

# Inferring the lowermost mantle thermo-chemical structure beneath the Western Pacific with seismic attenuation and shear-wave speed anomalies

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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 ( $d\ln V_s$ ) alone are unable to discriminate between purely thermal and thermo-chemical hypotheses. Seismic shear-wave attenuation, measured by the quality factor  $Q_s$ , 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  $d\ln V_s$  and  $Q_s$  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  $V_s$  and  $Q_s$  remain close to the PREM values, representing the horizontal average mantle, throughout the investigated depth-range, with  $d\ln V_s \sim -0.1\%$  and  $Q_s \sim 300$  (compared to  $Q_{\text{PREM}} = 312$ ). At the Western Pacific (WP) location, sampling the western tip of the Pacific LLSVP and the Caroline plume, both  $V_s$  and  $Q_s$  are substantially lower than PREM. Importantly,  $d\ln V_s$  and  $Q_s$  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  $Q_s$  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.

Keywords: Seismic waveform, Seismic attenuation, Mantle structure, LLSVP