

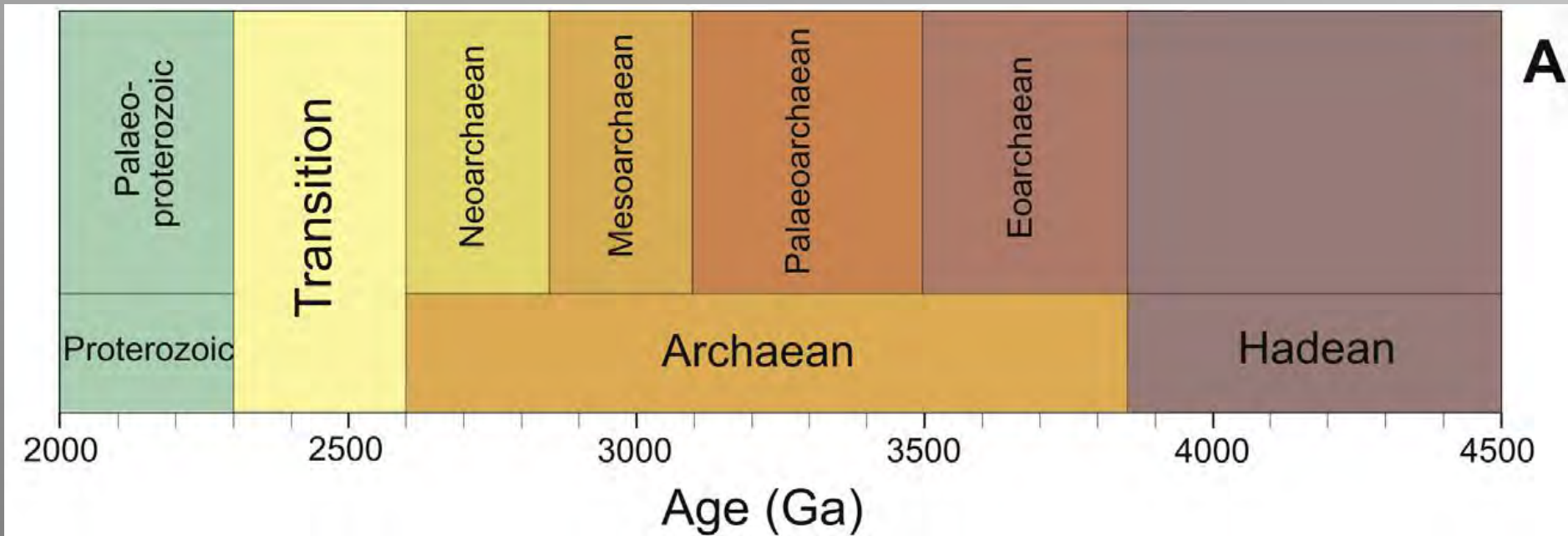
DYNAMIQUE DE LA TERRE

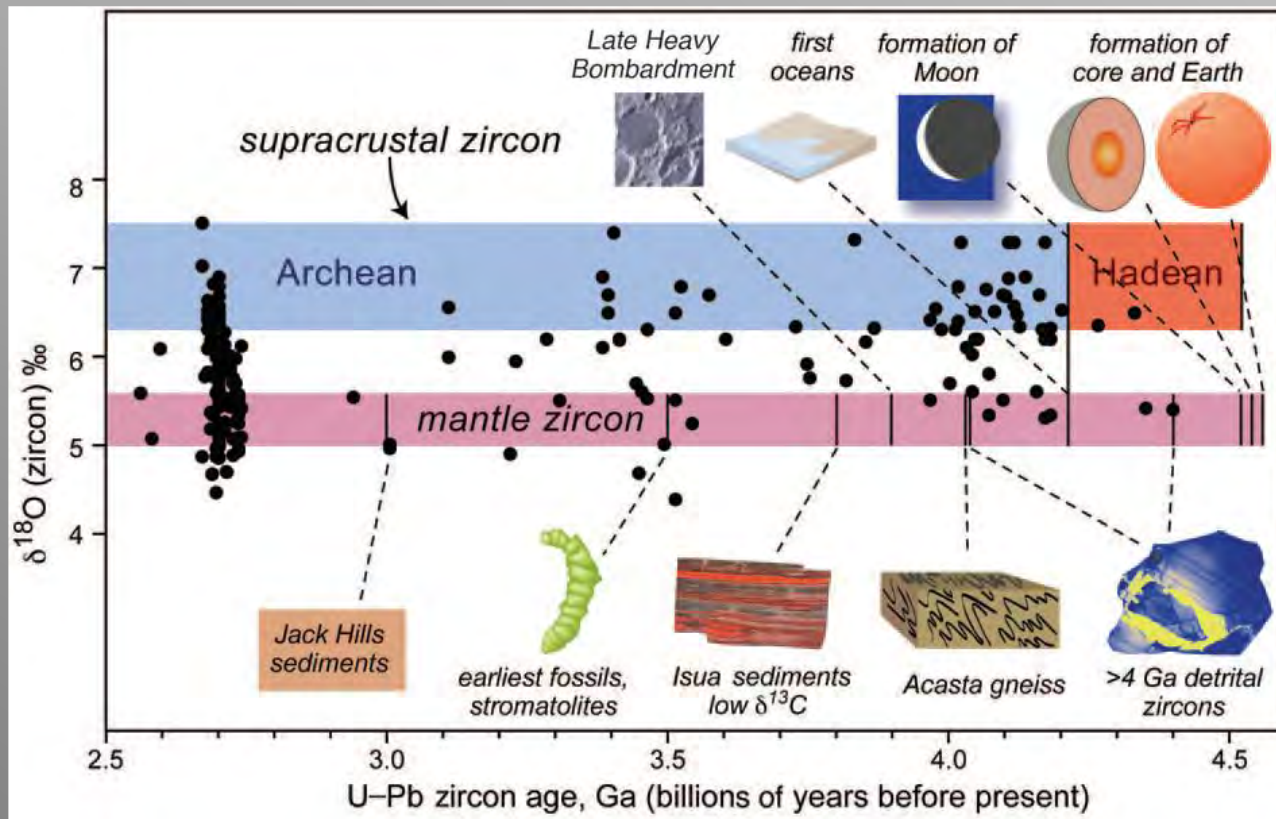
- TERRE PRIMITIVE

- ORIGINE ET EVOLUTION DE LA CROUTE CONTINENTALE

- RECYCLAGE

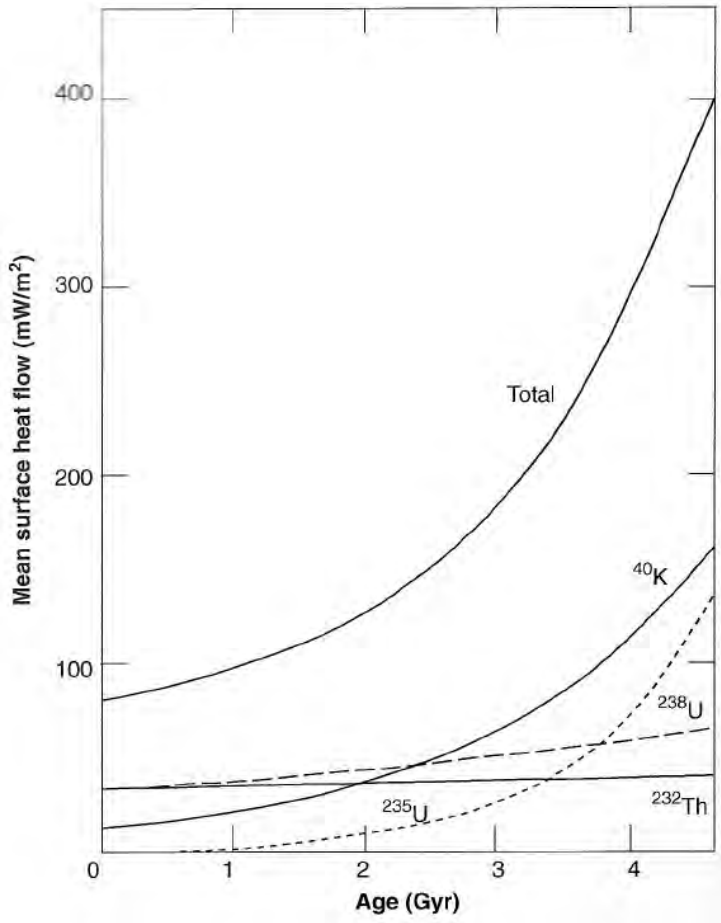
TERRE PRIMITIVE

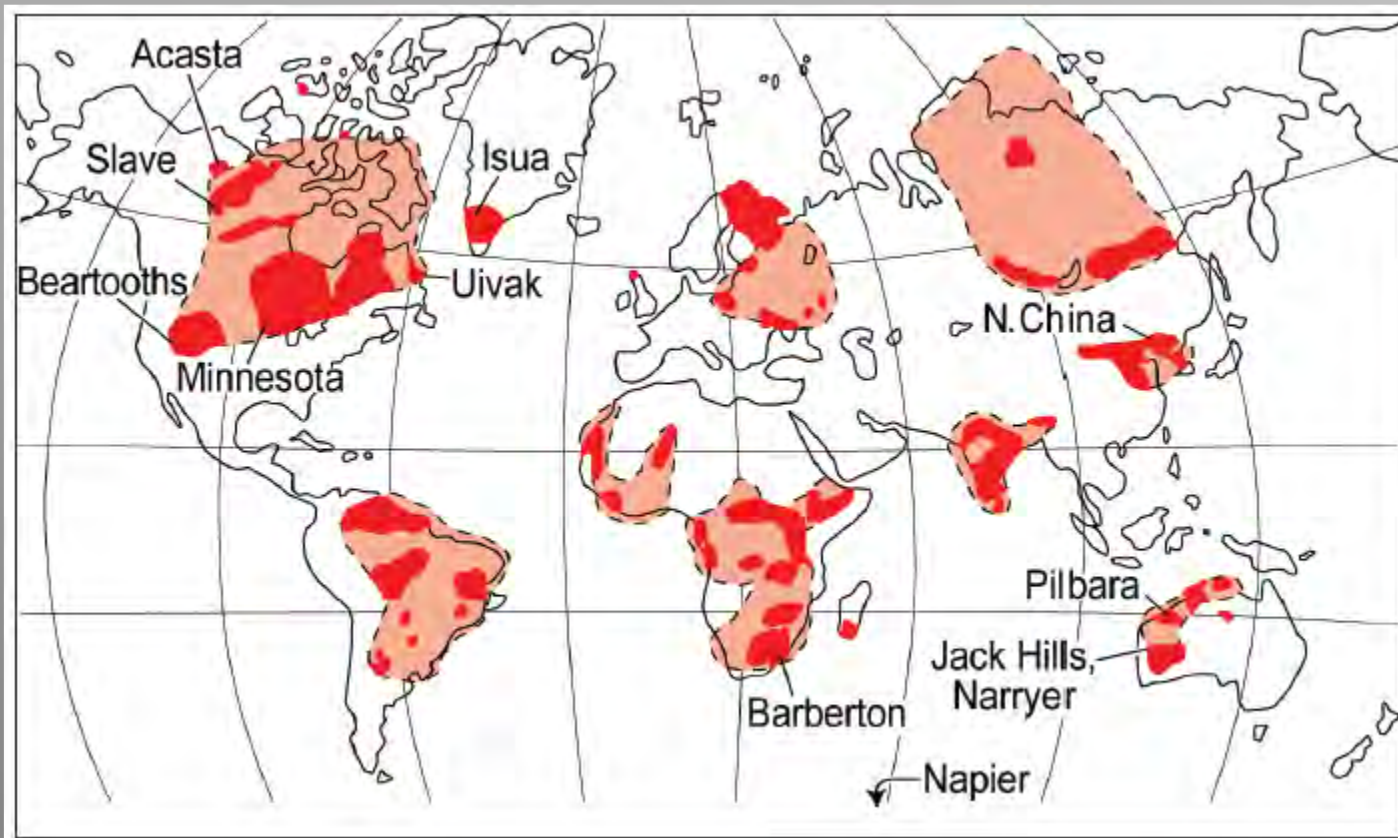






Décroissance du flux de chaleur avec le temps





Orange: Zones plus anciennes que 2,5 Ga

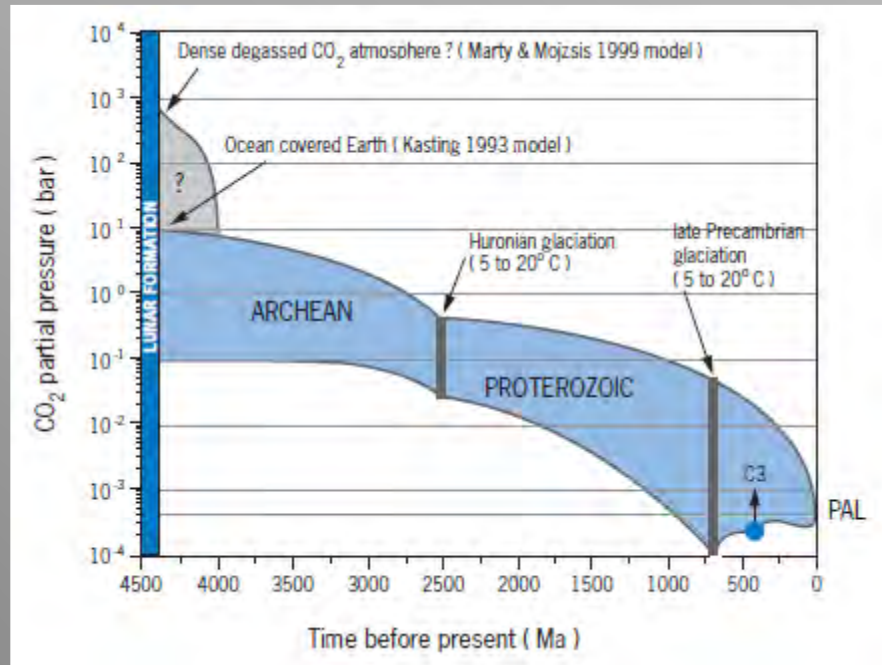
Orange clair: Zones supposées plus anciennes que 2,5 Ga

Noms: Régions avec roches ou zircons > 3,6 Ga

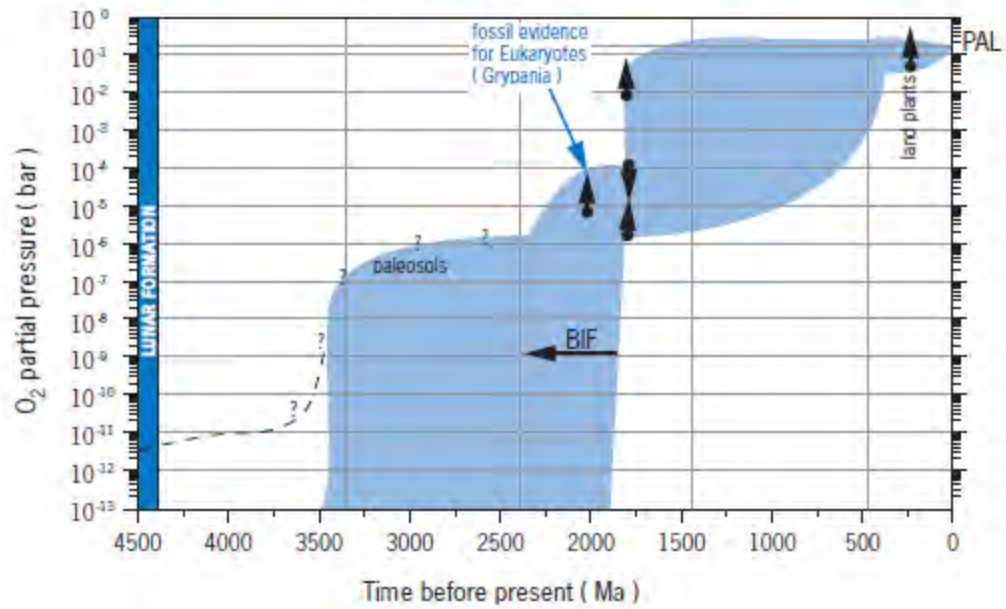
Bombardement météoritique



Origine et évolution de l'atmosphère



Partial Pressure of O₂ in the Atmosphere Over Time





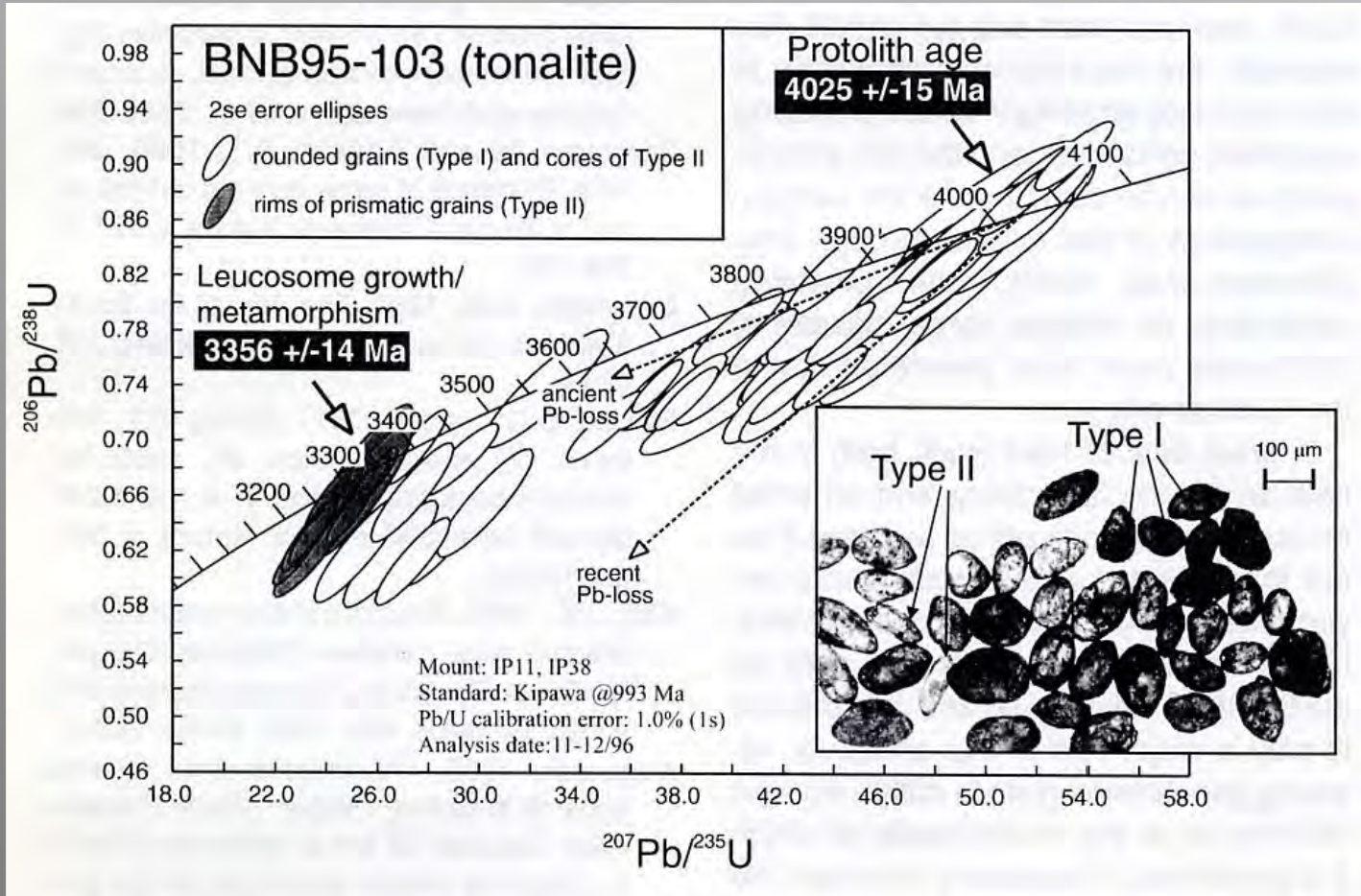
Terre chaude ou Terre froide?



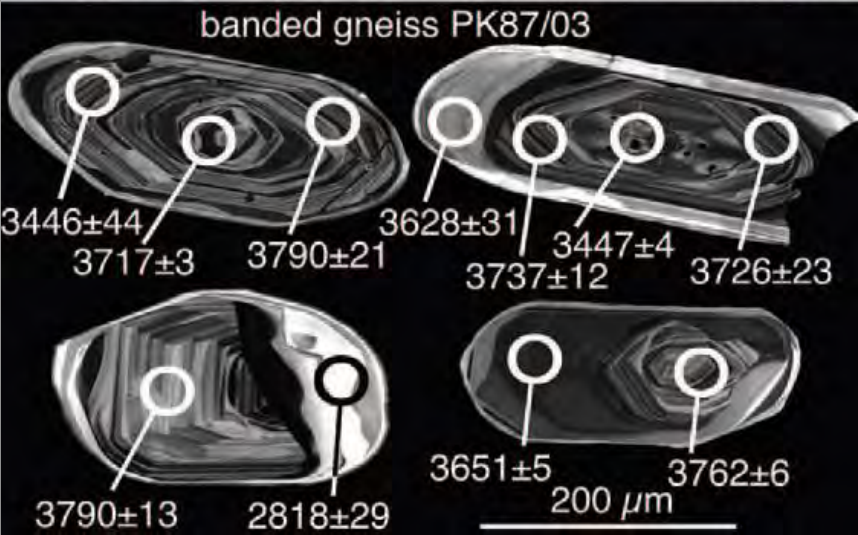
Gneiss d'Acasta (Canada)



Les plus anciennes roches sur Terre



Gneiss d'Itsaq (Groenland)



Des pillow-lavas et des sédiments

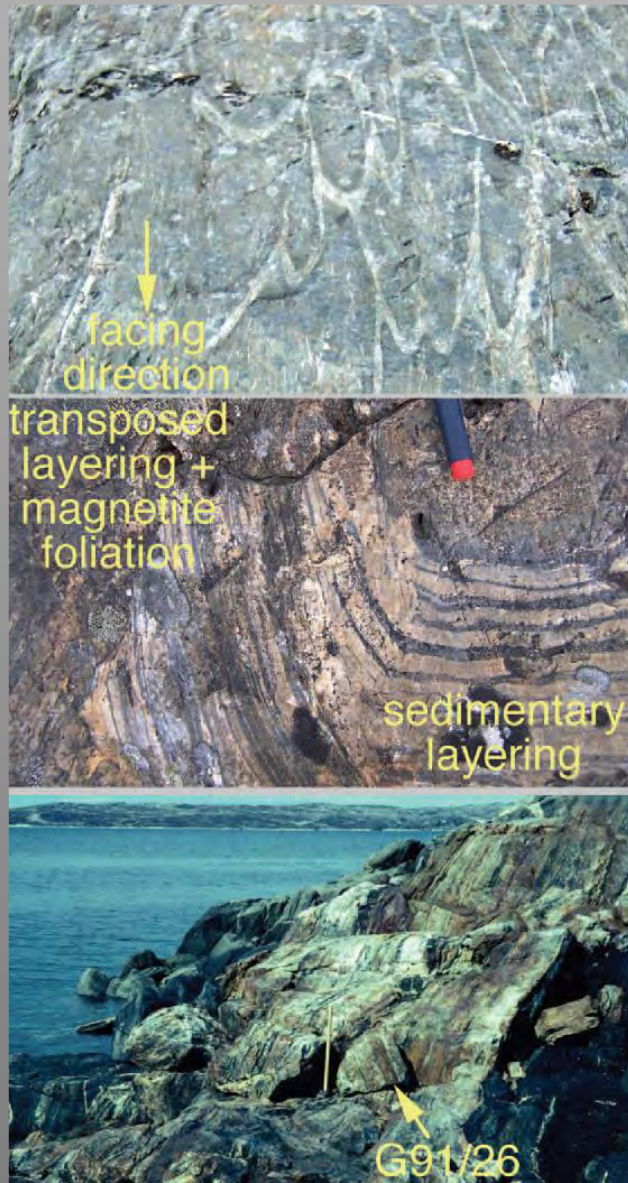
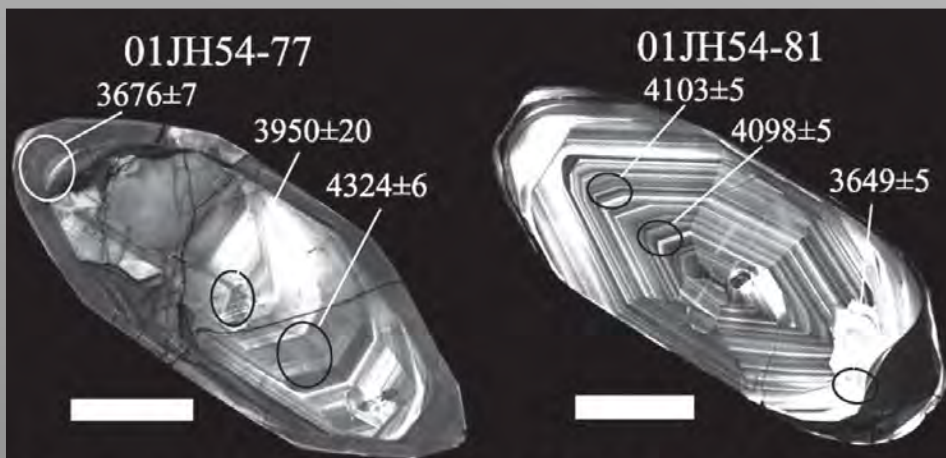


FIGURE 3 Candidates for the oldest volcanic and sedimentary rocks from the Itsaq Gneiss Complex, southwest Greenland. (A) Rare pillow lava structure in Isua amphibolites (discovered by Komiya et al. 1999). The shape of the pillows is well-enough preserved to allow determination of the top direction (arrow indicates facing direction). (B) Low-strain area of the water-laid banded iron formation in the Isua supracrustal belt. Original, albeit deformed, sedimentary layering (right) is rotated, strongly attenuated and overgrown by a magnetite foliation to form the typical regional banding in these rocks (left). (C) Approximately 5 m thick siliceous layer in amphibolites, Akilia Island. G91/26 marks the site of a magnetite-bearing unit with trace element and iron isotope signatures similar to those in Isua BIF. This is the contested candidate for Earth's oldest preserved sediment.



Source: *Cavosie et al., 2004 Precam. Res.*; *Valley et al., 2006 Science*

Les plus anciens zircons

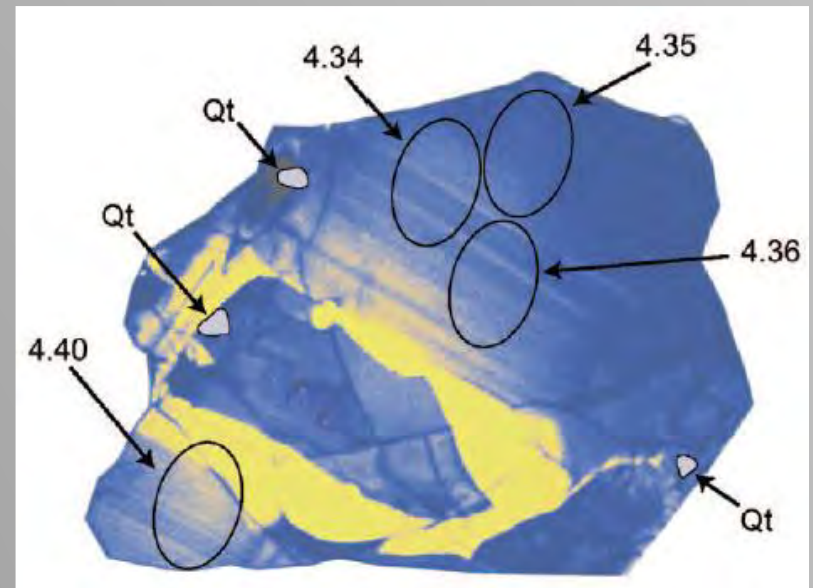
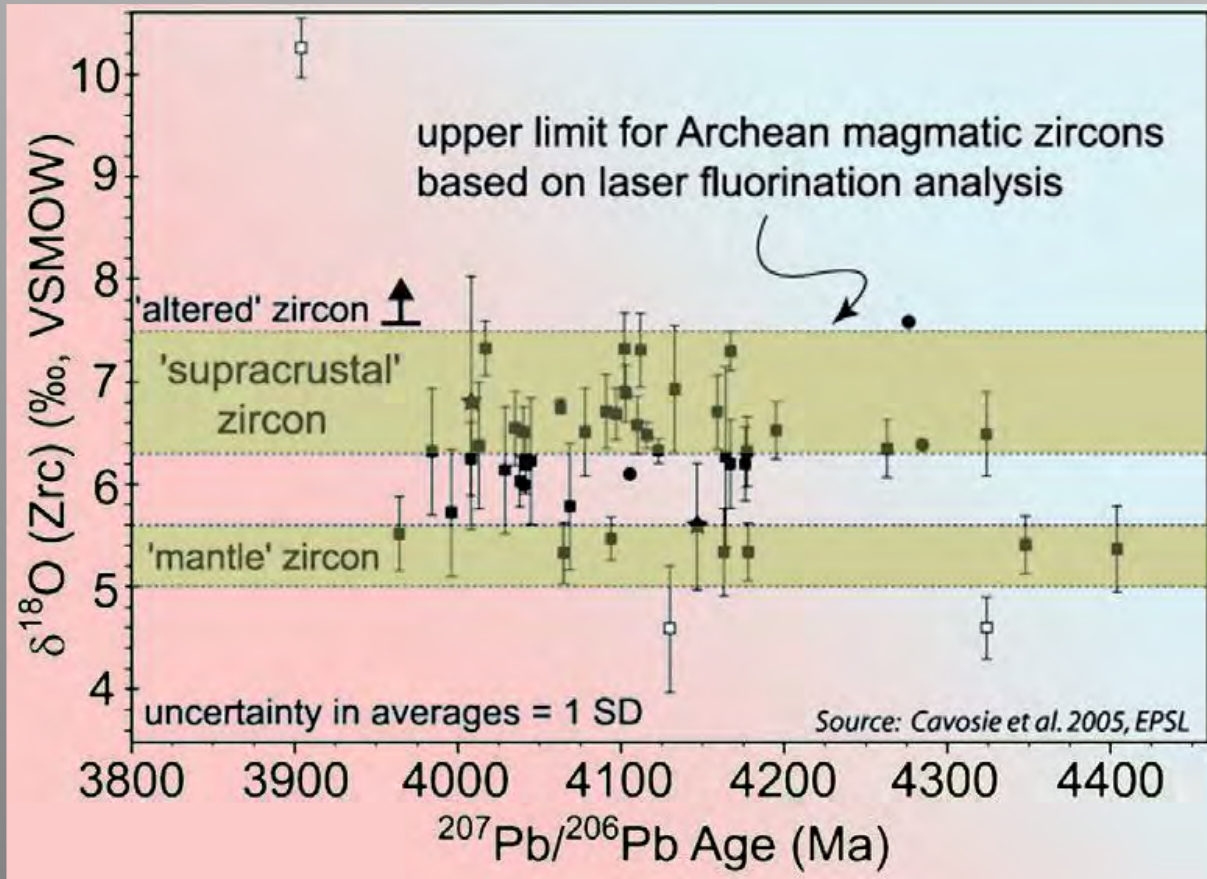
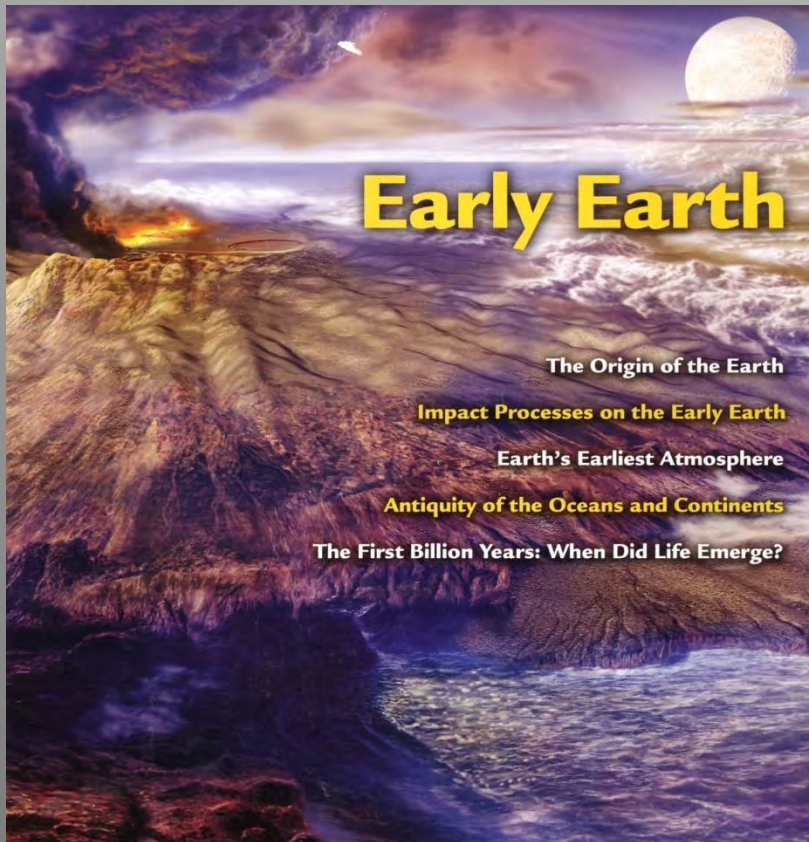


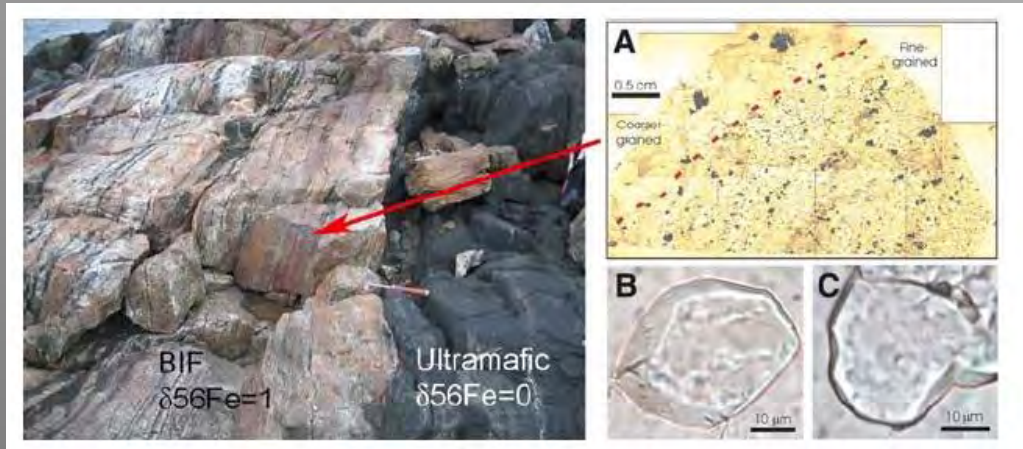
FIGURE 4 False colour cathodoluminescence image of the 200 μm diameter, approximately 4.4 Ga Jack Hills zircon. This zircon is the oldest-known part of Earth. Ion microprobe analytical sites are indicated by black ellipses with ages in billions of years. Qt denotes quartz inclusions in the zircon crystal. IMAGE SUPPLIED BY JOHN VALLEY



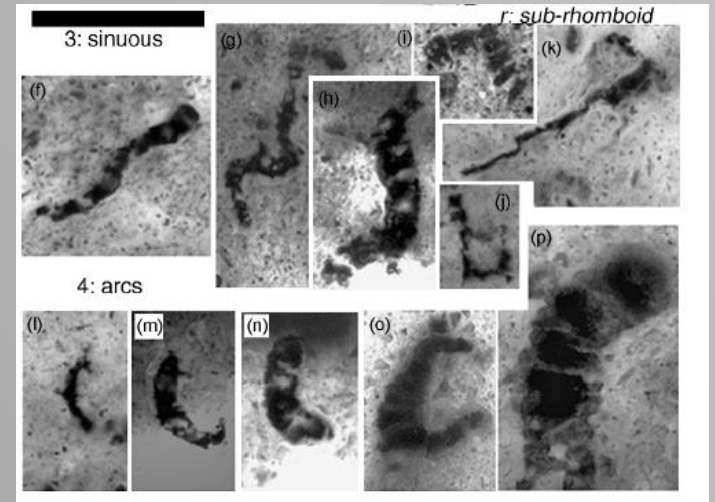
Où la vie est-elle apparue ?



Origine de la vie



Akilia, Gröenland, 3,8 Ga



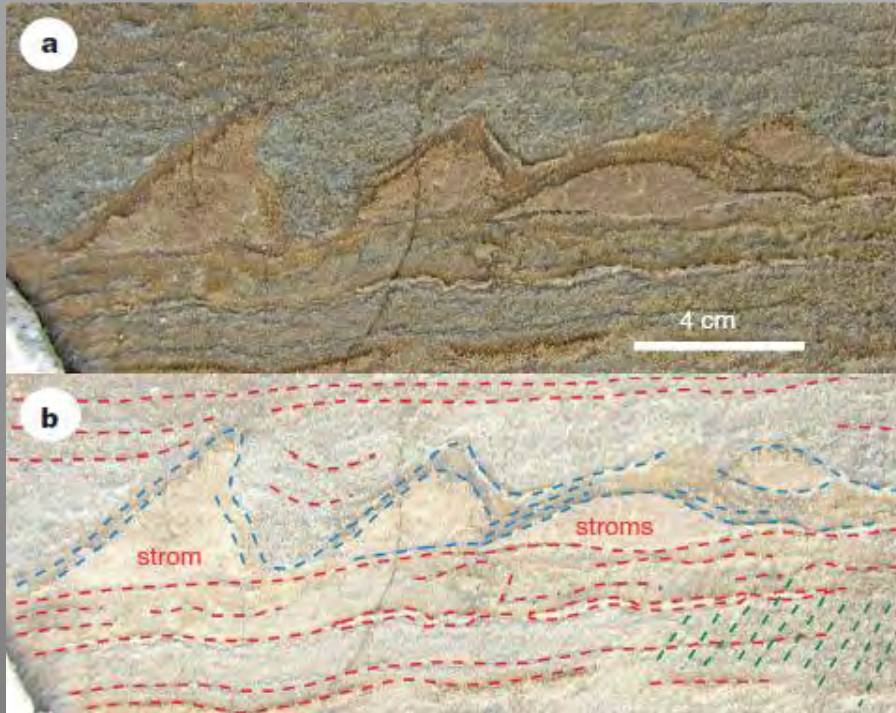
Premiers vrais fossiles:
3.5 milliards d'années ?

LETTER

doi:10.1038/nature19355

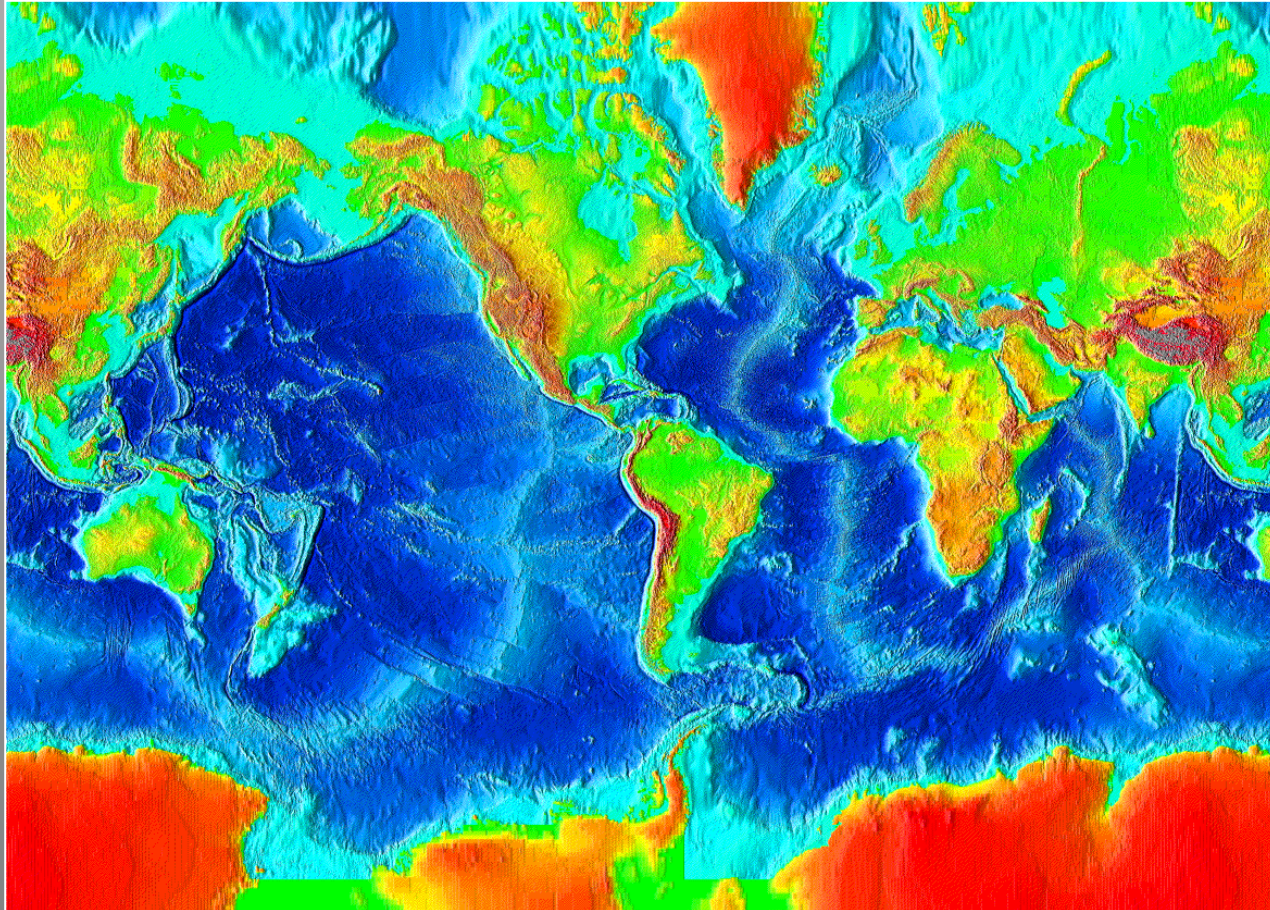
Rapid emergence of life shown by discovery of 3,700-million-year-old microbial structures

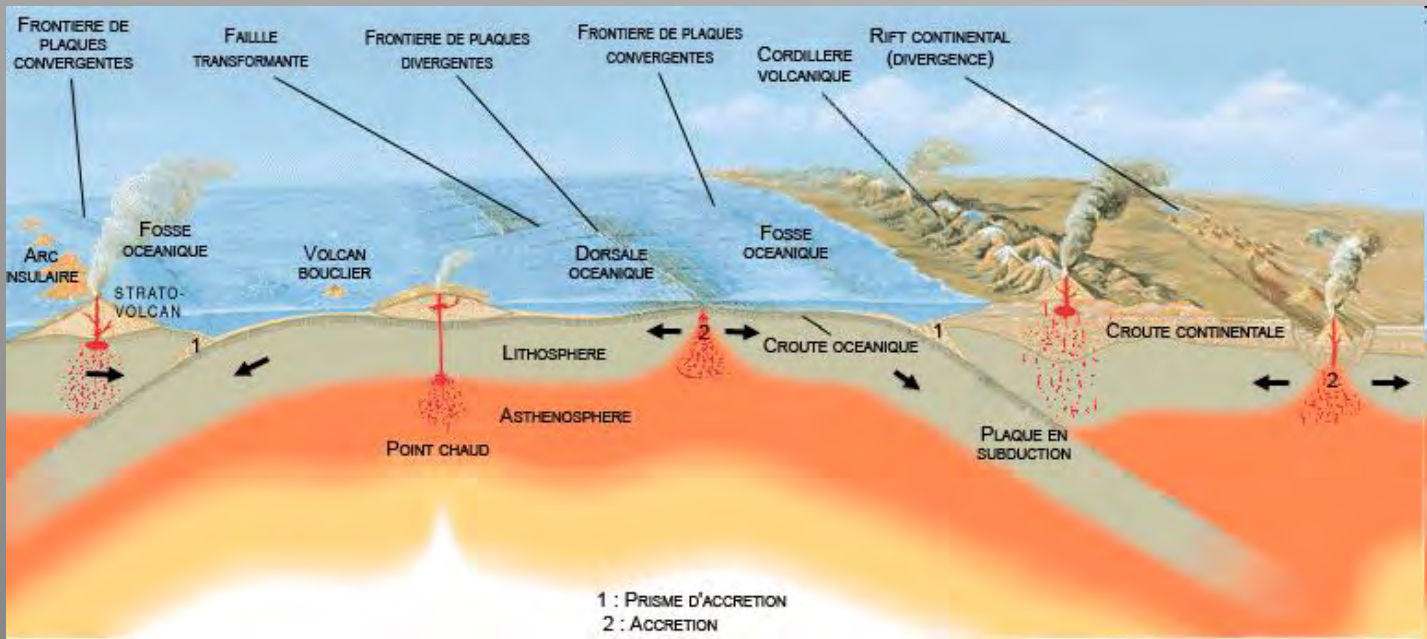
Allen P. Nutman^{1,2}, Vickie C. Bennett³, Clark R. L. Friend⁴, Martin J. Van Kranendonk^{2,5,6} & Allan R. Chivas¹



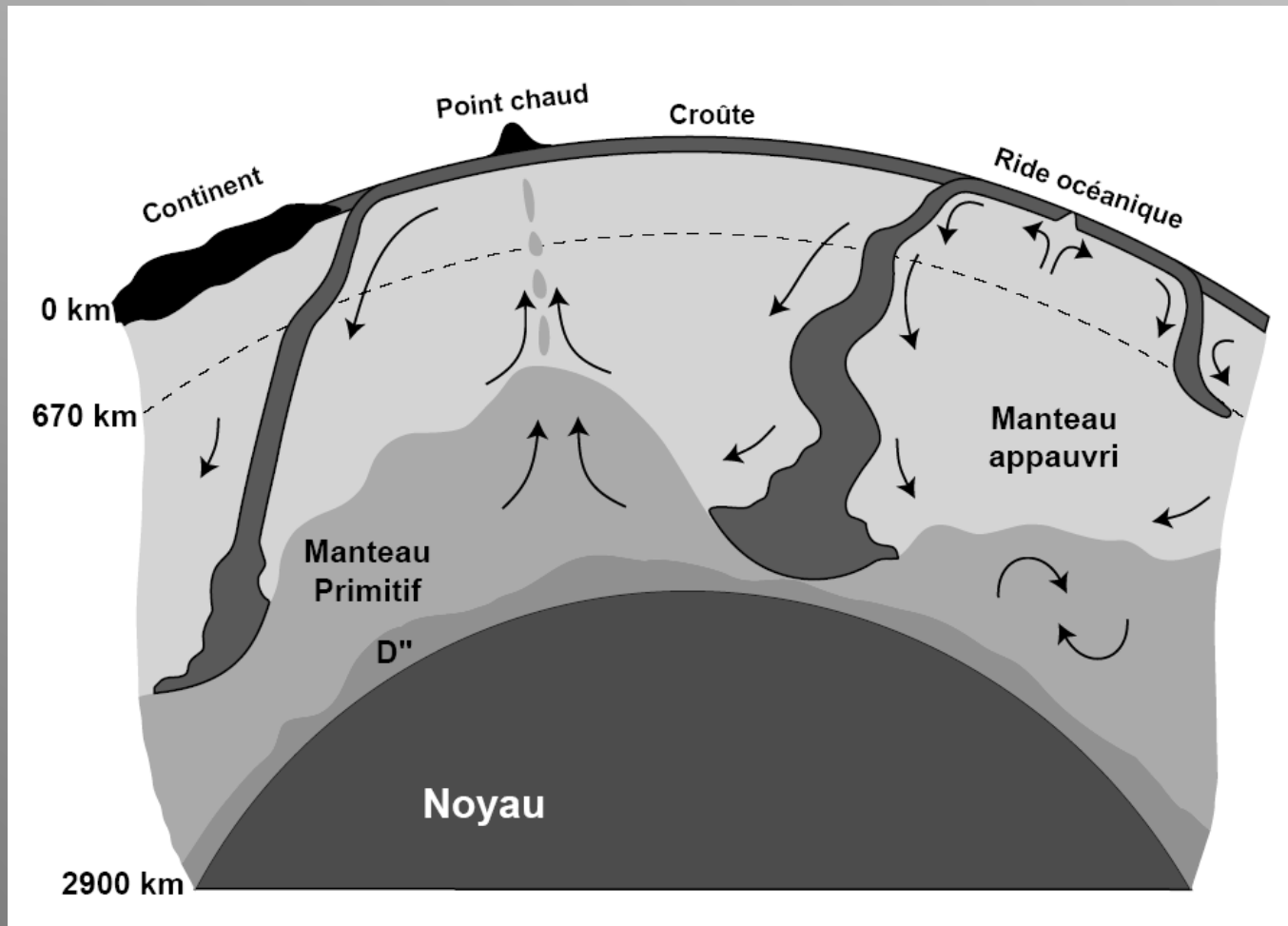
Biological activity is a major factor in Earth's chemical cycles, including facilitating CO₂ sequestration and providing climate feedbacks. Thus a key question in Earth's evolution is when did life arise and impact hydrosphere-atmosphere-lithosphere chemical cycles? Until now, evidence for the oldest life on Earth focused on debated stable isotopic signatures of 3,800–3,700 million year (Myr)-old metamorphosed sedimentary rocks and minerals^{1,2} from the Isua supracrustal belt (ISB), southwest Greenland³. Here we report evidence for ancient life from a newly exposed outcrop of 3,700-Myr-old metacarbonate rocks in the ISB that contain 1–4-cm-high stromatolites—macroscopically layered structures produced by microbial communities. The ISB stromatolites grew in a shallow marine environment, as indicated by seawater-like rare-earth element plus yttrium trace element signatures of the metacarbonates, and by interlayered detrital sedimentary rocks with cross-lamination and storm-wave generated breccias. The ISB stromatolites predate by 220 Myr the previous most convincing and generally accepted multidisciplinary evidence for oldest life remains in the 3,480-Myr-old Dresser Formation of the Pilbara Craton, Australia^{4,5}. The presence of the ISB stromatolites demonstrates the establishment of shallow marine carbonate production with biotic CO₂ sequestration by 3,700 million years ago (Ma), near the start of Earth's sedimentary record. A sophistication of life by 3,700 Ma is in accord with genetic molecular clock studies placing life's origin in the Hadean eon (>4,000 Ma)⁶.

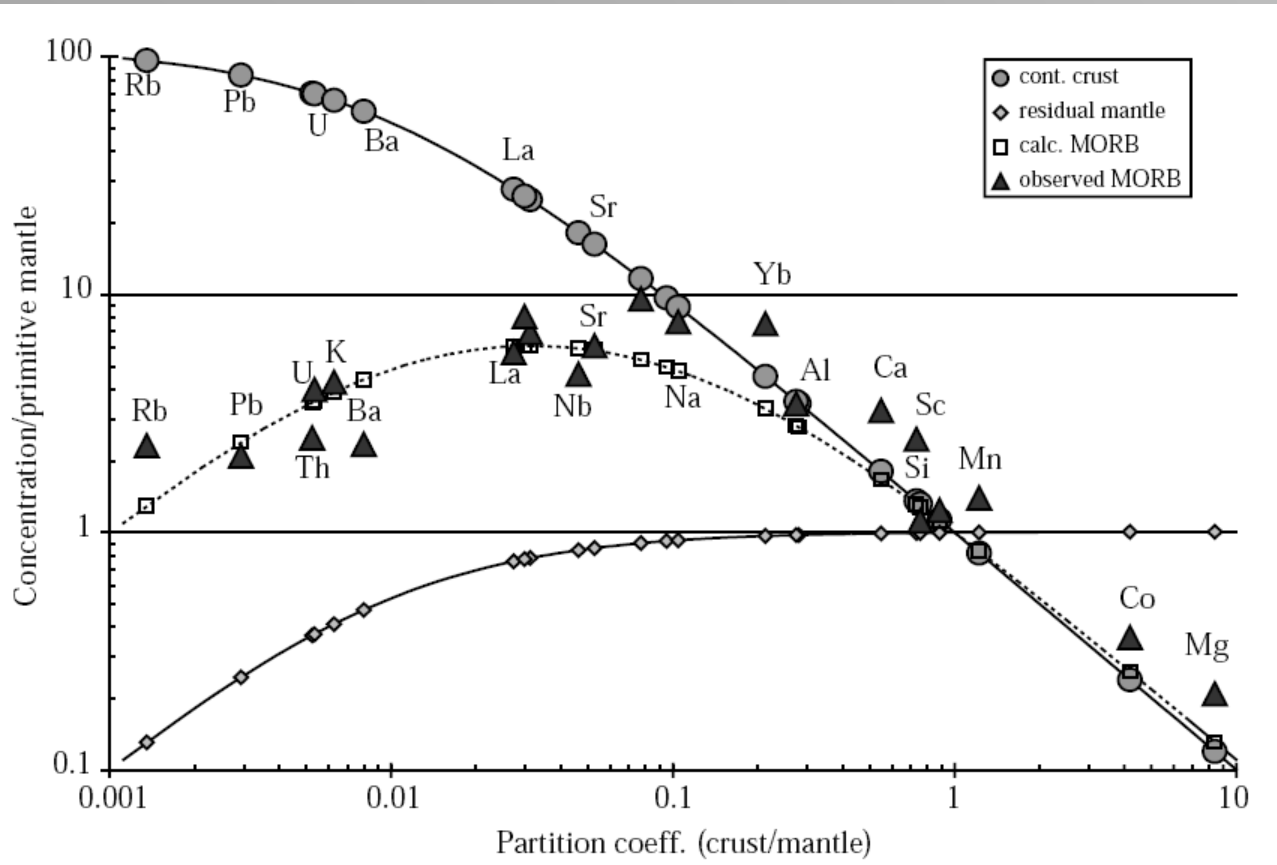
ORIGINE ET EVOLUTION DE LA CROUTE CONTINENTALE

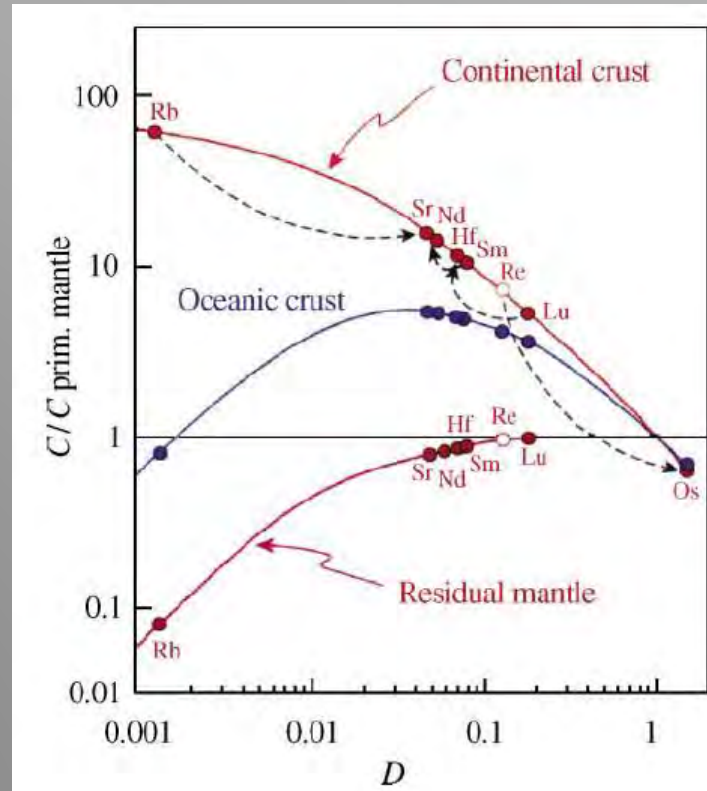
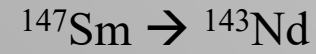
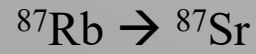




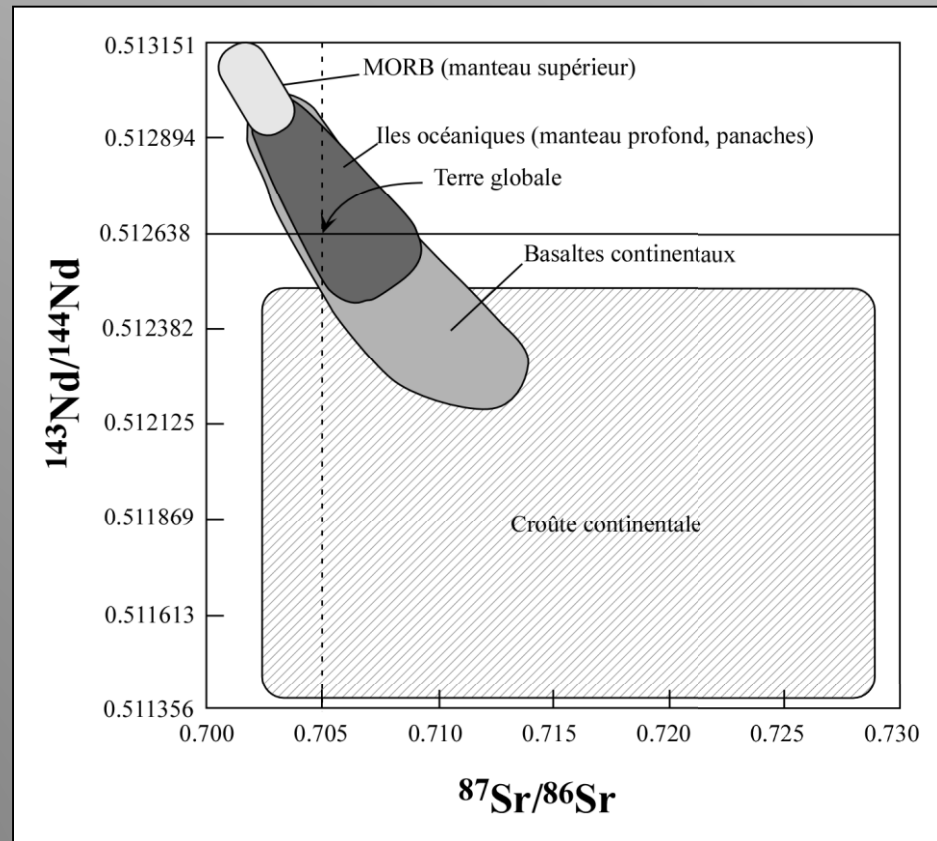
Vision moderne de la structure du manteau terrestre



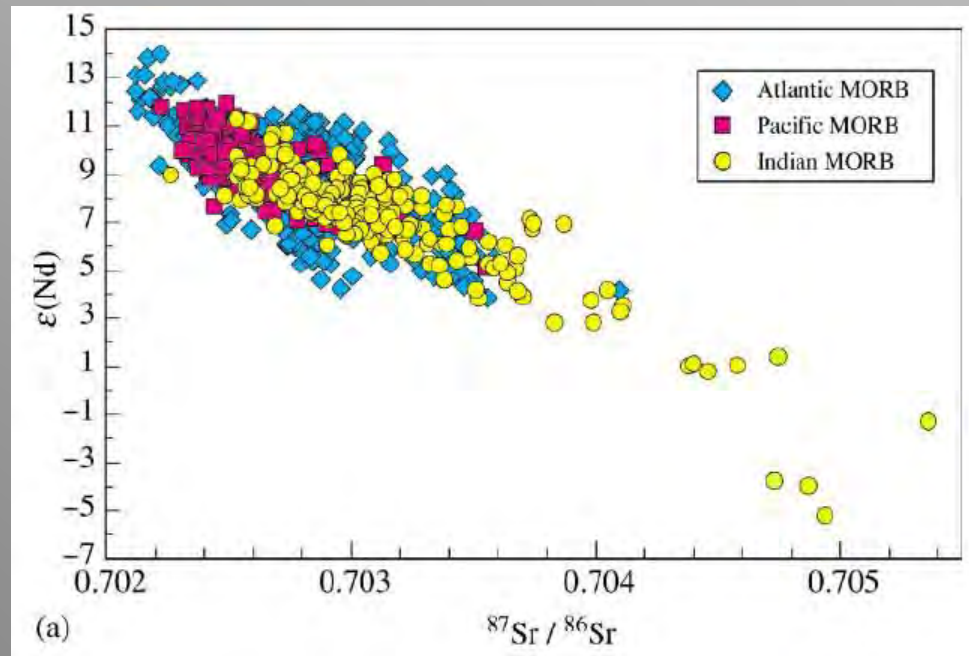


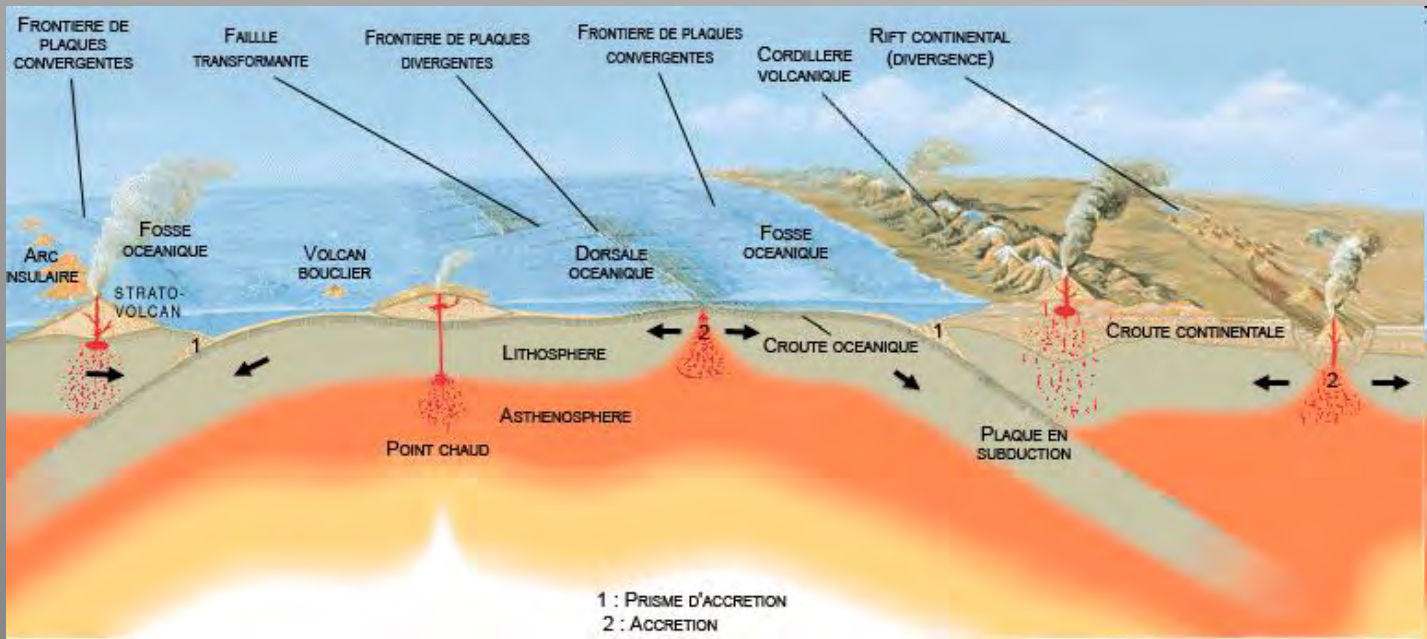


Découplage isotopique entre la croûte et le manteau

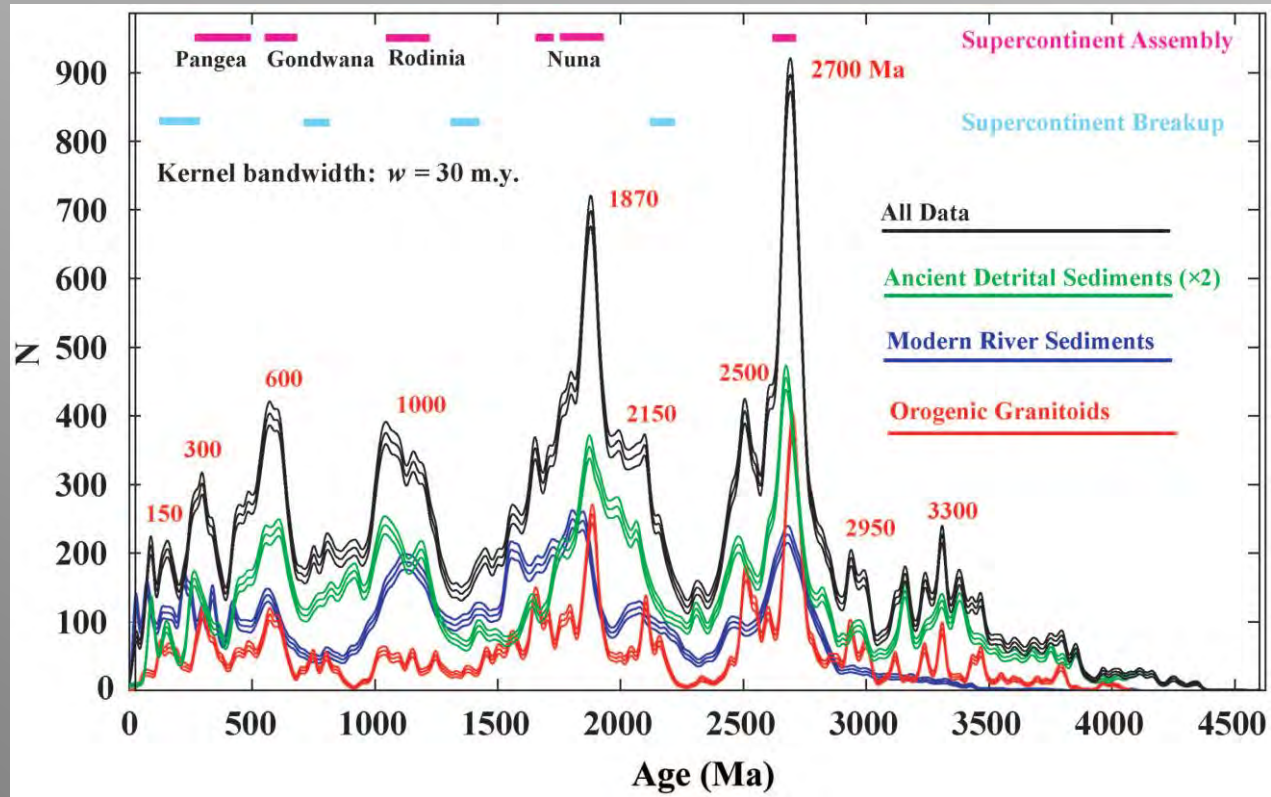


Homogénéité des MORB dans tous les océans

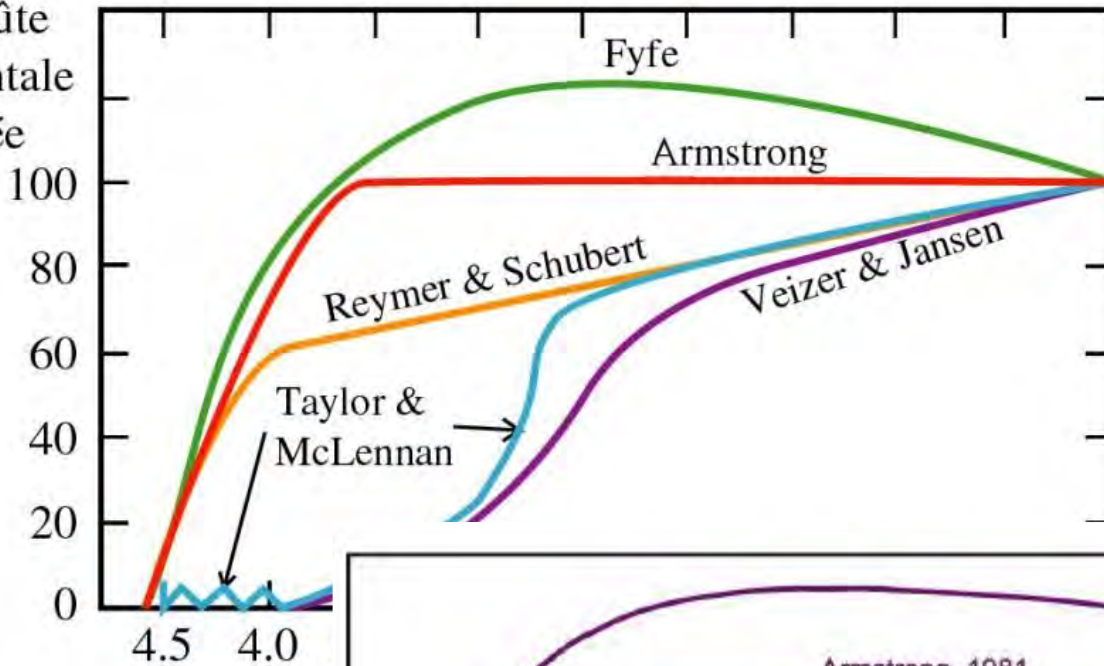




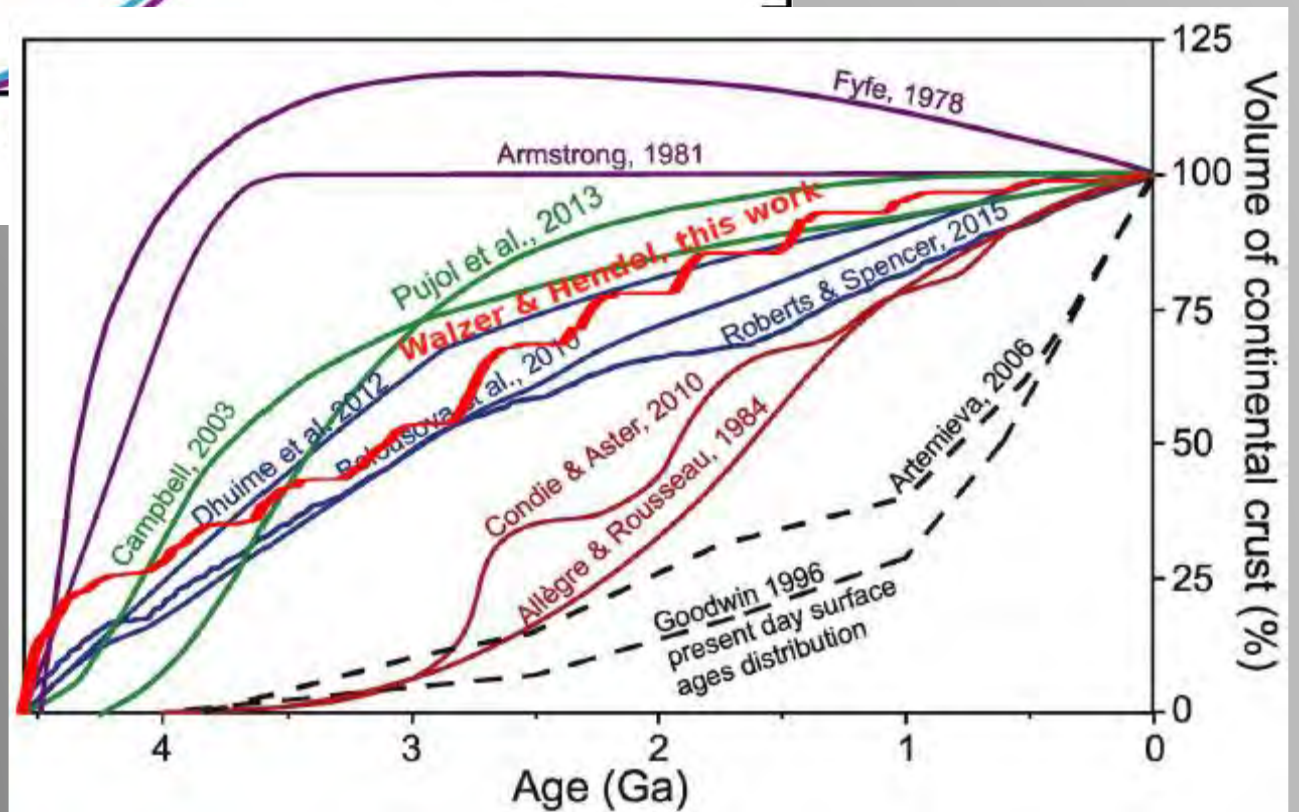
Connaitre l'âge de la croûte



% Croûte continentale formée



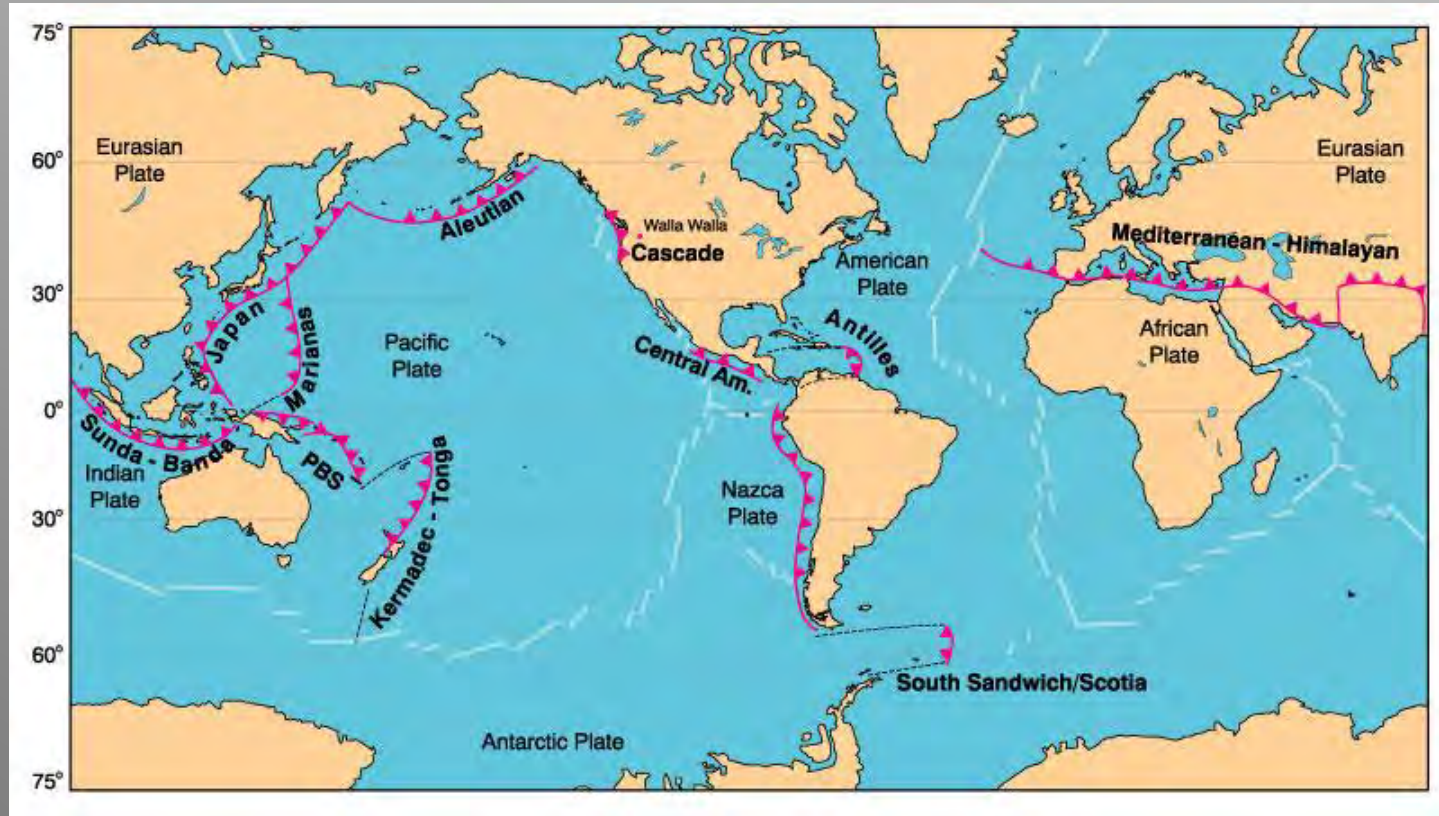
Croissance crustale

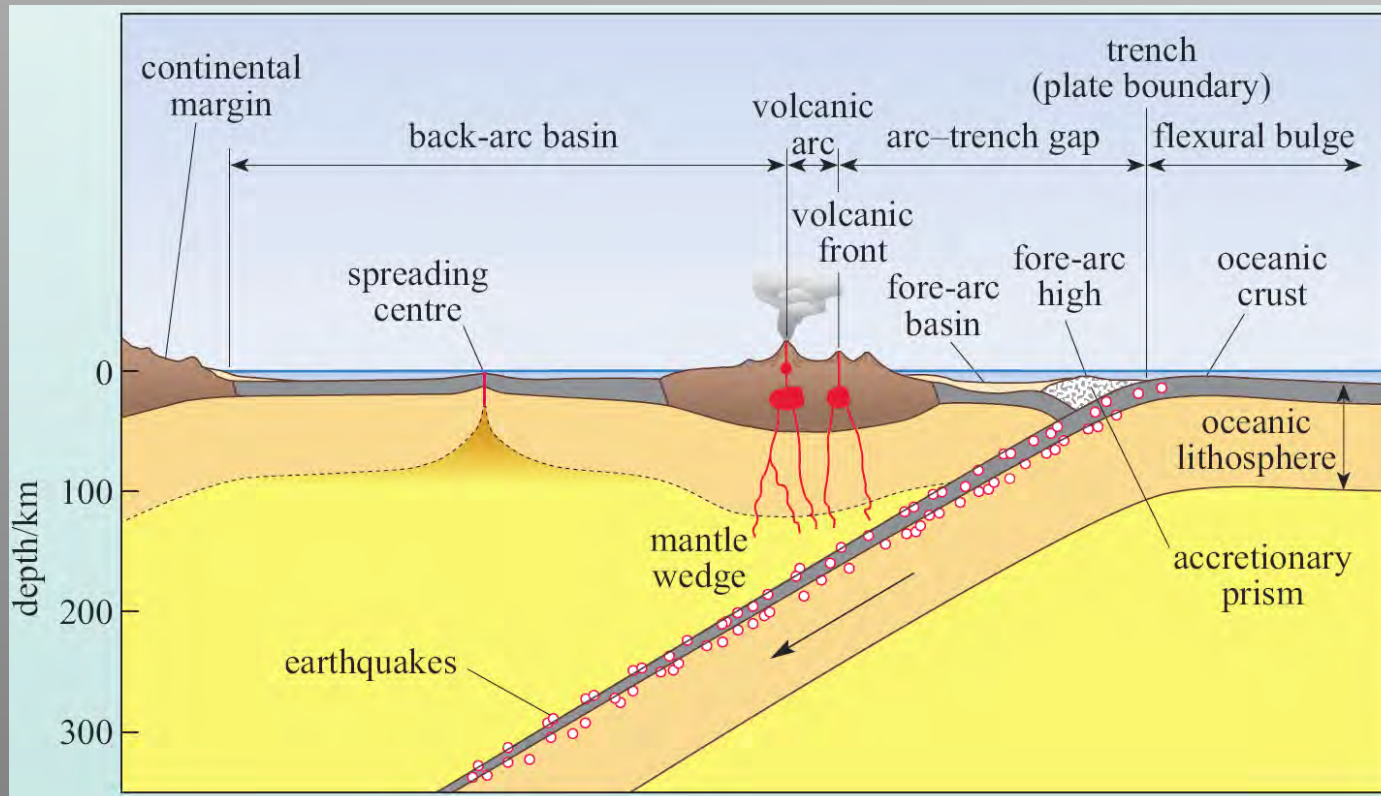


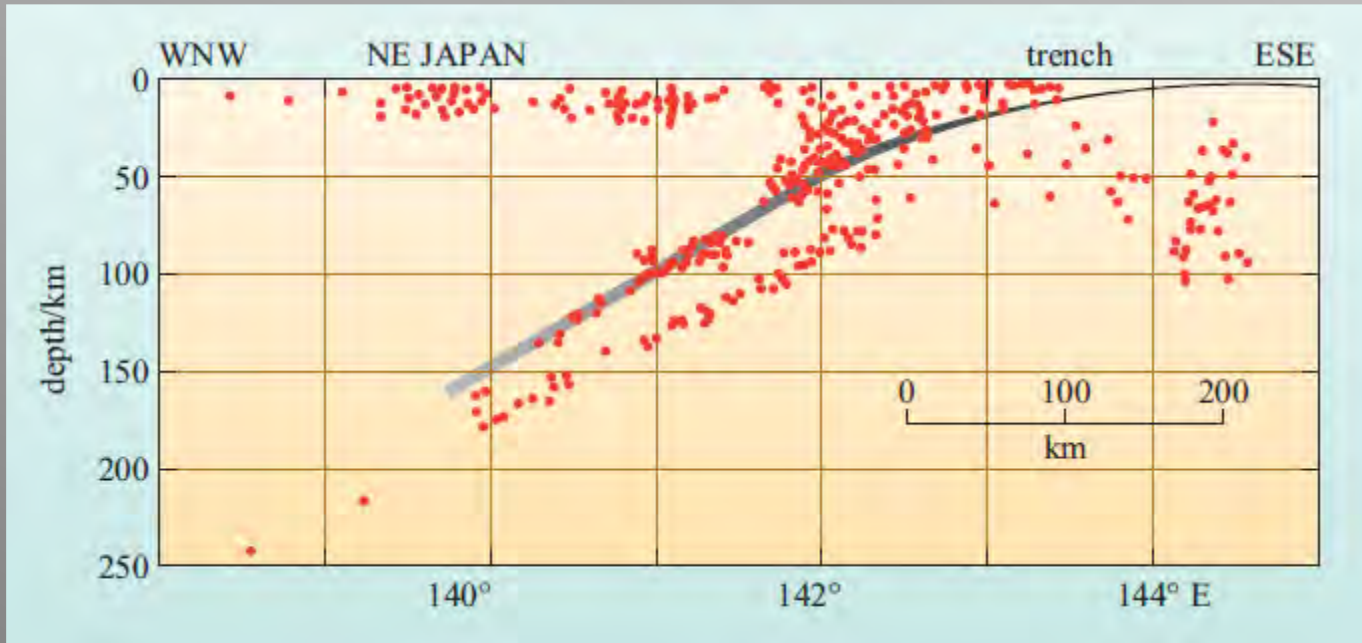
Volume of continental crust (%)

Age (Ga)

Océan-ocean → Island Arc (IA)
Océan-continent → Arc continental ou
Marge continental active

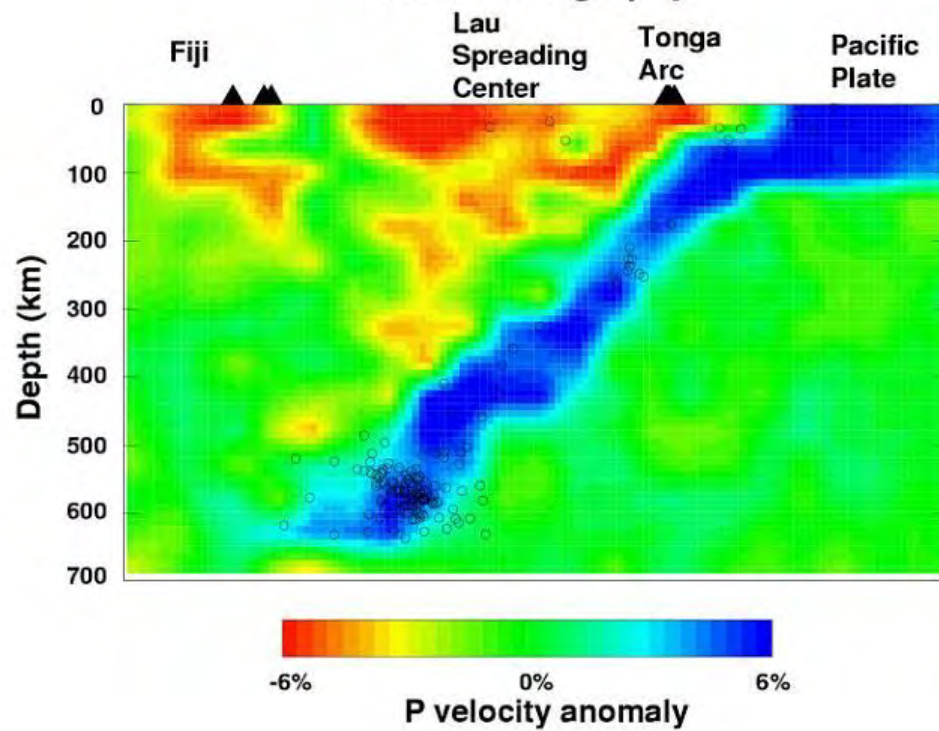




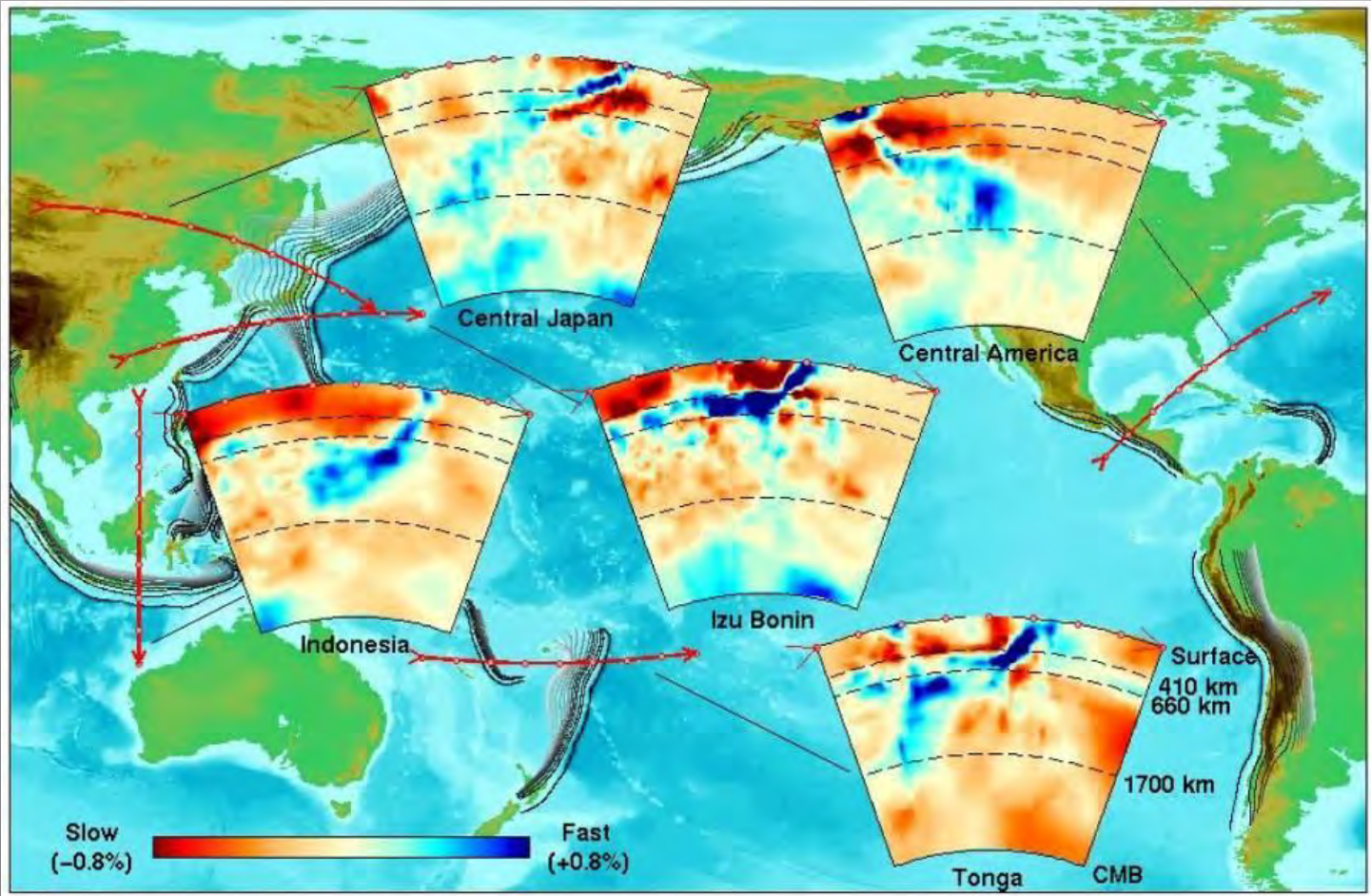


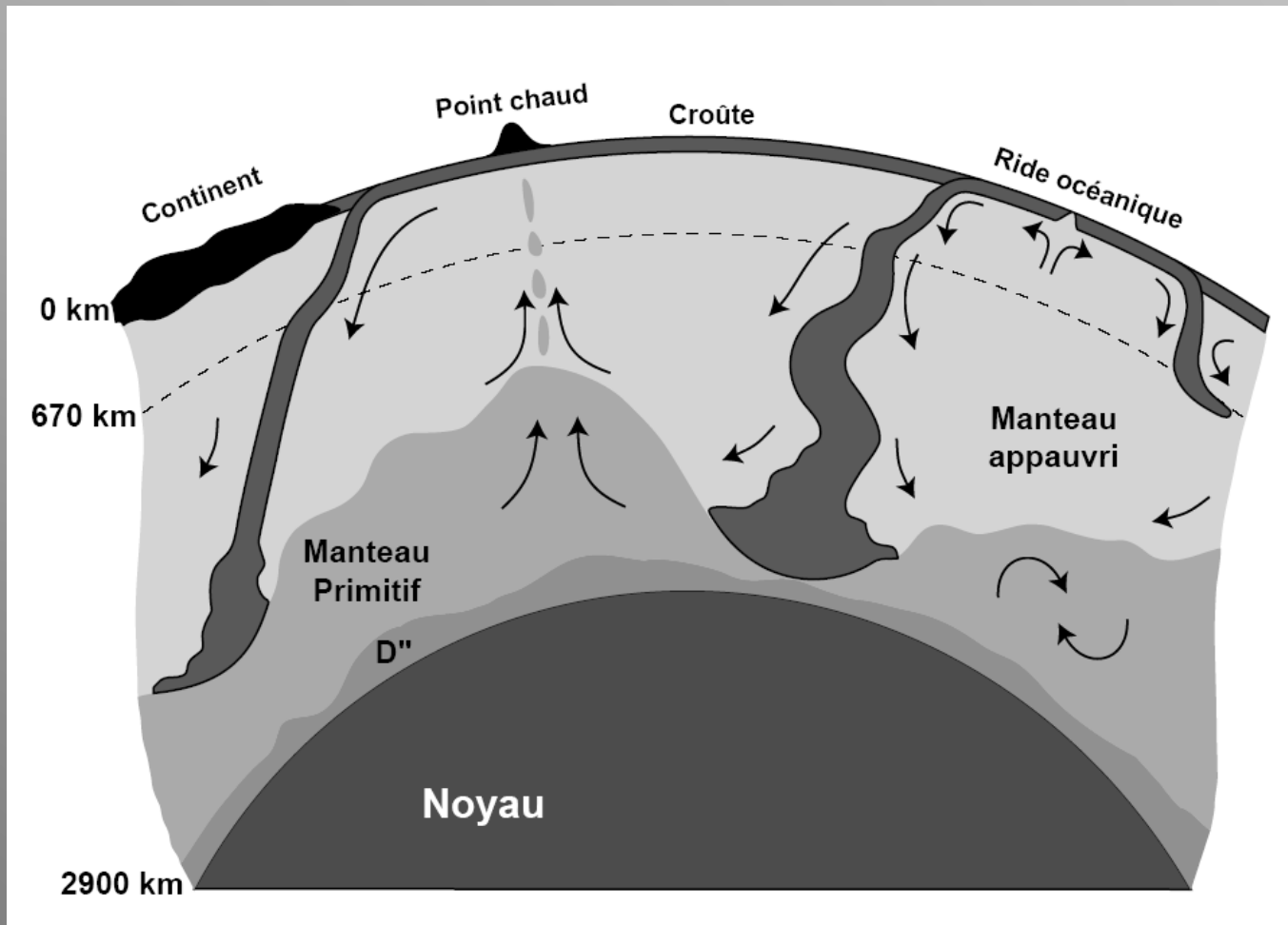
Rogers, 2007

P-wave Tomography



Où vont les plaques subductées ?



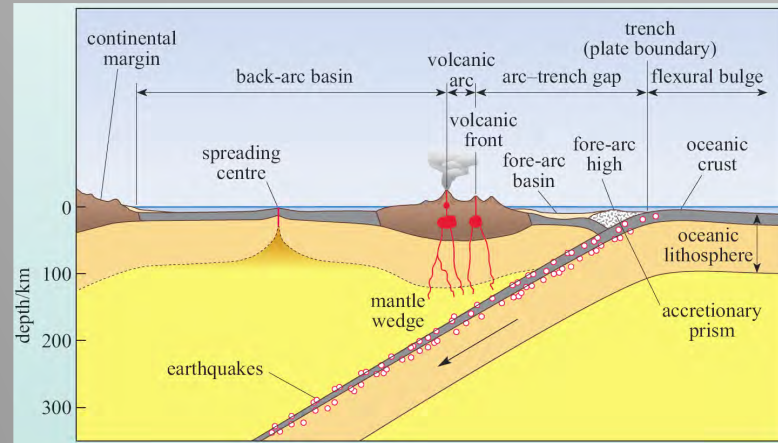
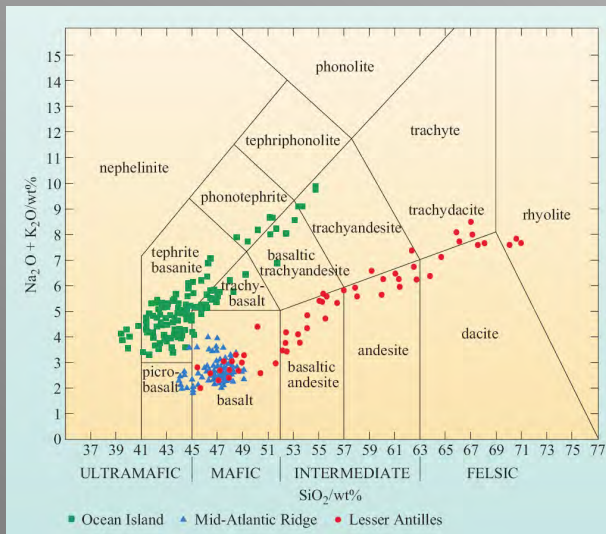


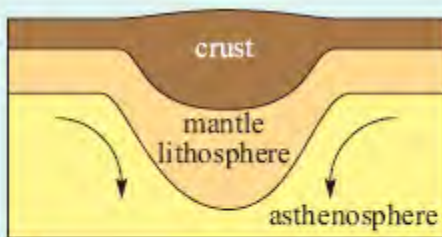
COMPOSITION DE LA CROÛTE CONTINENTALE

	Croûte supérieure	Croûte inférieure	Croûte totale
SiO₂	66.6	53.4	60.6
TiO₂	0.64	0.82	0.72
Al₂O₃	15.4	16.9	15.9
FeO	5.04	8.57	6.7
MnO	0.10	0.1	0.1
MgO	2.48	7.24	4.7
CaO	3.59	9.59	6.4
Na₂O	3.27	2.65	3.1
K₂O	2.80	0.61	1.8
P₂O₅	0.15	0.10	0.10
Total	100.07	99.98	100.12

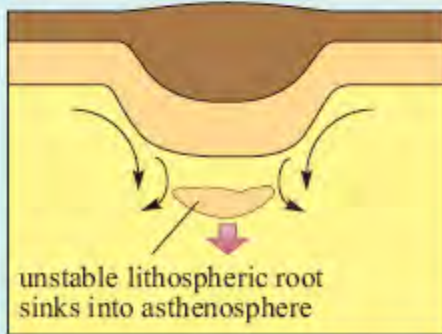
Croûte continentale globale: composition andésitique

Flux de matière venant du manteau dans les zones de subduction:
composition basaltique

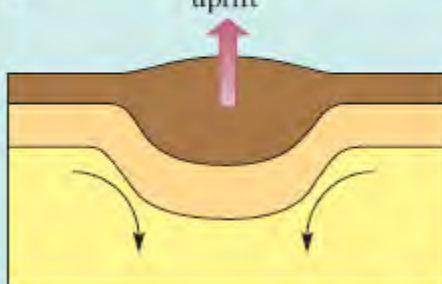




(a)

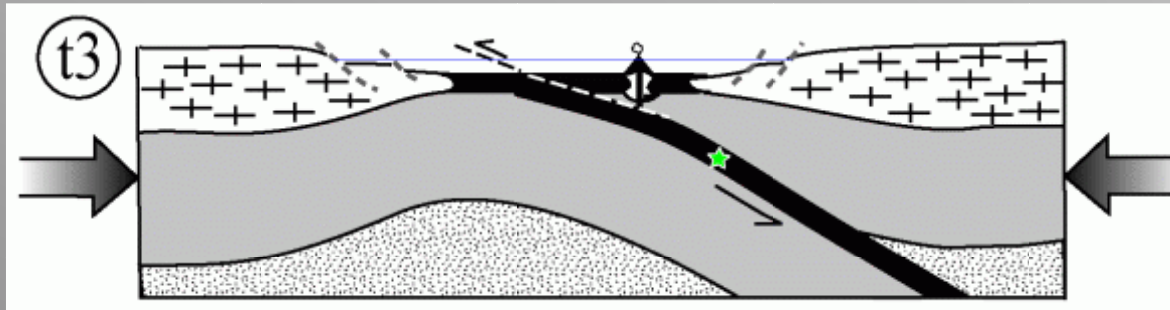


(b)

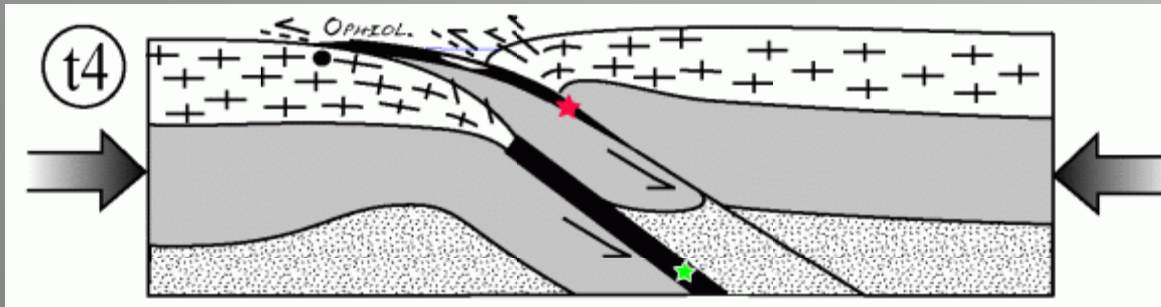


(c)

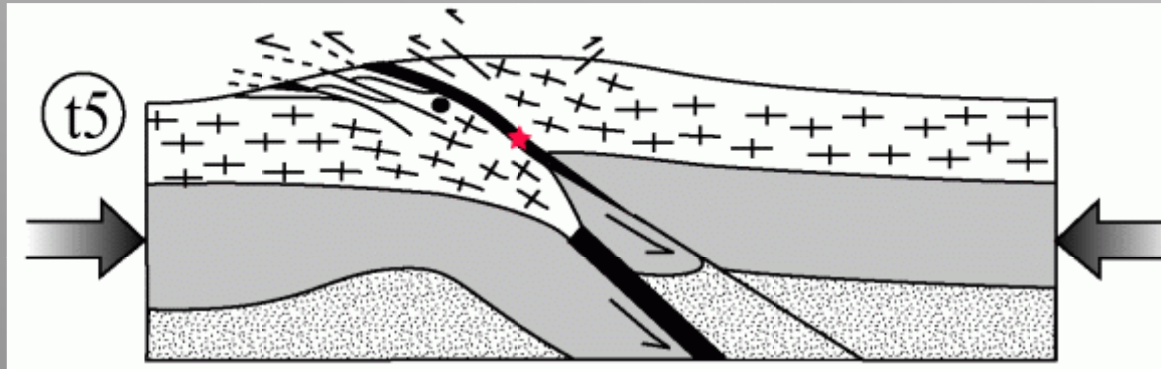
Fermeture de l'océan: subduction



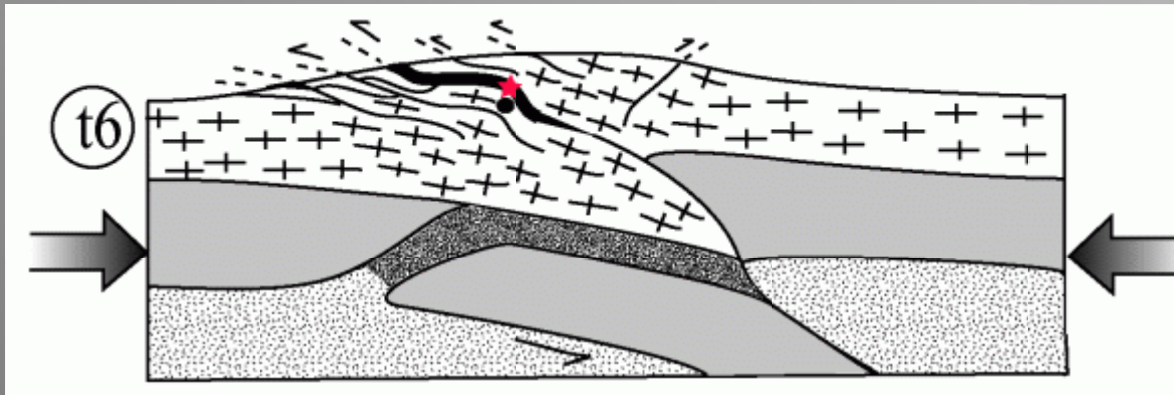
Fin de la subduction: collision continentale



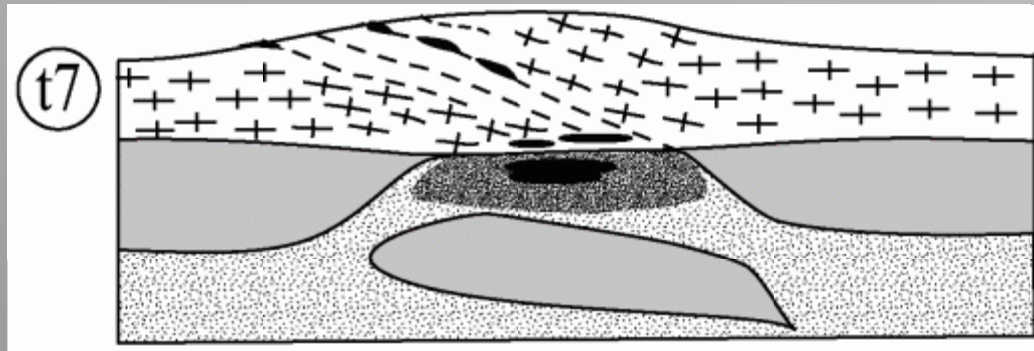
Formation d'une chaîne de montagne



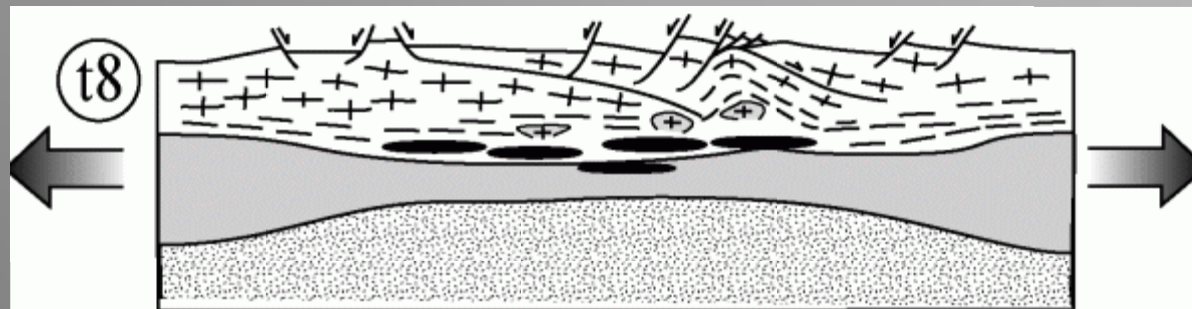
Détachement de la base de la lithosphère



Fusion partielle dans le manteau



Erosion, effondrement gravitaire: fusion partielle dans la croûte

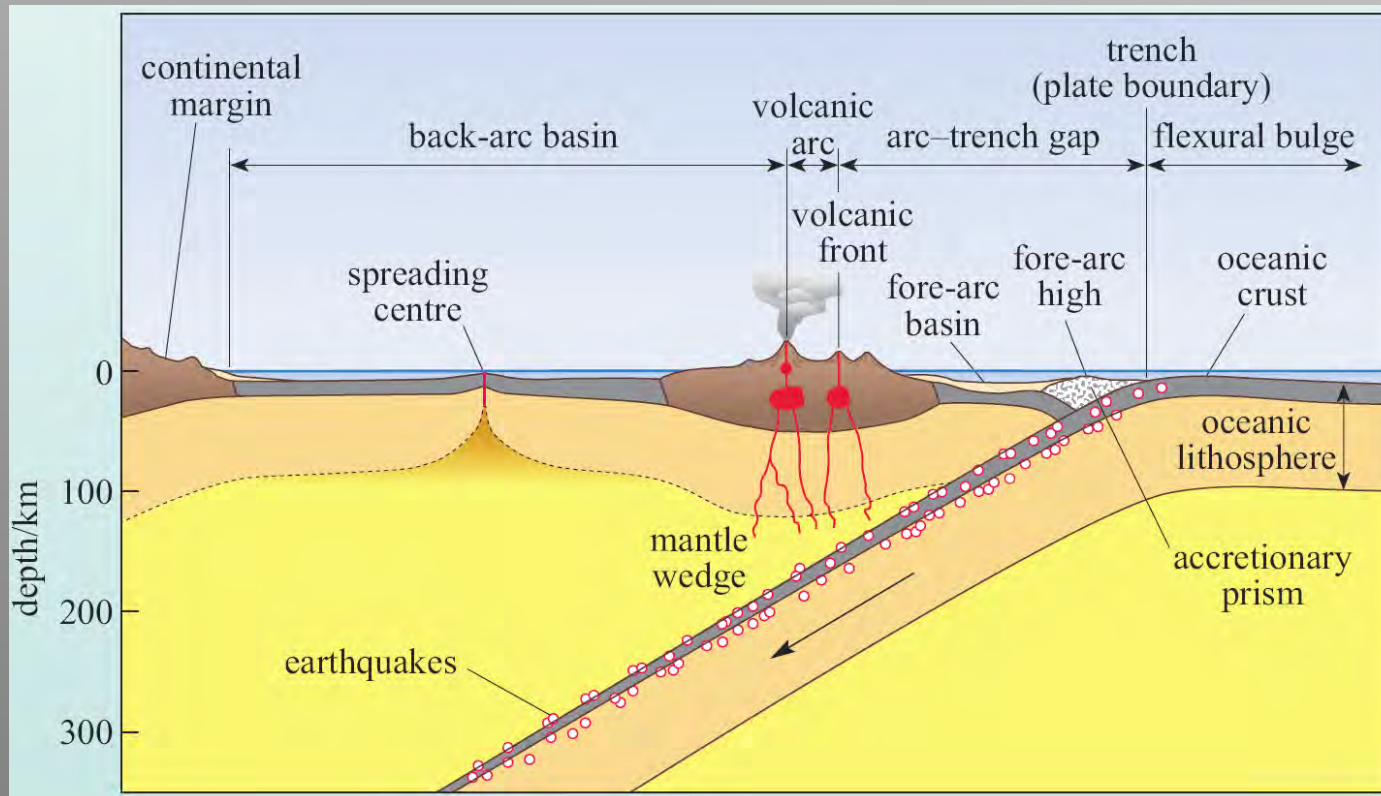




Wei-Hua Yao , Zheng-Xiang Li , Wu-Xian Li , Xuan-Ce Wang , Xian-Hua Li , Jin-Hui Yang

Post-kinematic lithospheric delamination of the Wuyi-Yunkai orogen in South China: Evidence from ca. 435- \pm 0.25-Ma high-Mg basalts

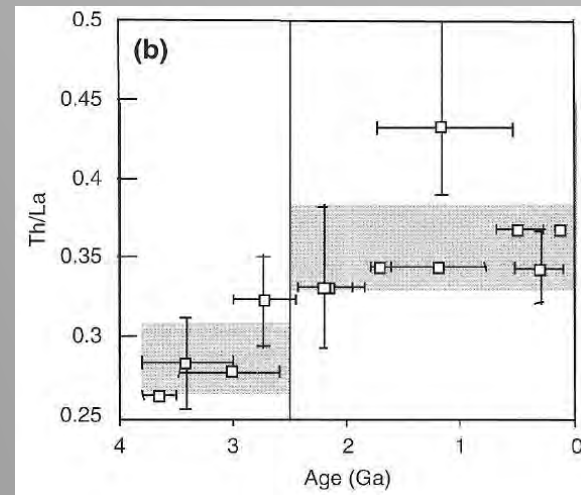
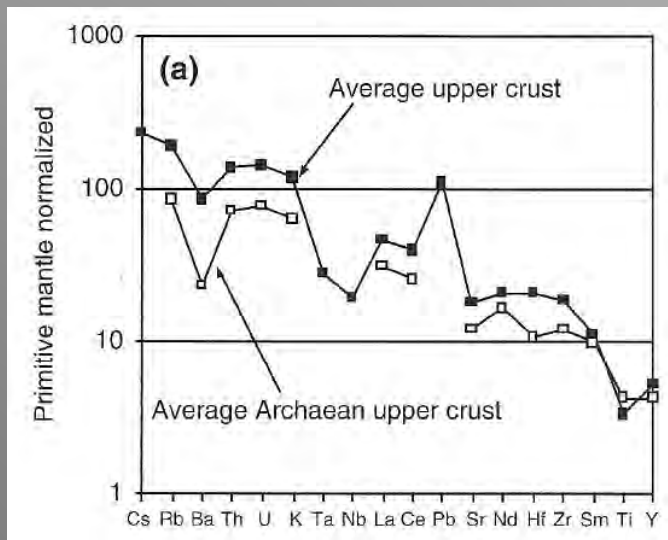
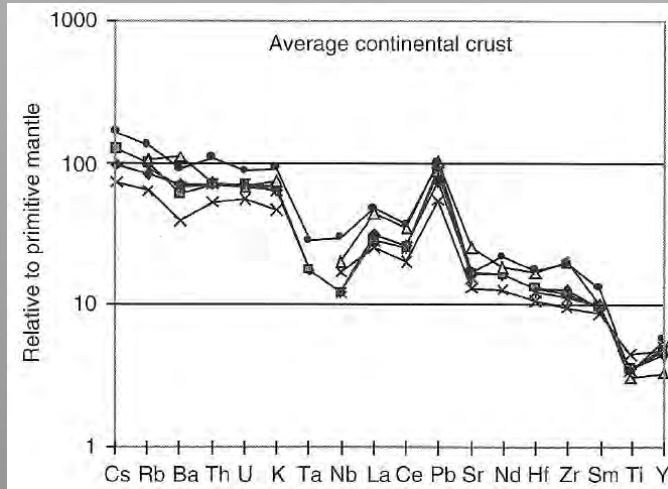
<http://dx.doi.org/10.1016/j.lithos.2012.06.033>



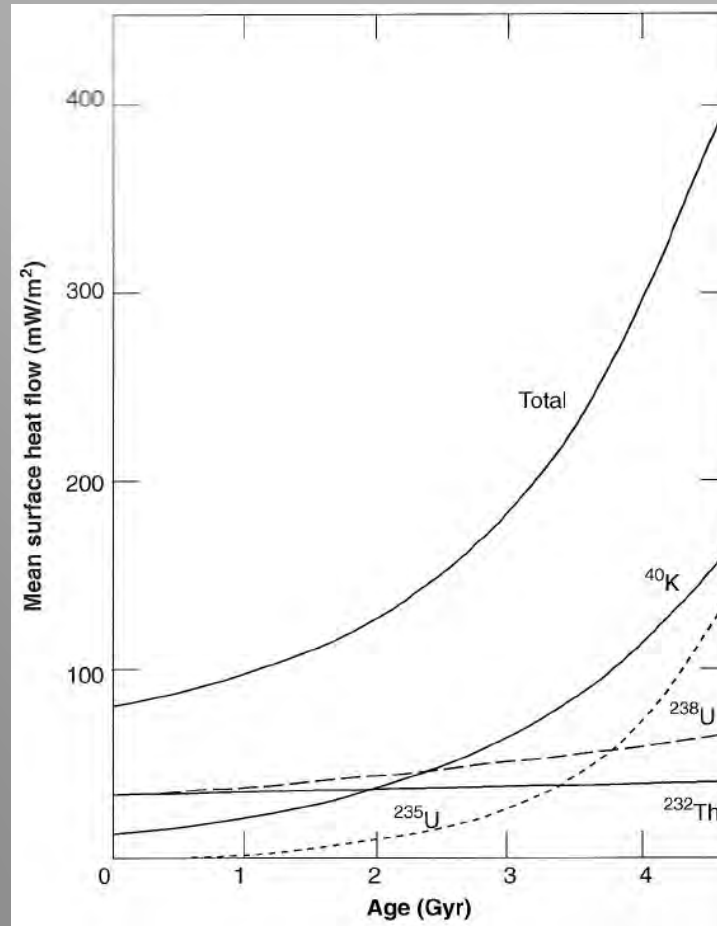
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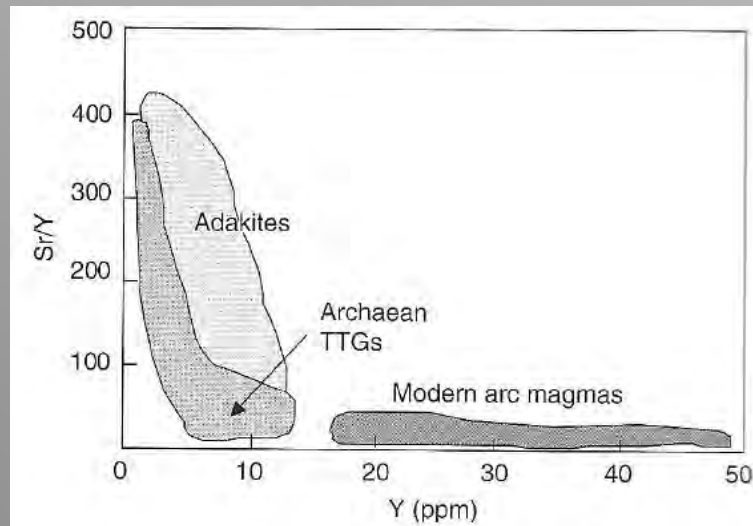
Différences de composition entre la croûte archéenne et la croûte globale



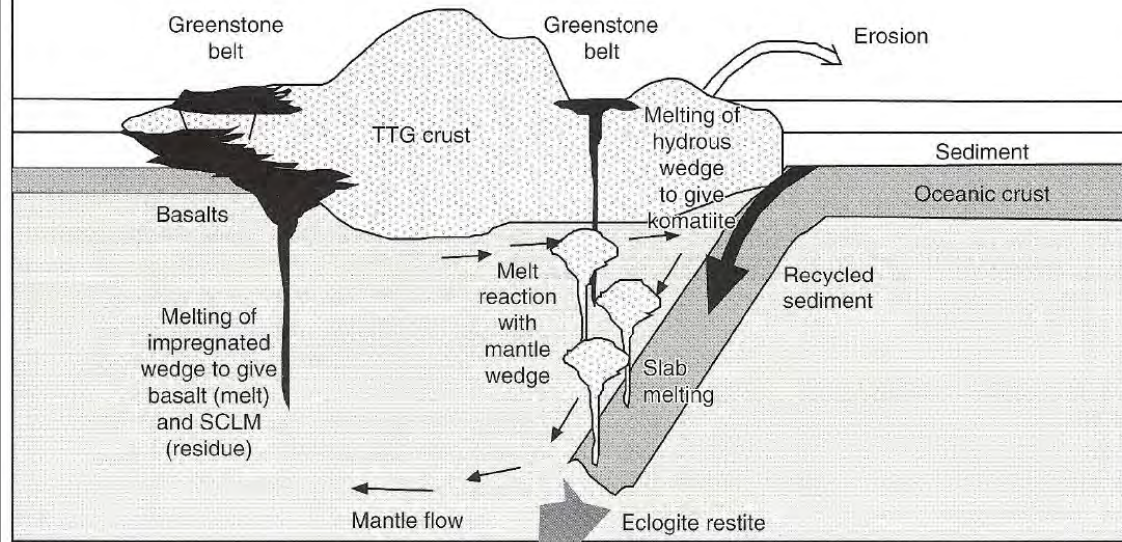
Décroissance du flux de chaleur avec le temps



Les adakites: un analogue pour la croûte archéenne ?



A model for Archaean continental growth



Bilan de matière dans les zones de subduction

Apports de magma dans les zones de subduction: 1,63 km³/an

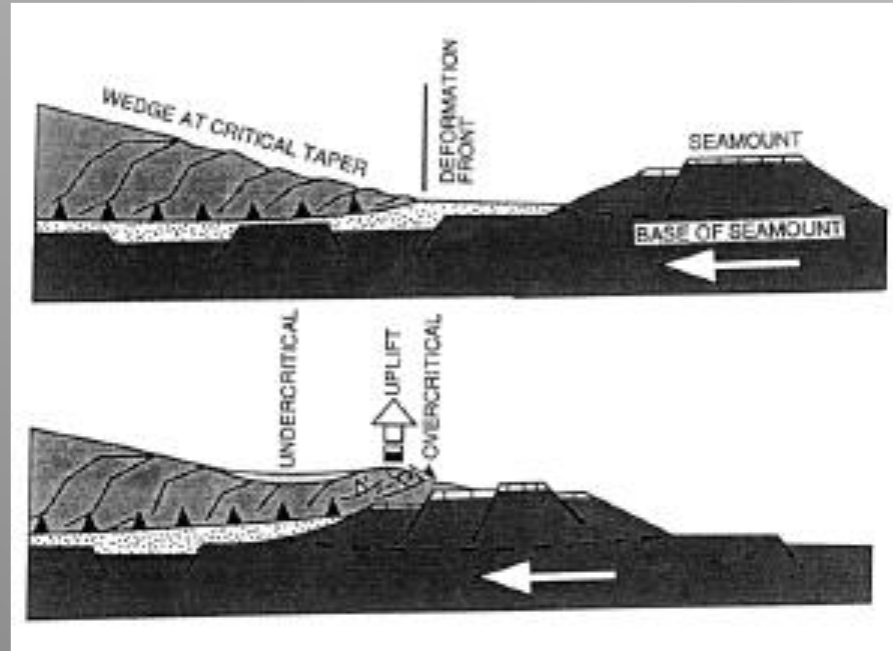
Subduction de croûte océanique: 20 km³/an

Subduction de sédiments: 0,7 km³/an

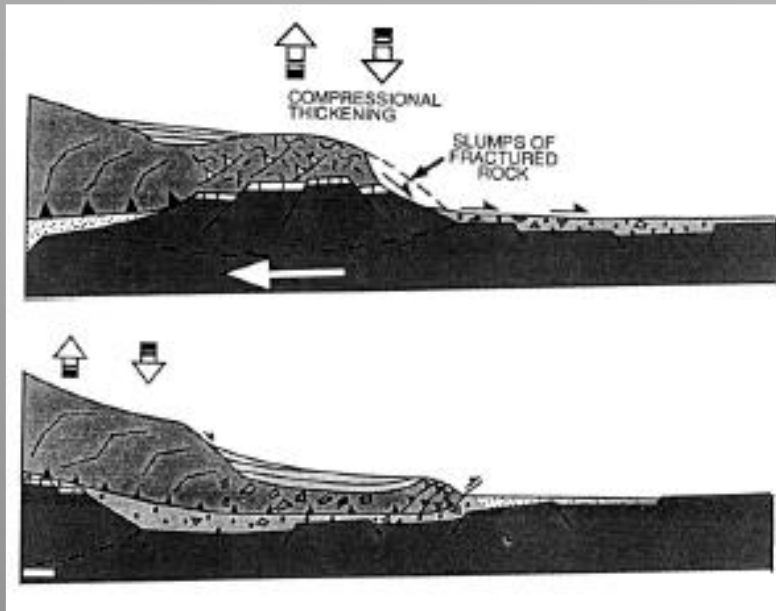
Erosion tectonique: 0,9 km³/an

Bilan:

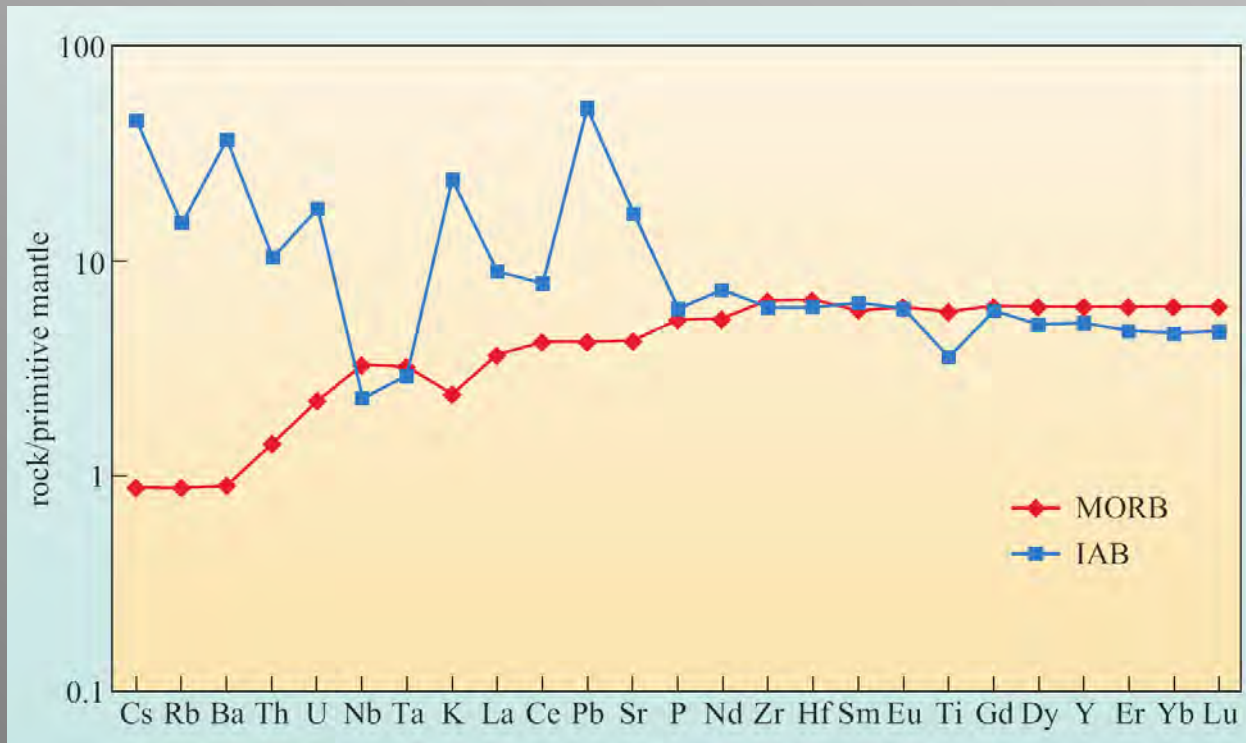
Pas de création de croûte continentale en ce moment sur Terre

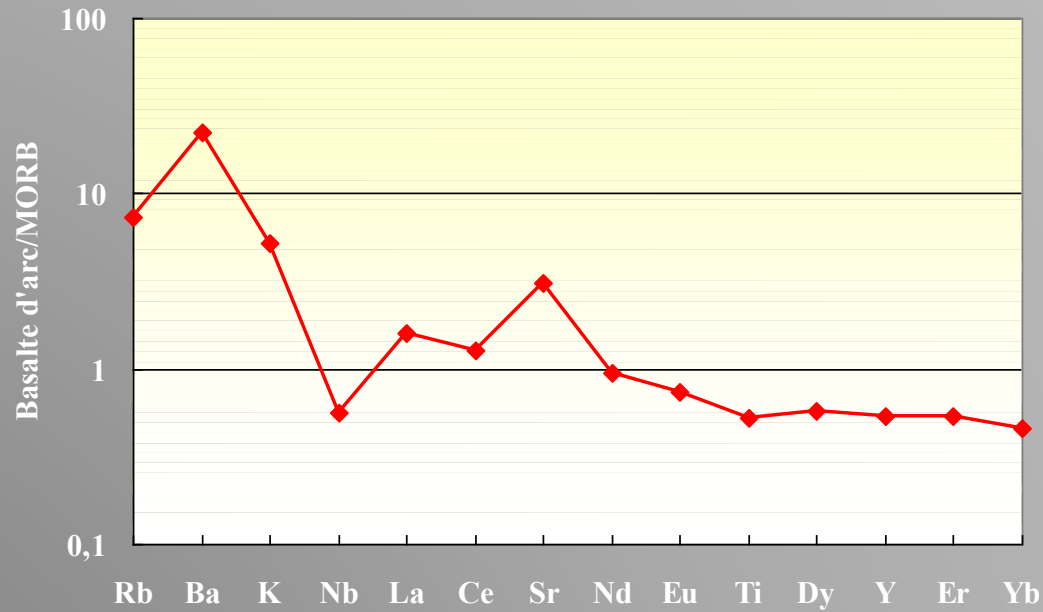


Von Huene and Scholl, 1991

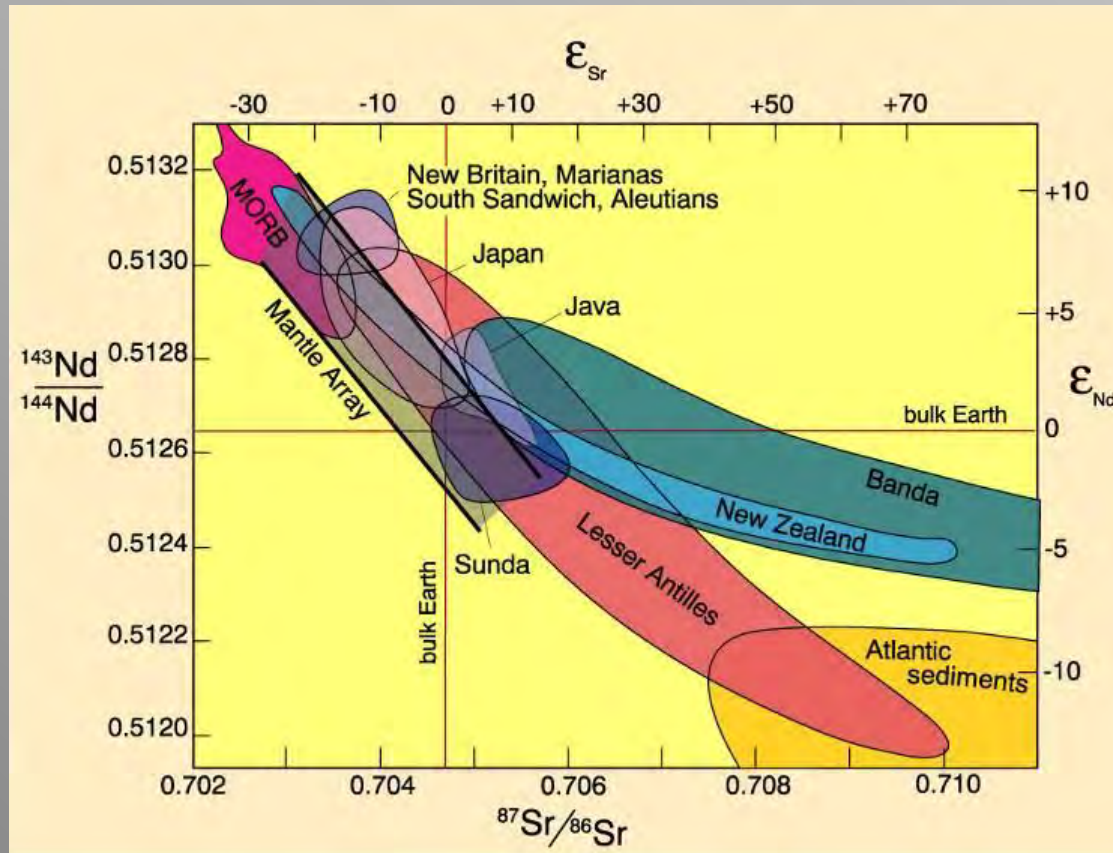


EVIDENCES GEOCHIMIQUES DU RECYCLAGE

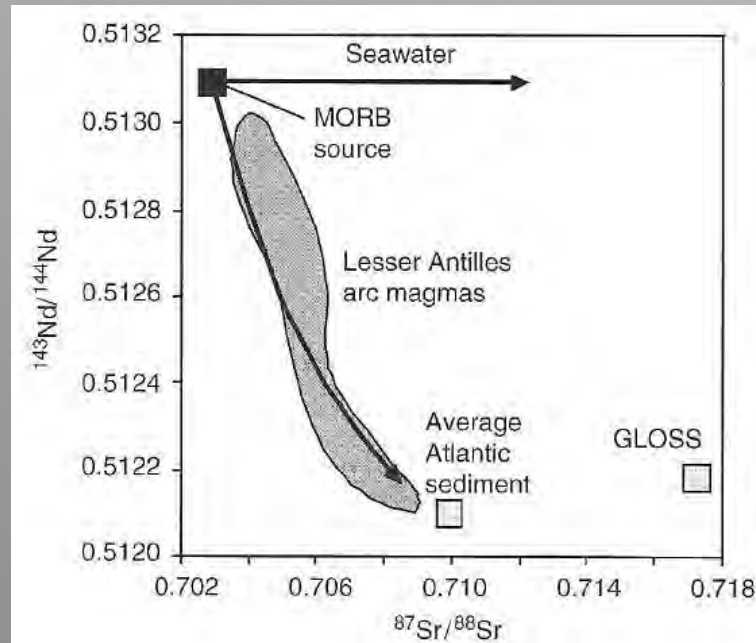


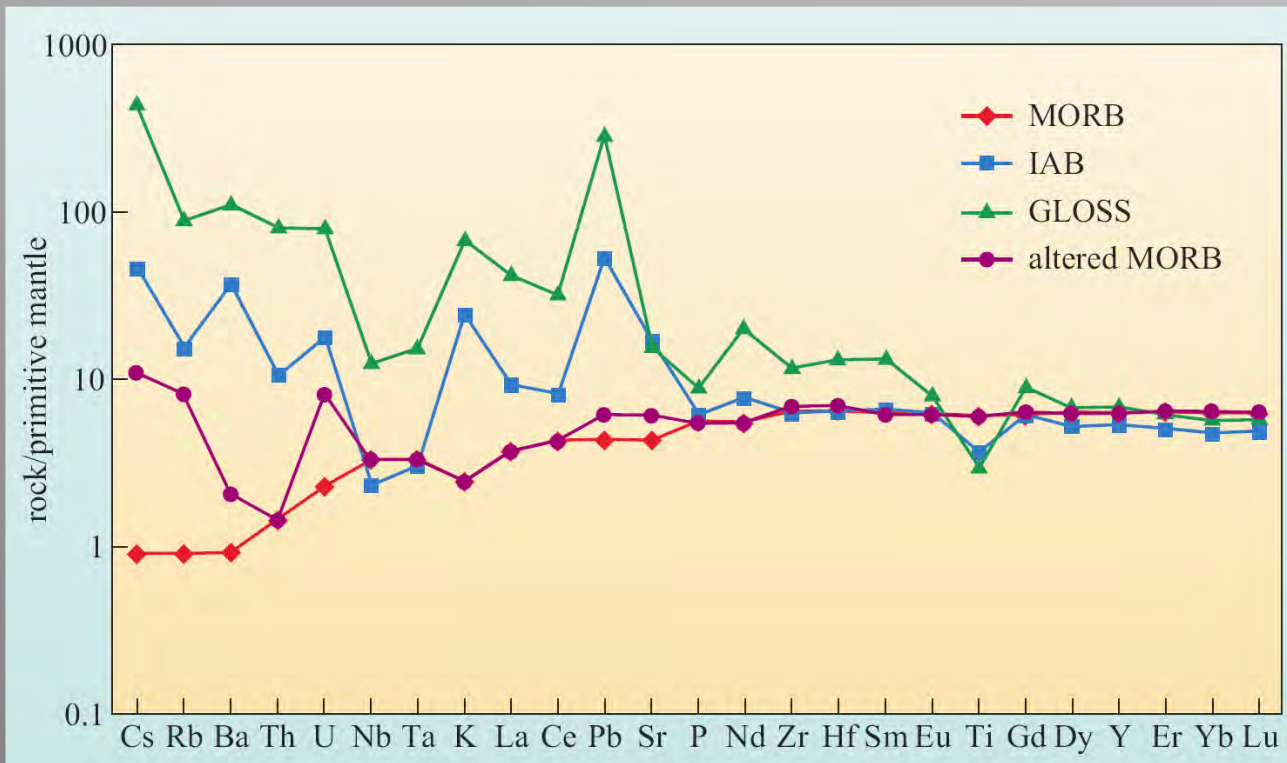


Les magmas d'arc sont caractérisés par de fortes teneurs en LILE (Rb, Ba, K, Sr) et LREE (La, Ce) et des anomalies négatives en Nb et, à un degré moindre, Ti. Leurs teneurs en HREE sont inférieures à celles des MORB.

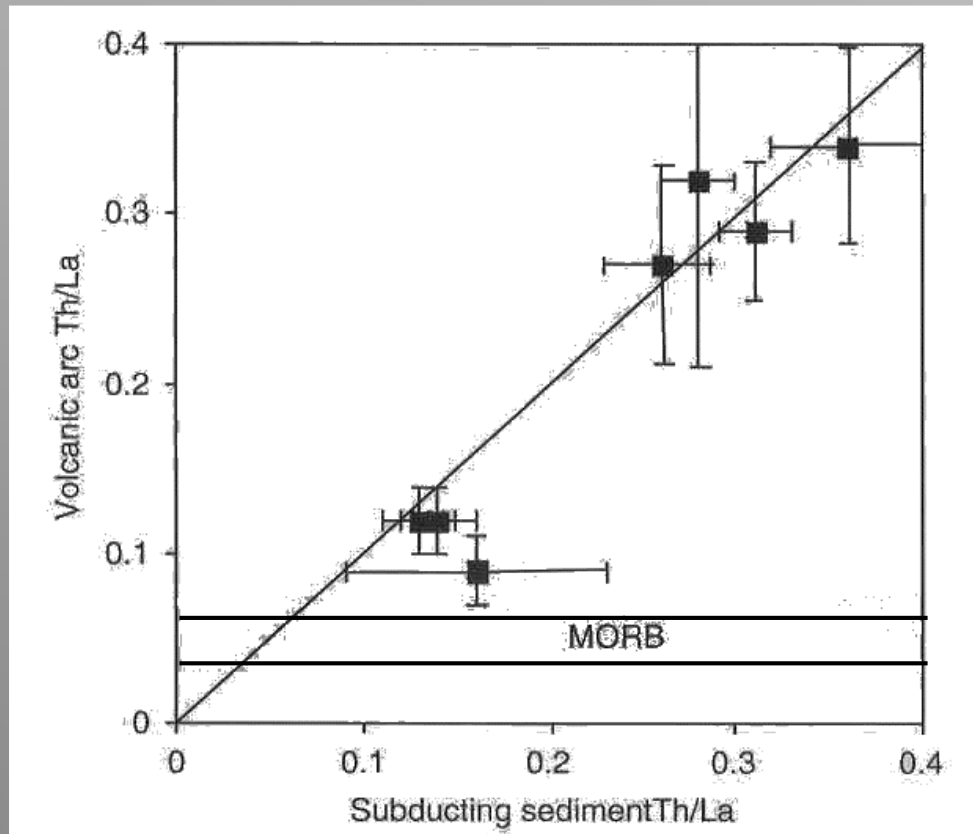


Les basaltes d'arc sont caractérisés par des rapports $^{87}\text{Sr}/^{86}\text{Sr}$ plus élevés que ceux des MORB et des rapports $^{143}\text{Nd}/^{144}\text{Nd}$ plus faibles, ainsi que par leur caractère plus radiogénique en Pb.

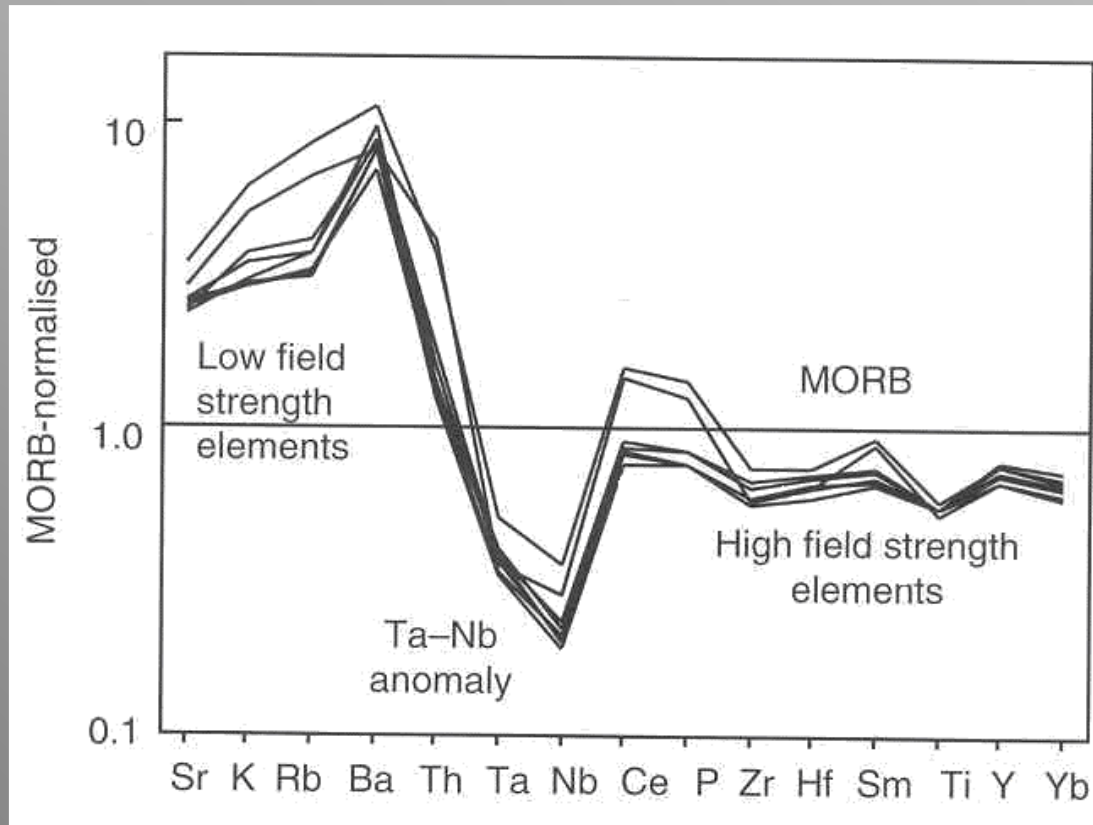




GLOSS = GLOBally Subducting Sediments



Composition des laves d'arcs

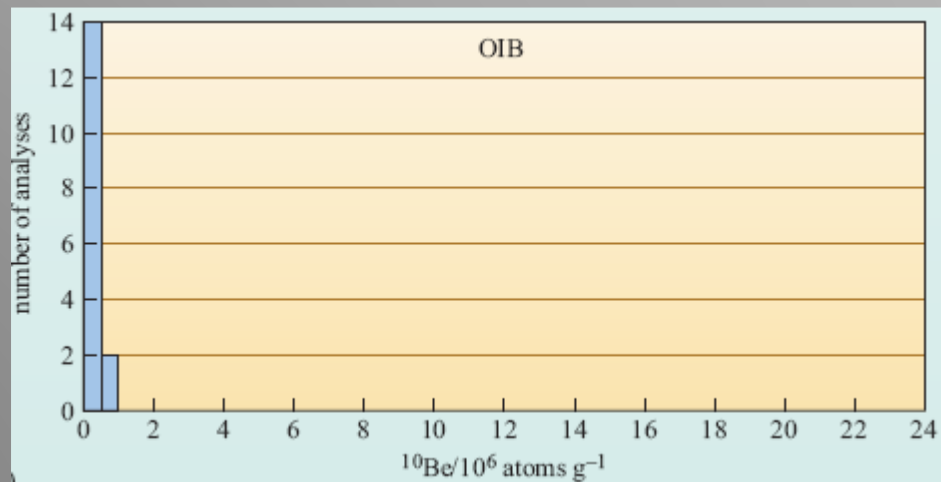
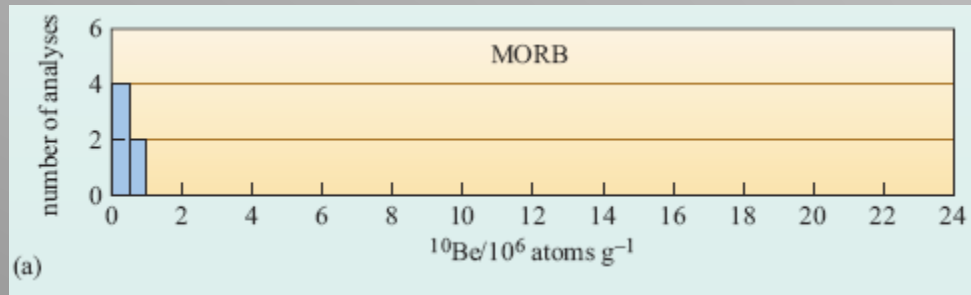


Argument isotopique fort: isotopes du Be

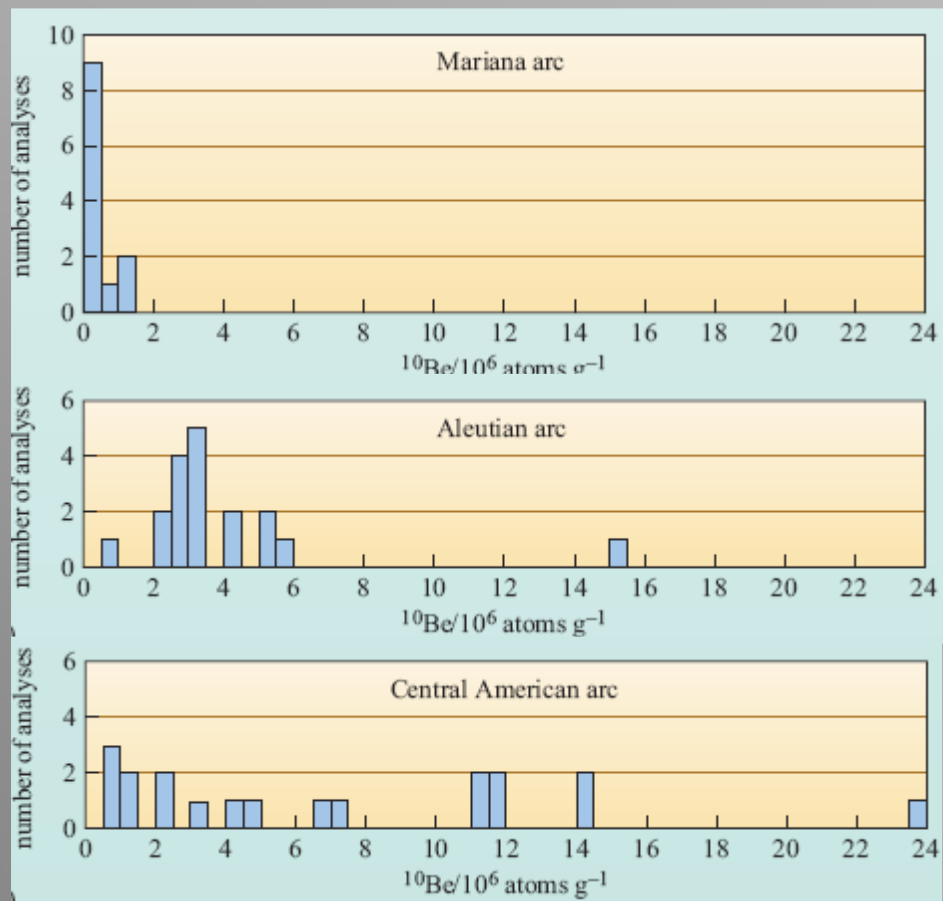


$$t_{1/2} = 1,51 * 10^6 \text{ a}$$

Teneurs en ^{10}Be dans les MORB et les OIB



Teneurs en ^{10}Be dans différents arcs volcaniques

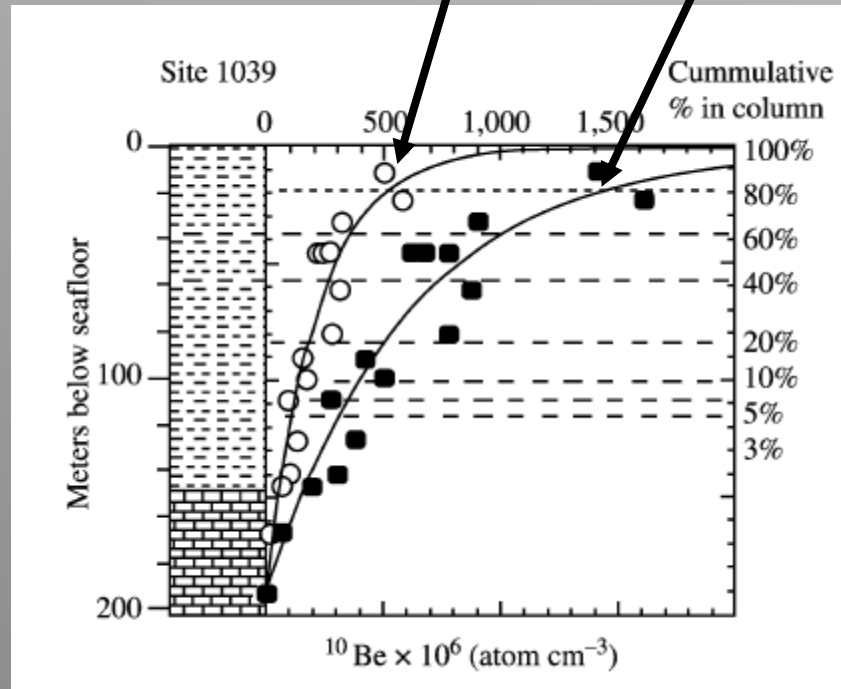


Pour avoir du ^{10}Be dans les laves d'arc,
il faut:

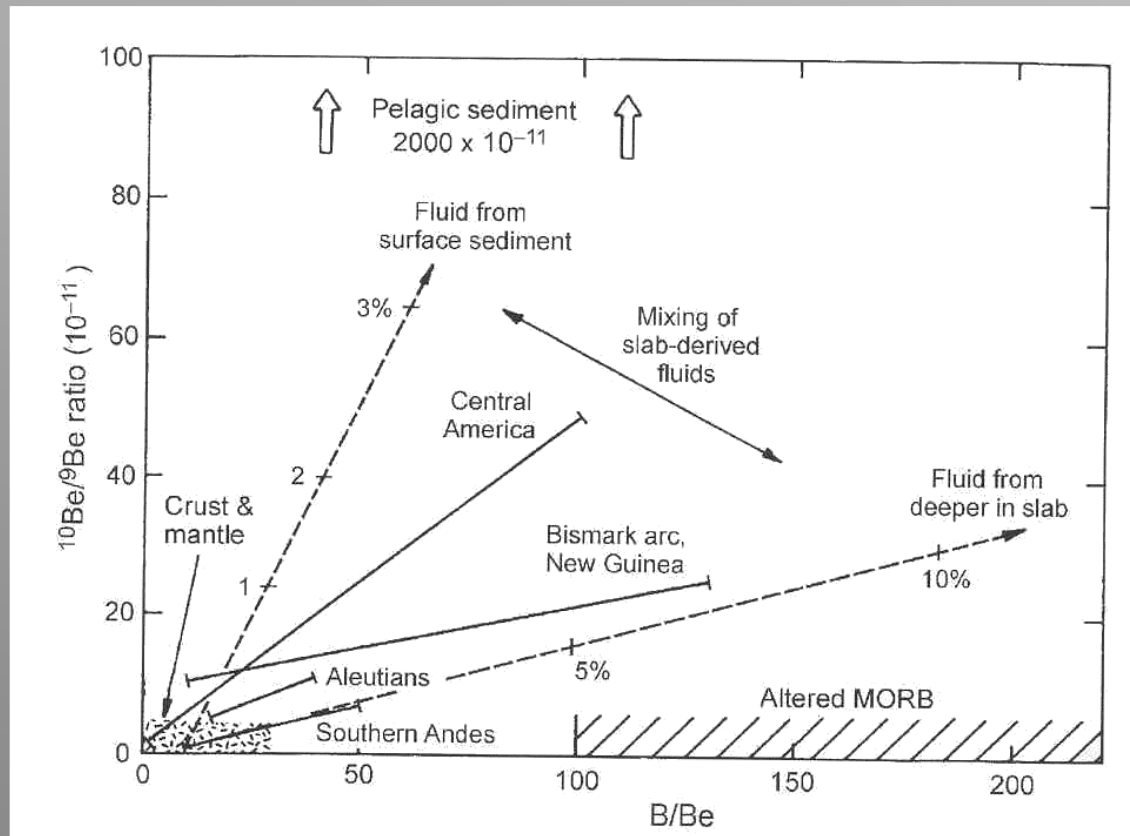
- Du ^{10}Be dans les sédiments
- Subduction des sédiments
- Eléments chimiques issus des sédiments dans la source des magmas
- Durée depuis la sédimentation jusqu'à la source magmatique < 20 Ma

Valeurs calculées sous l'arc volcanique

Valeurs dans les sédiments



Morris & Ryan, T.G. vol. 2



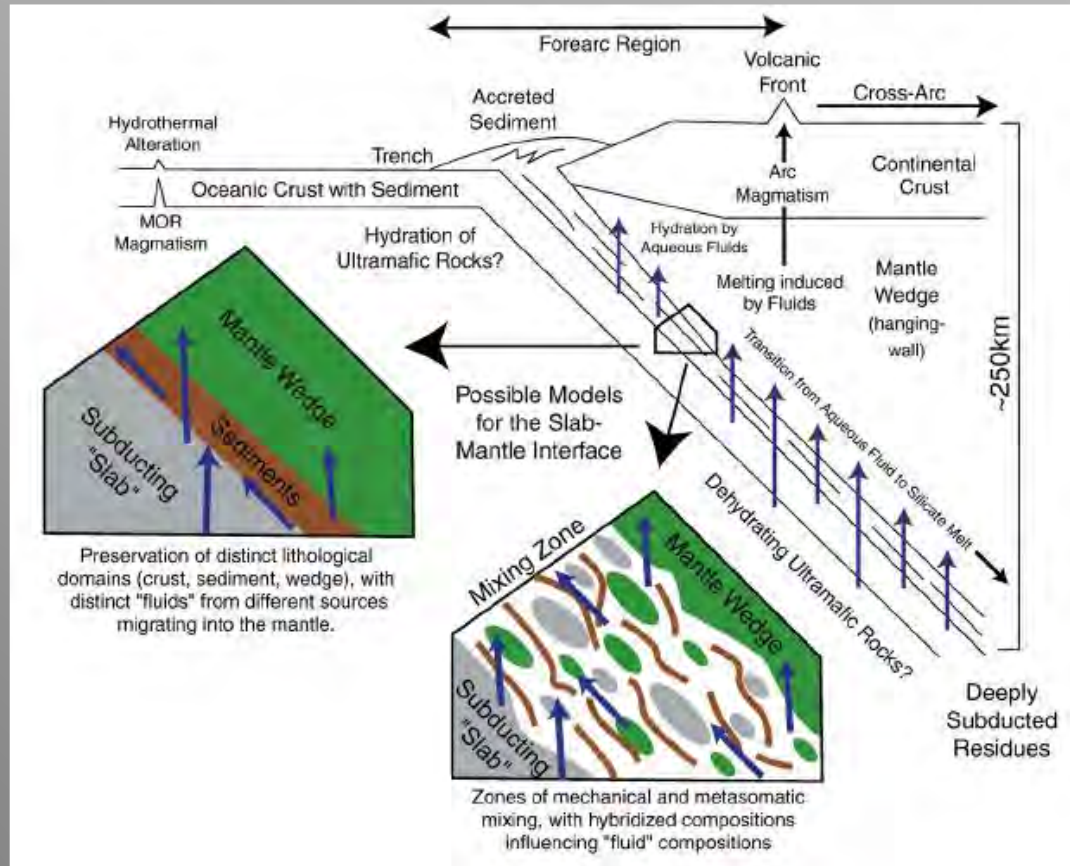
^{10}Be : sédiments supérieurs

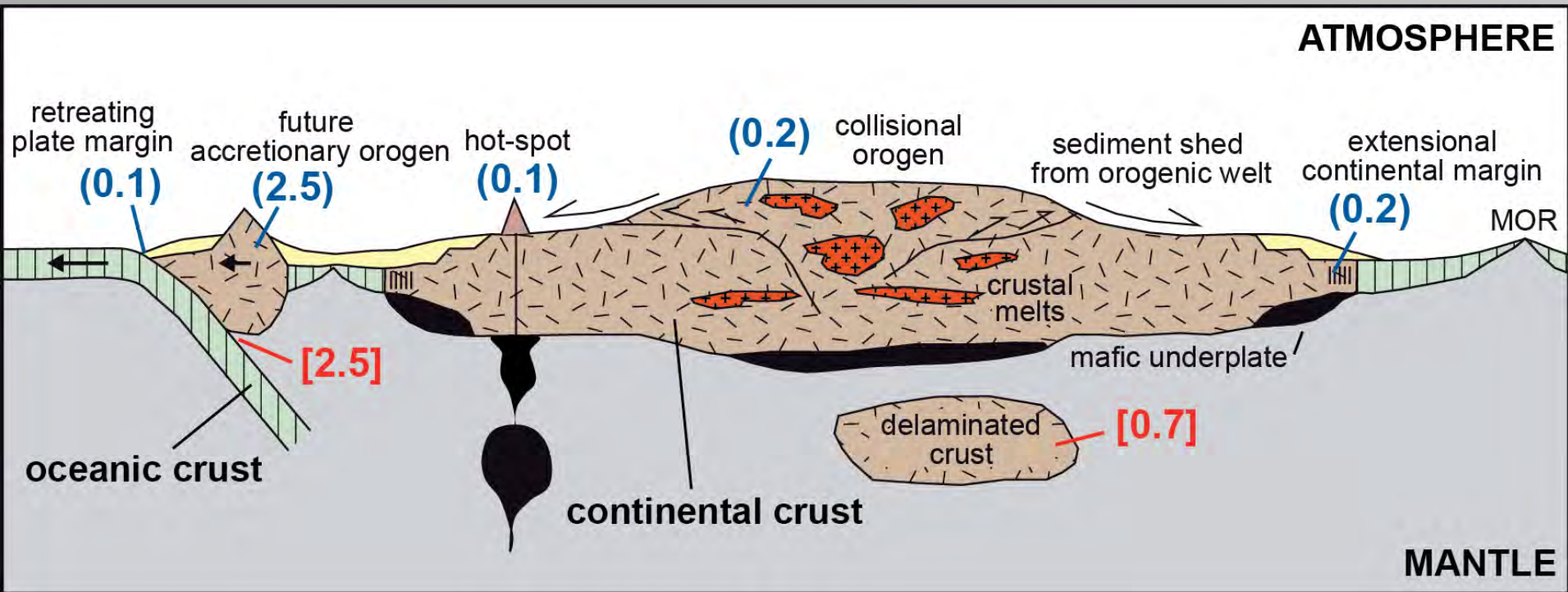
^9Be : toute la colonne sédimentaire

B: dans la croûte océanique

=> Homogénéisation par des fluides

Interface lithosphère subductée - manteau

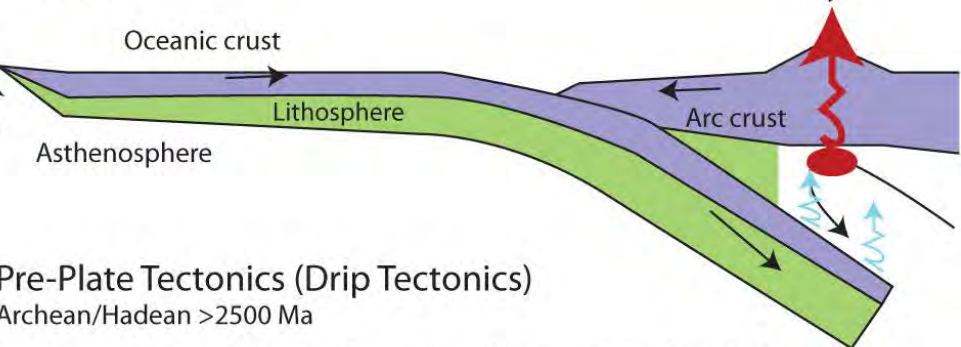




Dhuime

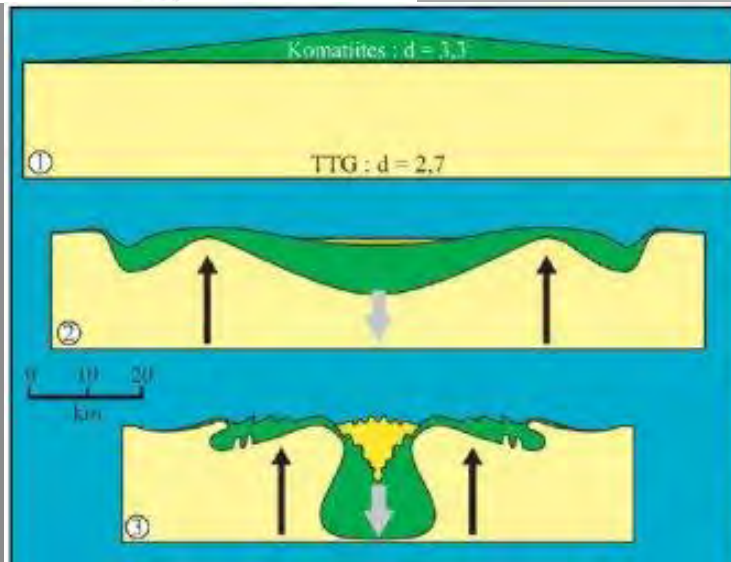
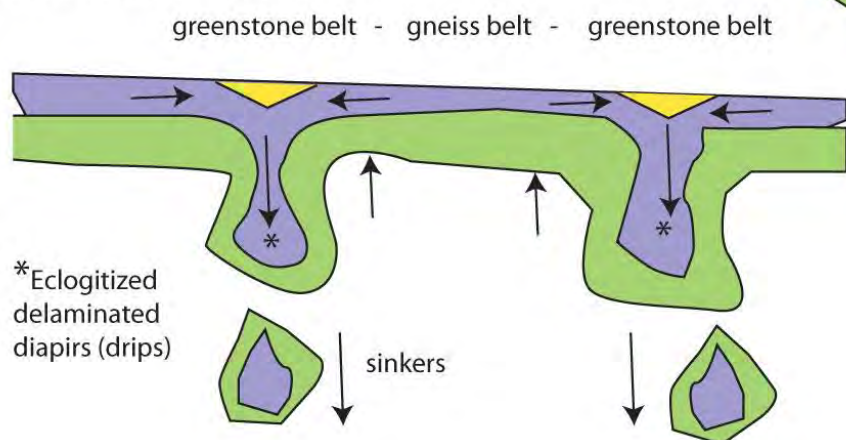
Plate Tectonics

<1000 Ma



Pre-Plate Tectonics (Drip Tectonics)

Archean/Hadean >2500 Ma





From the early Earth...

...to the modern Earth

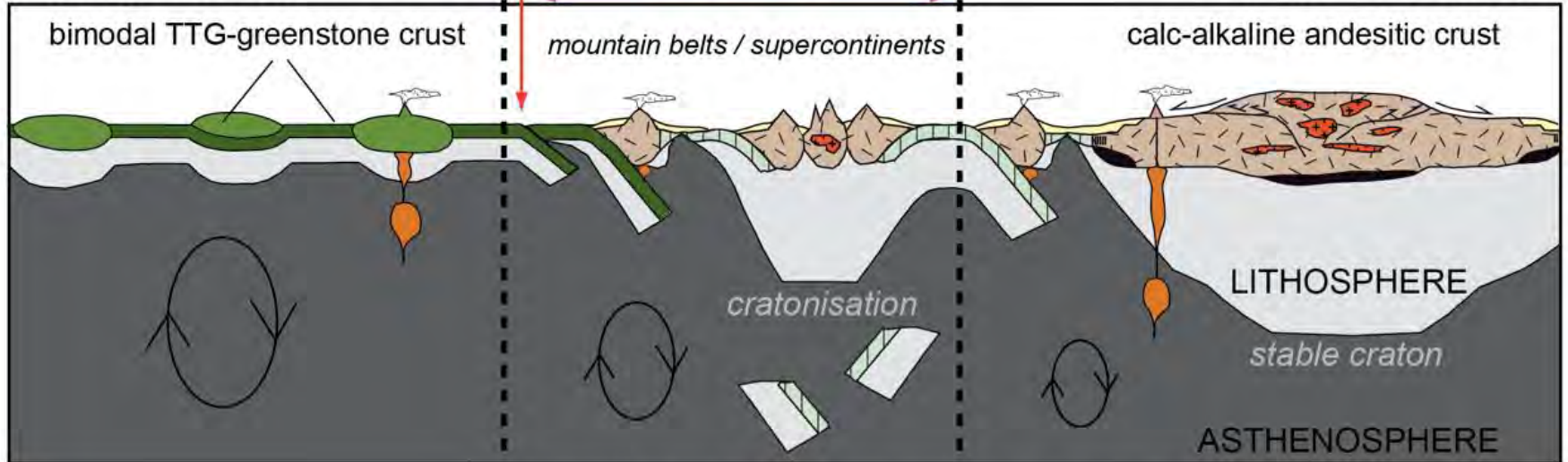


~4.5 Ga → >3 Ga

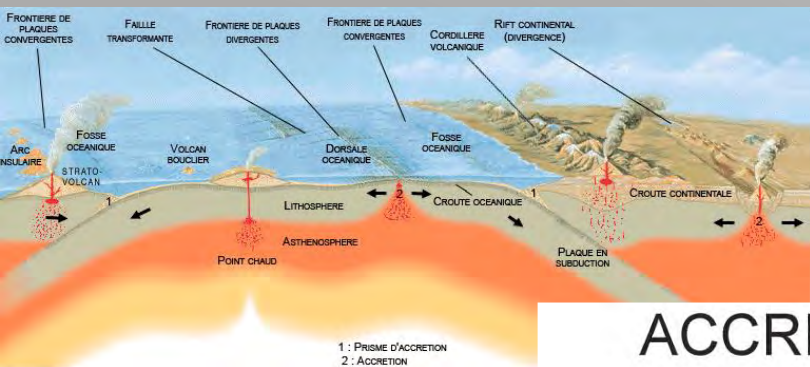
onset
of plate
tectonics

TRANSITION

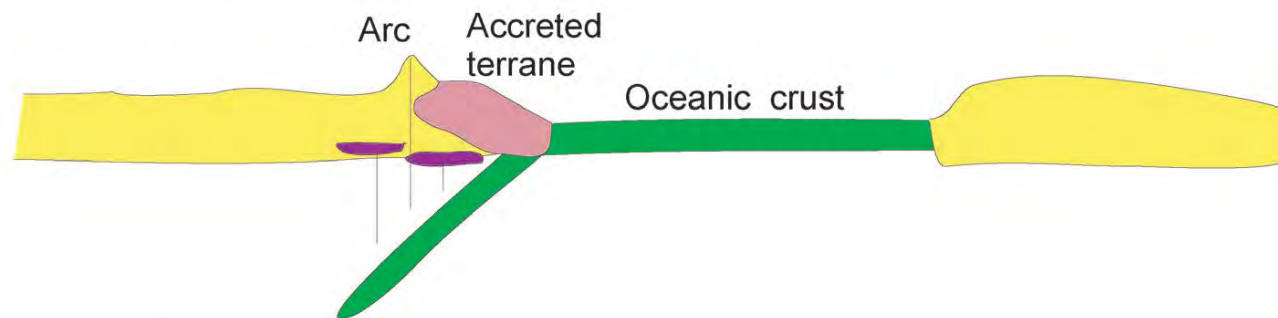
<3 Ga → Present day



decreasing mantle temperature / convection



ACCRETIONARY



COLLISIONAL

