

Previously on Rotace Země:

1. Euler dynamic equations

$$\left. \frac{d\mathbf{L}}{dt} \right|_{\text{prostor}} = \left. \frac{d\mathbf{L}}{dt} \right|_{\text{těleso}} + \boldsymbol{\Omega} \times \mathbf{L}$$

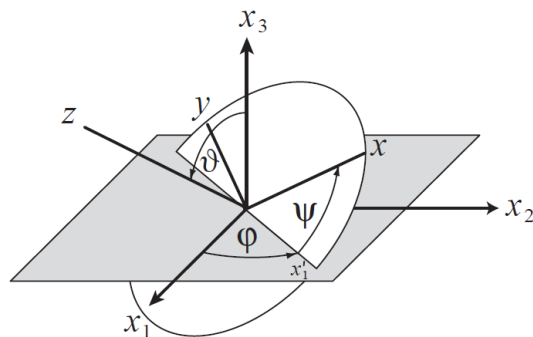
$$\mathbf{L} \cdot \boldsymbol{\xi} = \sum_a m^a \mathbf{r}^a \times (\boldsymbol{\Omega} \times \mathbf{r}^a) \cdot \boldsymbol{\xi} = \sum_a m^a (\boldsymbol{\xi} \times \mathbf{r}^a) \cdot (\boldsymbol{\Omega} \times \mathbf{r}^a) \equiv I(\boldsymbol{\xi}, \boldsymbol{\Omega})$$

In the co-rotating figure axes frame:

$$I_1 \dot{\Omega}_x - (I_2 - I_3) \Omega_y \Omega_z = M_x$$

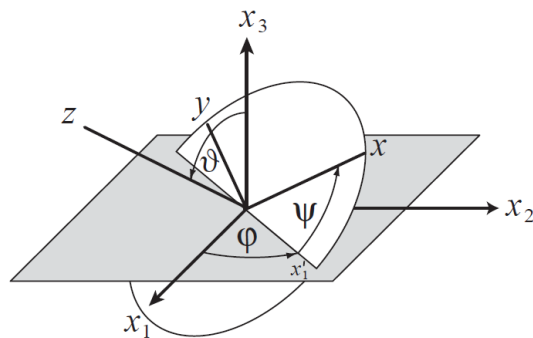
$$I_2 \dot{\Omega}_y - (I_3 - I_1) \Omega_z \Omega_x = M_y$$

$$I_3 \dot{\Omega}_z - (I_1 - I_2) \Omega_x \Omega_y = M_z$$



Previously on Rotace Země:

1. Euler dynamic equations
2. Free oscillator

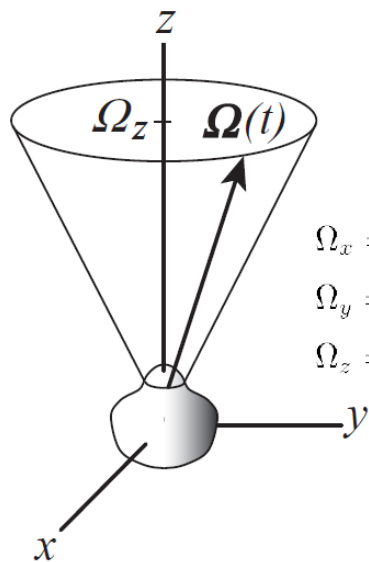


$\varphi \dots$ tzv. precesní úhel

$\vartheta \dots$ tzv. nutační úhel

$\psi \dots$ tzv. rotační úhel

$$\vartheta = \vartheta_0, \text{ kde } \tan \vartheta_0 = \frac{I_1 A}{I_3 \omega_0^z}, \varphi = \frac{A}{\sin \vartheta_0} t + \varphi_0, \psi = \omega_0 t + \delta$$

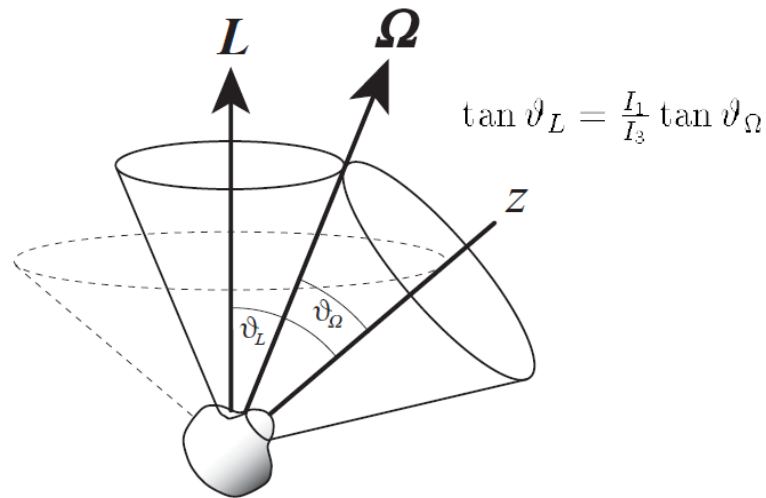


$$\Omega_x = A \sin(\omega_0 t + \delta),$$

$$\Omega_y = A \cos(\omega_0 t + \delta),$$

$$\Omega_z = \omega_0^z,$$

$$\vartheta_L = \vartheta_0$$



$$\tan \vartheta_L = \frac{I_1}{I_3} \tan \vartheta_\Omega$$

(Not really) previously on Rotace Země:

3. Forced oscillator

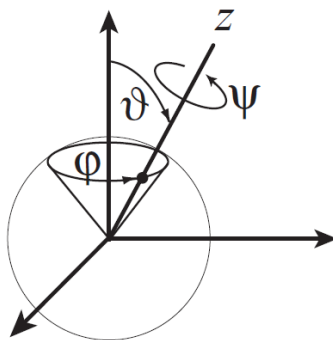
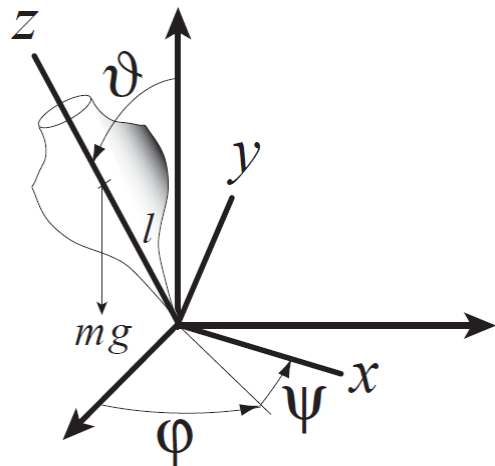
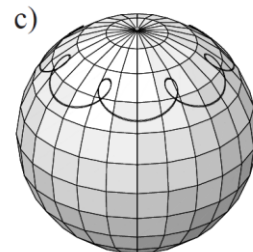
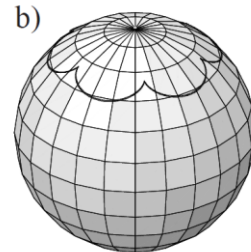
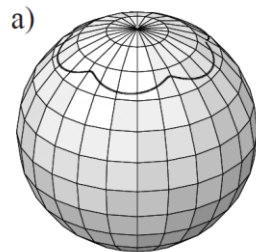


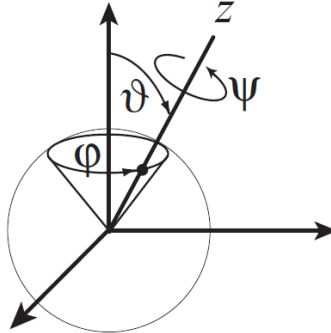
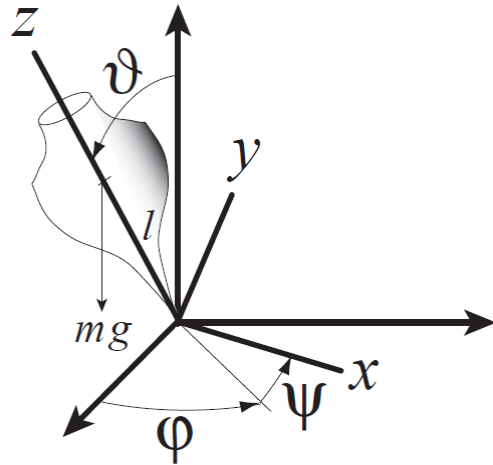
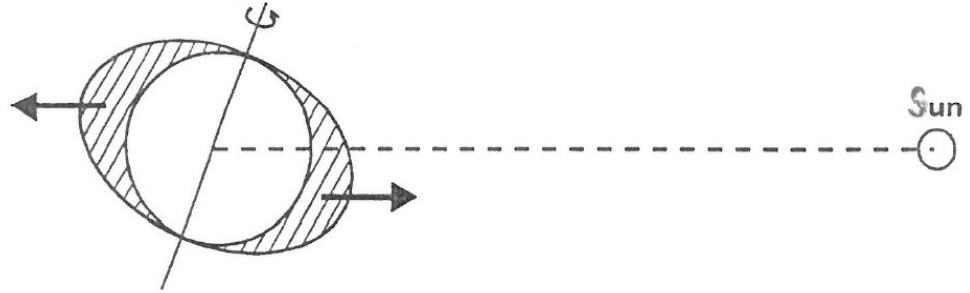
Figure axis in the inertial frame:



(Not really) previously on Rotace Země:

3. Forced oscillator

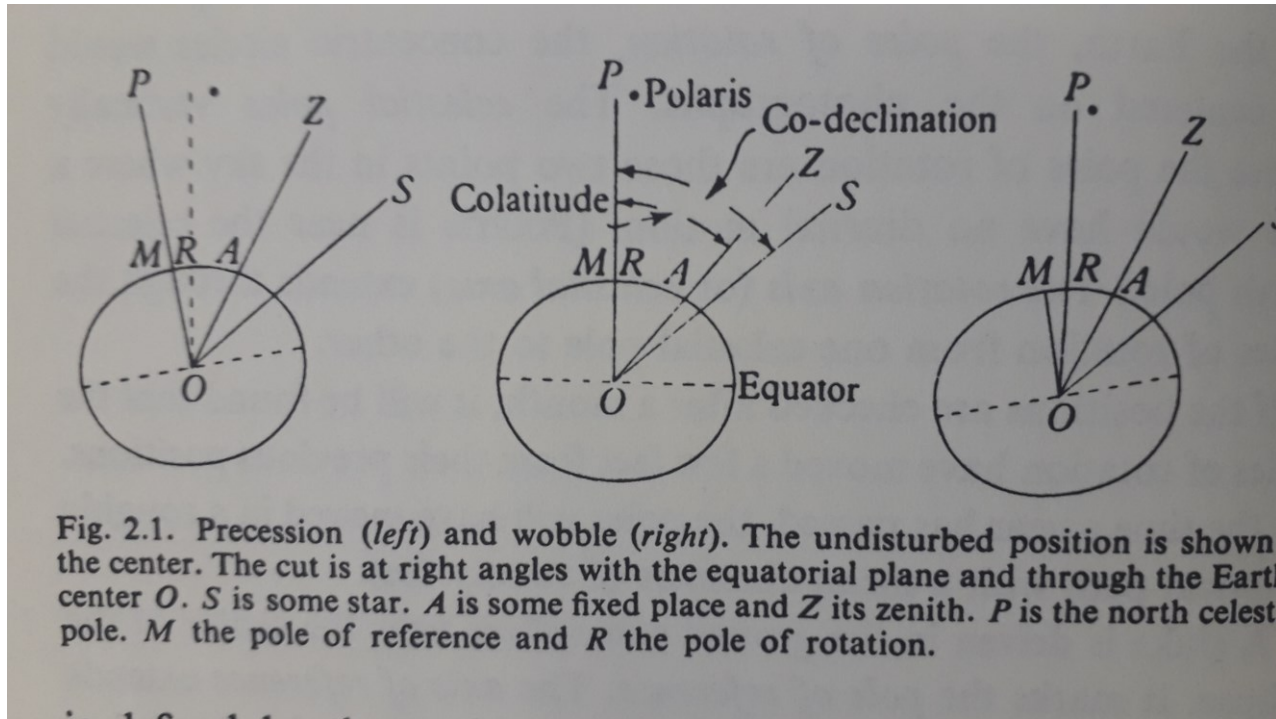
Scales: Degrees vs arc seconds



$$\frac{\omega_{P, Sun}}{\omega} = \frac{3}{2} \frac{G}{\omega} \frac{C - A}{C} \frac{M_S}{r_S^3} \cos \epsilon_S$$

$$\frac{\omega_{P, Moon}}{\omega} = \frac{3}{2} \frac{G}{\omega} \frac{C - A}{C} \frac{M_M}{r_M^3} \cos \epsilon_M$$

Observations: star inclinations vs measurement of latitude



Observations: star inclinations vs measurement of latitude

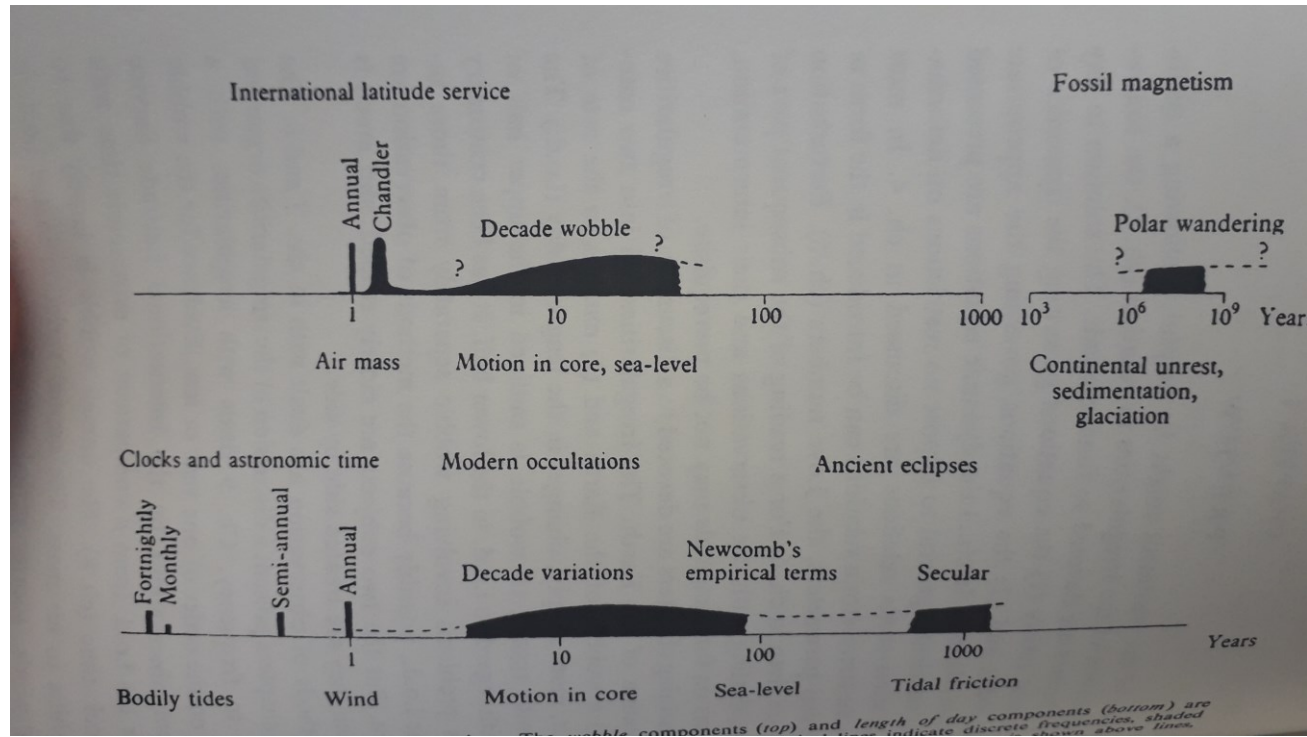


credit: 100 Proofs that the Earth is a Globe



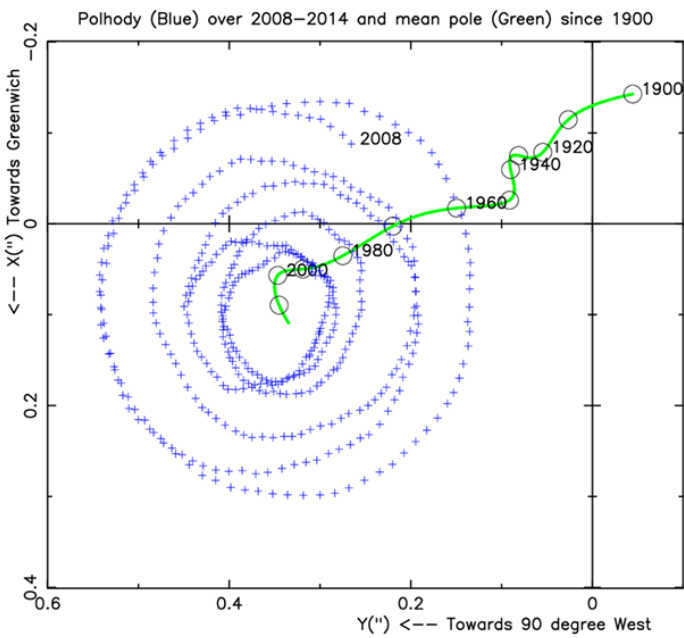
Ukiah, 1908

Observations: polar motion

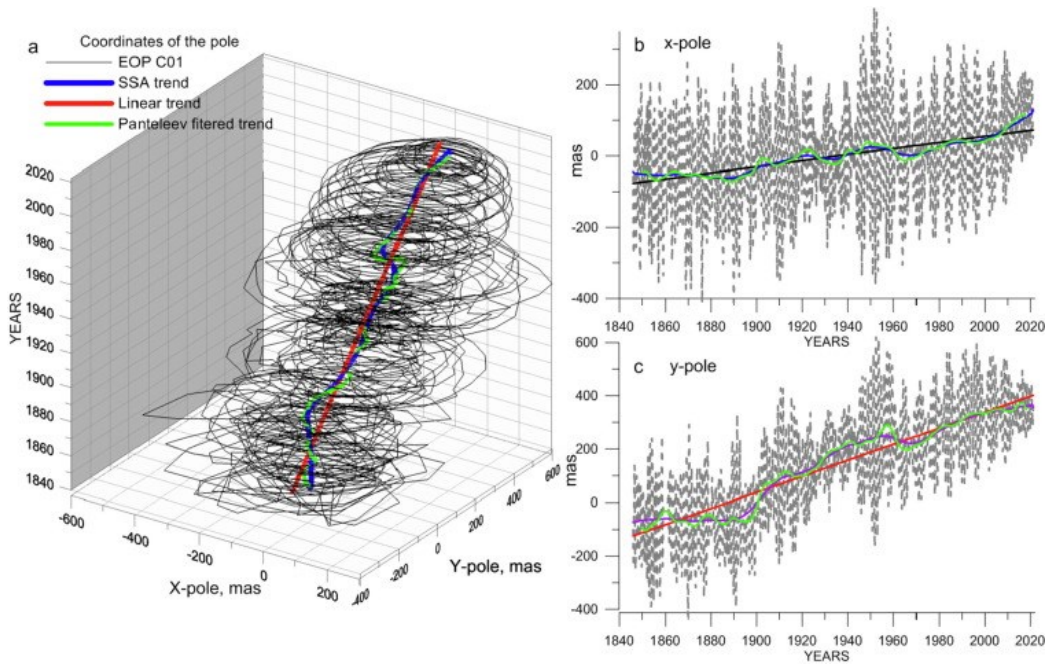


Munk and MacDonald: Rotation of the Earth

Observations: polar motion

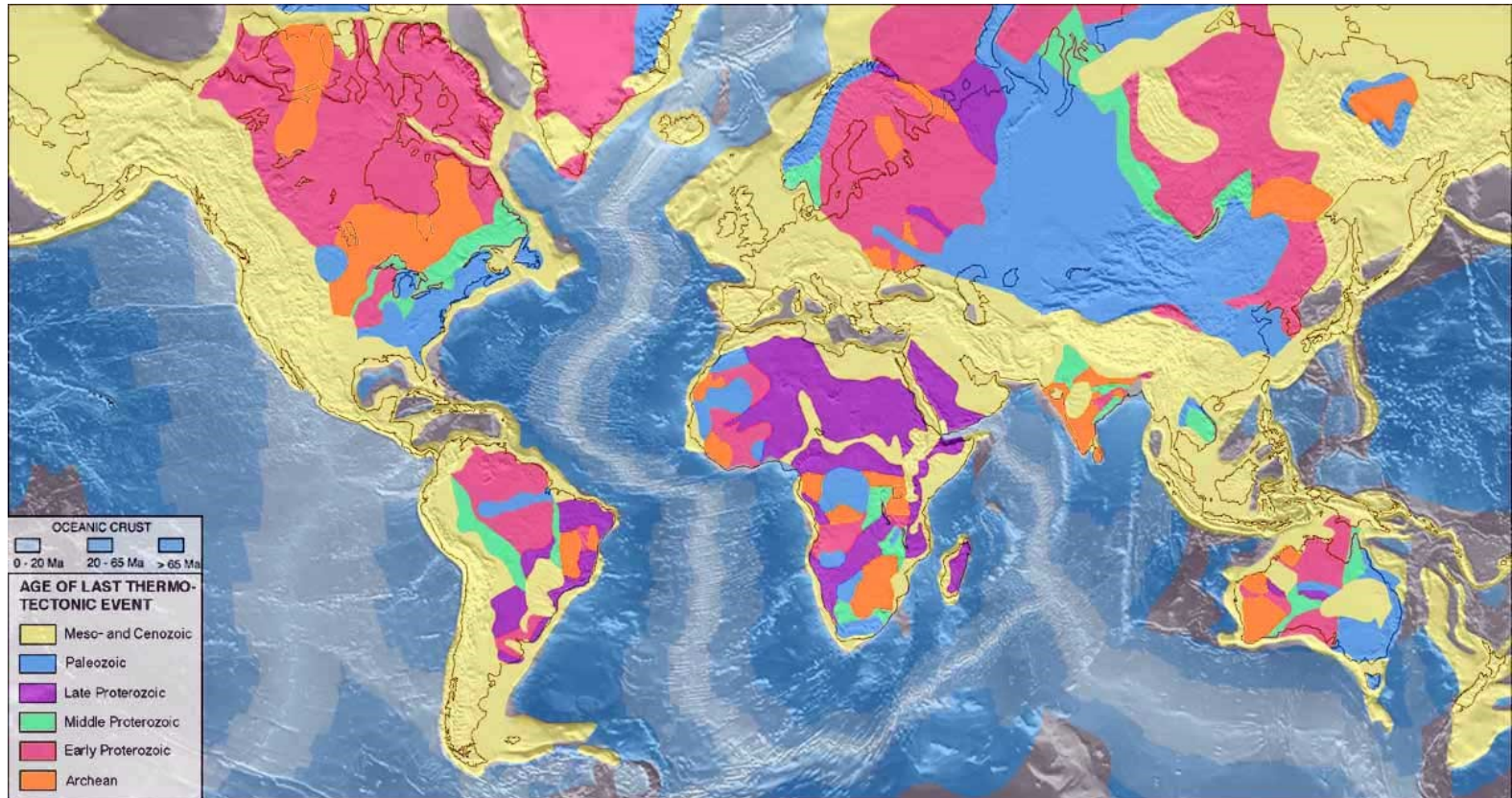


credit: 100 Proofs that the Earth is a Globe



credit: Zotov et al., 2022

Plate motions: crustal age, plate tectonics ...

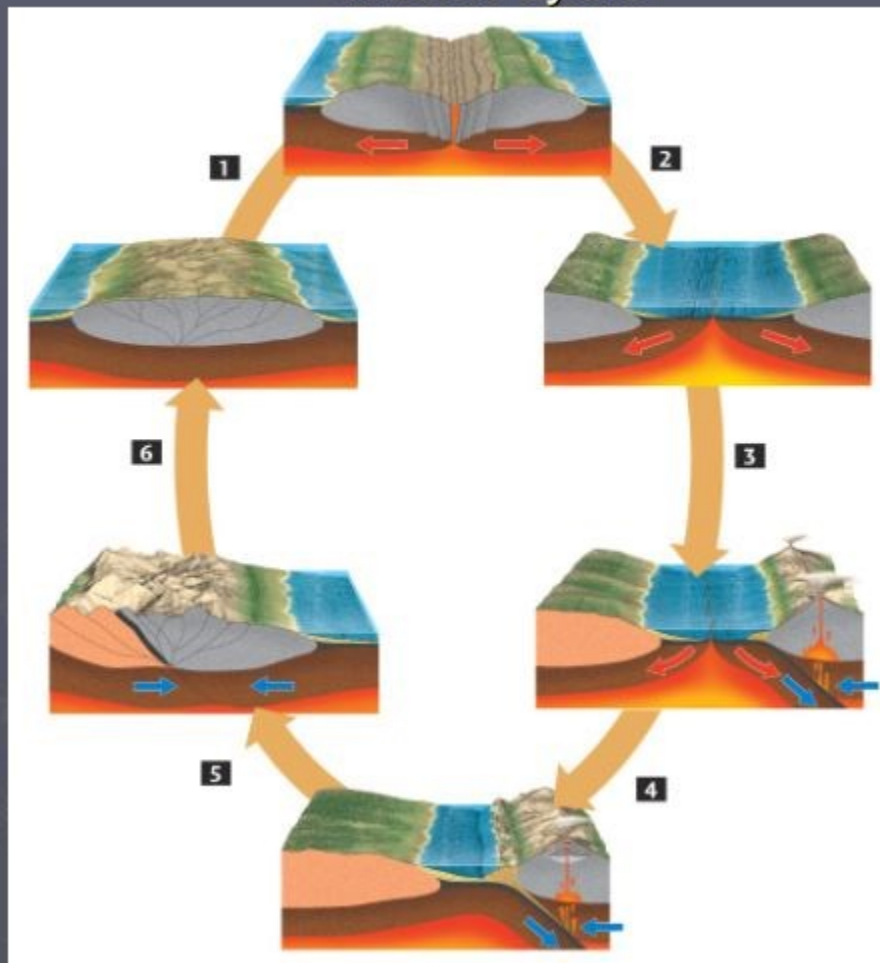


Wilson cycle

1. A continent rifts when it breaks up

6. The continent erodes, thinning the crust

5. As two continents collide orogeny thickens the crust and building mountains



2. As spreading continues an ocean opens, passive margin cools and sediments accumulate

3. Convergence begins; an oceanic plate subducts, creating a volcanic chain at an active margin

4. Terrain accretion-from the sedimentary wedge welds material to the continent

Plate motions: plate tectonics

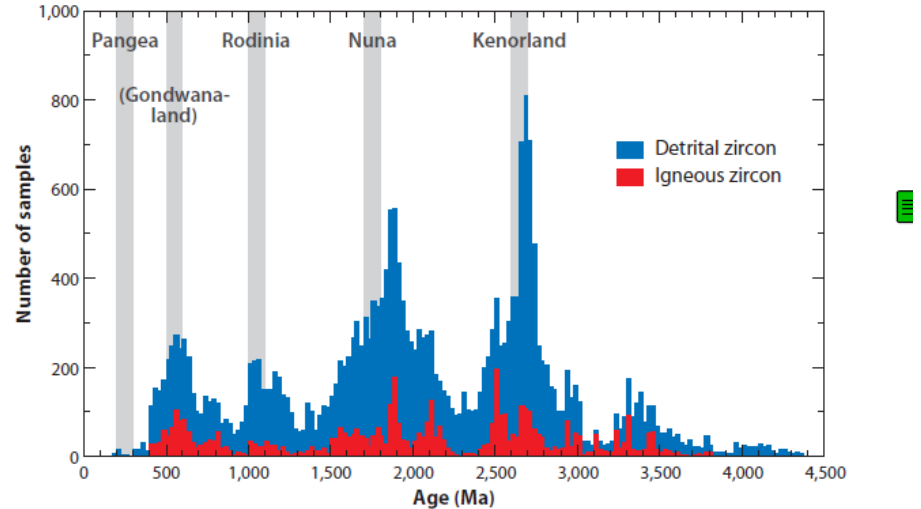
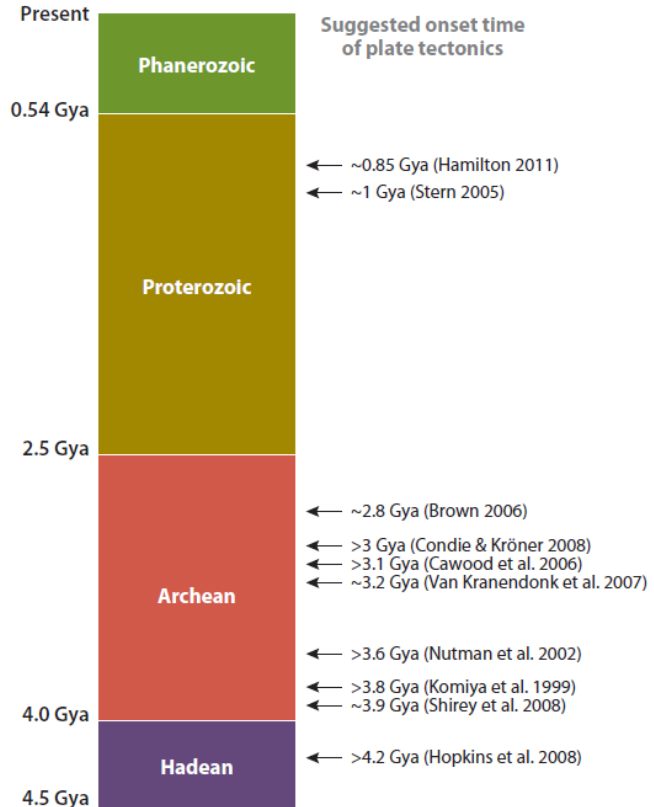
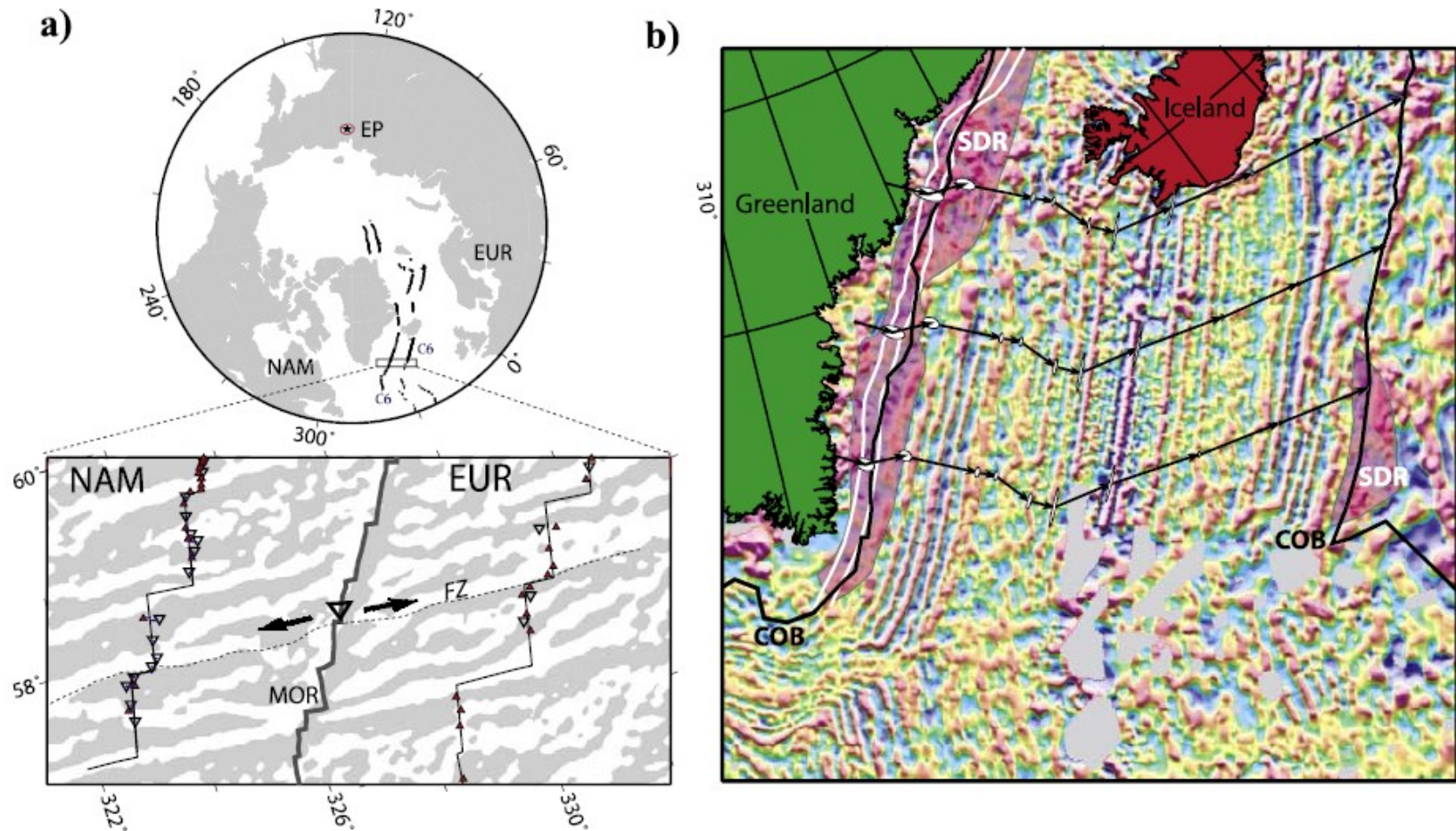


Figure 10

Distribution of U/Pb zircon ages in orogenic granitoids (red) and detrital zircon (blue) data sets compiled by Condie et al. (2009a). Also shown are the periods of supercontinent assemblies according to Hoffman (1997). The term Gondwanaland appears in parentheses because it may be better viewed as a building block of the more complete Pangea. Major peaks of zircon age distribution correlate well with the supercontinental cycle, reflecting high crustal production rates (e.g., Condie 1998) or high preservation rates during supercontinent assemblies (e.g., Hawkesworth et al. 2010).

From Korenaga: Initiation and Evolution of Plate Tectonics on Earth



Credit to all the following Figs: Torsvik et al., Global plate motion frames: toward a unified model

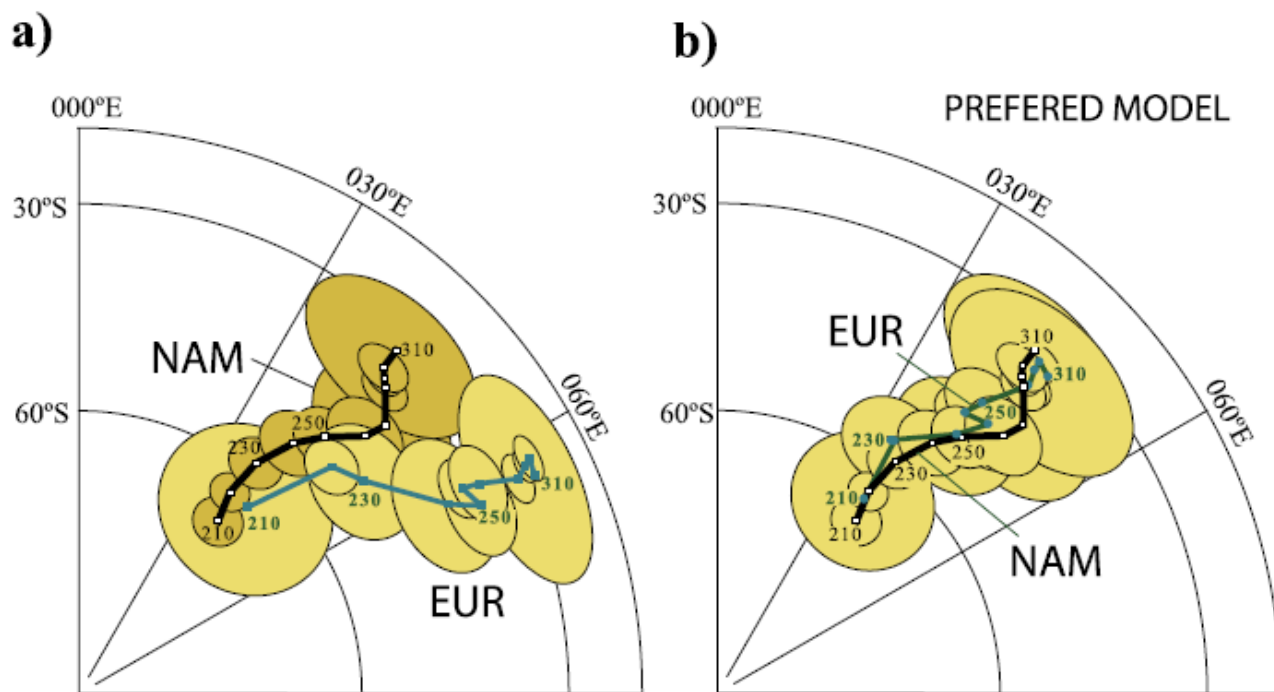
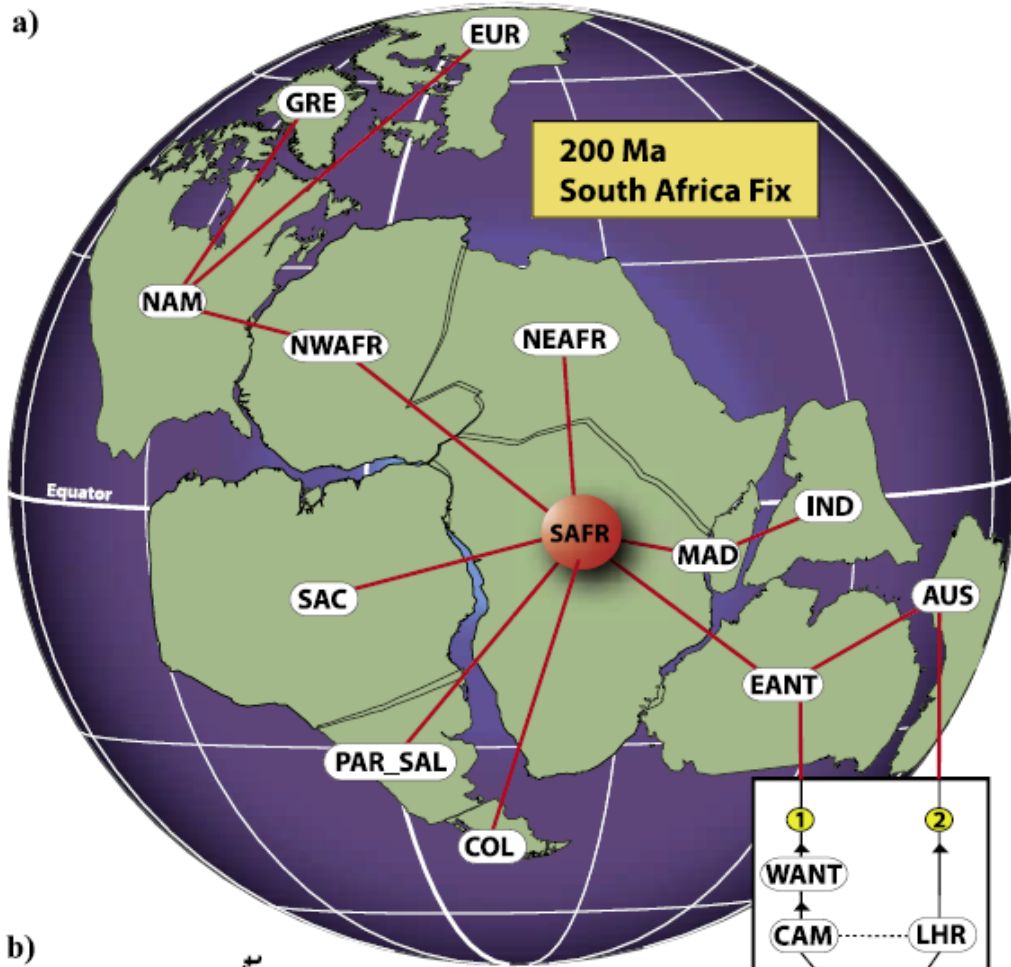


Figure 2. Comparison of NAM and EUR apparent polar wander paths (shown in South African coordinates) using different predrift fits for the North Atlantic. (a) “Traditional” mid-Jurassic Euler pole is used from *Royer et al.* [1992] (this 170 Ma stage pole is located at latitude 69.1°N , longitude 156.7°E , and angle -23.64°). (b) Minimization of the differences between the two paths by using a *Bullard et al.* [1965] fit from 310 to 240 Ma (latitude 88°N , longitude 27°E , and angle -38°) and then a gradual, interpolated change to a new fit at 200 Ma (see Table 1) (latitude 69°N , longitude 155.8°E , and angle -23.6°). A similar approach was devised by *Torsvik et al.* [2001b], but their Euler pole changeover was somewhat different.

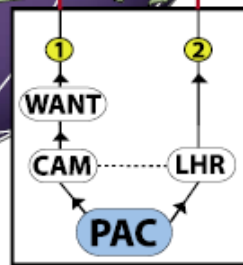


b)

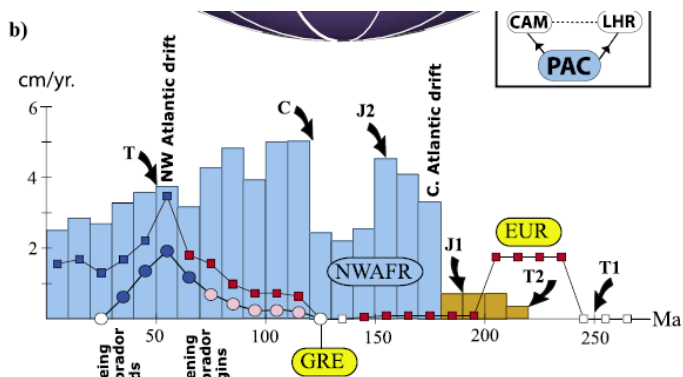
cm/yr.

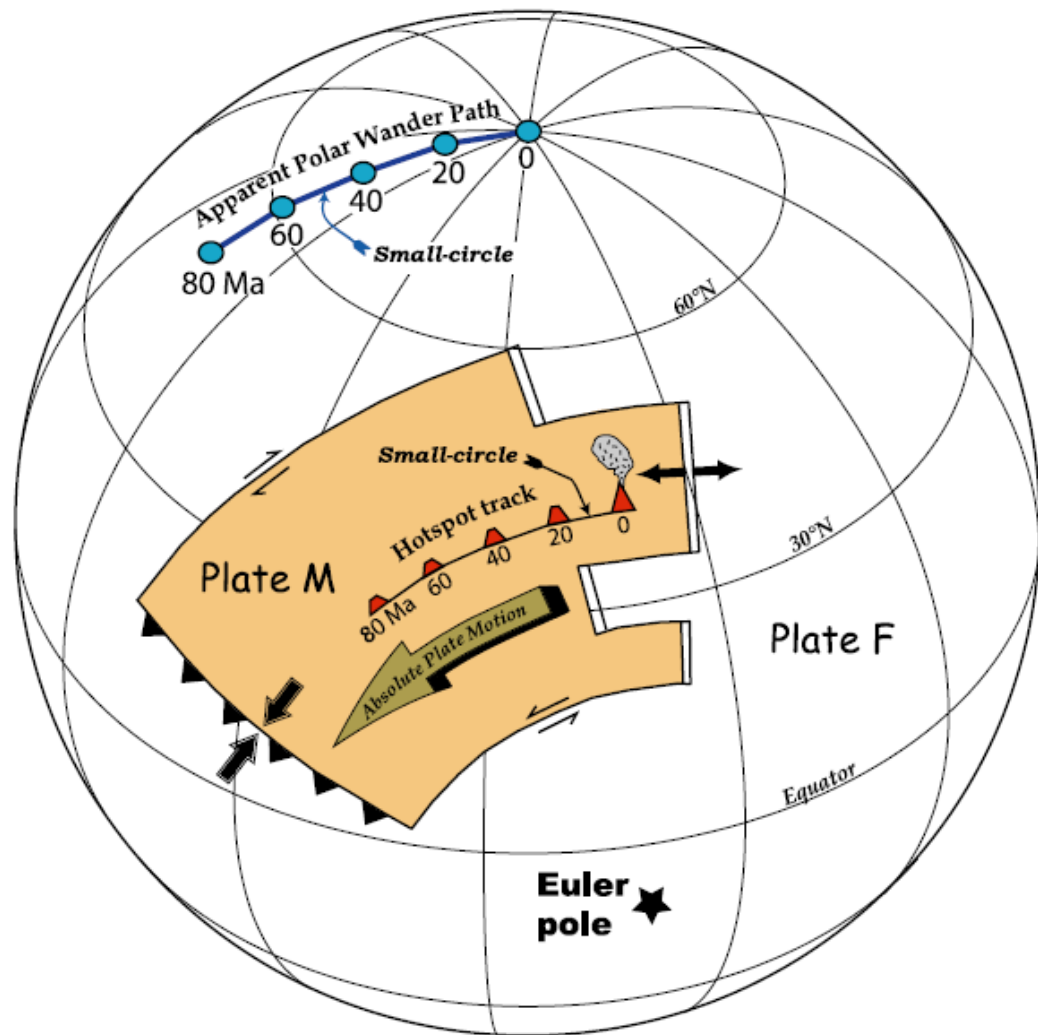
Atlantic drift

Atlantic drift



b)





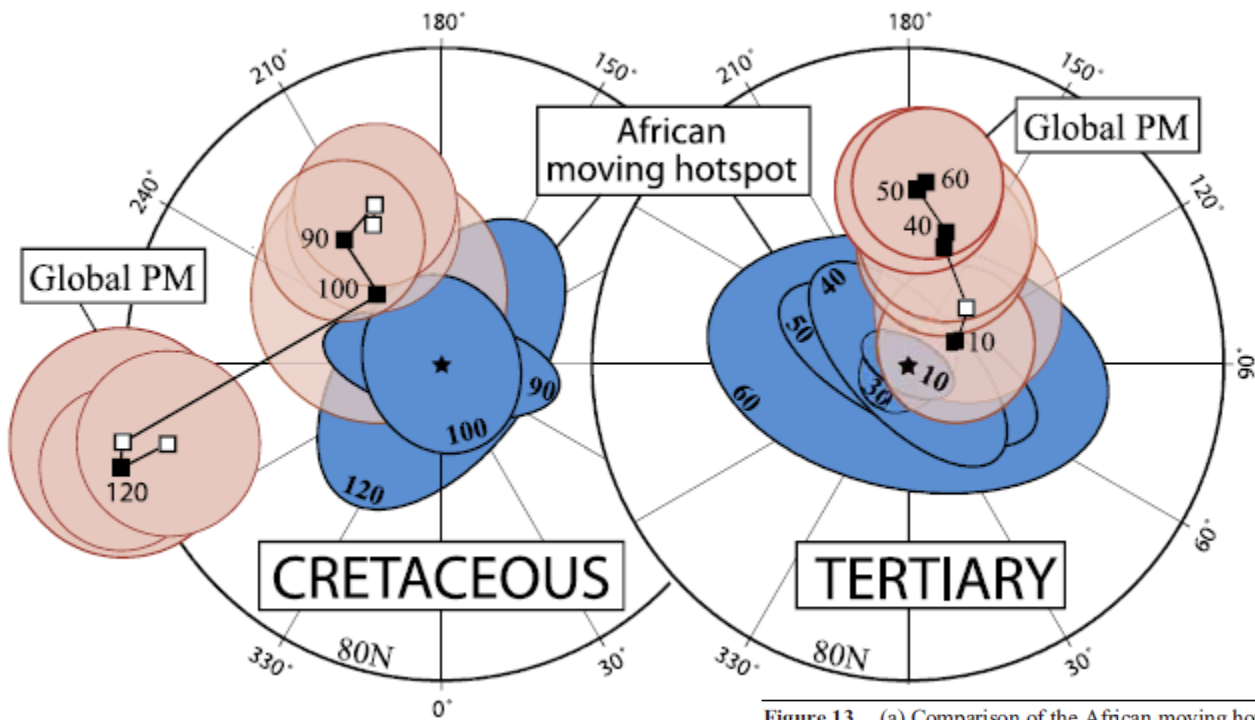


Figure 13. (a) Comparison of the African moving hot spot (with blue error ovals, centered on the rotation axis) and mean paleomagnetic north poles ("global PM" with pink A_{95}) rotated using the Euler poles from the African moving hot spot frame. Thus, deviation from +90° latitude (i.e., the rotation axis) can reflect errors in the hot spot frame and its rotation parameters, erroneous paleomagnetic poles, or true polar wander. For the Tertiary and Late Cretaceous (≤ 100 Ma), only the 50 Ma pole is significantly different from the moving hot spot frame at 95% confidence; for all other times the blue ovals and pink error circles (A_{95}) overlap. For the Early Cretaceous the 120 Ma pole and probably also the 110 and 130 Ma poles (which have no error ovals in the moving hot spot frame) are significantly different. Black squares denote times where there are corresponding errors in the hot spot frame; open squares denote where they are absent. (b) Differences (expressed as the great circle distance (GCD) in degrees) between the rotated paleomagnetic poles (as in Figure 13a) and the different fixed or moving hot spot frames. Shaded yellow outline represents the uncertainty in the paleomagnetic mean poles (A_{95}) when compared with the African moving hot spot framework. Grey circles are for interpolated or extrapolated Euler poles. The global moving hotspot frame is only shown for times after 83.5 Ma because the older part is based on the African fixed hot spot frame. For comparison we also show a previous African moving hot spot frame of Steinberger [2000] (mantle model 2, dashed black line). The latter frame is applicable only after 68 Ma.

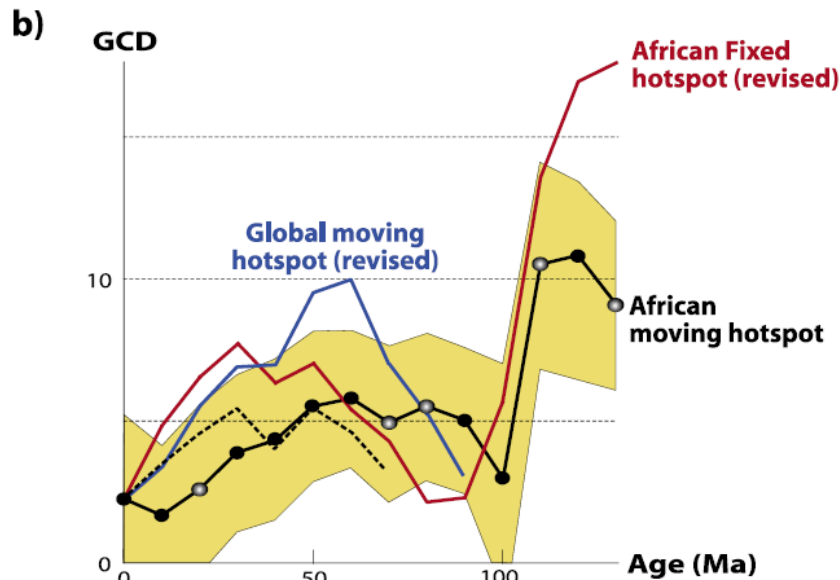


Figure 13

Figure 13. (a) Comparison of the African moving hot spot (with blue error ovals, centered on the rotation axis) and mean paleomagnetic north poles (“global PM” with pink A_{95}) rotated using the Euler poles from the African moving hot spot frame. Thus, deviation from $+90^\circ$ latitude (i.e., the rotation axis) can reflect errors in the hot spot frame and its rotation parameters, erroneous paleomagnetic poles, or true polar wander. For the Tertiary and Late Cretaceous (≤ 100 Ma), only the 50 Ma pole is significantly different from the moving hot spot frame at 95% confidence; for all other times the blue ovals and pink error circles (A_{95}) overlap. For the Early Cretaceous the 120 Ma pole and probably also the 110 and 130 Ma poles (which have no error ovals in the moving hot spot frame) are significantly different. Black squares denote times where there are corresponding errors in the hot spot frame; open squares denote where they are absent. (b) Differences (expressed as the great circle distance (GCD) in degrees) between the rotated paleomagnetic poles (as in Figure 13a) and the different fixed or moving hot spot frames. Shaded yellow outline represents the uncertainty in the paleomagnetic mean poles (A_{95}) when compared with the African moving hot spot framework. Grey circles are for interpolated or extrapolated Euler poles. The global moving hotspot frame is only shown for times after 83.5 Ma because the older part is based on the African fixed hot spot frame. For comparison we also show a previous African moving hot spot frame of Steinberger [2000] (mantle model 2, dashed black line). The latter frame is applicable only after 68 Ma.

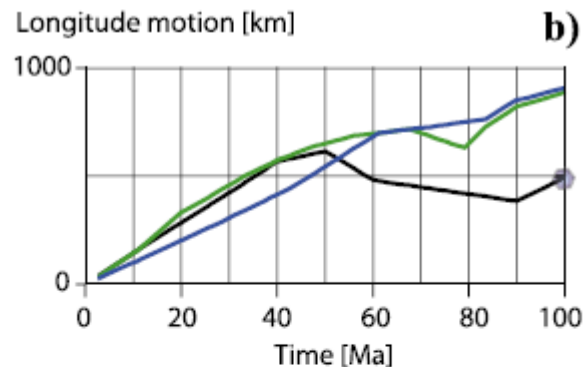
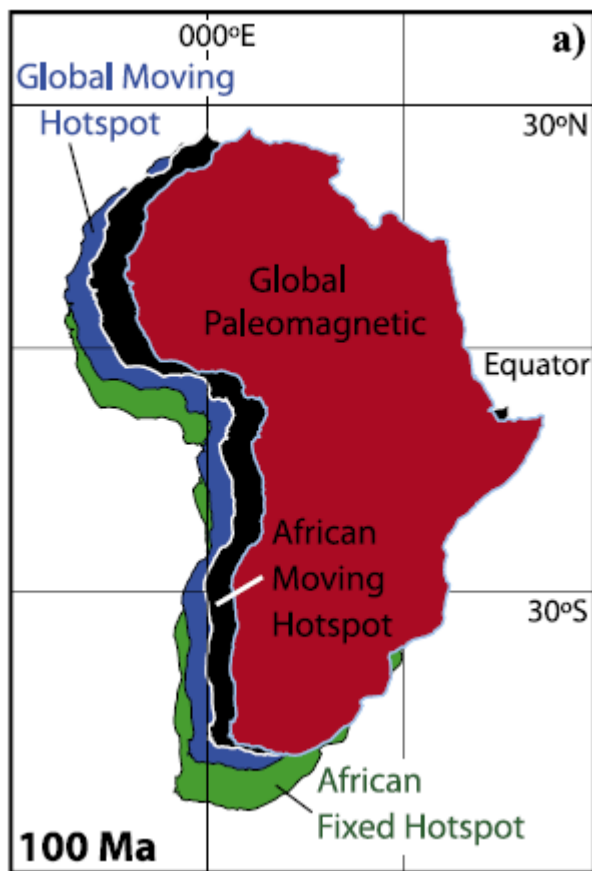
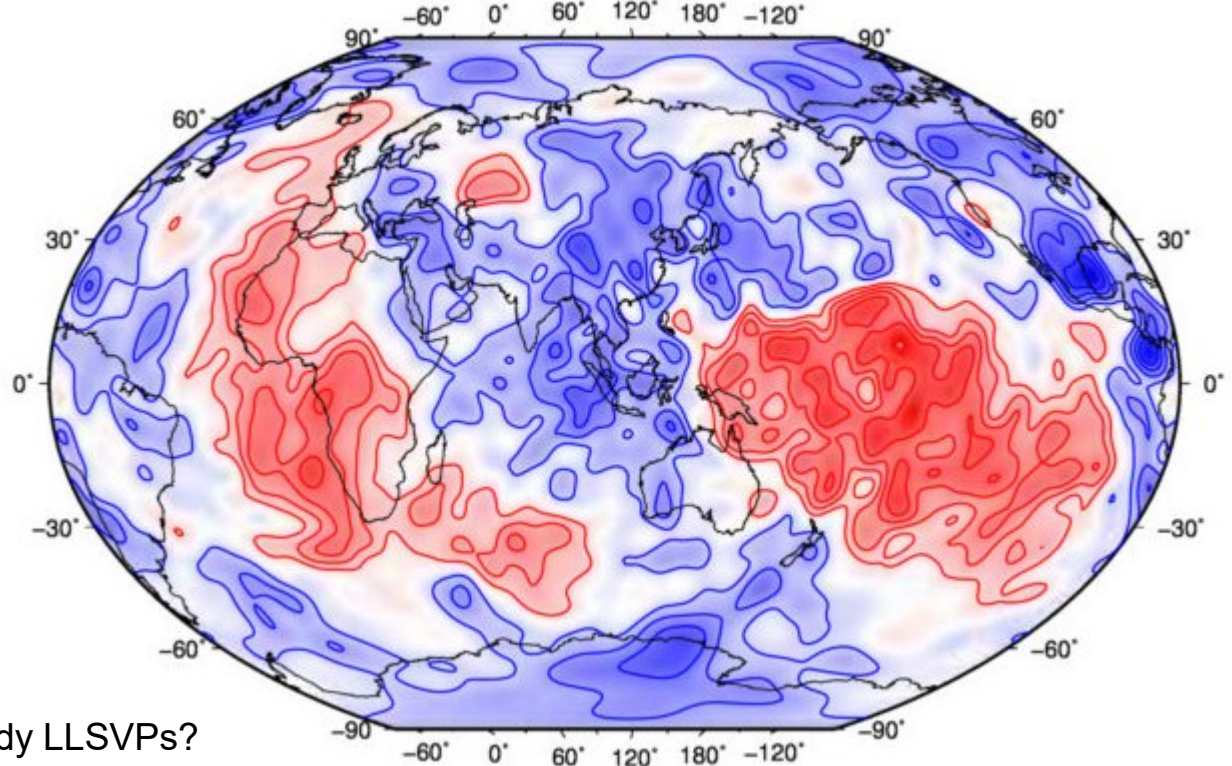


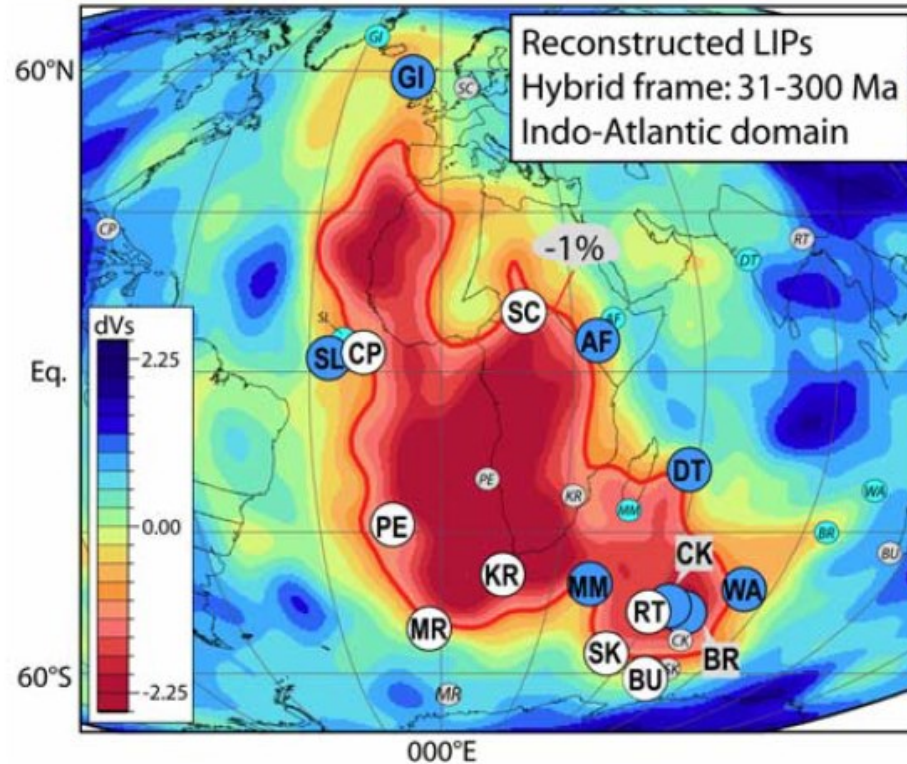
Figure 14. (a) Reconstruction of Africa at 100 Ma using all four reference frames discussed in the text. The continent's positions show longitude offsets from the global paleomagnetic framework, varying from 5° (African moving hot spot) to 9° (African fixed hot spot). African fixed hot spot predicts significantly more southerly latitudes for Africa than all other frames. (b) Cumulative eastward component of motion for Africa since 100 Ma as predicted from the African moving hot spot (black line), African fixed hot spot (green line), and global moving hot spot (blue line) reference frames. Mean motion is computed from a $1^\circ \times 1^\circ$ grid for the continental area of Africa.

Long wavelength structure of the lower mantle: LLSVP's



EGU blog: Should we still study LLSVPs?
(Jamie Ward)

Reconstructed frame: Large igneous province



Reconstructed frame: Diamonds

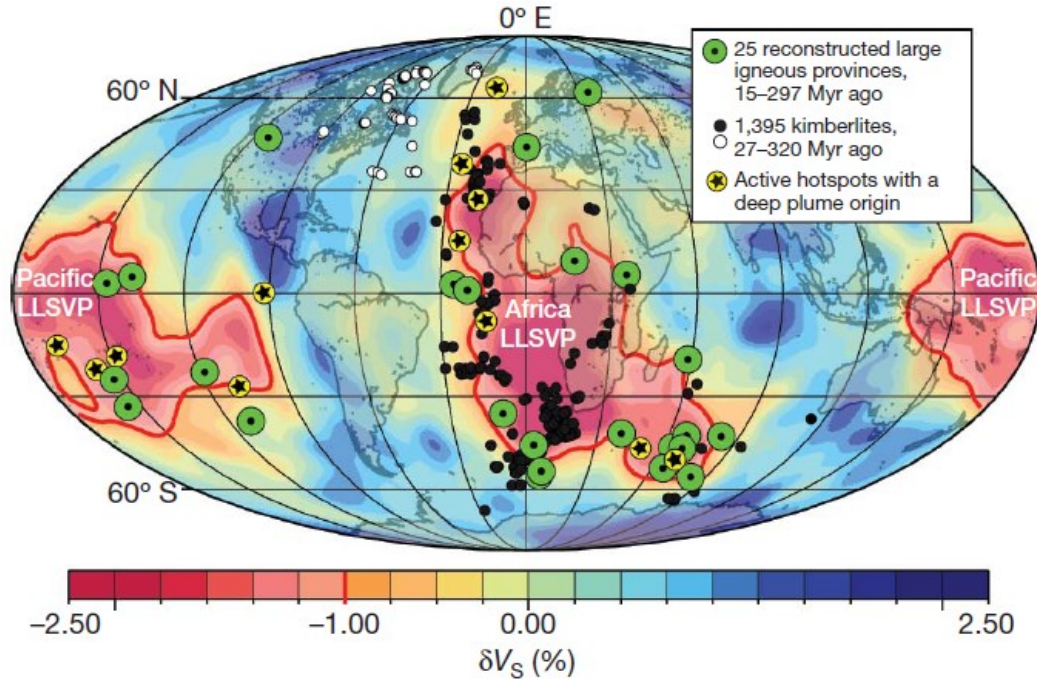


Figure 1 | Reconstructed large igneous provinces and kimberlites for the past 320 Myr with respect to shear-wave anomalies at the base of the mantle. The deep mantle (2,800 km on the SMEAN tomography model²⁰) is dominated by two LLSVPs beneath Africa and the Pacific. The 1% slow contour (approximating to the PGZs) is shown as a thick red line. 80% of all reconstructed kimberlite locations (black dots) of the past 320 Myr erupted near or over the sub-African PGZ. The most ‘anomalous’ kimberlites (17%) are from Canada (white dots). Present-day continents are shown as a background, to illustrate the distribution of hotspots classified as being of deep-plume origin¹⁸ and present-day shear-wave velocity anomalies (percentage δV_s), and bear no geographical relationship to reconstructed kimberlites or large igneous provinces.

Reconstructed frame: True polar wander?

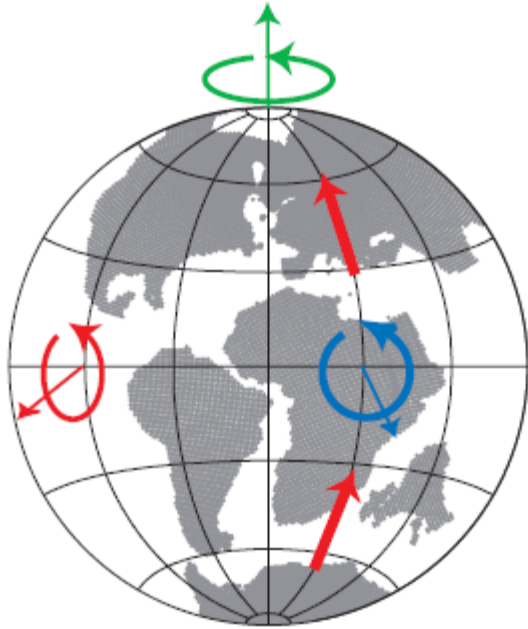
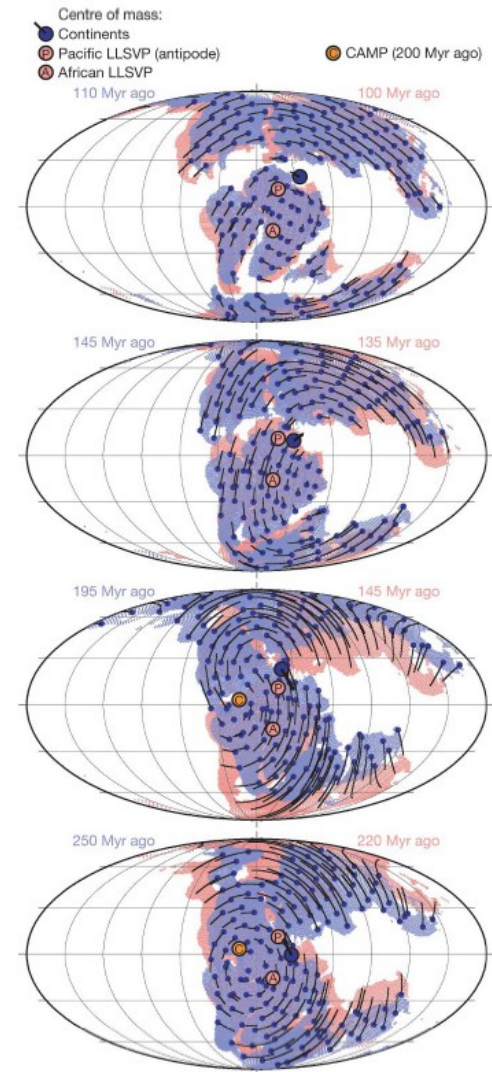


Figure 1 | Coordinate system in which the mean motion (rotation) of continents is described. One axis (blue) is on the Equator at the same longitude as the continents' centre of mass. The second axis (red) is on the Equator 90° away; rotation around this axis corresponds to coherent northward or southward motion of all continents. The third axis (green) is the Earth's spin axis; rotation around it corresponds to west–east motion.

Steinberger et al.: Absolute plate motions and TPW in the absence of hotspot tracks, *Nature*



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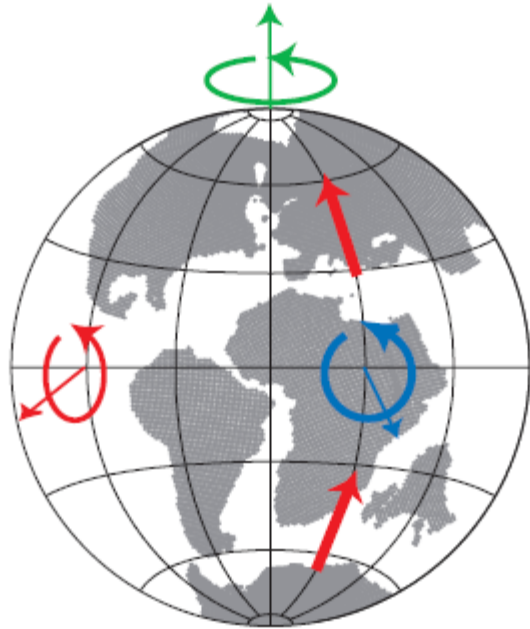


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