Constrain the crust and upper mantle structure beneath the equatorial Eastern Pacific Rise from ambient noise and earthquake surface waves

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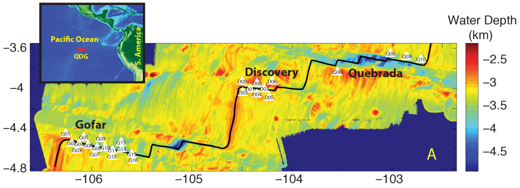
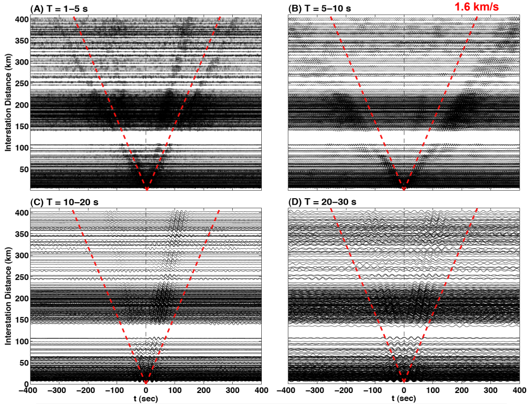
1. OBS Data



We use about one-year vertical-component broadband data recorded by 28 OBSs deployed at the Quebrada/Discovery/Gofar (QDG) transform faults region on the equatorial East Pacific Rise. We apply ambient noise analysis and earthquake surface wave two-station analysis to measure the interstation phase velocity dispersion curves to investigate the average crustal and upper mantle structure beneath the equatorial Eastern Pacific Rise.

2. Green's Function from Ambient Noise Cross-Correlation

We apply a band-pass filter in four period bands (1-5.5 s, 4.5-10.5 s, 9.5-20.5 s, 19.5-30.5 s) to one-day long data segments (vertical component). Subsequently, we apply one-bit cross-correlation to the filtered data in each period band and the obtained cross-correlation (CF) is filtered again in the same period band. The daily CFs in the four period bands are then stacked to form the broad band daily CFs (between 1 and 30 s period) for the dispersion analysis.

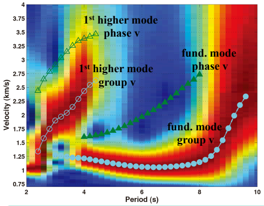


Yearly cross-correlation functions (CFs) for all OBS station pairs in four period bands

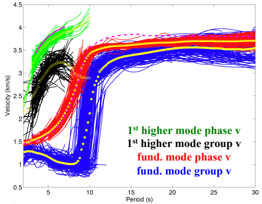
We observe both the fundamental mode and the first higher-mode Scholte-Rayleigh waves in CFs in the 1-5 s and 5-10 s period bands. In the 10-20 s and 20-30 s period bands we only observe the fundamental mode Rayleigh waves.

3. Dispersion from Ambient Noise Analysis

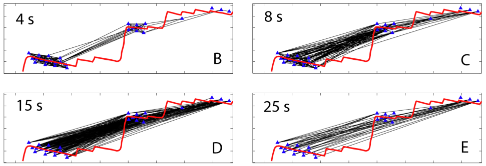
We measure all interstation Rayleigh wave fundamental- and the first higher-mode phase and group velocity curves (in the period band 2 – 30 s) using time-variable filtering technique and phase velocity image analysis.



Example of dispersion measurements from CF



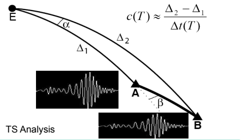
All measured interstation dispersion curves



Path coverage for the fundamental-mode phase-velocity measurements at four different periods

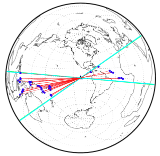
4. Phase Velocity Dispersion from Earthquake Surface Waves

We measure all possible interstation Rayleigh wave fundamental mode phase velocity dispersion curves (in the period band 20 – 100 s) using a two-station (TS) analysis of teleseismic surface waves.

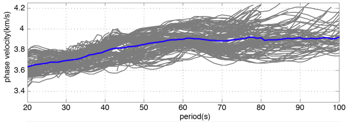


$$c(T) \approx \frac{\Delta_2 - \Delta_1}{\Delta t(T)}$$

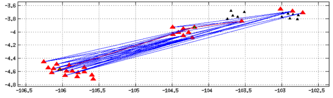
Schematic diagram for teleseismic TS analysis



Earthquakes used in this study (blue dots)



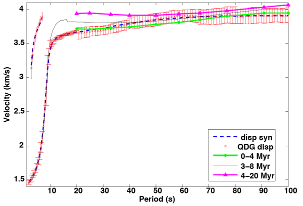
All measured interstation phase velocity dispersion curves (gray) and their average (blue)



Ray path distribution for all dispersion measurements

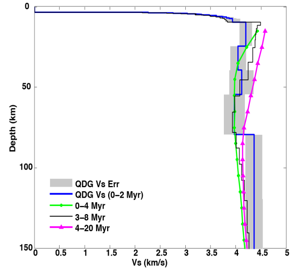
4. Joint Inversion for 1-D Vs Structure

We combine the average phase velocity dispersion data from ambient noise (between 2 – 20 s) and teleseismic surface waves (20 – 100 s), which was then used to invert for the 1-D Vs structure in the crust and upper mantle using a global search neighborhood algorithm (NA) (Yao et al., 2006; Yao et al., 2011).

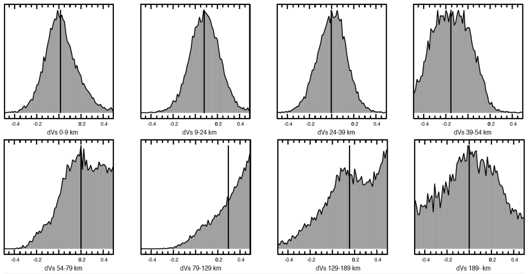


Observed (in red, with error bar) and synthetic (dashed blue, from the posterior mean model of NA) average Rayleigh wave phase-velocity dispersion. Black line: from Harmon et al. (2007). Green and magenta lines: from Nishimura and Forsyth (1989).

A pronounced low-velocity zone, with shear velocities ~ 4.0 km/s, appears between 25-80 km depth due to upwelling of hot asthenospheric material and partial melting. Along with previous results, our study indicates that Vs in the uppermost oceanic mantle increases with increasing seafloor age, consistent with age-related lithospheric cooling.



The posterior mean Vs model (blue line) and its standard error (shaded region) obtained from NA. Black line: Vs from Harmon et al. (2007). Green and magenta lines: Vs from Nishimura and Forsyth (1989).



The distribution of 1-D posterior probability density function of the 8 model parameters from NA. Horizontal axes: perturbation range of each parameter with respect to the reference value; black lines: the posterior mean values.

References

- Harmon, N., Forsyth, D., Webb, S., 2007. Using ambient seismic noise to determine short-period phase velocities and shallow shear velocities in the young oceanic lithosphere. Bull. Seismol. Soc. Am., 97(6), 2009-2023, doi:10.1785/0120070050.
- Nishimura, C. E., Forsyth, D. W., 1989. The anisotropic structure of the upper mantle in the Pacific, Geophy. J., 96, 203-229.
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