

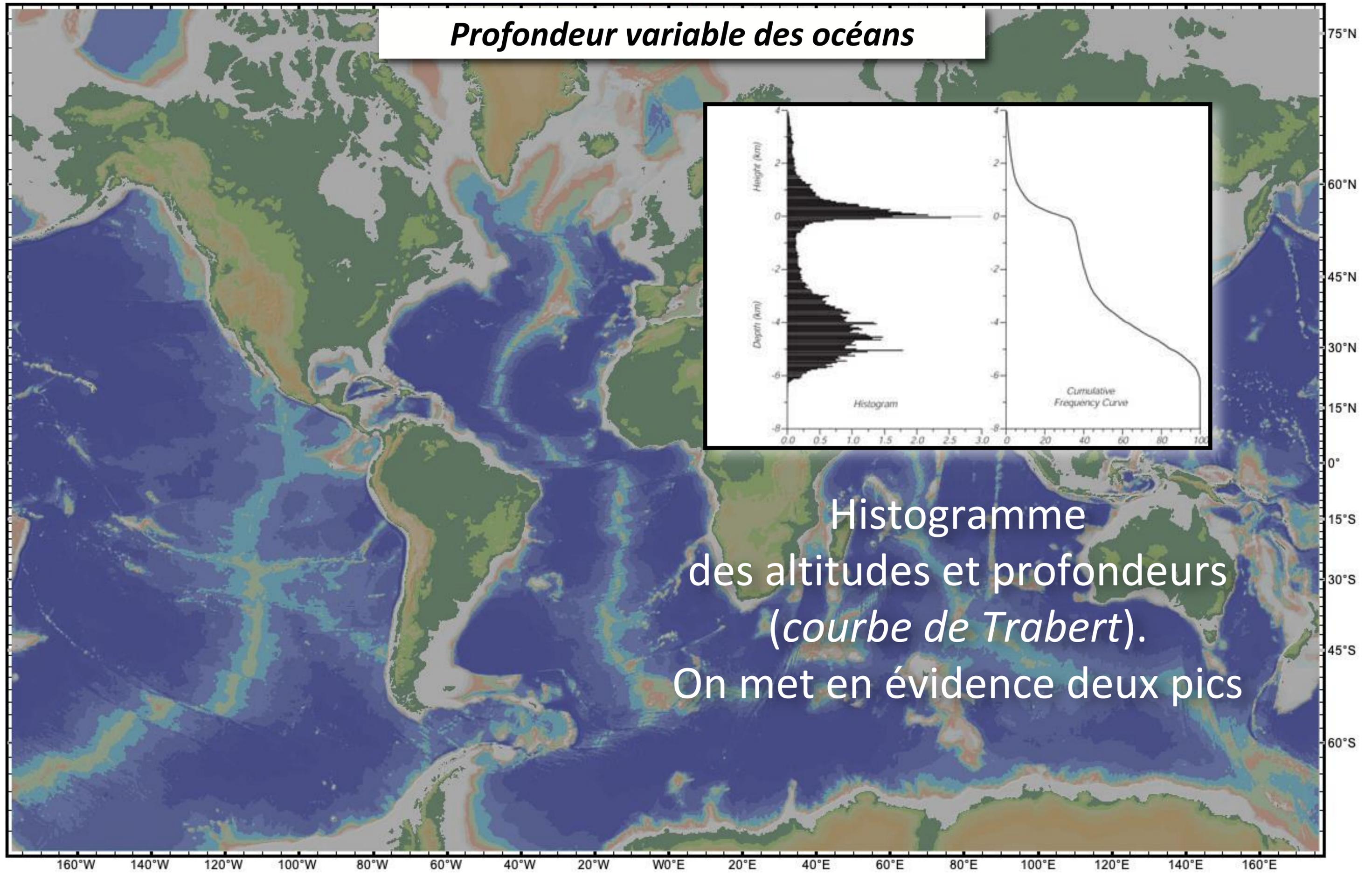
Université Populaire d'Antony, le 12 mars 2026

L'histoire des océans

Laurent JOLIVET

Sorbonne Université

Profondeur variable des océans



Histogramme
des altitudes et profondeurs
(*courbe de Trabert*).
On met en évidence deux pics

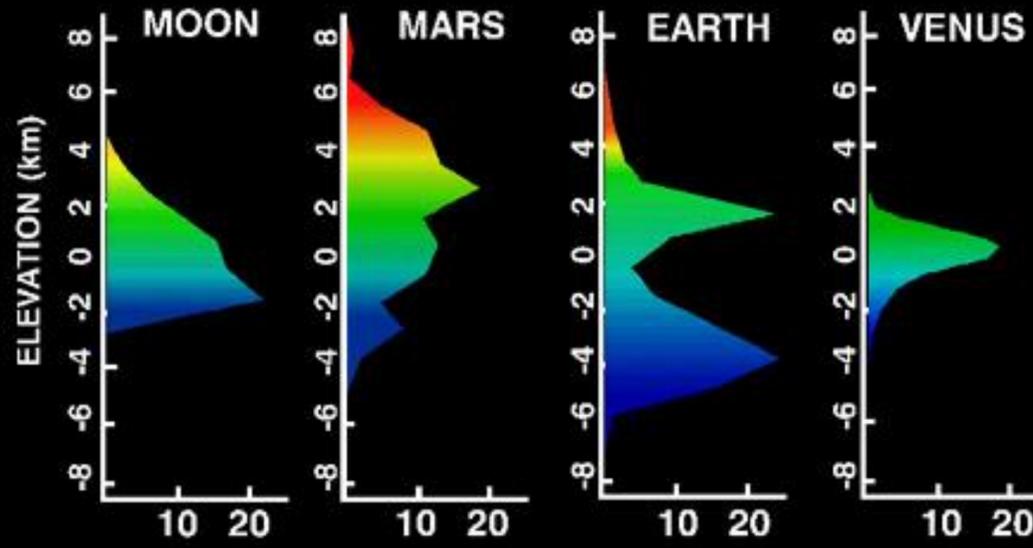
Cette distribution bimodale
caractérise la Terre
et sa
tectonique des plaques

Continent

*Plateau
continental*

Plaine
Abyssale

COMPARATIVE HYPSONOMETRIES



URL: <http://comp.uark.edu/~sboss>

University of Arkansas



De quoi la Terre est-elle faite ?

Densité: $d = 2-2,3$

Sédiments, ici la craie du Crétacé



Densité: $d = 2,6$

N

S

~50 cm

Granite, ici l'Île d'Elbe

N

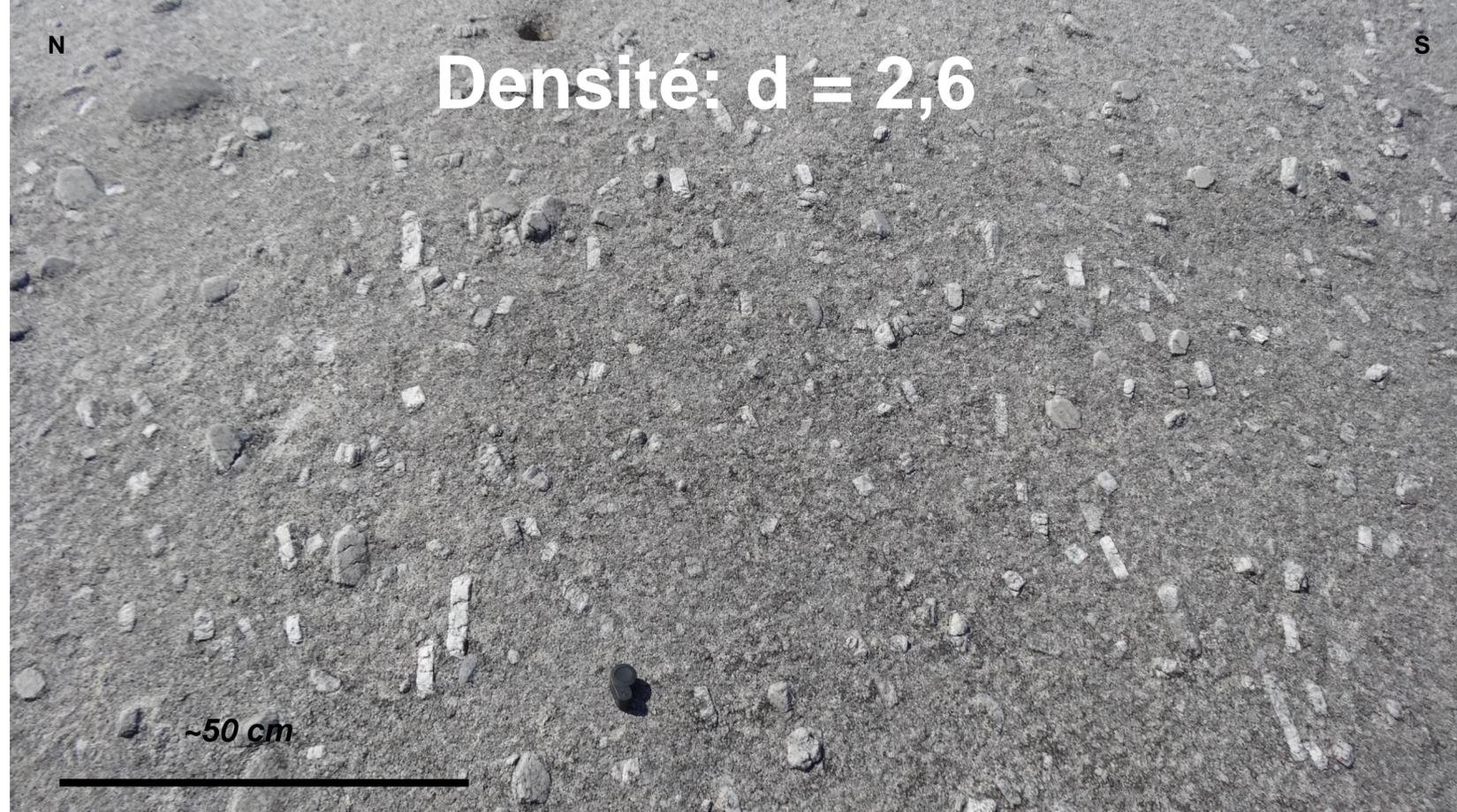
S

~1 m

N

S

~50 cm



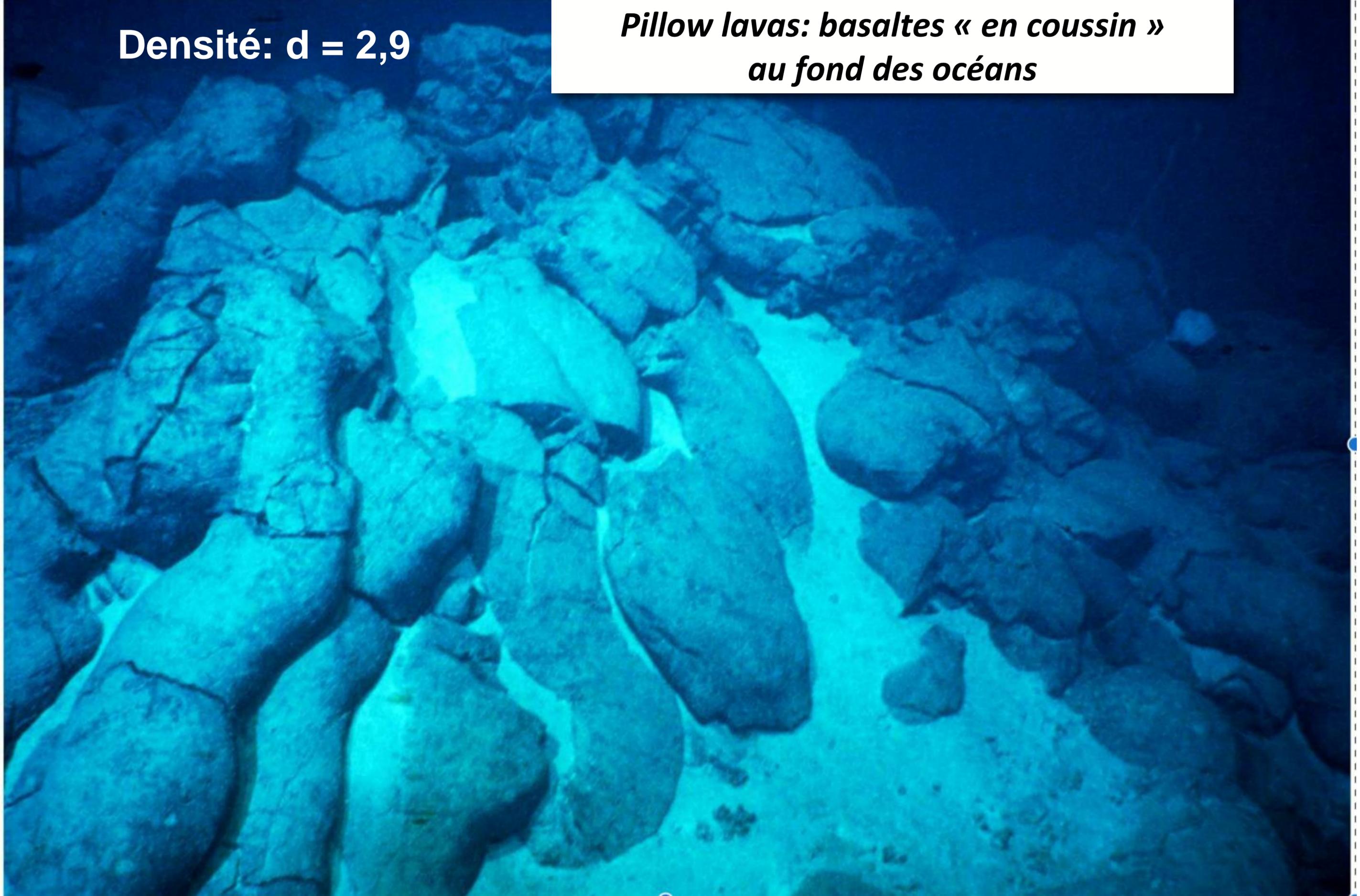
Densité: $d = 2,9$

Coulée de basaltes primés (Bort-les-Orgues)



Densité: $d = 2,9$

*Pillow lavas: basaltes « en coussin »
au fond des océans*



Enclave de « péridotite » dans un basalte du Massif central



Photographie : Pierre Thomas

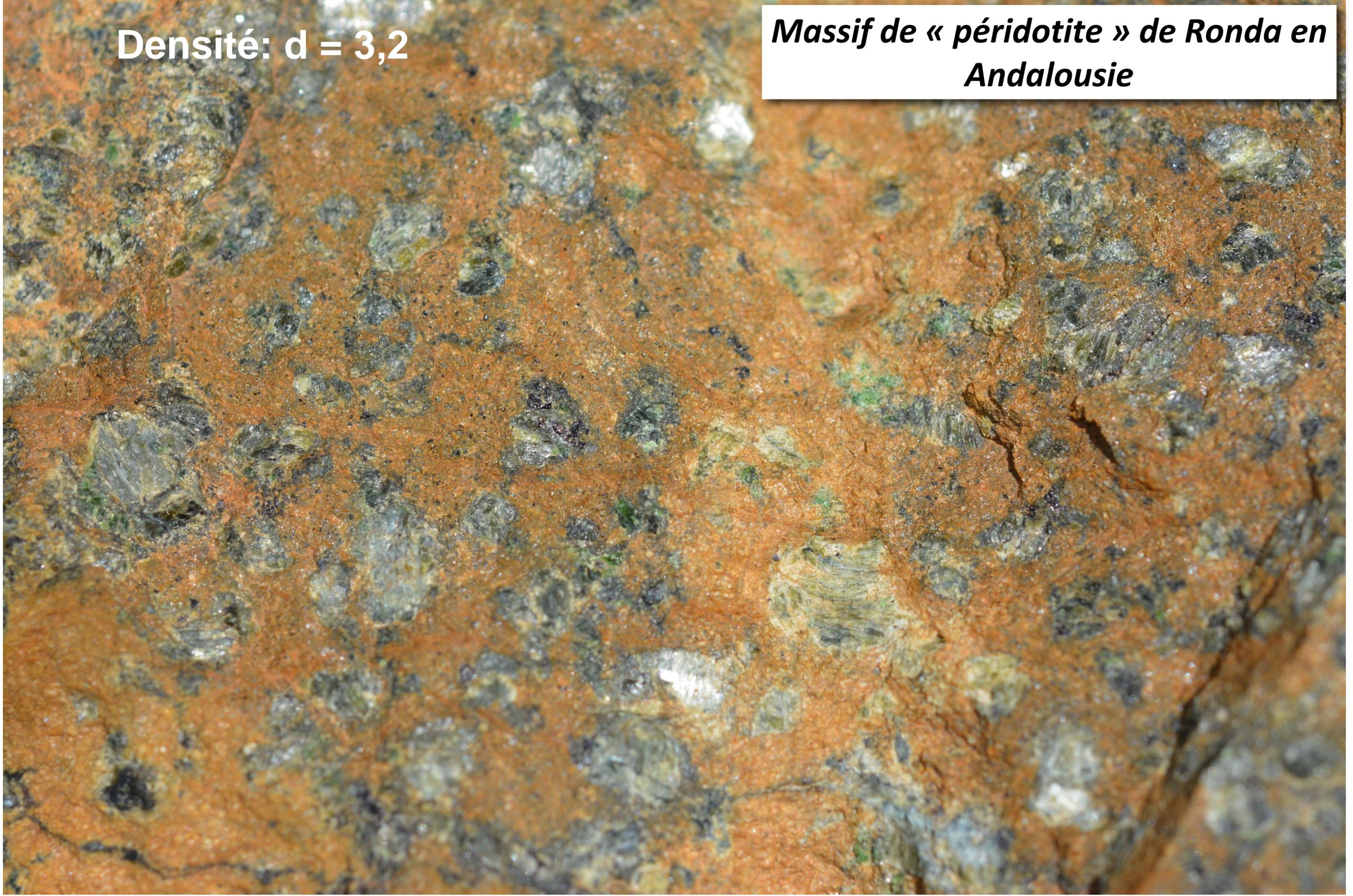
Densité: $d = 3,27$

*Massif de « péridotite » de Ronda en
Andalousie*



Densité: $d = 3,2$

*Massif de « péridotite » de Ronda en
Andalousie*



Densité: $d = 3,2$

***Massif de « péridotite » de Ronda en
Andalousie***

70% du volume de la Terre:

le « manteau » est constitué de ces péridotites

Le manteau est surmonté de la « croûte »

continentale avec ses granites,

ou océanique avec ses basaltes,

et au-dessus les sédiments

Son épaisseur varie de quelques km à 80 km

Anomalies du champ de pesanteur à grande échelle et principe d'isostasie:

En 1855, Pratt et Airy confirment en Himalaya l'observation de Bouguer en 1750: les montagnes semblent plus légères qu'on ne s'y attendait. Il faut donc supposer que la masse du relief est compensée en profondeur.

Deux modèles d'**ISOSTASIE** sont alors proposés (*isostasie* = ~ *flottaison*)

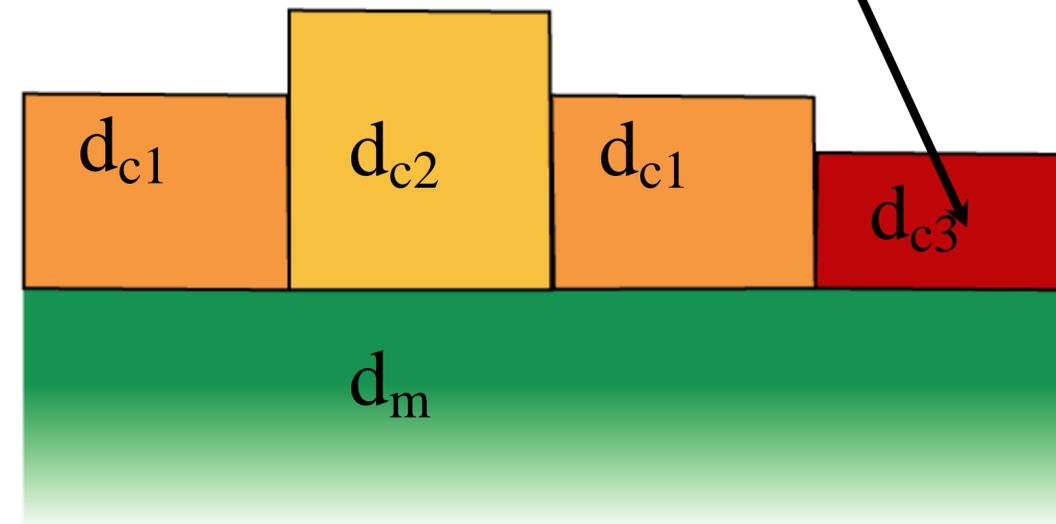
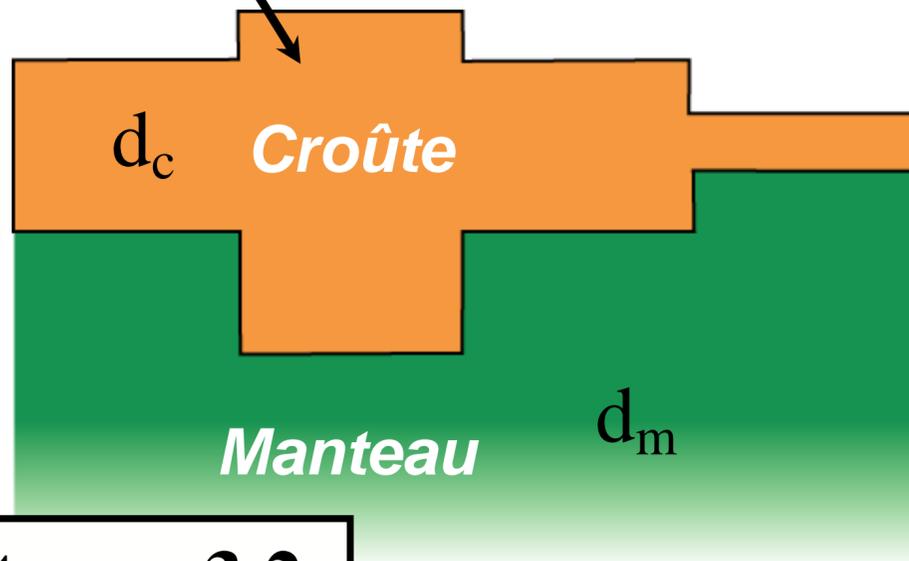
Modèle d'Airy

Modèle de Pratt

densité de la croûte continentale : 2.6

densité de la croûte océanique : 2.9

Moho

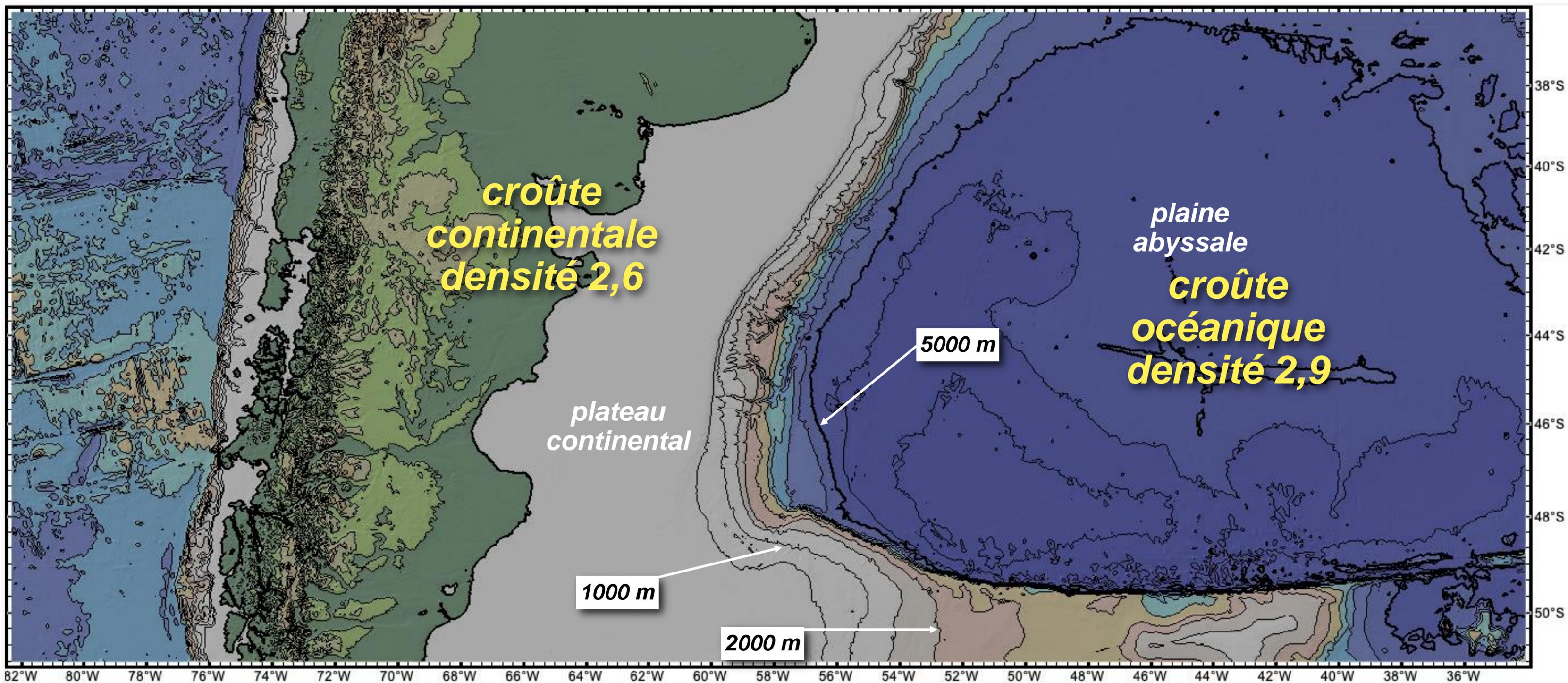


densité du manteau : 3.2

(analogie avec un iceberg)

(Dans le modèle de Pratt les différences de densité correspondent à des différences de température)

La distribution bimodale des altitudes et des profondeurs traduit deux types de croûte différents



Si Al O Fe Mg K Ca

Si Mg O Fe K

Fe Ni

manteau supérieur

manteau

inferieur

D''

noyau

liquide

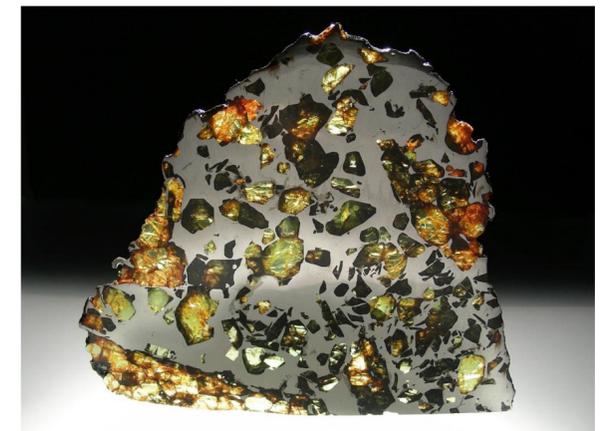
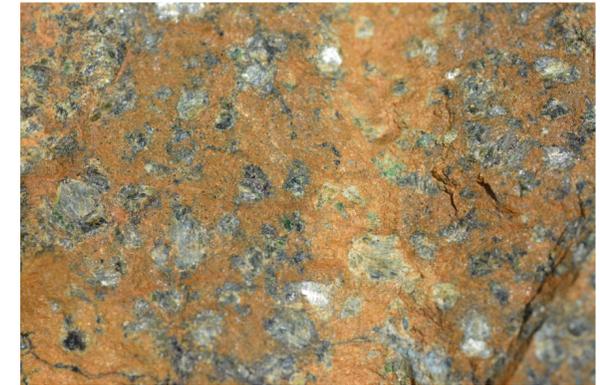
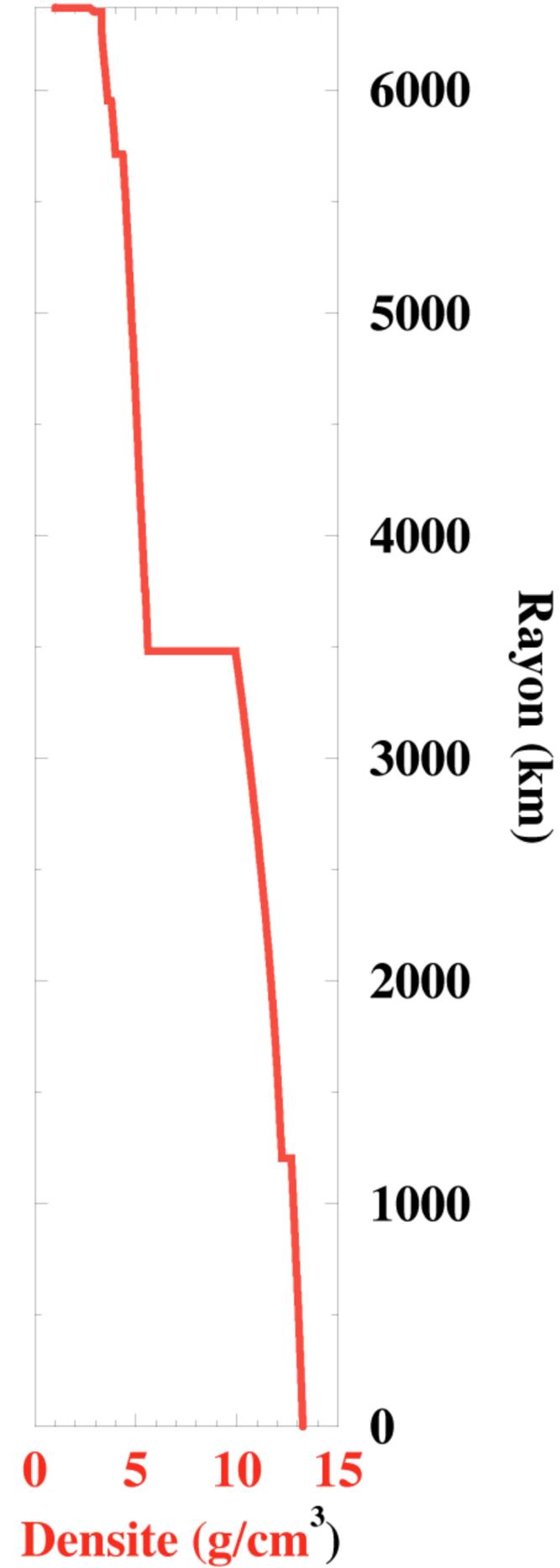
graine

410

660

2900

5100



<https://actugeologique.fr/2020/07/origine-des-pallasites-des-meteorites-constituees-de-metal-et-de-silicate-a-ete-elucidee/>

Modèle de Terre PREM:

Preliminary Reference Earth Model

Croûte, lithosphère, asthénosphère

prisme
d'accrétion

canal de subduction

croûte cont.

serpentine

croûte océanique

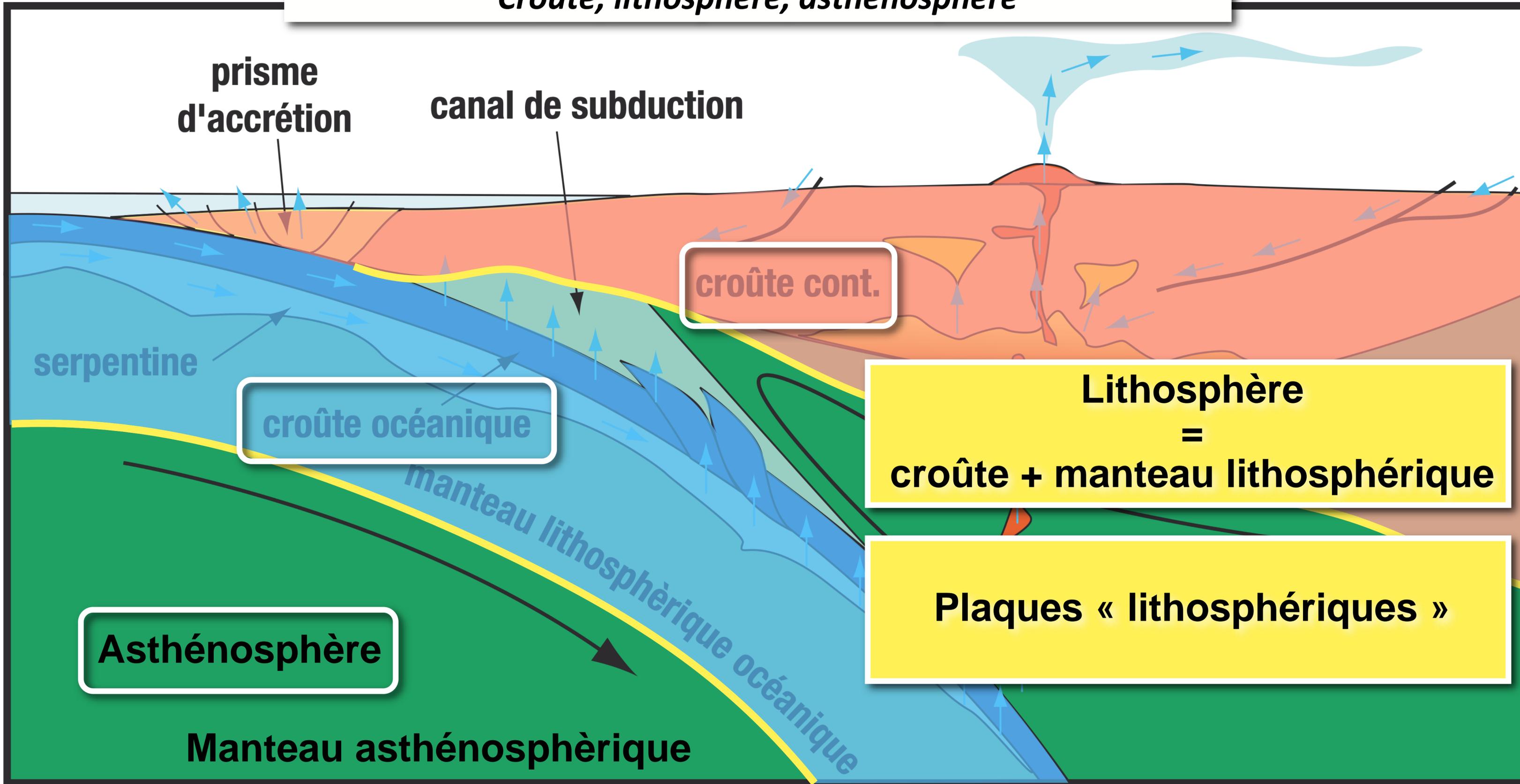
**Lithosphère
=
croûte + manteau lithosphérique**

Plaques « lithosphériques »

Asthénosphère

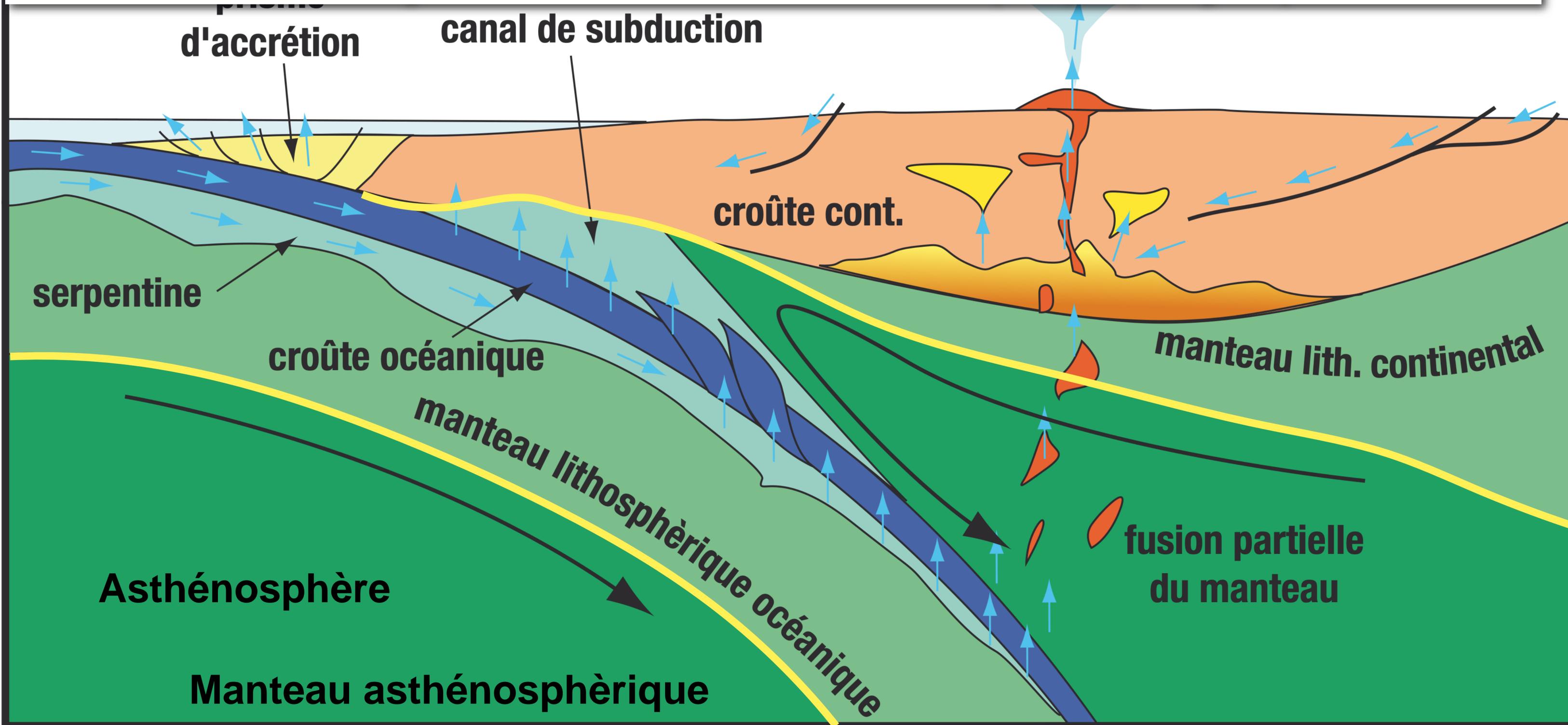
Manteau asthénosphérique

manteau lithosphérique océanique



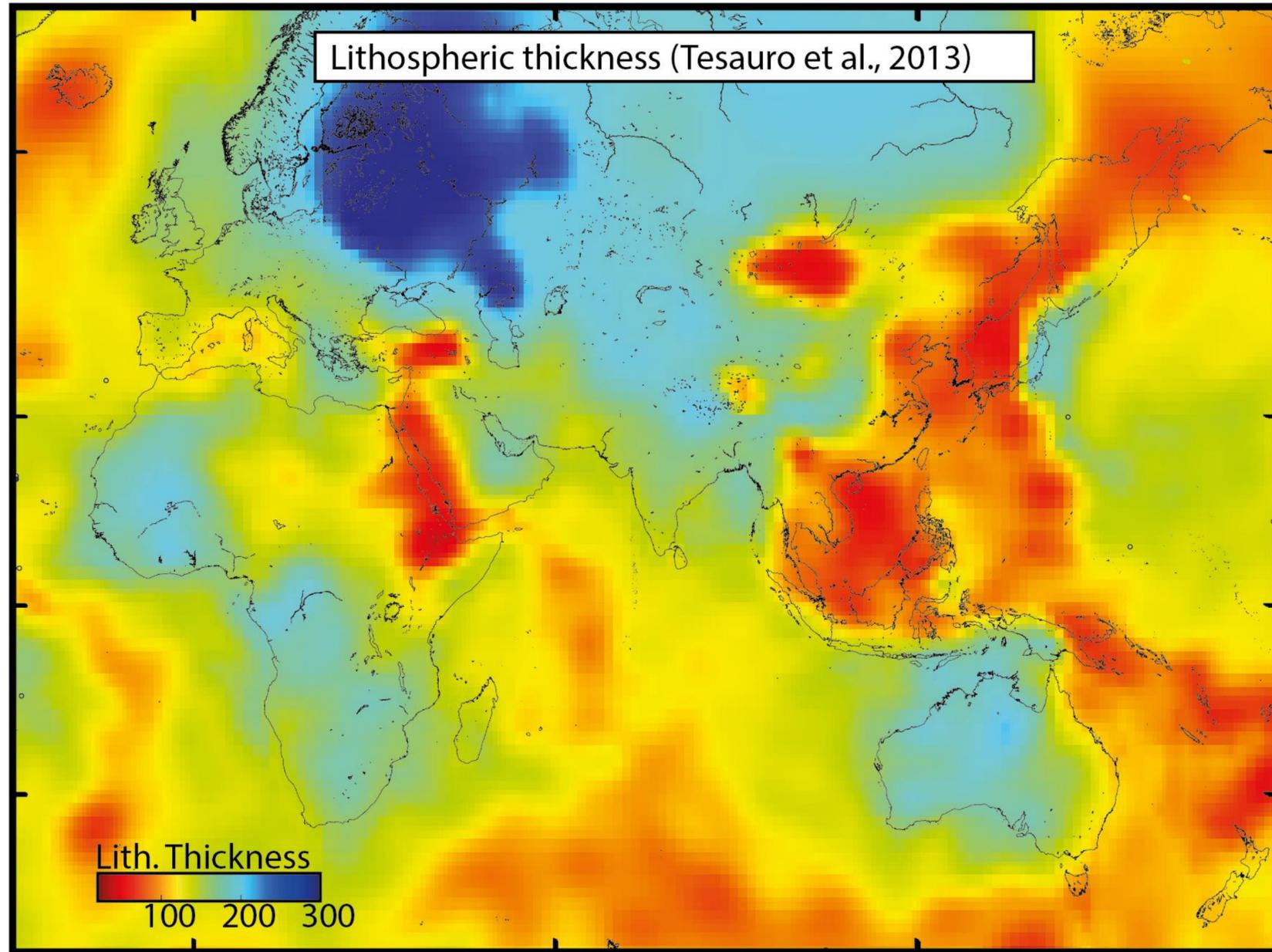
La lithosphère interagit avec l'atmosphère et les océans, d'une part, et avec le manteau asthénosphérique, d'autre part.

Elle échange de la chaleur et des éléments chimiques (eau, magmas).

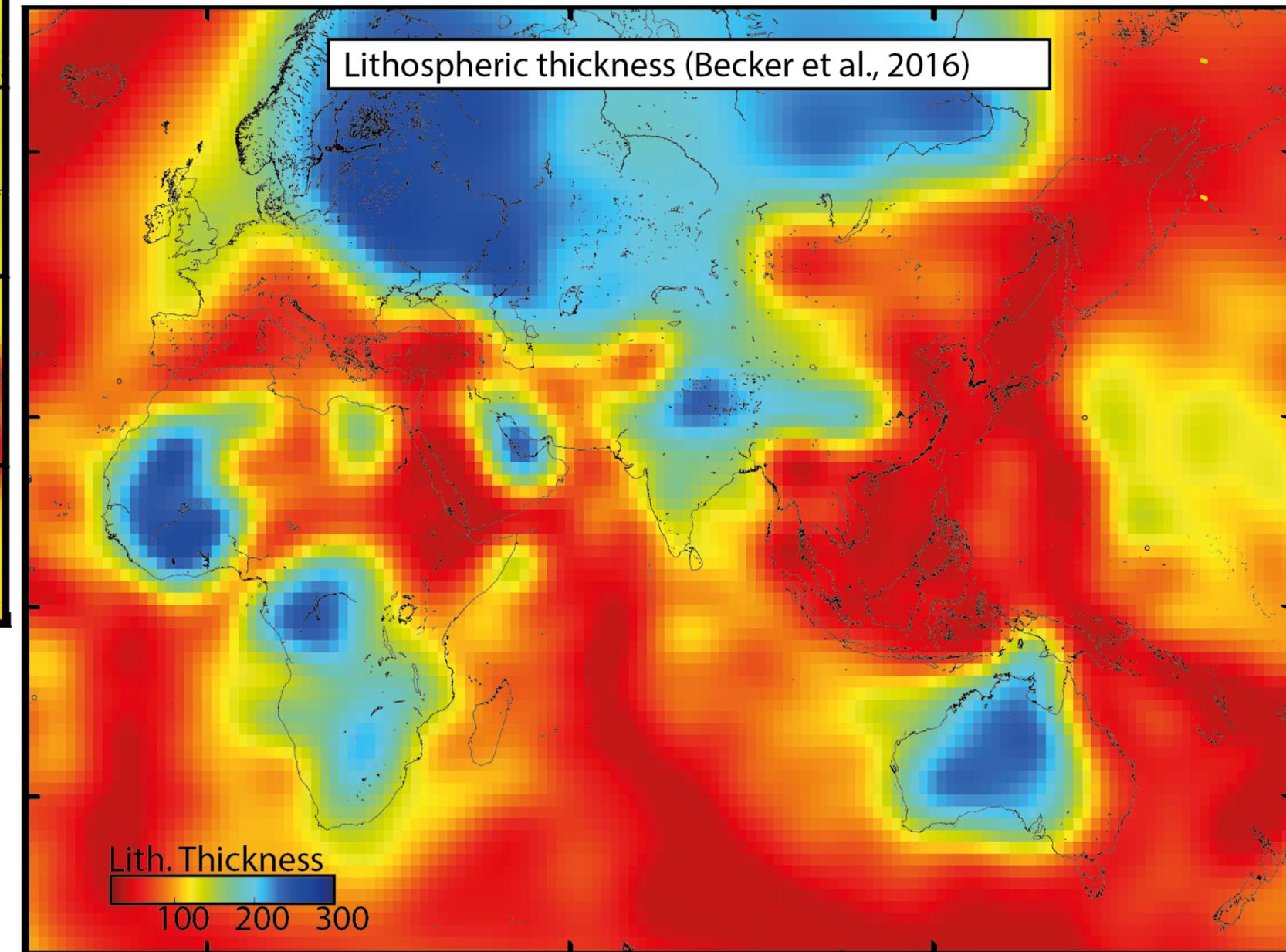


Épaisseur de la lithosphère, épaisseur des plaques :

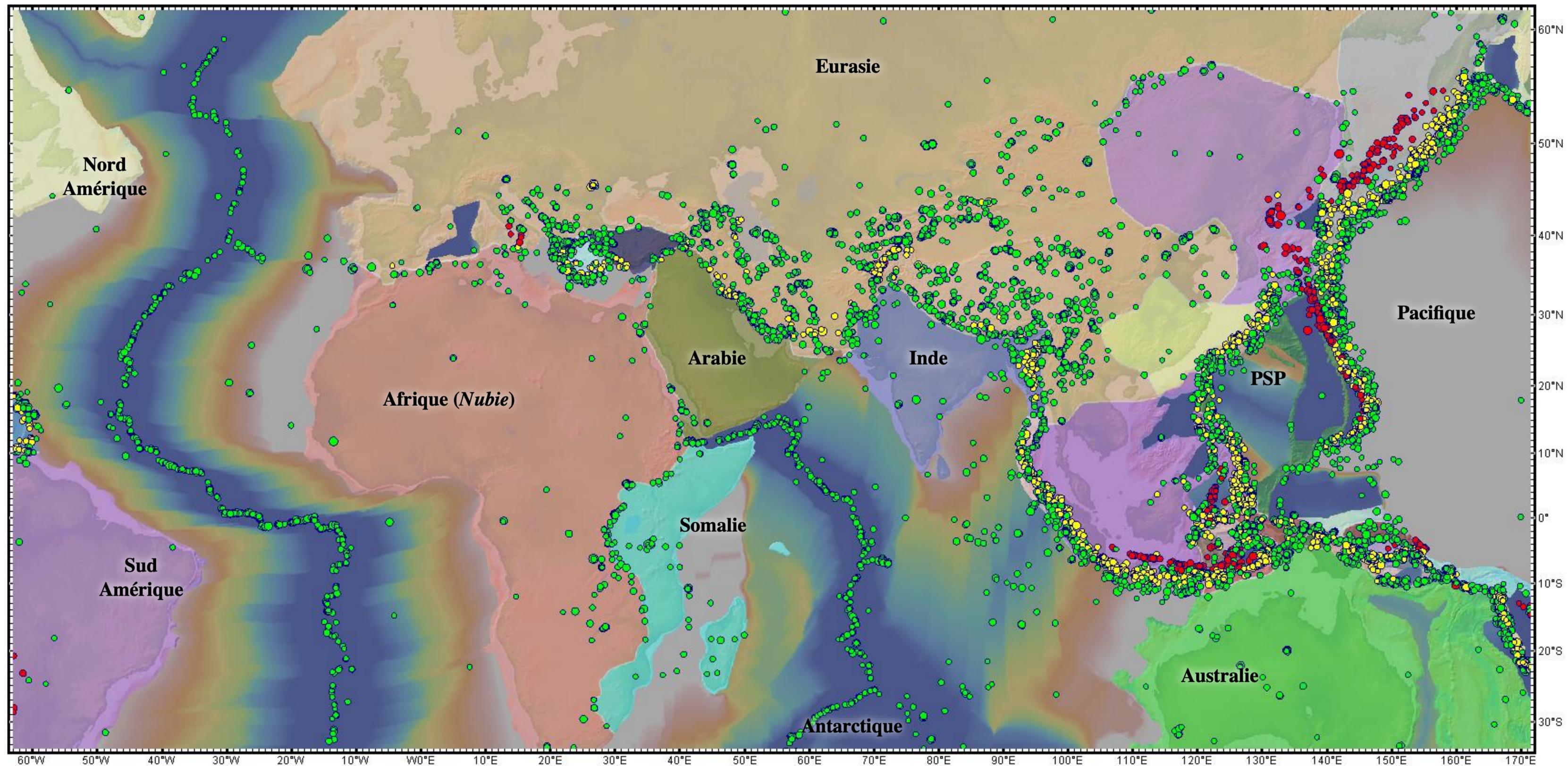
Lithospheric thickness (Tesauro et al., 2013)



Lithospheric thickness (Becker et al., 2016)



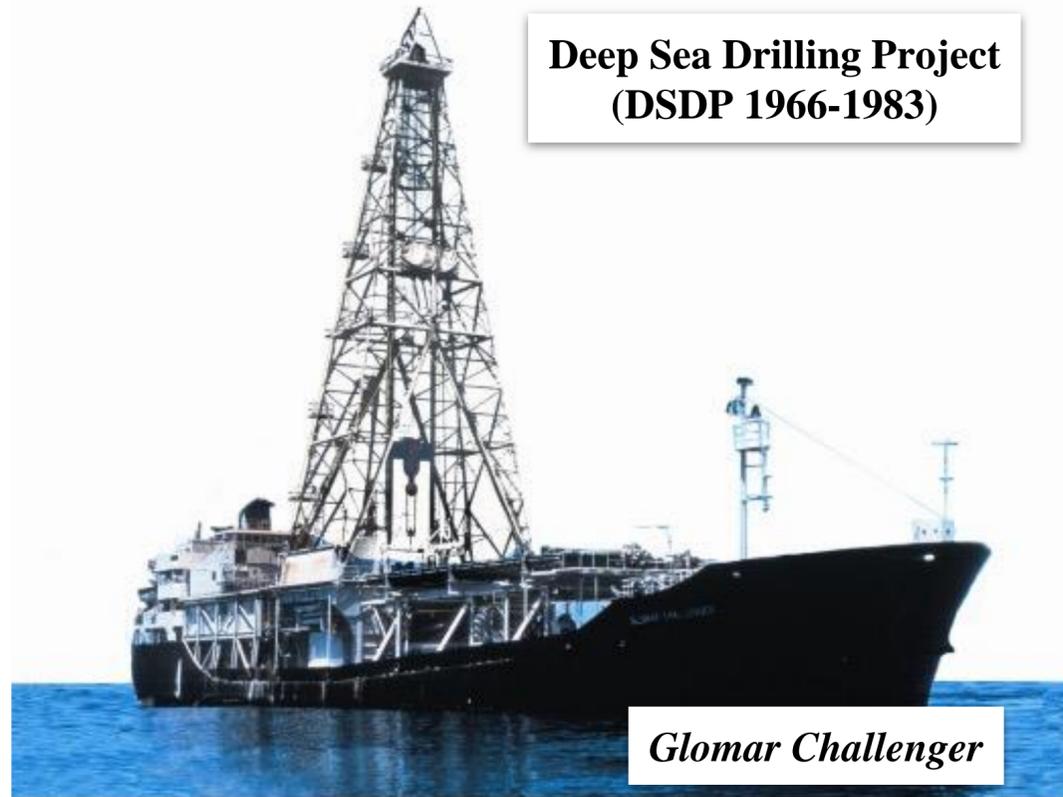
Séismes, limites de plaques et âge du fond des océans



A world map showing ocean bathymetry and topography. The map uses a color scale where darker blues represent deeper ocean depths, lighter blues and greens represent continental shelves and shallower waters, and brown and tan represent landmasses. The map includes latitude and longitude markings along the edges. A central text overlay reads:

Explorer les océans, la grande affaire du XX^{ème} siècle

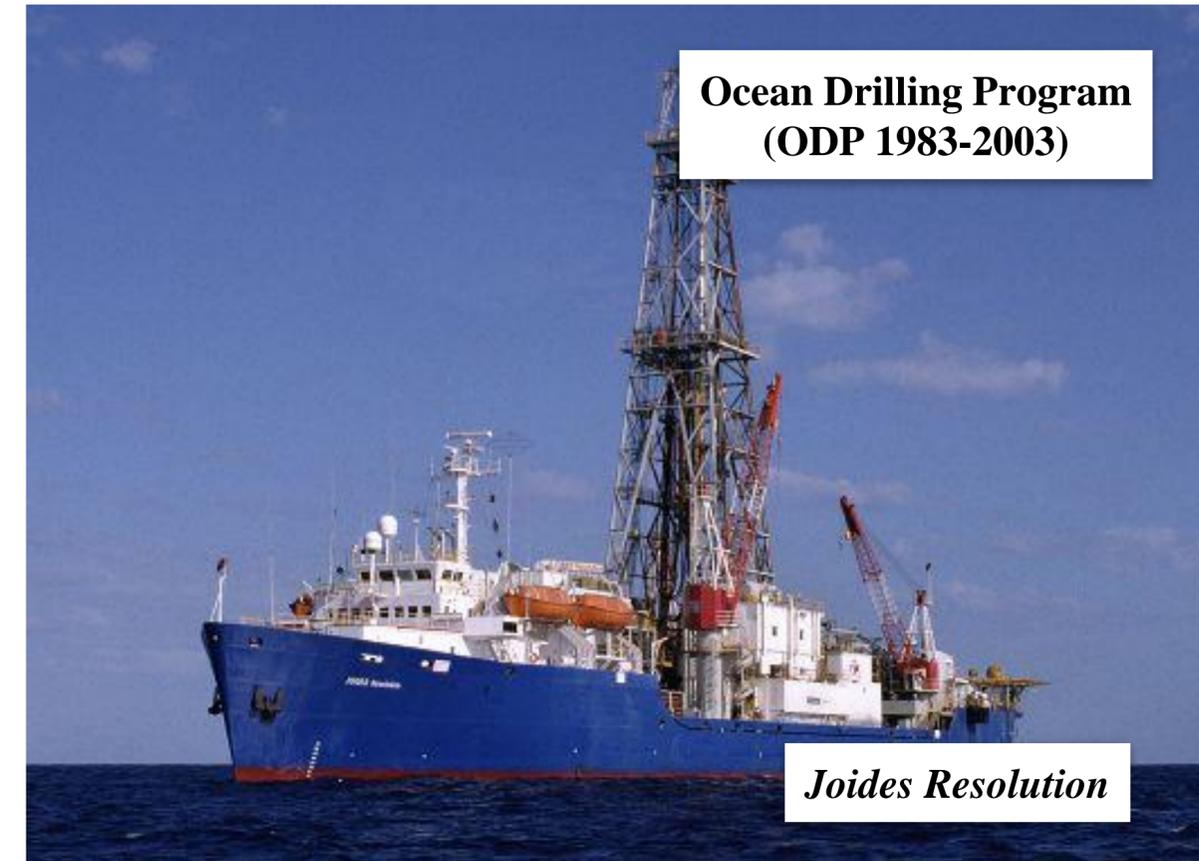
50 ans de forages océaniques



**Deep Sea Drilling Project
(DSDP 1966-1983)**

Glomar Challenger

SIO Archives/UCSD



**Ocean Drilling Program
(ODP 1983-2003)**

Joides Resolution



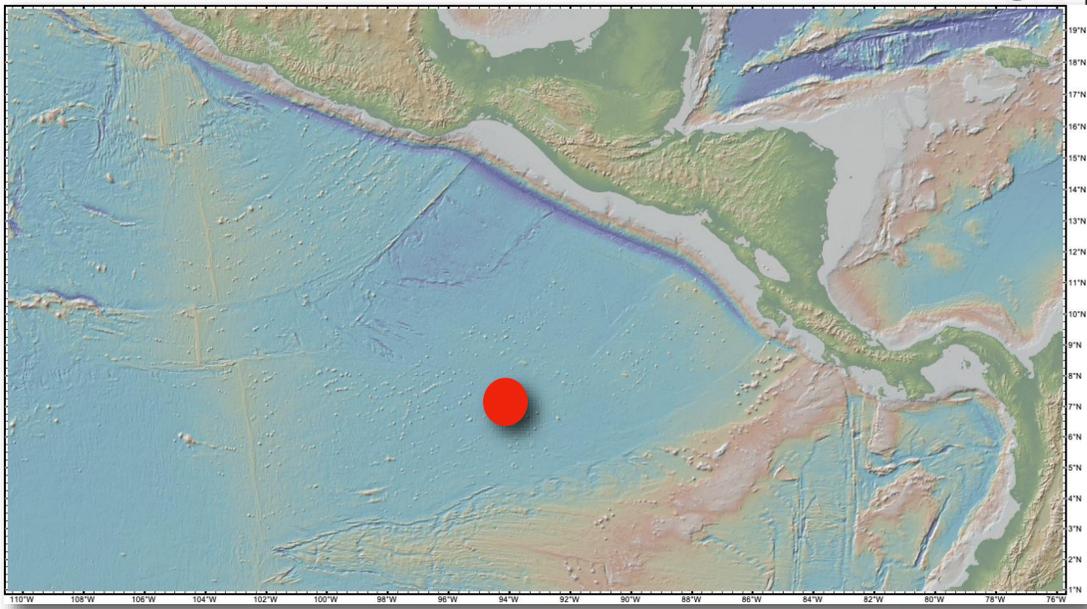
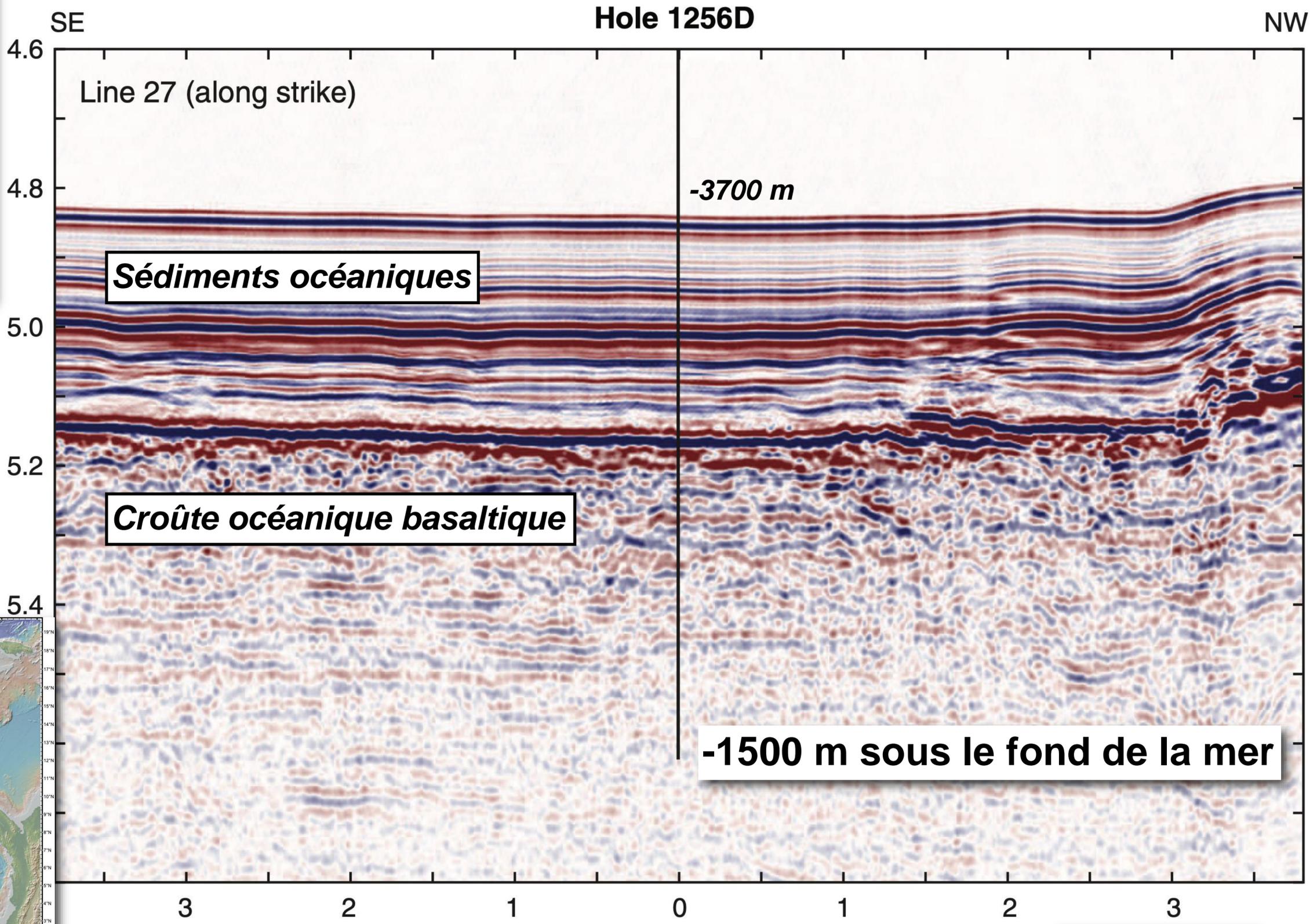
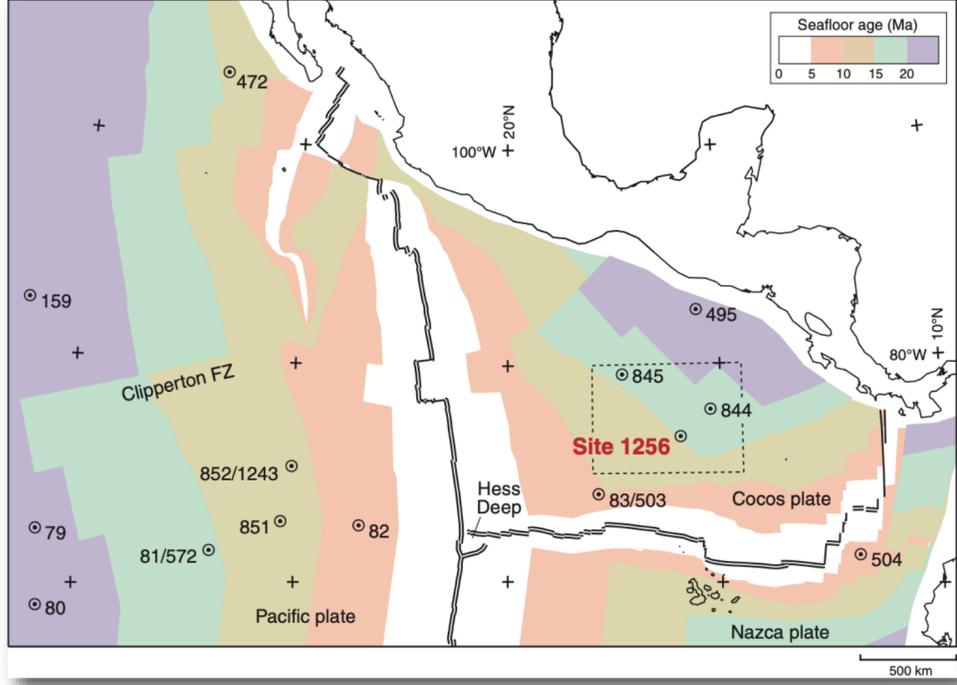
**Integrated Ocean Drilling Program
(IODP 2003-aujourd'hui)**



ちきゅう
CHIKYU

Chikyu + Joides Resolution

Drilling the oceanic crust



Distance from Hole 1256D (km)

Teagle *et al.*, 2012

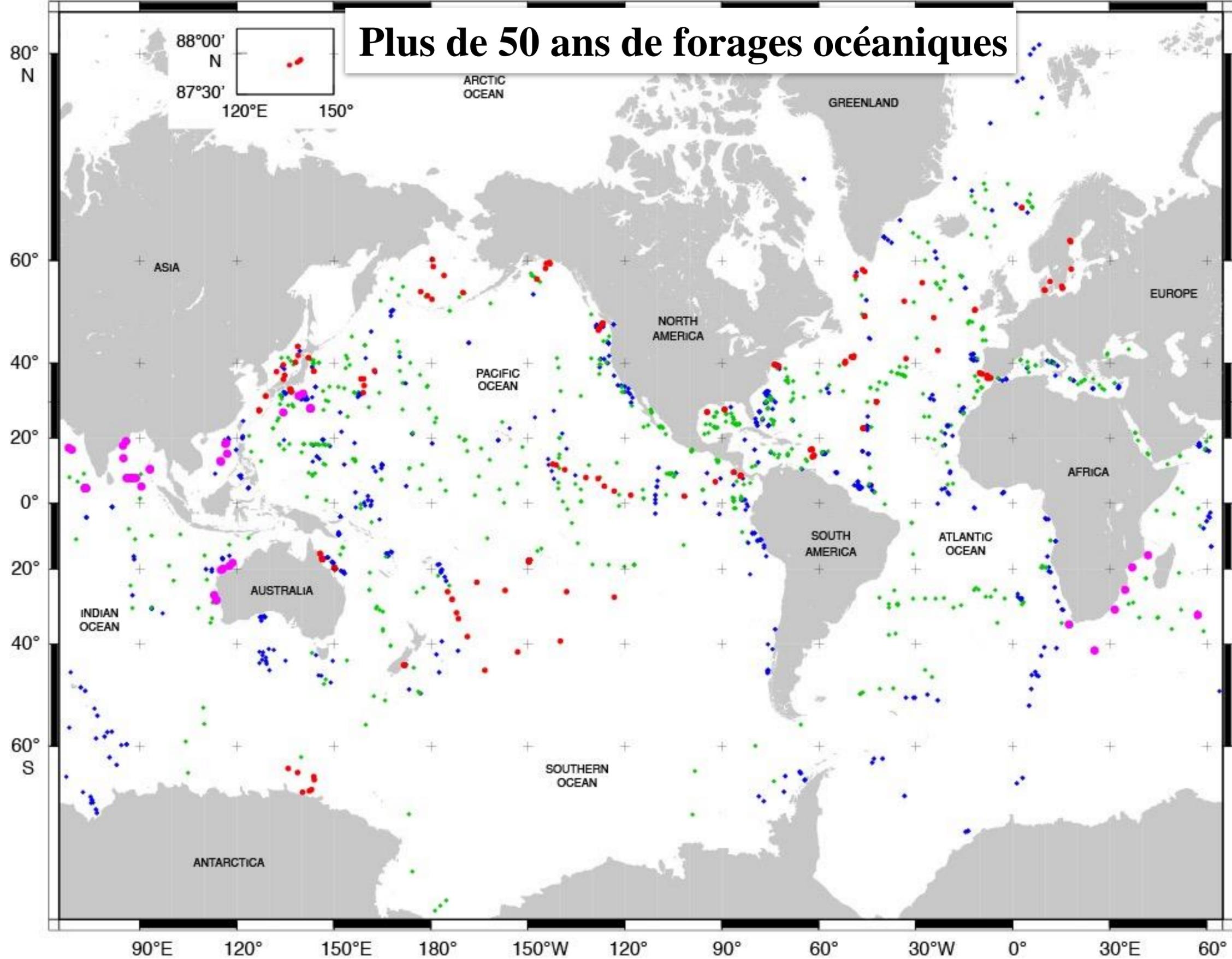
ODP Leg 127, Mer du Japon, 1989: forages profonds



Plus de 50 ans de forages océaniques



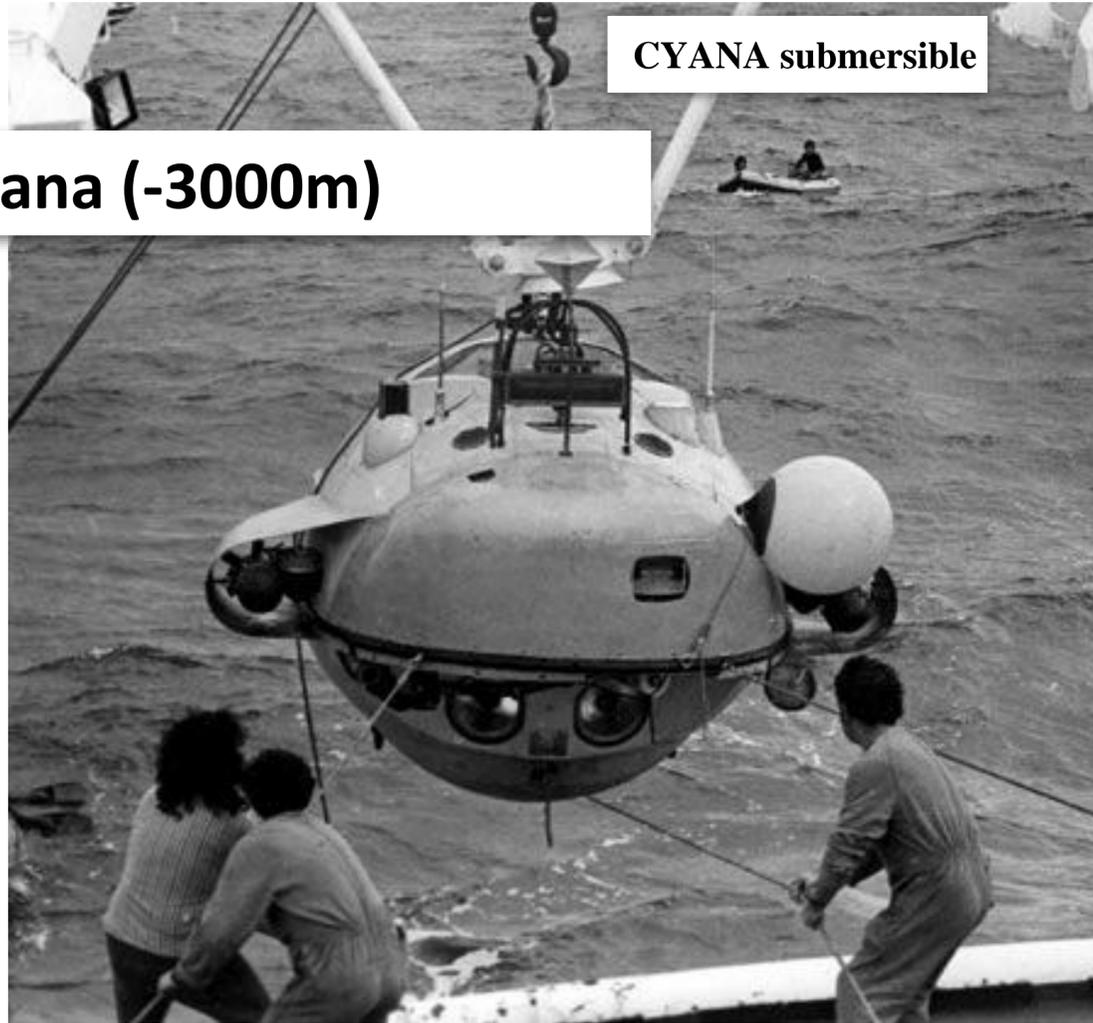
Plus de 50 ans de forages océaniques



DSDP Legs 1–96 (●), ODP Legs 100–210 (●), IODP Expeditions 301–348 (●), IODP Expeditions 349–361 (●)

Les submersibles autonomes

La Cyana (-3000m)



CYANA submersible

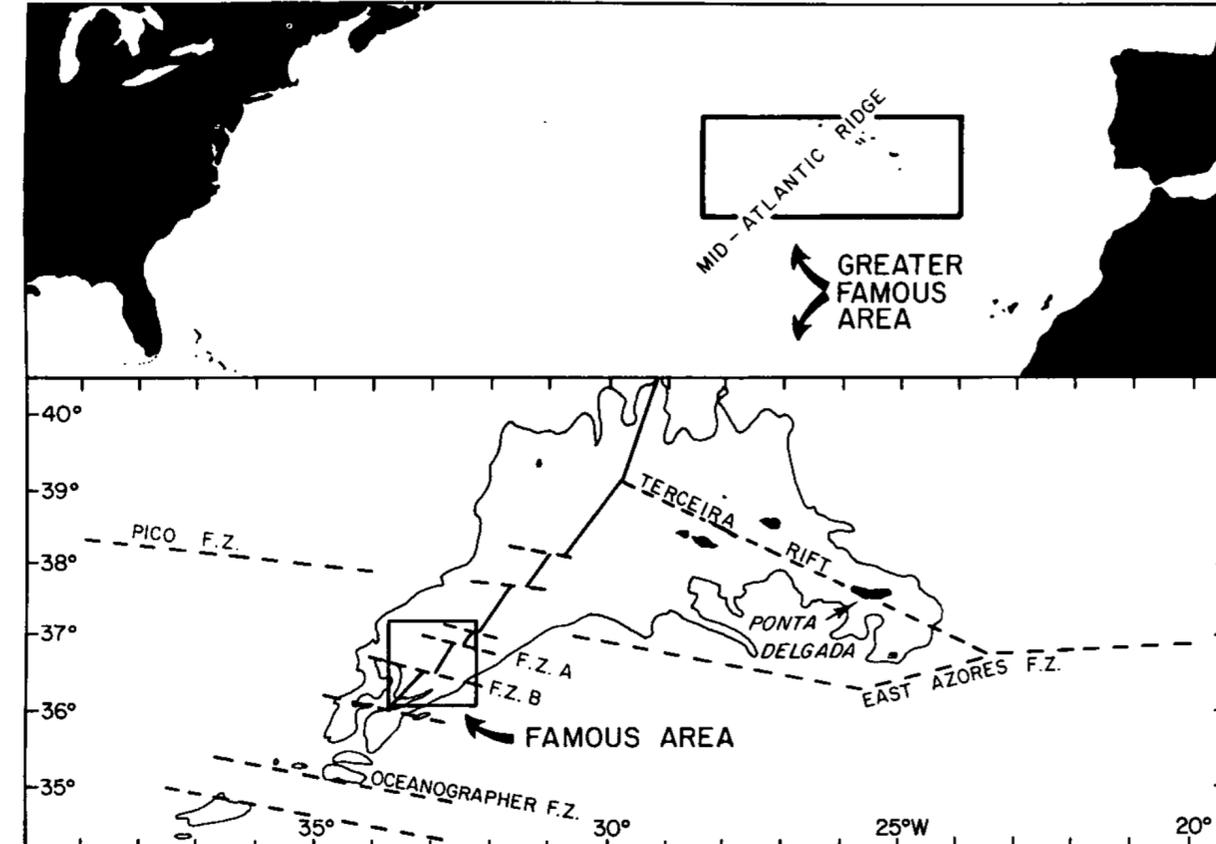


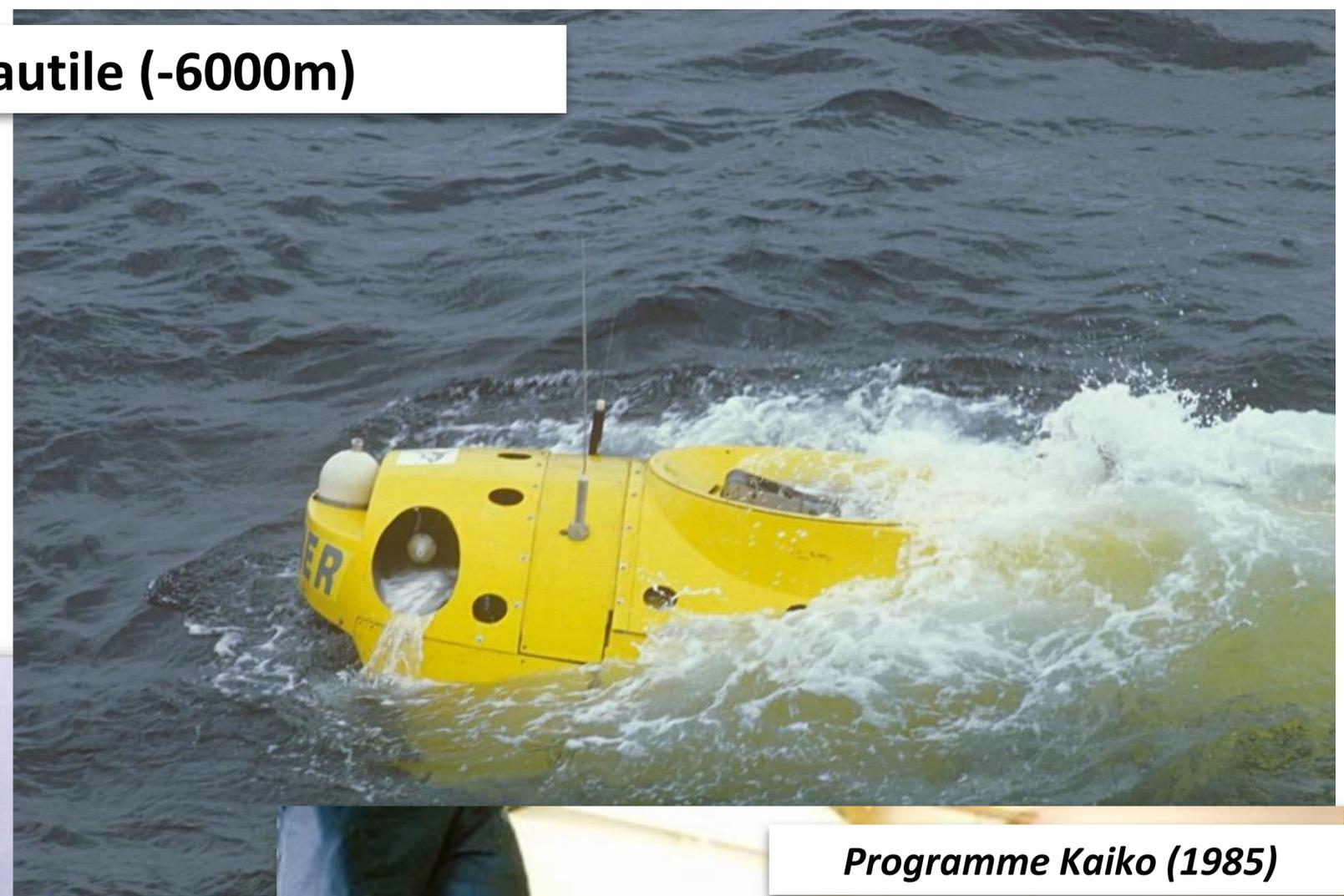
Figure 2. Greater FAMOUS and FAMOUS areas. The 2,000-m isobath is shown in the lower figure.

**The French-American cruise « FAMOUS »
(French-American Mid Ocean Undersea
Survey) on the Mid-Atlantic Ridge**

ALVIN submersible



Le Nautille (-6000m)



Programme Kaiko (1985)

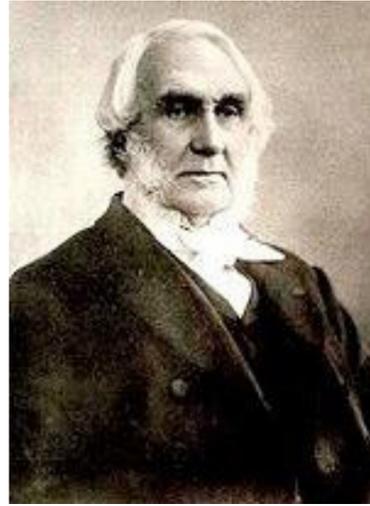




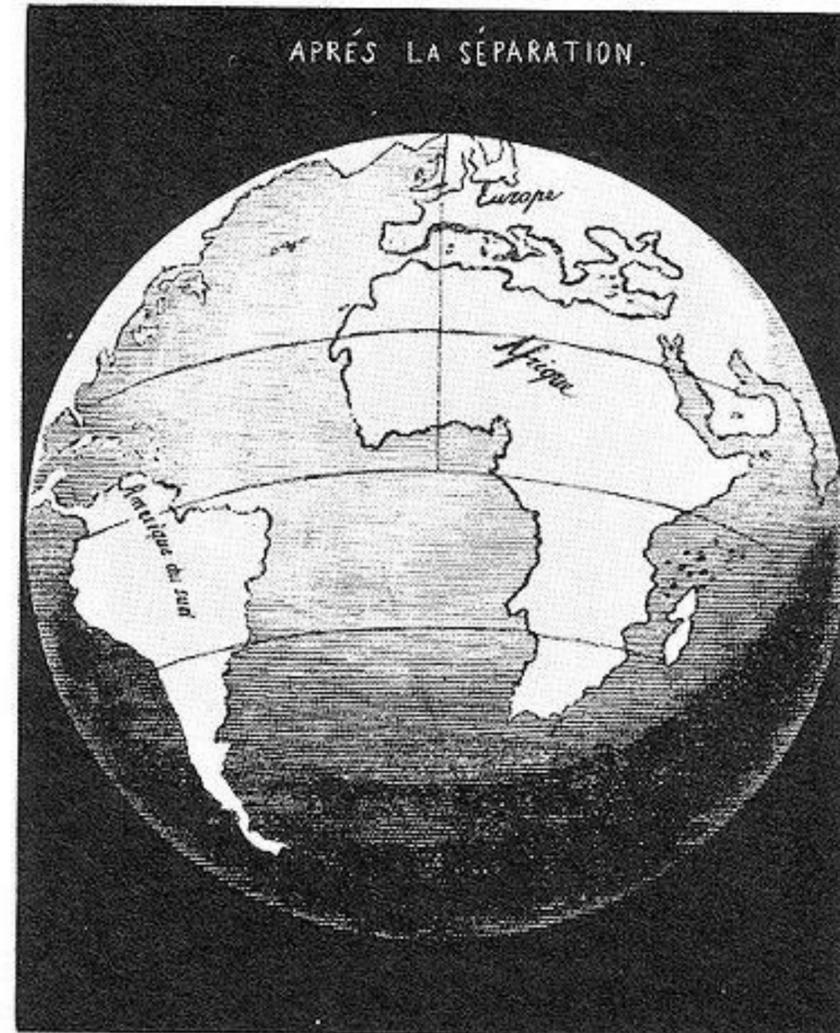
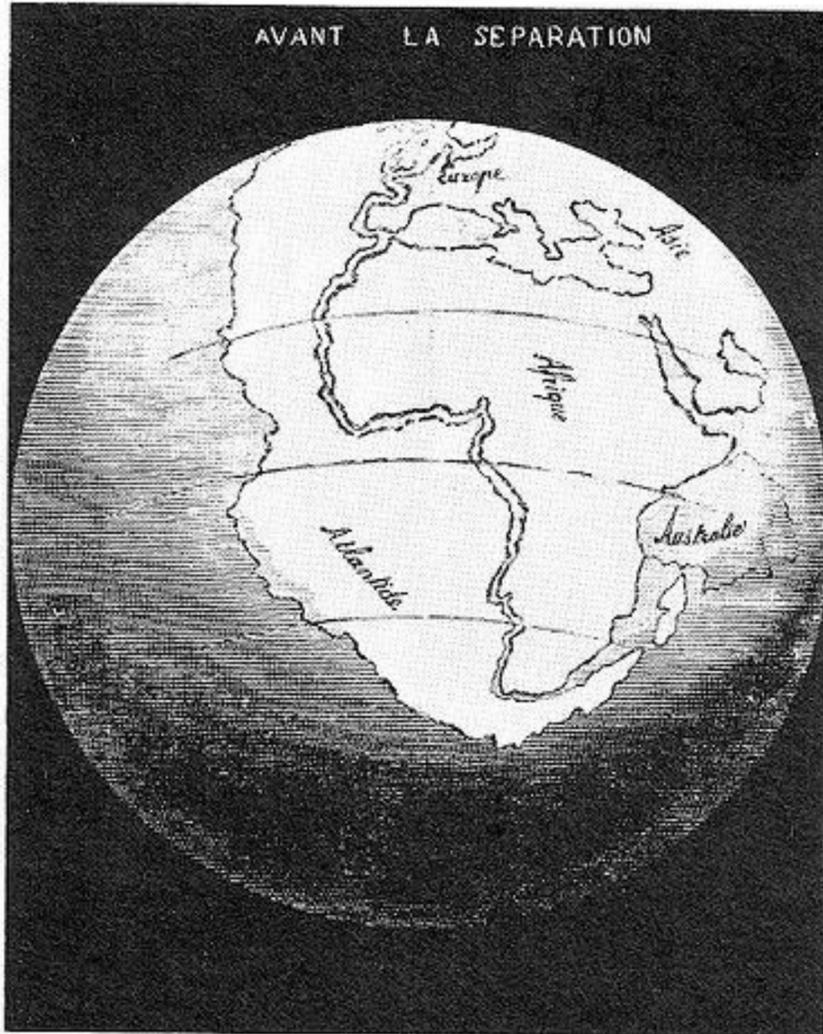
Un peu d'histoire:

de la dérive des continents à la tectonique des plaques

Dérive des continents

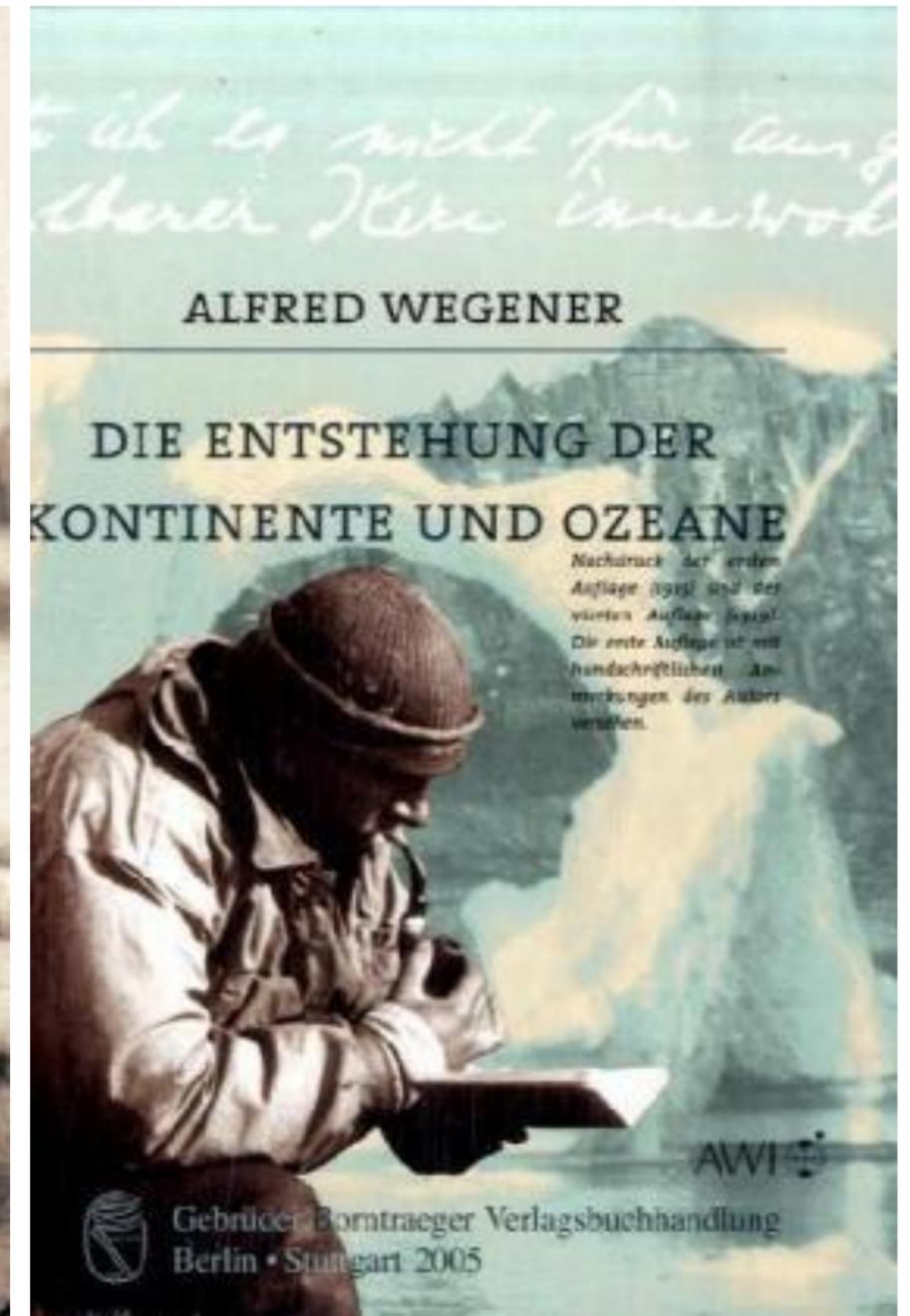
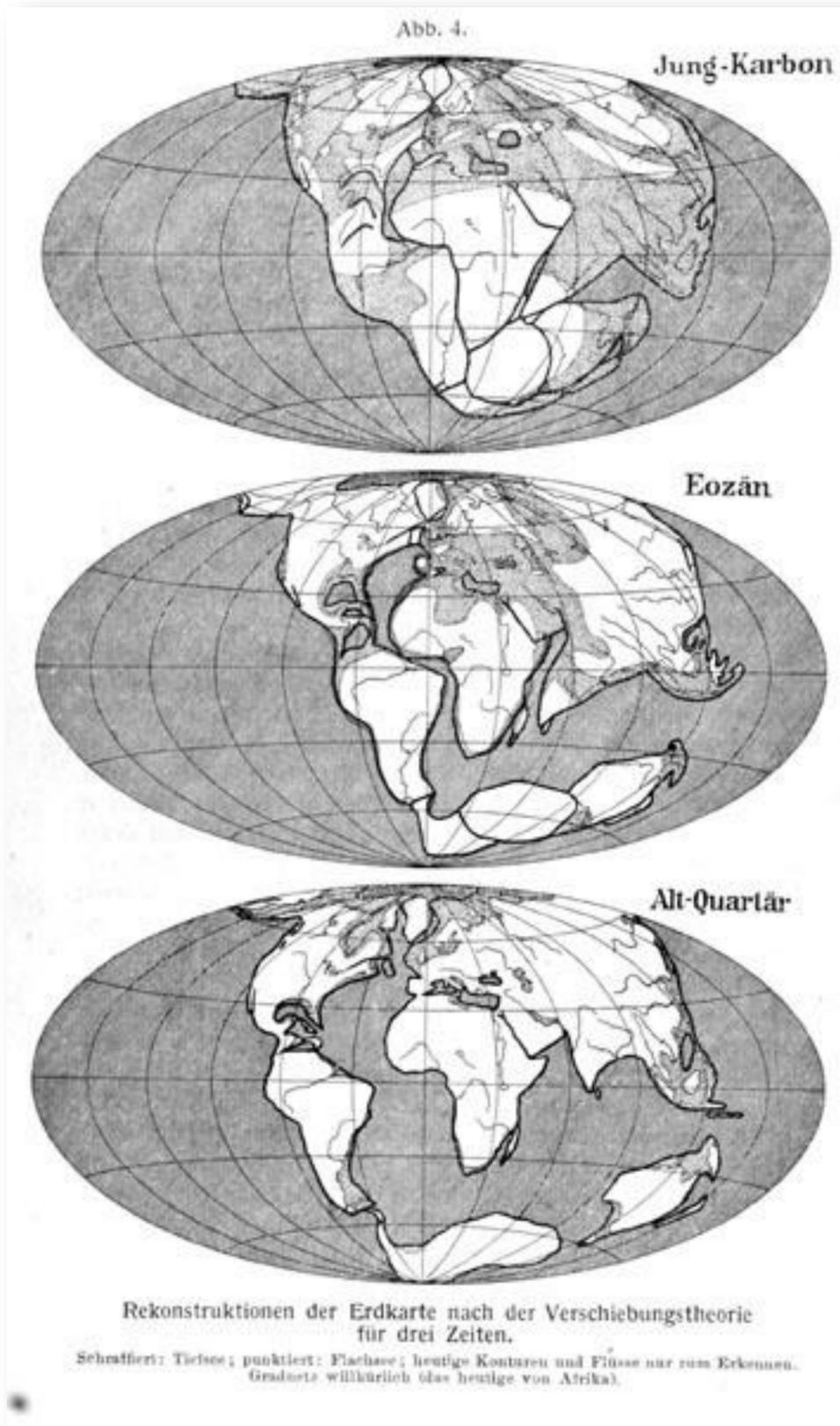


Osmond Fisher (1817-1914) géologue britannique, *tenant d'un modèle de Terre en refroidissement*, note les similitudes de la forme des continents et propose qu'ils aient été autrefois réunis.



Antonio Snider-Pellegrini, géographe français (1802-1885) propose une première reconstitution de la Pangée avant le modèle d'Alfred Wegener. Il avait trouvé des plantes fossiles datant du Carbonifère identiques de part et d'autre de l'Atlantique. *Il pensait que le déluge biblique était la cause de la séparation des continents.*

Dérive des continents

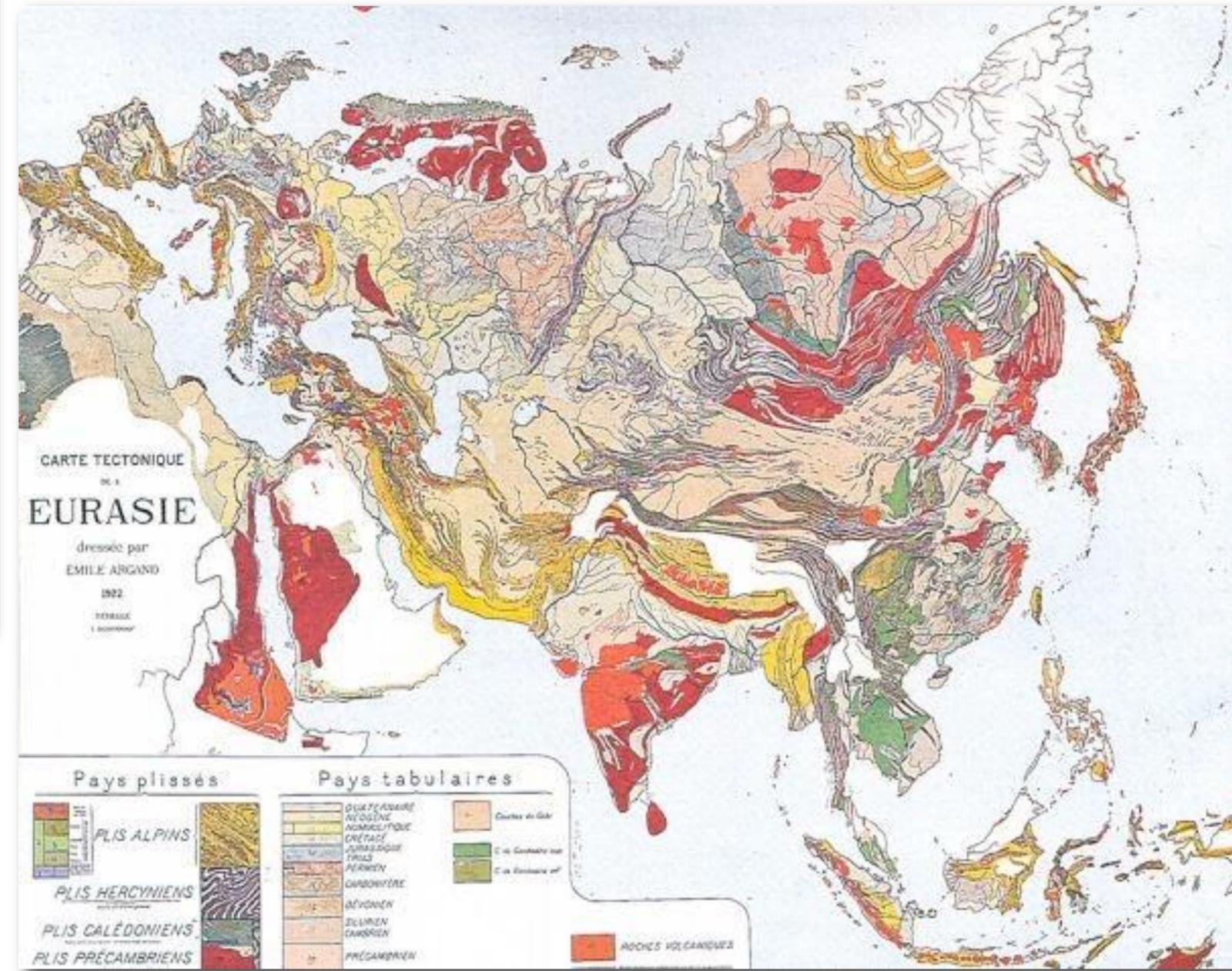


**Alfred Wegener: Die Entstehung der Kontinente (1912, 1915)
Die Entstehung der Kontinente und Ozeane (1915, 1929)**

Collision des continents: une conséquence de la dérive



La formation des chaînes de montagnes par la collision de deux continents, selon Emile Argand (1924)



**Chaleur de la Terre, convection
et mouvements en surface,
chaînes de montagnes...**



Sir Arthur Holmes (1890-1965), the British geologist who contributed to our understanding of Earth's age. Photo courtesy of University of Edinburgh, Department of Geology and Geophysics

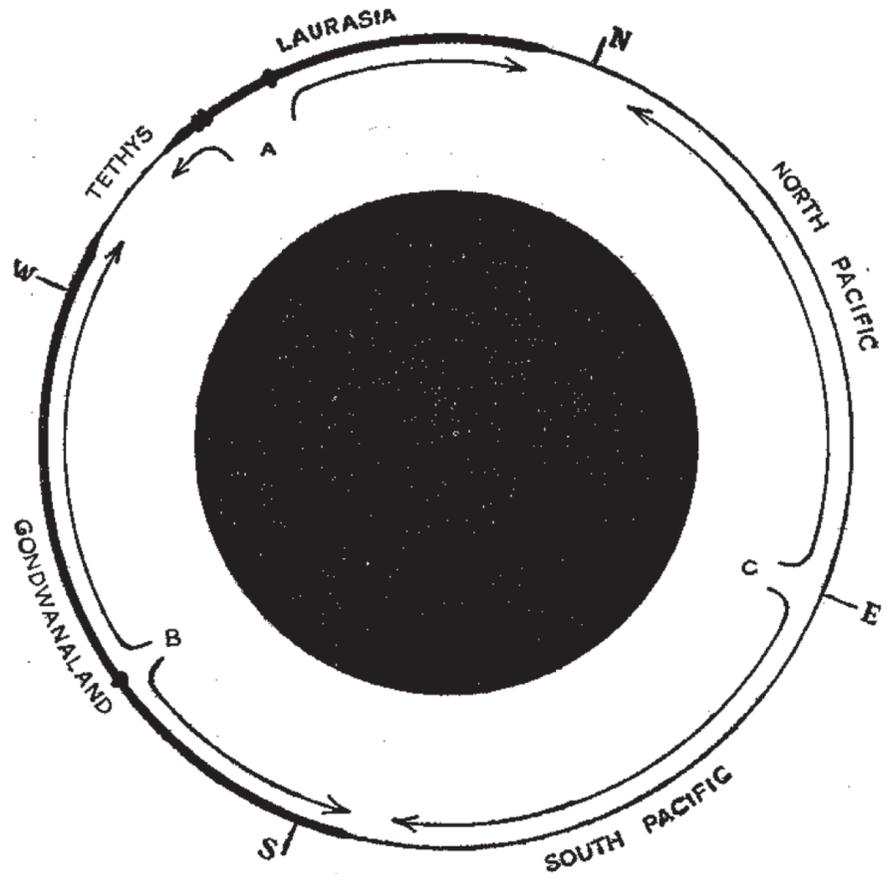
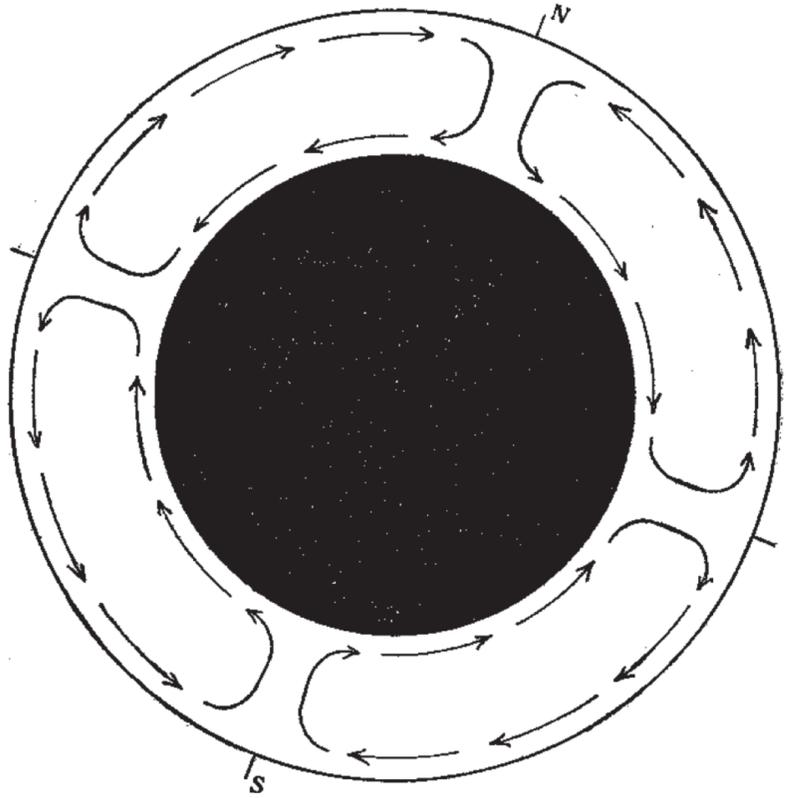


Fig. 5.

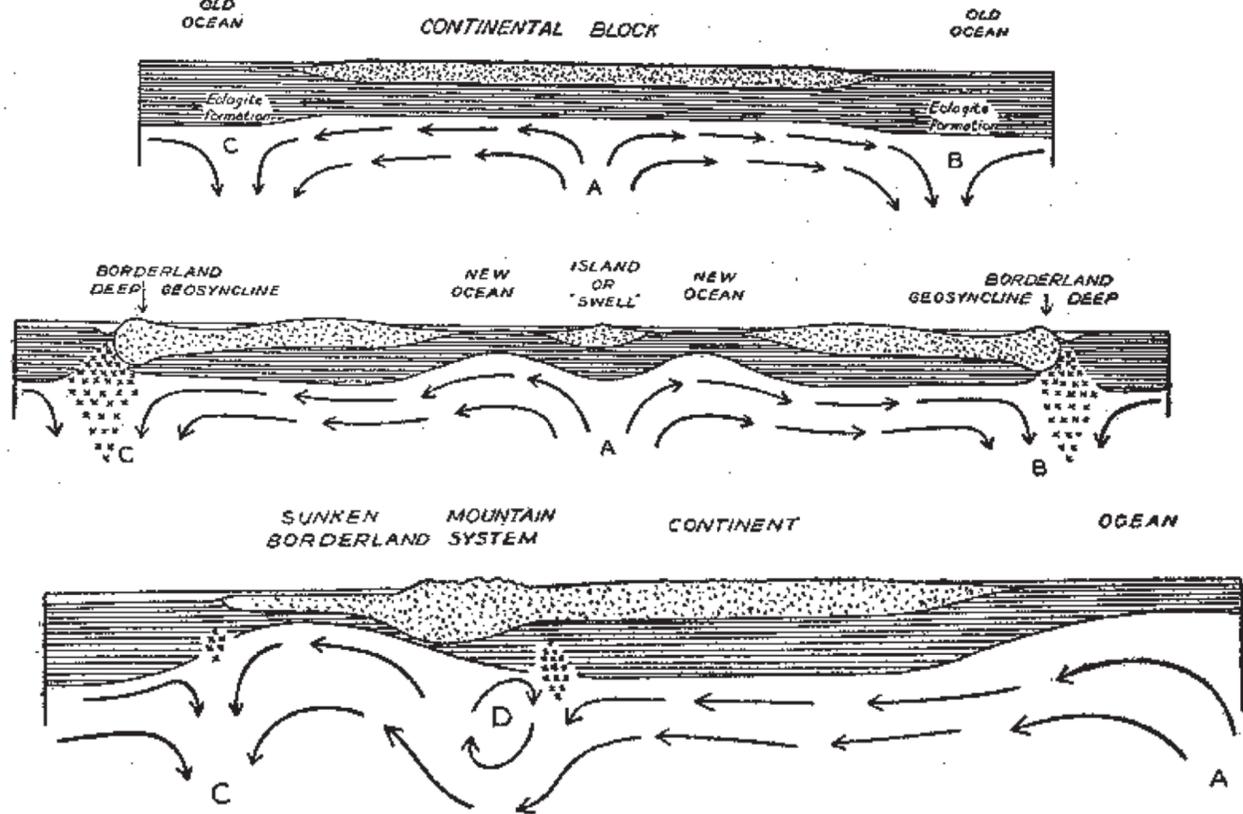


Fig. 4.

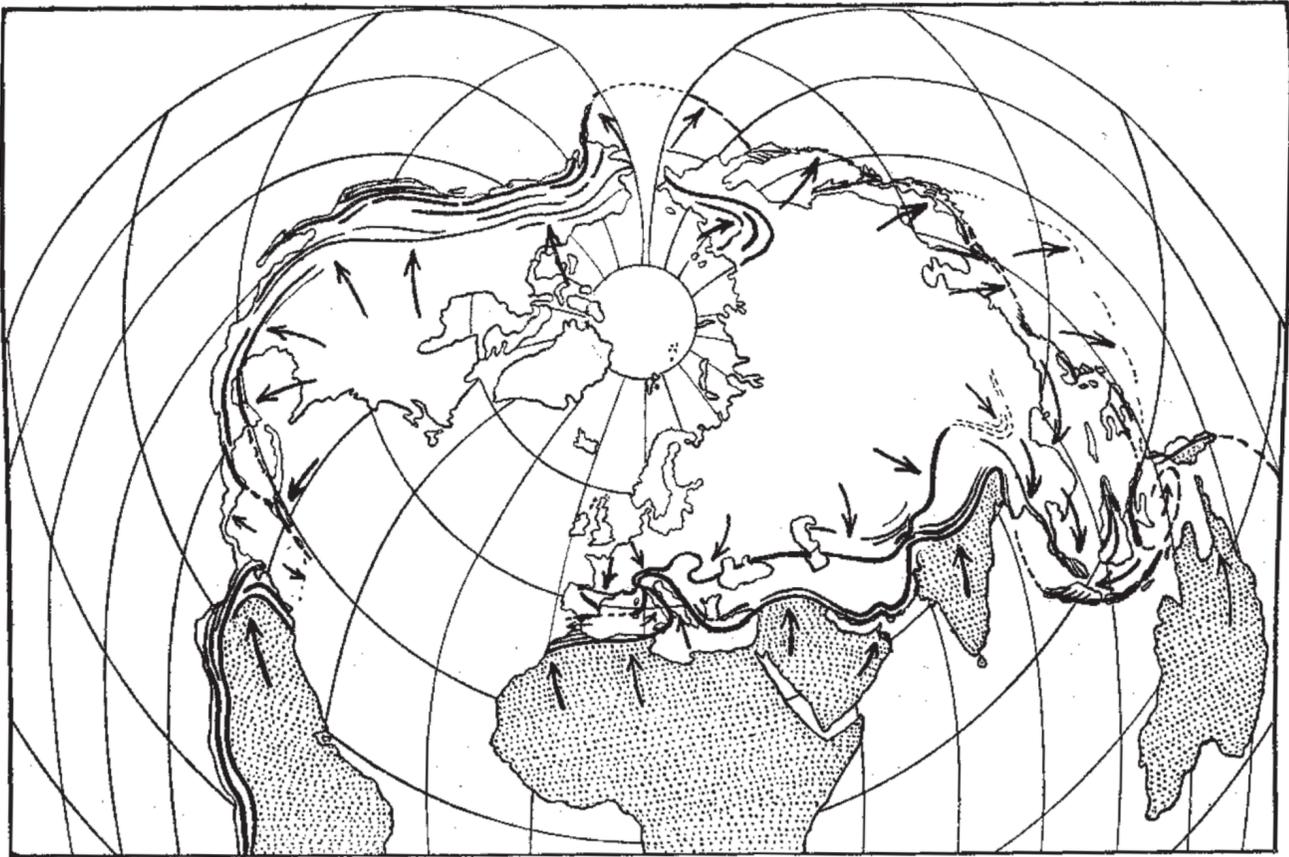


Fig. 6. Scale: 1 : 170 x 10⁶.

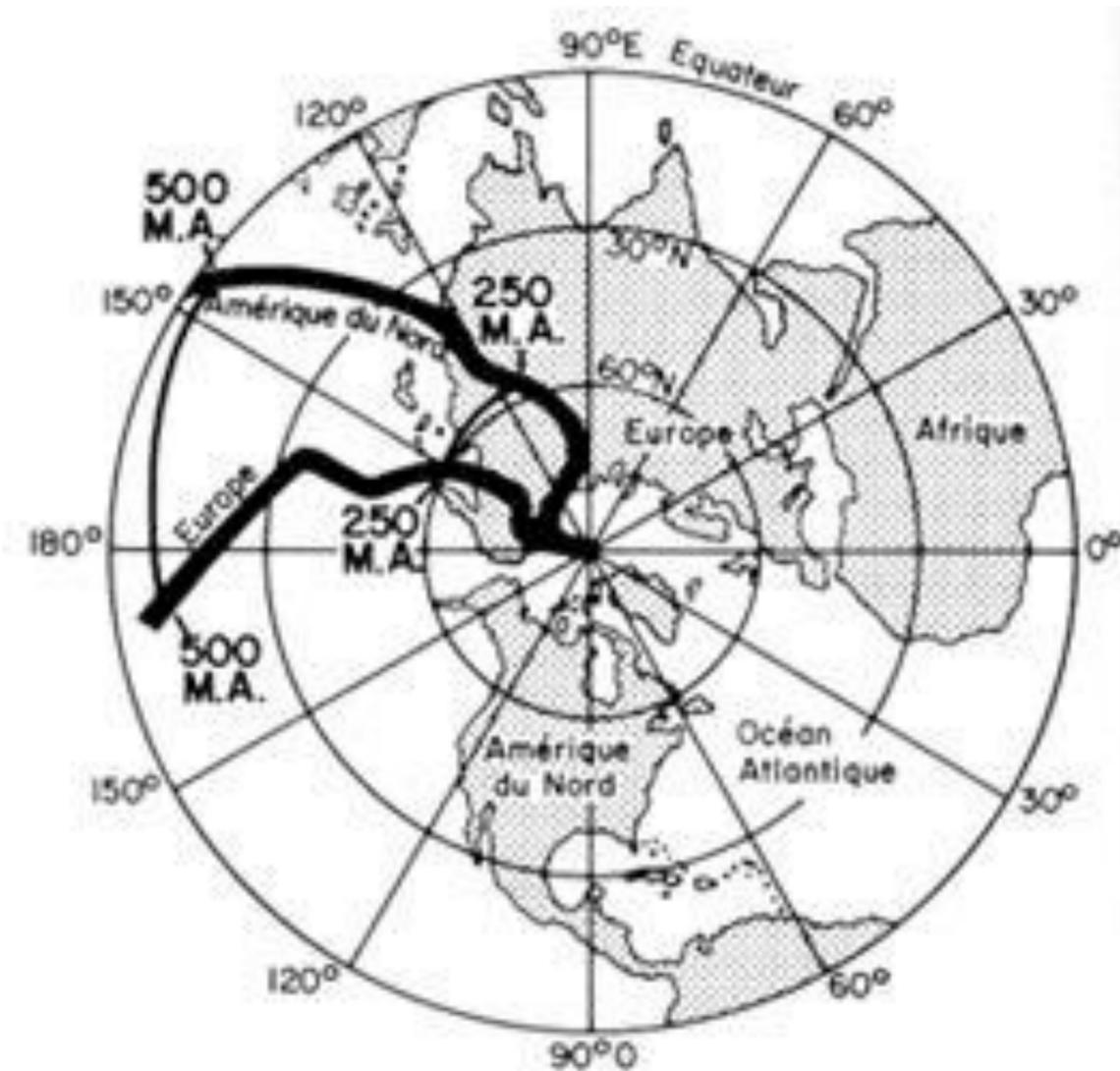
Arthur Holmes
Radioactivity and Earth Movements (1931)



Patrick Blackett, Keith Runcorn & Ted Irving

Les découvertes des paléomagnéticiens apportent les premières preuves indépendantes de la dérive des continents à la fin des années 50

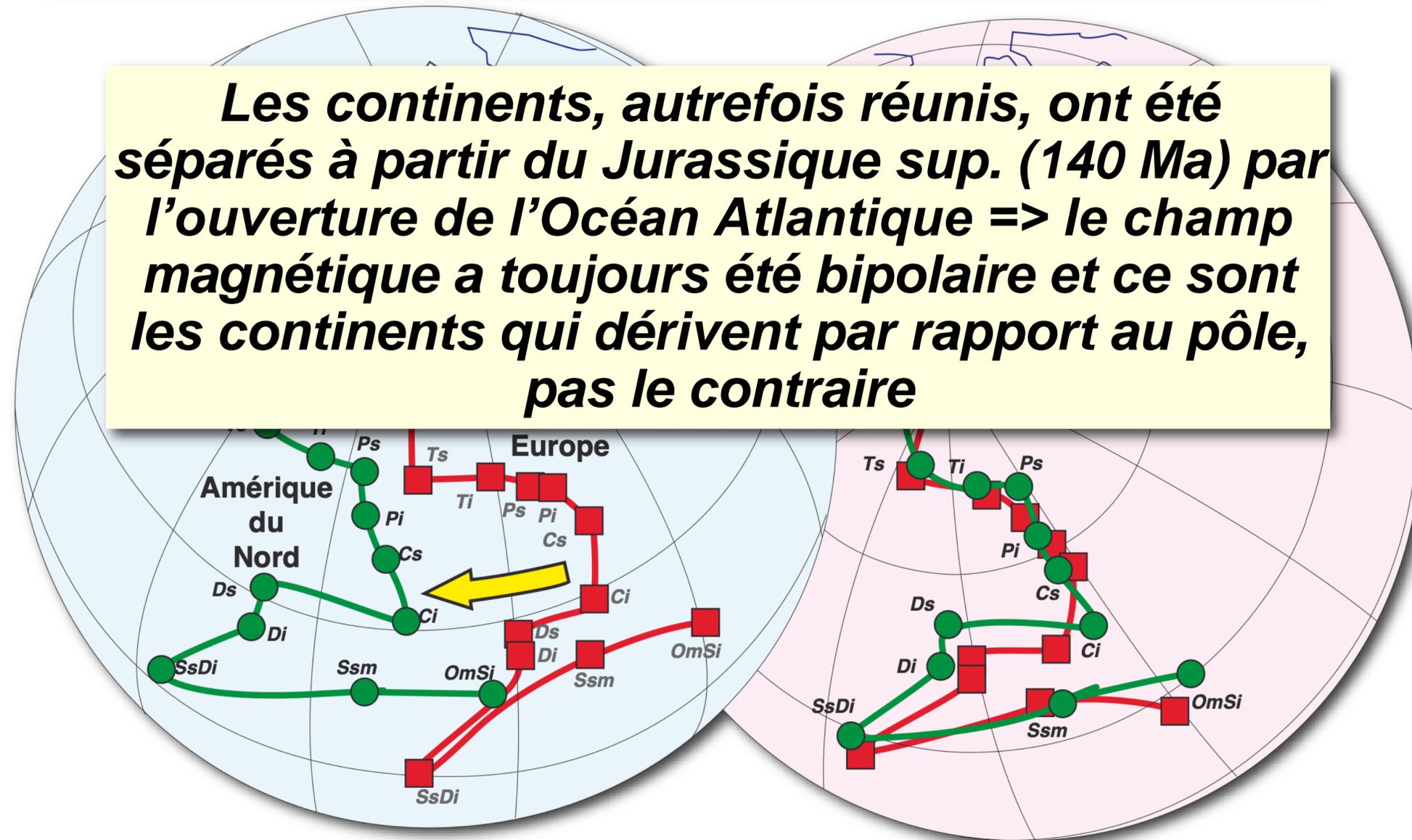
Chemins de dérive apparente du pôle magnétique



Runcorn, S.K.: Palaeomagnetic evidence for continental drift and its geophysical cause, in S.K. Runcorn (ed) Continental Drift, New York, Academic Press, 1962

Apparent polar wander paths of North America and Eurasia

Les continents, autrefois réunis, ont été séparés à partir du Jurassique sup. (140 Ma) par l'ouverture de l'Océan Atlantique => le champ magnétique a toujours été bipolaire et ce sont les continents qui dérivent par rapport au pôle, pas le contraire



Actuel

Avant l'ouverture de l'atlantique

Des ceintures continues de séismes

LA ZONE SEISMIQUE MEDIANE INDO-ATLANTIQUE

By J. P. ROTHÉ

Professeur à l'Université de Strasbourg, Directeur du Bureau international de Séismologie

The distribution of earthquake epicentres in the Atlantic and Indian Oceans is discussed; numerous new epicentres are listed. It is shown that the line of epicentres following the mid-Atlantic Ridge is continued round the Cape of Good Hope and joins the similar line marking the central ridge of the Indian Ocean. It seems, therefore, that these two ridges are related structures.

Source: *Proceedings of the Royal Society of London. Series A, Mathematical and Physical Sciences*, Vol. 222, No. 1150, A Discussion on the Floor of the Atlantic Ocean (Mar. 18, 1954), pp. 387-397

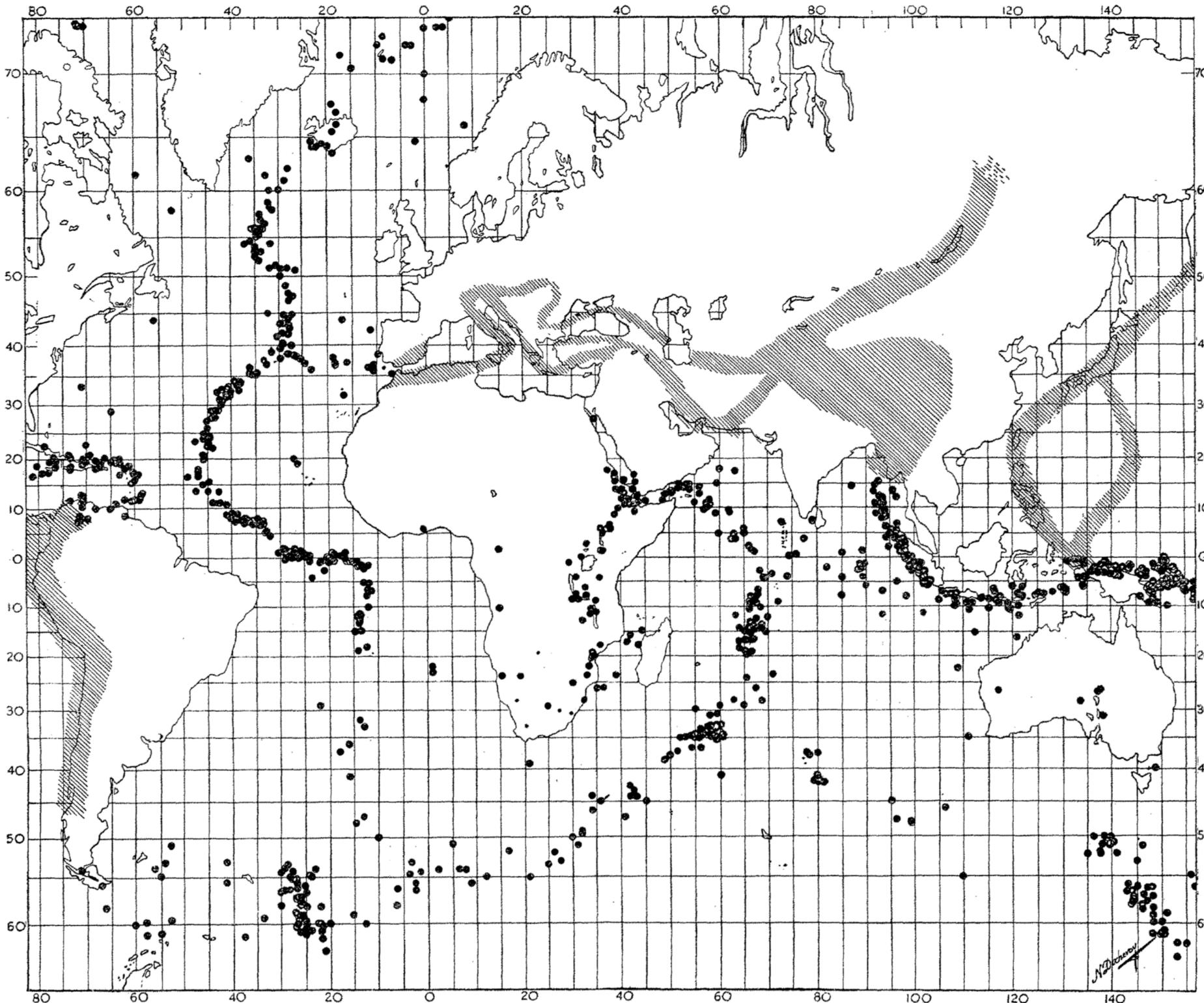
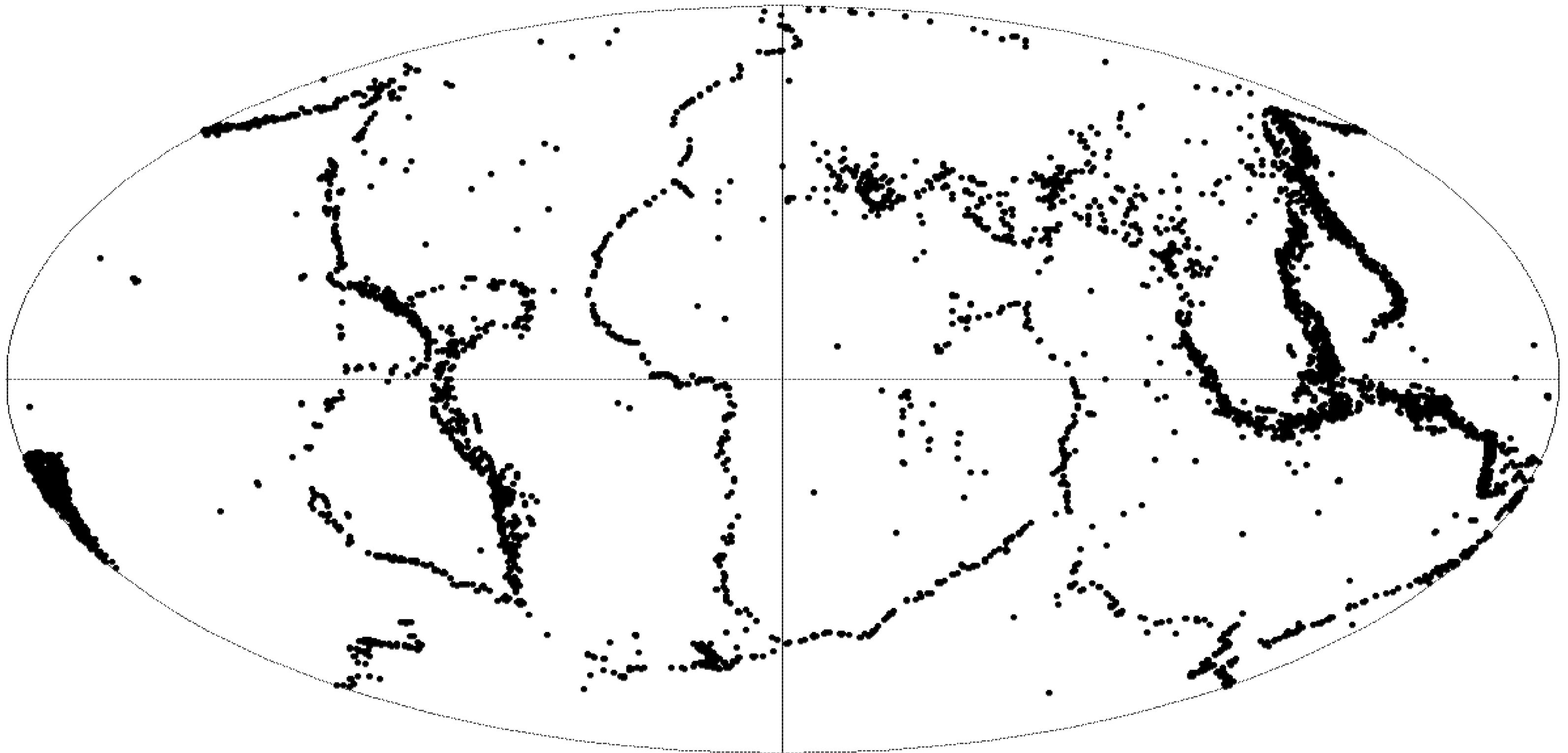


FIGURE 27. Epicentres des séismes de la zone médiane indo-atlantique et des régions voisines; les zones hachurées marquent l'emplacement des autres grandes zones séismiques.

=> La déformation active est restreinte à des zones étroites et continues qui entourent des domaines asismiques

La limite continents/océans est parfois très sismique (*marges actives*), parfois pas du tout ou très peu (*marges passives*)

Répartition des séismes en carte:
des ceintures continues autour de zones peu sismiques



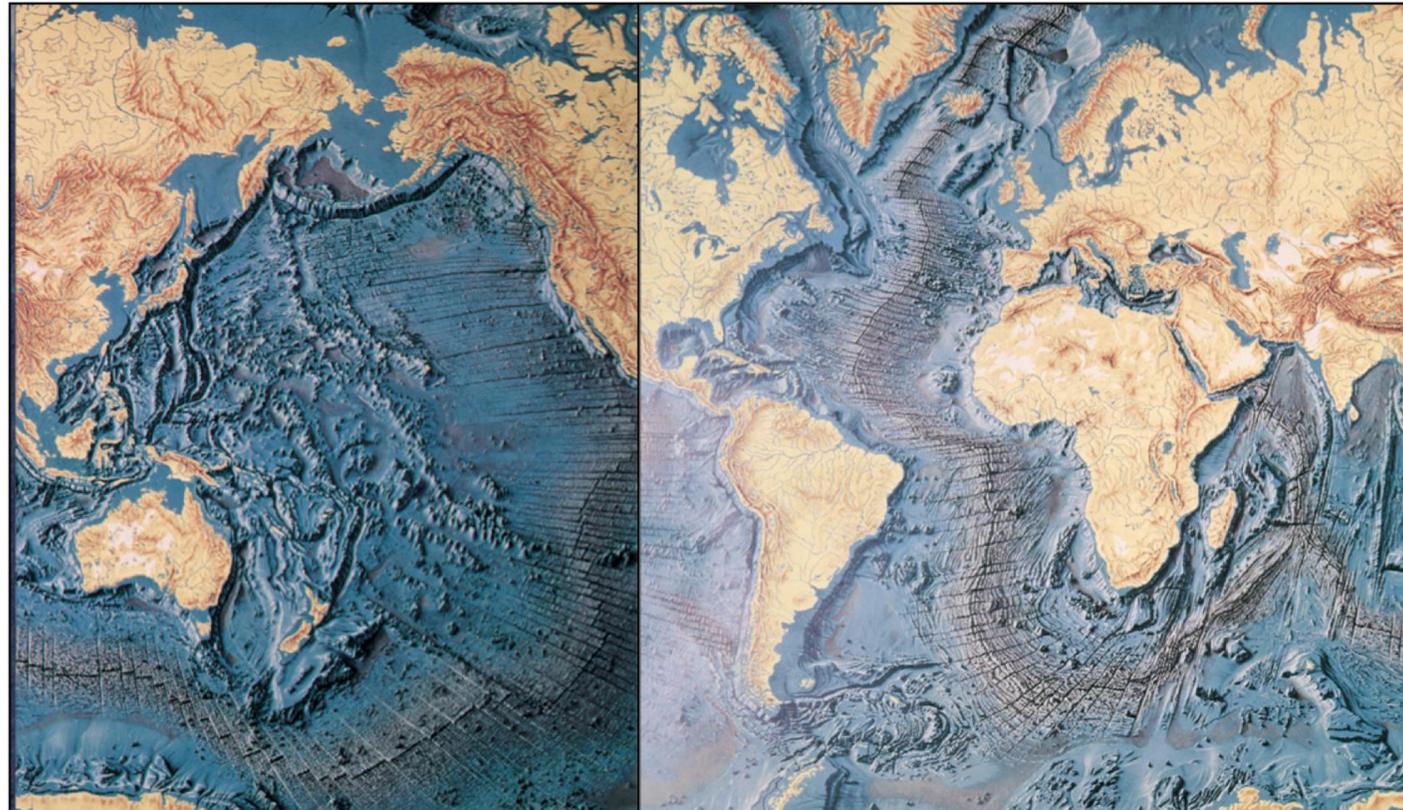
Cartographie du fond des océans: *Un autre monde révélé*



Maurice Ewing et le *Vema*



Marie Tharp et Bruce Heezen



Découverte et cartographie des dorsales média-océaniques

Les campagnes océanographiques des années 50 permirent la découverte d'une chaîne de montages continue sous les océans sur plus de 50 000 km. Chaque océan possède sa, ou ses, dorsales.

Marie Tharp découvre le rift à l'axe de la dorsale médio-atlantique et propose que les dorsales soient des zones en divergence

Inversions du champ magnétique



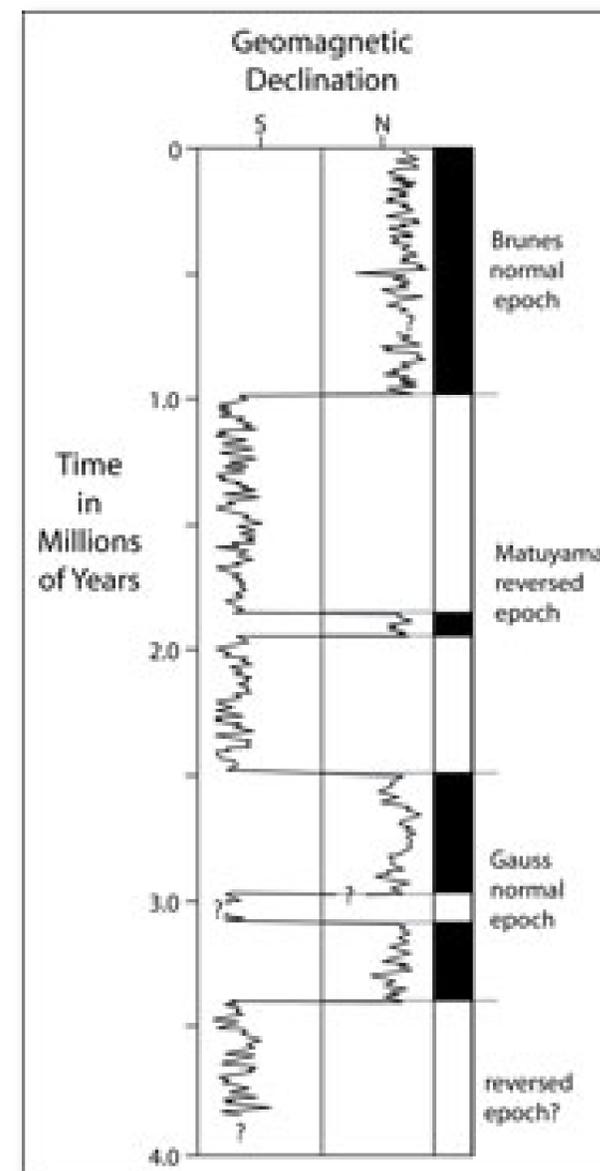
Figure 2 : Allan Cox (seated), Richard Doell (L), and Brent Dalrymple (R) at a gas mass spectrometer. This photo was taken sometime in the early 1960s. Image courtesy of Stanford School of Earth Sciences.

In the late 1950's and 1960's, a group of geologists at the US Geological Survey in Menlo Park was testing the notion that the Earth's magnetic field periodically reverses its orientation, such that compasses that normally point toward the north at the Earth's surface, would instead point towards the south. A group of scientists, consisting of Allan Cox (who subsequently joined the Stanford faculty and became Dean of the School of Earth Sciences), Brent Dalrymple, and Richard Doell (Fig. 2) systematically studied the orientation of the Earth's magnetic field as it was preserved in volcanic rocks that cooled and acquired their magnetism shortly after they were erupted. This group demonstrated that reversals of the Earth's magnetic field had occurred, and they were able to use radioactive isotopes to date the reversals. The result was a time scale based on variations in the Earth's magnetic field, which later proved to be the "Rosetta Stone" for deciphering the pattern of magnetic anomalies on the sea floor. (Fig. 3)

Découverte de l'aimantation des roches: Melloni 1853

Découverte des inversions: Bruhnes, 1901, 1906
Matuyama date les inversions à la même époque

Elsasser et Bullard développent ensuite l'idée de la dynamo terrestre



La première figure montrant les âges des inversions du champ magnétique. Le début de l'échelle temporelle des inversions (Cox, Dalrymple & Doell, 1963)

Expansion des fonds océaniques

La théorie de l'expansion des fonds océaniques est d'abord formulée par Robert S. Dietz (1961) et Harry H. Hess (1962).
L'idée originale est de Harry Hess, comme Robert Dietz l'a lui-même reconnu.

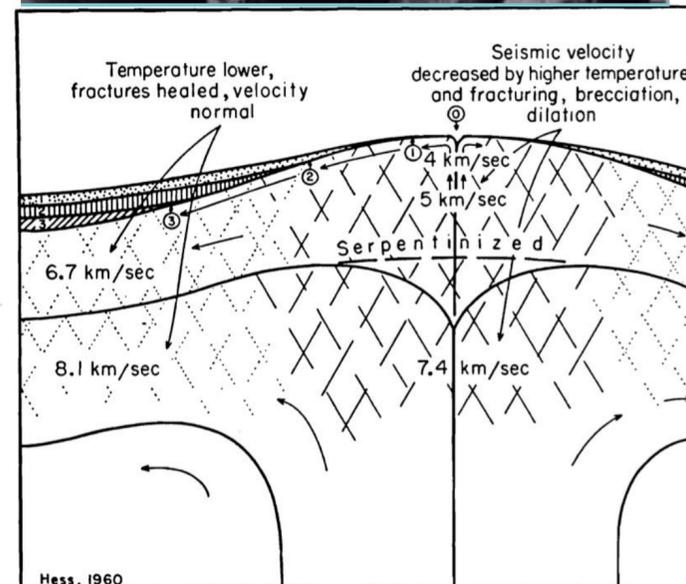
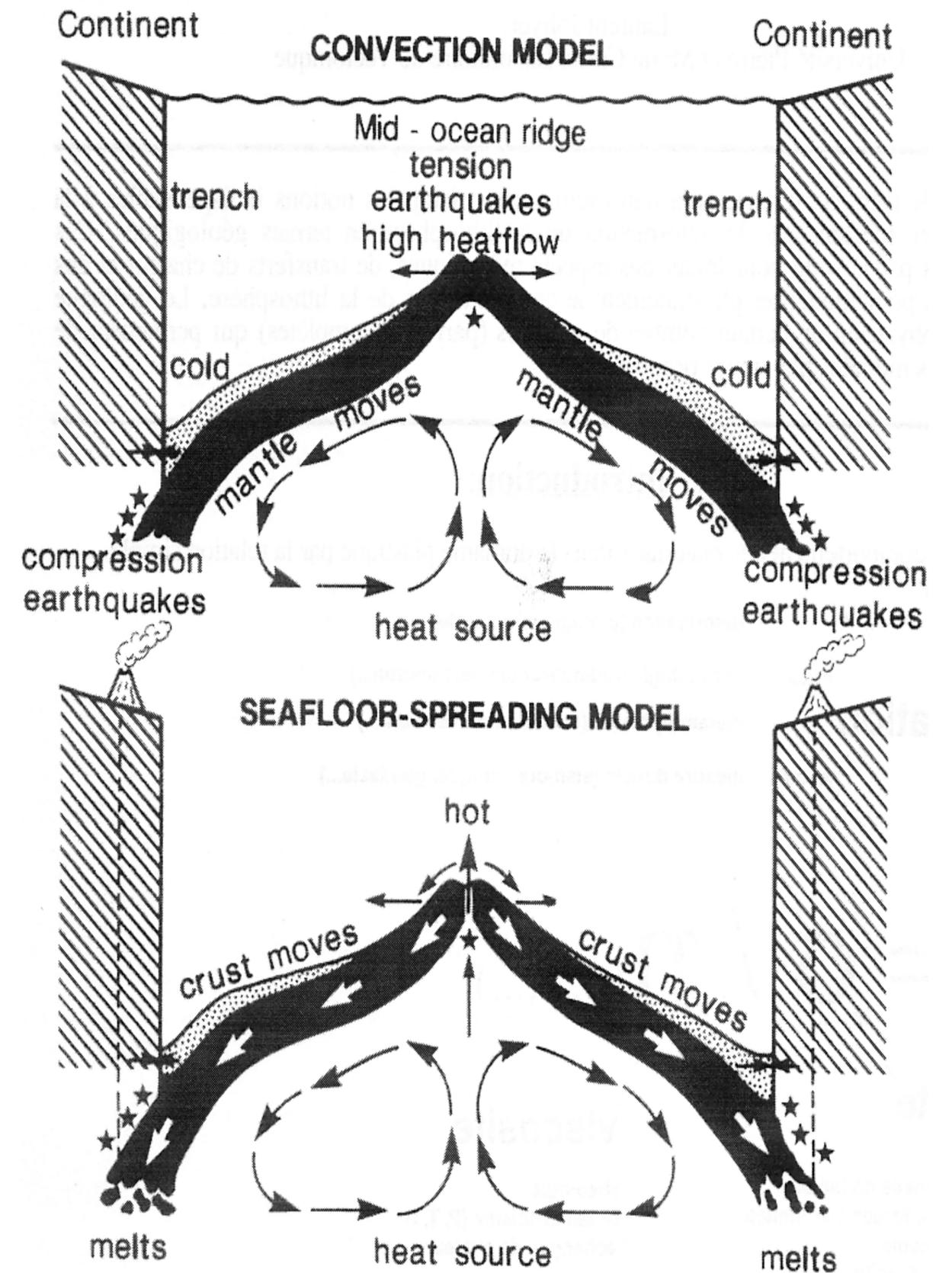


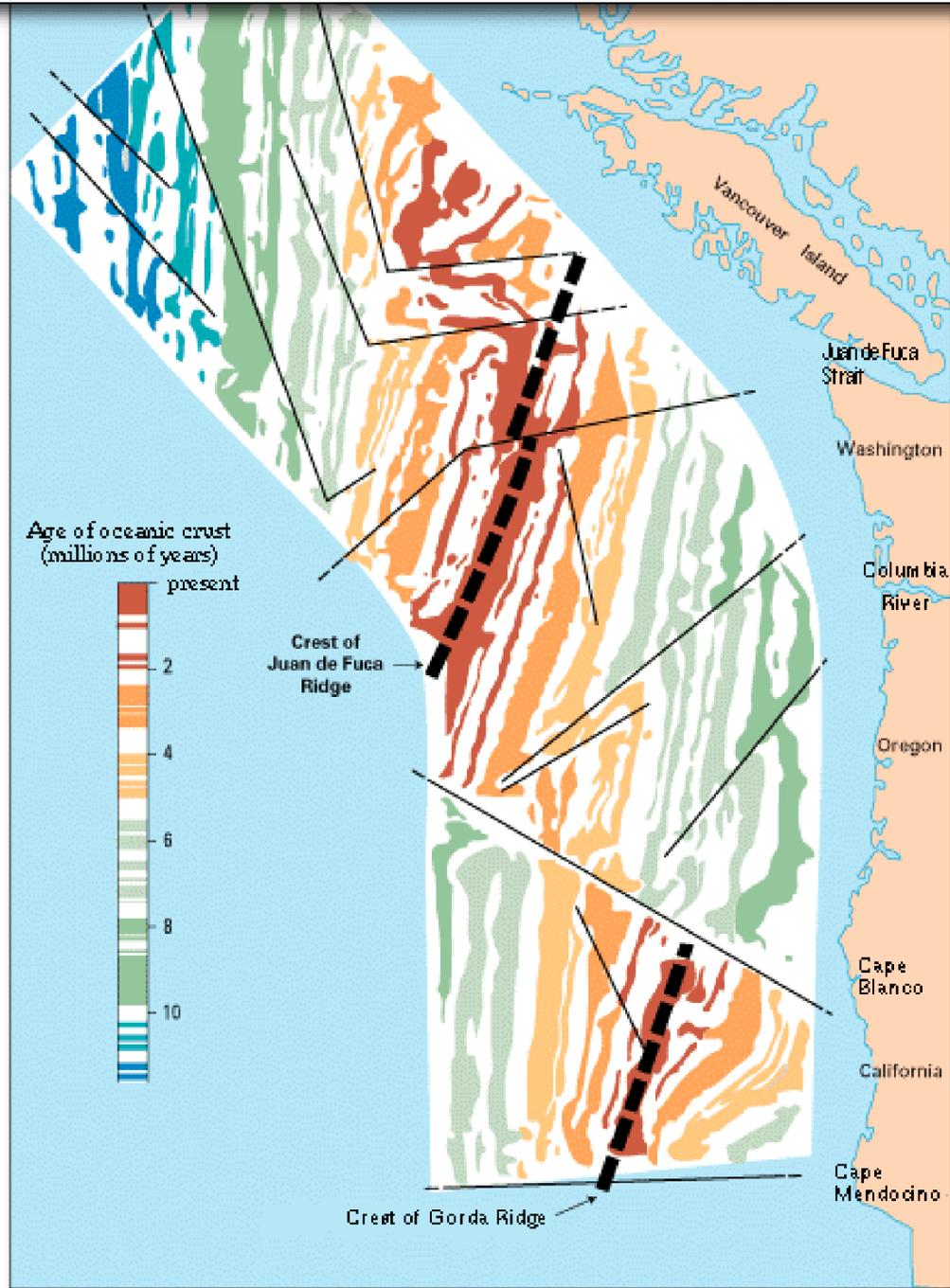
Figure 7. Diagram to represent (1) apparent progressive overlap of ocean sediments on a mid-ocean ridge which would actually be the effect of the mantle moving laterally away from ridge crest, and (2) the postulated fracturing where convective flow changes direction from vertical to horizontal. Fracturing and higher temperature could account for the lower seismic velocities on ridge crests, and cooling and healing of the fractures with time, the return to normal velocities on the flanks.



convection

Harry Hess, 1962

Anomalies magnétiques symétriques et test positif de l'idée de Hess



MAGNETIC ANOMALIES OVER OCEANIC RIDGES

By F. J. VINE and DR. D. H. MATTHEWS
Department of Geodesy and Geophysics, University of Cambridge

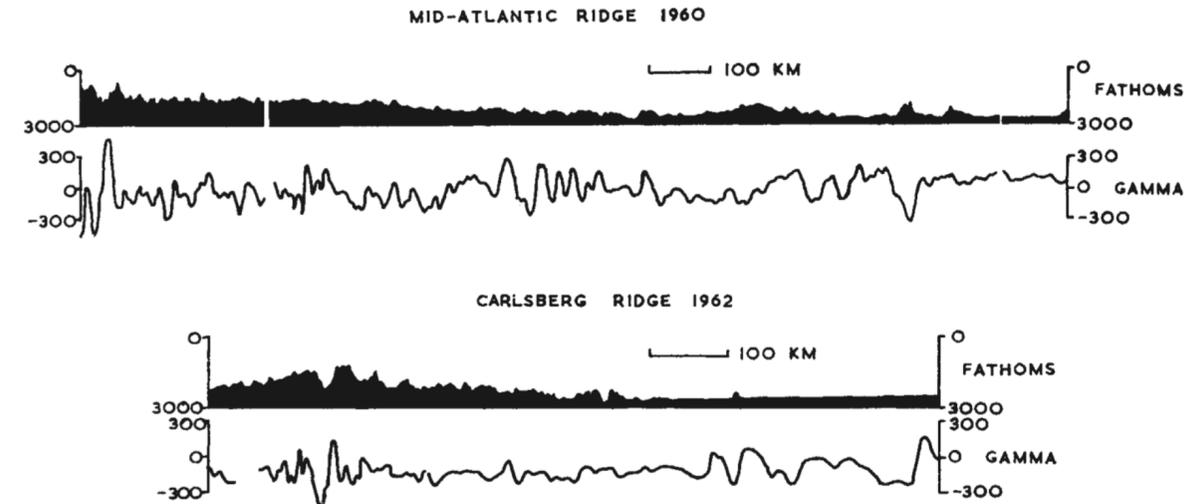
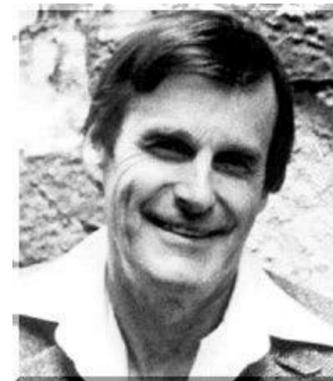


Fig. 1. Profiles showing bathymetry and the associated total magnetic field anomaly observed on crossing the North Atlantic and the north-west Indian Oceans. Upper profile from 45° 17' N. 28° 27' W. to 45° 19' N. 11° 29' W. Lower profile from 30° 5' N. 61° 57' E. to 10° 10' N. 66° 27' E.



Lawrence W. Morley

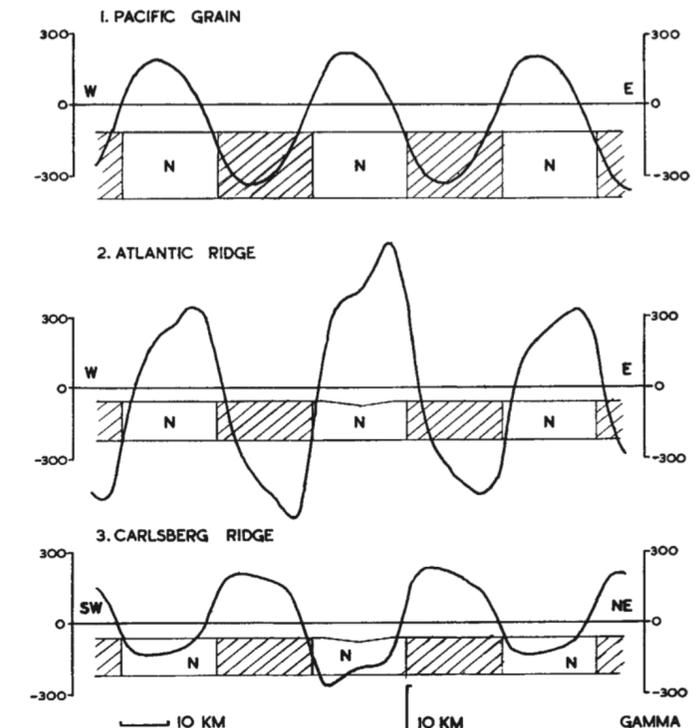


Fig. 4. Magnetic profiles computed for various crustal models. Crustal blocks marked N, normally magnetized; diagonally shaded blocks, reversely magnetized. Effective susceptibility of blocks, 0.0027, except for the block under the median valley in profiles 2 and 3, 0.0053.

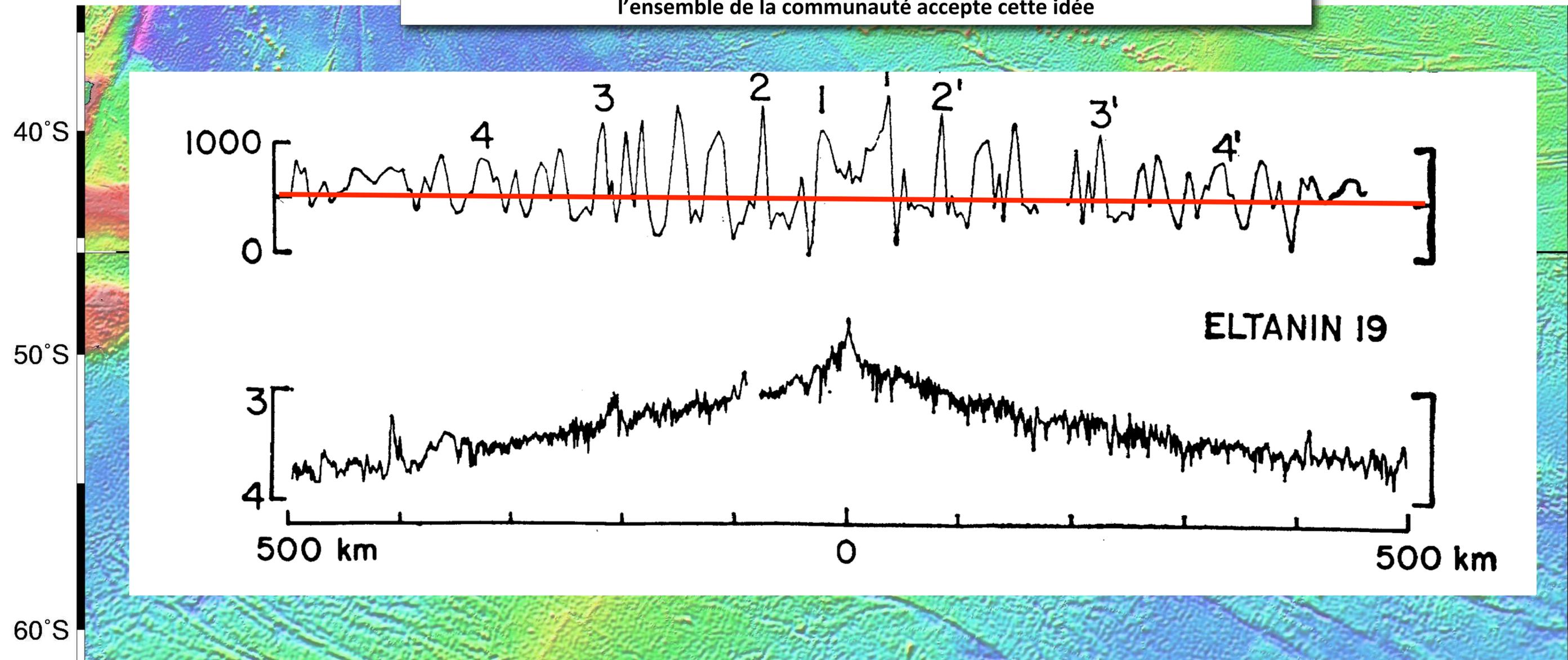
La découverte des anomalies magnétiques par Raff & Mason (1961) et leur interprétation comme un enregistrement des inversions du champ magnétique au cours de l'expansion des fonds océaniques par Vine & Matthews (1963) et en même temps par Morley.



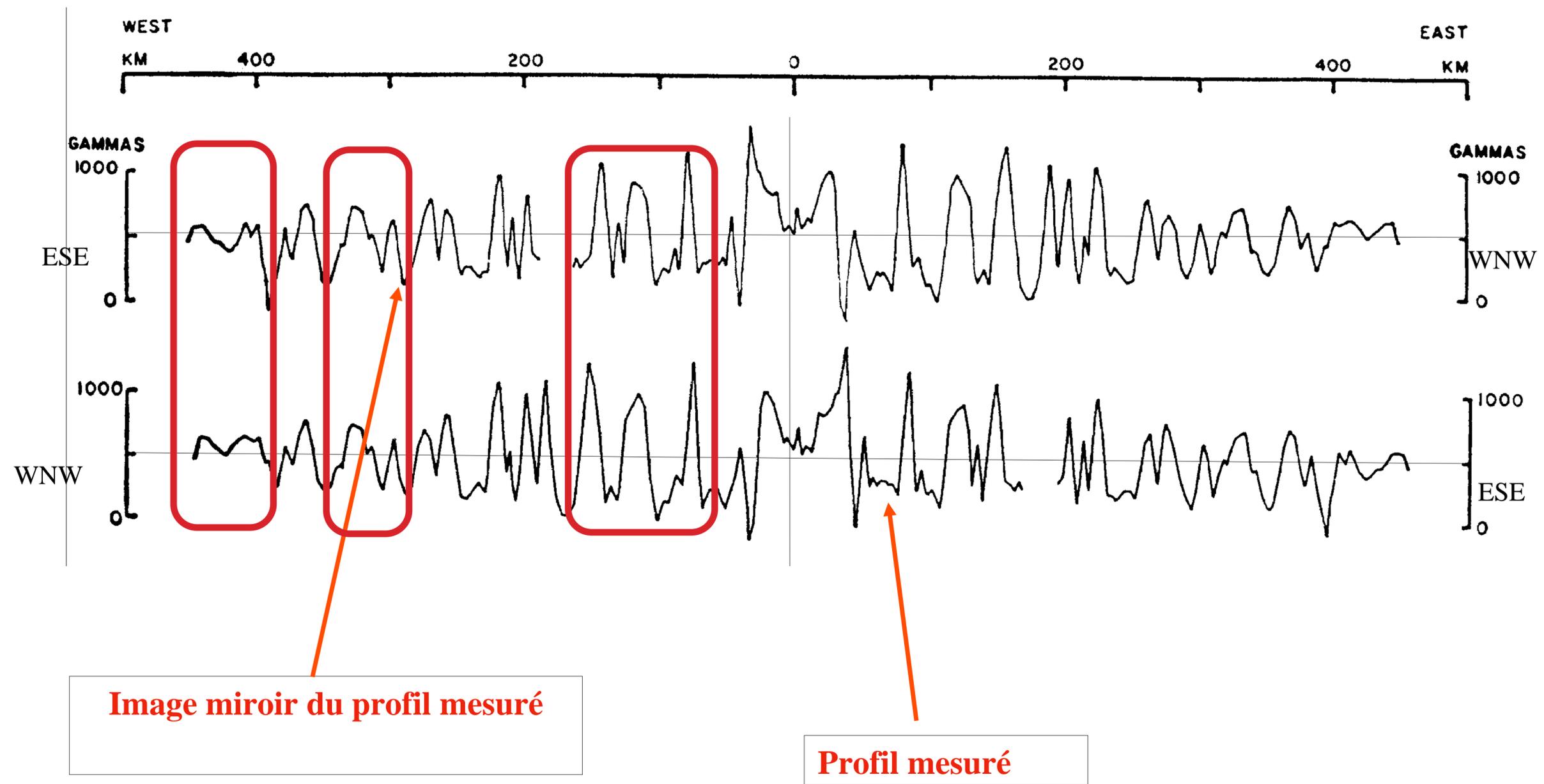
Matthews, Vine et McKenzie

Anomalies magnétiques et test positif de l'idée de Hess: le « *magic profile* »

Il fallut attendre la publication du « magic profile » par Pitman & Heirtzler (1966) pour que l'ensemble de la communauté accepte cette idée



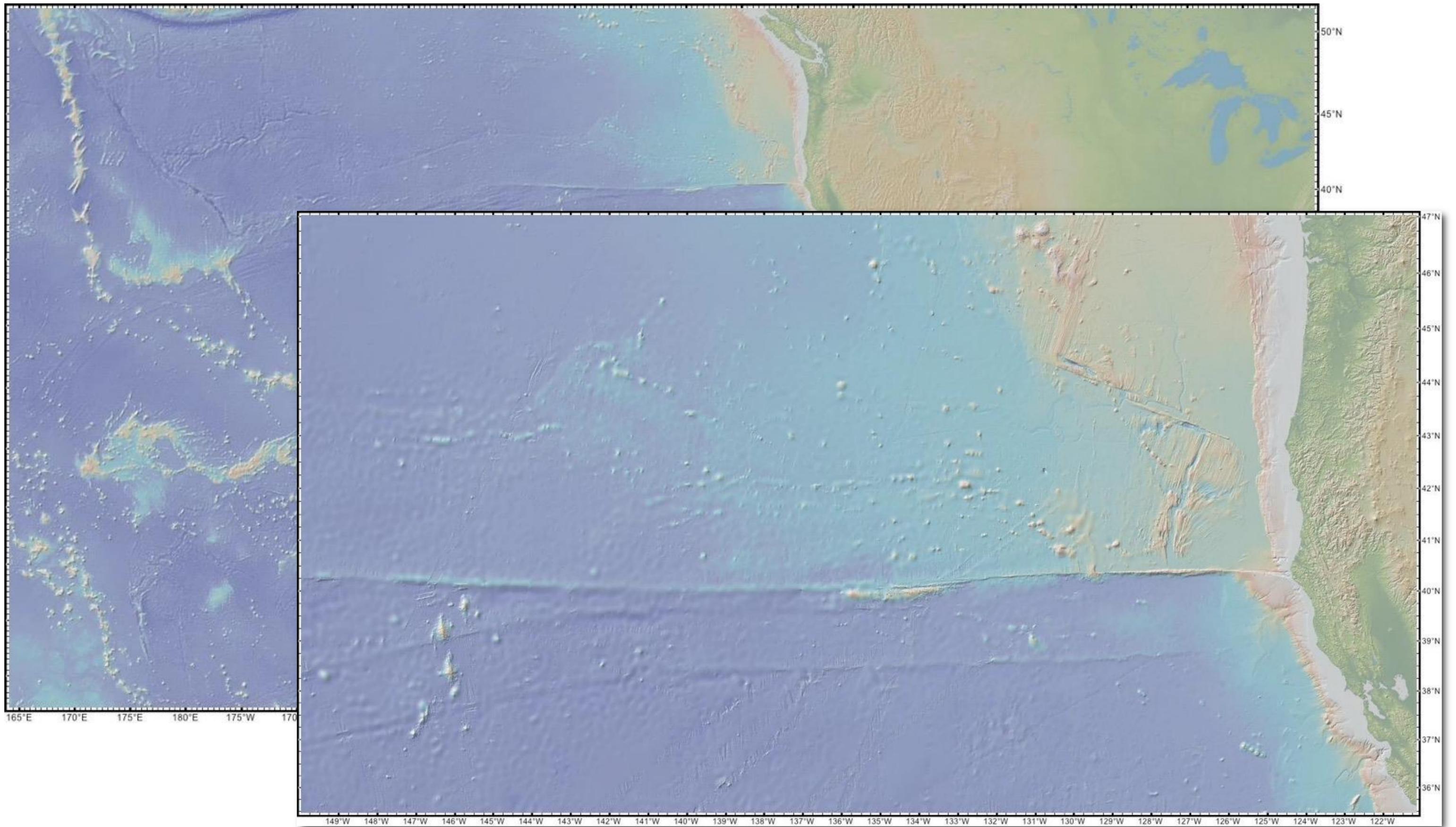
Routes du navire océanographique Eltanin en 1960 (Columbia University) pour enregistrer les variations du champ magnétique

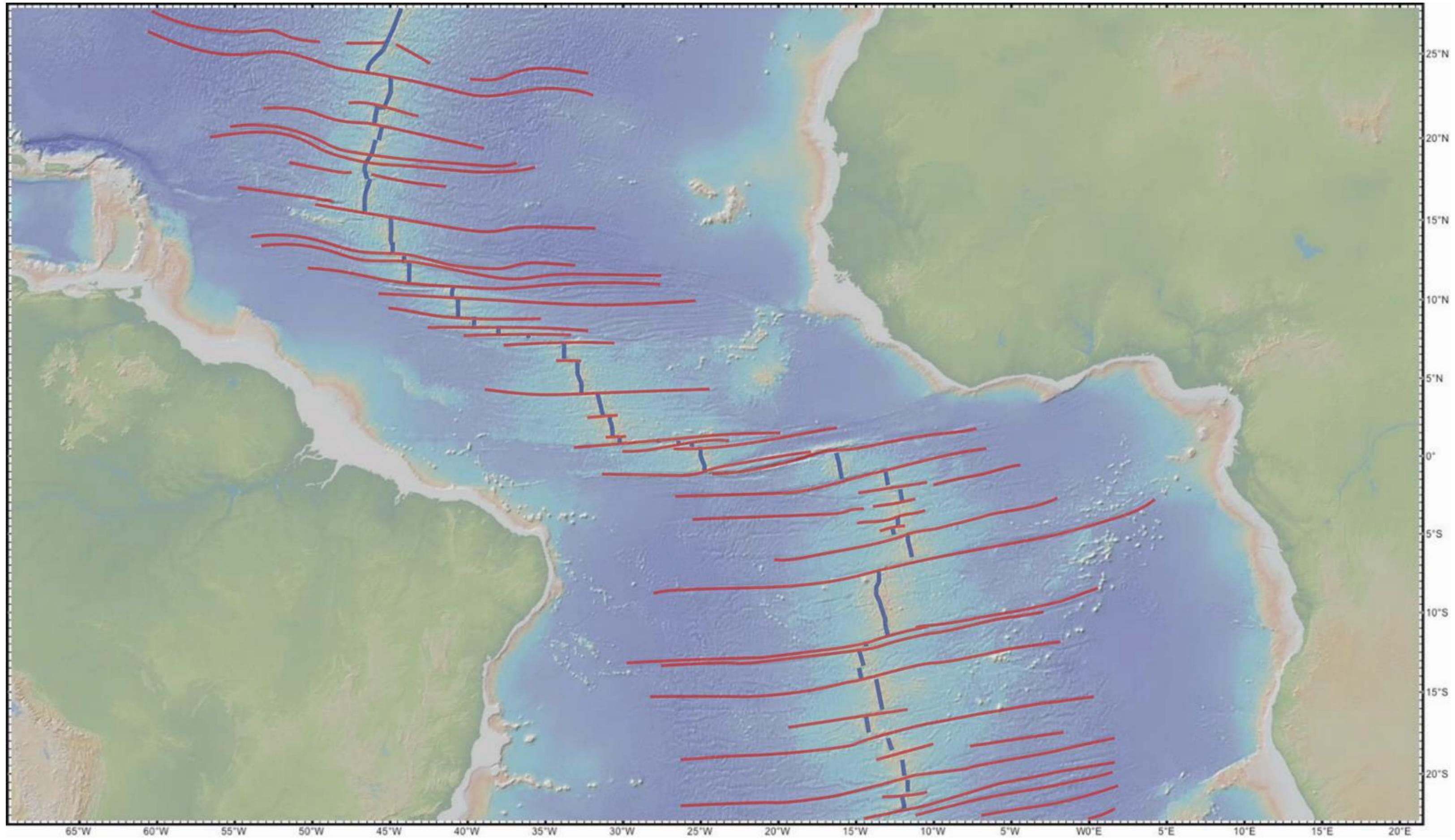


Symétrie du profil magnétique Eltanin 19

Extrait d'un cours de Cornell Univ.

Pitman & Heirtzler, 1966







A NEW CLASS OF FAULTS AND THEIR BEARING ON CONTINENTAL DRIFT

By PROF. J. TUZO WILSON, O.B.E.
Institute of Earth Sciences, University of Toronto

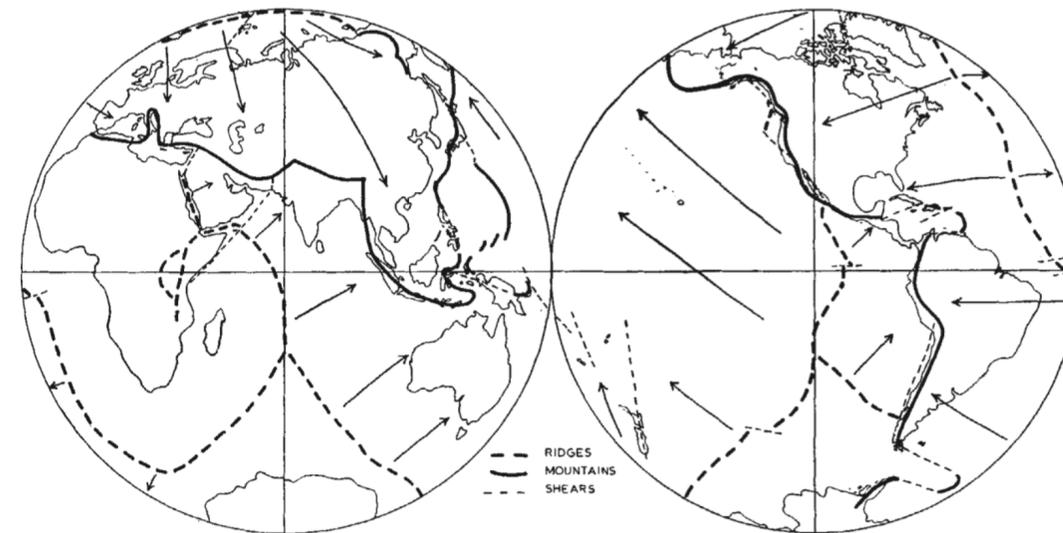


Fig 1. Sketch map illustrating the present network of mobile belts, comprising the active primary mountains and island arcs in compression (solid lines), active transform faults in horizontal shear (light dashed lines) and active mid-ocean ridges in tension (heavy dashed lines)

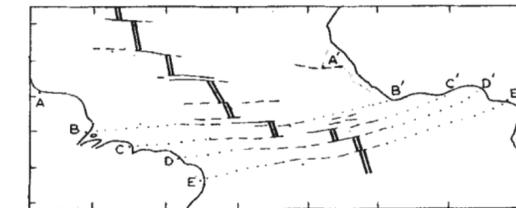


Fig. 7. Sketch (after Krause and Heezen *et al.*) showing how the Mid-Atlantic ridge is offset to the left by active transform faults which have dextral motions if the rift is expanding (see Fig. 4a). ||, Mid-ocean ridge; —, active fault; - - -, inactive fault trace;, hypothetical extension of fault

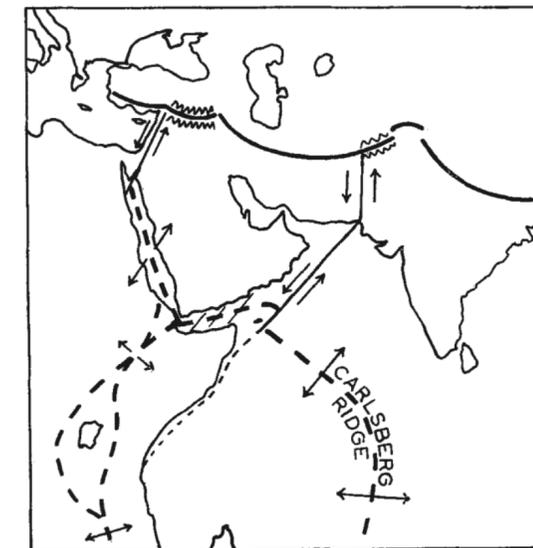


Fig. 8. Sketch illustrating the end of the Carlsberg mid-ocean ridge by a large transform fault (ridge-convex arc type) extending to the Hindu Kush, the end of the rift up the Red Sea by a similar transform fault extending into Turkey and the still younger East African rifts

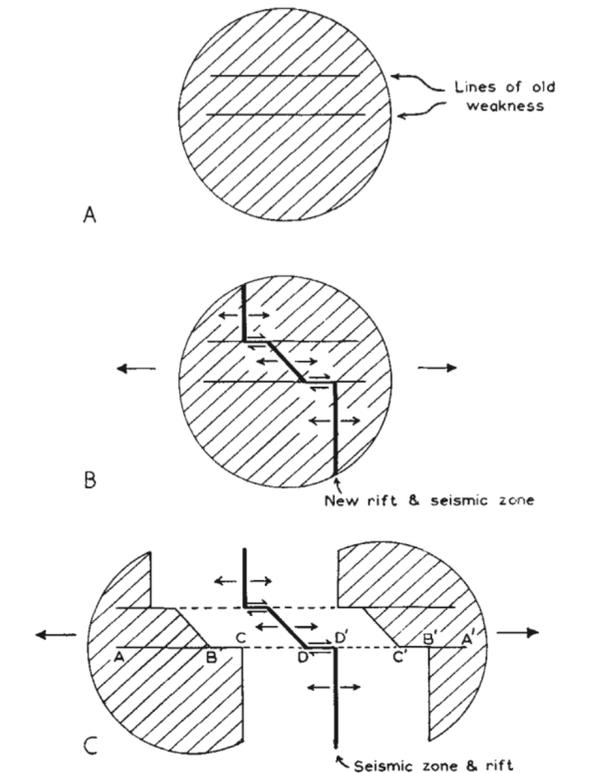
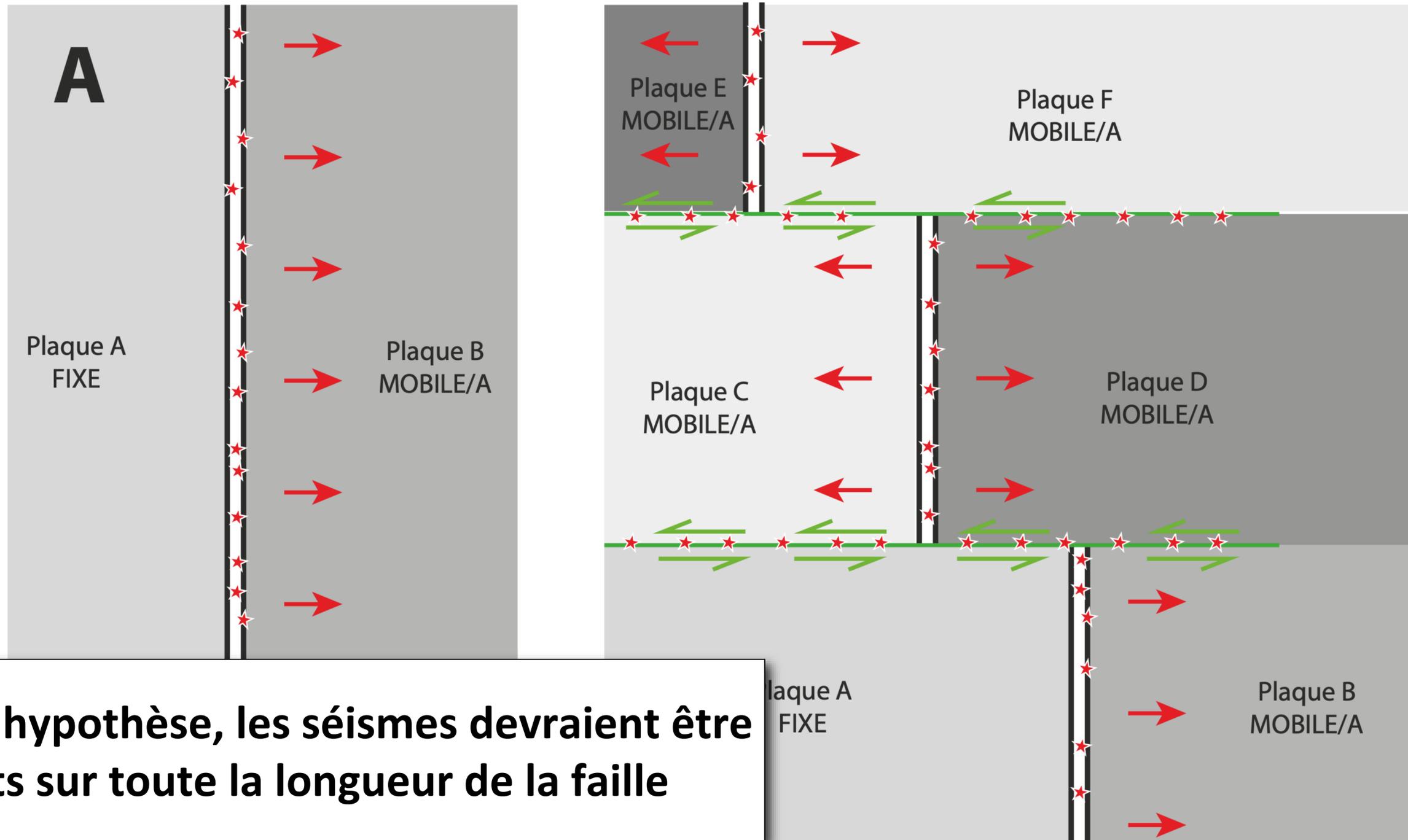


Fig. 6. Diagram illustrating three stages in the rifting of a continent into two parts (for example, South America and Africa). There will be seismic activity along the heavy lines only

John Tuzo Wilson introduit le concept de faille transformante et invente la tectonique des plaques

Dorsale recoupée par des failles décrochantes schéma incohérent et non-conforme aux observations

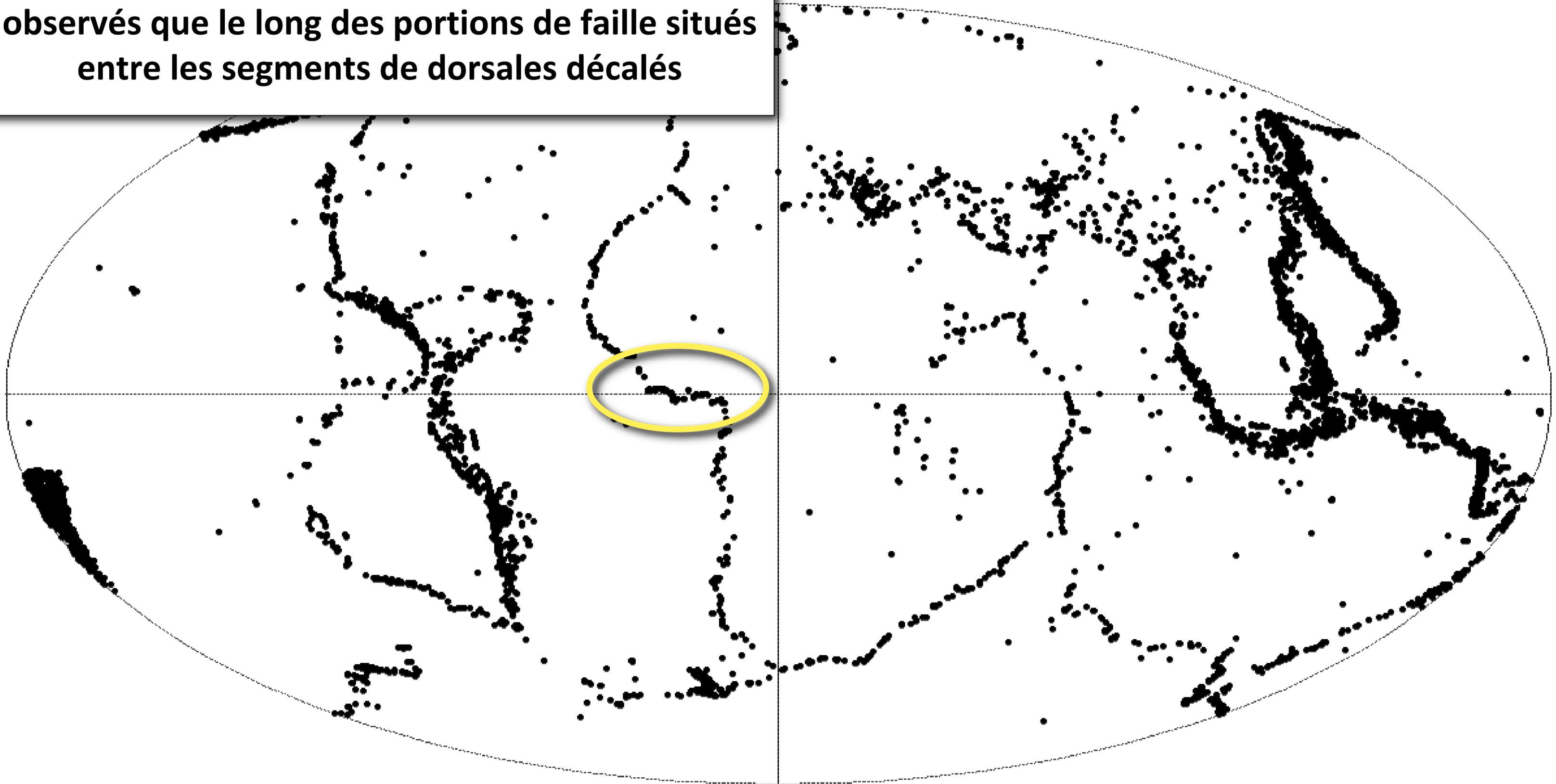


TEMPS X

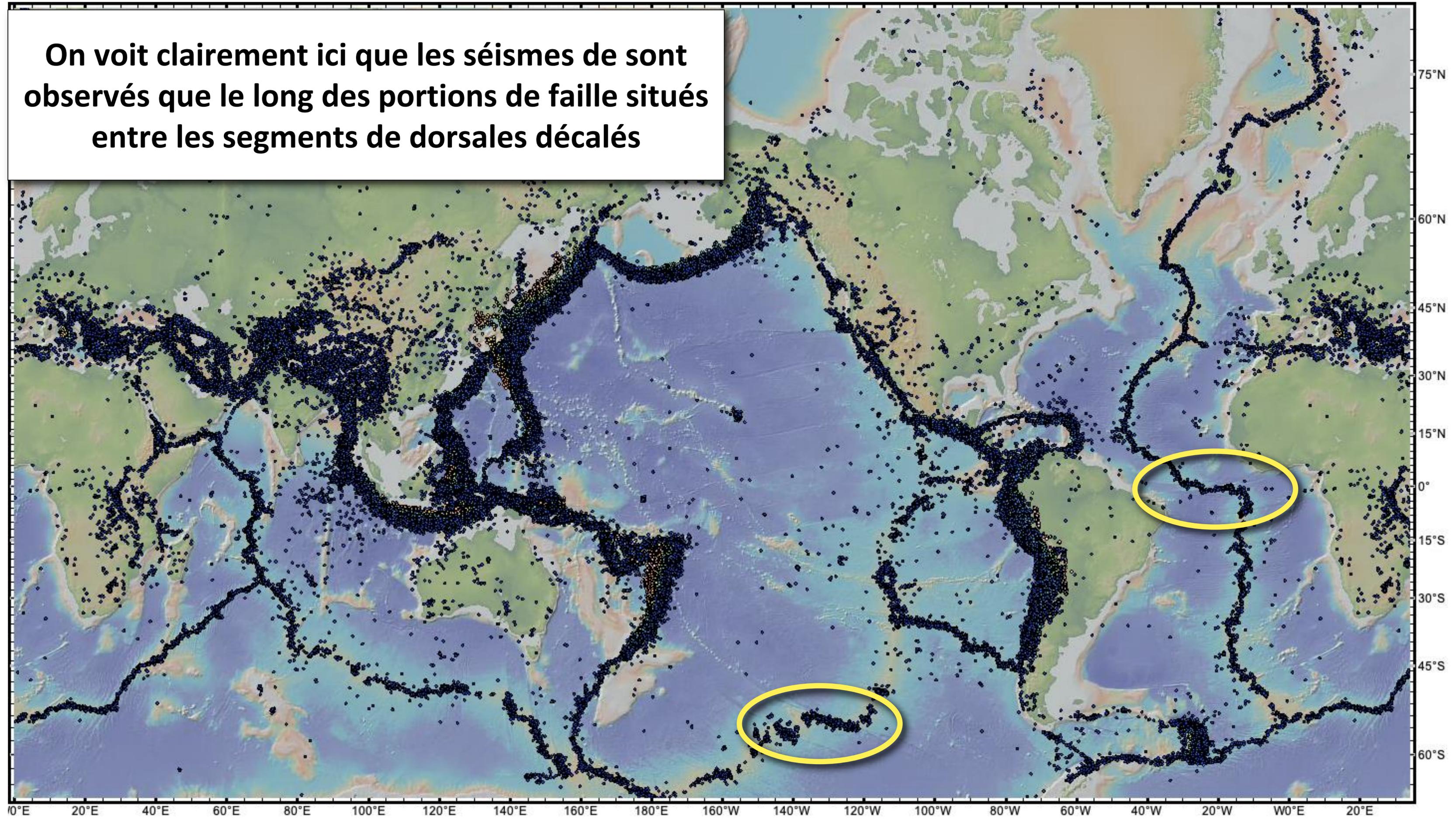
TEMPS X+1

Selon cette hypothèse, les séismes devraient être présents sur toute la longueur de la faille

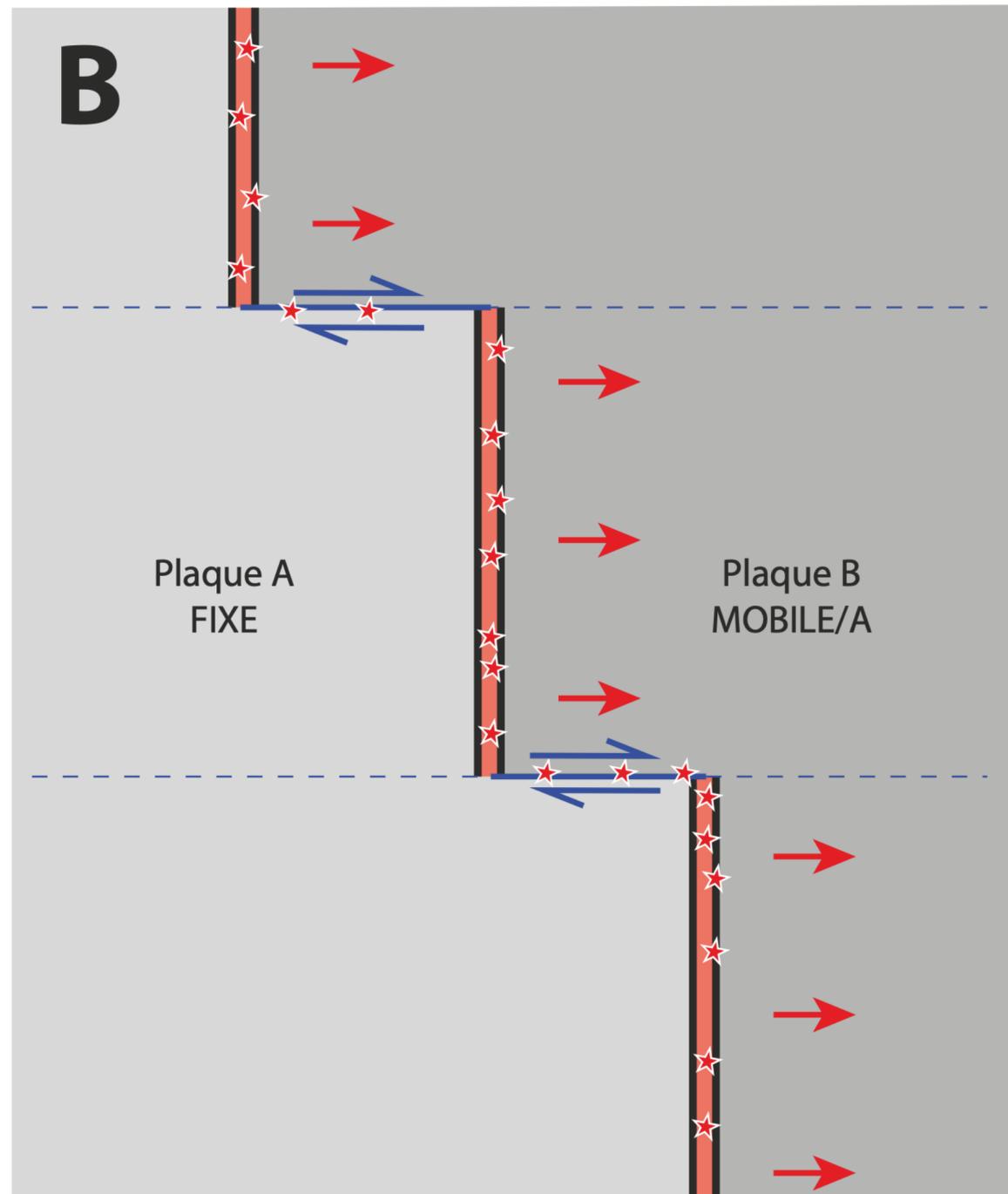
On voit clairement ici que les séismes ne sont observés que le long des portions de faille situés entre les segments de dorsales décalés



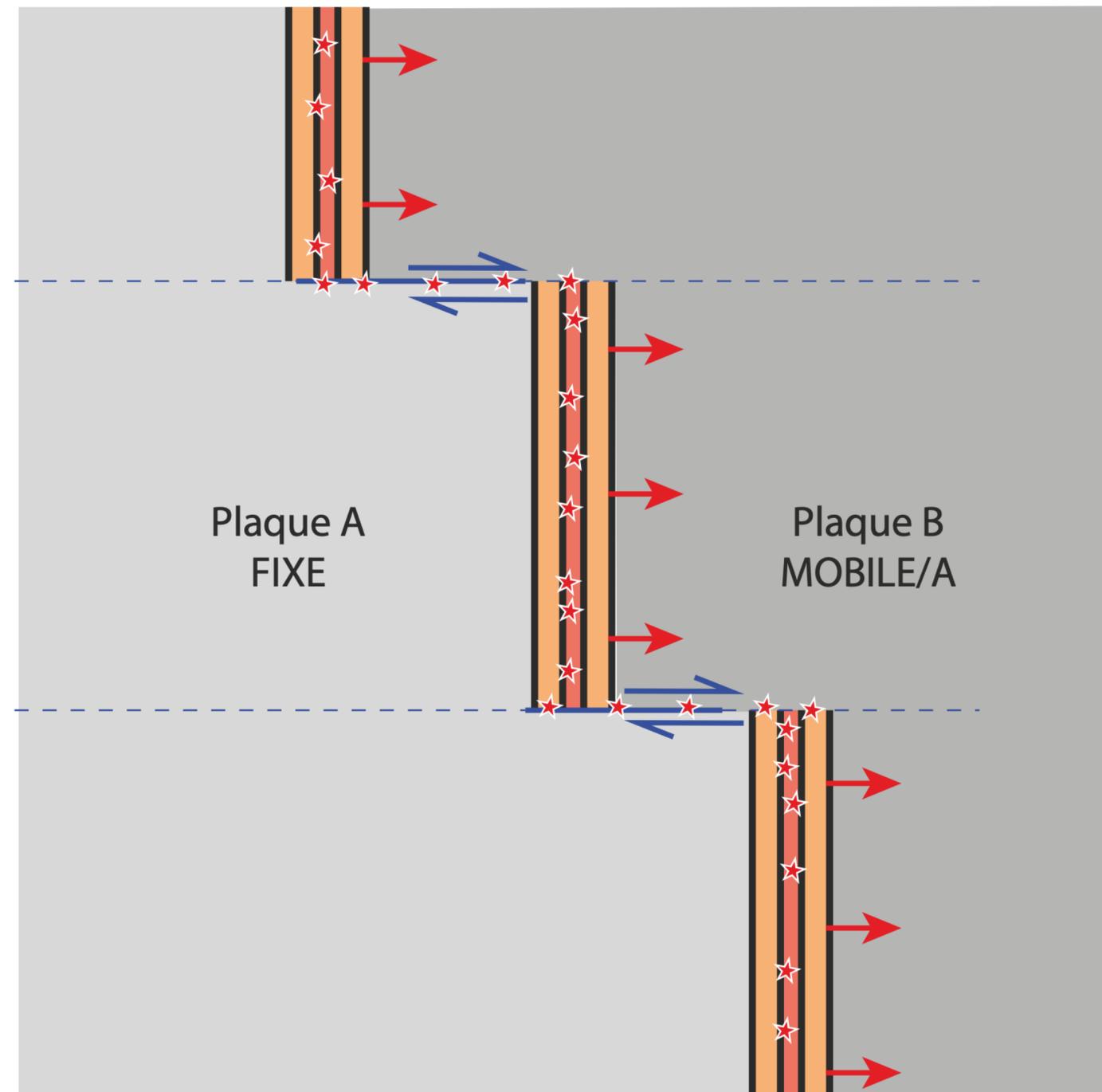
On voit clairement ici que les séismes de sont observés que le long des portions de faille situés entre les segments de dorsales décalés



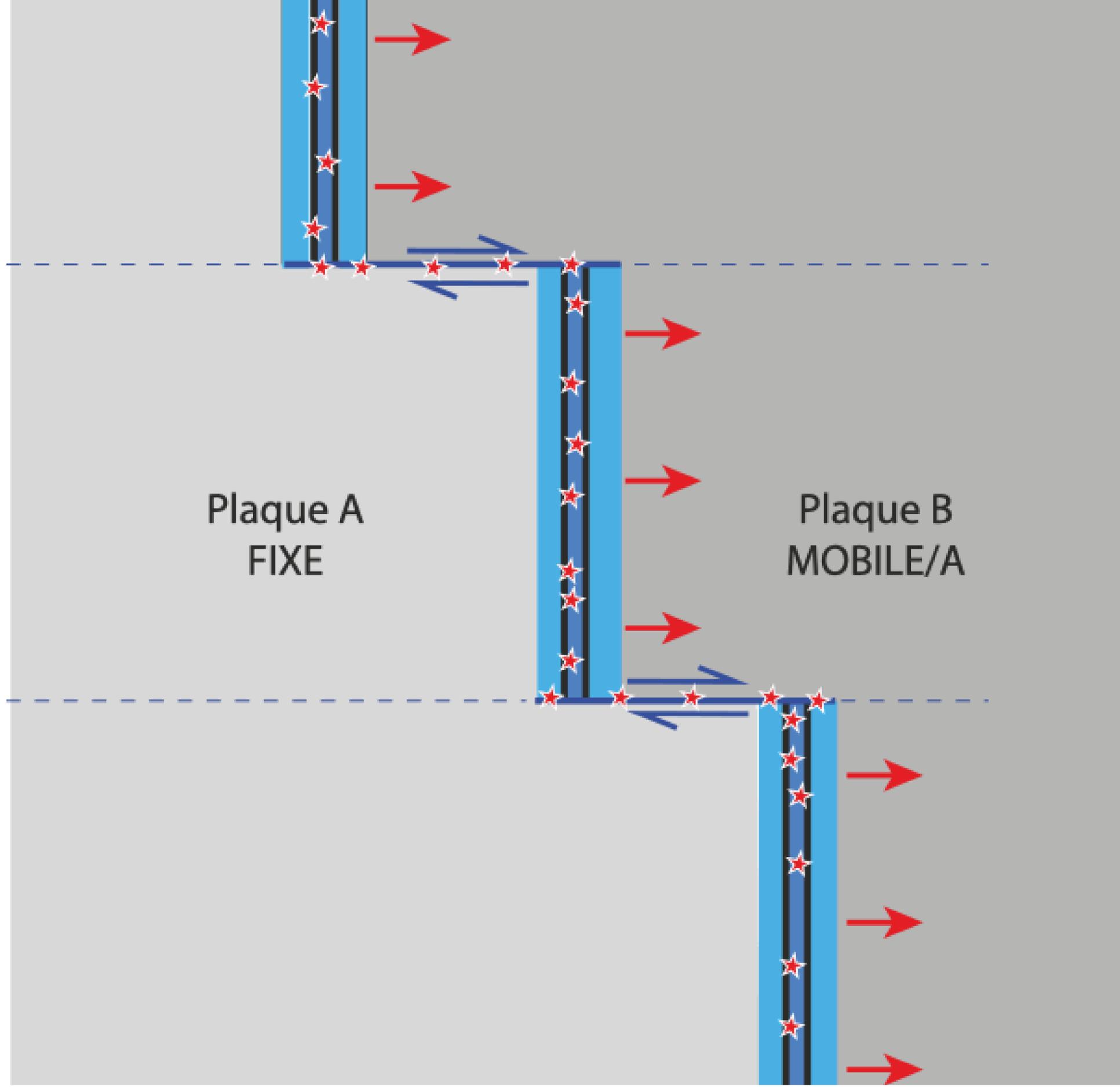
Dorsale décalée par des failles transformantes schéma cohérent et conforme de Coode/Wilson



TEMPS X



TEMPS X+1



Rises, Trenches, Great Faults, and Crustal Blocks¹

W. JASON MORGAN

*Department of Geology, Princeton University, Princeton, New Jersey 08540
and Department of Geology and Geophysics, Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543*



Jason Morgan montre pour la première fois que les failles transformantes sont des petit cercles autour de pôles de rotation eulérien autour desquels des plaques rigides tournent

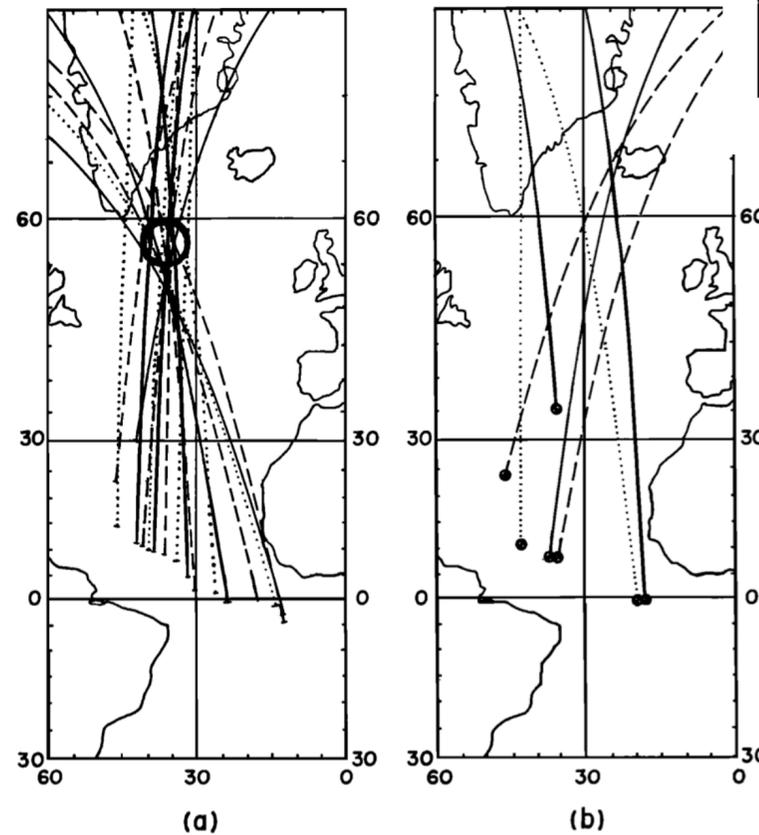


Fig. 8. Great circles perpendicular to the strike of offsets of the mid-Atlantic ridge are shown in (a). With one exception, all of these lines pass within the circle centered at 58°N, 36°W. Great circles perpendicular to the strike determined by earthquake mechanism solutions are shown in (b).

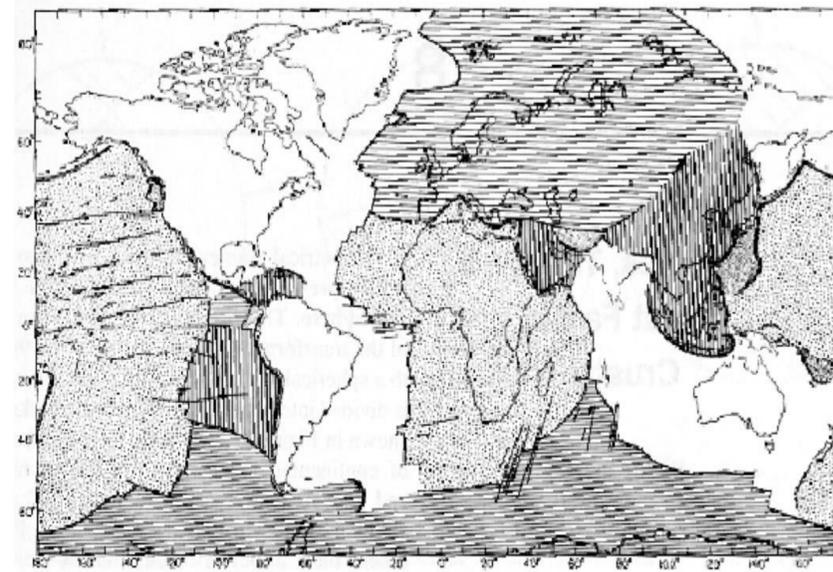
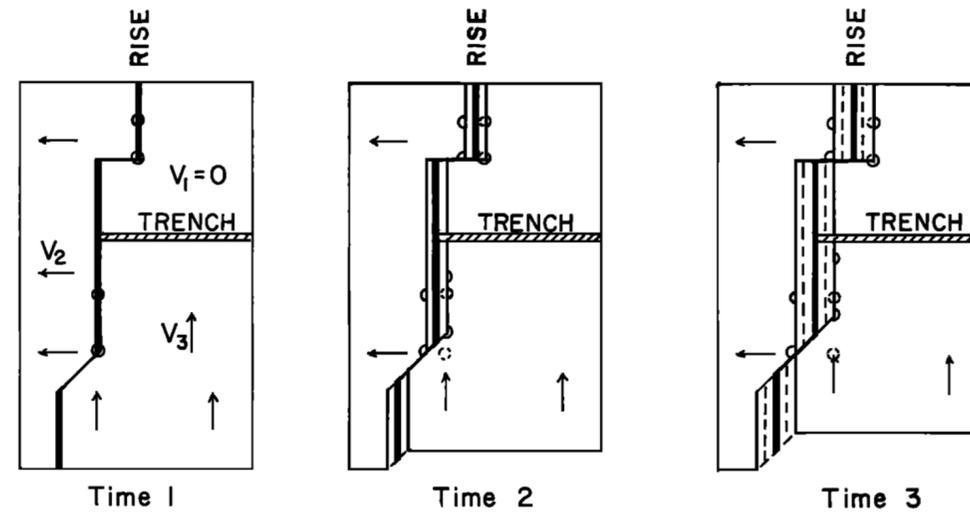


Figure 8-1

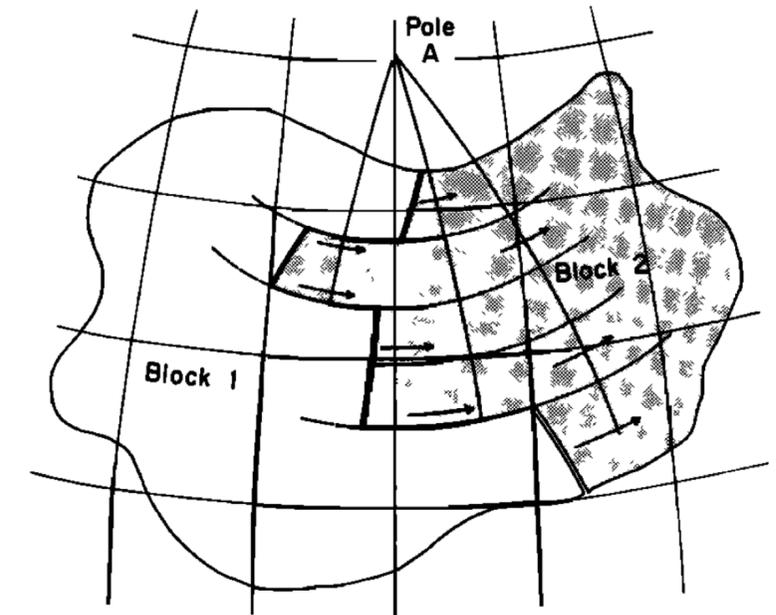


Fig. 4. On a sphere, the motion of block 2 relative to block 1 must be a rotation about some pole. All faults on the boundary between 1 and 2 must be small circles concentric about the pole A.

3 tests de la tectonique des plaques

NATURE, VOL. 216, DECEMBER 30, 1967

The North Pacific: an Example of Tectonics on a Sphere

by

D. P. McKENZIE

R. L. PARKER

Institute of Geophysics and Planetary Physics,
University of California at San Diego

Individual aseismic areas move as rigid plates on the surface of a sphere. Application of the Mercator projection to slip vectors shows that the paving stone theory of world tectonics is correct and applies to about a quarter of the Earth's surface.

**Dan McKenzie et R.L. Parker
testent l'hypothèse de Wilson
en utilisant les vecteurs-
glissement des séismes,
montrant la rigidité des
plaques**

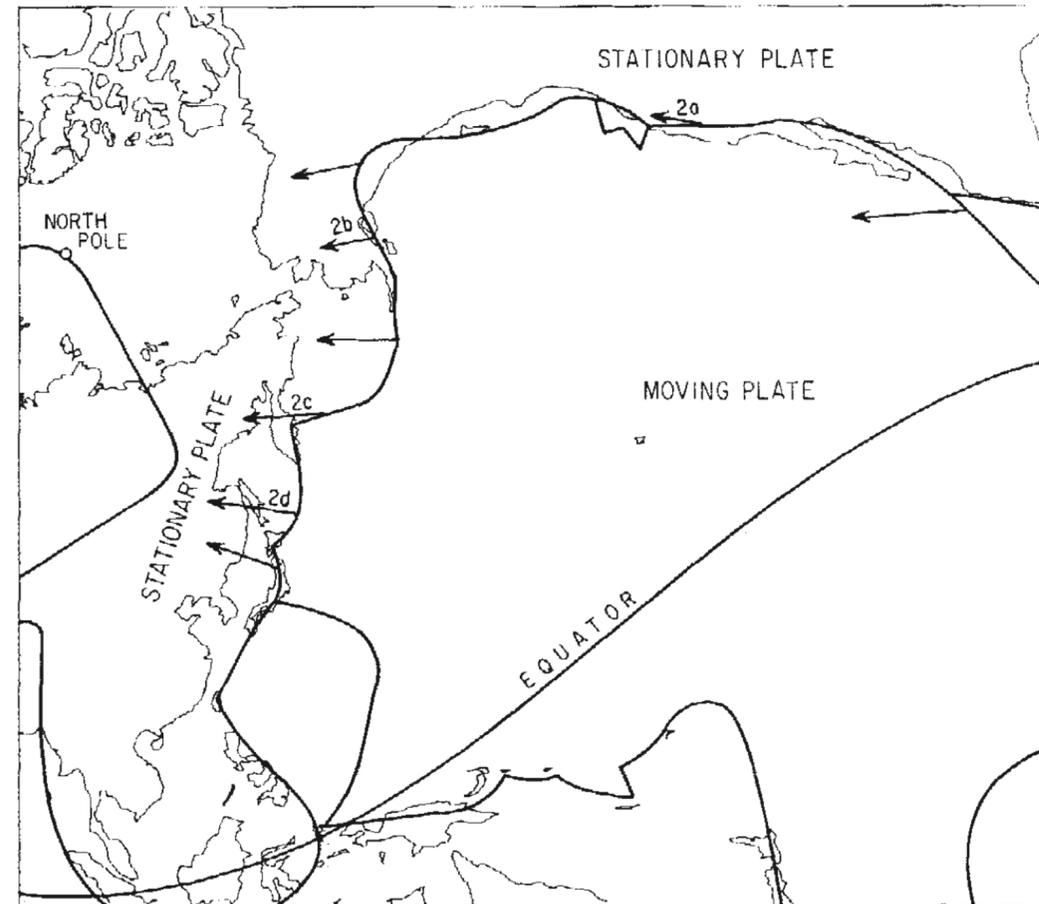


Fig. 3. A Mercator projection of the Pacific with a pole at 50° N., 85° W. The arrows show the direction of motion of the Pacific plate relative to that containing North America and Kamchatka. If both plates are rigid all slip vectors must be parallel with each other and with the upper and lower boundaries of the figure. Possible boundaries of other plates are sketched.

Xavier Le Pichon propose le premier modèle cinématique global avec des vitesses et des directions de mouvement quantifiées

Sea-Floor Spreading and Continental Drift¹

XAVIER LE PICHON²

*Lamont Geological Observatory, Columbia University
Palisades, New York 10962*

A geometrical model of the surface of the earth is obtained in terms of rigid blocks in relative motion with respect to each other. With this model a simplified but complete and consistent picture of the global pattern of surface motion is given on the basis of data on sea-floor spreading. In particular, the vectors of differential movement in the 'compressive' belts are computed. An attempt is made to use this model to obtain a reconstruction of the history of spreading during the Cenozoic era. This history of spreading follows closely one previously advocated to explain the distribution of sediments in the oceans.

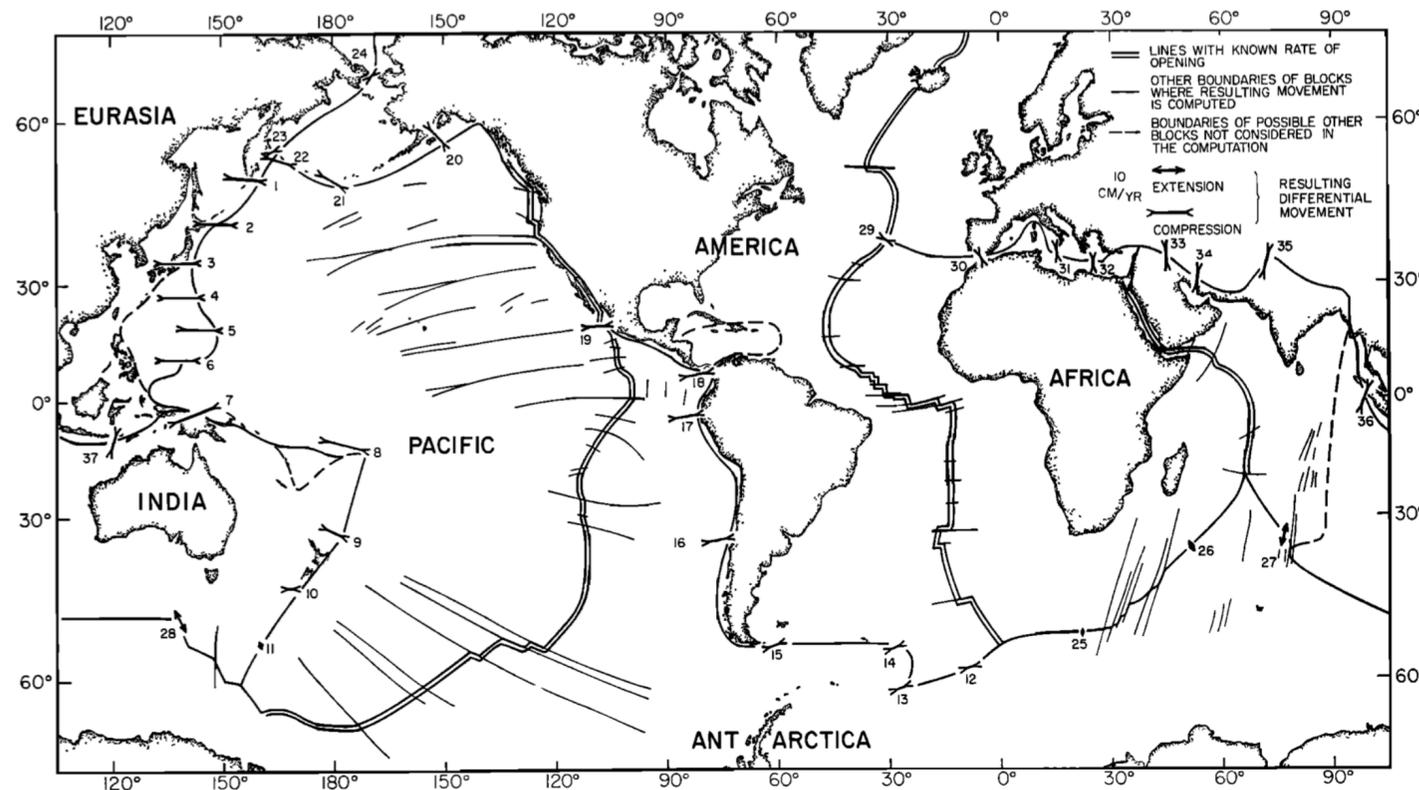
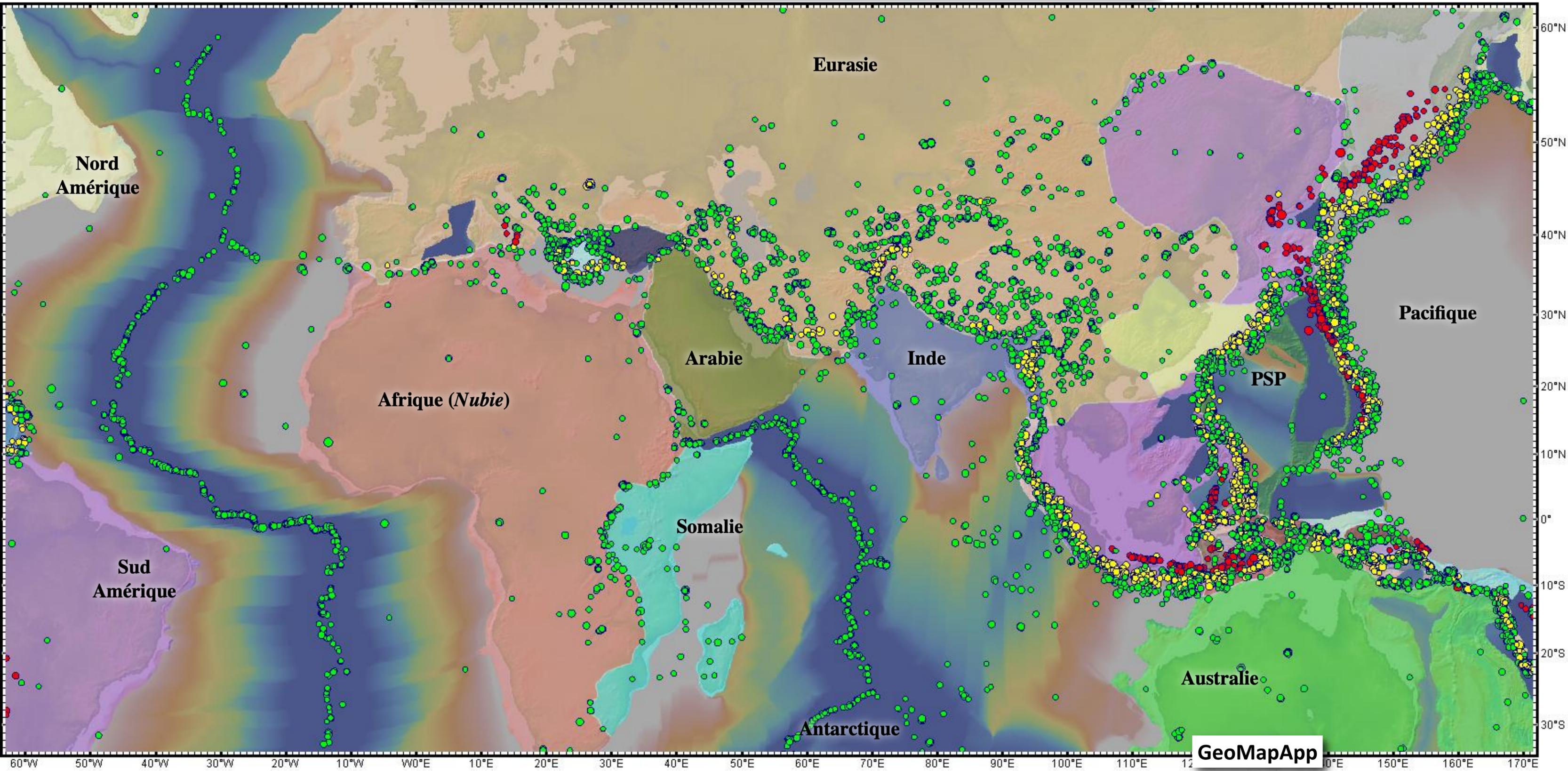


Fig. 6. The locations of the boundaries of the six blocks used in the computations. The numbers next to the vectors of differential movement refer to Table 5. Note that the boundaries where the rate of shortening or slippage exceeds about 2 cm/yr account for most of the world earthquake activity.



Scanned at the American Institute of Physics

Séismes, limites de plaques et âge du fond des océans



Avec la tectonique des plaques vient l'idée de la lithosphère « sismologique »

Deep Earthquake Zones, Anomalous Structures in the Upper Mantle, and the Lithosphere¹

JACK OLIVER AND BRYAN ISACKS

Lamont Geological Observatory, Columbia University
Palisades, New York 10964

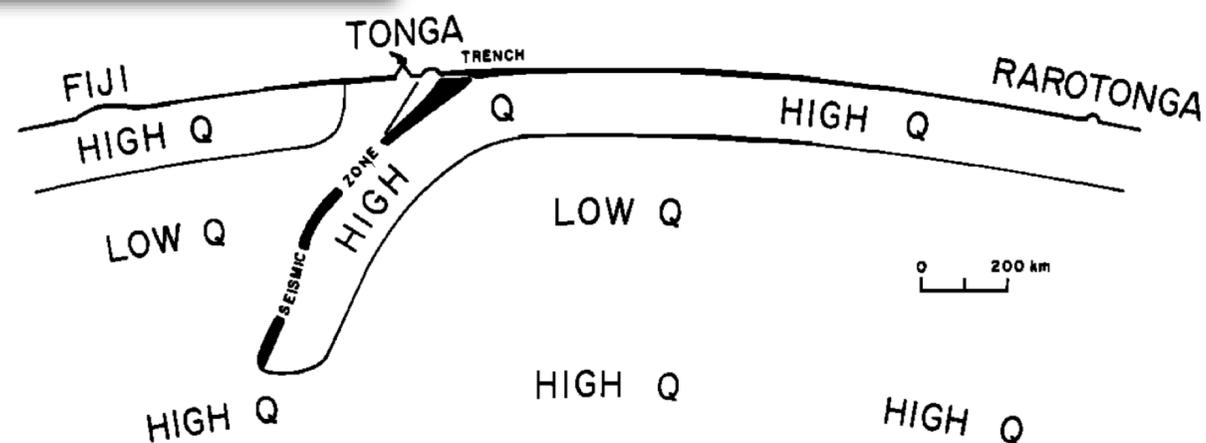


Fig. 13. Hypothetical section through Fiji, Tonga, and Rarotonga based on data of this paper. Boundaries between high Q and low Q zones are not well determined but can be taken as a first approximation.

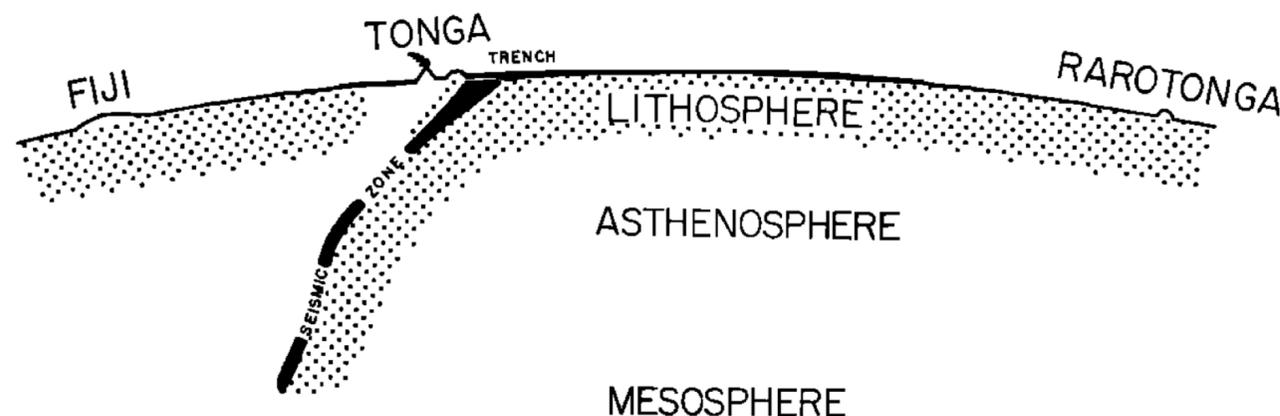


Fig. 14. Hypothetical section through Fiji, Tonga, and Rarotonga, assuming Q correlates with strength. The lithosphere and mesosphere are zones of significant strength, and the asthenosphere is a zone of vanishing strength on appropriate time scale. The terminology is that of *Daly* [1940].

La tectonique des plaques en 3D avec les sismologues

Isacks et al., 1968

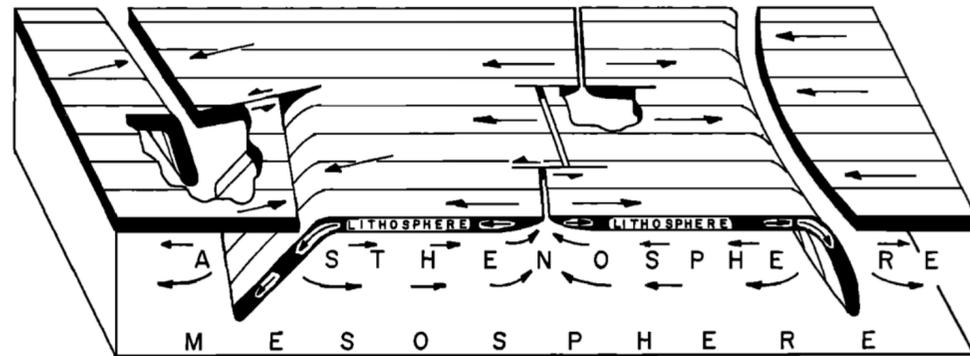


Fig. 1. Block diagram illustrating schematically the configurations and roles of the lithosphere, asthenosphere, and mesosphere in a version of the new global tectonics in which the lithosphere, a layer of strength, plays a key role. Arrows on lithosphere indicate relative movements of adjoining blocks. Arrows in asthenosphere represent possible compensating flow in response to downward movement of segments of lithosphere. One arc-to-arc transform fault appears at left between oppositely facing zones of convergence (island arcs), two ridge-to-ridge transform faults along ocean ridge at center, simple arc structure at right.

Fig. 3. (Opposite) Summary map of slip vectors derived from earthquake mechanism studies. Arrows indicate horizontal component of direction of relative motion of block on which arrow is drawn to adjoining block. Crests of world rift system are denoted by double lines; island arcs, and arc-like features, by bold single lines; major transform faults, by thin single lines. Both slip vectors are shown for an earthquake near the western end of the Azores-Gibraltar ridge since a rational choice between the two could not be made. Compare with directions computed by Le Pichon (Figure 2).

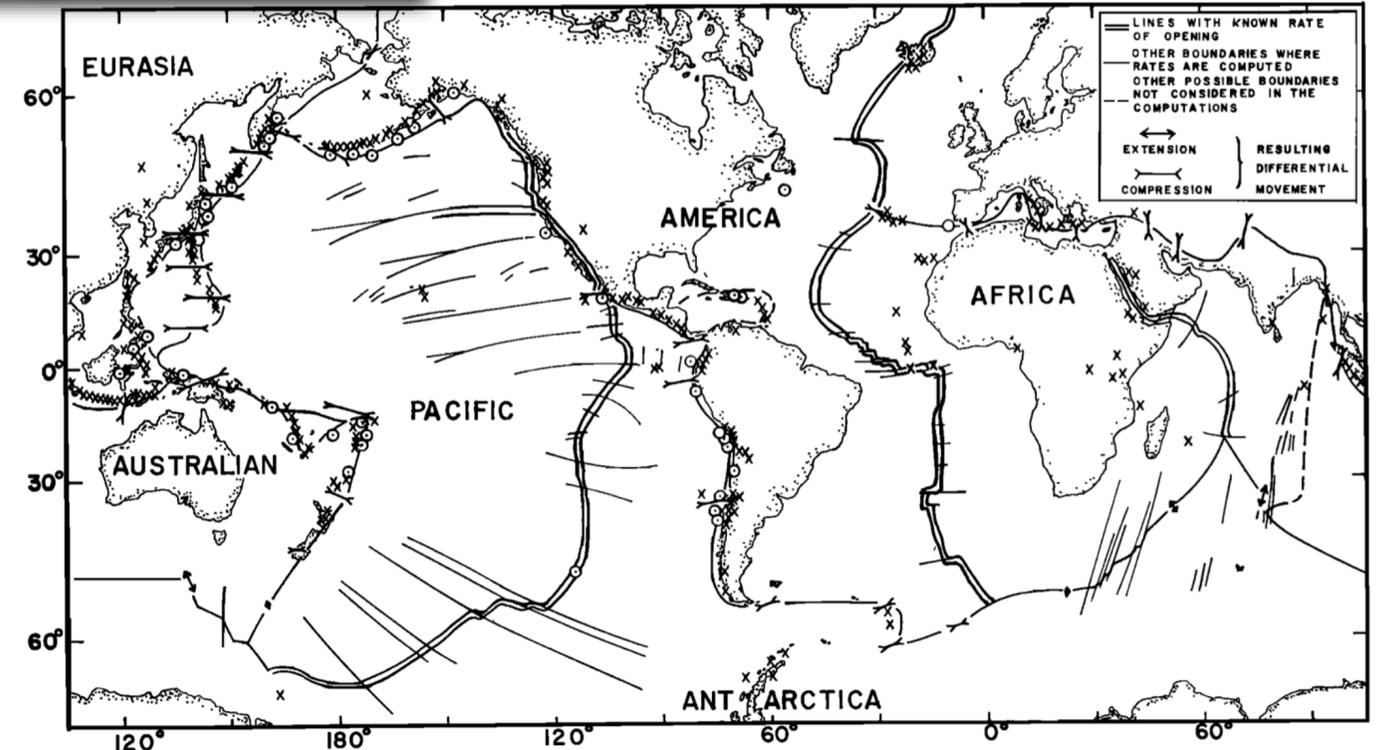


Fig. 2. Computed rates of compression and extension along boundaries of six lithospheric blocks [after Le Pichon, 1968]. Computed movements were derived from rates of spreading determined from magnetic data and from orientations of fracture zones along features indicated by double lines. The extensional and compressional symbols in the legend represent rates of 10 cm/yr; other similar symbols are scaled proportionally. Symbols appearing as diamonds represent small computed rates of extension for which the arrowheads coalesced. Historically active volcanoes [Gutenberg and Richter, 1954] are denoted by crosses. Open circles represent earthquakes that generated tsunamis (seismic sea waves) detected at distances of 1000 km or more from the source.

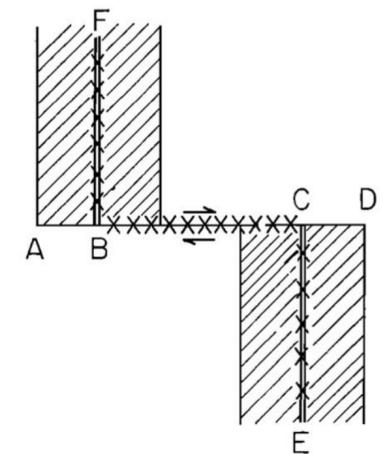
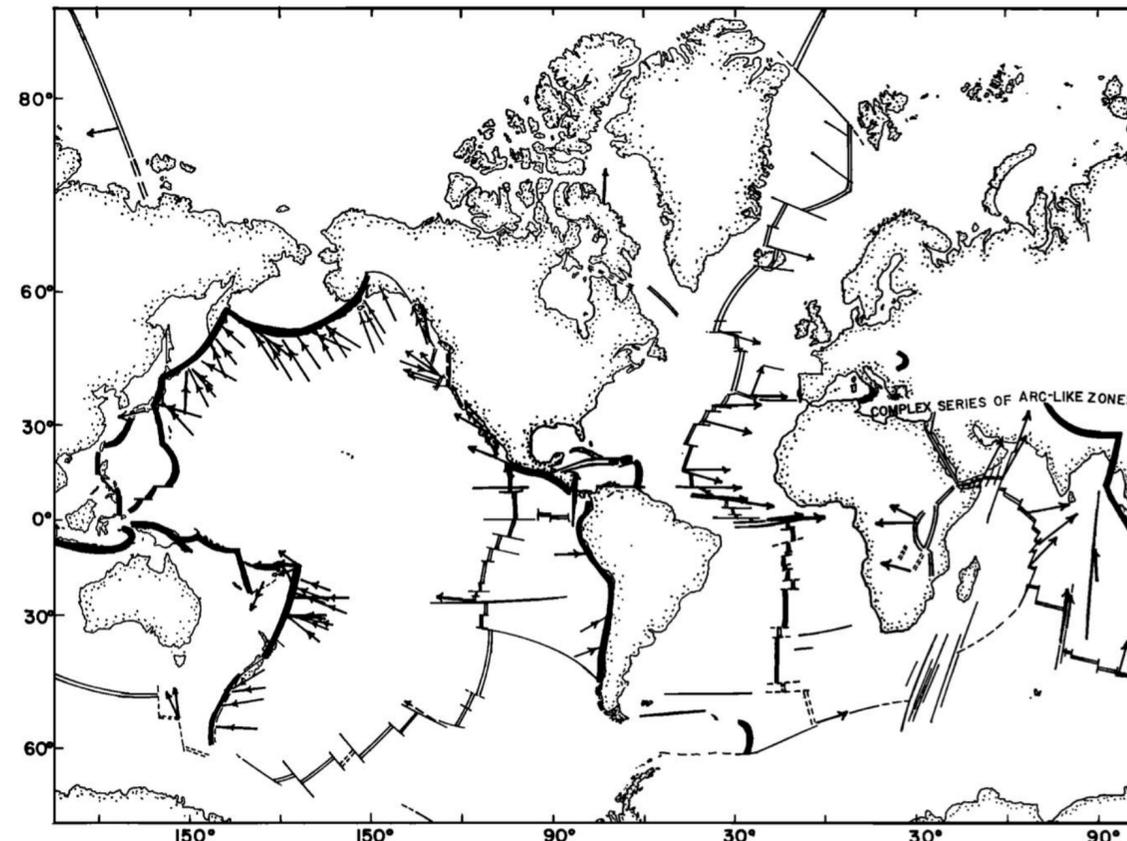
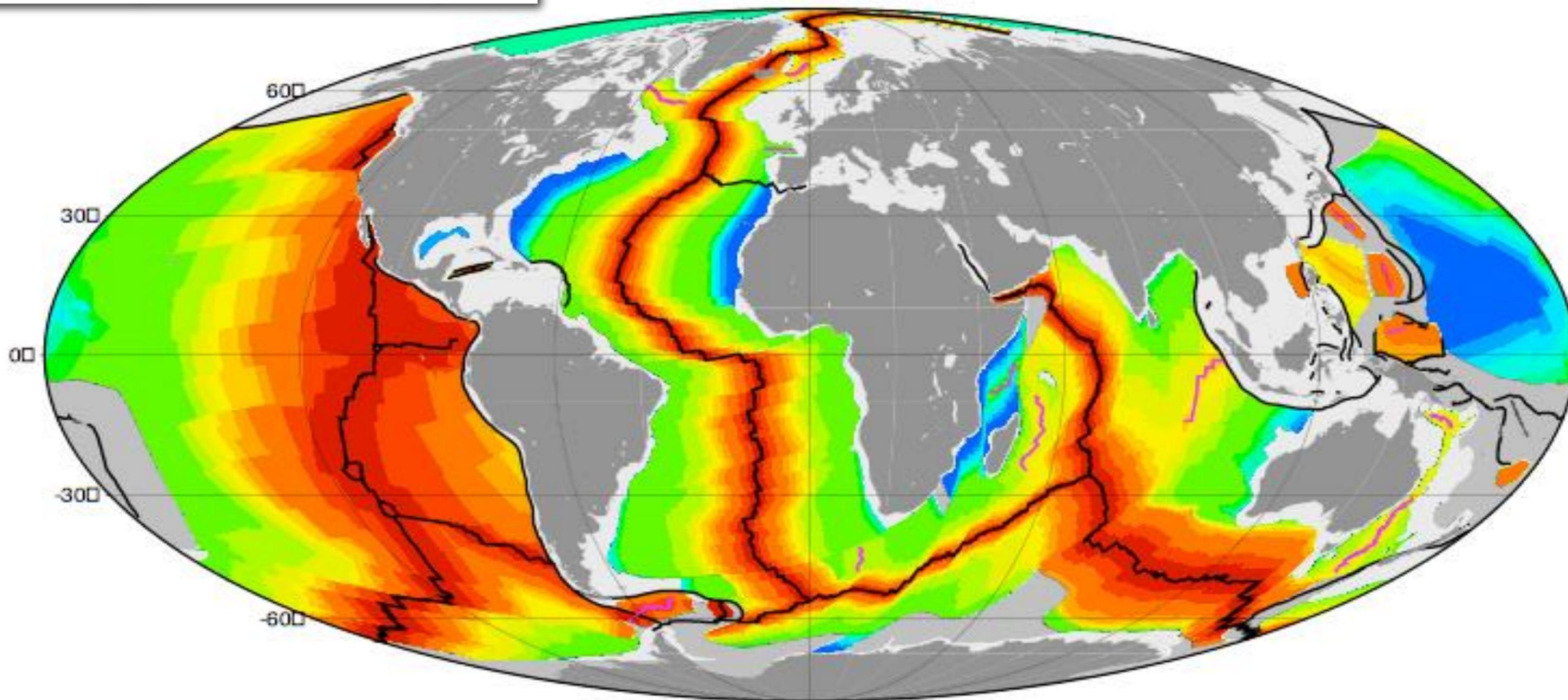


Fig. 4. An idealized model of sea-floor spreading and transform faulting of the ridge-ridge type. Hatching indicates new surface area created during a given period of sea-floor spreading along the active ridge crests BF and CE. Present seismicity (indicated by crosses) is confined to ridge crests and to segment BC of the fracture zone AD. Arrows denote sense of shear motion along active segment BC.

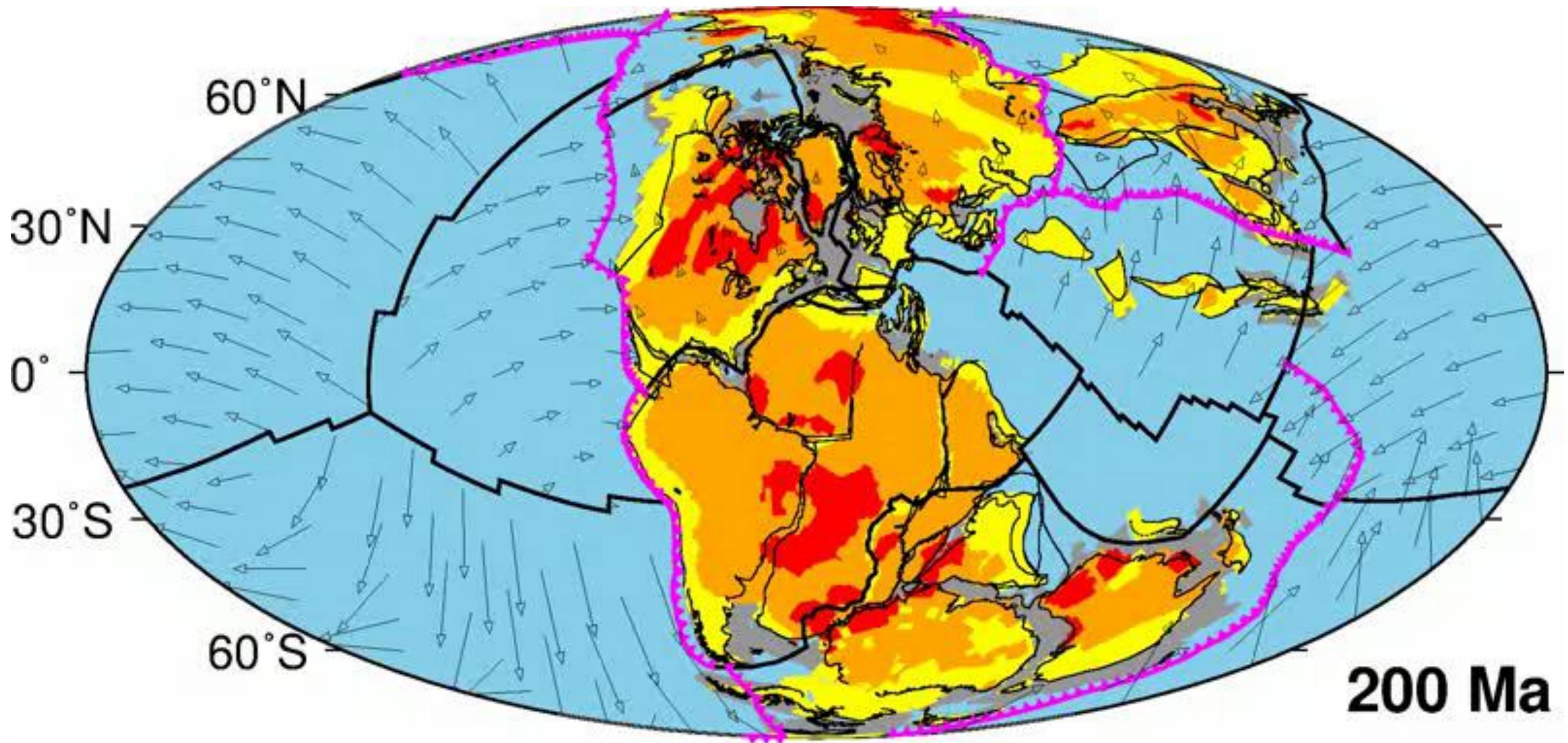
Carte de l'âge des fonds océaniques

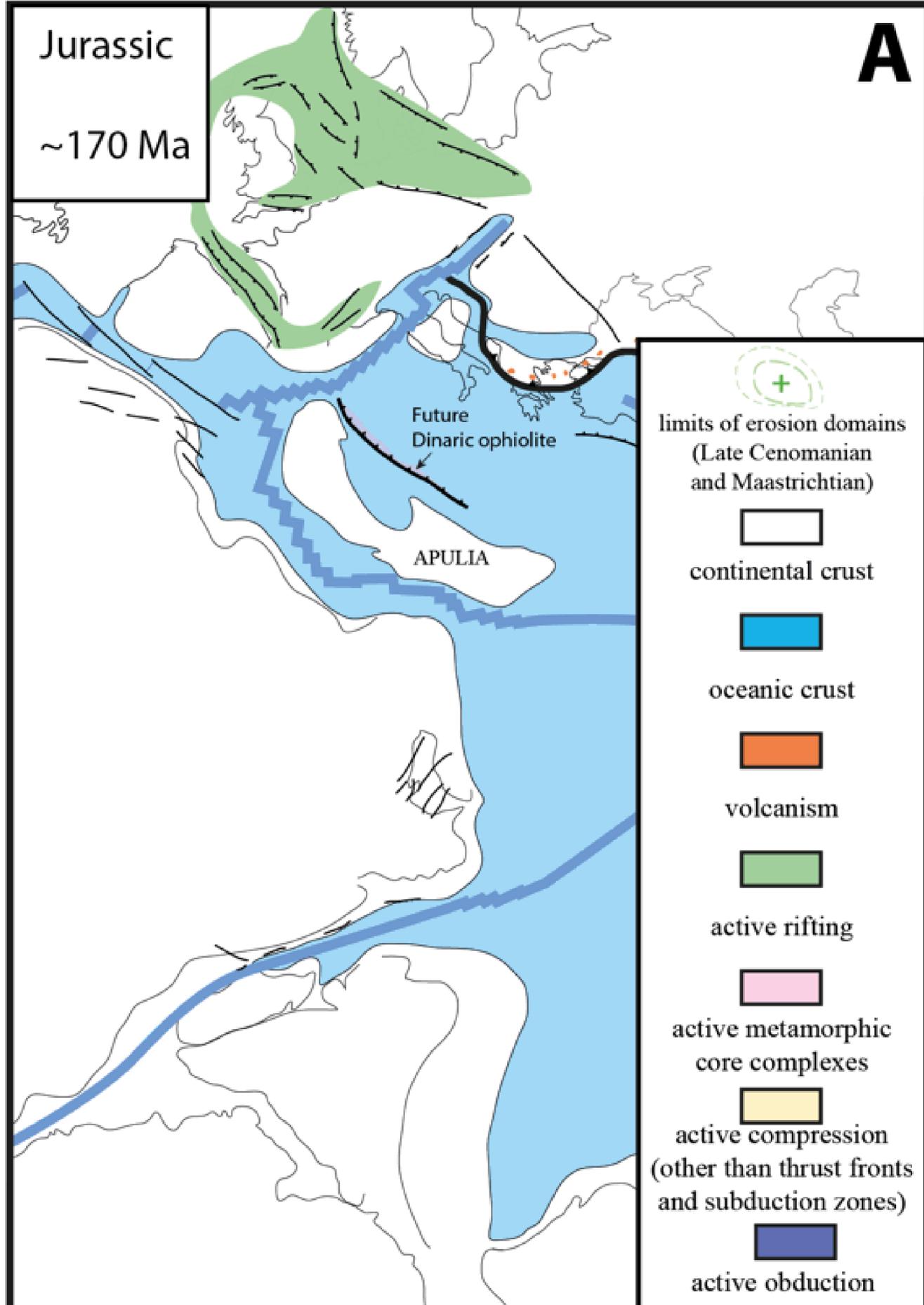


Müller et al. 1997



Age [Ma]







400 Ma- EMSIAN-EIFELLIAN boundary
(Stampfli & Borel, 2002)



240 Ma- ANISIAN (Stampfli & Borel, 2002)



Le moteur du mouvement des plaques:
Convection du manteau

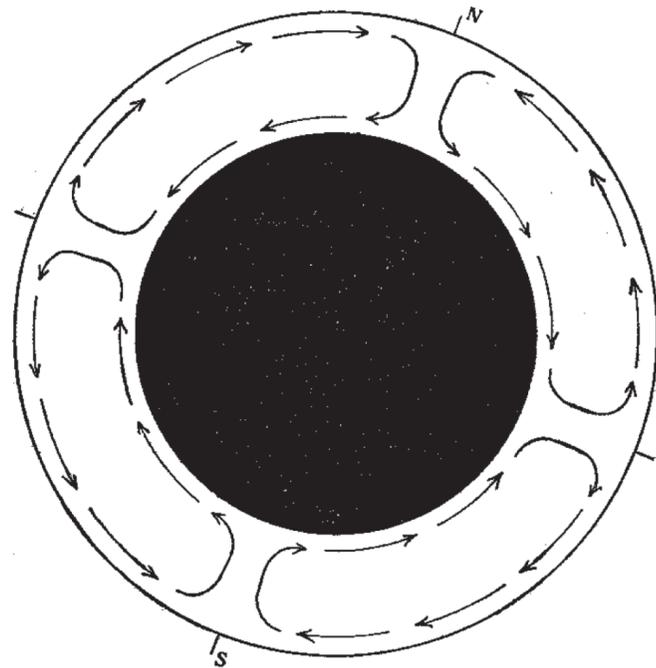


Fig. 1.

THE SUB-CONTINENTAL CIRCULATION.

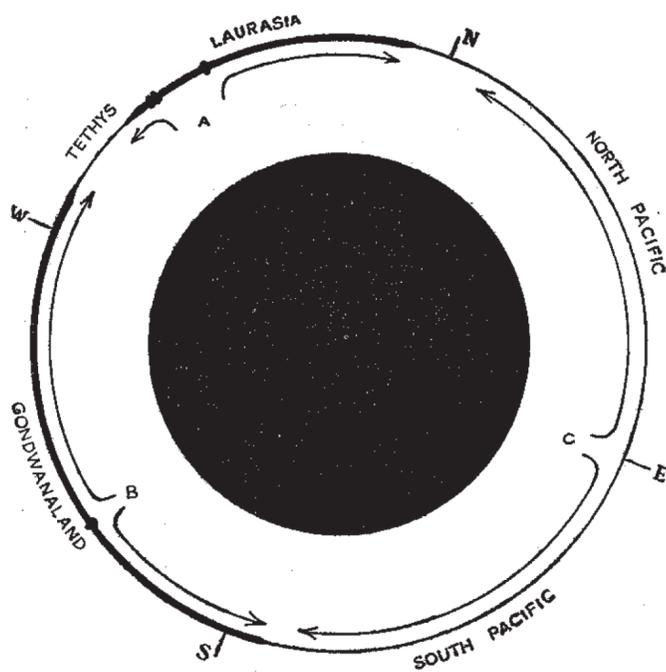
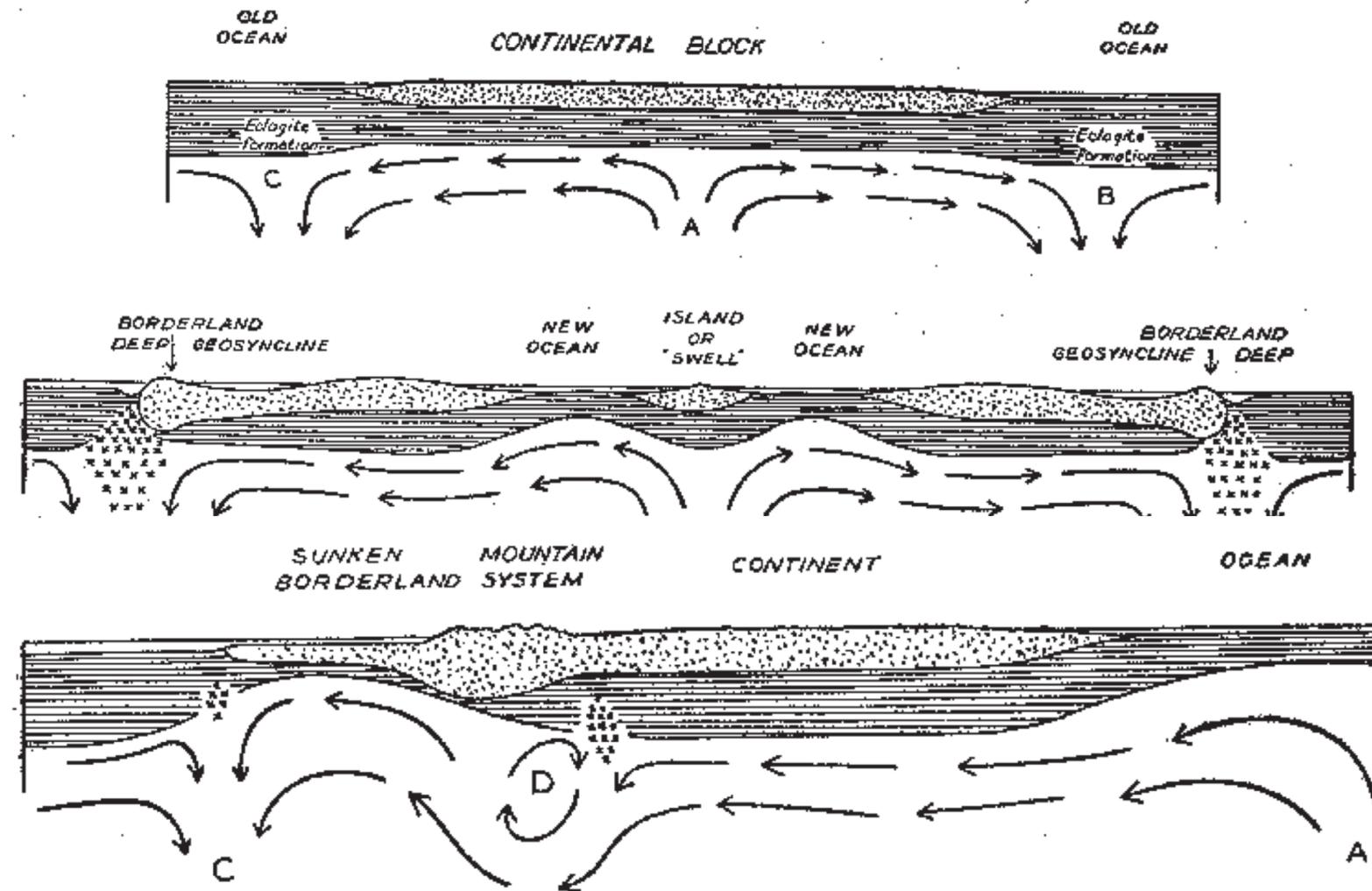


Fig. 5.

Arthur Holmes
Radioactivity and Earth Movements (1931)

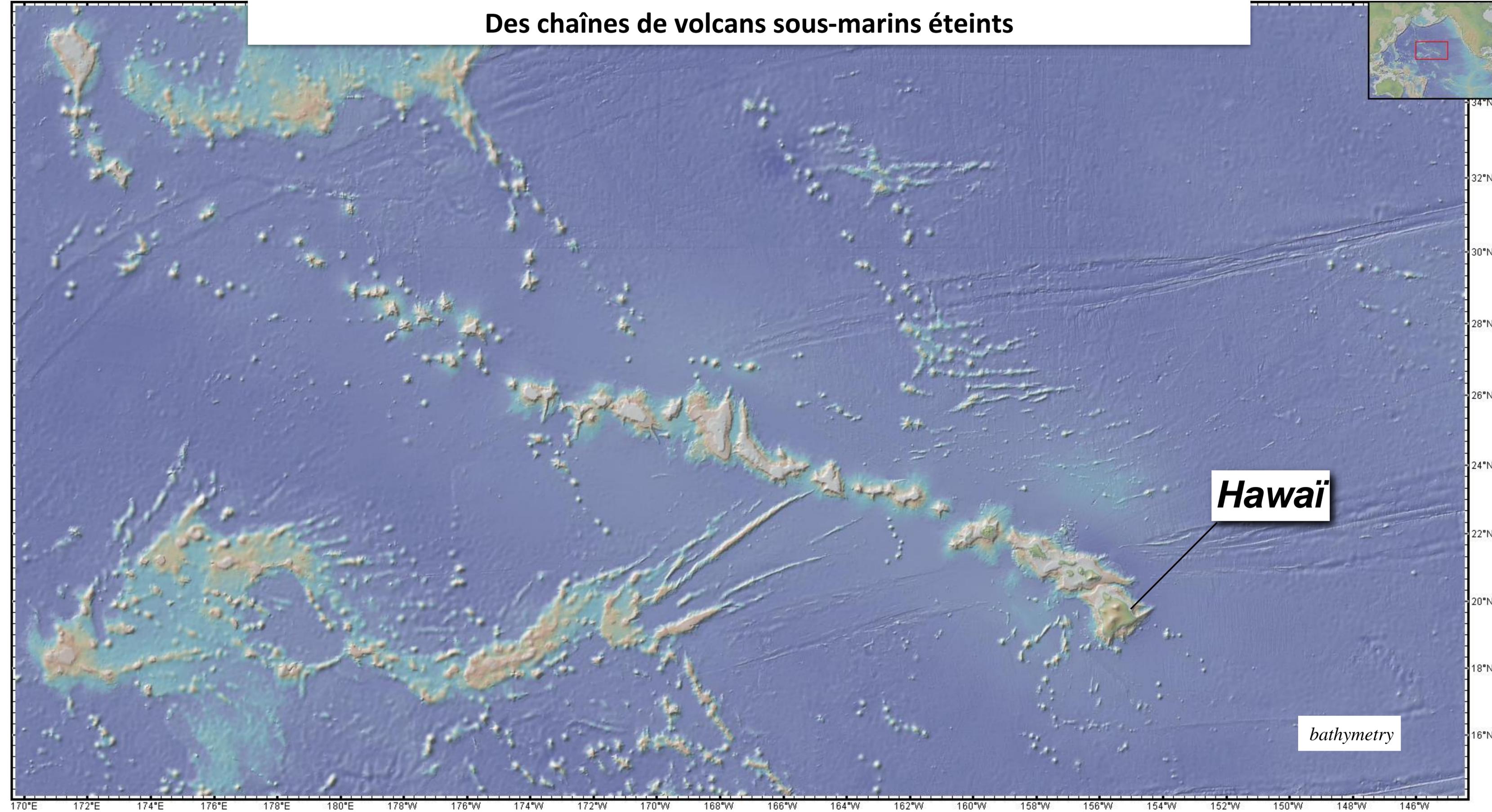


Chaleur de la Terre et radioactivité, convection interne et mouvements en surface, chaînes de montagnes...



Sir Arthur Holmes (1890-1965), the British geologist who contributed to our understanding of Earth's age. Photo courtesy of University of Edinburgh, Department of Geology and Geophysics

Des chaînes de volcans sous-marins éteints



Hawaiï

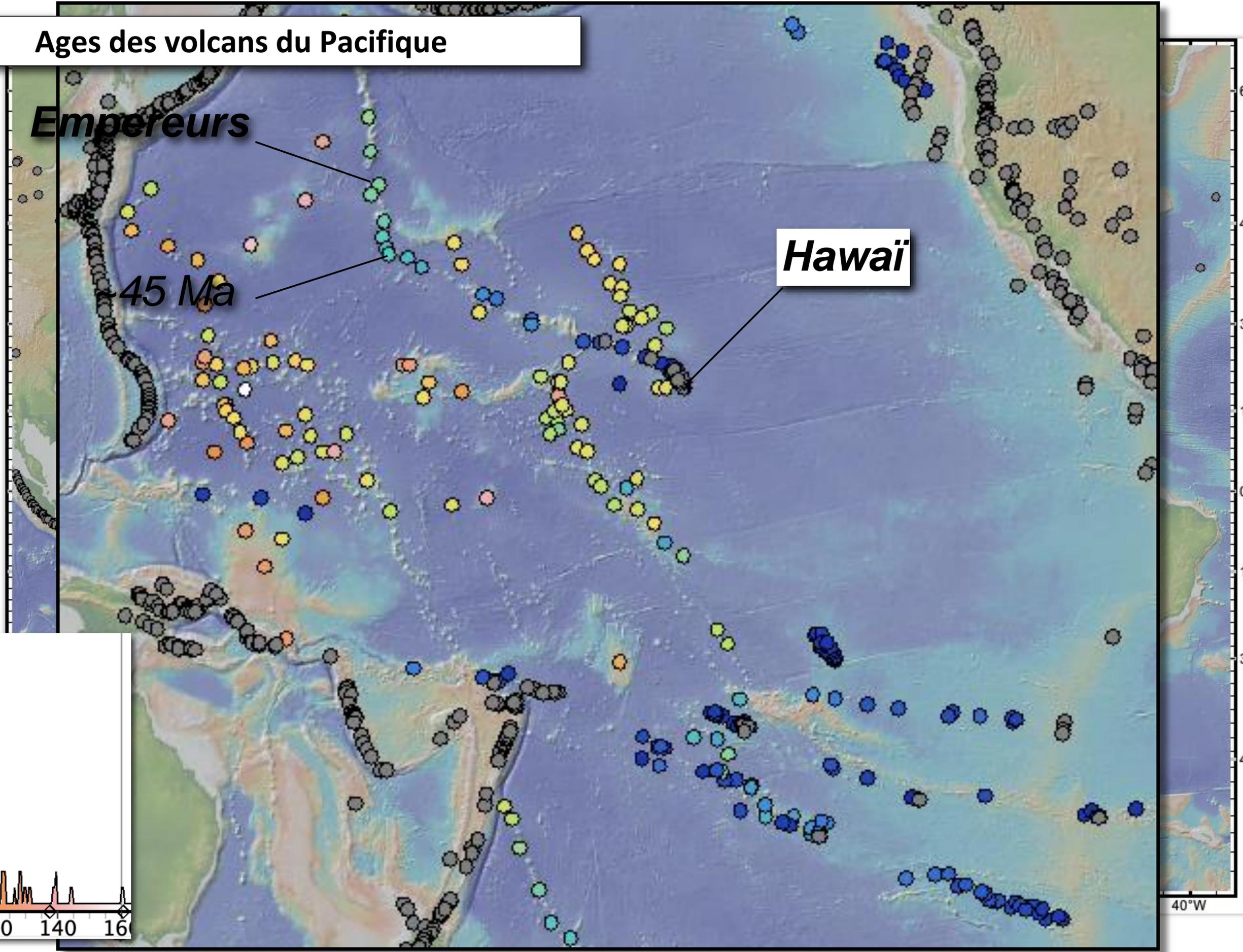
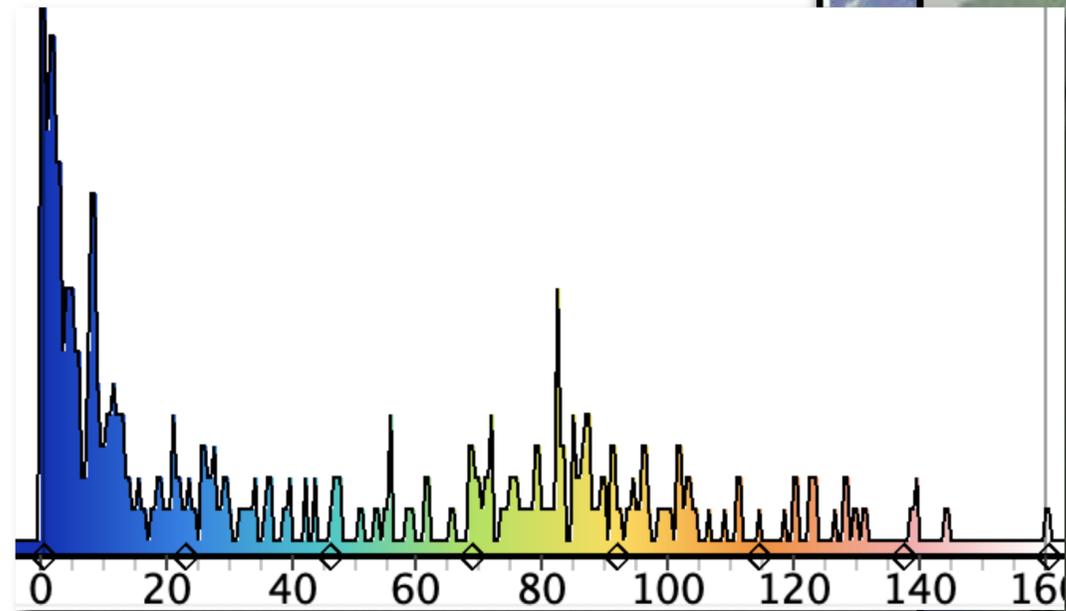
bathymetry

Ages des volcans du Pacifique

Empereurs

45 Ma

Hawaï



LEGEND

- Median Ridge
- Flow Direction
- Island Chain
- Fault

La notion de point chaud

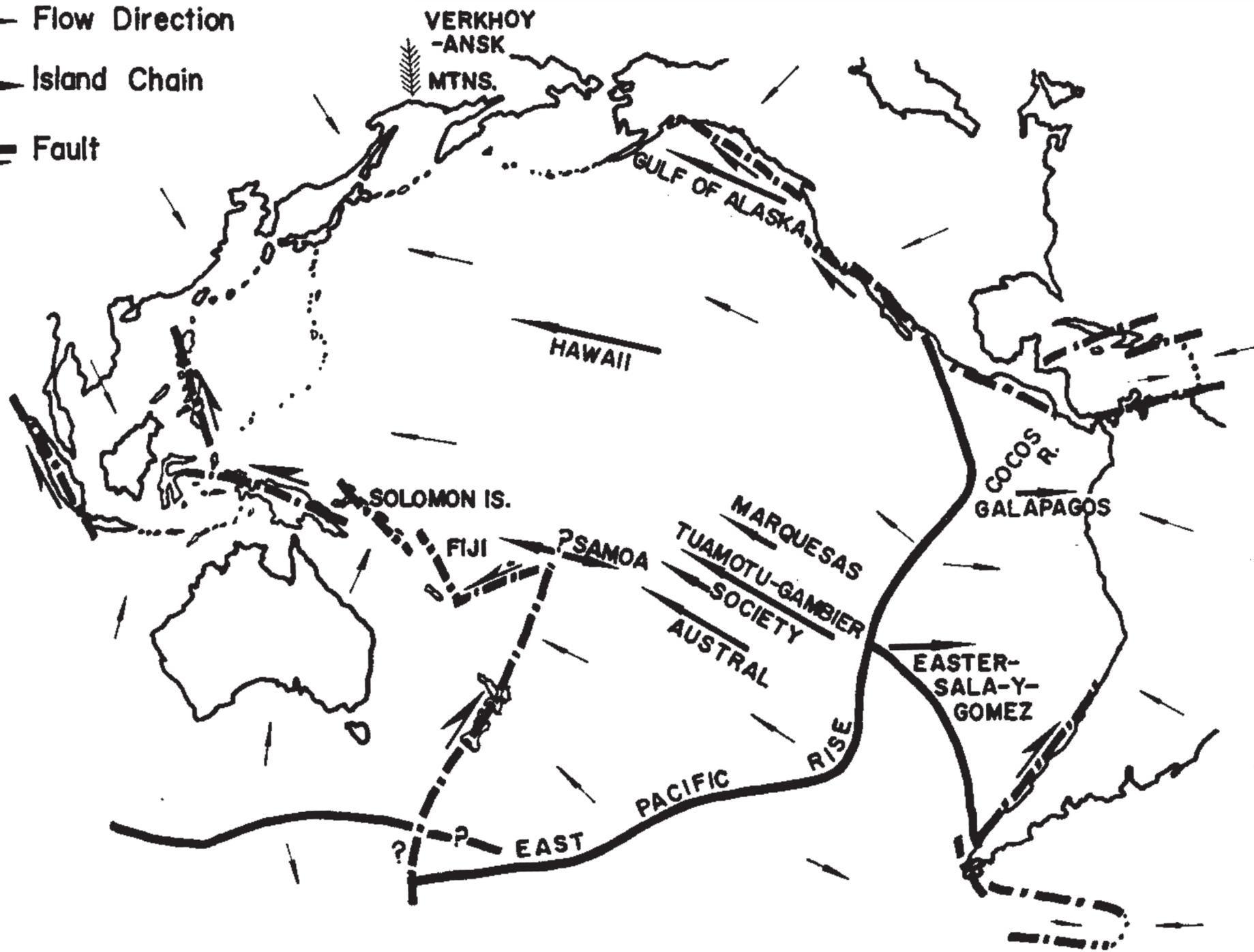


FIG. 1. Sketch of Pacific Ocean. Heavy arrows show nine linear chains of islands and seamounts which increase in age in direction of arrow. Single-headed arrows show direction of motion, where known, along large transcurrent faults. Small arrows show postulated direction of flow away from median ridges.

Tuzo Wilson, 1963

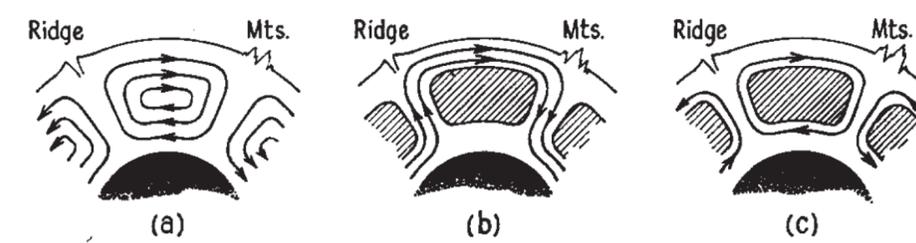


FIG. 2. Three possible modes of convection in the Earth's mantle.

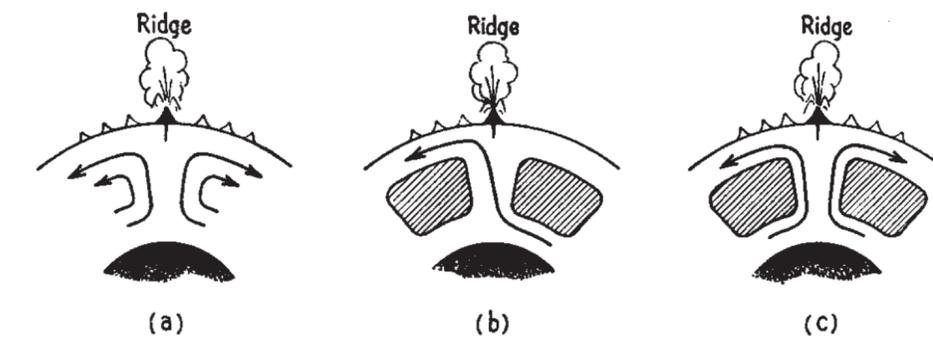


FIG. 3. Some possible patterns of convection, showing that, if active volcanoes form over rising vertical currents, chains of extinct volcanoes might be formed by the horizontal flow or the currents. The shaded areas represent stable cores of cells.

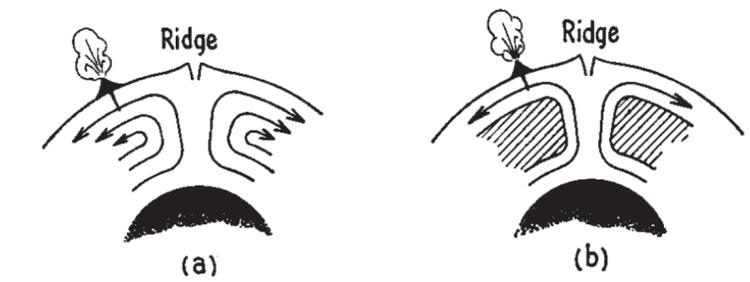


FIG. 4. Diagram to illustrate that in general if lava is generated at some other point of a convecting system than over a rising current, then only one volcano will be generated.

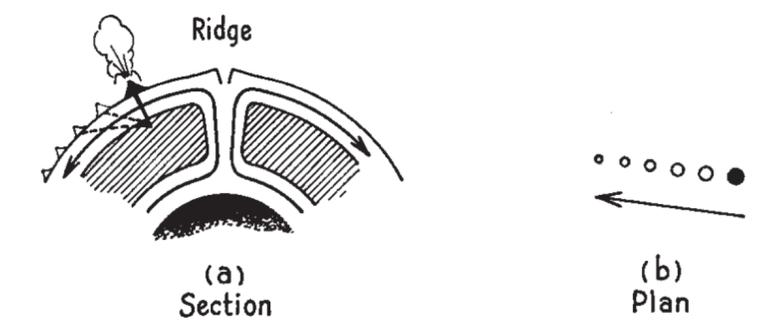


FIG. 5. Diagram to illustrate that if lava is generated in the stable core of a convection cell, and the surface is carried by the jet stream, then one source can give rise to a chain of extinct volcanoes even if the source is not over a rising current. This is proposed as a possible origin of the Hawaiian chain of islands.

La notion de point chaud

Cinématique absolue

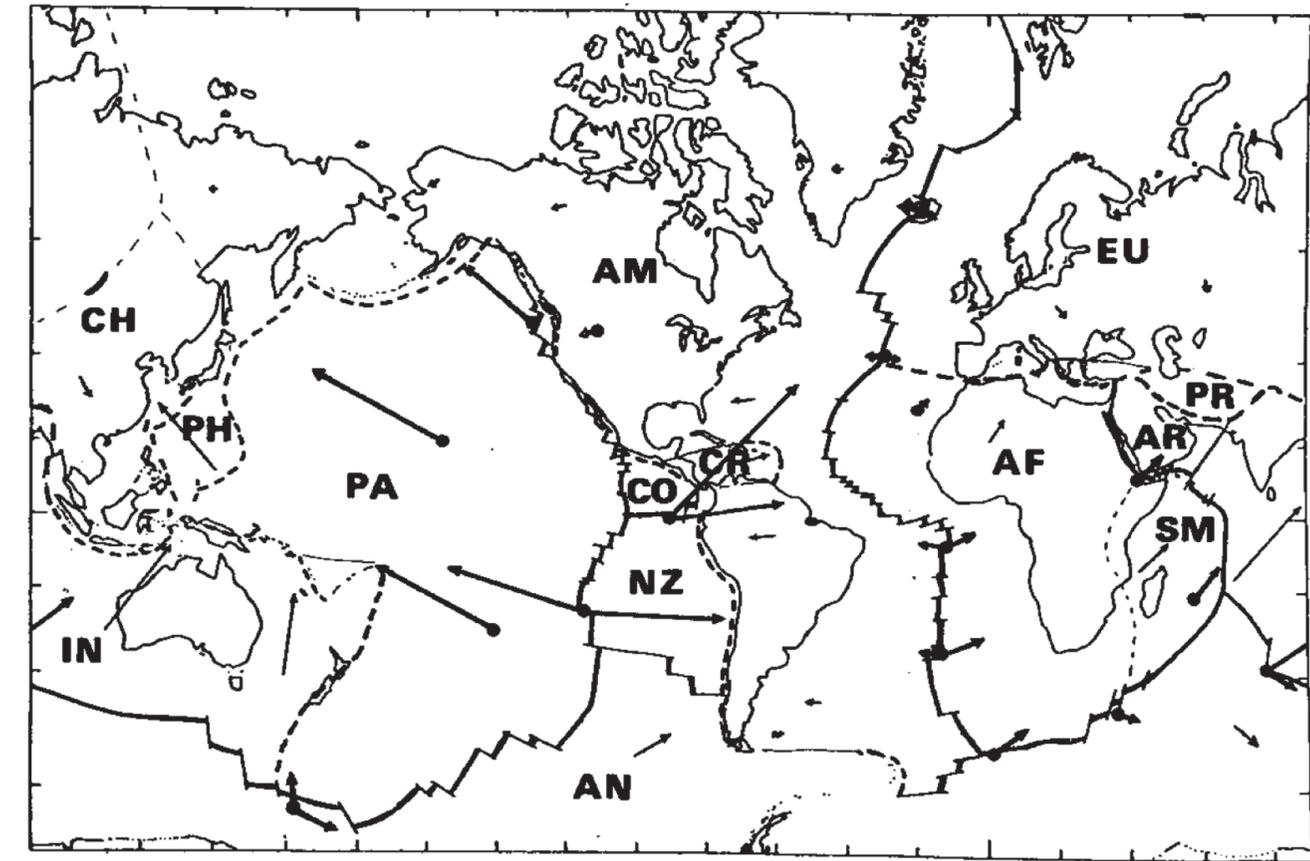
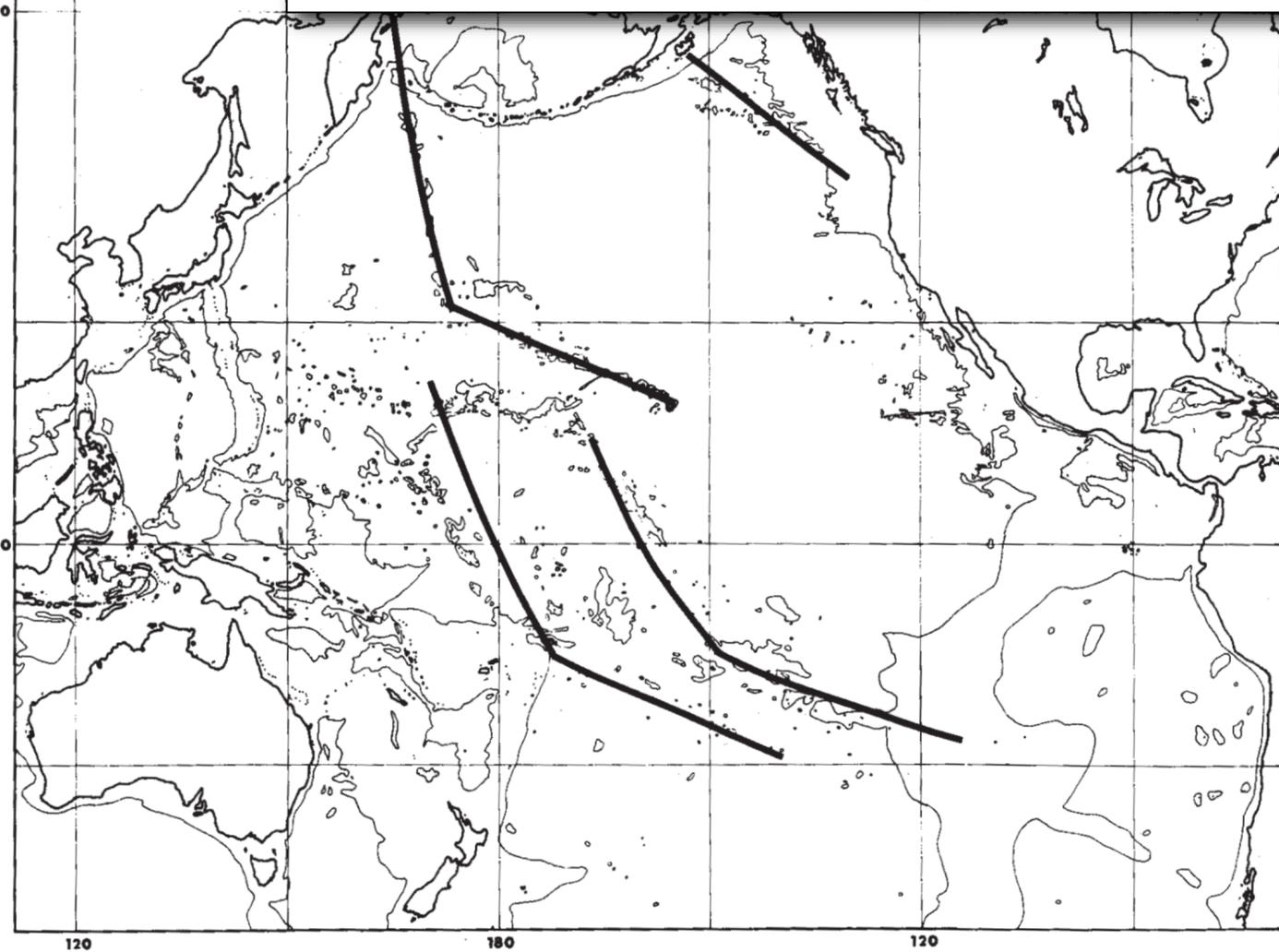


FIG. 1—Hot-spot trajectories constructed by rotating Pacific plate over four fixed hot-spots.

FIG. 3—Present motions of plates over hot-spots. Relative plate motions were determined from fault strikes and spreading rates on rise boundaries; with an appropriate constant rotation added, absolute motions of each plate over mantle were determined. Lengths of arrows are proportional to plate speed.

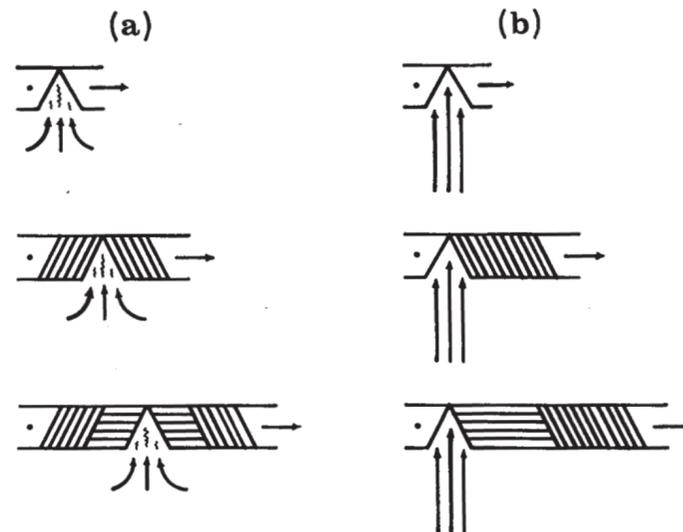


FIG. 5—In these symmetrical and asymmetric models of sea-floor spreading, left lithospheric plate is constrained to be fixed and right plate to move away at constant velocity. (a) If asthenosphere near rise fills gap made as plates move apart, symmetrical sea-floor spreading results. (b) If location of rising current is influenced strongly by conditions near bottom of asthenosphere, one-sided sea-floor spreading results.

Les mouvements / manteau profond

Plaques rapides, plaques lentes

Jason Morgan, 1972

Cinématique absolue, plaques lentes et plaques rapides

Les plaques rapides ont une grande longueur de leurs frontières en subduction et possèdent peu de portions continentales ou pas du tout.

60

30

0

30

60

60

120

180

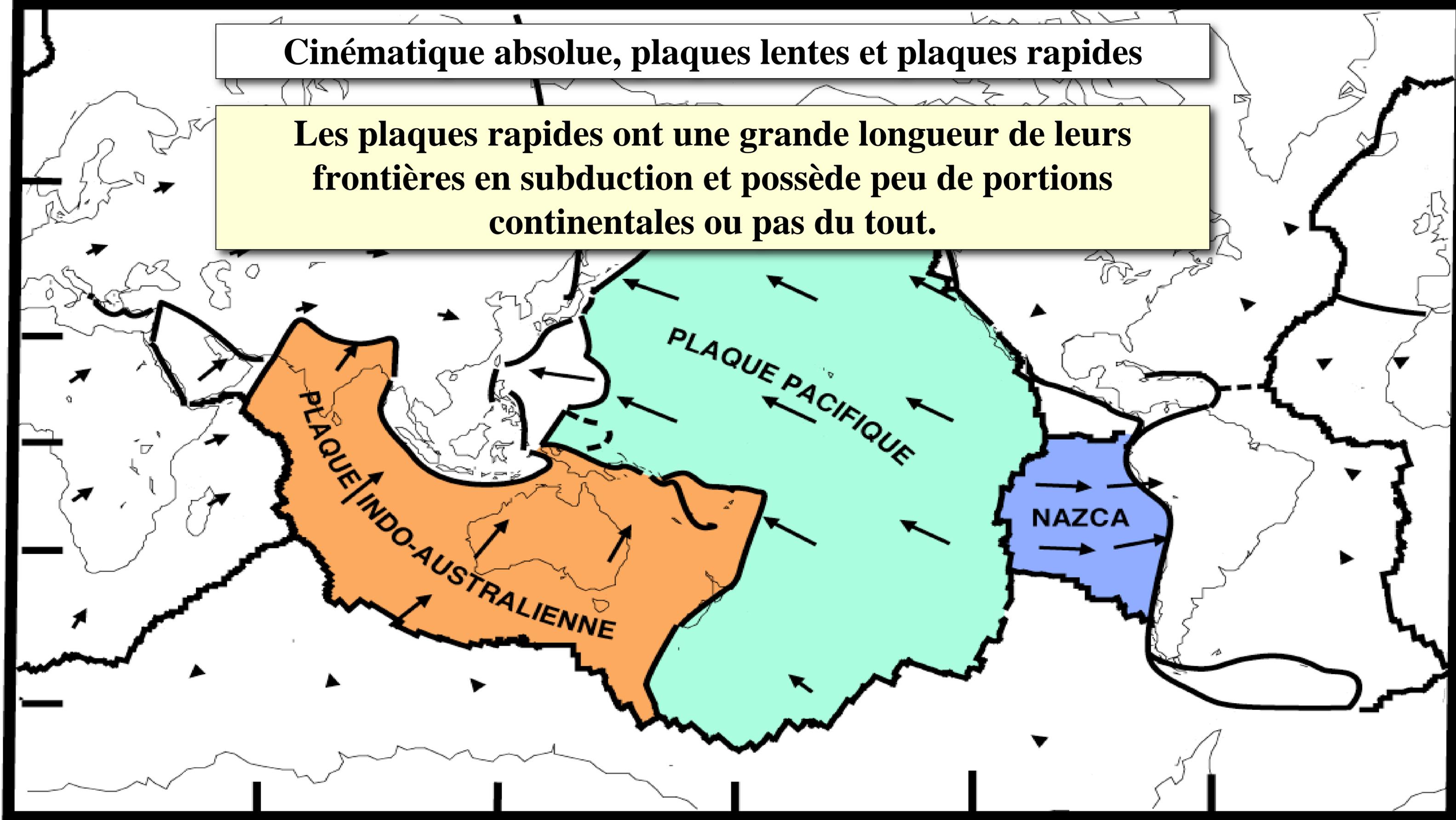
120

60

PLAQUE INDO-AUSTRALIENNE

PLAQUE PACIFIQUE

NAZCA



Racines des points chauds dans le manteau inférieur, les panaches mantelliques

Points-chauds

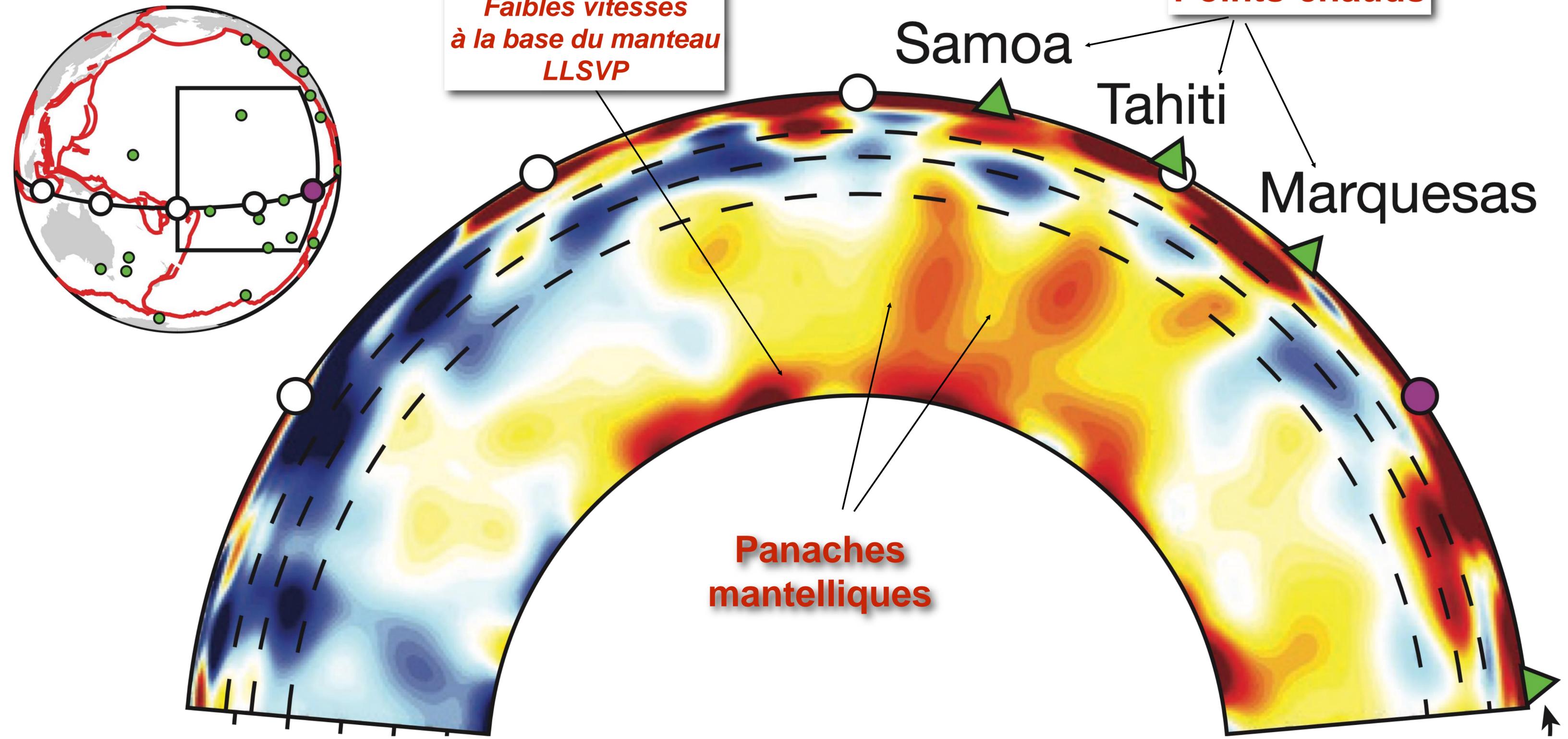
Faibles vitesses
à la base du manteau
LLSVP

Samoa

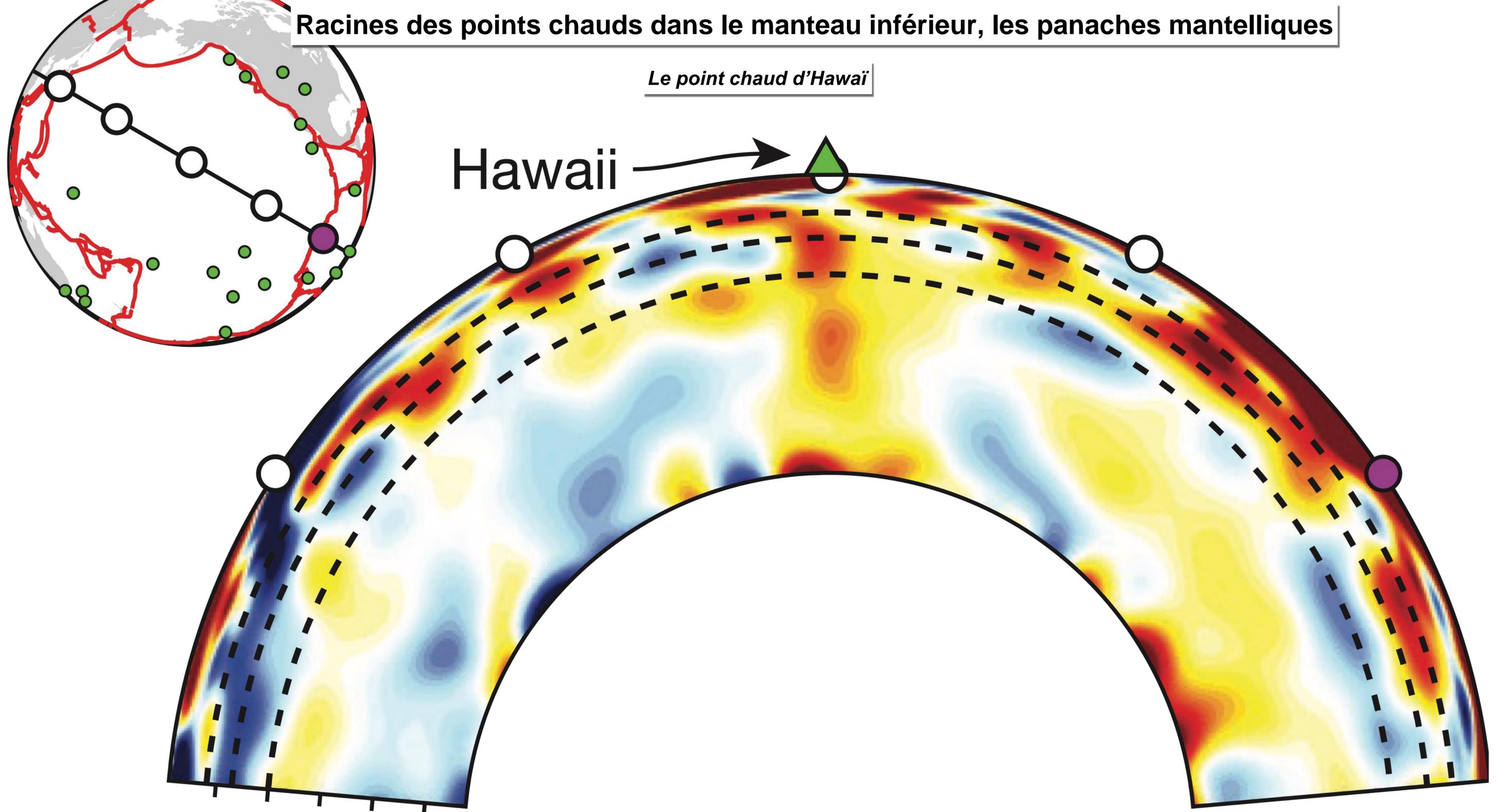
Tahiti

Marquesas

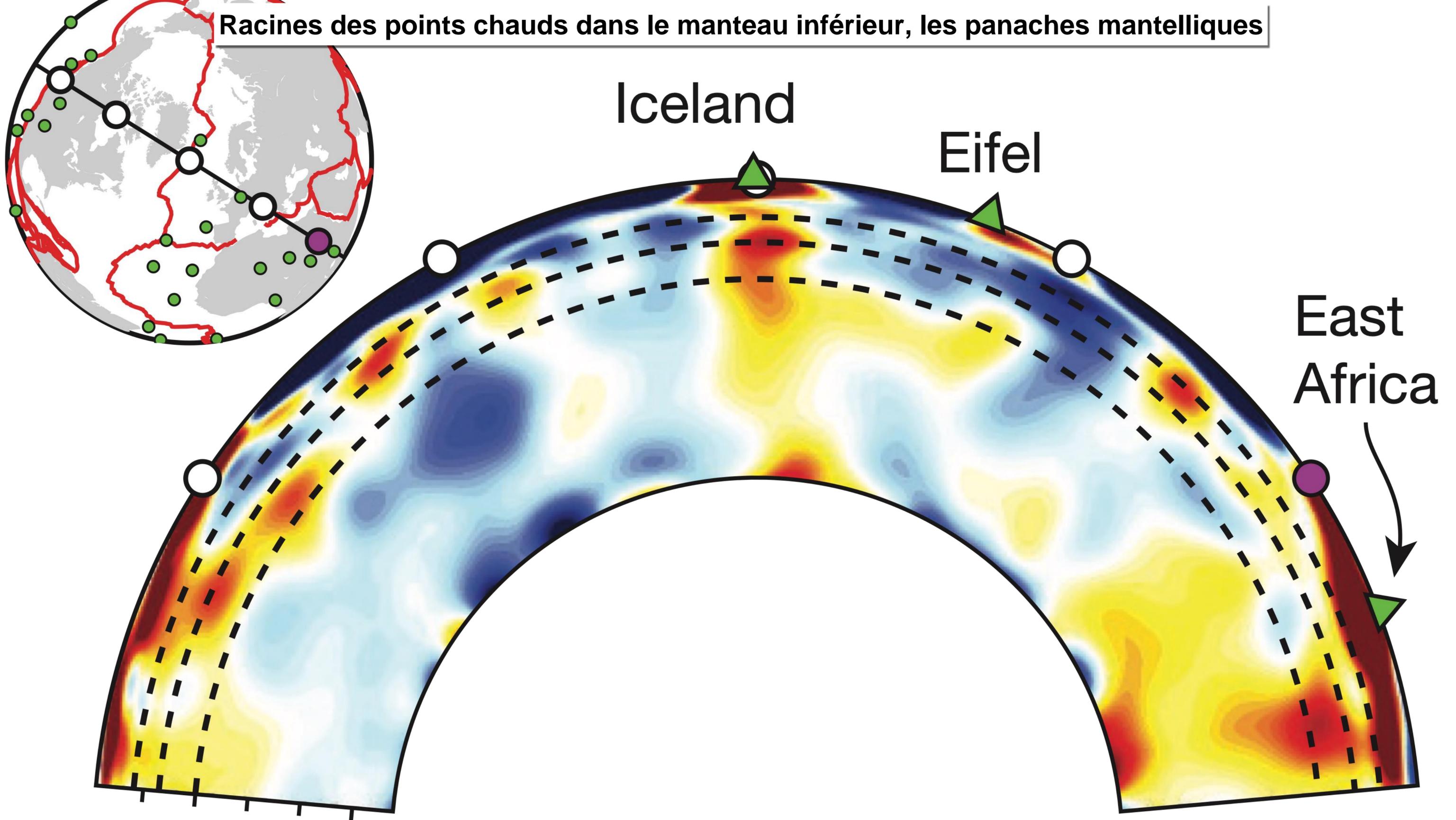
Panaches
mantelliques

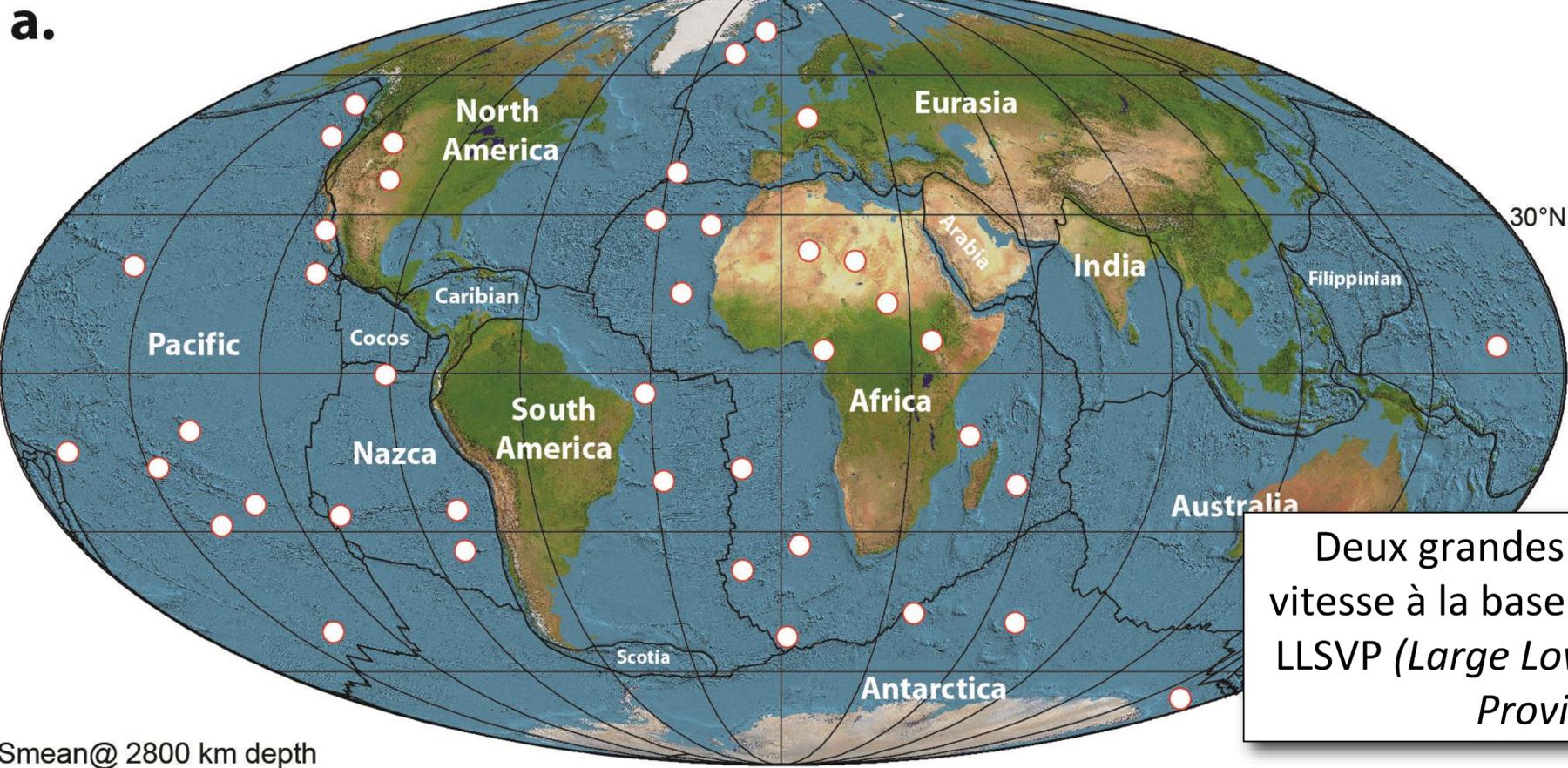


Racines des points chauds dans le manteau inférieur, les panaches mantelliques

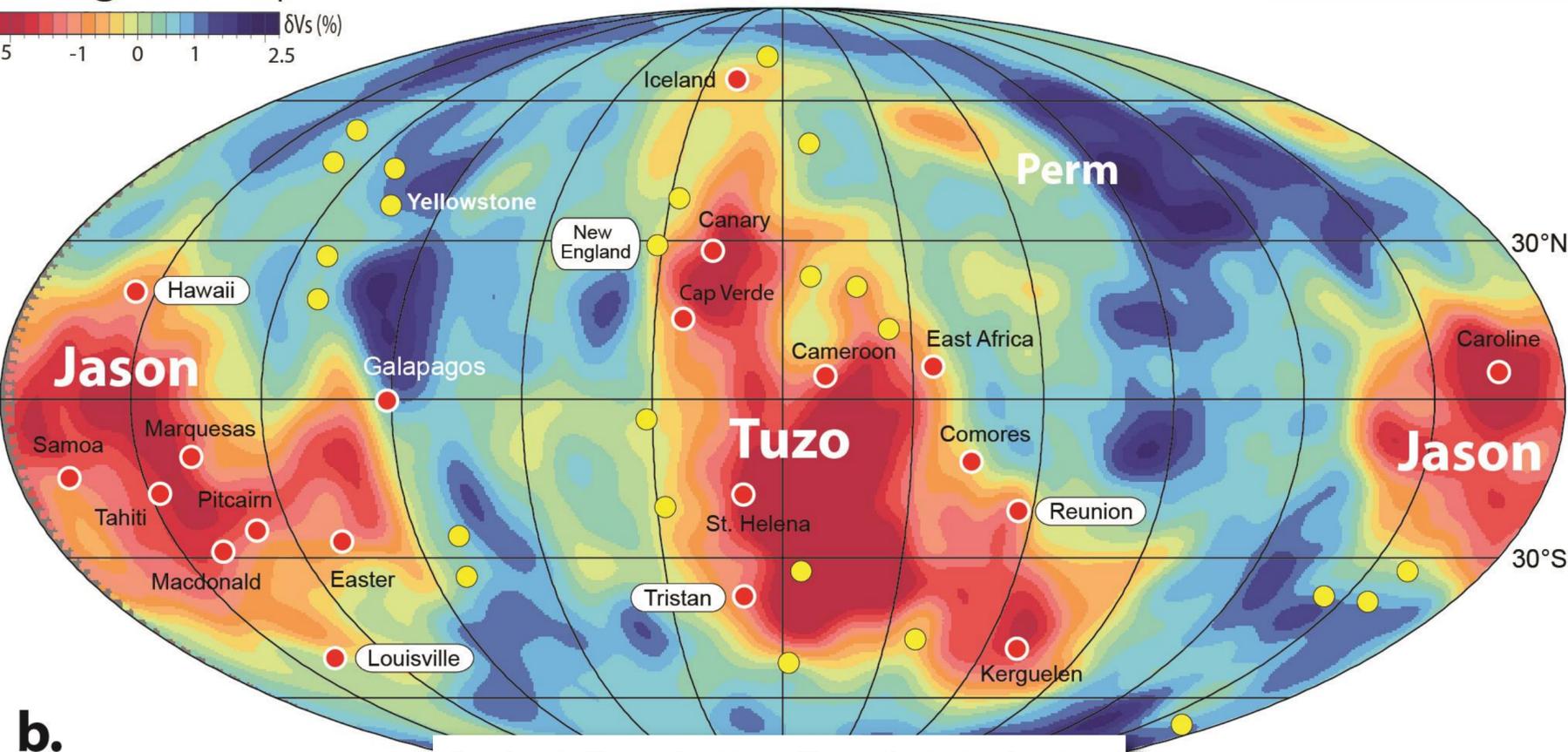
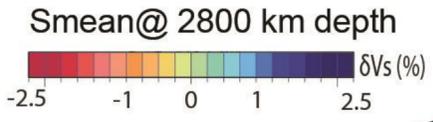
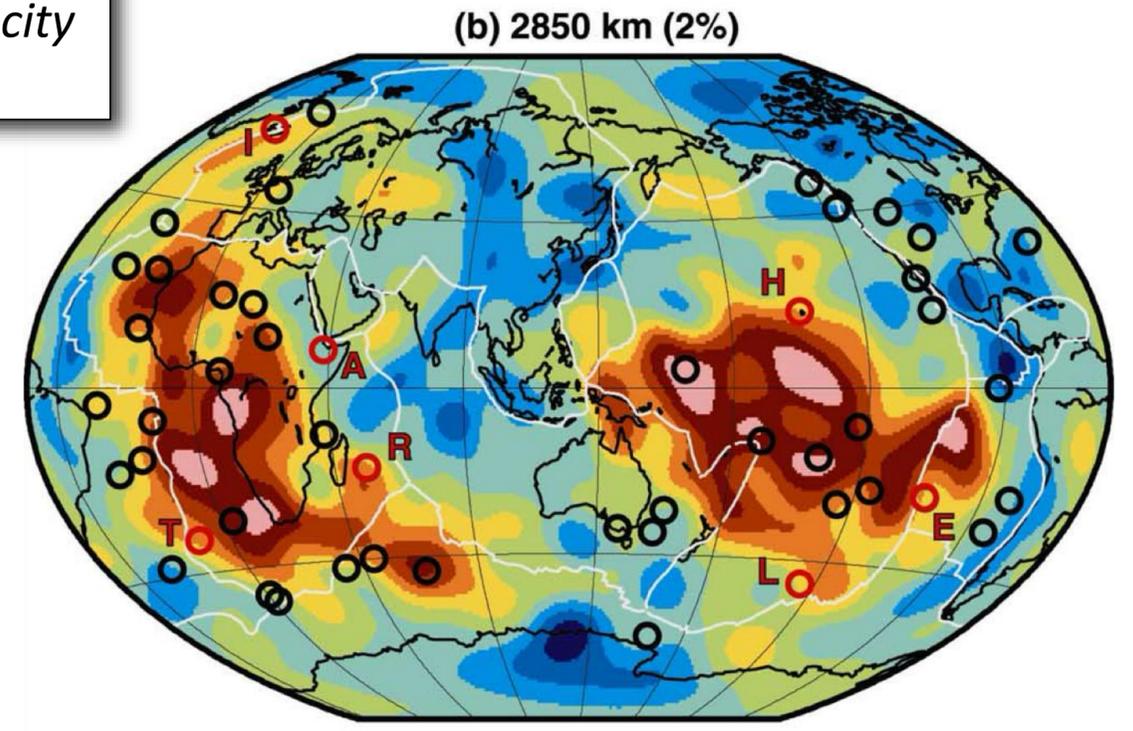
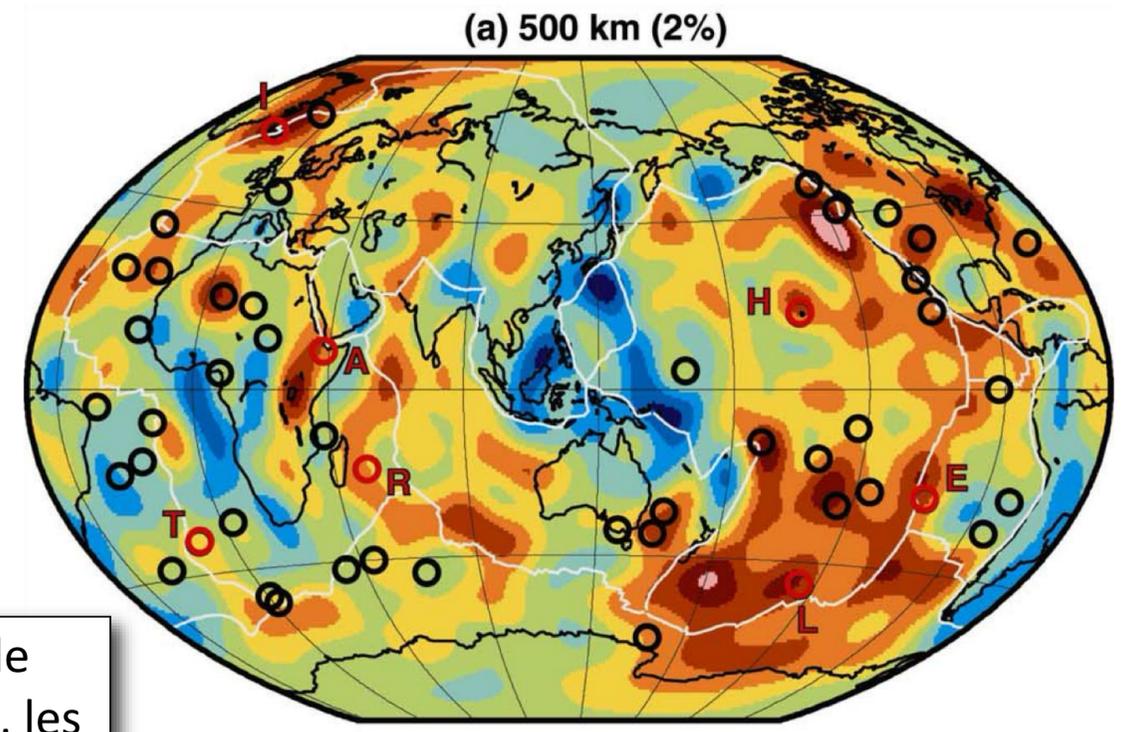


Racines des points chauds dans le manteau inférieur, les panaches mantelliques





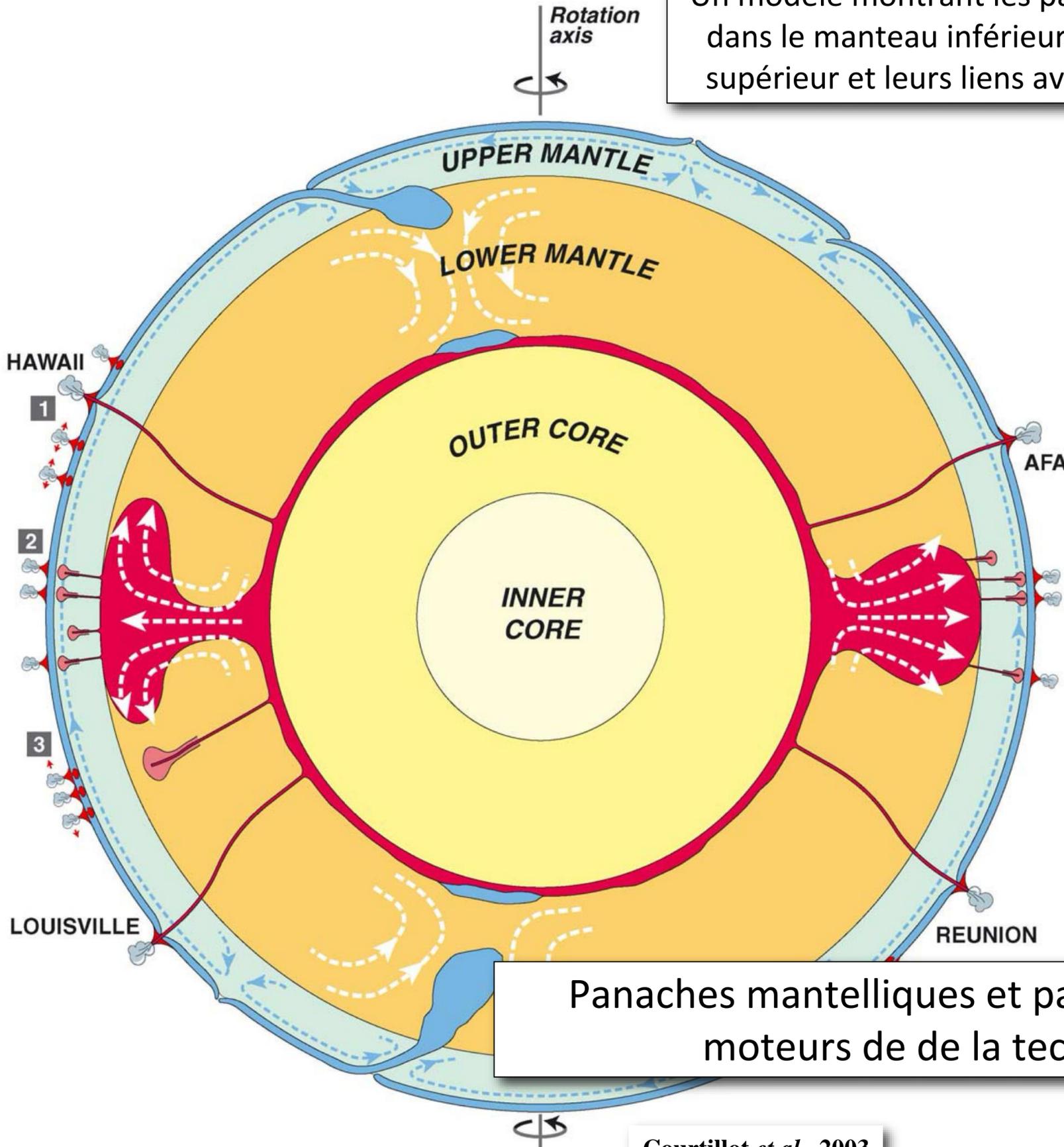
Deux grandes zones à faible vitesse à la base du manteau, les LLSVP (*Large Low Shear Velocity Provinces*)



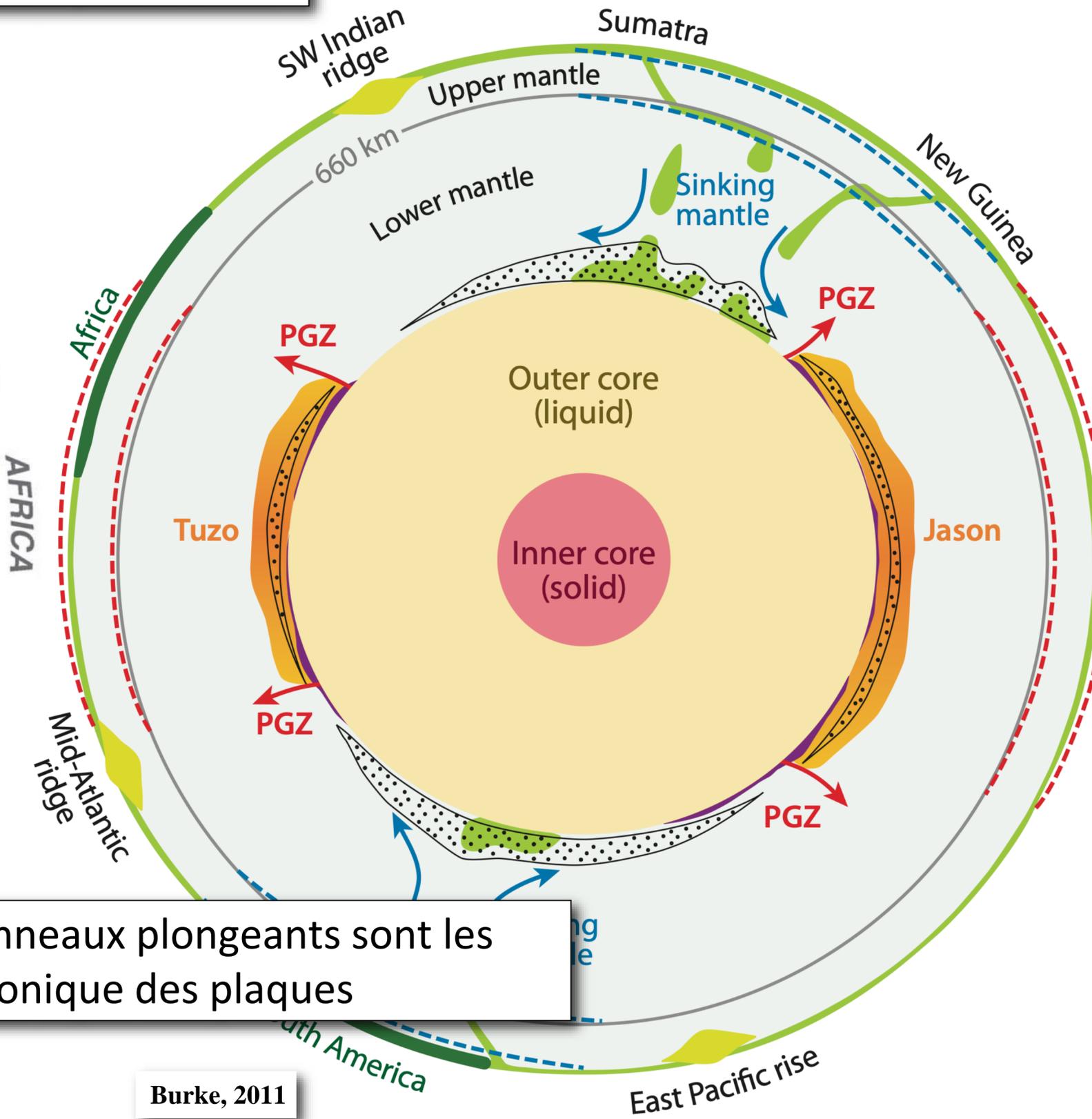
b. Burke & Torsvik, 2004; Torsvik & Cocks, 2016

Courtilot *et al.*, 2003

Un modèle montrant les panaches mantelliques dans le manteau inférieur et dans le manteau supérieur et leurs liens avec les points chauds



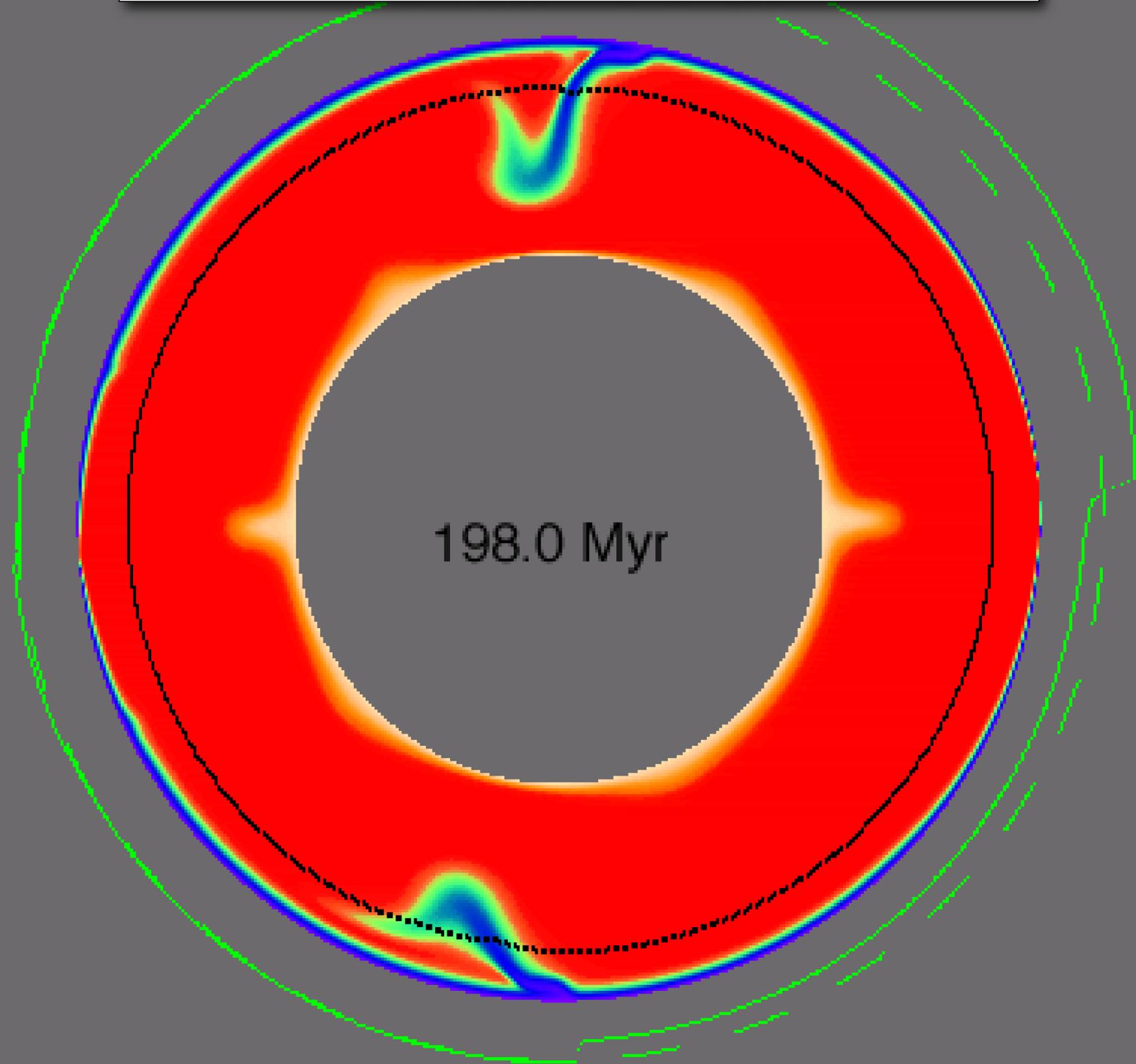
Courtilot et al., 2003



Burke, 2011

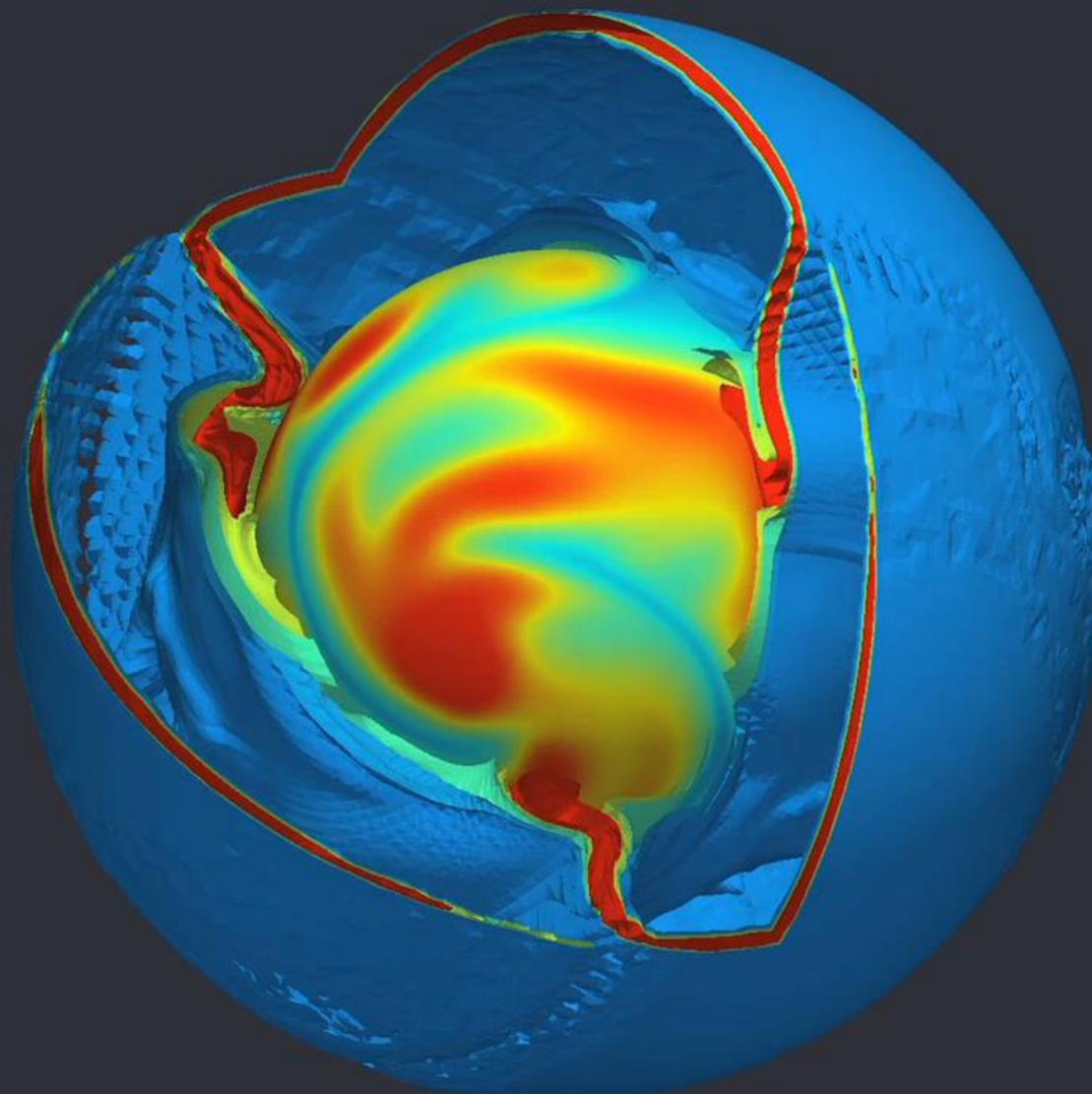
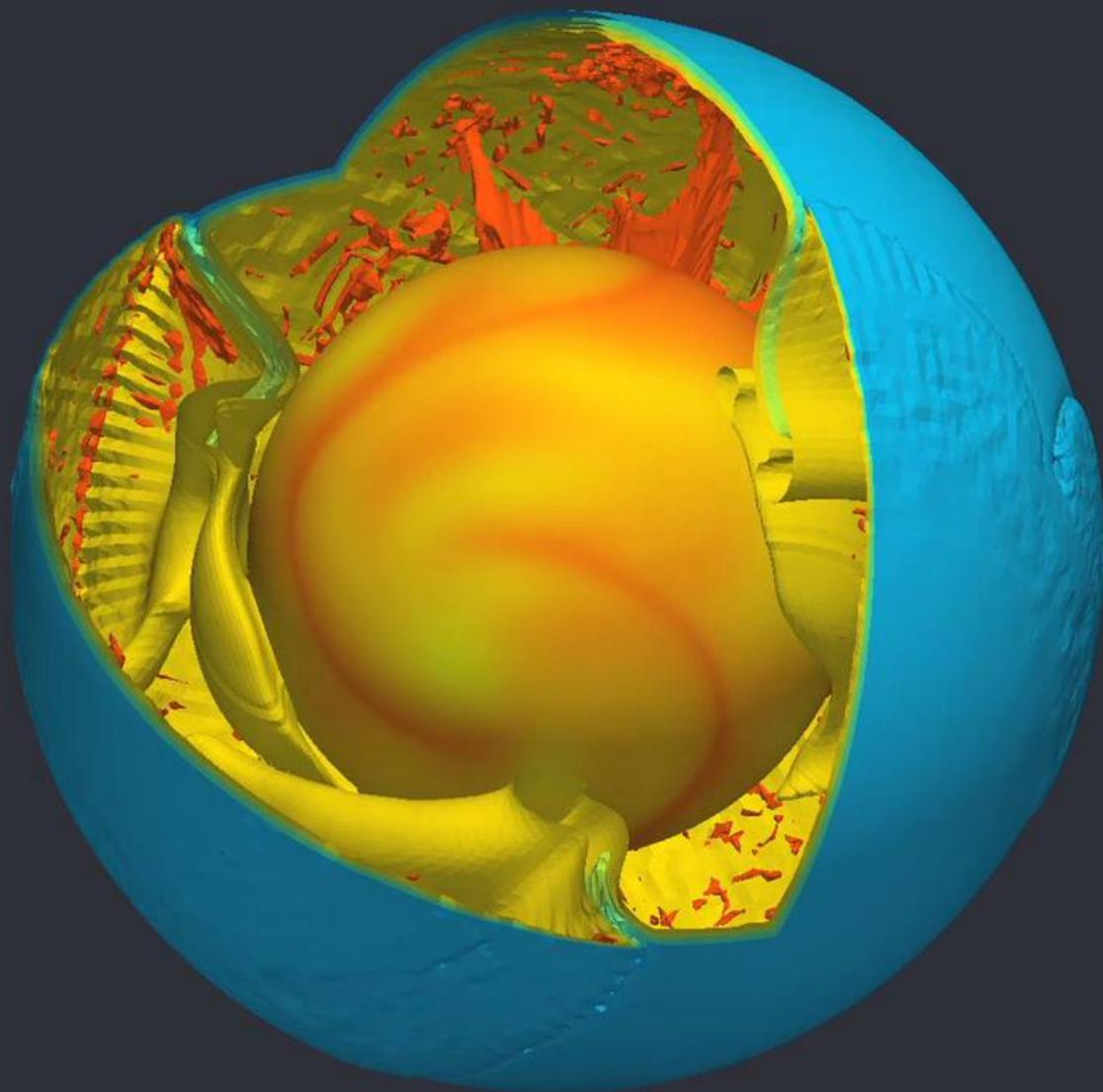
Panaches mantelliques et panneaux plongeants sont les moteurs de de la tectonique des plaques

Convection mantellique



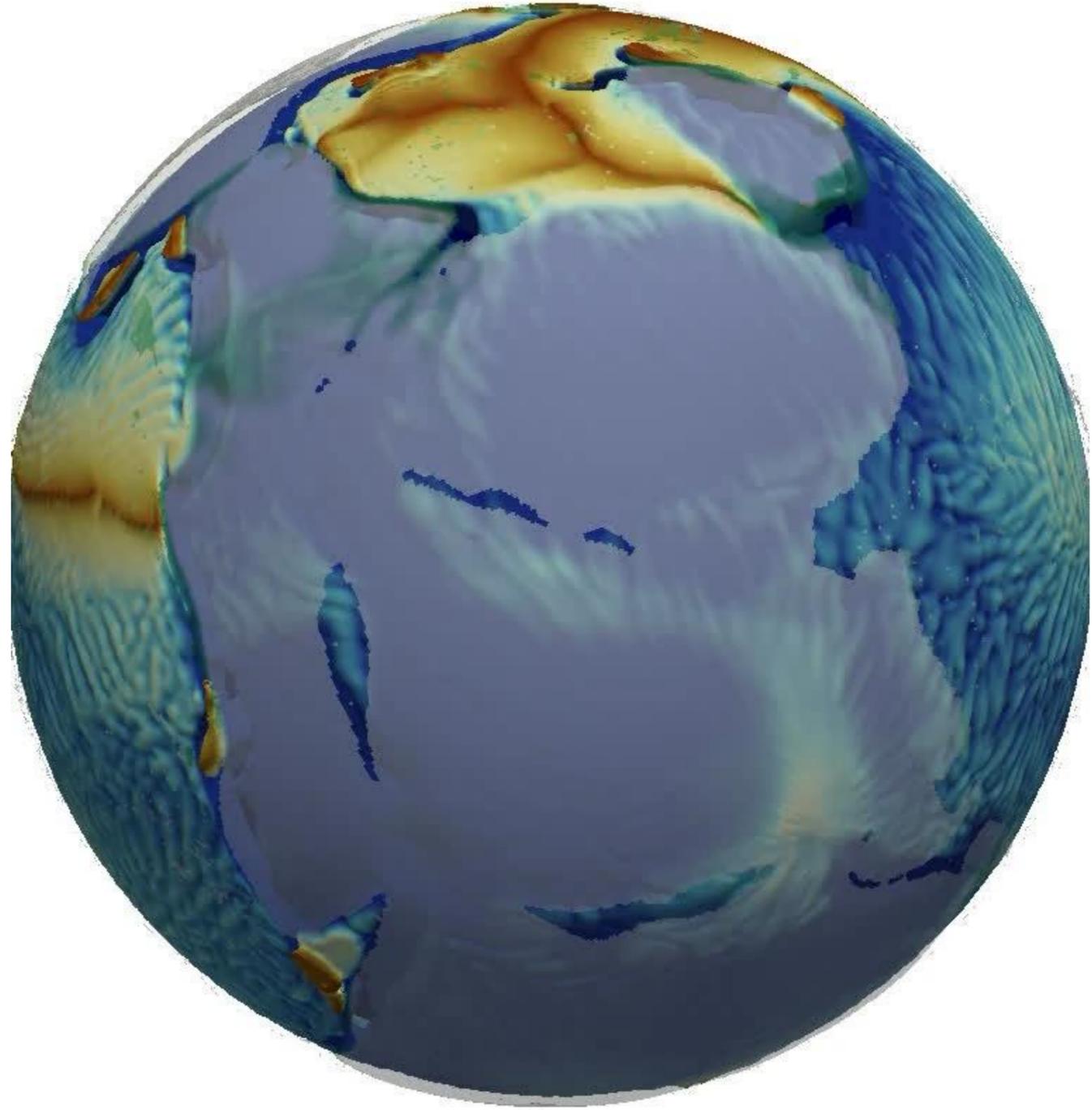
Michael Gurnis, Caltech

Dynamique de la lithosphère pendant la convection



Rolf et al., 2012

Recul des zones de subduction



Coltice et al., 2019