Wave-equation based techniques to explore crustal structure along the axis of the East Pacific Rise 9ºN

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With the recent improvements and accessibility to enhanced computational power, we are now able to apply more sophisticated methods to deep-water, active seismic datasets and explore the Earth’s oceanic crust in greater detail. Here, we use a suit of wave-equation based techniques to look at the structure of the upper oceanic crust formed along the East Pacific Rise (EPR) between 9º16’ and 9º 56’N. The 2-D multi-channel, collected in 2008 along the EPR, we first extrapolate to a constant level just above the seafloor to suppress seafloor diffractions and to facilitate further inversion processes. We then apply wave-equation tomography, using first refraction arrival, to extract information on long- to mid-wavelength structures within the first 500 m of the upper crust. The resulting velocity model shows presence of localized low velocity anomalies, 5-10 % lower than the background velocity. The most prominent one is observed within the hydrothermally and magmatically dynamic region located north of 9º46’N, represented by well defined pipe-like zones of low velocity we interpret as presence of hydrothermal pathways. Their spatial distribution and association with previously mapped geological features help us to discriminate between the up- and down-going pathway. The two anomalies present beneath the two vent clusters are interpreted as the up-going fluid pathways. We suggest the remaining anomalies collocated with the morpho-tectonic deviations of the ridge axis as the ideal loci for seawater to penetrate the crust and potentially establish the down-going stream. The velocity model obtained from wave-equation tomography is further used as a starting model for waveform inversion. As the wave-equation tomography provides good match in travel-time and phase of the refraction event within the given data window, we can perform waveform inversion even though the low frequency and offset of the data is limited (useful signal > 4 Hz and offset range is smaller than 6 km) that could lead to cycle skipping. The resulting velocity introduced additional details in velocity models, which are spatially matched with individual fine-scale tectonic discontinuities and or vent orifices, and reflect processes related to local fracturing and cracking.

Keywords: wave-form inversion, mid-ocean ridge, hydrothermal circulation