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The interplay of tectonic metamorphic and melt-related processes in the exhumation history of the Erro-Tobbio ophiolitic peridotite (Voltri Massif – Ligurian Alps, Italy).

G.B. Piccardo (1), **E. Poggi** (1) and R.L.M. Vissers (2)

(1) DIPTERIS, University of Genova, Genova, Italy (poggi@dipteris.unige.it), (2) Departement of Earth Sciences, Utrecht University, Utrecht, The Netherlands

The Erro-Tobbio (ET) ophiolitic peridotite (Voltri Massif – Ligurian Alps, Italy) is a fragment of subcontinental lithospheric mantle that has been emplaced at crustal, sub-oceanic levels during rifting and opening of the Jurassic Ligurian Tethys. Previous structural and petrologic studies (Drury et al., 1990; Vissers et al., 1991; Hoogerduijn Strating et al., 1993) have demonstrated that the ET peridotites were uplifted along a subsolidus P-T trajectory, starting from subcontinental lithospheric mantle depths (T = 1000-1100˚C and spinel-facies conditions), in response to the lithospheric extension leading to opening of the Ligurian Tethys. Peridotites were deformed along km-scale extensional shear zones, forming spinel peridotite tectonites, spinel- and plagioclase-bearing mylonites, hornblende/chlorite peridotite mylonites and, finally, serpentinite mylonites.

The presence of discrete MORB gabbroic intrusions and gabbroic and basaltic dikes cutting deformed peridotites strongly suggests that lithosphere extension and thinning was accompanied by near-adiabatic upwelling and decompressional partial melting of the underlying asthenosphere.

Our recent investigations (Piccardo et al., 2004a, 2004b) reveal that, prior to intrusion of aggregate MORB melts, pristine spinel-facies peridotite tectonites were partly transformed into granular spinel and plagioclase peridotites which show peculiar structural and compositional characteristics, suggesting melt-rock interaction processes. This evidence indicates that melt fractions from the molten asthenosphere migrated upwards by diffuse porous flow through, and reacted with the overlying extending lithosphere, causing significant modification of the mantle peridotites.

Structural and compositional evidence indicate that the mantle lithosphere was initially percolated, at spinel-facies conditions, by pyroxene(-silica)-undersaturated, depleted fractional melt increments, with MORB affinity. At shallower levels, under plagioclase-facies conditions, both lithospheric and reactive spinel peridotites were percolated and impregnated by orthopyroxene(-silica)-saturated depleted fractional melt increments, showing MORB affinity, which partially dissolved mantle Cpx and precipitated Opx + Plg. This event formed “impregnated” plagioclase-rich peridotites, enriched in basaltic components. The interstitial crystallization of plagioclase-rich microgranular noritic material caused clogging of the melt flow channels and eventually impeding melt migration of MORB-type fractional melts via diffuse porous flow through the mantle lithosphere. Further uprising asthenospheric melts were forced to migrate along structural and compositional discontinuities: pyroxene(-silica)-undersaturated melts completely dissolved plagioclase and pyroxenes of the ambient peridotite and formed high porosity, high permeability dunite channels. Cpx compositions of gabbroic dikelets related to dunites indicate that the migrating melts were still MORB-type depleted single melt increments. The formation of replacive dunites represents a late melt-related event: the ongoing tectonic evolution is characterized by strongly localized deformation along km-scale shear zones under plagioclase-facies condition, forming plagioclase-bearing tectonites and mylonites.

Further exhumation at increasing conductive heat loss brought these peridotites to more cold and brittle regimes where upward melt migration was only permitted by dyking. Uprising melts were already aggregate MORBs: this suggests that the pertinent change of the melt migration mechanism (i.e. from melt percolation to melt intrusion) was followed by a significant modification of the melt dynamics in the molten asthenosphere, towards more oceanic conditions.

Our present knowledge suggests that inception of asthenosphere partial melting, in response to lithosphere extension and thinning, and asthenosphere-lithosphere interaction by melt reactive percolation strongly modified the compositional and rheological characteristics of the lithospheric mantle: softening and weakening of the extending mantle lithosphere could have been important factors in the transition from passive lithosphere extension to active oceanic spreading.

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