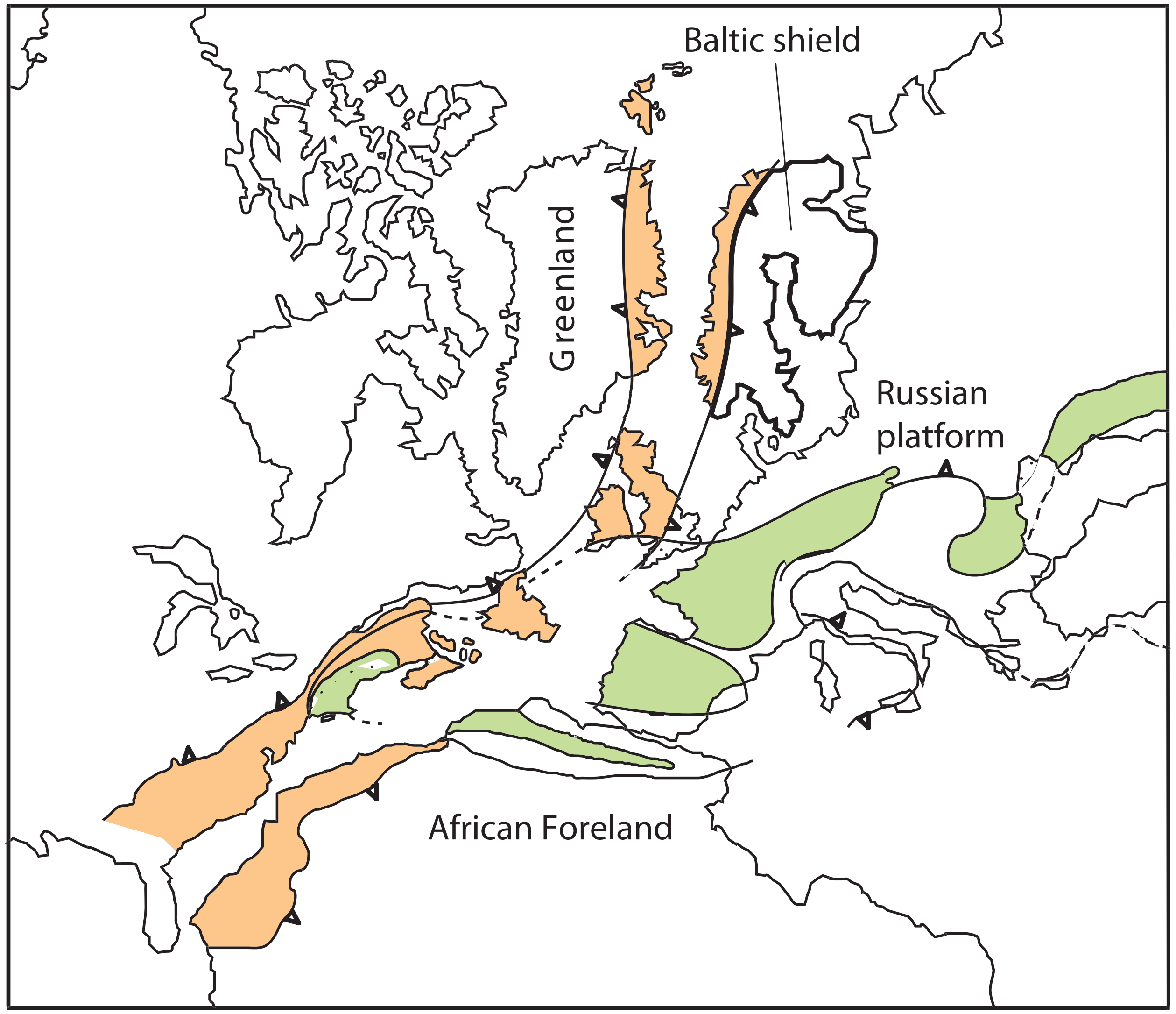
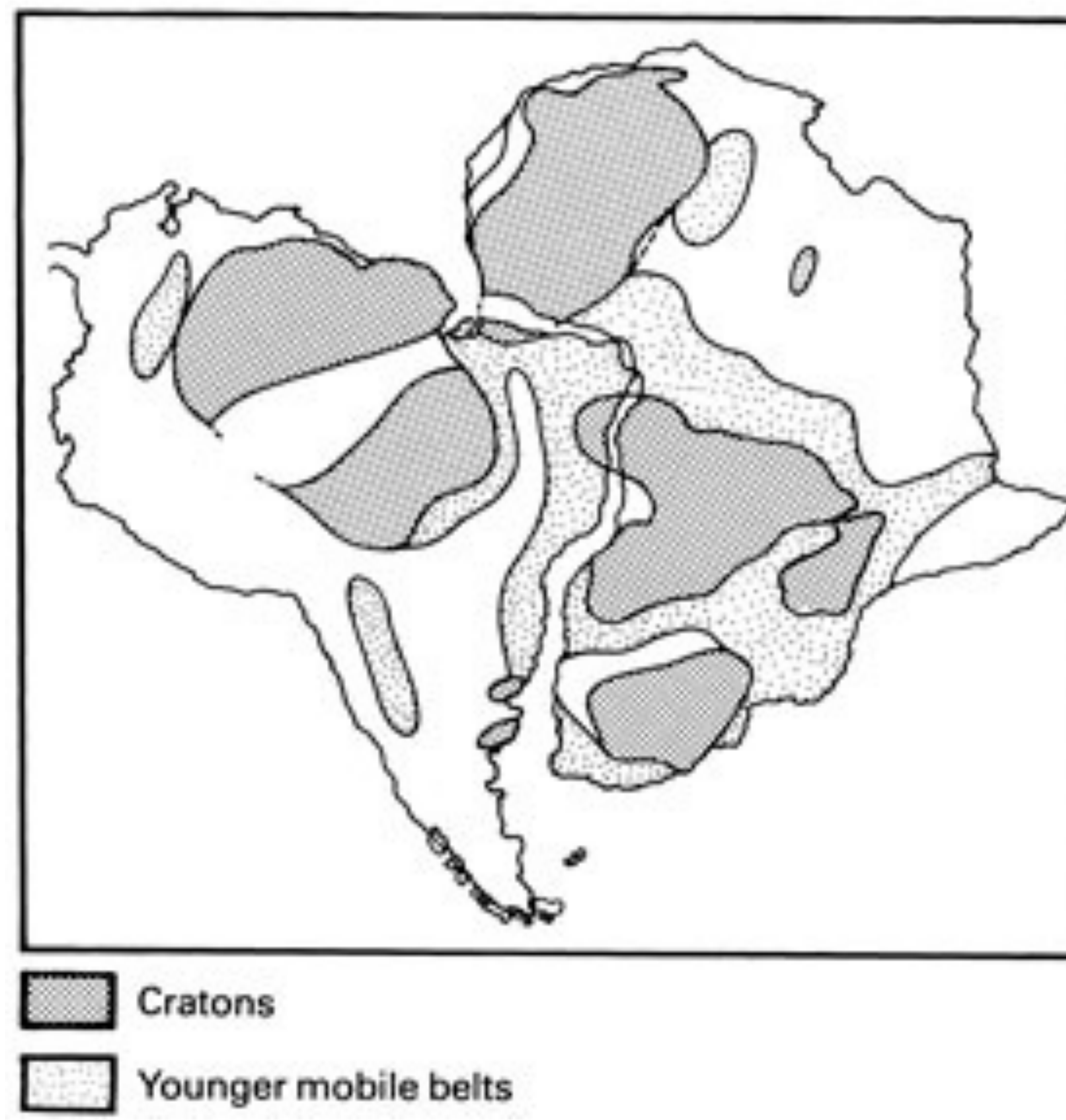
02- Die Plattentektonik

Geological evidences for continental drift

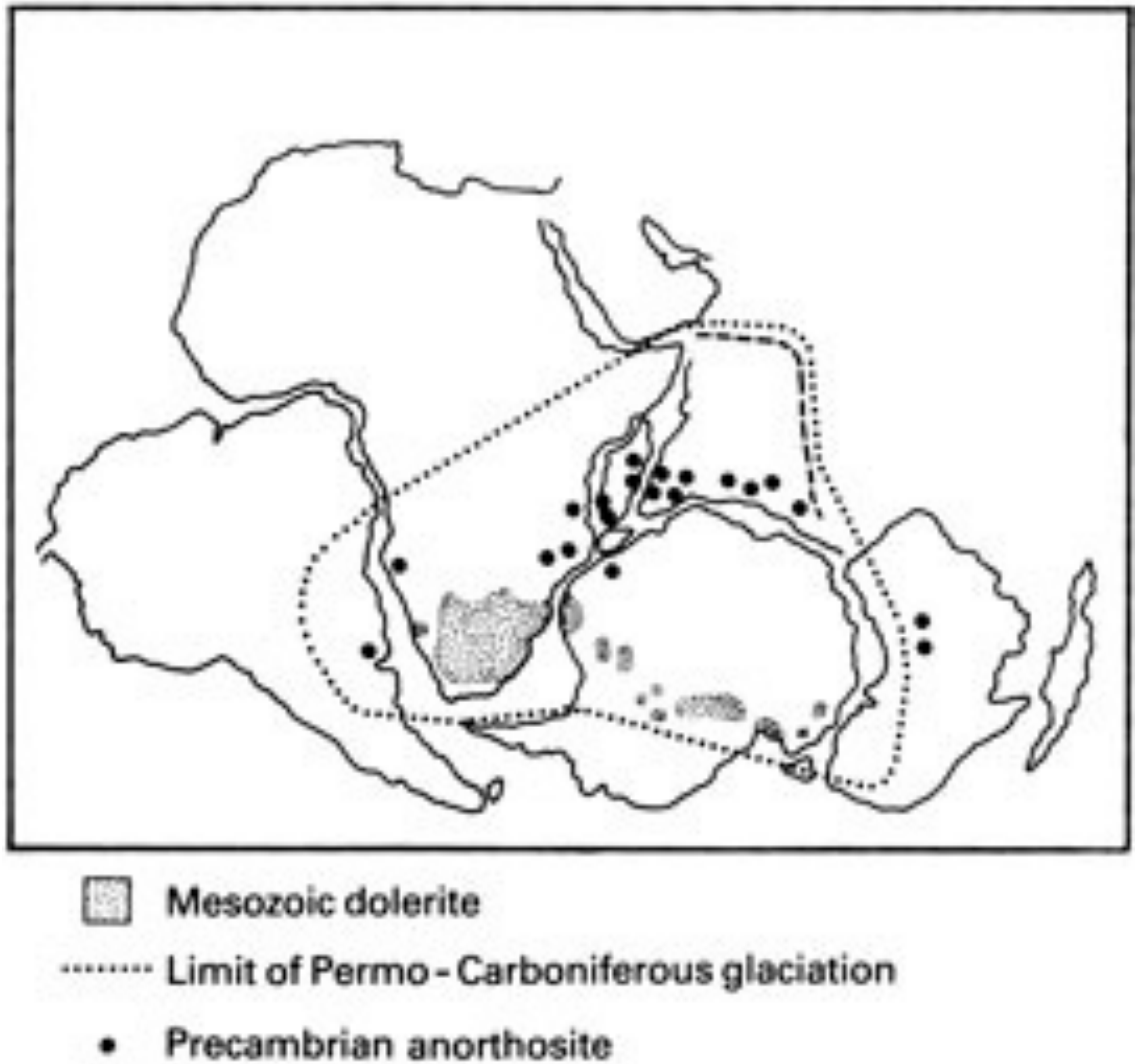


The fit of the continents around the North Atlantic, after Bullard et al. (1965), and the trends of the Appalachian-Caledonian and Variscan (early and late Paleozoic) fold belts (orange and green respectively).

Correlation of cratons and younger mobile belts across the closed southern Atlantic Ocean

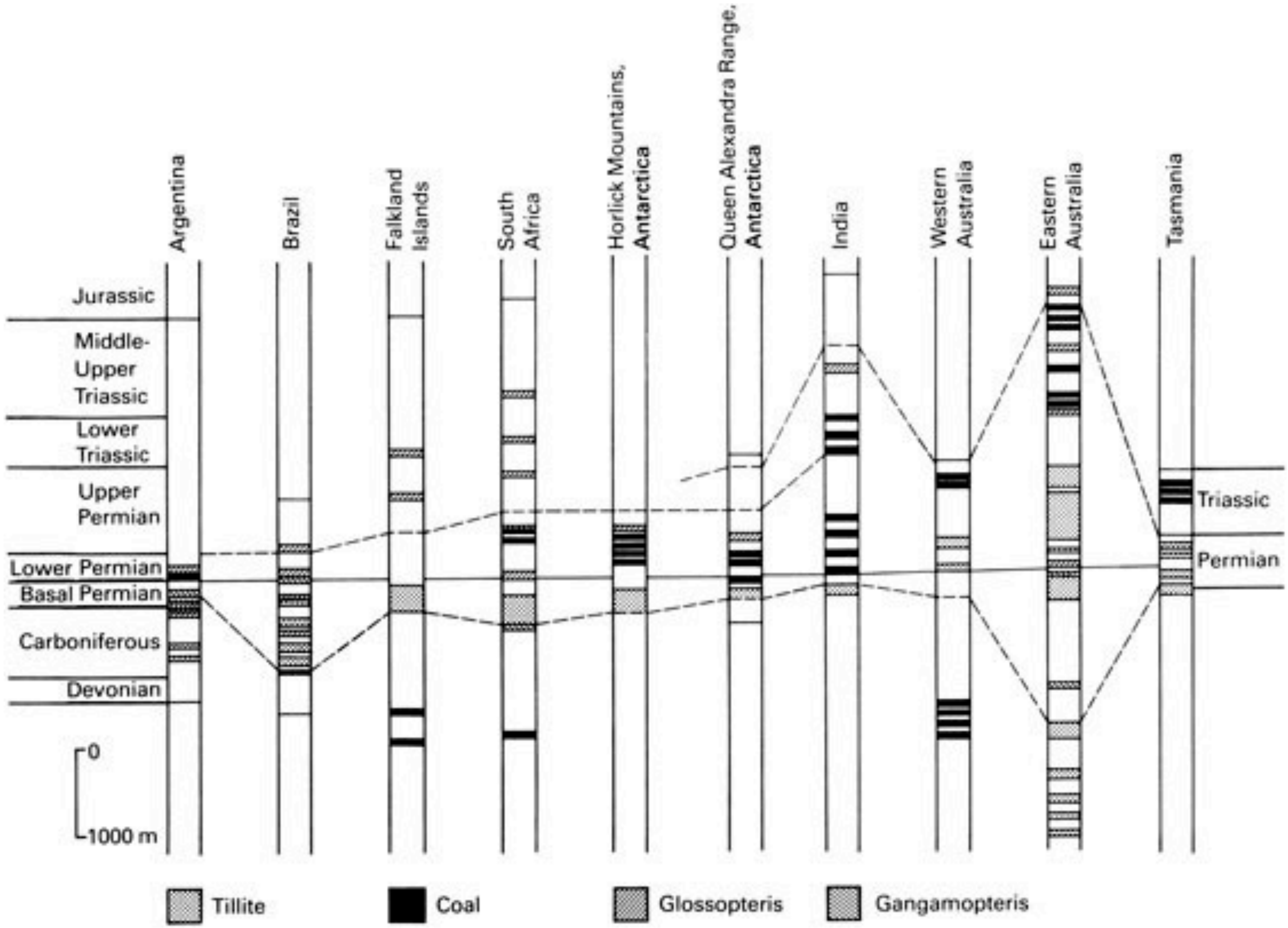


Geological evidences for continental drift



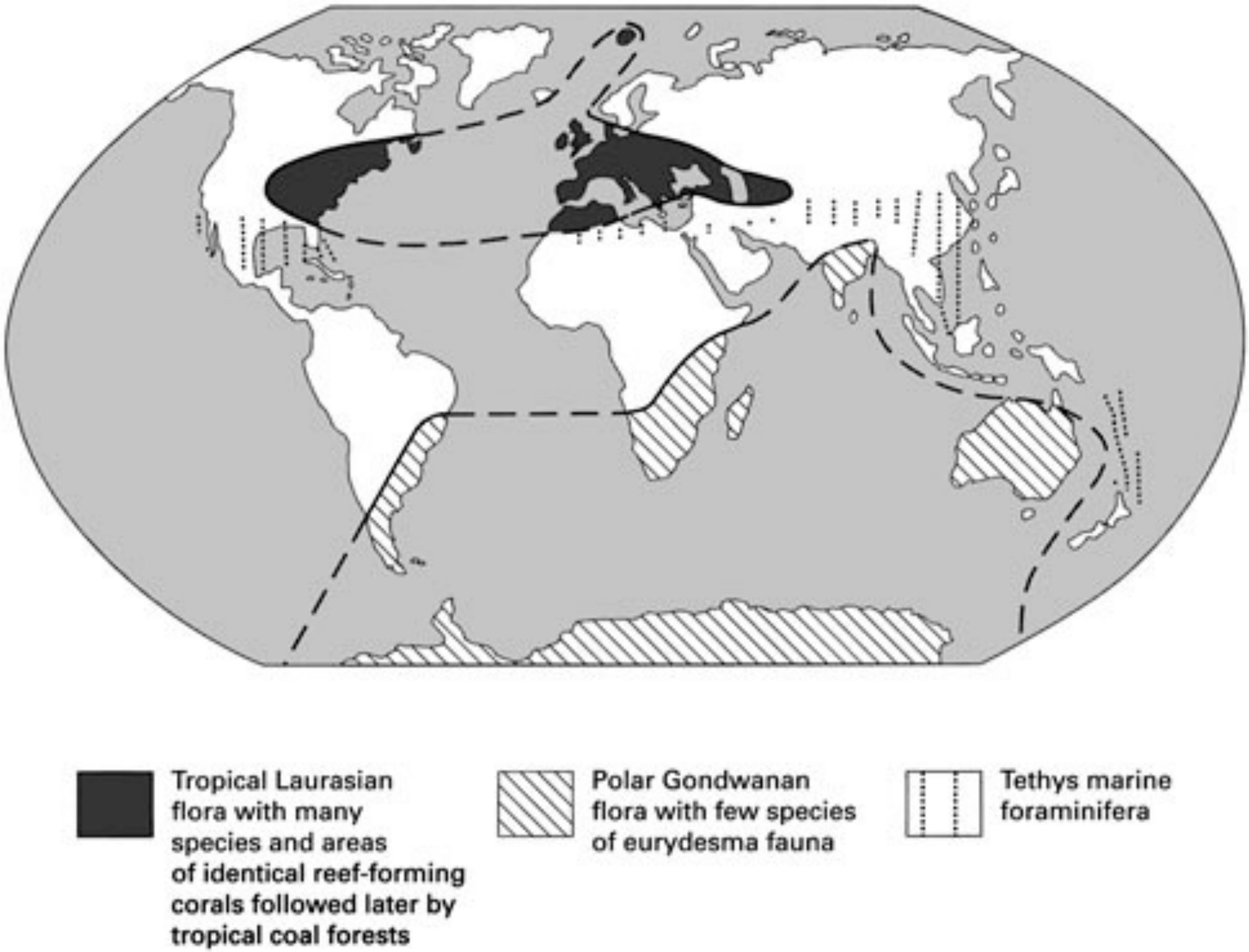
Correlation of Permo-Carboniferous glacial deposits, Mesozoic dolerites, and Precambrian anorthosites between the reconstructed continents of Gondwana (after Smith & Hallam, 1970)

Geological evidences for continental drift



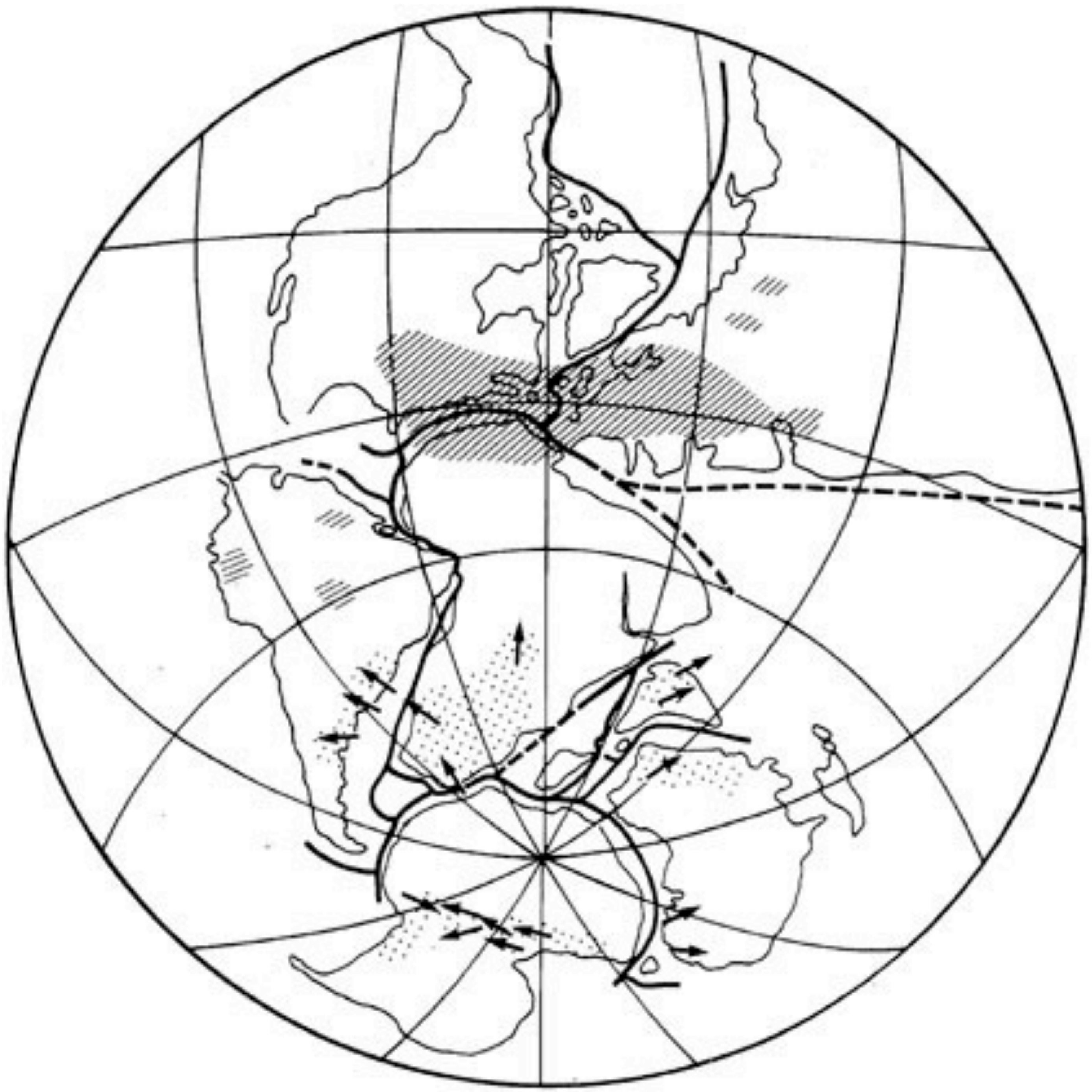
Correlation of stratigraphy between Gondwana continents (from Hurley, 1968)

Paleoclimatological evidences for continental drift



Present distributions of Pangean flora and fauna
(from Tarling & Tarling,1971)

Paleoclimatological evidences for continental drift

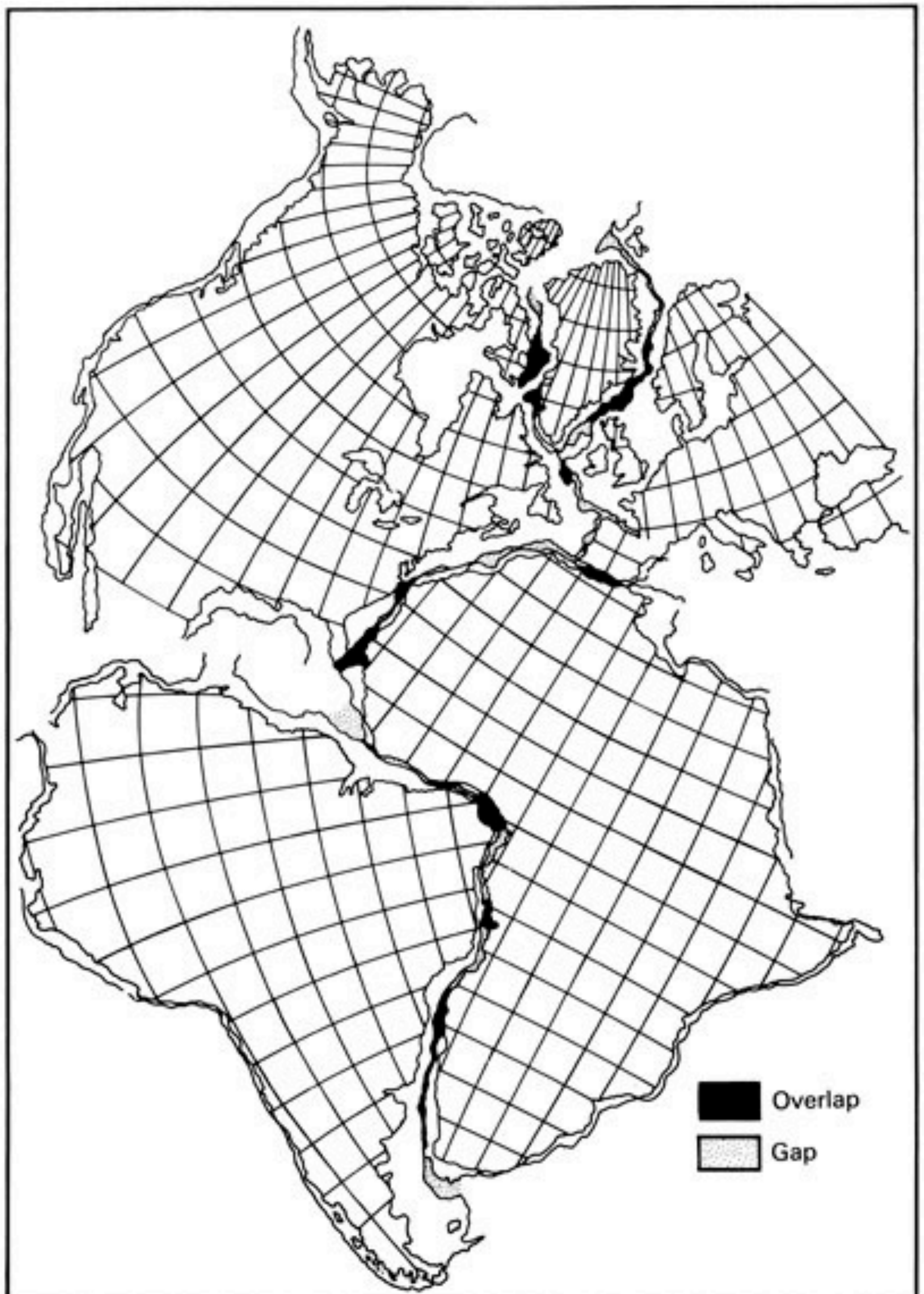


Areas of tropical coal forests at 300 Ma which some 50 Ma later became vast hot deserts

Areas of glaciation between 300 and 250 Ma with arrows indicating known directions of ice movement

Use of paleoclimatic data to control and confirm continental reconstructions (from Tarling & Tarling, 1971)

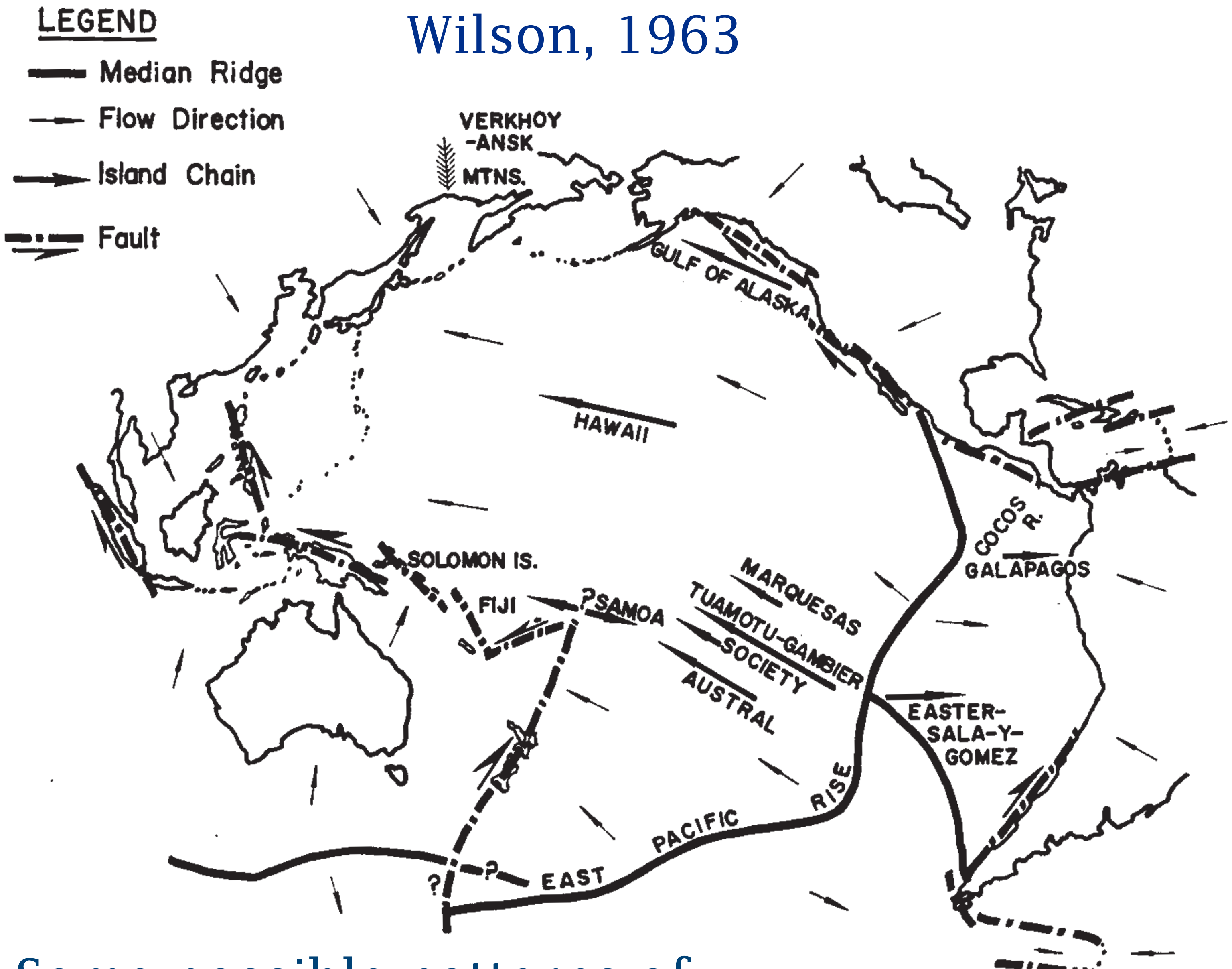
Continental drift reconstruction



The first mathematical reassembly of continents based solely on geometric criteria was performed by Bullard et al. (1965), who fitted together the continents on either side of the Atlantic. This was accomplished by sequentially fitting pairs of continents after determining their best fitting poles of rotation. The only rotation involving parts of the same landmass is that of the Iberian penin- sular with respect to the rest of Europe. This is justified because of the known presence of oceanic lithosphere in the Bay of Biscay which is closed by this rotation. Geologic evidence and information provided by magnetic lineations in the Atlantic indicate that the reconstruction represents the continental configuration during late Triassic/early Jurassic times approximately 200 Ma ago.

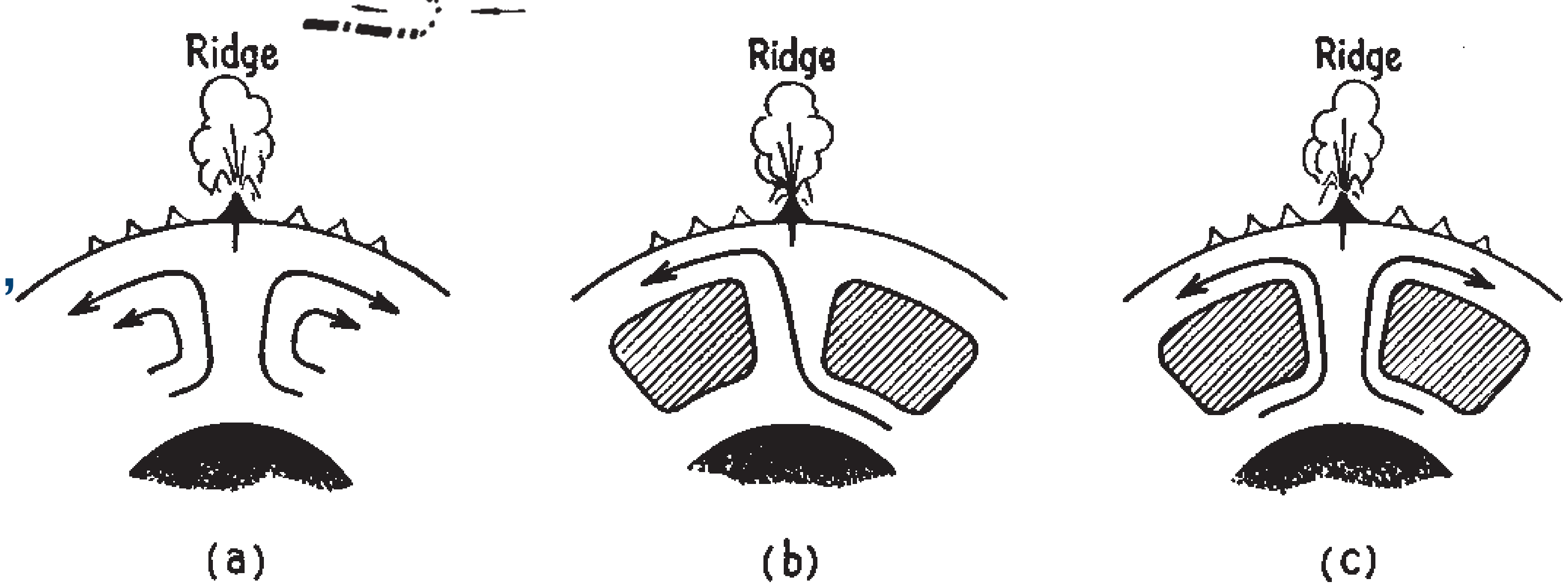
Hot-spots

Wilson, 1963

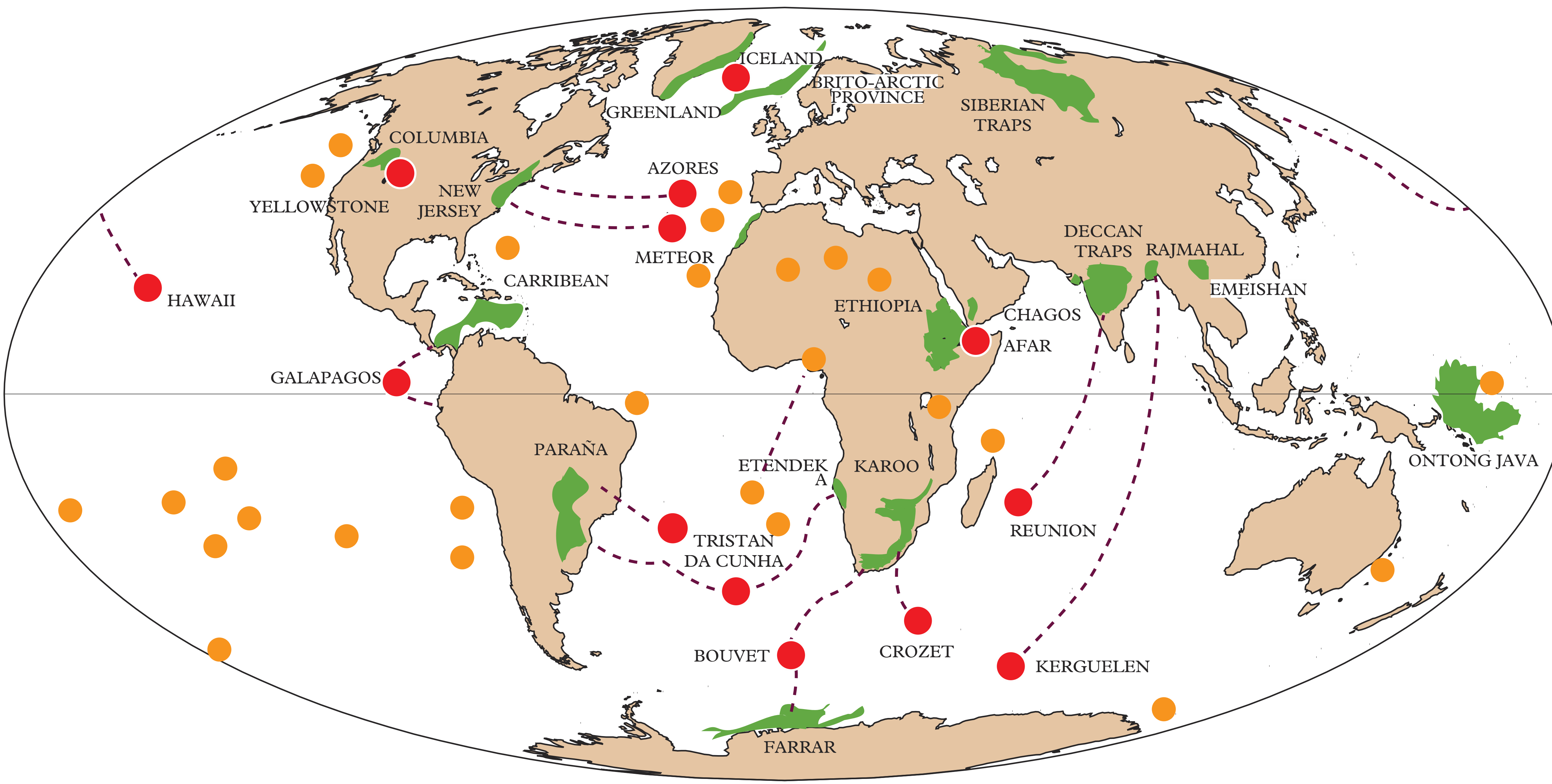


Sketch of the Pacific ocean. Heavy arrow show nine linear chains of islands and seamounts which increase in age in direction of arrow. Single-headed arrows show direction of motion, where known, along large transcurrents faults. Small arrows show postulated direction of flow away from median ridges.

Some possible patterns of convection, showing that, if active volcanos form overrrising vertical currents, chains of extinct volcanoes might be formed by the horizontal flow or the currents. The shaded areas represent stable cores of cells



Hot-spots

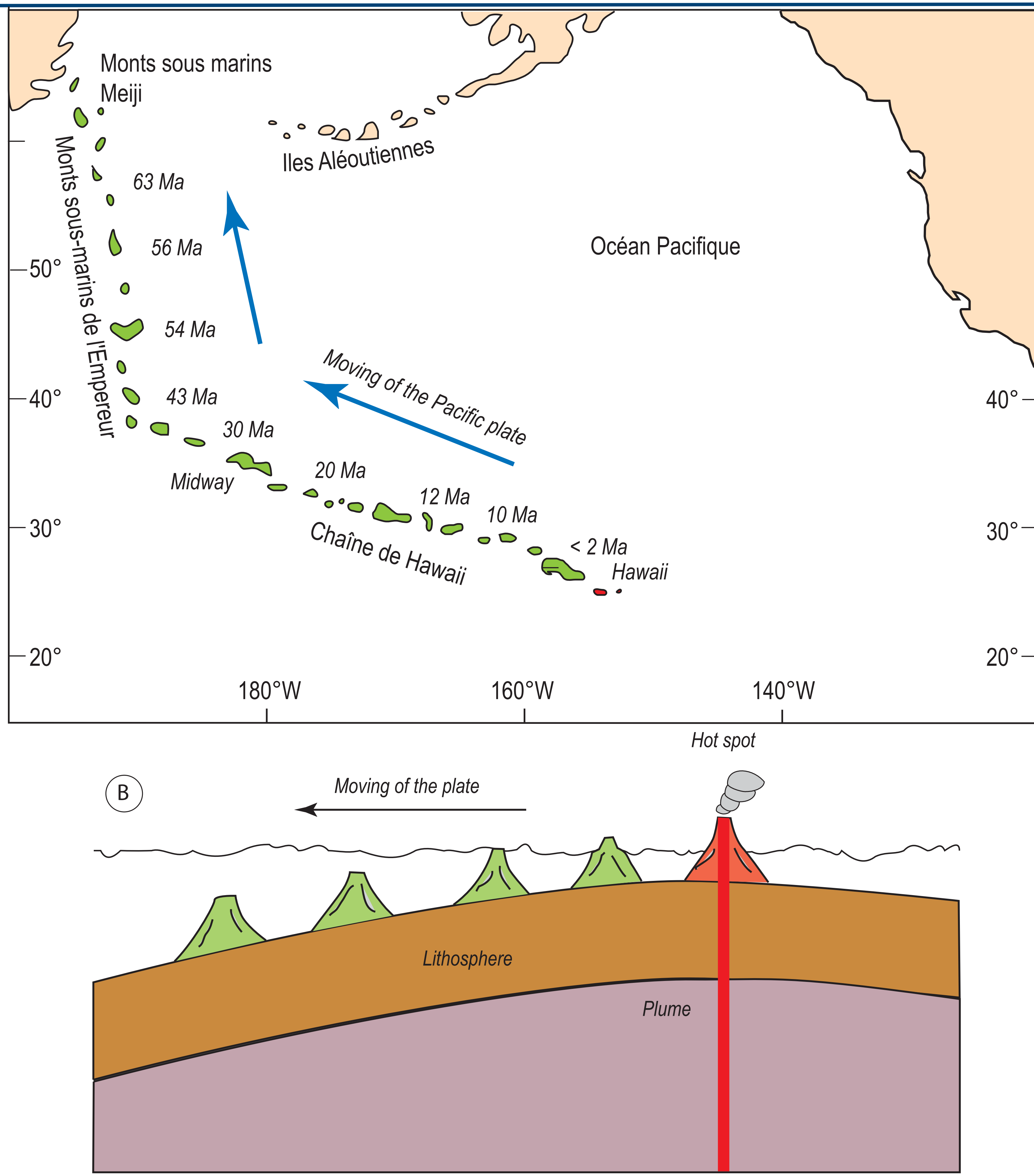


World map of the main traps (or flood basalts).

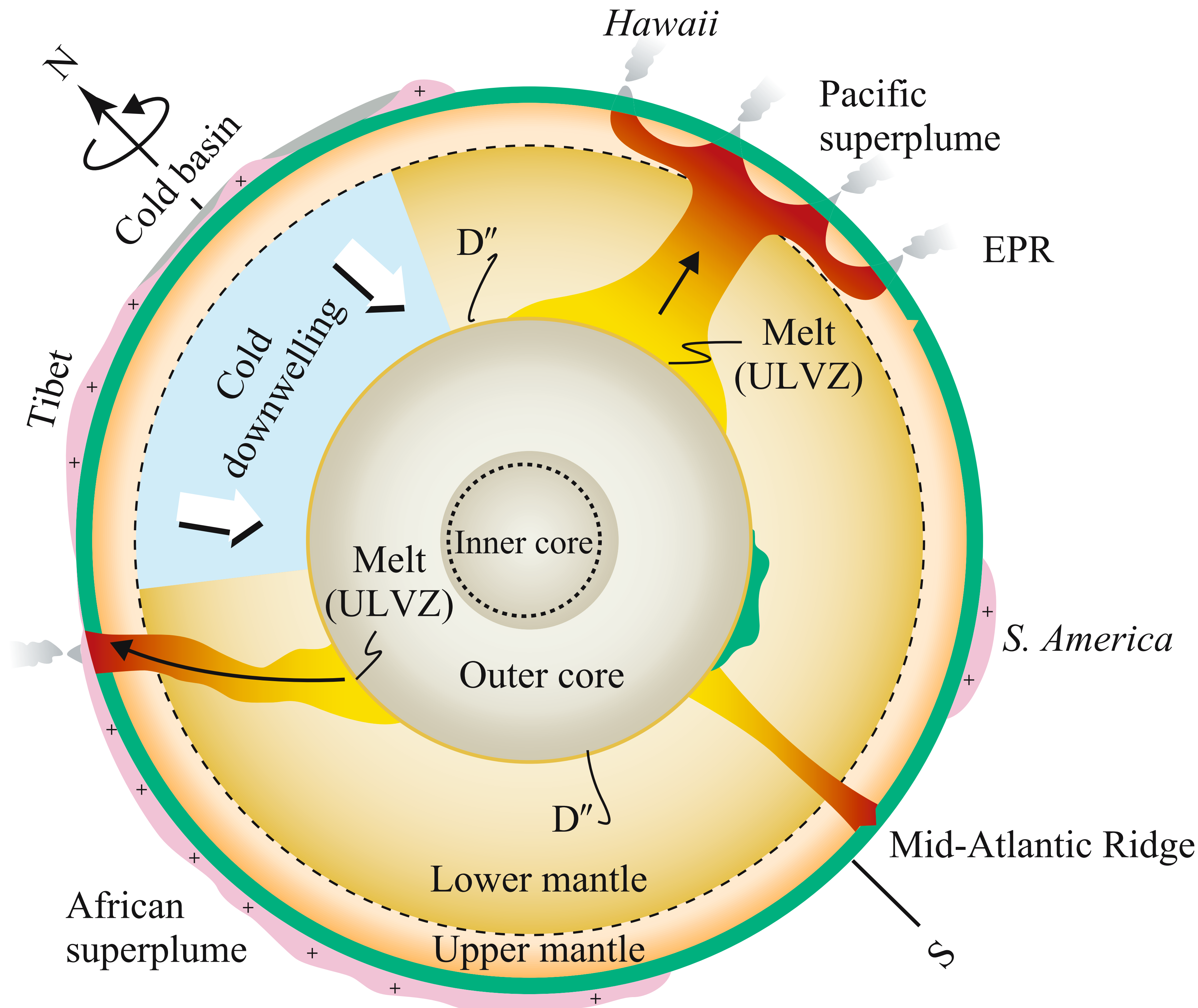
Some have been linked to the currently active hot spot volcanoes, whose birth may be the cause of the traps.

Active hot spot volcanoes not related to traps

Hot-spots



R. Bousquet 2009-2010


Hawaii
Pacific superplume
EPR
N
Cold basin
Tibet
Cold downwelling
D″
Melt (ULVZ)
Inner core
Melt (ULVZ)
Outer core
S. America
D″
Mid-Atlantic Ridge
Lower mantle
Upper mantle
African superplume
S

Sea-floor spreading

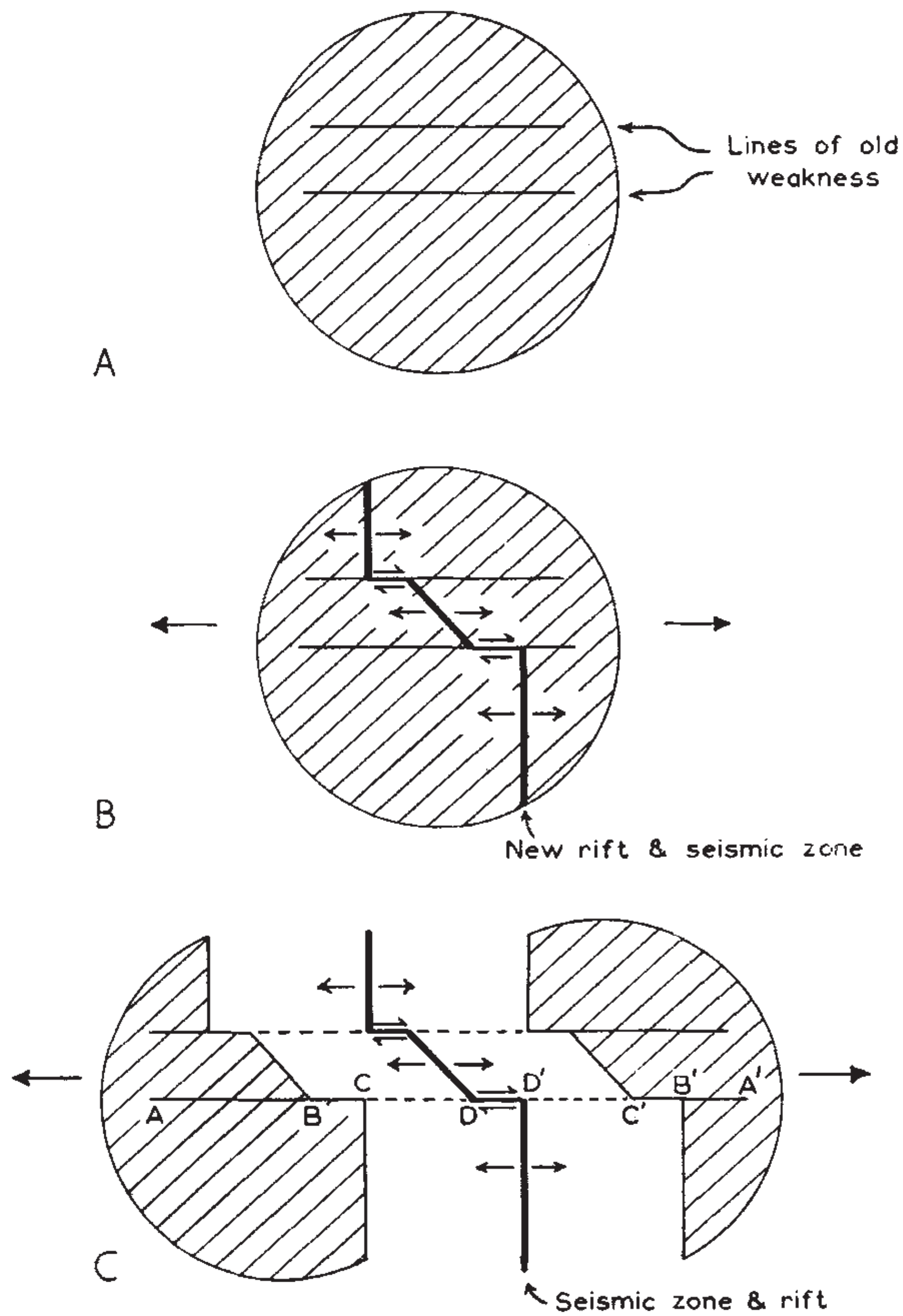
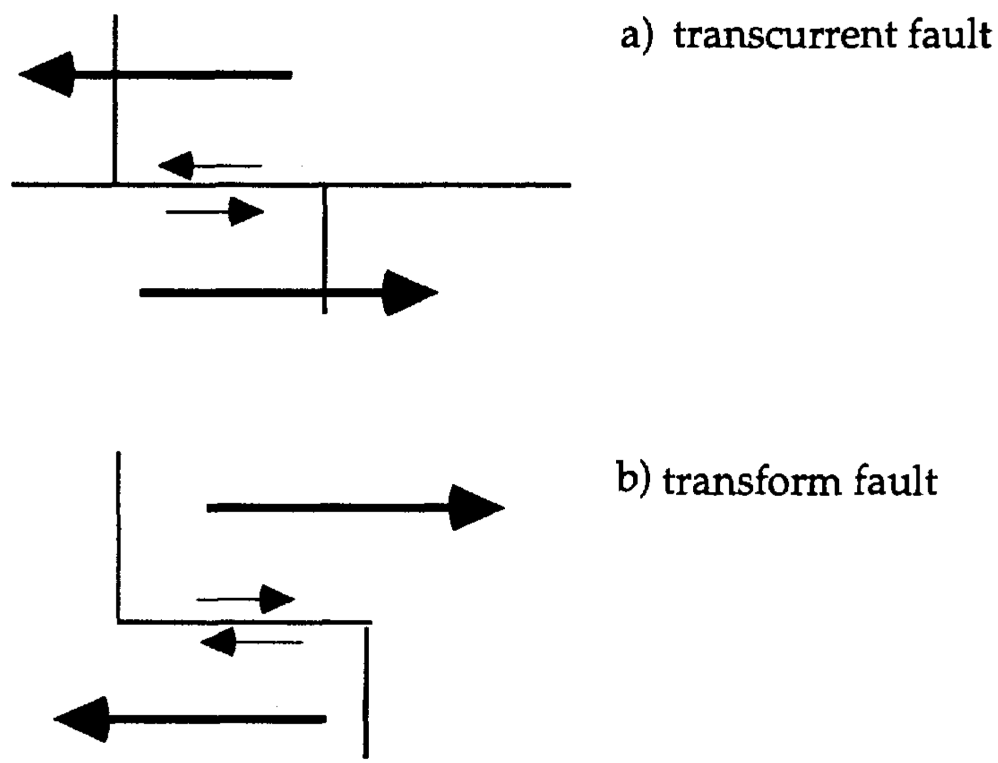


Fig. 6. Diagram illustrating three stages in the rifting of a continent into two parts (for example, South America and Africa). There will be seismic activity along the heavy lines only



The difference between transcurrent and transform faults. (a) In a transcurrent (or strike-slip) fault, the direction of movement can be determined from the offset of a feature intersecting the fault. If the feature is moved to the left, it is a left-lateral fault, as shown here. The north side of the fault has moved to the left (west), the south side of the fault has moved to the right (east), and the fault may continue indefinitely. (b) In a ridge-to-ridge transform fault, a section of the mid-ocean ridge is fractured perpendicular to its length. In this case, the right side of the ridge is moving to the right (east), the left side is moving to the left (west), and the sense of motion is opposite of that illustrated in (a). Note also that the fault does not extend indefinitely, but terminates against the north-south running ridge segments.

Wilson, 1965

Geometry on a sphere

Morgan, 1967

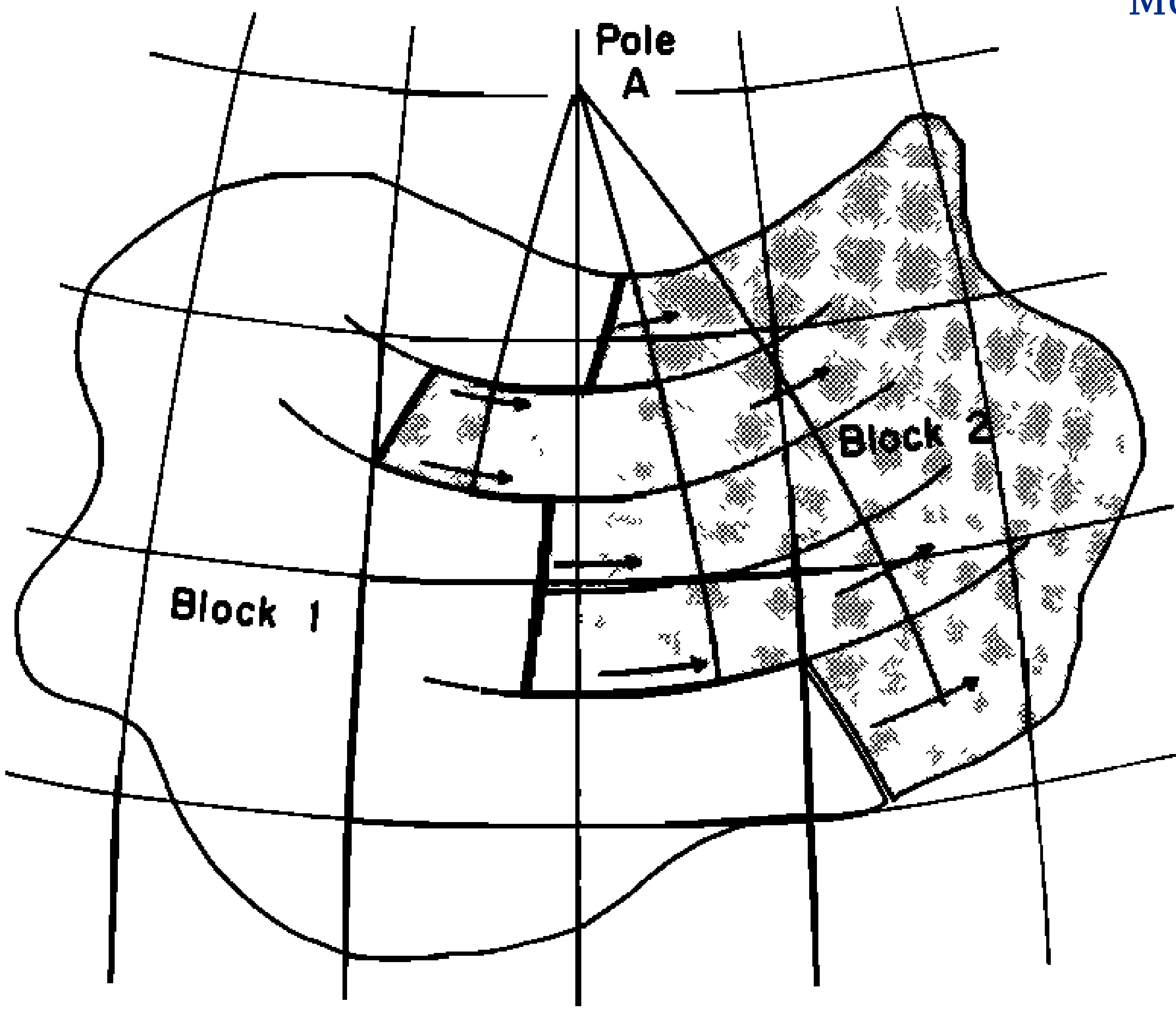
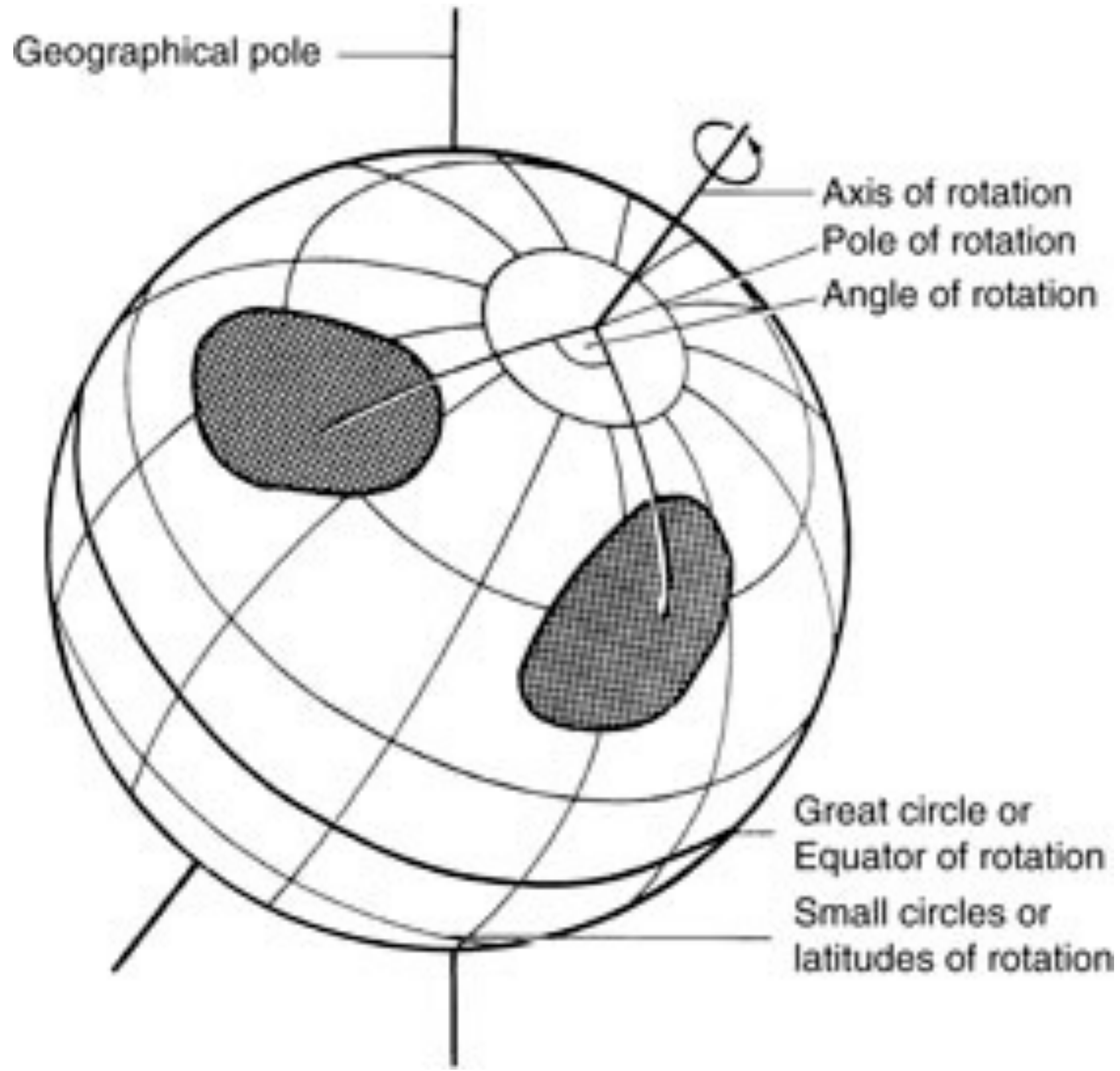
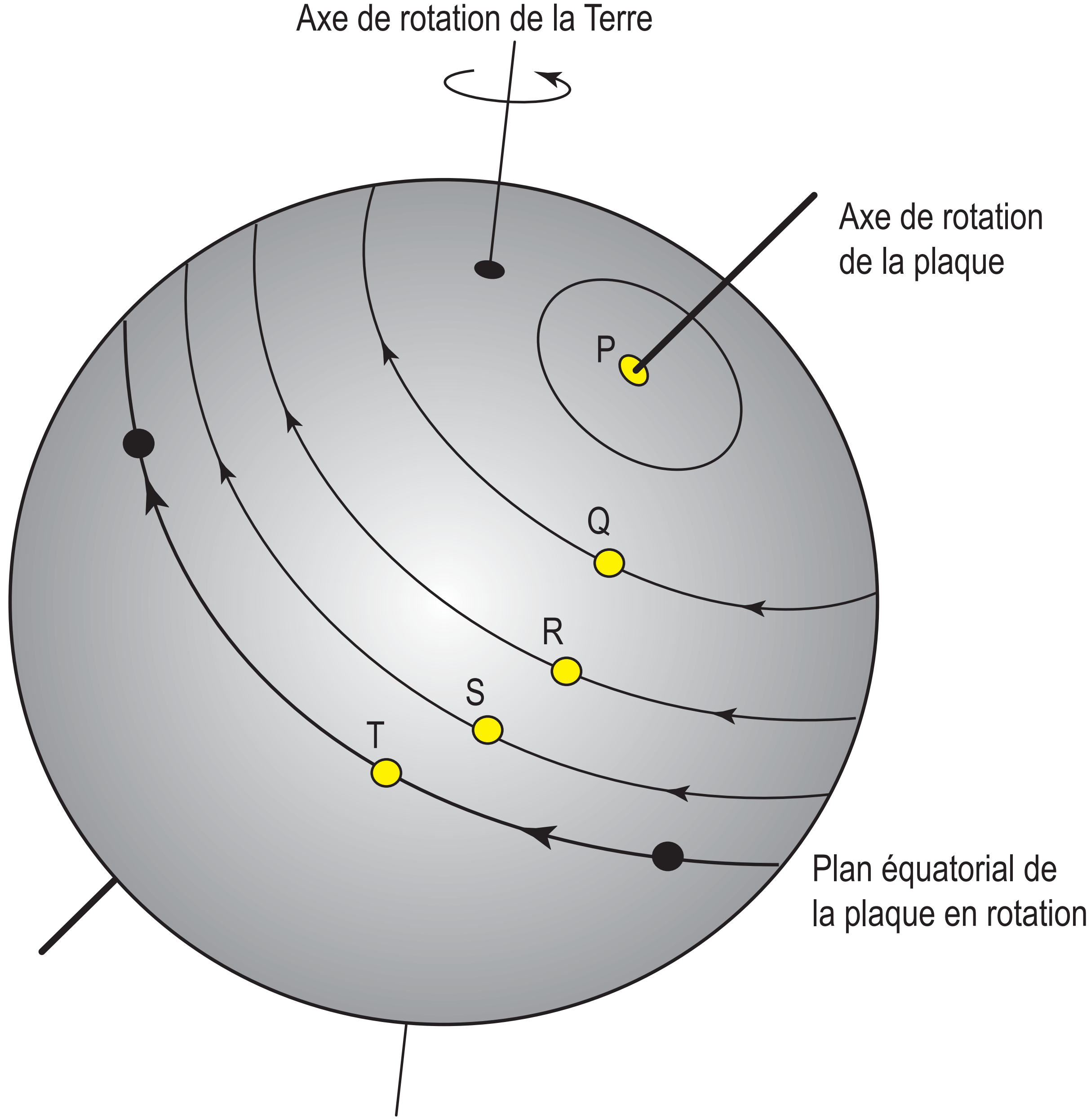


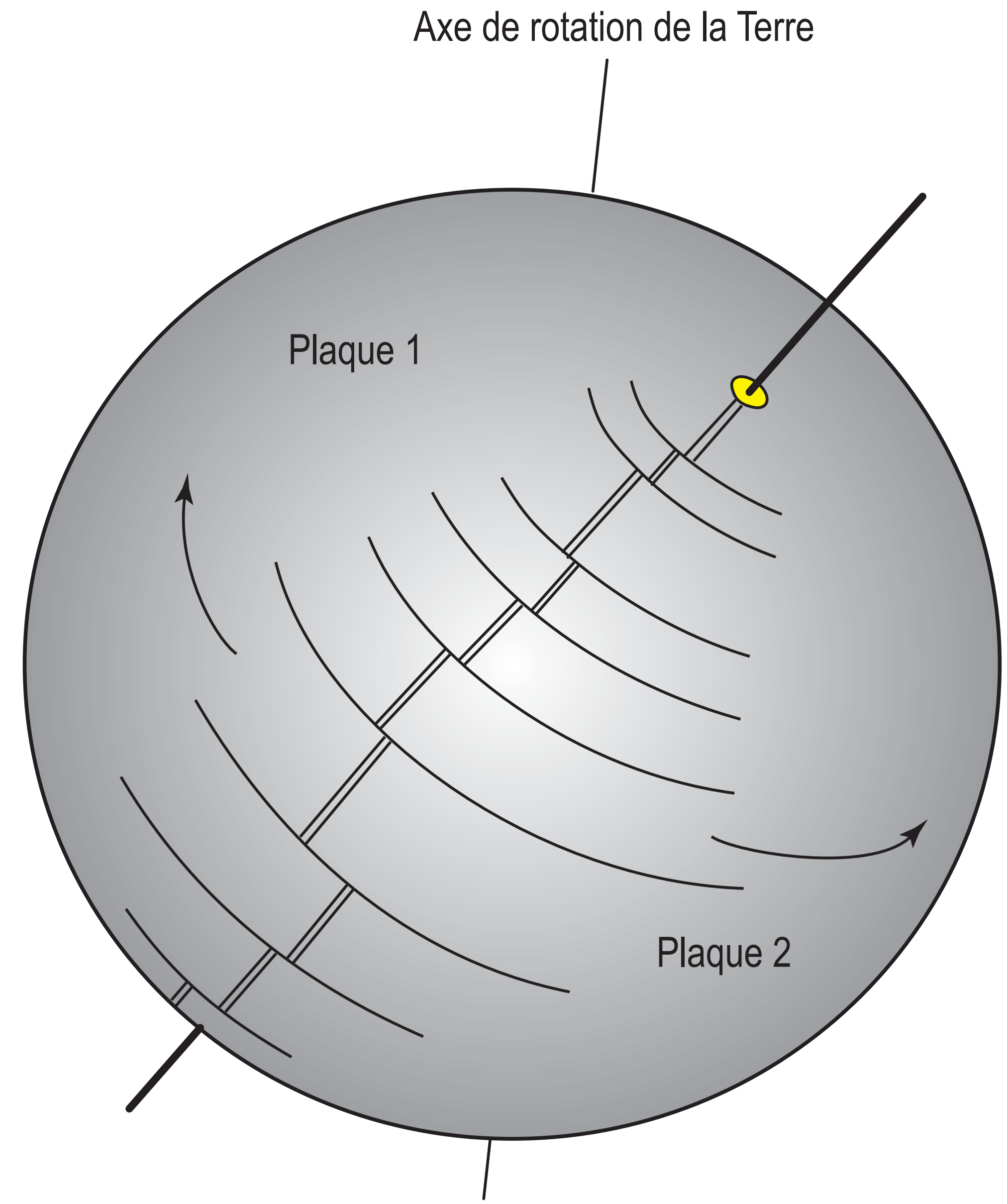
Fig. 4. On a sphere, the motion of block 2 elative to block 1 must be a rotation about some ole. All faults on the boundary between 1 and 2 nust be small circles concentric about the pole A.



The Euler's theorem states that the movement of a portion of a sphere across its surface is uniquely defined by a single angular rotation about a pole of rotation.

The pole of rotation, and its antipodal point on the opposite diameter of the sphere, are the only two points which remain in a fixed position relative to the moving portion. Consequently, the movement of a continent across the surface of the Earth to its pre-drift position can be described by its pole and angle of rotation


Axe de rotation de la Terre
Axe de rotation
de la plaque
P
Q
R
S
T
Plan équatorial de
la plaque en rotation


Axe de rotation de la Terre
Plaque 1
Plaque 2

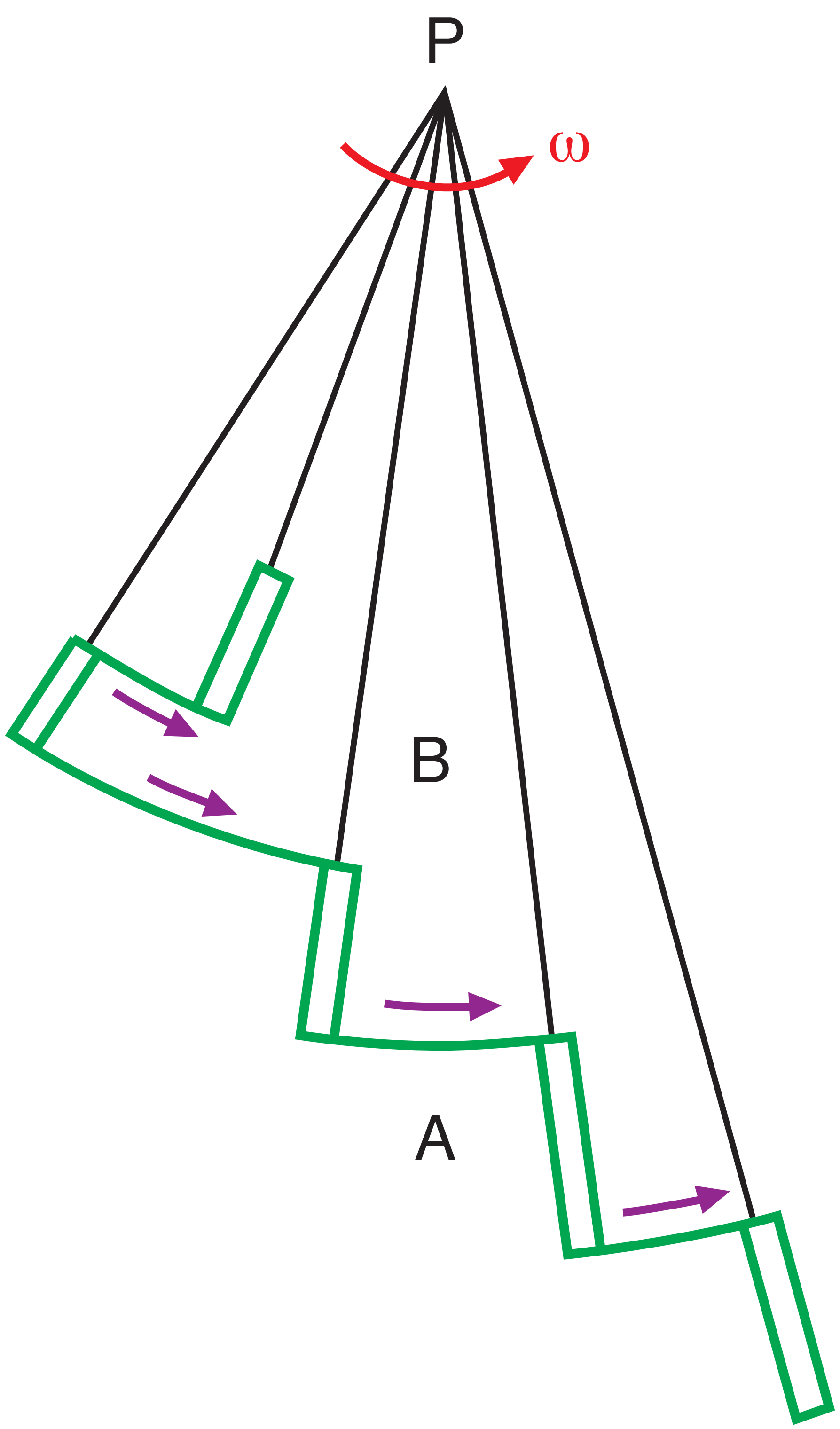
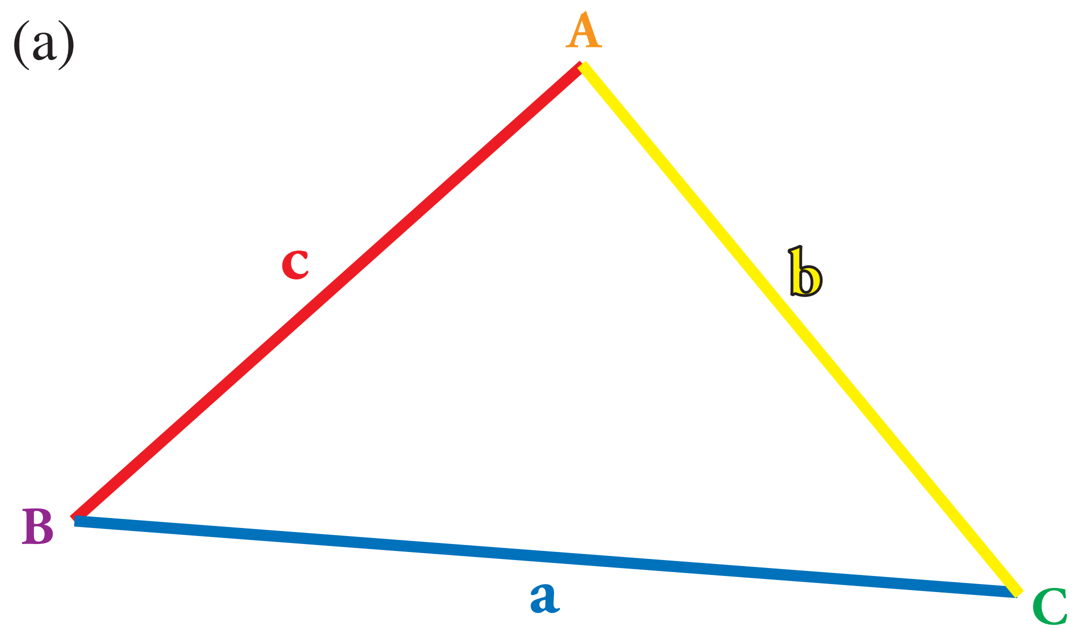


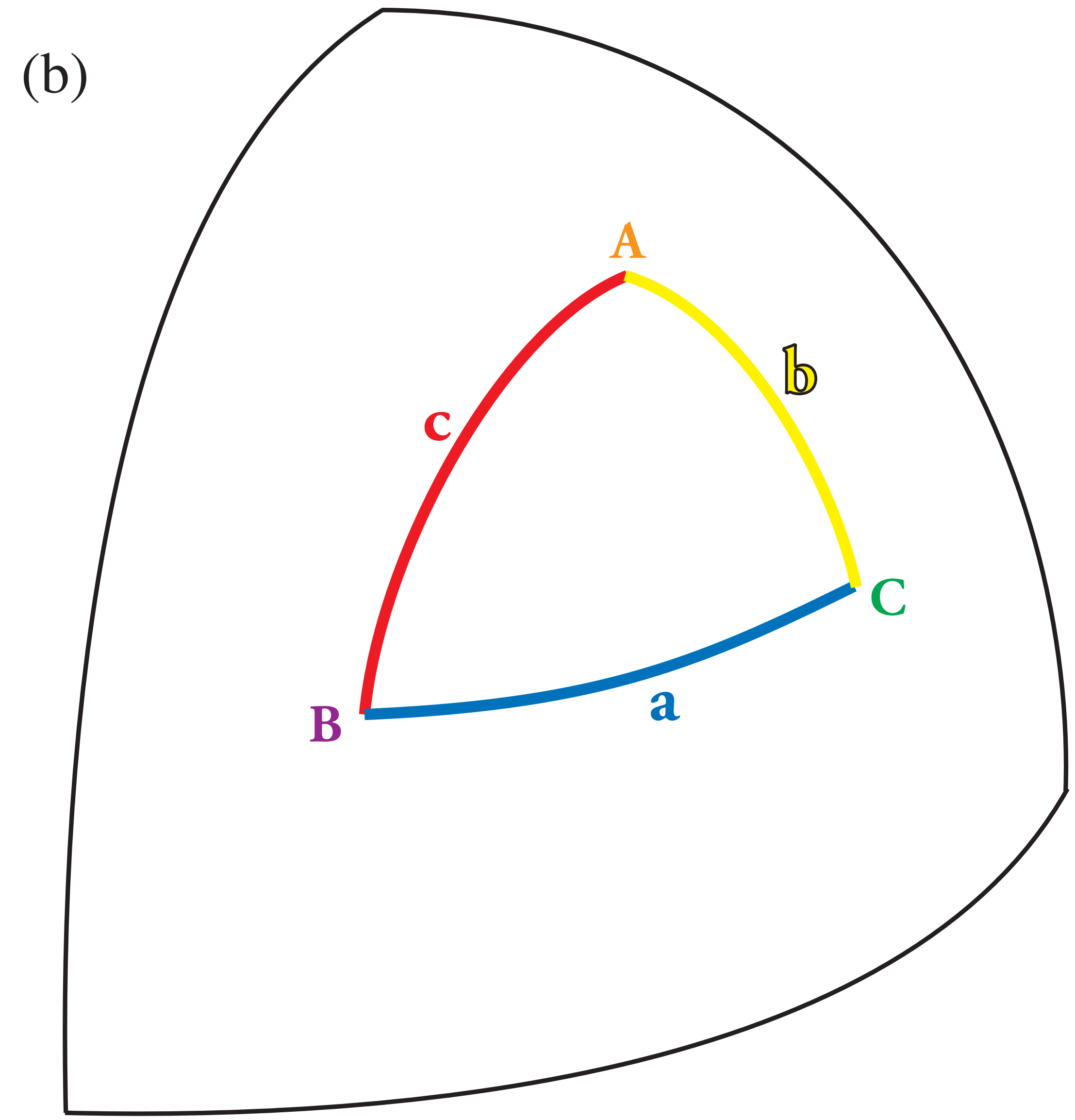
Plate B is moving counter-clockwise relative to plate A.

The motion is defined by the angular velocity **ω** about the pole of rotation P.

Double lines are ridge segments, and arrows denote direction of motion on transform fault

Bücher



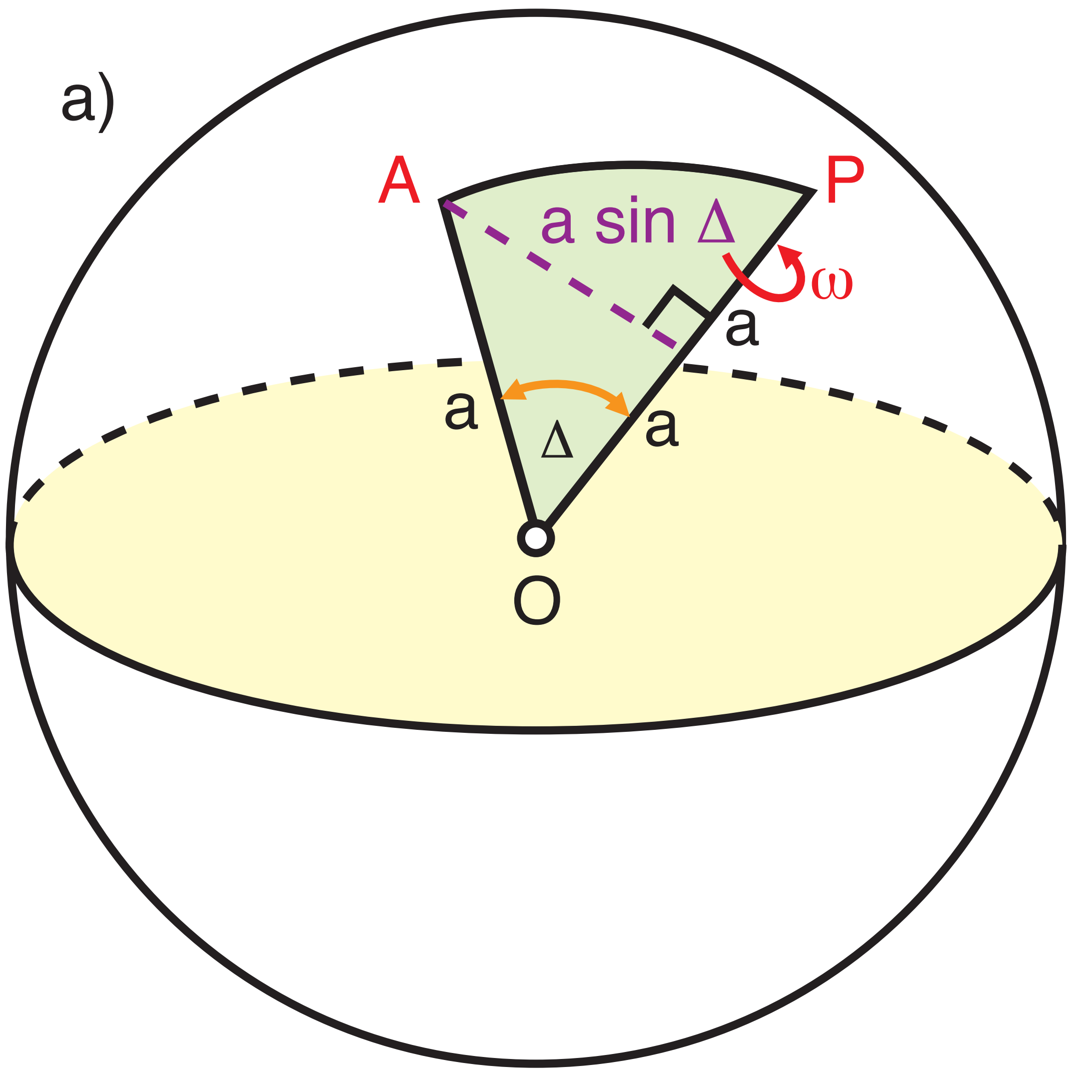


$$\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}$$

$$a^2 = b^2 + c^2 - 2bc\cos A$$

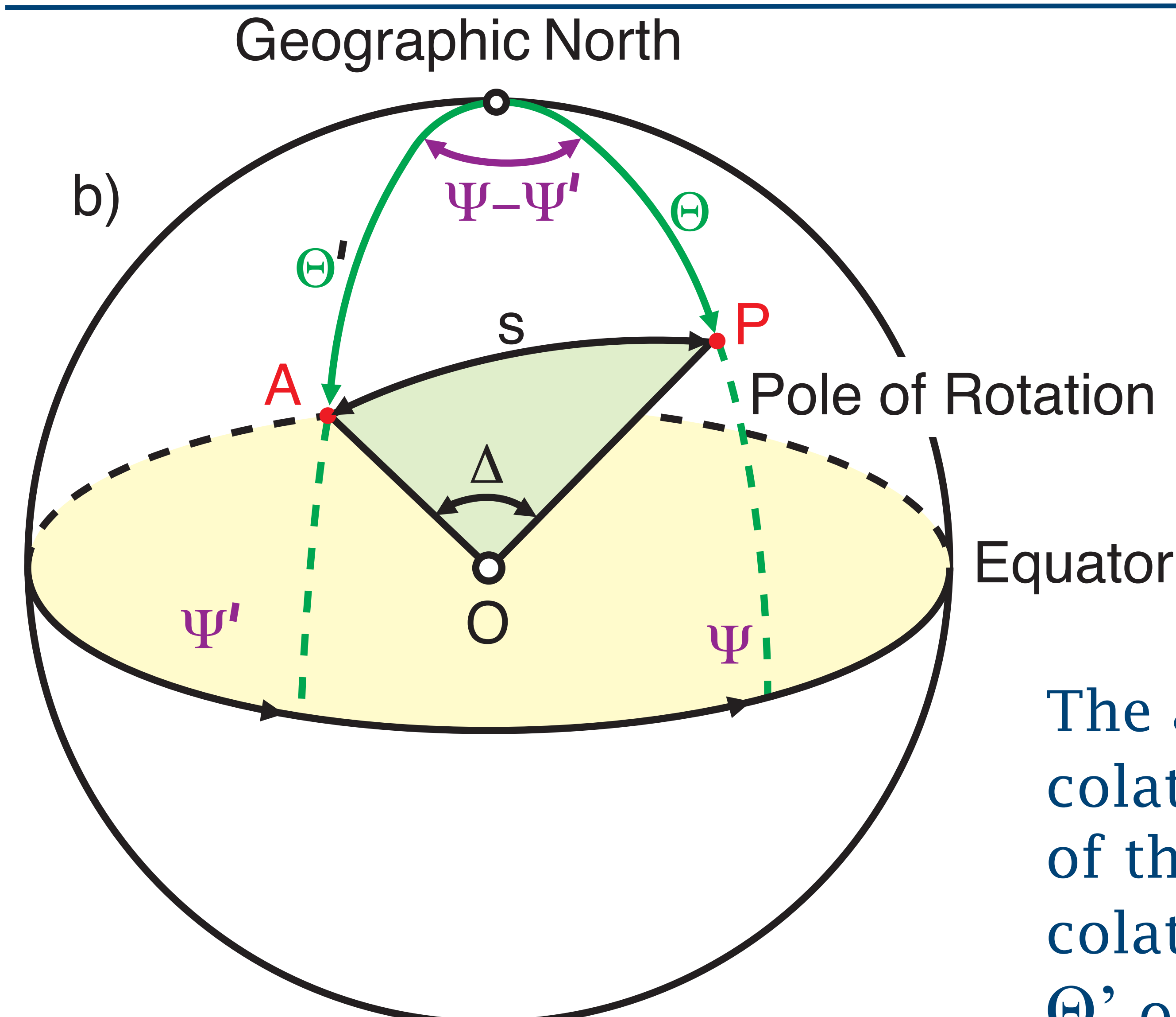
$$\frac{\sin A}{\cos a} = \frac{\sin B}{\cos b} = \frac{\sin C}{\cos c}$$

$$\cos a = \cos b \cos c + \sin b \sin c \cos A$$



$$u_{rel} = \omega a \sin \Delta$$

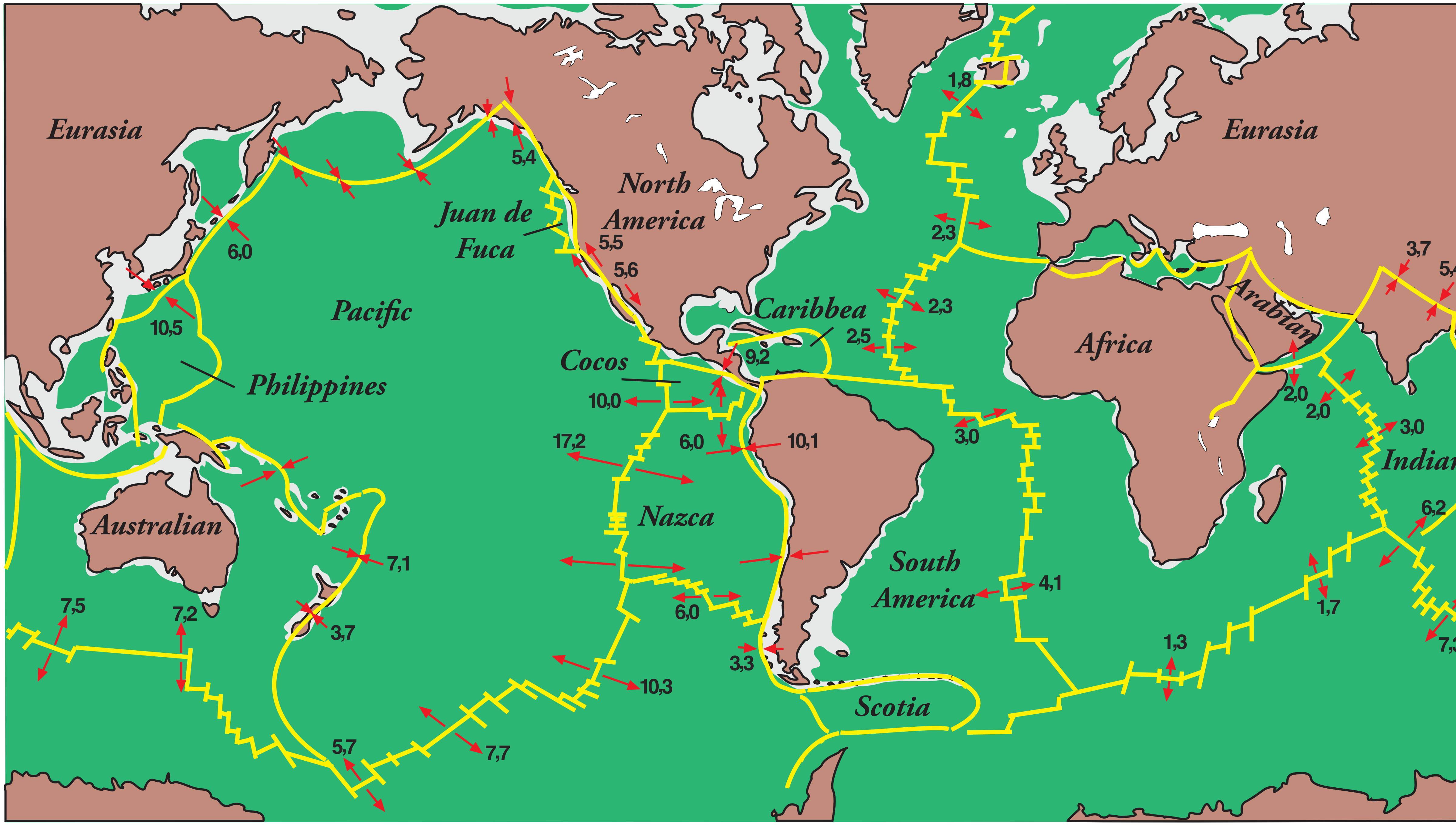
where a is the radius of the Earth
and Δ is the angle subtended at
the center of the Earth by the pole
of rotation P and the point A on
the plate boundary



The angle Δ is related to the colatitude Θ and east longitude Ψ of the rotation pole and the colatitude Ψ’ and east longitude Θ’ of the point on the plate boundary A

$$\cos \Delta = \cos \Theta \cos \Theta' + \sin \Theta \sin \Theta' \cos\left(\Psi - \Psi'\right)$$

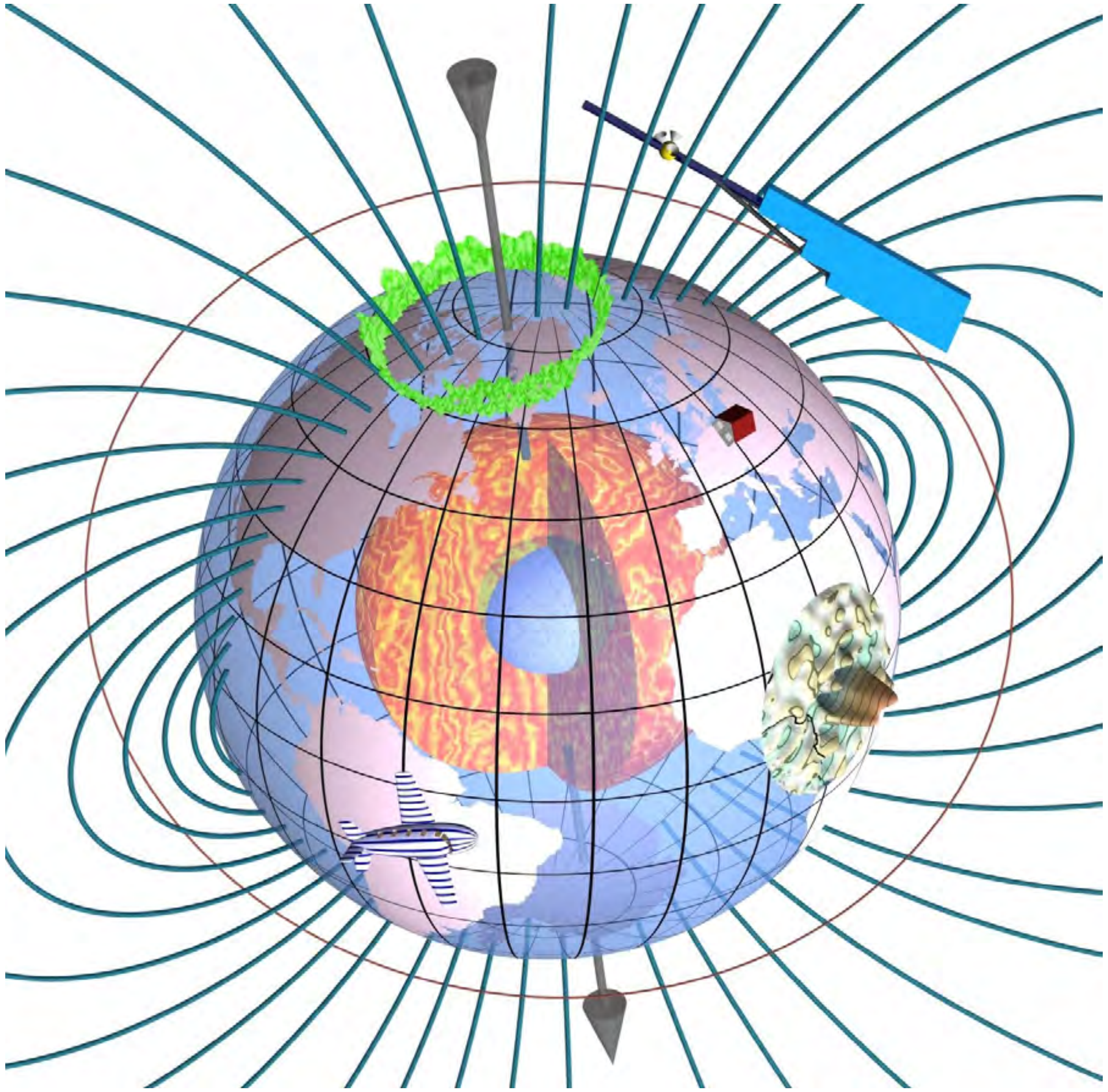
Die Plattentektonik, heutige Model

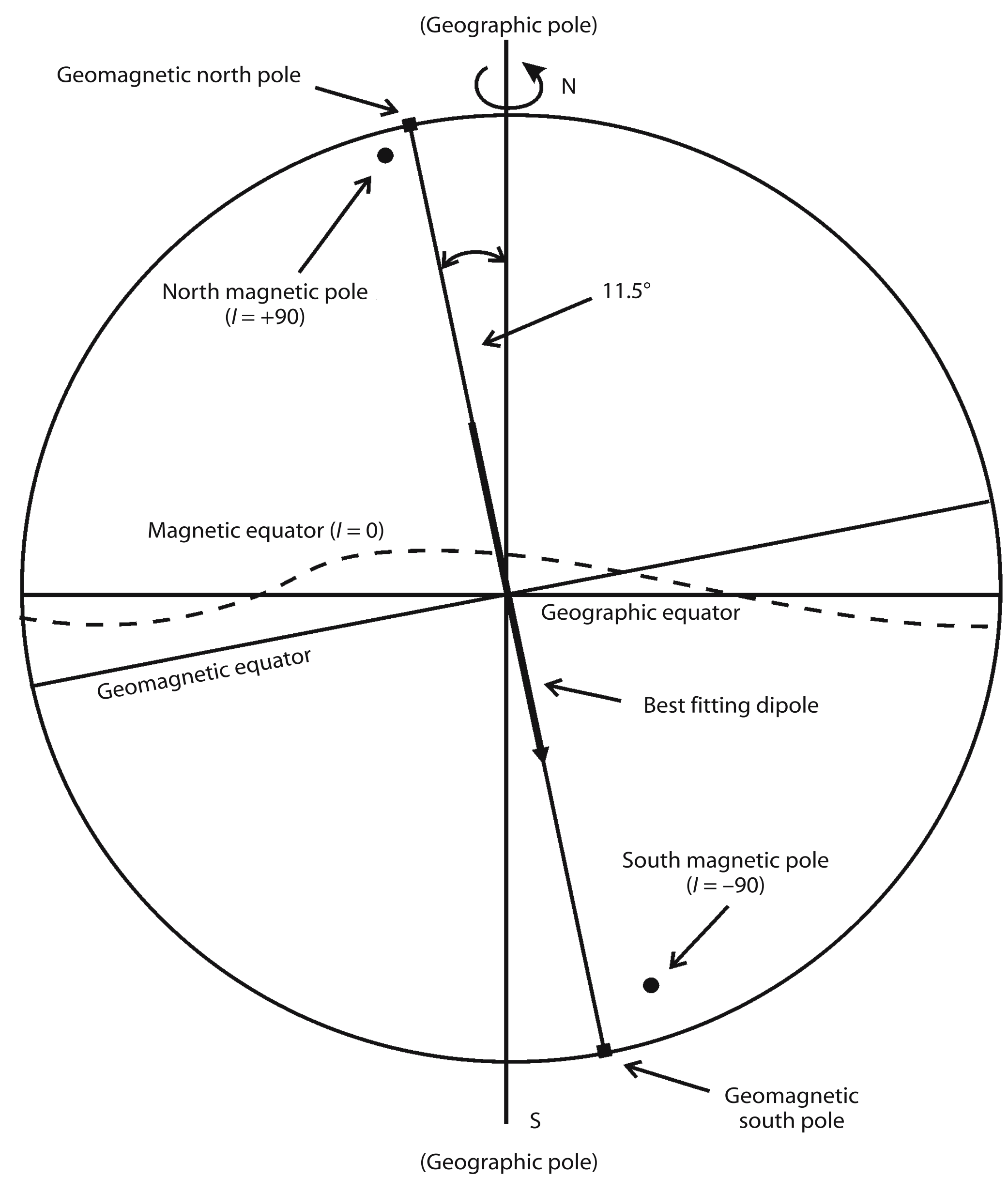


Plattenränder

Divergent | Konvergent | **4,1** Rate in cm/a | "kontinentale Schelfe" | "kontinentale Schilde" | Ozean

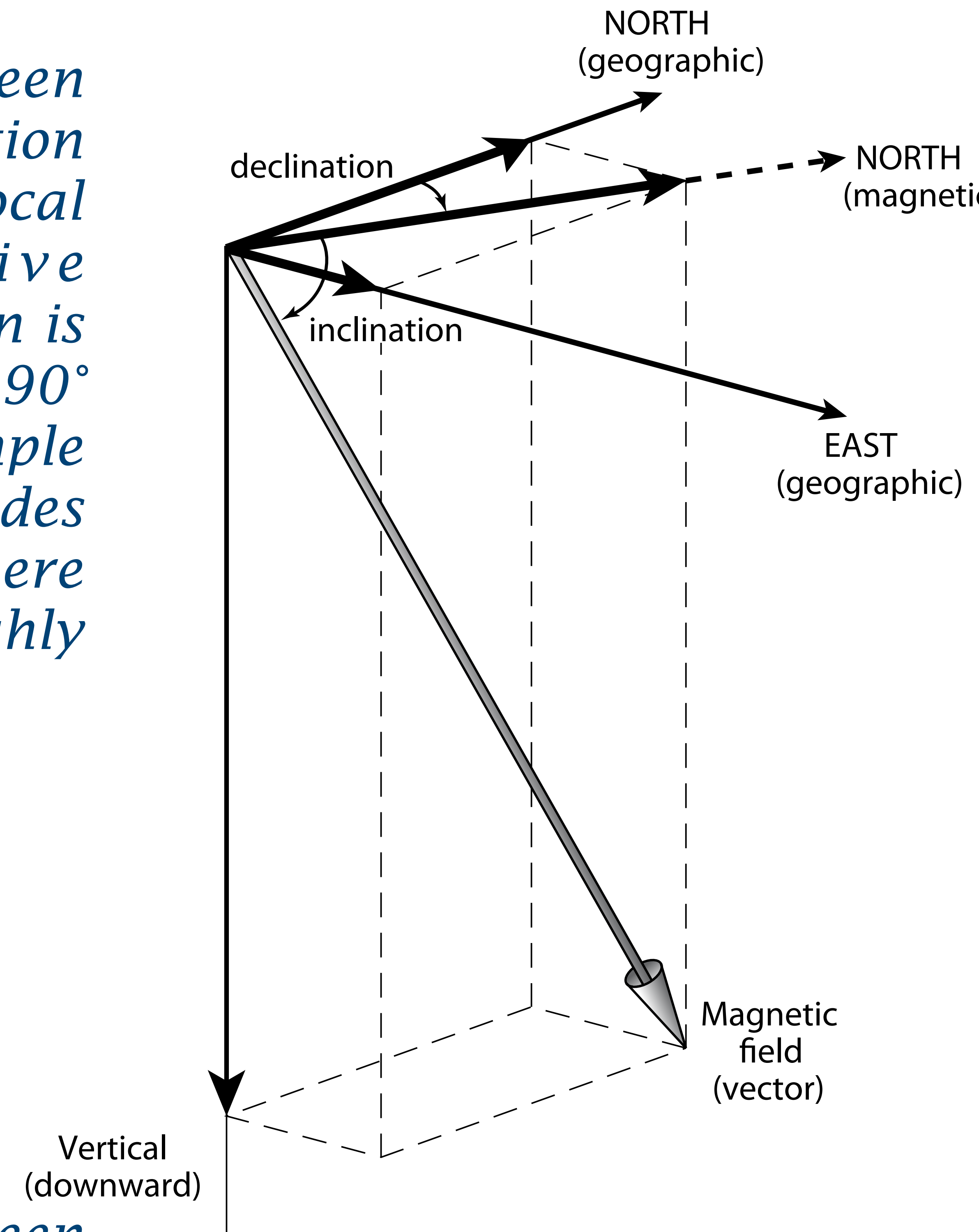
Earth's magnetism





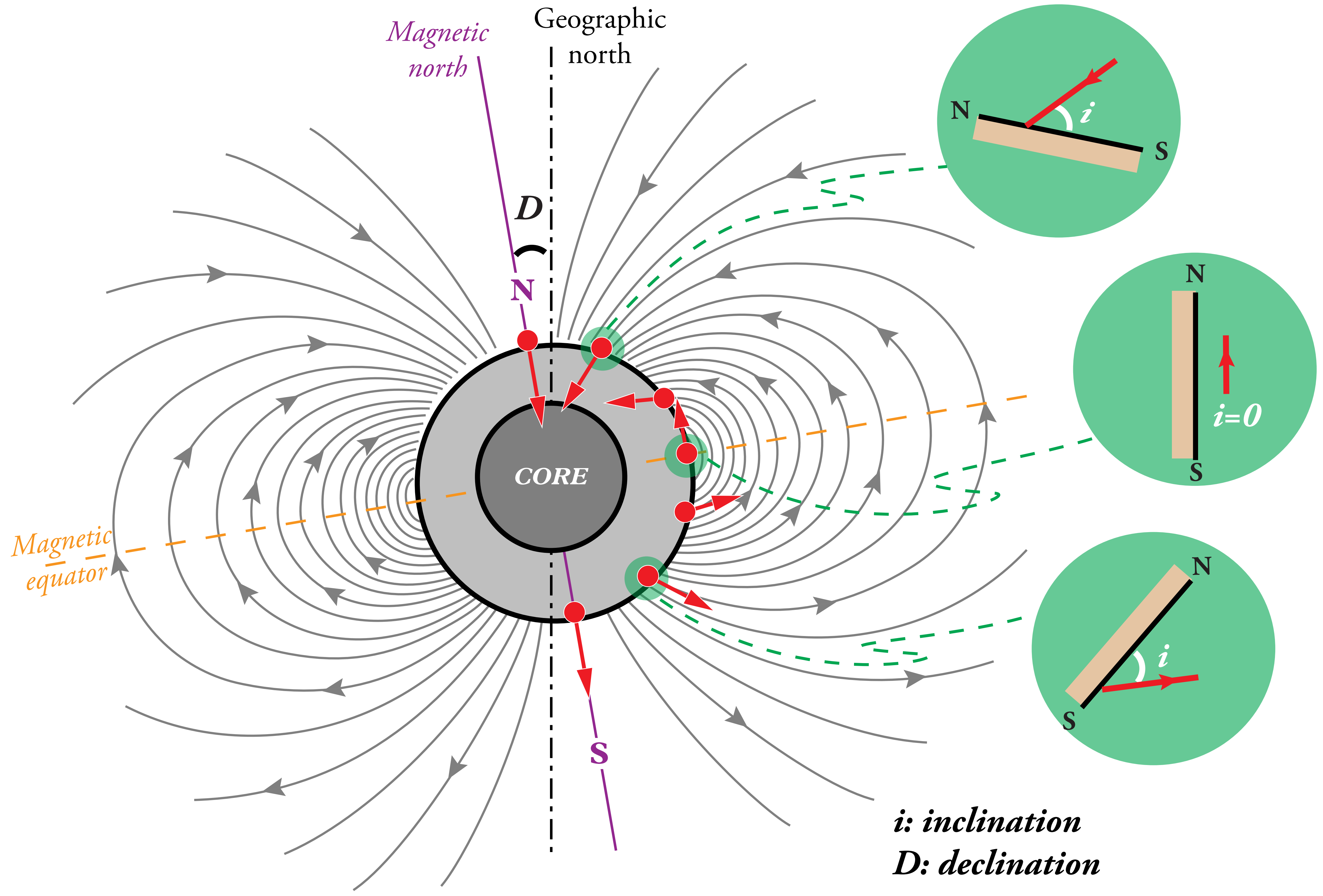
Earth’s magnetism

Inclination (magnetic): *The angle between the magnetic field direction (or the direction of magnetization in a rock) and the local horizontal plane (counted positive downwards, negative upwards). Inclination is zero at the magnetic equator and ±90° (vertical) at the magnetic poles. A simple formula helps to derive magnetic latitudes from magnetic inclination in the case where the field is that of a dipole (which is roughly the case for the Earth)*



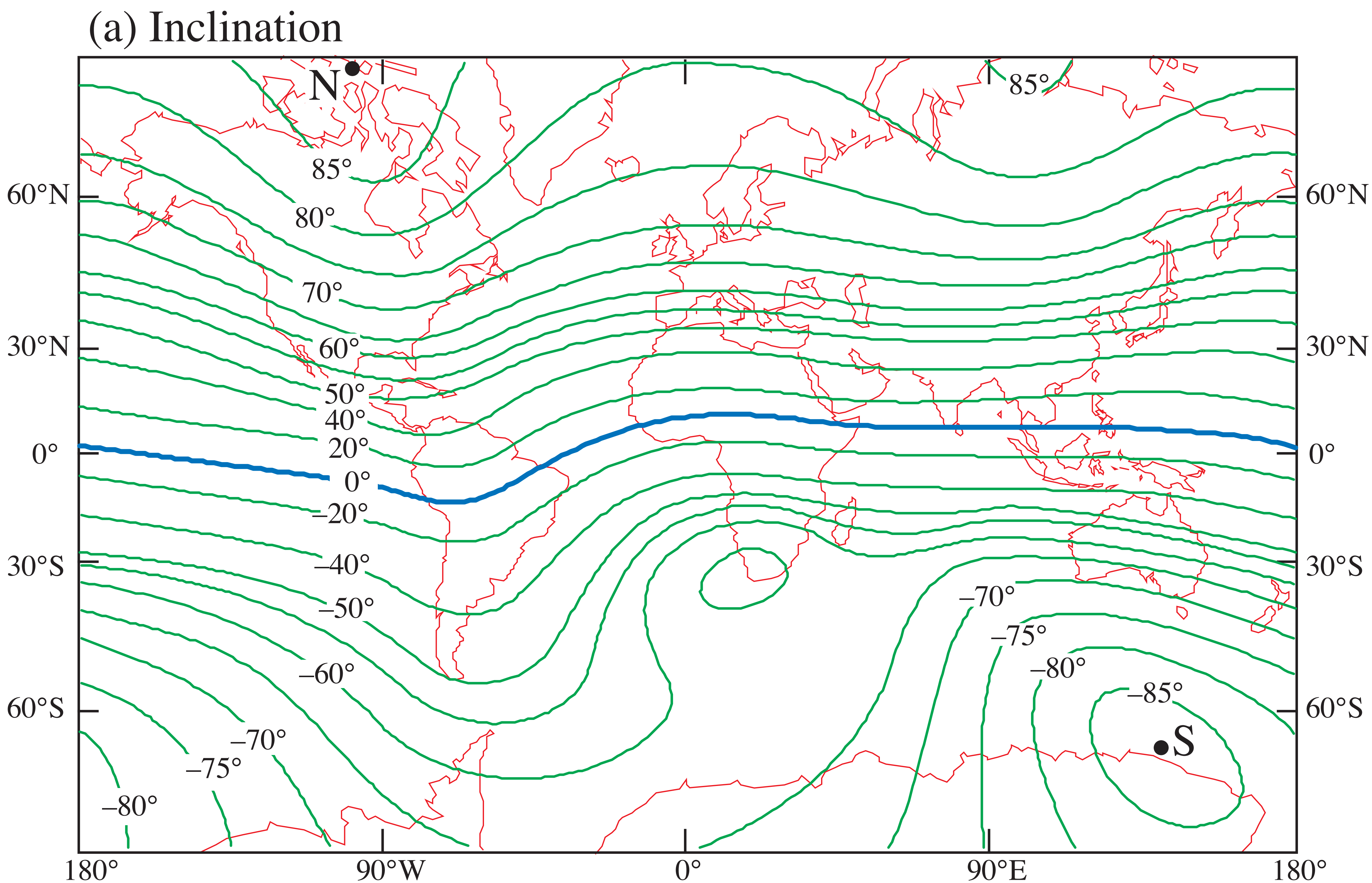
Declination (magnetic): *The angle between magnetic north (as given by the compass needle)and geographic north (in the horizontal plane, counted positive eastward)*

Earth's magnetism



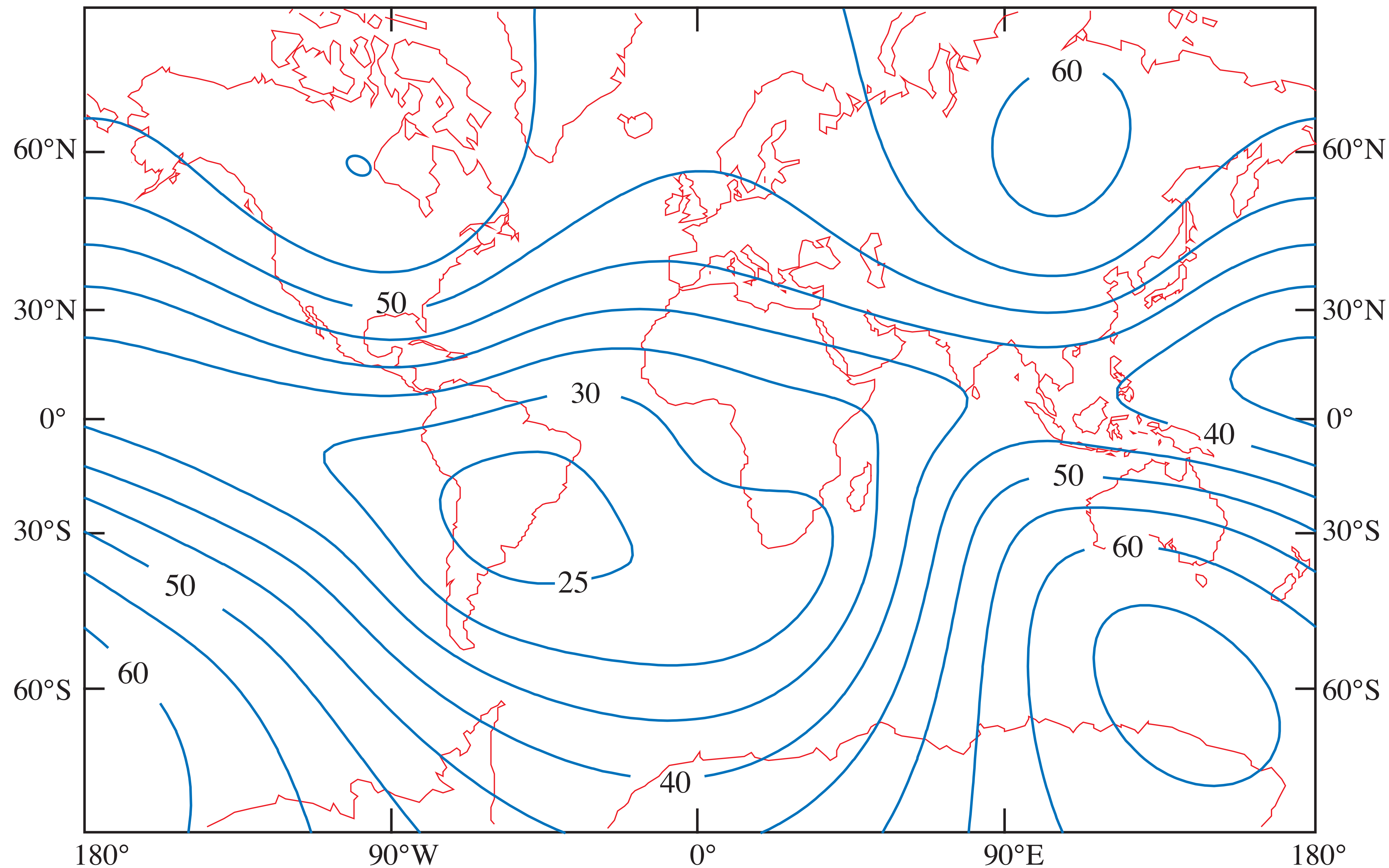
***i*: inclination**
***D*: declination**

Earth's magnetism

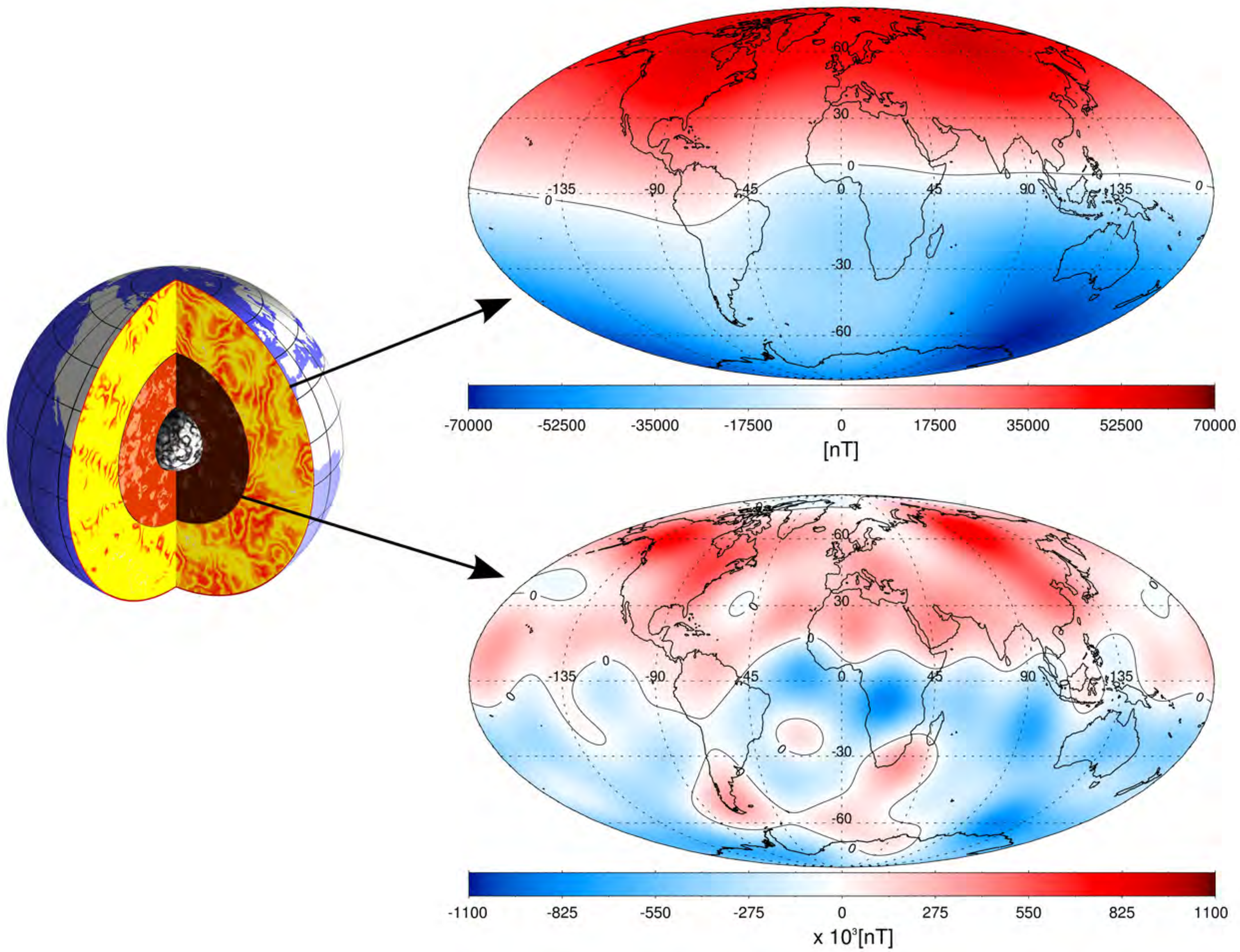


Earth's magnetism

(b) Total intensity

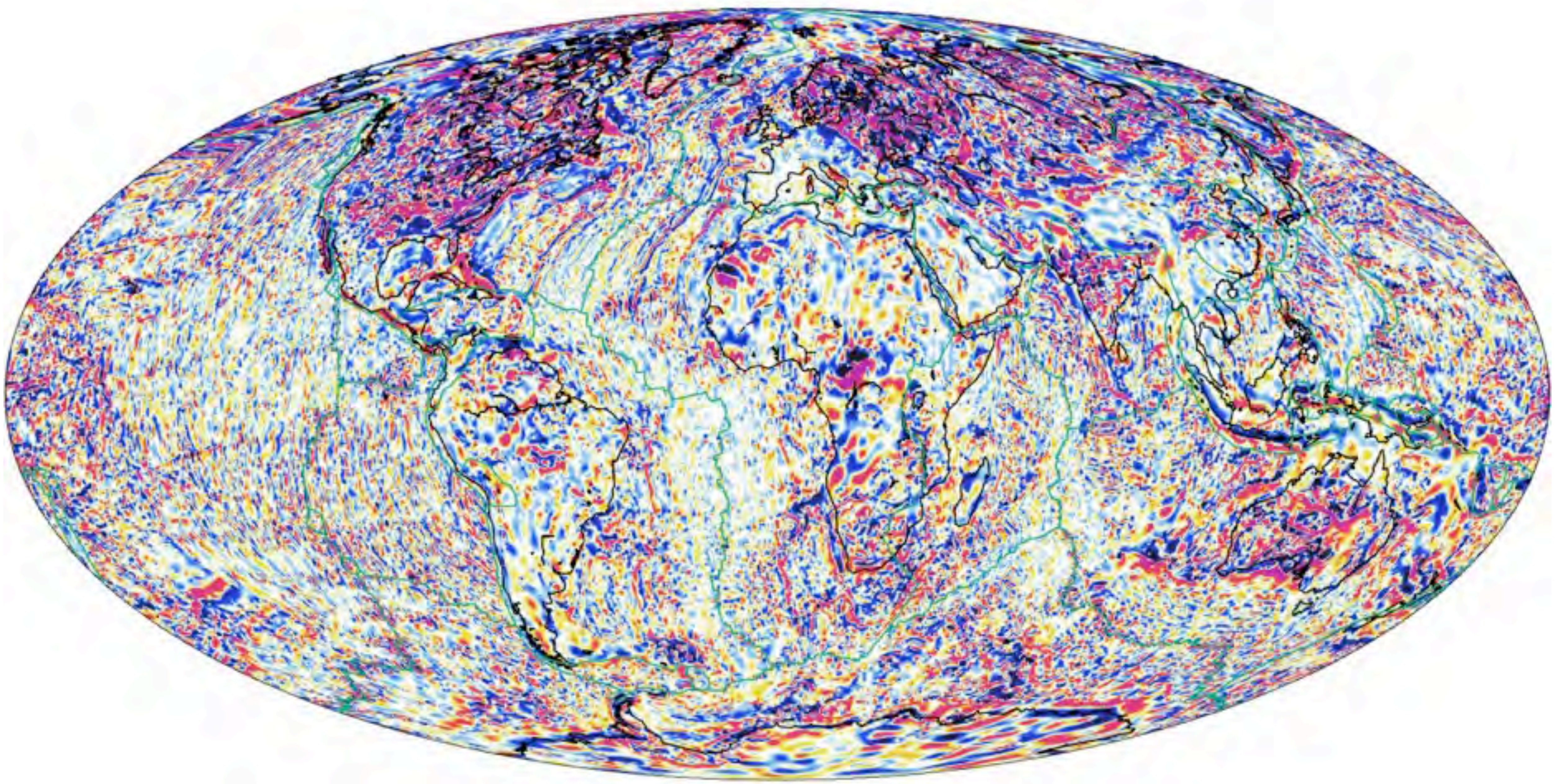


Earth's magnetism



The internal structure of the Earth (left side) and the vertical component of the geomagnetic field represented at the surface (top right side) and at the core-mantle boundary (bottom right side), for the epoch 2005.0 (based on the Olsen et al. (2006) model). The core magnetic field is mainly dipolar but the field is modulated by smaller scales. The structure of the vertical component depends on the depth at which the magnetic field is represented, the smaller scales being more apparent at the core-mantle boundary than at the Earth's surface. For dynamo modelling, the magnetic field is represented at the core-mantle boundary

Magnetism on the Earth

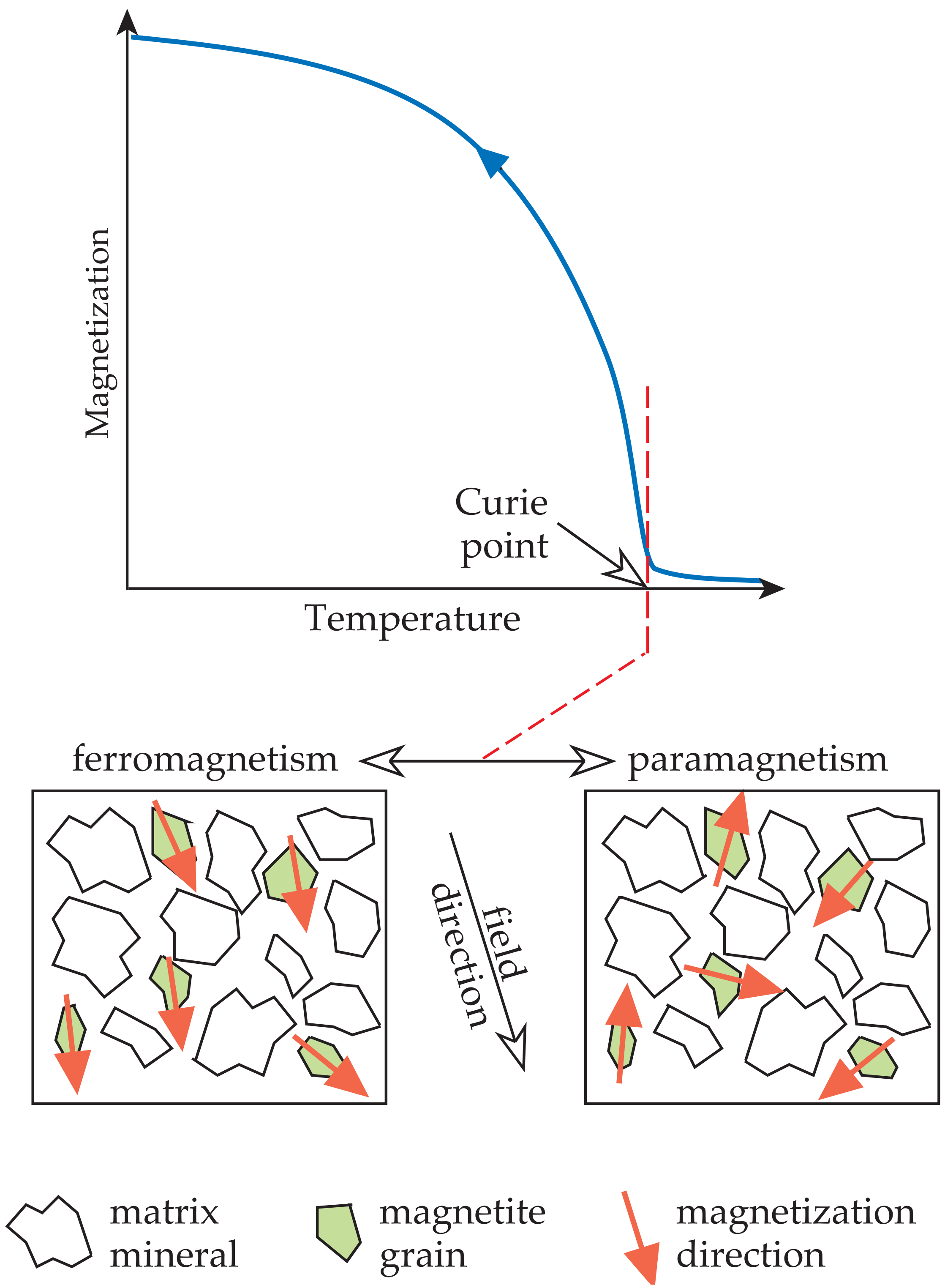


Magnetism recorded on land or on sea is showing different patterns:
- fine and regular in the oceans
- irregular and coarse on the continent

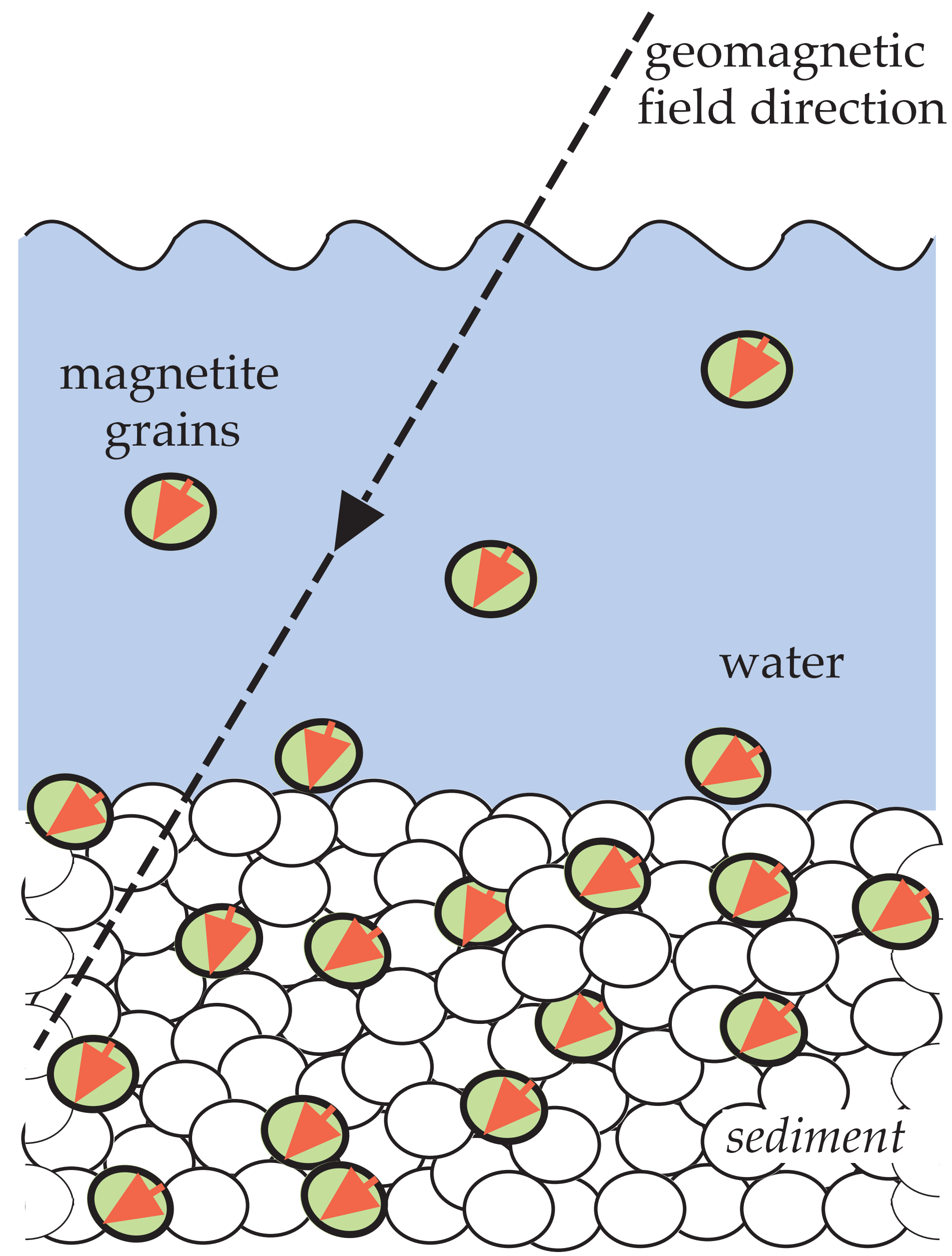
Paleomagnetism

Recording of the Earth's magnetism within rocks

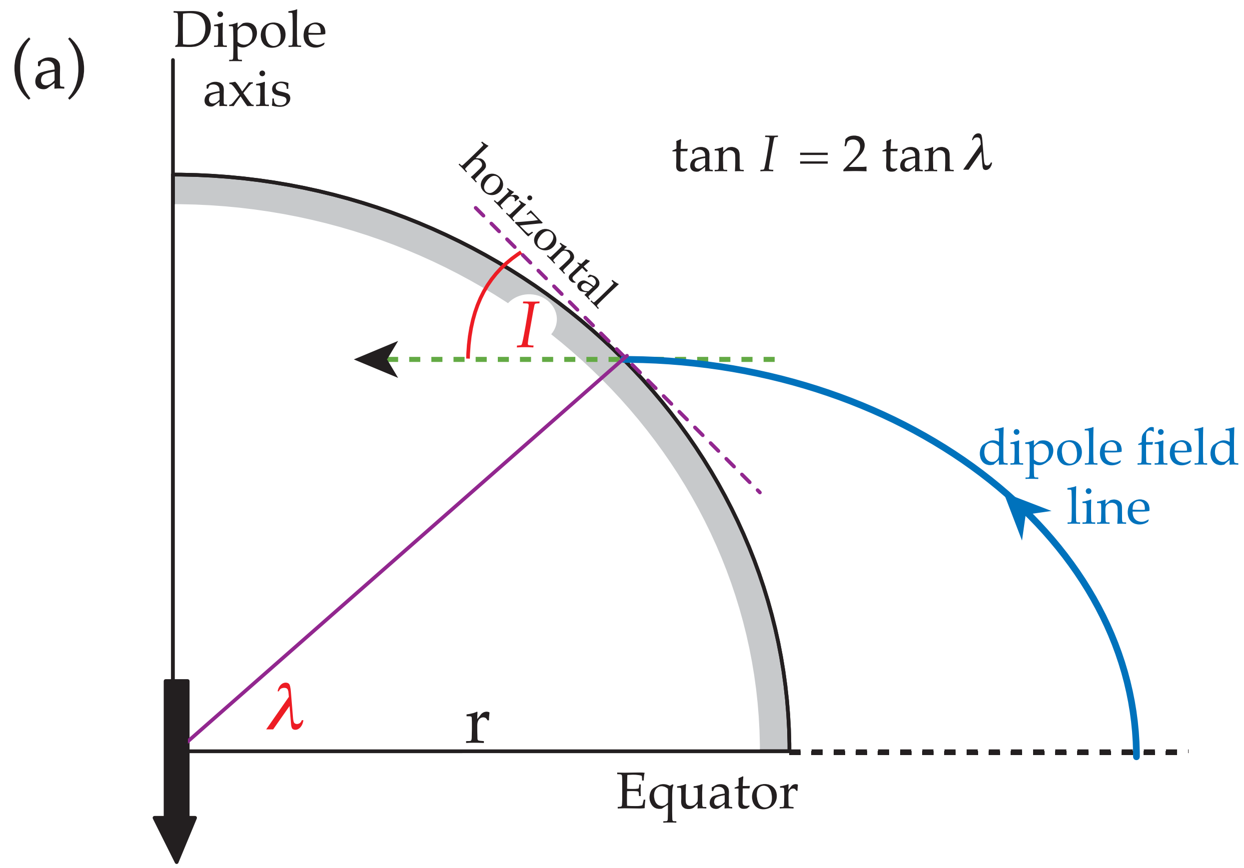
Igneous rocks



Sedimentary rocks

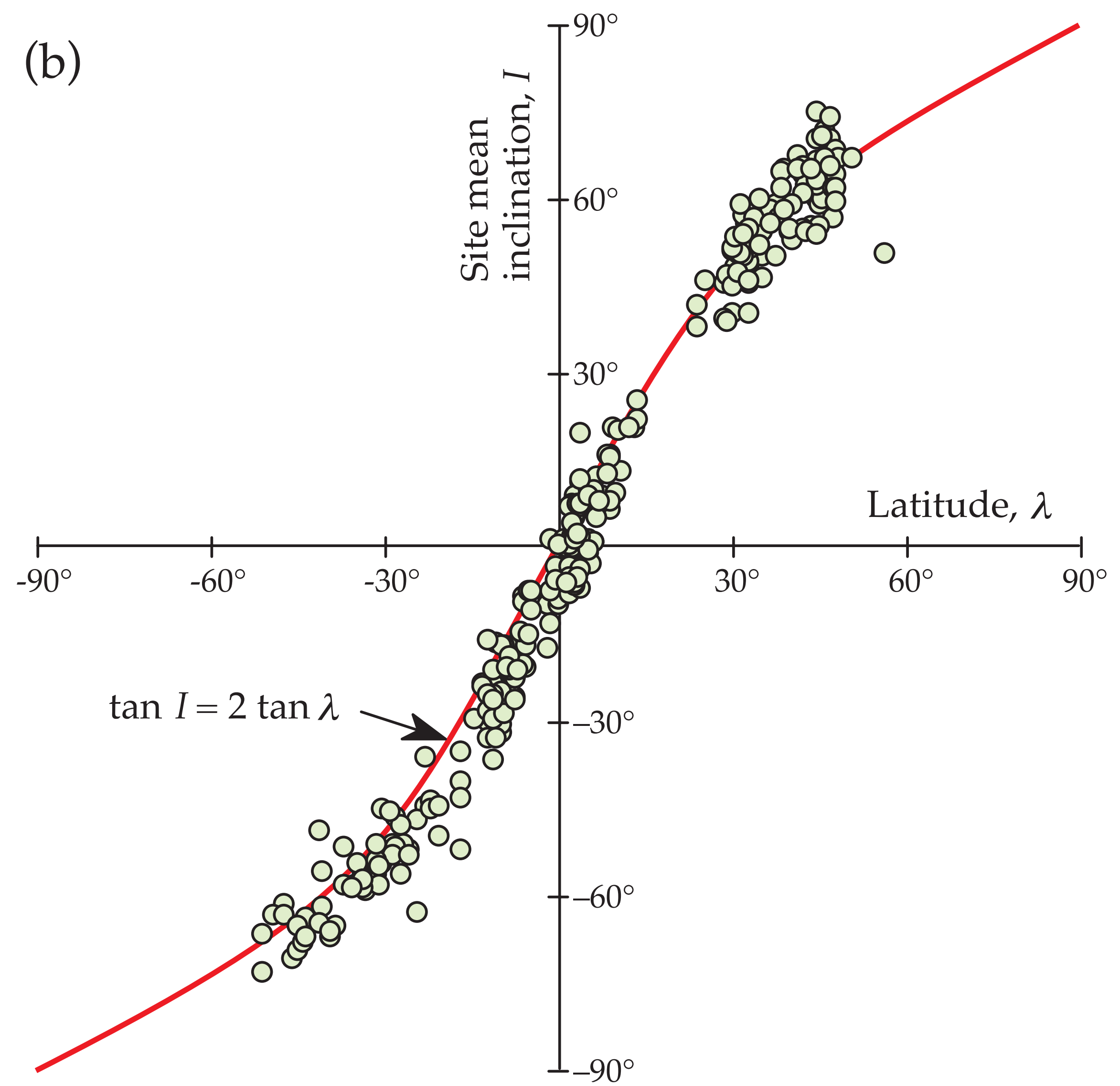


Paleomagnetism

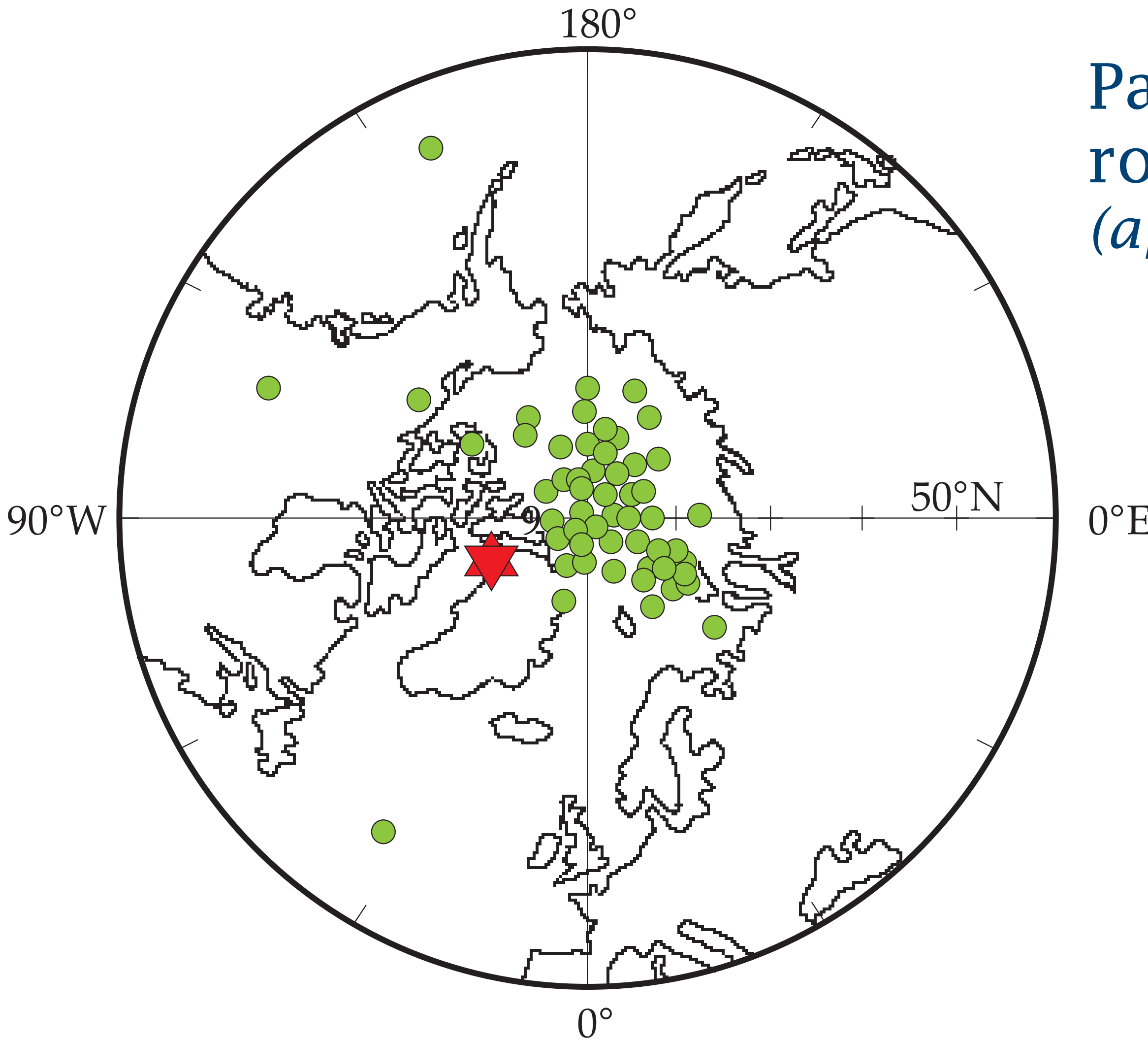


(a) The geocentric axial dipole hypothesis predicts the relationship tan I =2tan λ between the inclination I of a dipole field and the magnetic latitude λ.

(b) The inclinations measured in modern deep- sea sediment cores agree well with the theoretical curve (based on data from Schneider and Kent, 1990).



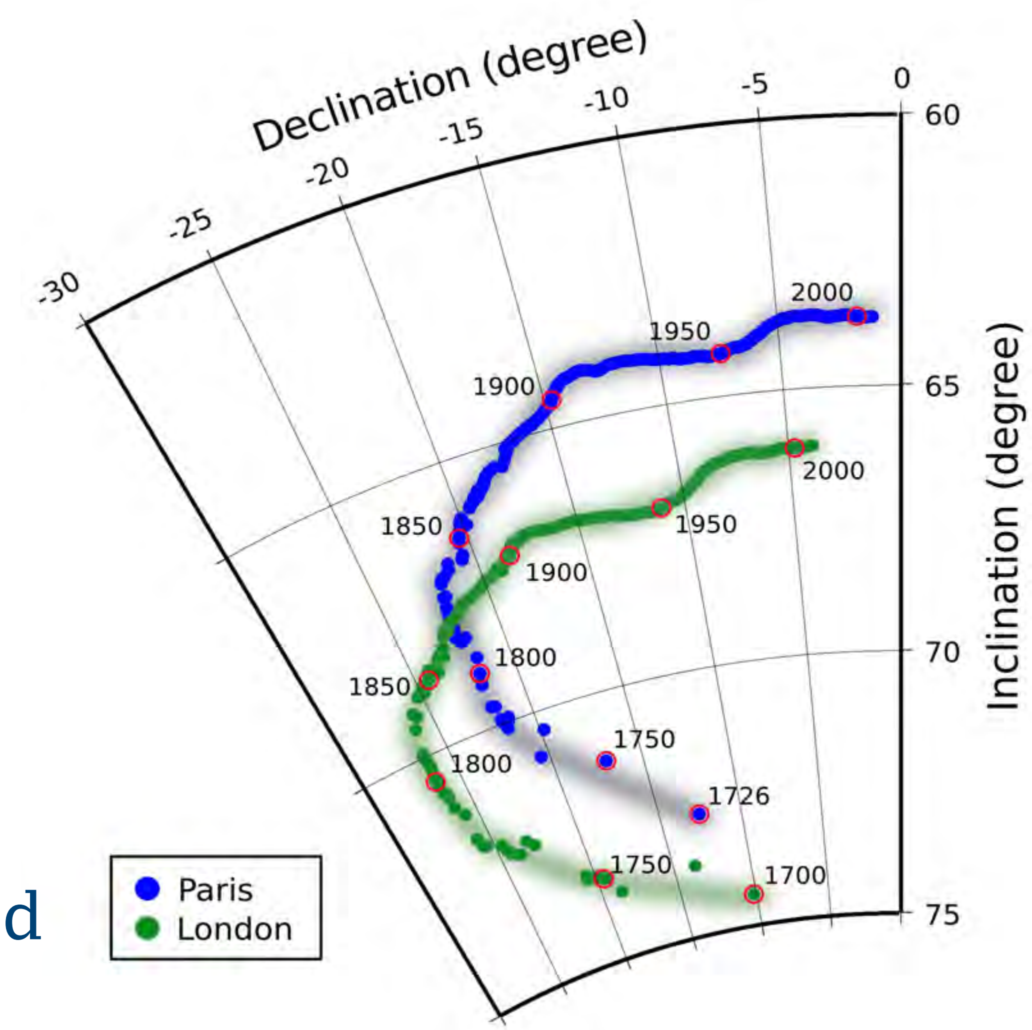
Paleomagnetism



Plio-Pleistocene to Recent paleomagnetic poles (younger than 5 Ma)

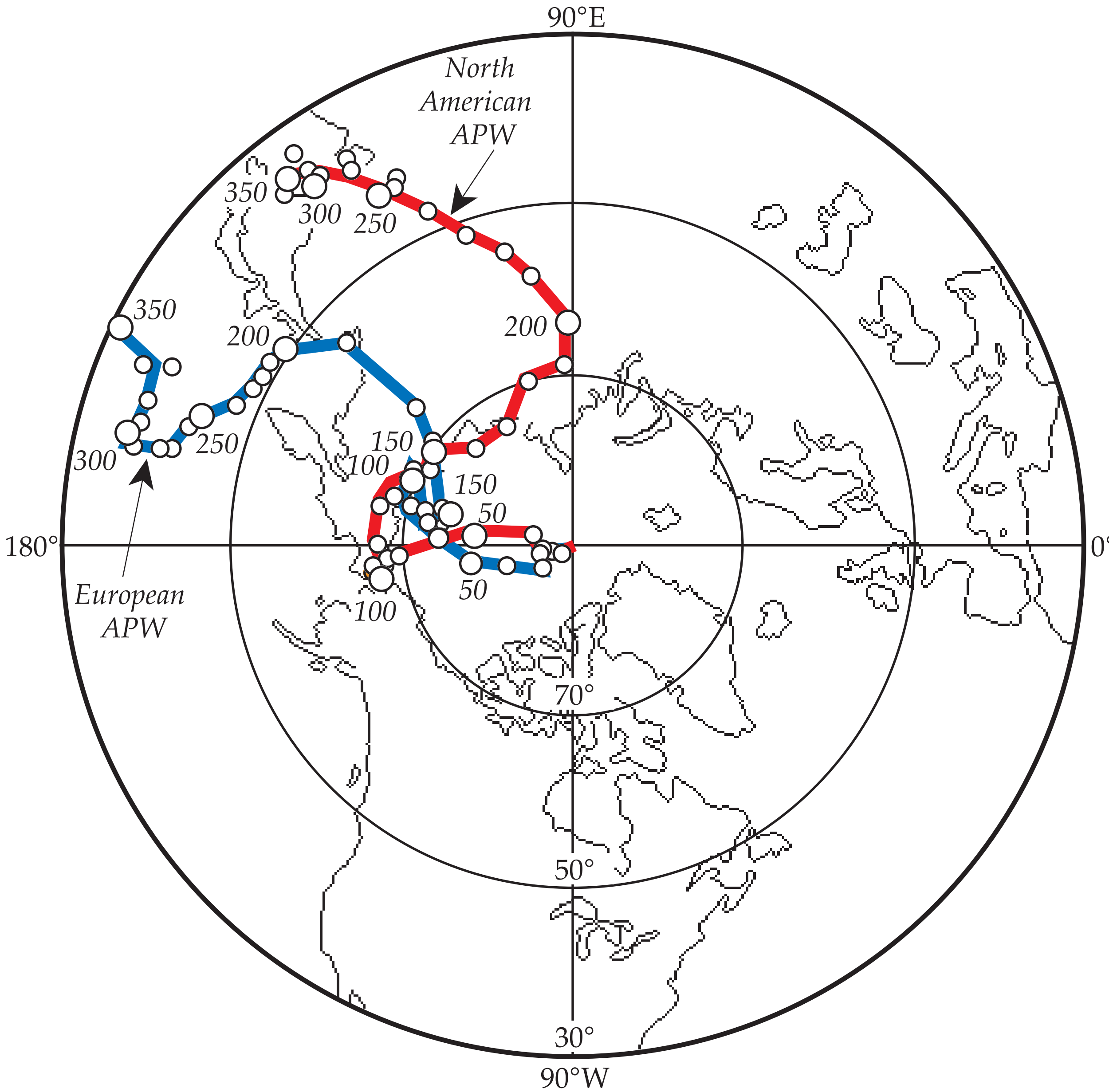
Present-day geomagnetic pole

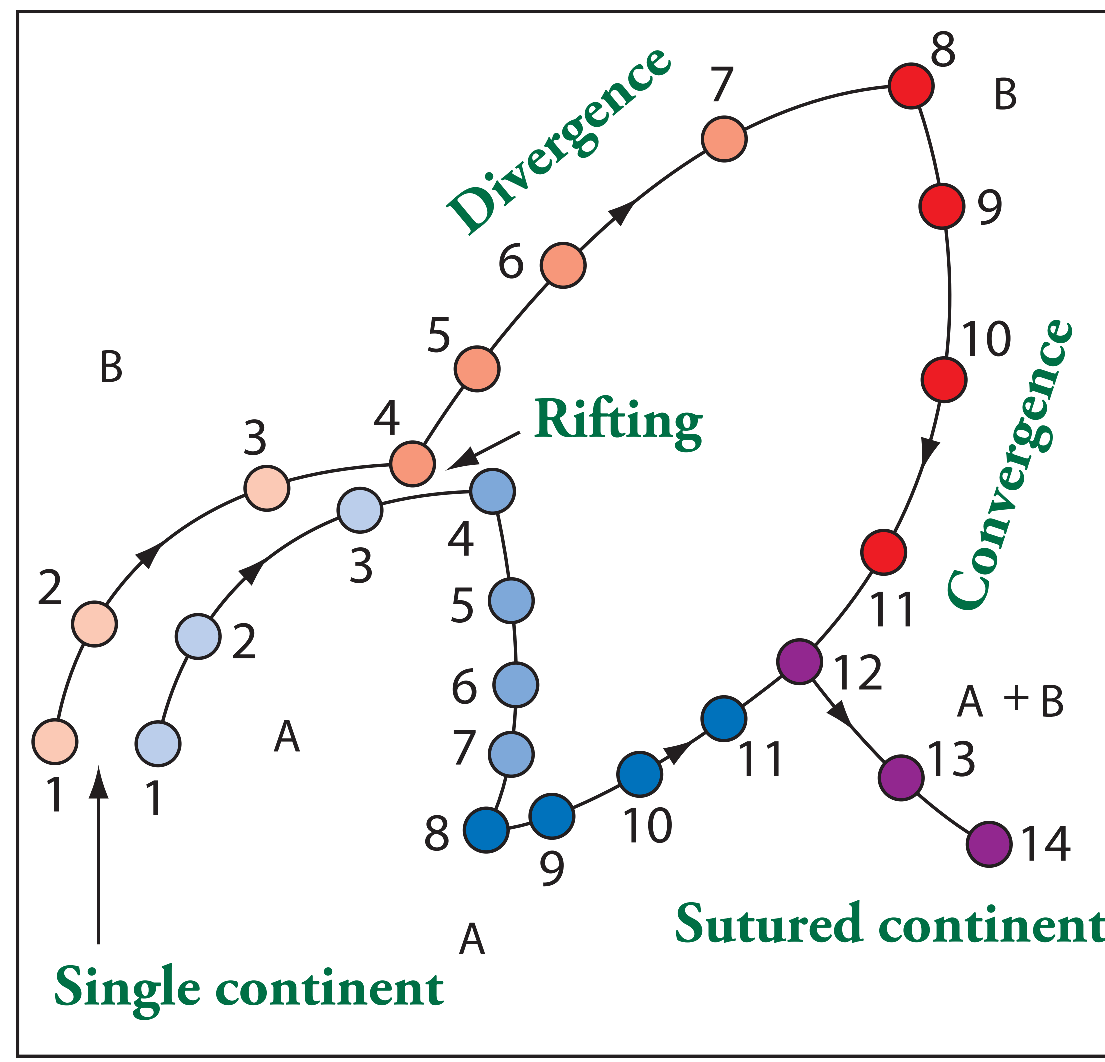
Paleomagnetic pole positions for rocks of Plio-Pleistocene to Recent age *(after McElhinny, 1973)*



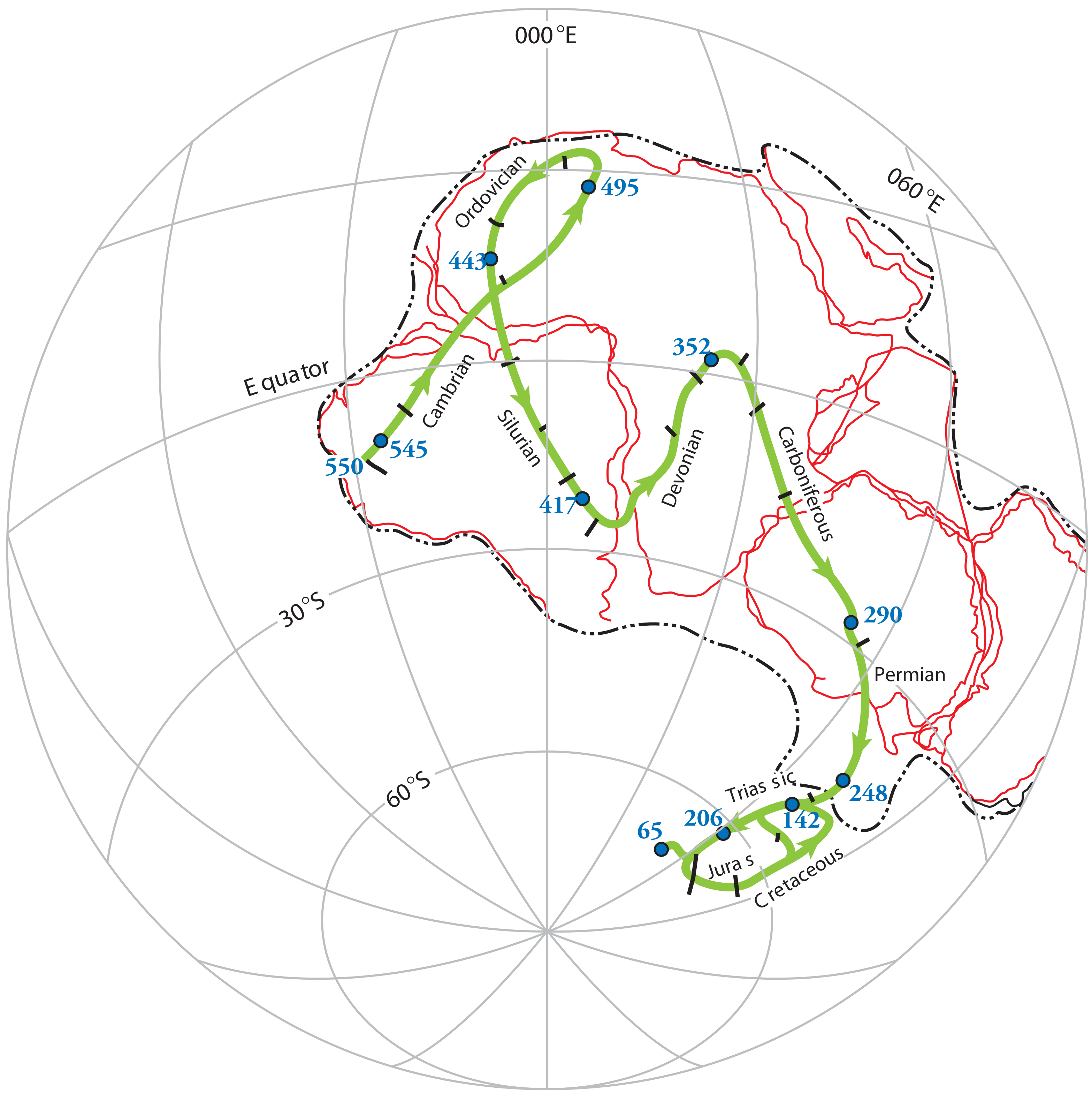
The direction of the Earth's magnetic field for two declination series, Paris and London.

Paleomagnetism

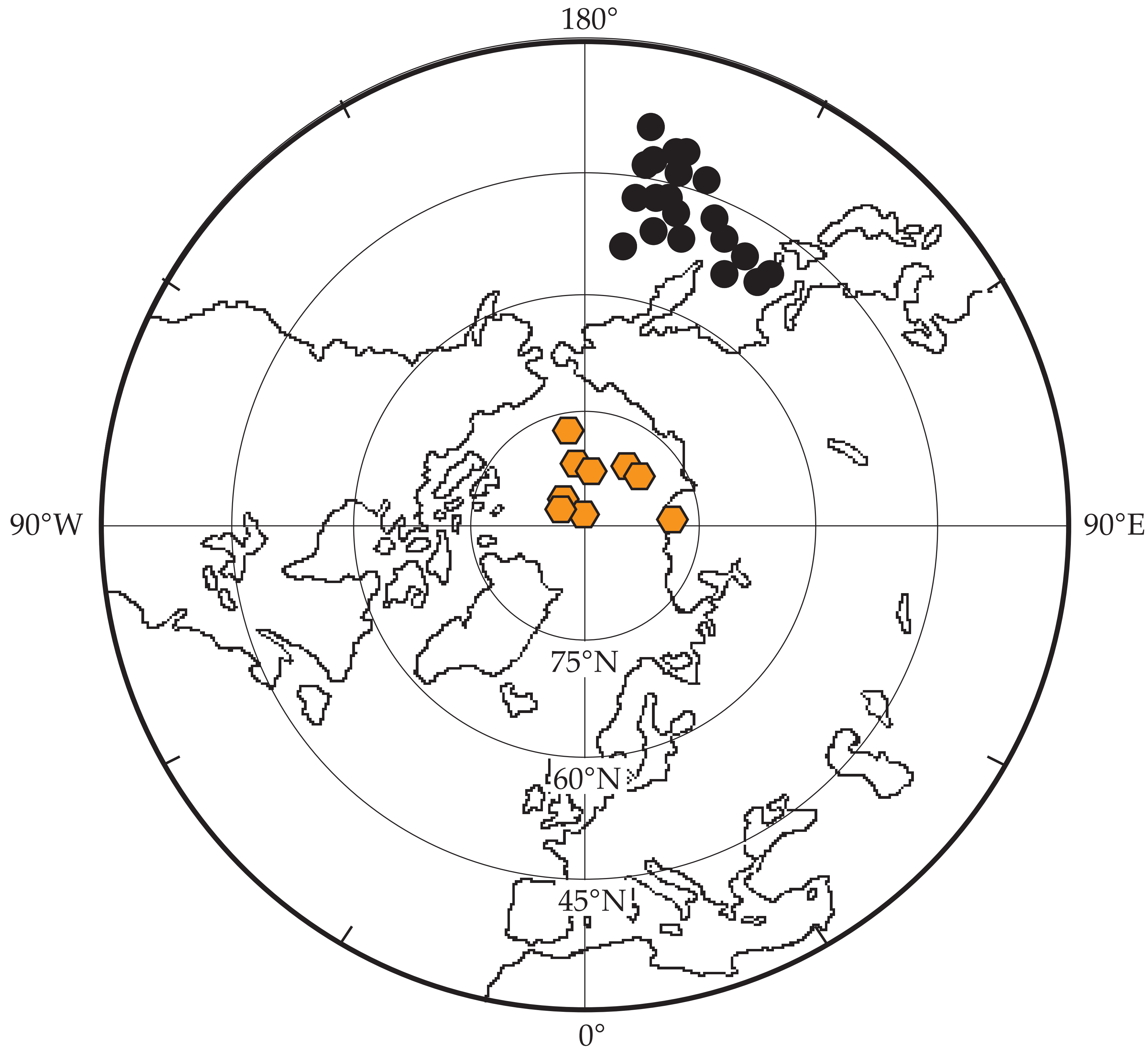




Paleomagnetism



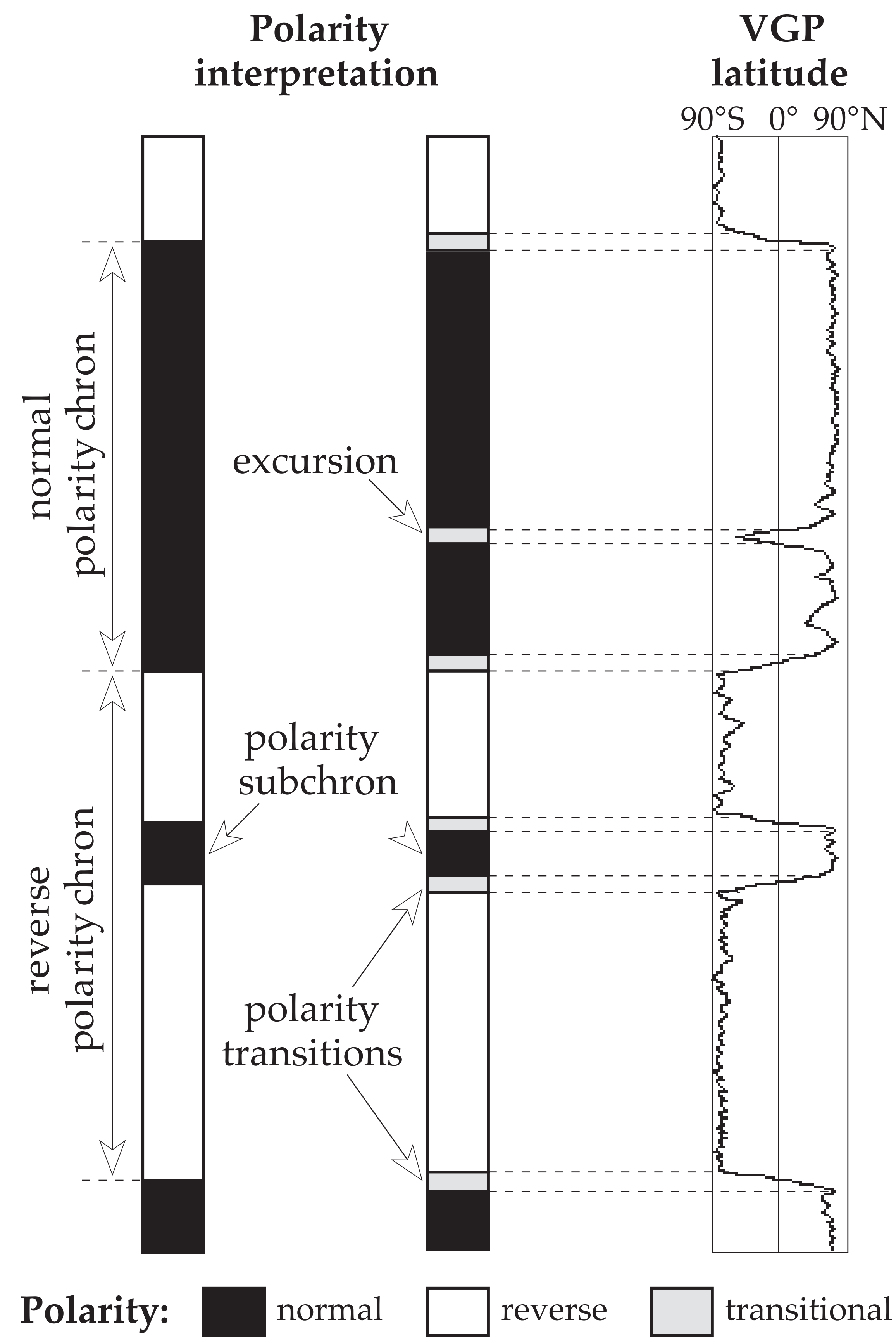
Paleomagnetism



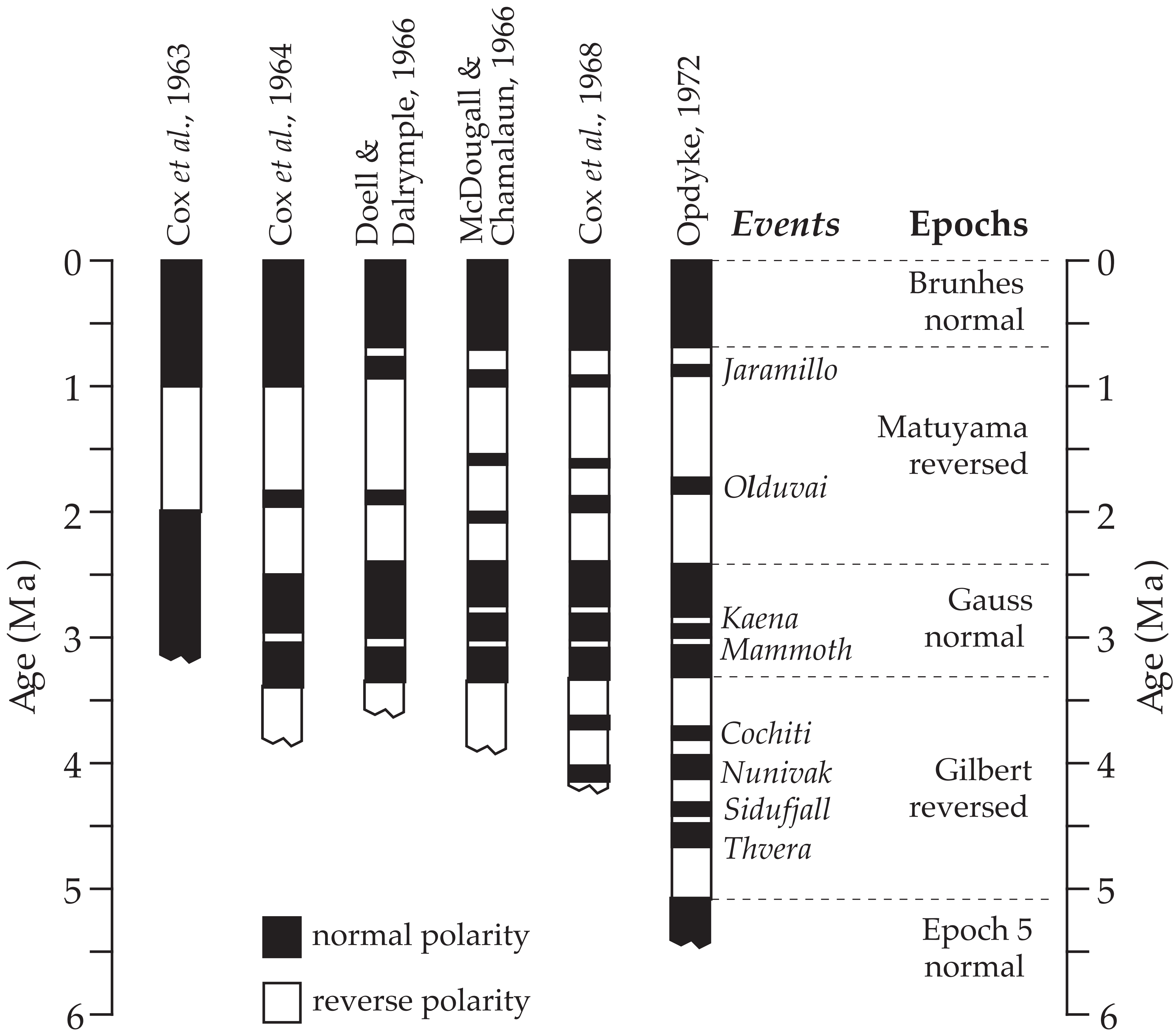
European paleomagnetic poles:

- Pliocene and Pleistocene
- Permian

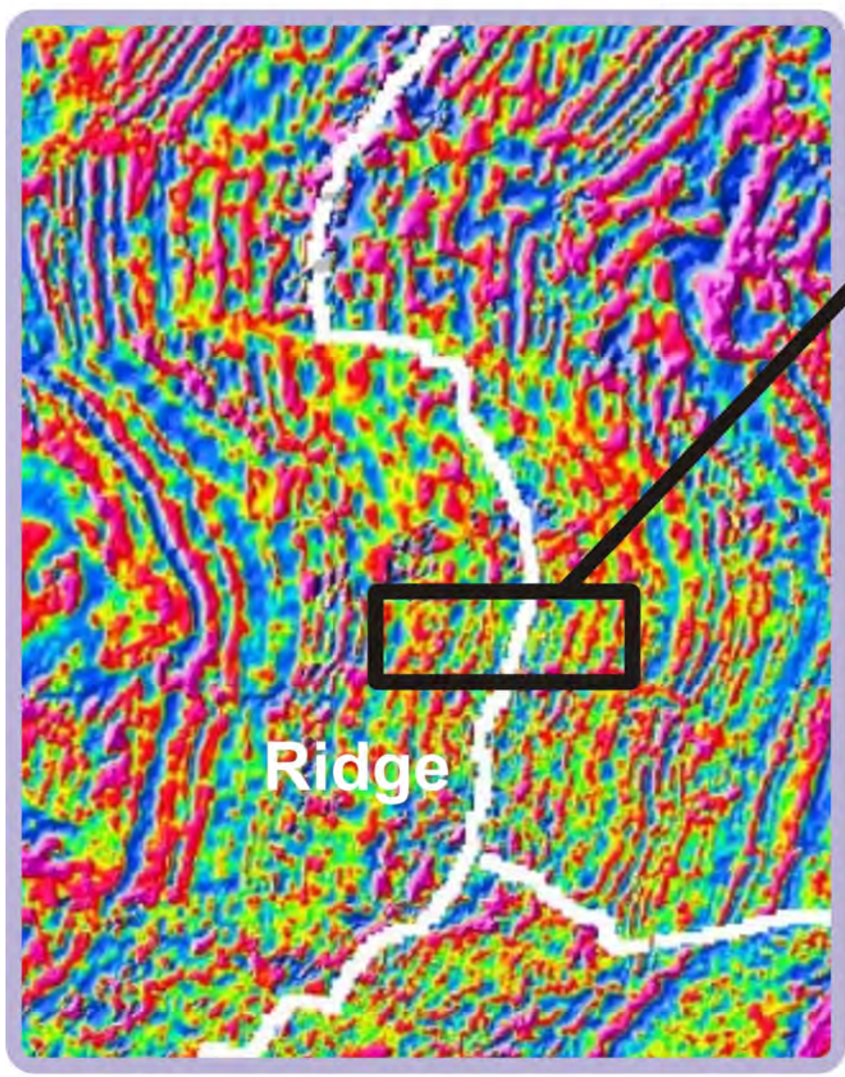
Paleomagnetic scale

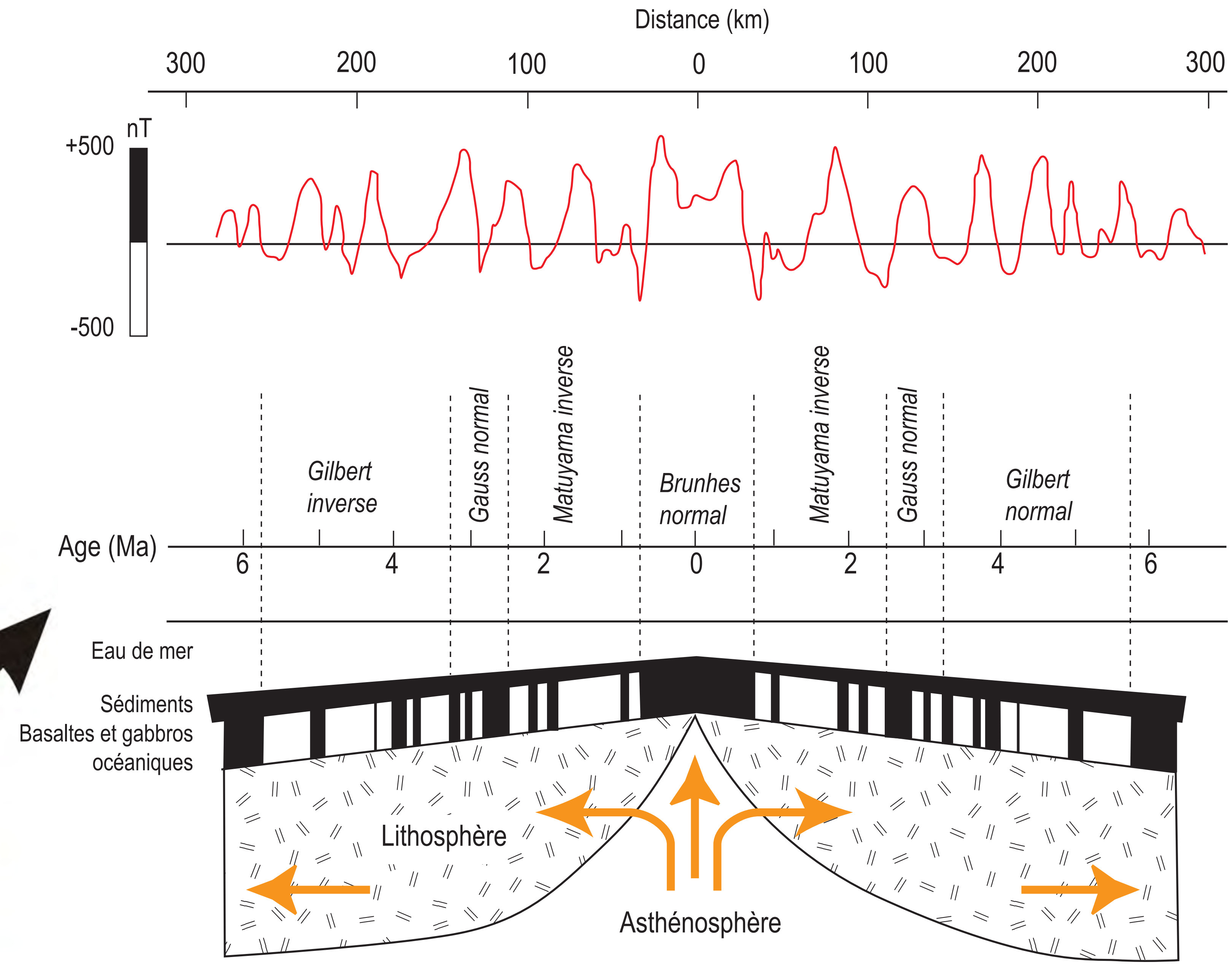


Paleomagnetic scale

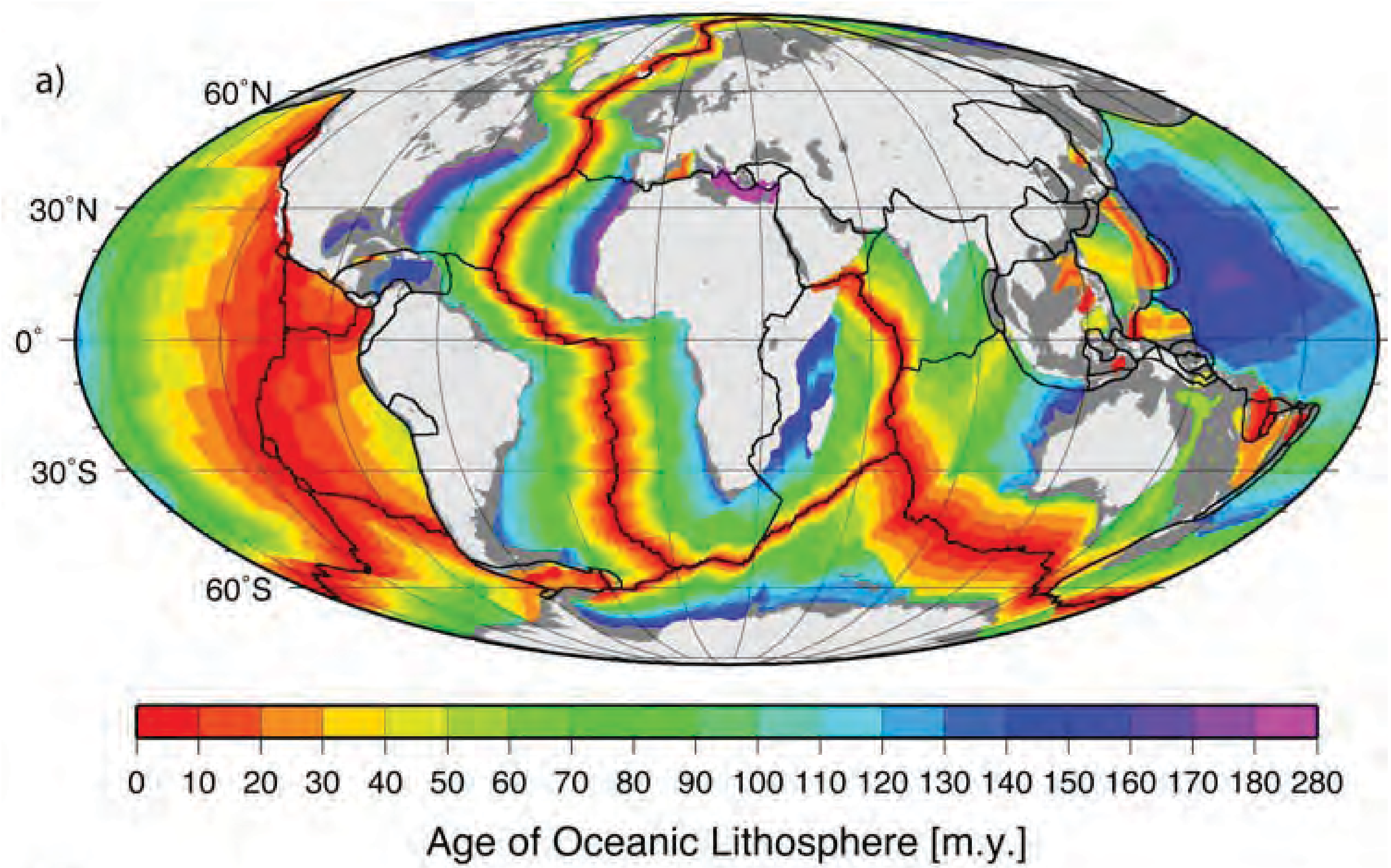


Paleomagnetism

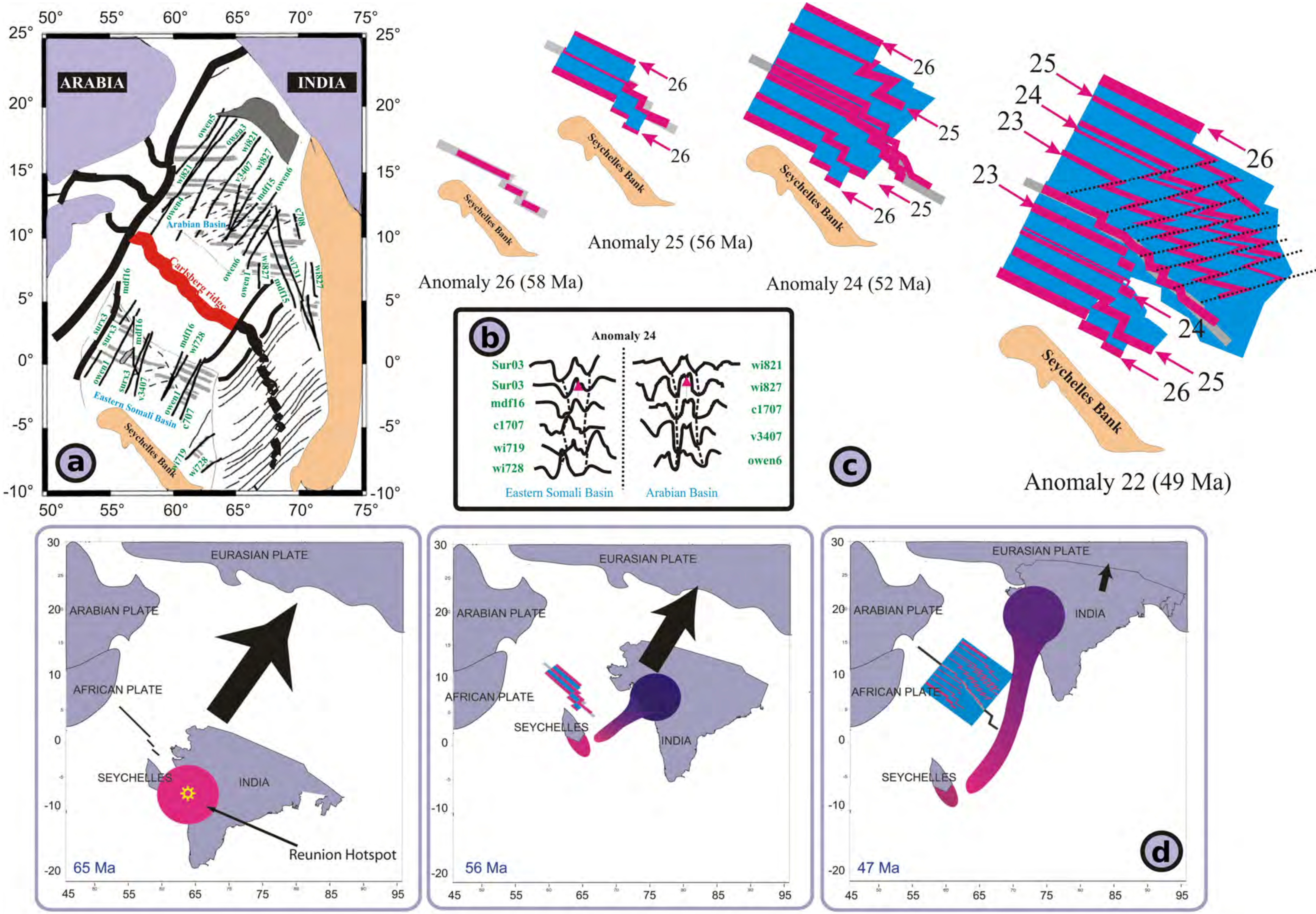




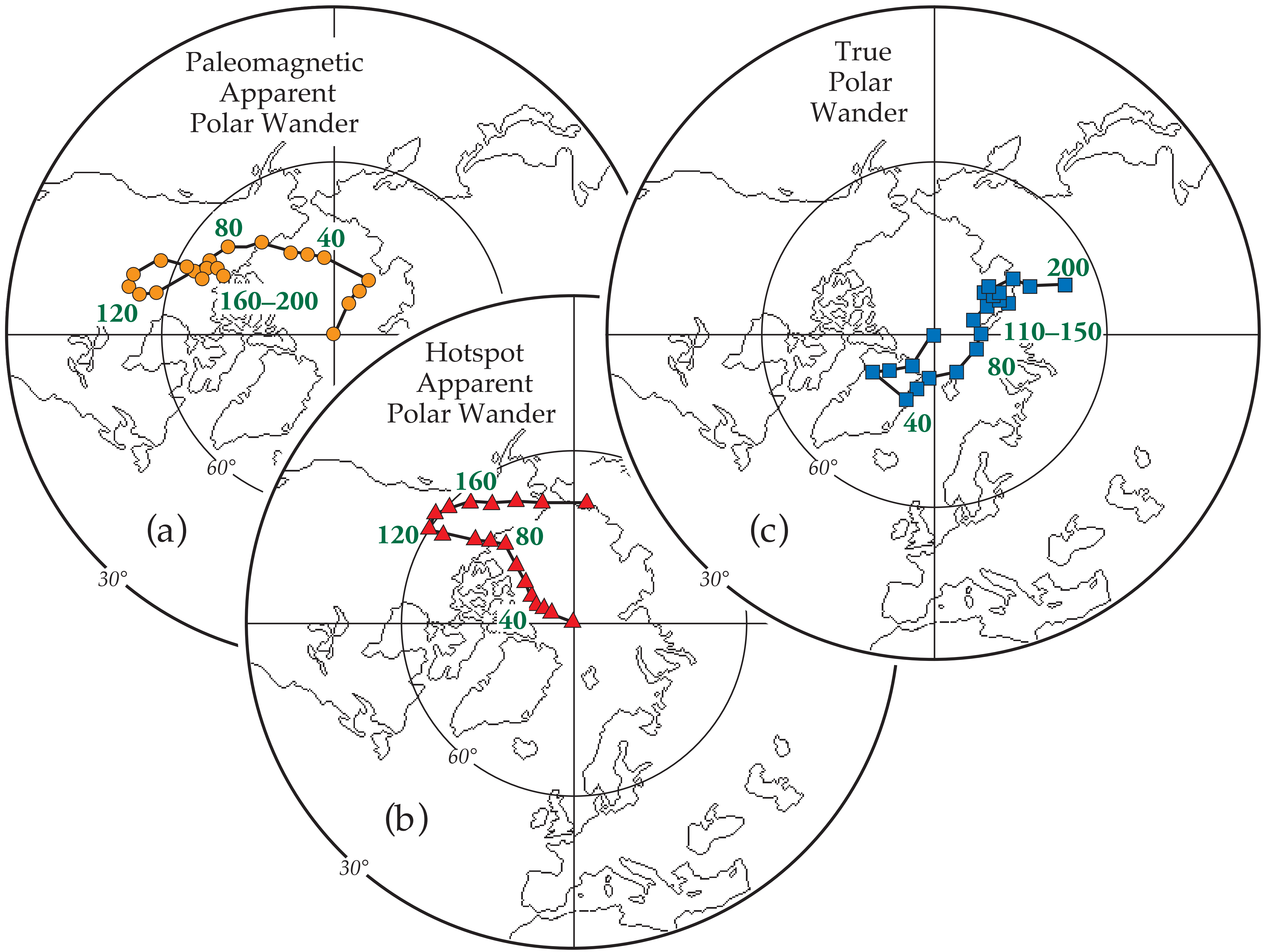
Paleomagnetism vs. age in oceans



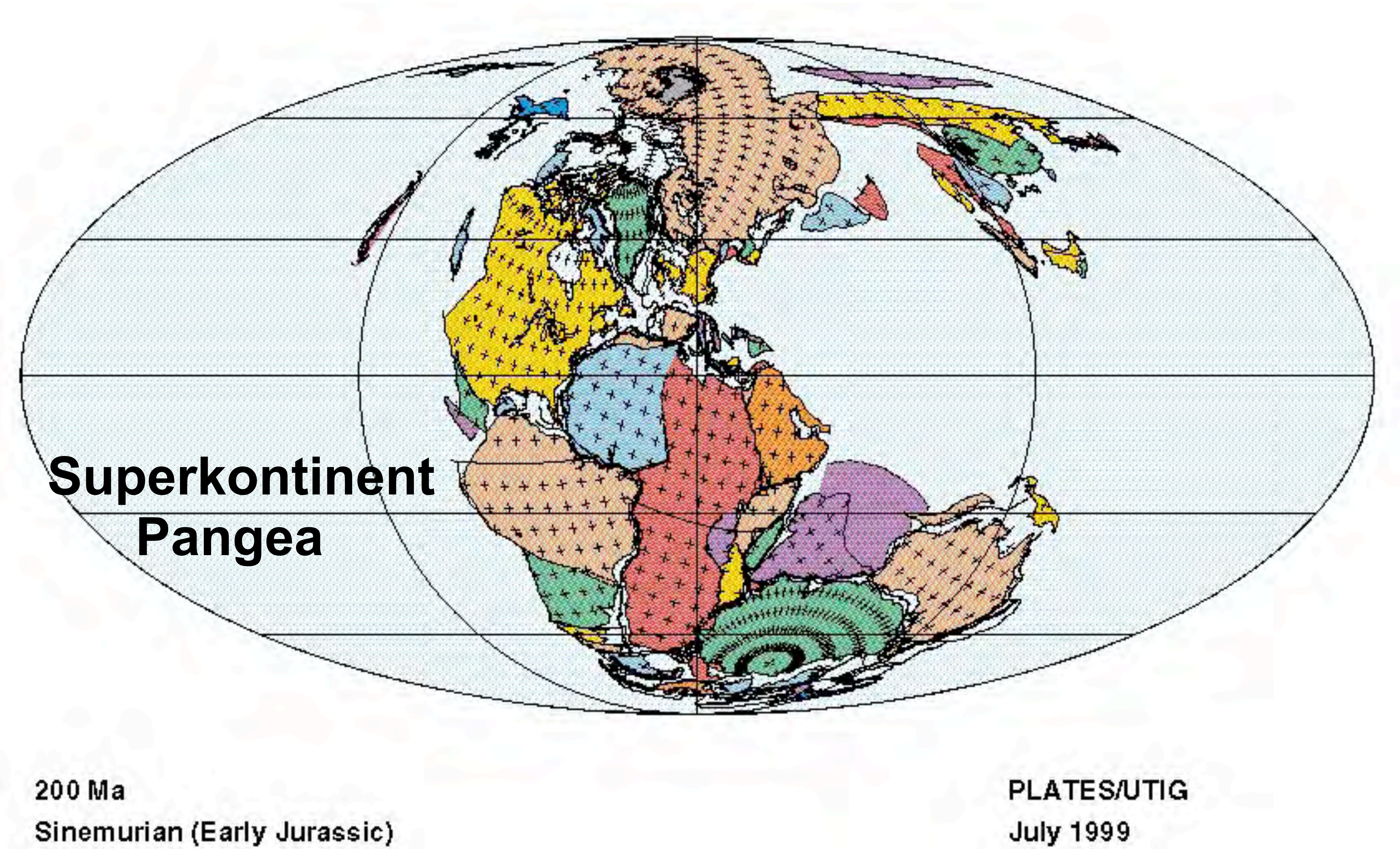
Paleomagnetism & plate movement



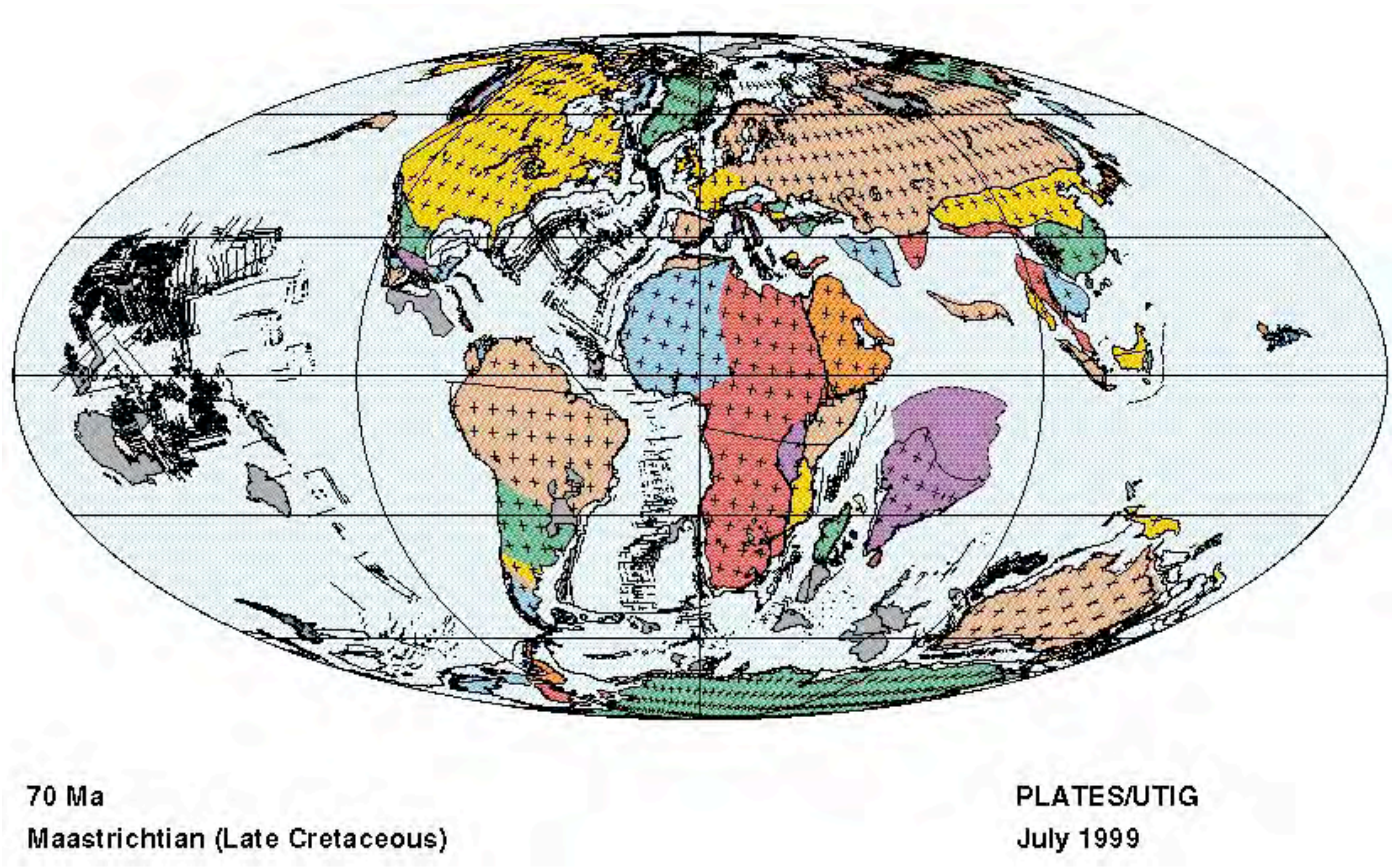
Paleomagnetism



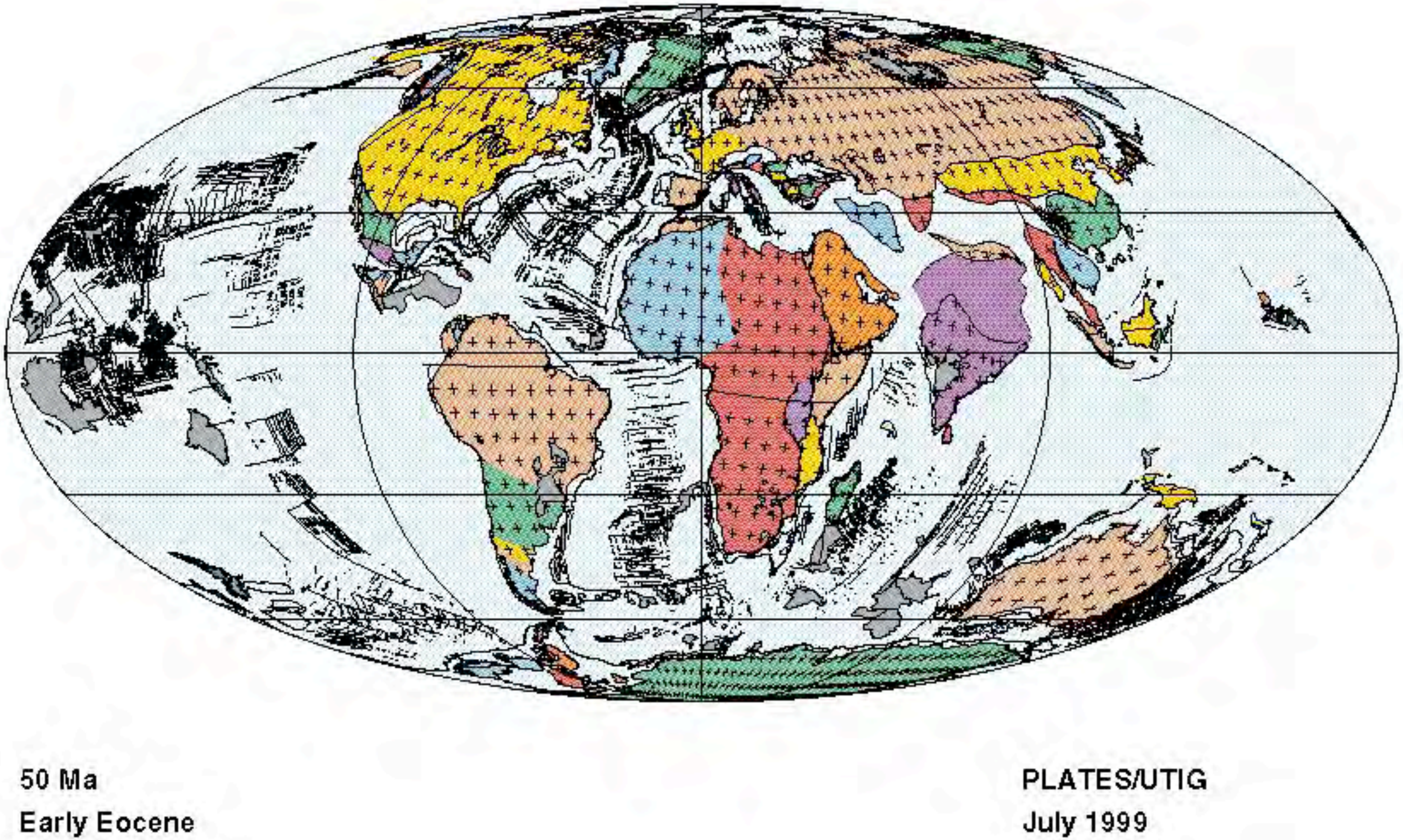
Vor 200 Millionen Jahren



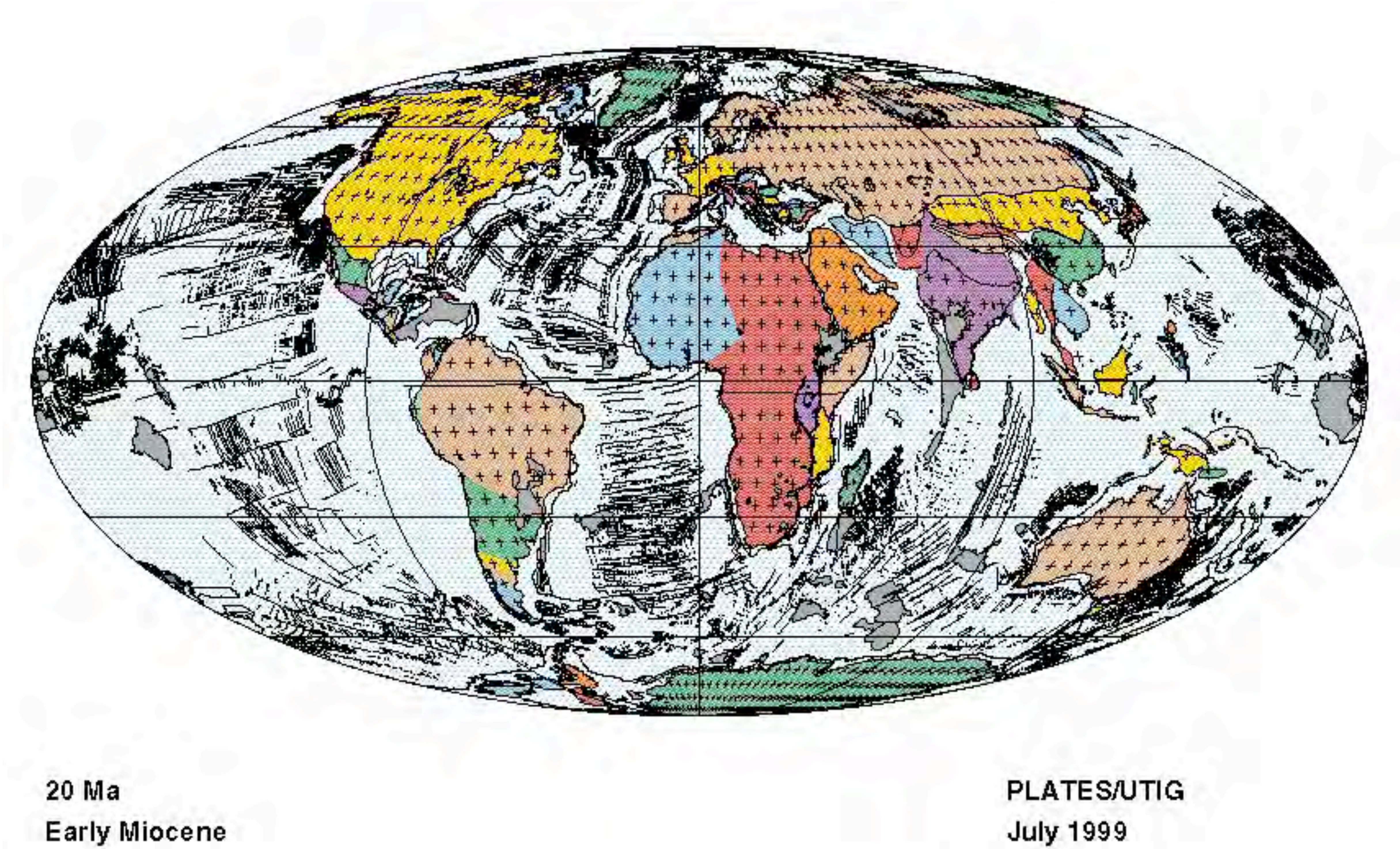
Vor 70 Millionen Jahren



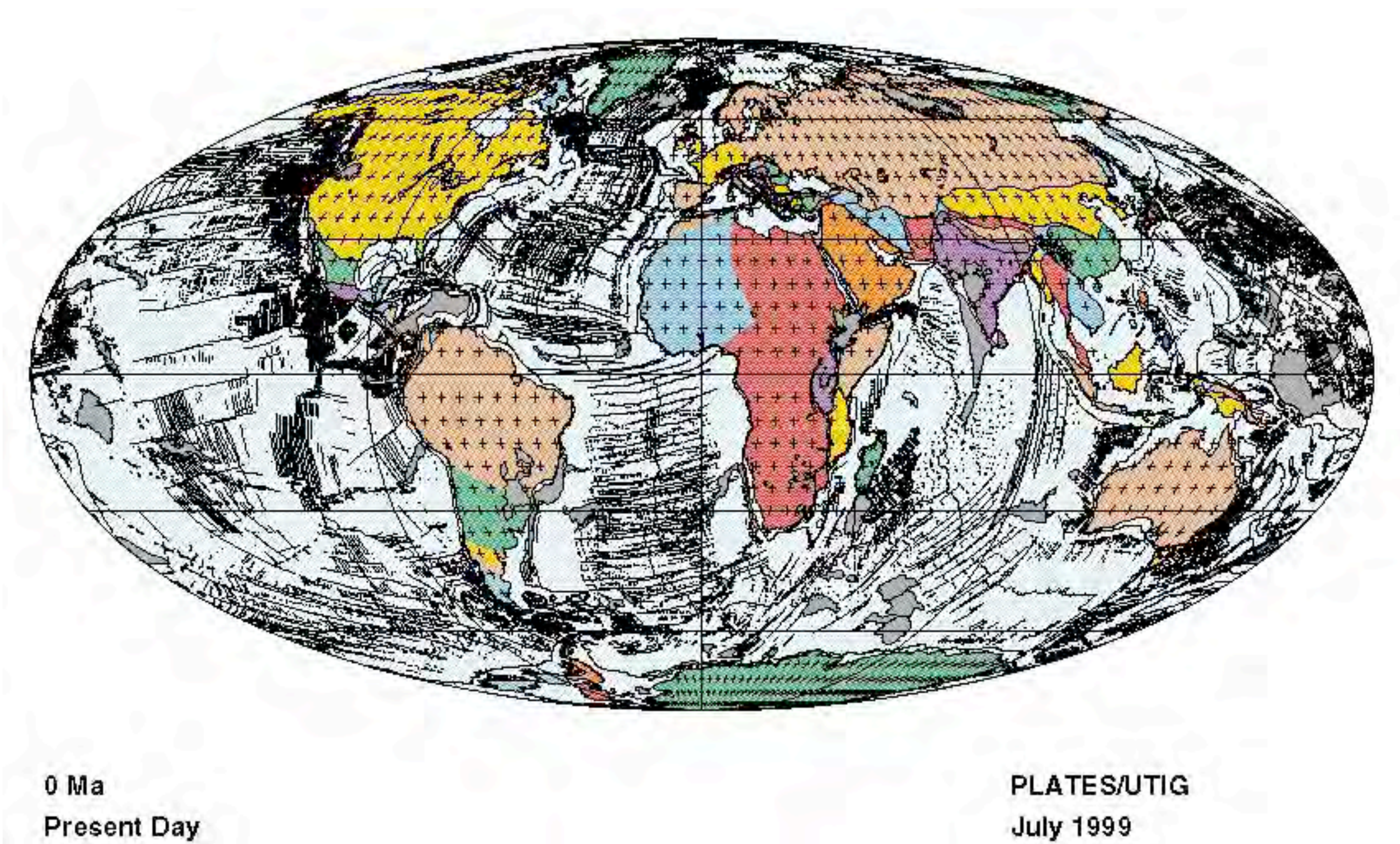
Vor 50 Millionen Jahren



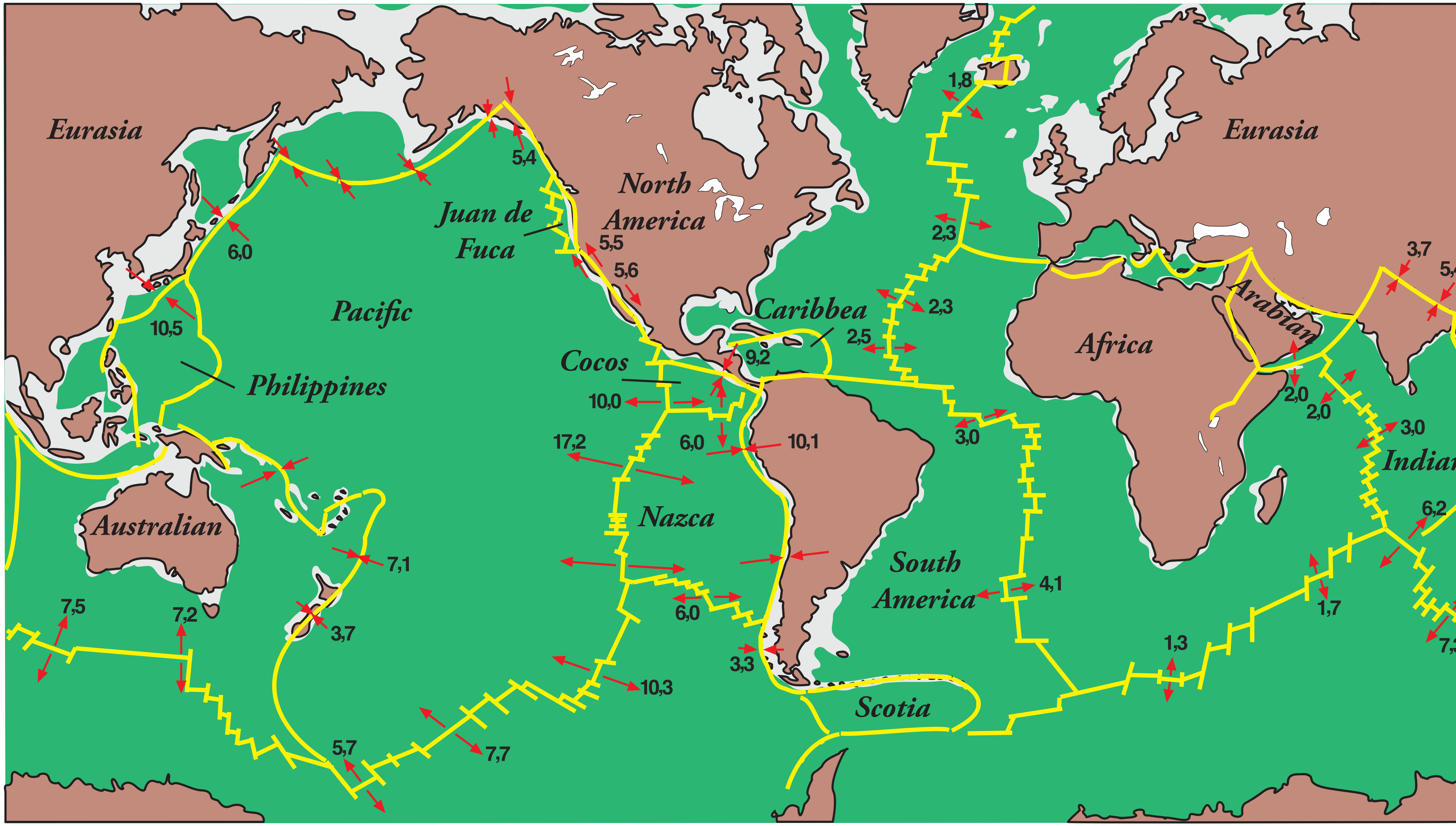
Vor 20 Millionen Jahren



Heute



Die Plattentektonik, heutige Model



Plattenränder

Divergent — Konvergent — **4,1** Rate in cm/a — "kontinentale Schelfe" — "kontinentale Schilde" — Ozean