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On the Origin of Plagioclase Peridotite: Crystallization in a Thick Thermal Lithosphere

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Three mutually non-exclusive genetic models have been proposed to explain the occurrence of plagioclase peridotites in the Earth's upper mantle. (i) Development of upper mantle diapirs representing relatively undepleted 'fertile' upper mantle with incomplete melt extraction and subsequent rapid cooling and partial crystallization of melt pockets [1,2], (ii) generation of fertile rocks by impregnation of basaltic liquids, melt/rock reaction and subsequent equilibration [1,3], or (iii) formation of plagioclase by subsolidus metamorphic reactions during uplift from spinel to plagioclase facies conditions [4,5]. We present textural and mineral chemistry data (EMS, LA-ICP-MS) from peridotites of the Alps and Apennine in support of hypothesis (ii) that many peridotites may have been substantially modified by melt/rock reactions with MORB-like basaltic liquids producing plagioclase-bearing peridotites similar to those occurring at present-day magma-poor passive margins [6] and along (ultra-) slow-spreading ridges [3]. Such impregnated peridotites were intruded by gabbros. The vicinity of (cold) continental mantle to juvenile (ultra-) slow spreading ridges and/or the slow spreading rate might be the reason for a thick and relatively cold mantle lithosphere that forces migrating magmas to stagnate and crystallize in the mantle. Major and trace element chemistry of clinopyroxene and spinel is distinctly different between relict continental mantle, residual peridotite and infiltrated mantle (for example: $Na_2O > 1.2$ wt%, $(Gd/Yb)_N \leq 1$ for cpx of spinel peridotite; $Na_2O < 0.8$ wt%, $(Gd/Yb)_N > 1$ for cpx of plagioclase peridotite). Within the plagioclase peridotites, LREE depleted peridotites are preserved, representing either 'primary' refractory residues of near-

fractional melting or ‘secondary’ products of melt/rock reaction at increasing melt mass (pyx + liq1 -> ol + liq2). Trace element modeling suggests that ‘true’ refractory peridotites experienced an equal degree of melting in the garnet and spinel peridotite field. The Nd isotopic signature of such depleted cpx indicates a Permian or older age of depletion of many of these fractional melting residues, demonstrating that old sub-continental mantle forms part of the oceanic lithosphere and might be substantially modified and refertilized by migrating magmas [7,8]. Resetting of isotopic signatures approaching those of the migrating magmas might be an important consequence of refertilization. Substantial volumes of magma never reach the surface and represent a magmatic, but non-volcanic stage corresponding to ‘crust-free’ generation of oceanic lithosphere. A 20% of ‘gabbroic rock types’ (including true gabbro bodies and impregnated peridotites) would correspond to 4 km of oceanic crust that are dispersely distributed in the upper 20 km of the oceanic lithosphere. Such ‘non-volcanic’ periods are followed by or interfere with common magmatic and volcanic stages, where melt is extracted from the asthenosphere, migrating through the lithosphere within isolated dunite channels and/or fractures and form MOR-type gabbroic intrusions at depth and/or extruded at the sea-floor (MOR-type basaltic flows).

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