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Magma-rock interactions above plumes: Effects on seismic velocities and anisotropy in the lithospheric mantle

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Reactional percolation of magmas above mantle plumes may significantly modify the 3 parameters that control the physical properties of a mantle rock: mineralogical composition, chemistry (in particular, Fe content), and microstructure. To constrain the extent of this process and its consequences on the oceanic lithosphere seismic properties, we studied the relation between petrological processes and microstructure in mantle xenoliths from hotspots characterized by variable magma volumes: the Austral-Cook, Society, and Marquesas islands in the South Pacific Superswell and Hawaii. Polynesian and Hawaiian spinel-lherzolites show evidence of late crystallization of clinopyroxene, which may result from a near-solidus melt-freezing reaction and variable Fe enrichment. Olivine forsterite contents vary continuously from Fo91 to Fo85. Fo contents as low as 81 are observed in dunites and wehrlites. Yet, these rocks display microstructures and Ni contents that preclude a cumulate origin, suggesting that they result from melt/rock reactions involving pyroxene dissolution/olivine precipitation followed, in the wehrlites, by cpx crystallisation. These observations suggest that the lithosphere above a mantle plume undergoes a complex sequence of magmatic processes that significantly change its composition. These compositional changes, particularly Fe enrichment in olivine, result in lower P- and S-waves velocities. Relative to normal lithospheric mantle, compositionally-induced seismic anomalies may attain –2.2% for S-waves and -1% for P-waves. Smaller negative anomalies for P-waves are due to a higher sensitivity to modal composition. Conversely, crystal preferred orientations (CPO) and seismic anisotropy are little affected by these processes. Lherzolites and harzburgites, independent from composition, that show high-temperature porphyroclastic microstructures have strong olivine CPO. Dunites and wehrlites, as well as

some Hawaiian harzburgites, display annealing microstructures to which is associated a progressive dispersion of the olivine CPO. Very weak, almost random olivine CPO is nevertheless rare, suggesting that CPO destruction is restricted to domains of intense magma-rock interaction due to localized flow or accumulation of magmas.