# Significant shear and bulk attenuation in the Tonga-Lau subduction system

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We image the 3-D attenuation structures of the Tonga subduction zone and the Lau back-arc basin using local earthquake waveforms recorded by the 2009-2010 Ridge2000 Lau Spreading Center Imaging project. Amplitude spectra of P and S waves from local earthquakes are inverted for the path-average attenuation operator ($t^*$) along with the seismic moment and corner frequency with varying frequency-dependent exponent ($\alpha$). Analysis shows that the data are best fit by the assumption of $\alpha \approx 0.3$, supporting the laboratory-based models of grain boundary sliding. The $t^*$ measurements are inverted with various techniques to obtain 3-D tomographic models of $Q_P$, $Q_S$, and $Q_P/Q_S$. Results show strong anomalies of high *P*- and *S*-wave attenuation within the upper 100 km of the mantle beneath the back-arc basin. Perhaps the highest seismic attenuation ($Q_P < 30$ and $Q_S < 20$) known in the mantle is found immediately beneath the spreading center. High attenuation anomalies form an inclined zone dipping from the back-arc spreading centers to the west away from the slab. This high-attenuation zone in the back-arc requires not only abnormally high temperature but also the existence of partial melt, suggesting that hot materials supplied from the Australian mantle upwell along with the mantle wedge flow pattern, triggering extensive decompression melting near the back-arc spreading centers. The back-arc basin attenuation anomalies show low $Q_P/Q_S$ ratios (< 1.5), in contrast to more conventional $Q_P/Q_S$ ratios (> 1.8) beneath the Fiji Plateau. This suggests that the bulk attenuation is as large as the shear attenuation beneath the back-arc spreading centers and near the Tonga slab, where abundance of partial melt and free water are expected, invoking mechanisms of bulk attenuation involving free fluids.

Keywords: Back-arc spreading, Seismic attenuation, Partial melting, Tonga subduction zone, Lau basin