

# Structural and petrologic evolution of the subcontinental mantle from rifting to drifting at the Adria margin: insights from the Lanzo peridotites in the Western Alps.

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The Lanzo Massif peridotites were originally located in the Western Alpine sector of the Jurassic Ligurian Tethys, going from Ocean-Continent Transition (OCT) settings (the North Lanzo body) to more Internal Oceanic (MIO) settings (the South-Central Lanzo bodies). The Lanzo peridotites were involved in the tectonic and magmatic processes related to the extensional evolution of the mantle lithosphere (i.e., mantle exhumation and melt percolation) of the Europe-Adria system leading to the rifting and opening of the Jurassic Ligurian Tethys basin (Piccardo, 2008).

Present knowledge on the Lanzo massif indicate that the evolution of the South-Central and North Lanzo mantle sections was remarkably different. In fact:

- (1) the North Lanzo peridotites (i) were significantly recrystallized at plagioclase-peridotite facies conditions (i.e. underwent significant subsolidus exhumation), (ii) escaped reactive percolation at spinel-peridotite facies conditions, (iii) was, later on, impregnated at plagioclase-peridotite facies conditions by aggregate MORB melts, and (iv) underwent focused percolation of alkaline melts;
- (2) the South-Central Lanzo peridotites (i) underwent significant melt reactive percolation at spinel-peridotite facies conditions, (ii) were deeply impregnated by melts at plagioclase-peridotite facies conditions, and (iii) underwent focused percolation of aggregate MORB melts and, sporadically, of alkaline melts.

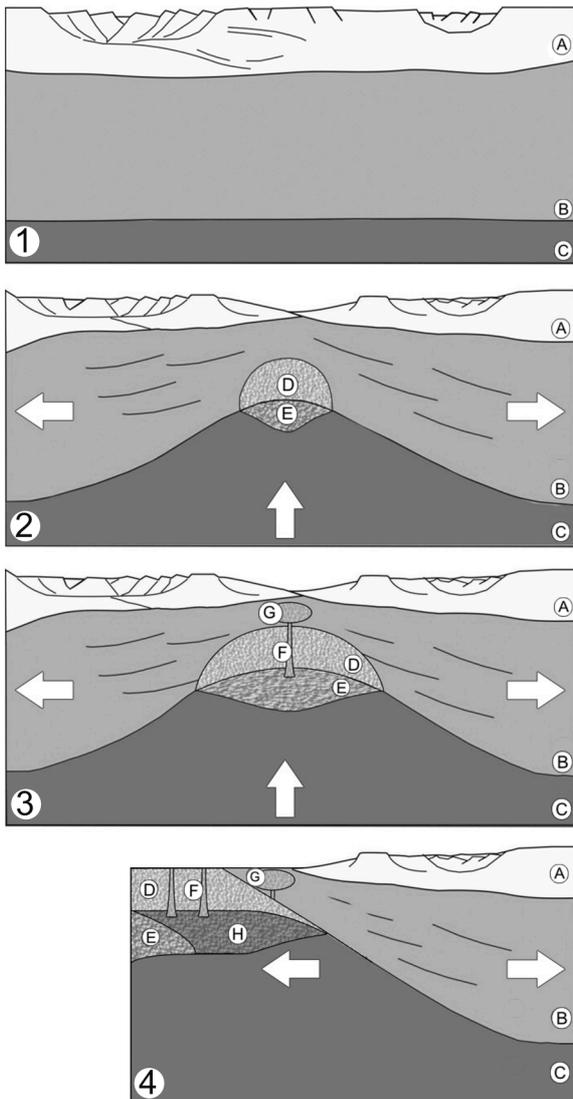
The lithospheric protoliths of the North and South-Central Lanzo peridotites were, most probably, originally located at different depths in the sub-continental lithosphere and evolved at different times, relatively to the decompression partial melting of the underlying asthenosphere and the melt migration processes in the lithosphere related to the rifting stages in the Ligurian Tethys basin (Piccardo et al., 2007a and 2007b). In fact, the North Lanzo peridotite section was impregnated by aggregate MORB melts when it was already exhumed to plagioclase-peridotite facies conditions ( $P < 1$  GPa). By contrast, the South-Central Lanzo peridotite section was diffusely and reactively percolated by MORB-type fractional melts when it was still resident at deeper levels under spinel-peridotite facies conditions ( $P > 1$  GPa), and was later impregnated by MORB-type fractional melts at plagioclase-peridotite facies conditions, prior to focused percolation of aggregate MORB melts and, sporadically, alkaline melts.

In summary, the Nord Lanzo peridotites solely record melt percolation and impregnation by the aggregate MORB melts which migrated through the South-Central Lanzo peridotites by focused percolation within replacive harzburgite-dunite channels. This fact is in favour of the hypothesis that the Nord Lanzo peridotite protoliths were located at shallow lithospheric levels than the South-Central Lanzo peridotite protoliths with respect to the axial zone of the system, above the melting asthenosphere.

The early MORB-type fractional melts, formed in the upwelling asthenosphere at the inception of decompressional melting, infiltrated and modified the deeper spinel-peridotite facies lithospheric mantle levels (i.e., the South-Central Lanzo peridotite protoliths), forming the South-Central Lanzo depleted reactive spinel peridotites. Subsequently, MORB-type fractional melts percolated the reacted and depleted levels (i.e., the South-Central Lanzo peridotite protoliths) when they have been exhumed to plagioclase-peridotite facies conditions, forming the South-Central Lanzo impregnated plagioclase peridotites (*impregnation by fractional MORB melts*). Accordingly, plagioclase peridotites were formed by impregnation by MORB-type fractional melts mostly at the expenses of the depleted reactive peridotite protoliths of South-Central Lanzo. The shallower lithospheric mantle levels (i.e., the North Lanzo peridotite protoliths) escaped these melt-peridotite interaction

events caused by MORB-type fractional melts and preserved their pyroxenite banding and pristine fertile lherzolite composition.

Subsequently, the focused migration within harzburgite-dunite channels allowed to aggregate MORB melts to pass through the deeper plagioclase-impregnated levels (i.e., the South-Central Lanzo plagioclase peridotites) and to percolate diffusely the shallower, more fertile levels (i.e., the North Lanzo peridotites), producing significant interstitial crystallization and impregnation by aggregate MORB (*impregnation by aggregate MORB melts*) in the North Lanzo pyroxenite-bearing fertile lherzolites.



*The evolution of the Lanzo Massif (Italian Western Alps) in the frame of rifting of the Jurassic Ligurian Tethys.*

(1) *The pre-Triassic setting: (A) = continental crust; (B) = Sub-continental mantle lithosphere; (C) = Asthenosphere (non to scale);*

(2) *Extension driven by far-field forces led to significant thinning of the continental lithosphere, causing: (i) exhumation of the shallower lithospheric mantle to plagioclase-facies conditions (i.e., Lanzo North protoliths); (ii) adiabatic upwelling and inception of decompressional melting of the asthenosphere (E) ; (iii) porous flow percolation through the lower mantle lithosphere (i.e., Lanzo South protoliths) of MORB-type fractional melts which escaped aggregation, survived unmixed and migrated isolated, forming reactive and impregnated peridotites (D);*

(3) *Increase of partial melting during progressive decompression, where the single melt fractions were more efficiently mixed and completely aggregated to form MORB magmas. Aggregate MORB magmas passed through the South Lanzo peridotites by focused migration within replacive harzburgite-dunite channels (F), undergoing variable fractionation by olivine crystallization, and infiltrated the North Lanzo peridotites (G); refractory residua (H) after asthenosphere partial melting which were accreted to the thermal lithosphere;*

(4) *Ongoing lithosphere extension and stretching by means of km-scale shear zones caused the break-up*

*of the continental crust and the sea-floor exposure of the sub-continental lithospheric mantle. The strongly modified South Lanzo peridotites, deriving from originally deeper mantle sectors, were exposed at the sea-floor at more Internal Oceanic (MIO) settings of the basin, whereas the North Lanzo peridotites, deriving from originally shallower mantle sectors, were confined to more External Ocean-Continent Transition (OCT) zones of the basin, close to the Adria continental margin.*

Lithosphere extension and thinning related to rifting of the Ligurian Tethys system caused (Piccardo, 2008):

(1) the exhumation of the spinel-peridotite facies lithospheric mantle and, particularly, the transition to plagioclase-peridotite facies conditions of the North Lanzo peridotite protoliths;

- (2) the adiabatic upwelling and decompressional partial melting of the underlying asthenosphere which formed MORB-type single melts increments by fractional melting which survived isolated and migrated upwards by diffuse porous flow;
- (3) the porous flow percolation of the single melt increments through the South-Central Lanzo peridotite protoliths which formed reactive depleted peridotites, at spinel-peridotite facies conditions, and impregnated plagioclase peridotites, at plagioclase-peridotite facies conditions;
- (4) the coalescence of the melt fractions to form aggregate MORB magmas which passed through the South-Central Lanzo peridotites by focused migration within replacive harzburgite-dunite channels and infiltrated the North Lanzo peridotites.

Ongoing lithosphere extension and stretching caused the progressive upwelling of the South Lanzo peridotites deriving from originally deeper mantle sectors, the breakup of the continental crust and the sea-floor exhumation of the sub-continental lithospheric mantle. Accordingly, the South Lanzo peridotites were exposed at the sea-floor at more Internal Oceanic (MIO) settings of the basin, whereas the North Lanzo peridotites, deriving from originally shallower mantle sectors, were confined to more External Ocean-Continent Transition (OCT) zones of the basin, close to the Adria continental margin.

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