No mantle convection and enigmatic subduction of oceanic lithosphere

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Abstract.
In the paper double seismic zones are discussed as a phenomenon confirming penetration of oceanic lithosphere through the mantle as solid and extremely hard medium. Formation of such medium has been performed by solidification of Earth from core-mantle boundary upwards. Lower mantle formed under extremely high pressure prevents any earthquakes. Upper mantle is suitable for formation of embrittlement and earthquakes in double seismic zones. Continental lithosphere overriding oceanic lithosphere forms subducton zones firmly anchored in mantle. Deeply steeping subduction zones penetrate mantle burning its way by melting probably as far as through core-mantle boundary. Oceanic lithosphere grows in mid-ocean ridges with half speed of the front of plate. Driving forces are tides. Movements of plates confirm hotspot tracks. Hotspots are probably of meteoric origin. They penetrate through mantle in same way as subducton zones. Material created in penetration moves upwards by buoyancy and during its subsidence creates hotspot tracks over 10 000 km, however their penetration as far as core-mantle boundary is not proven.

Introduction

In 1931 Arthur Holmes introduced the concept of mantle convection as a motive force to drive continental drift. Harry Hess (1962) adopted the idea of mantle convection as a critical component of seafloor spreading, which became an integral part of plate tectonics. This idea is absolutely incorrect, it contradicts to any observations and even worst, mantle convection should draw oceanic lithosphere deeply into mantle. This imagination persists till present. Present knowledge states that mantle is a solid body forming firm carapace round the Earth’s core, as confirmed by the travel of seismic P and S waves. The Earth quickly rotates and its solid structure allows only negligible flattening 20 km. The axis Earth’s rotation is firmly stable with regard of ecliptic by presence of Moon as proved Laskar et al. 1993.and also with regard of solid mantle, neglecting pole wobble variations and small irregular polar drift. Lithospheric plates really move, continental plates collide and moving oceanic lithosphere, created in mid-ocean ridges enigmatically disappears, dropping down in subduction zones. How oceanic lithosphere can pass through solid and brittle mantle, being only slightly dense then surrounding mantle, which density increases with depth, remains an enigma solved in this paper.

Double subduction and double seismic zones.

Present plate tectonics considering mantle convection imagines that oceanic lithosphere is separated apart in mid-ocean ridges by uprising flow and ending parts are driven to depth by convecting flow in mantle (Fig. 1.

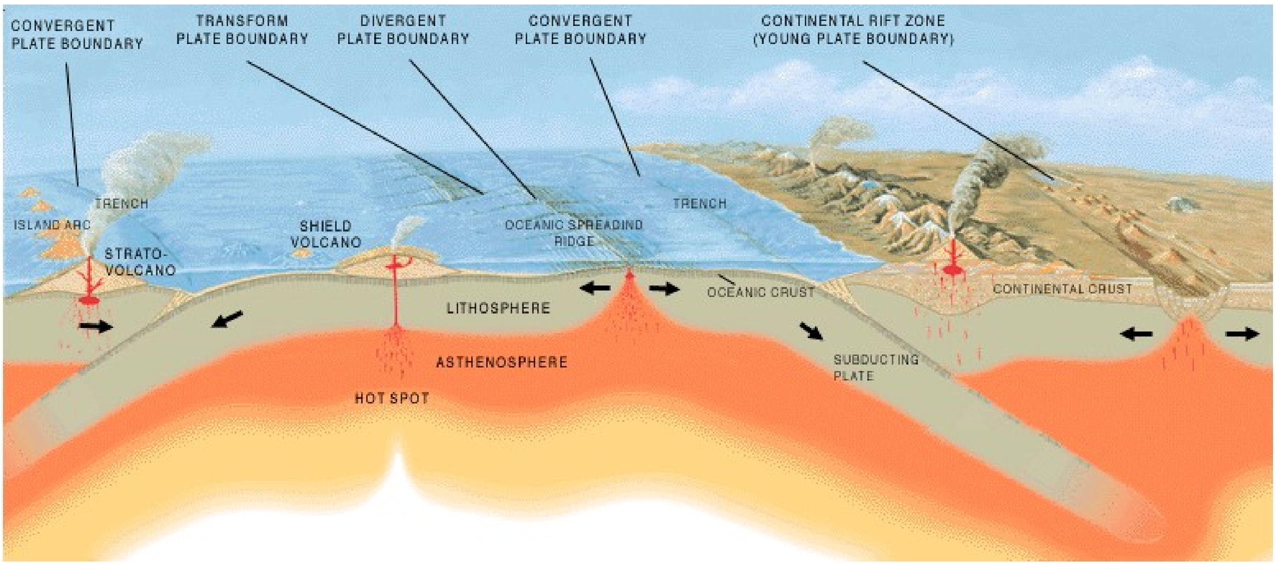

Figure 1 Imagination of double subduction zones. Black arrows mark separation in mid-ocean ridge and direction of subducted parts into depth. Surrounding continents can push closer subducted parts (Molucca), what again contradicts to reality Figure is taken from Universe Today 2.11.2009.

Reality is quite different. Subduction zones are firmly anchored in mantle and on the contrary, mid-ocean ridges move with half speed of the moving plate (Fig. 2).

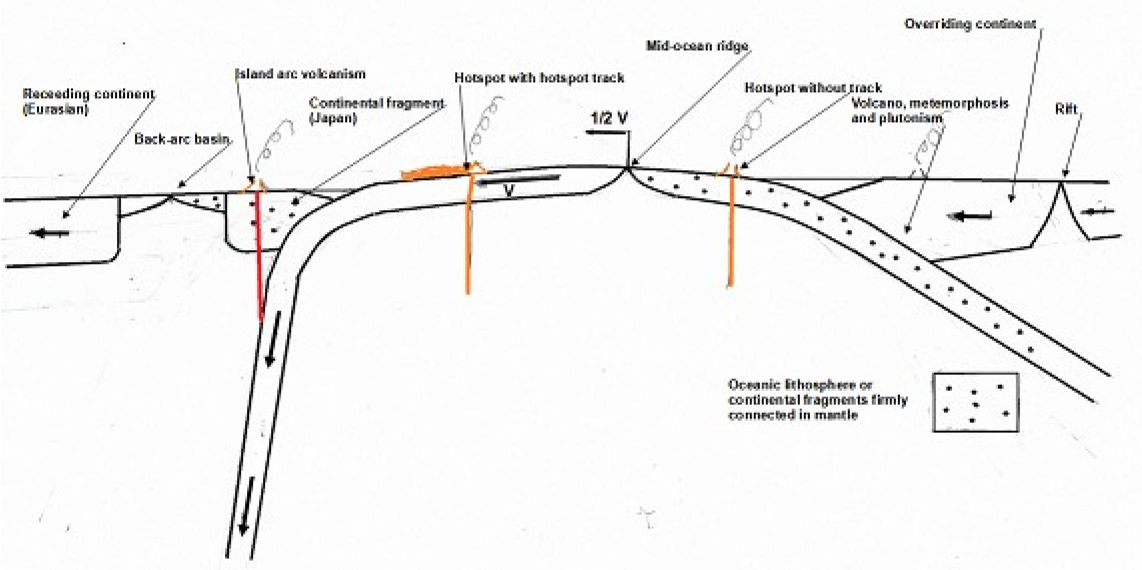

Figure 2. Real lithospheric plates movement. In figure plates move westward, only subduction zones, mantle plumes and continental fragment adjacent to subduction zone remain fixed over mantle.

In Ostřihanský 2021 it has been shown that lithospheric plates move westward and only Pacific. Indo-Australian and African move also with northward component. This movement is caused by tides, which act in 2 components: westward 10^{16} Nm and stronger north-southward 10^{22} Nm, acting perpendicularly and helping by that to weak westward lithospheric component (See Appendix in Ostřihanský 2022). As Fig. 2 shows, oceanic lithosphere in front of mid-ocean ridges is firmly connected to mantle; it grows by overriding of continental plate and by movement of mid-ocean ridge. Therefore with extreme mantle hardness and embrittlement is no problem. Oceanic lithosphere behind mid-ocean ridge moves by tides over melted low velocity zone (LVZ). However how oceanic lithosphere passes through hard and brittle mantle being only slightly heavier than mantle remains enigma. It is evident that gravity can help steeply dipping subduction zone and hypothetically last possibility remains that subducting oceanic lithosphere burns itself a hole in mantle. This hypothesis of burning through mantle, new discovery of **double seismic zone** extremely favorably supported.

Double seismic zone (DSZ) has been discovered by Hasegawa et al. 1978 beneath Honshu and after a publication gap, at present time almost all subduction zones are considered as double seismic zones. Figure 3 shows the most important double seismic zones.

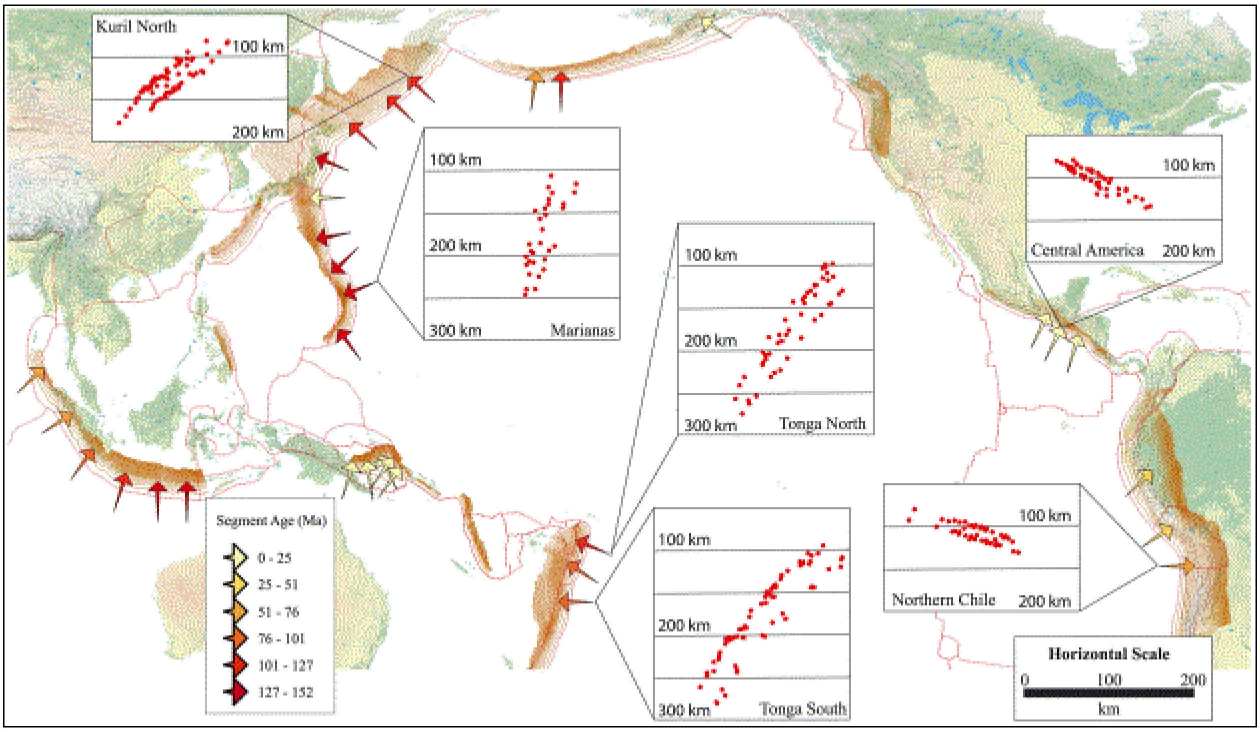

Figure 3 shows double seismic zones, as depicted by Florez and Prieto 2019. Double seismic zones occur in intermediate subduction zones in dept 100 – 300 km. Wei et al 2017 reported Tonga subduction zone reaching 450 km. As evident, subduction zones overridden by continental lithosphere are shallow and slightly inclined. Steeply dipping subduction zones are deep with wide gap between earthquake planes, with good condition for oceanic lithosphere burning through mantle, supported by gravity.

Conditions in deep Earth's interior

A variety of mechanisms have been proposed to explain DSZ earthquakes, including dehydration embrittlement, plastic shear instability, transformational faulting and fluid-related embrittlement.It is evident that dehydratation embrittlrmrnt plays important role after 100 km depth, but most important role plays decompression in greater depth and increase in temperature, which in depth 100-400 km reaches 1500-2000 ºC (Jeanloz and Morris 1986), forming ideal conditions for melting. To keep low temperature melting, decompression is necessary, because according to Clausius Clapeyron eqation, melting temperature is dependent on ambient pressure and decrease with increasing pressure. In next it will be explained that in intermediate earthquake depth there are good condition for oceanic lithosphere burning the hole into depth.

Let us present simple relations for gradient of melting point (Jacobs 1974) and adiabatic temperature gradient (Jeffreys 1929) and demonstrate how these gradients will operate in relation to gradients of temperature in given time in Earth and what follows from it for extreme hardness and strength in mantle. Effect of pressure on melting point is given by Clausius-Clapeyron equation.

$$\frac{dT_m}{dp} = \frac{dT_m}{L}\left(\frac{1}{\varrho_1} - \frac{1}{\varrho_2}\right)$$

where T_m is melting point, L latent heat of melting, ρ_1 , ρ_2 are densities in liquid and in solid state.

Considering hydrostatic equilibrium, change of pressure with depth is given

$$\frac{dp}{dz} = g\,\varrho$$

From both equations follows (*g* is constant of gravity):

$$\frac{dT_m}{dz} = \frac{g \cdot T_m}{L} \cdot \left(1 - \frac{\varrho_1}{\varrho_2}\right)$$

In theory of convection, adiabatic gradient is very important given by relation

$$\frac{dT_m}{dz} = \frac{g \cdot \alpha \cdot T_m}{\varrho \cdot c_p}$$

where α is volume coefficient of thermal expansibility and c_p specific heat under constant pressure.

As far as the temperature gradient dT/dz is bigger than adiabatic, the movement of fluid occurs in direction upwards. Movement is stopped if both gradients are equal, possibly movement is reversed, as far as the temperature gradient is smaller than adiabatic.

As it follows from calculations for supposed constants (Jeffreys 1929. Jacobs 1974) the gradient of melting point is about 10x larger than adiabatic temperature gradient and from this reason the Earth solidified from core-mantle boundary upwards.

Consequences

Lower parts of mantle has been exposed to enormous pressure before solidifying, resulting in extremely strong and hard medium. (Remember, diamond created from graphite under large pressure and having melting temperature over 4000 ºC). Pressure in lower mantle is 130 GPa according to the PREM model (Dziewonski and Anderson, 1981). However if this part solidifies in extremely strong and hard medium, compression strength is paralyzed. This is phenomenon named in previous author’s (Ostřihanský 2020) papers “bathyscaphe effect.“, when pressure does not act, but medium is subjected to surrounding temperature. In subduction of oceanic lithosphere, temperature plays the most Important role. According to model results (Boehler 1993, 1996) the temperature is about 1000 ºC at the base in the crust, around 3500 ºC at the base of the mantle and around 5000 ºC at Earth's center.

Pacific plate makes large movement by tides. Considering only part of Hawaii–Emperor Seamount chain, Part only up to elbow, i.e. from Hawaii as far as Midway Is. equals 3000 km. long. It means that subduction from trench reached core-mantle boundary at 2900 km depth. To reach such depth is possible only by burning of oceanic lithosphere and pnetration through extreme solid mantle being melted and continuing into depth, falling in still increasing temperature. Up to 400 km, mantle is not quite solid; decompression makes subducting part to burn through mantle, but forming embrittlement of surrounding parts. Deeper, the mantle is absolutely solid though that no earthquakes are created and burning to depth continuous without any embrittlement to core or remains over mantle dispersed.

Subducting oceanic lithosphere burning down to still hotter medium is melted and heavier component continues to the depth. Lighter component rises up burning mantle above forming vent in overlying mantle driven by buoyancy. This light component forms volcanics of island arcs. Formation of hot spots is similar. Hotspots, probably of meteoritic origin is melted, burn down by gravity underlying mantle and melt formed by melting rises up, forming hotspot tracks. Burning towards depth still continues, but scarcely hotspot reaches core-mantle boundary, nevertheless forming hotspot tracks over 10 thousands kilometers.

Note:

Burning is generally considered as chemical reaction between fuel and oxygen. In our case burning is considered as consequent melting of intruding subduction oceanic lithosphere driven by gravity to depth into medium of increasing temperature. It means that heavy part still subsides reacting with still hotter medium and lighter upraises..

Conclusion

Formation of subduction of oceanic lithosphere by overriding continental lithosphere represents no problem. Complication arises in case of steeply dipping oceanic subduction zones formed by gravity subsidence, Stumbling point is, where oceanic lihosphere is in contact with solid mantle. Conditions are created where contacting part is melted. Perhaps real burning creating large temperature being in contact with oxygen of water transfers heat into mantle and melting.. This melting continues consequently as far a core –mantle boundary. Reason is, that in contact decompression occurs, which causes melting in accordance with Clausius-Clapeyron equation and still heavier melt supports subduction..

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