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The extreme heterogeneity of the ophiolitic peridotites from the Jurassic Ligurian Tethys: causes and consequences.

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Ophiolitic peridotites from the oceanic lithosphere of the Jurassic Ligurian Tethys, at present cropping along the Western Alpine - Northern Apennine (WA-NA) system, are sections of subcontinental mantle of the Europe-Adria lithosphere, which underwent exhumation from lithospheric depths and sea-floor exposure in response to the pre-oceanic lithosphere extension, leading to oceanic opening.

Recent field, petrologic-geochemical investigations (Piccardo, 2003; Piccardo et al., 2004a, 2004b, 2005, 2006) on WA-NA ophiolitic peridotites (i.e. Lanzo South, Erro-Tobbio, External and Internal Ligurides, Monte Maggiore) have allowed us to document the extreme structural and compositional variability of these ophiolitic peridotite bodies and to place further contraints on the petrochemical processes responsible for the modification of mantle lithosphere during exhumation related to passive lithosphere extension.

The pristine lithospheric protolith was formed by spinel peridotites intercaleted by pyroxenites. Spinel peridotites underwent a widespread structural recovering to coarse granular textures and significant pyroxene depletion, which are coupled to diffuse presence of pyroxene-dissolving, olivine-forming microtextures.

Structural features and mineralogical reactions indicate that these “reactive”, pyroxene-depleted, spinel harzburgites were formed by melt-rock interaction with uprising pyroxene(-silica)-undersaturated melts. Cpx trace element compositions indicate that the percolating melts were single melt increments, with MORB affinity, formed by low degrees (1-5%) of fractional melting of a spinel-facies (and rarely

garnet-facies) asthenospheric DM source. When exhumed at shallower levels (at plagioclase-facies conditions) both lithospheric and reactive spinel peridotites were diffusely transformed to plagioclase-enriched peridotites which show peculiar micro-textures indicative of both melt-rock reaction and melt interstitial crystallisation.

Mineralogical reactions and Cpx trace element compositions suggest that the percolating melts were variably pyroxene(-silica)-saturated single melt increments with MORB affinity, formed by low degrees (1-6%) of fractional melting of a spinel-facies DM source.

Textural evidence indicates that the percolating melts underwent incipient crystallisation of first cumulus minerals (i.e. pyroxenes and plagioclase) within the percolated peridotite; accordingly, the ambient temperature should have been lowered by conductive heat loss below the liquidus temperature of the percolating melts. This event formed “impregnated” plagioclase peridotites, enriched in basaltic components. The interstitial crystallisation of plagioclase-rich microgabbroic material caused clogging of the melt flow channels and stopping of melt migration via diffuse porous flow.

Previous rock types are cut by strongly refractory, coarse granular, spinel harzburgites and dunites, in form of metre- to decametre-wide elongated bodies, which show dissolution textures on relict pyroxenes and, sporadically, interstitial crystallisation of new magmatic Cpx. Field relationships and mineralogical reactions suggest that these strongly depleted channels were formed by the focused migration of pyroxene-undersaturated melts, which completely dissolved plagioclase and pyroxenes of the ambient peridotite. Trace element composition of interstitial Cpx suggest that migrating melts in these focused channels were both depleted single melt increments and already aggregate MORB.

Accordingly, our studies evidence the fundamental role of melt-related processes in the modification of pristine mantle lithosphere during exhumation related to lithosphere extension.

Early open system melt migration (melt reactive percolation at spinel facies conditions) suggests that temperature of ambient peridotite should have been brought close to the liquidus temperature of the percolating basaltic melts, whereas crystallisation of cumulus minerals (melt impregnation at plagioclase-facies conditions) corresponds to a progressive decrease of the temperature of the system below that of the liquidus of the percolating melts, reasonably due to conductive heat loss.

Accordingly, upward migration of asthenospheric melts was coupled to significant heating of the mantle lithosphere. Heating and weakening (i.e. thermo-mechanical erosion) of the lithosphere should have been an important factor in the “rapid” evolution of the extensional system from passive extension to oceanic spreading in the Ligurian Tethys.

Our studies on WA-NA ophiolitic peridotites suggest that, at extensional settings: i) significant compositional modifications of the lithospheric mantle can be induced by upward percolation of asthenospheric melts; ii) the thermo-mechanical erosion of the extending mantle lithosphere play a fundamental role in the continental break-up and the inception of the oceanic spreading.

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