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Ambient-Noise Interferometry Across the Yakima Fold and Thrust Belt: Surface-Wave Modes and Shallow Velocity Heterogeneity

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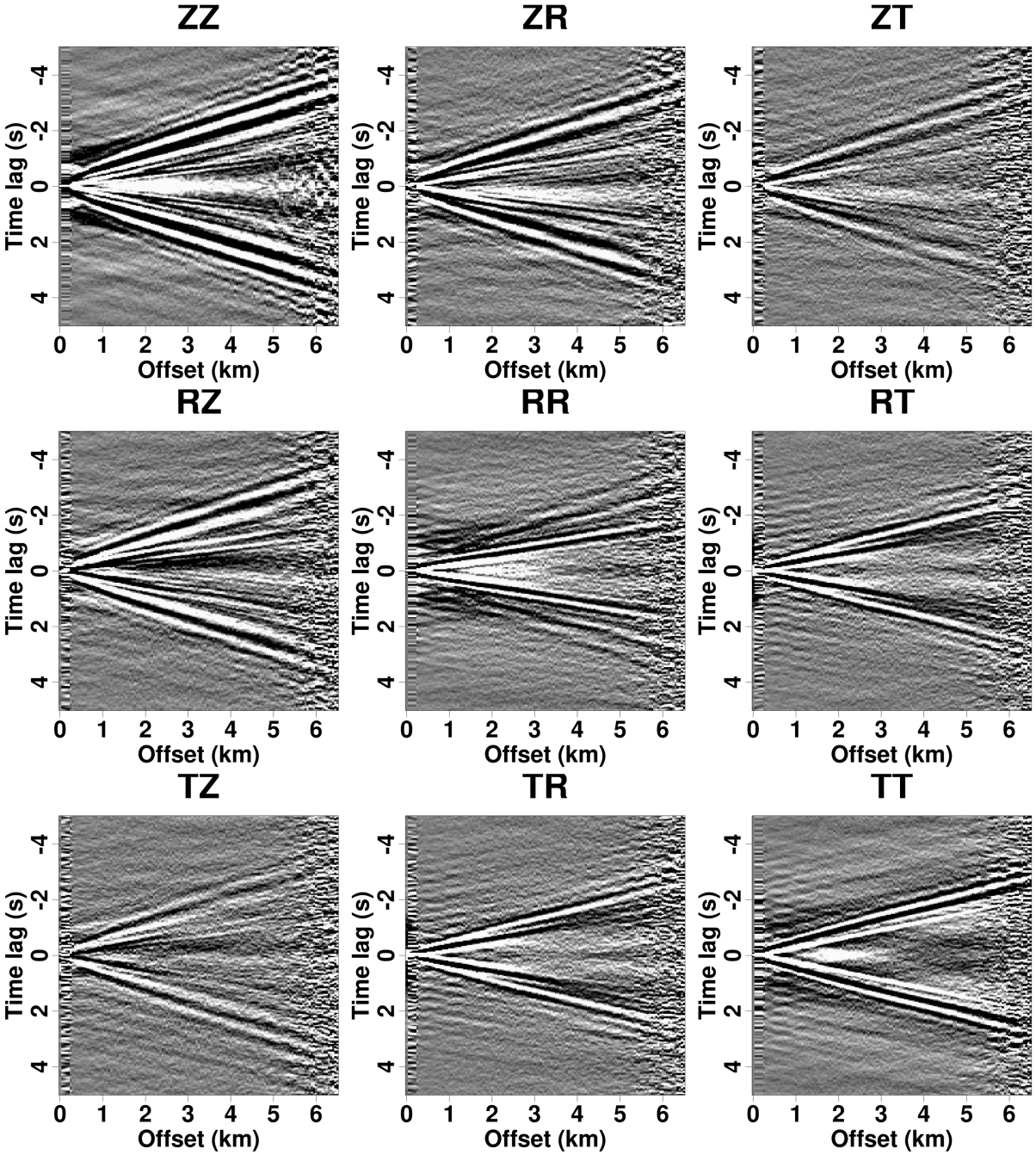
Abstract Text:
We present ambient-noise interferometry results from the Horse Heaven Hills, an anticlinal ridge of the Yakima Fold and Thrust Belt in south-central Washington, where the Columbia River Basalt Group is strongly layered, with dense flow interiors alternating with weathered, low-velocity flow tops. Data were acquired for Project TrapRock, a Carbon Containment Lab and Washington Geological Survey effort characterizing the basalt as a reservoir for permanent geologic carbon storage. Seven weeks of continuous data were recorded on 144 three-component 2 Hz nodes over a 5.5 km aperture. After conditioning (decimation, detrending, window selection, temporal balancing) and a magnitude-distance criterion that removes earthquake windows (1125 of 1200 hourly windows retained), we compute GPU cross-coherence correlations for all nine component pairs and rotate them into a station-pair radial-transverse frame.

The nine-component virtual shot gathers (VSGs) partition as expected for a surface-wave-dominated field: ZZ and RR (Rayleigh) and TT (Love) carry strong dispersive moveout, ZR/RZ are energetic and reciprocity-linked, and the Rayleigh-Love cross terms are weak but non-zero. Both show normal dispersion, and at least one higher-mode Rayleigh branch appears on RR. Stack convergence follows an N^-1/2 law until co-component terms depart after about 30 h as coherent signal emerges. Wavelength scaling places sensitivity between about 70 m and 1 km depth.

Imaged wavelengths (0.5 km to 3.5 km) far exceed the 170 m of relief, so the topography is sub-wavelength and wavefronts cross the array undeflected. Rayleigh-Love cross-term energy rises toward high frequency, indicating lateral velocity heterogeneity concentrated in the shallow section. Because both Rayleigh and Love branches are recovered, the VSGs constrain a fully elastic

model. We plan ambient-noise tomography for the lateral framework, then trans-dimensional Bayesian inversion of the dispersion, with HVSR as a joint constraint, to recover Vs(z) with data-driven layering and quantified uncertainty; higher modes add depth leverage beyond the fundamental. These results establish a pre-injection baseline for planned time-lapse monitoring. Project TrapRock is funded by the Washington Department of Commerce under the state's Climate Commitment Act.



Plain-Language Summary:

Storing carbon dioxide underground is one way to keep it out of the atmosphere. In south-central Washington, a thick stack of ancient lava flows is being studied as a possible storage site. Before anything can be stored there, we need to

know what the rock looks like below the surface: how it is layered, how fast it is, and whether it changes from place to place.

Instead of setting off explosions or using heavy equipment to make sound waves, we listened to the faint background hum that the Earth makes all the time, from ocean waves, wind, and human activity. We placed 144 small seismic recorders across a ridge and left them running for seven weeks. By comparing what any two recorders heard at the same moment, we can turn that random hum into a picture of waves traveling between them.

The waves behaved the way we expected for this kind of rock, and they show that the shallowest layers vary the most from place to place. These recordings give us a starting picture to compare against later, after carbon dioxide is injected.

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Poster preferred. This is the pre-injection baseline for a planned time-lapse survey at a carbon storage site.

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