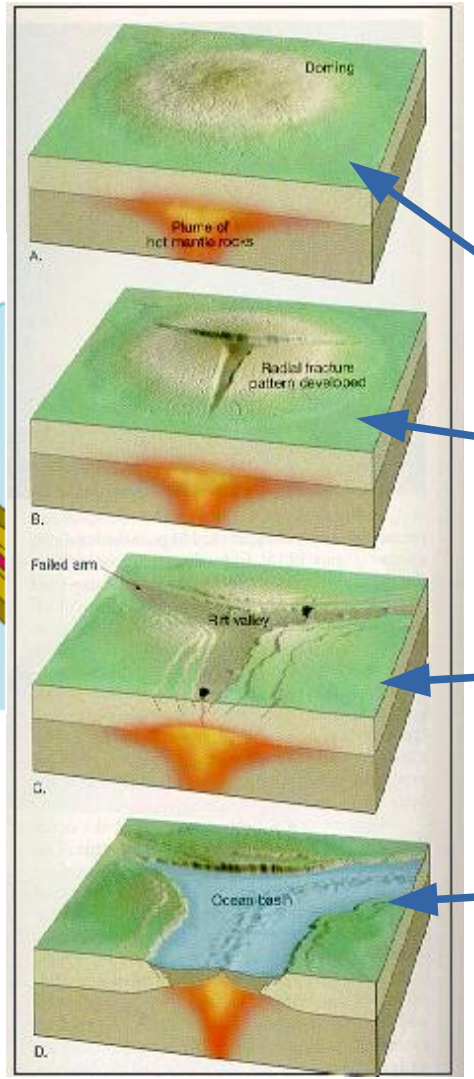


Pangea breakup as recorded in Nova Scotia geology

Principles of rifting and drifting applied to Maritime Canada that has the Afar region as a modern analog



Present Afar triple junction



Hot plume in mantle upwarps lithosphere of continent

Cracks develop (generally in a triple junction), forming rift valleys

Zones where adjacent fractures connect allow further spreading to produce an ocean

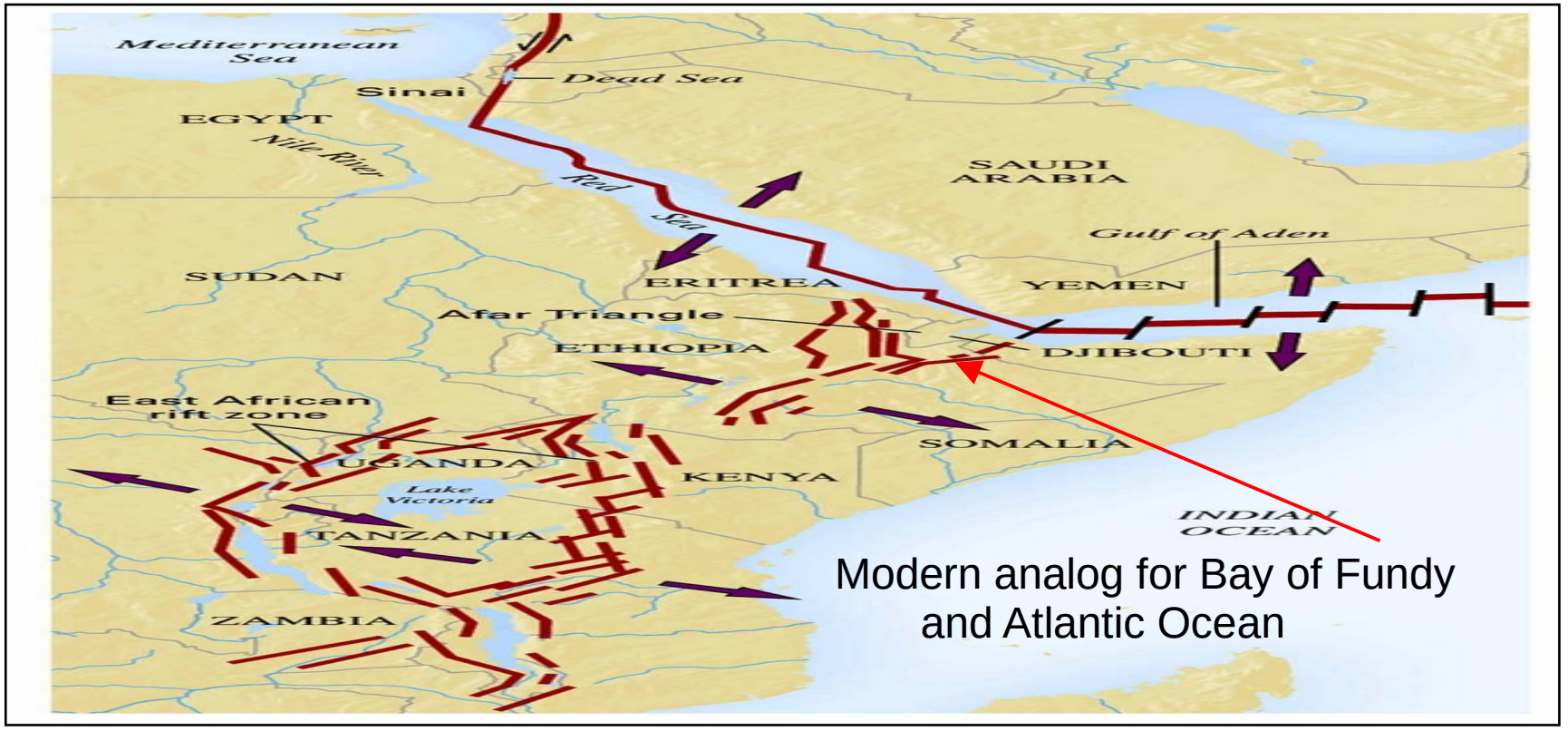
Failed arm ceases to spread (Bay of Fundy basin represents a “failed arm” of the Atlantic Ocean basin)

https://www.youtube.com/watch?app=desktop&v=ssrmdGtcoNA

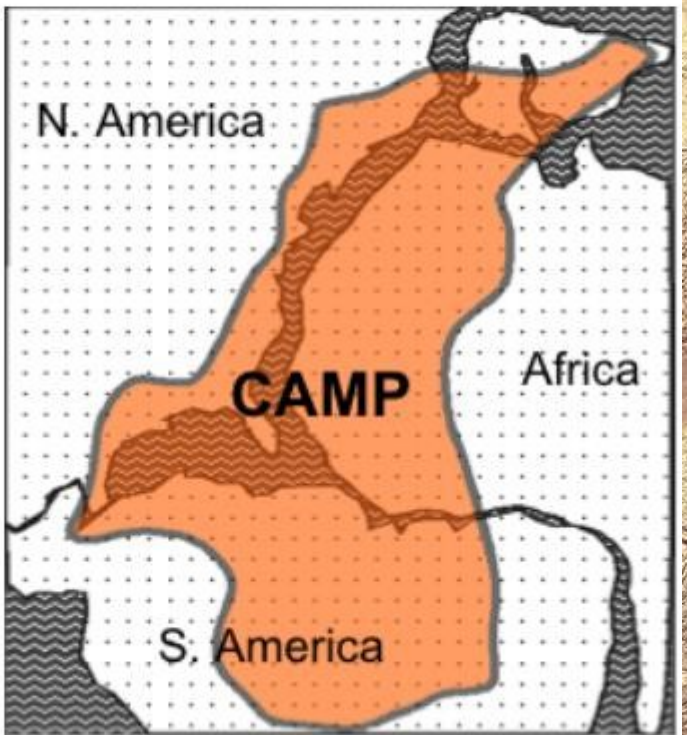
East African Rift Zone

Active: Red Sea and Gulf of Aden Failed Arm: Great Rift Valley (aulocogen)

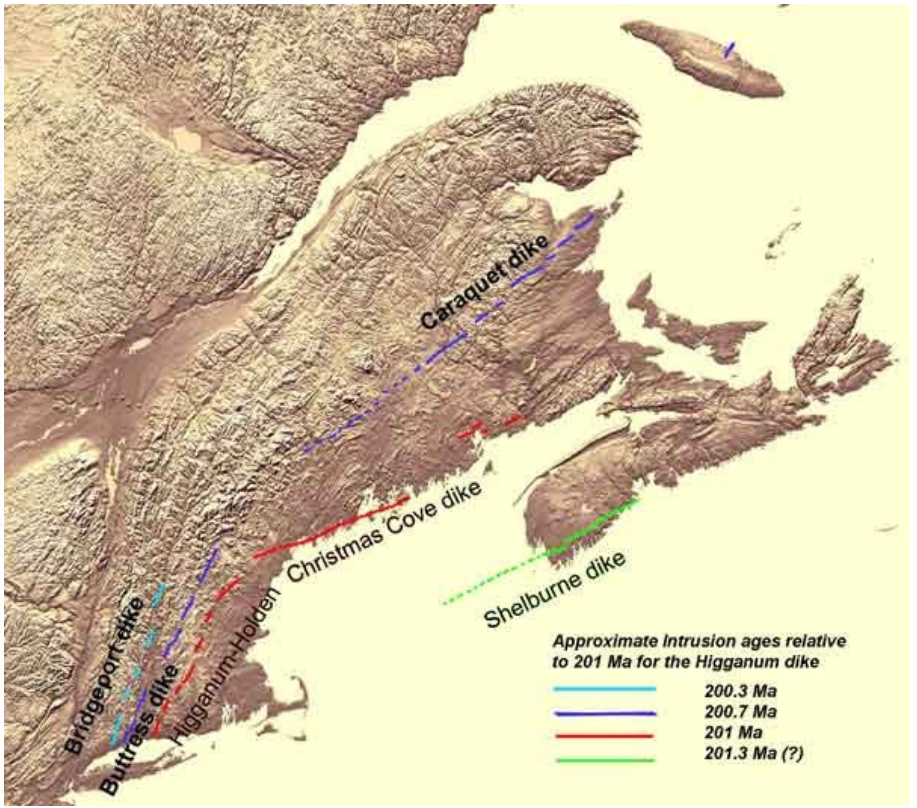
(https://slideplayer.com/slide/4322539/)



Central Atlantic Magmatic Province (CAMP)

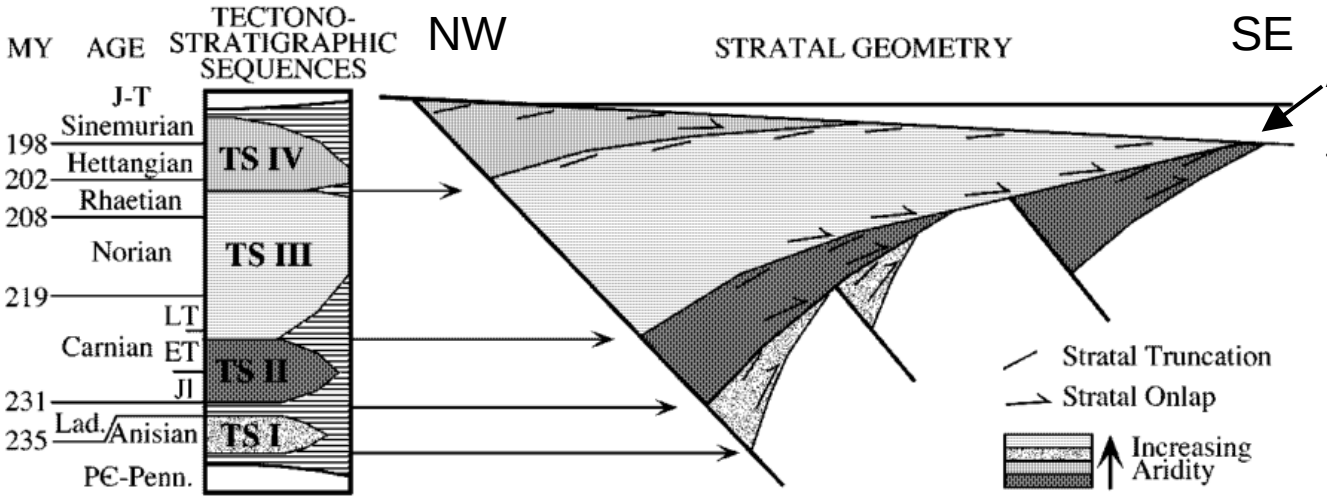


200 Ma Dikes: Northern Appalachians

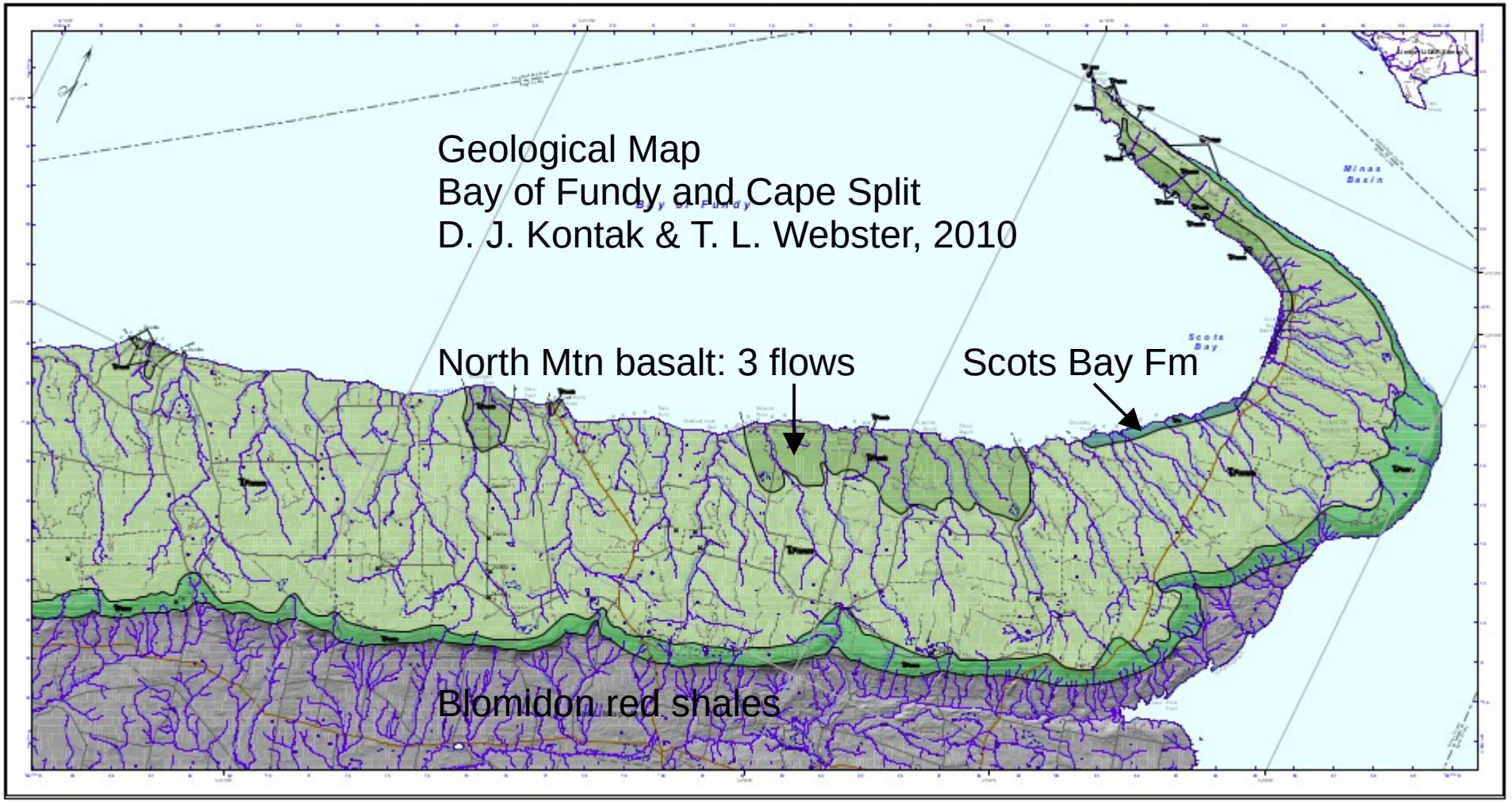


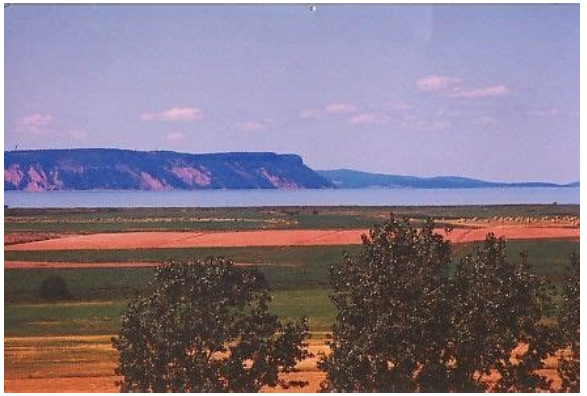
https://www.ldeo.columbia.edu/~polsen/nbcp/rationale.html

NW-SE cross section of Bay of Fundy showing half rifts: Olsen, 1997



At Evangeline Beach, the beds dip south towards the shore suggesting there may be a fault here also.


Geological Map
Bay of Fundy and Cape Split
D. J. Kontak & T. L. Webster, 2010
North Mtn basalt: 3 flows
Scots Bay Fm
Blomidon red shales
Minas Basin
Scots Bay



Triassic redbeds overlain by basalts

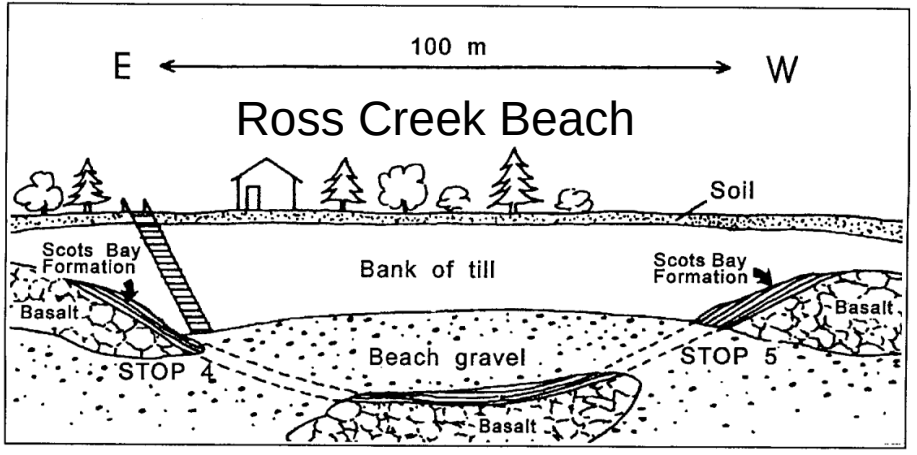


Figure 3: Detailed sketch of the geology in the cliff at stops 4 and 5.

Carbonferous unconformably overlain by Triassic redbeds at Rainy Cove

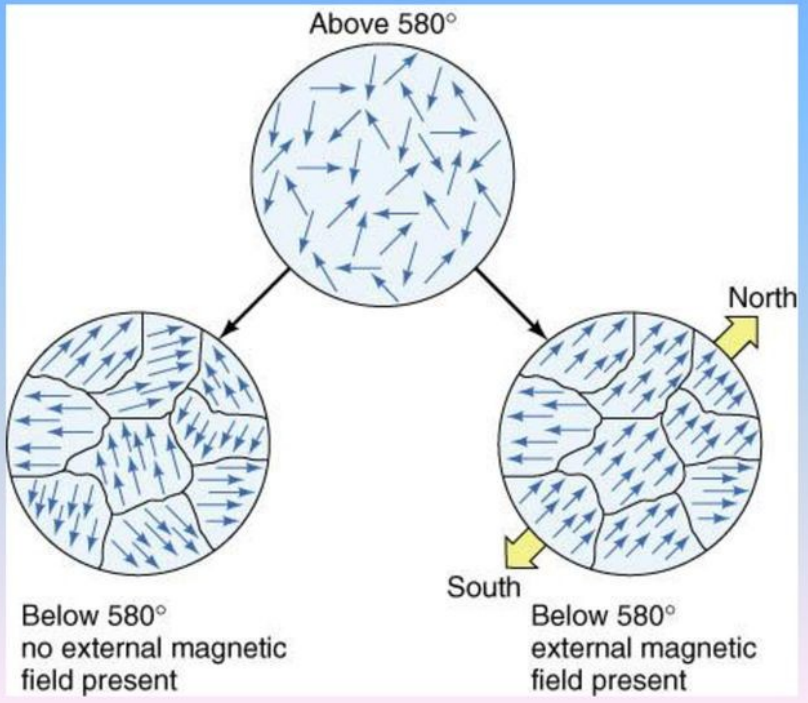
(Earth Science Society 2015)

Jurassic fossils

Clevosaurus bairdi skull

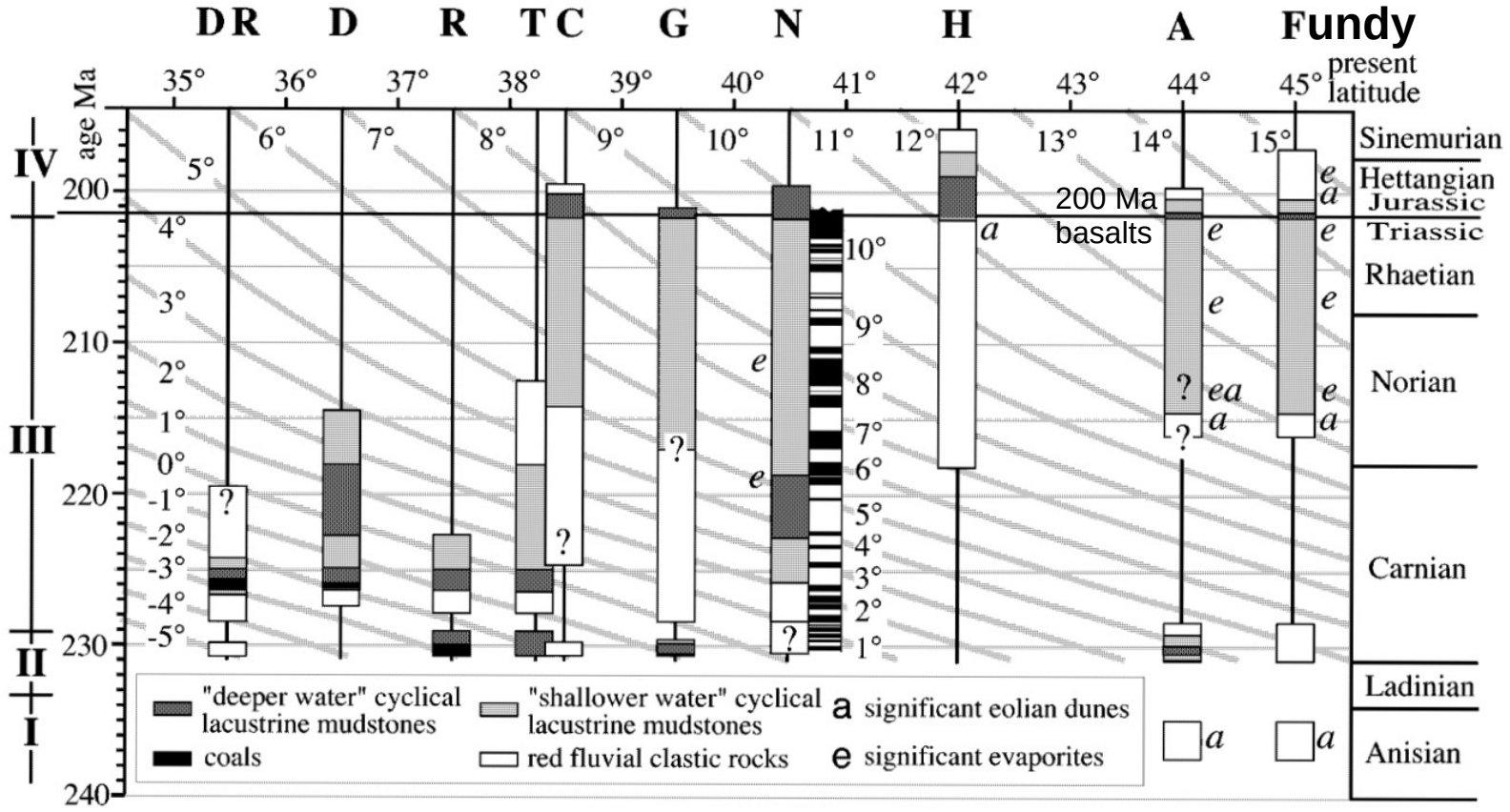
Silicified Tree trunk

- As the lava hardens, the ***magnetic orientation*** is preserved and provides a record of the current Earth's magnetic field.



http://www.mrsciguy.com/EarthScience/magnet.html

S->N Latitude of Triassic-Jurassic sections in East North America (Olsen, 1997) showing 14->45° migration of 200 million year old North Mountain basalts



DR=Deep River, D=Danville, R=Richmond, T=Taylorsville, C=Culpeper, G=Gettysburg, N=Newark, H= Hartford. A=Argana Blue lines show paleolatitude

<u>Cross section of Present-Day NS continental passive margin</u> (Deptuck 2020)

NW SE

Shelf Slope Rise with salt domes (pink)

~100 kms to Nova Scotia coastline