Radial thermo-chemical structure beneath Western and Northern Pacific inferred from seismic waveform inversion

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The Earth's deep mantle seismic structure is dominated by two large low shear-wave velocity provinces (LLSVPs) located beneath Africa and the Pacific. These structures have been observed by many studies and data sets, but their nature, purely thermal or thermo-chemical, is still debated. Due to trade-off between temperature and composition, maps of shear-wave velocity anomalies (dln VS) alone are unable to discriminate between purely thermal and thermo-chemical hypotheses. Seismic shear-wave attenuation, measured by the quality factor Qs, strongly depends on temperature and may bring additional information on this parameter, allowing to resolve the trade-off between temperature and composition. Here, we invert seismic waveform data jointly for radial models of dln VS and Qs at two different locations beneath the Pacific, and from a depth of 2000 km down to the core-mantle boundary (CMB). At the Northern Pacific (NP) location, sampling a region around 50° N latitude and 180° E longitude, around VS and Qs remain close to the PREM values, representing the horizontal average mantle, throughout the investigated depth-range, with dln VS ~ -0.1% and Qs ~ 300 (compared to QsPREM = 312). At the Western Pacific (WP) location, sampling the western tip of the Pacific LLSVP and the Caroline plume, both VS and Qs are substantially lower than PREM. Importantly, dln VS and Qs sharply decrease in the lowermost 500 km, from -0.6 % and 255 at 2500 km, to -2.5% and 215 close to the CMB. We then show that WP models cannot be explained by thermal anomalies alone, but require excess in iron of 3.5 to 4.5 % from the CMB up to 2600 km, and about 0.4 to 1.0 % at shallower depths. This later enrichment may be due to the entrainment of small amounts of the Pacific LLSVP material by the Caroline plume. The values of Qs we observe give an estimate of the temperature anomalies, around 300-400 K close to the CMB, and 150 K at shallower depths. By contrast, NP models may have a purely thermal origin and can be explained by a temperature excess of about 50 K.