Final Technical Report

Refined Seismic Amplification Forecasting by Improved Basin-Structure imaging with noise correlation methods

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The cities of Seattle and Tacoma lie largely atop deep sedimentary basins. These basins amplify and distort the seismic waves from nearby moderate and large earthquakes in ways that need to be understood if we are to anticipate the hazard from future earthquakes. Hazard maps are strongly dependent on the accuracy of basin shear wave velocity models and basin surfaces waves, converted from incident shear waves, are a particular hazard in the Seattle basin [Frankel, et al 2007].

We obtained the SHIPS dataset and used it to extract short-period Rayleigh waves in the Seattle basin using ambient noise techniques. The SHIPS dataset is augmented by nearby stations of the Pacific Northwest Seismic Network (PNSN) and Earthscope's Transportable Array (TA). We use ray theory and a Born approximation to forward model Rayleigh wave phase velocities and invert for the 2-D velocity structure at a range of frequencies.

Since the recording period of the SHIPS array was short (~40 days), many of the station pairs did not produce measurable surface waves. However, we were able to extract data from ~3000 paths over 7 periods between 2-10 seconds to constrain the upper few kilometers of the basin. Data coverage is excellent in the city of Seattle and some of the surrounding communities. Our Rayleigh wave phase velocity model clearly shows the location and magnitude of the Seattle fault and basin.

We developed a 3-D inverse method to calculate the shear wave velocity of the Seattle Basin using our Rayleigh wave phase velocity model [Delorey and Vidale, 2008]. Our forward calculation uses a normal mode method developed by Tekeuchi and Saito [1972]. Our results show that shear wave velocities are on average 20% slower than the estimates used for current seismic hazard maps (Figure 1). The effect on hazard assessment has not been determined at this point.

We are in the process of integrating our results into regional models in collaboration with Art Frankel. We are computing three-dimensional finite-difference seismograms incorporating velocity, density and attenuation variations, and constructing improved models for predicted ground shaking during various realistic earthquake scenarios. Then, working with Art Frankel we will use these improved models to help quantify the risk of strong shaking to the

urban environment and critical infrastructure, as Art has already done with previous models.

Delorey, A. A. and Vidale, J. E. (2008), A Slower and More Dangerous Seattle Basin - Application of Noise Correlation to Shallow Basin Surface Waves, Eos Trans. AGU, 89(53), Fall Meet. Suppl., Abstract S31A-1874.

Frankel, A.D., Stephenson, W.J., Carver, D.L., Williams, R.A., Odum, J.K, and Rhea, S., 2007, Seismic hazard maps for Seattle, Washington, incorporating 3D sedimentary basin effects, nonlinear site response, and rupture directivity: U.S. Geological Survey Open-File Report 2007-1175, 77 p., 3 pls.

Takeuchi, H., and M. Saito (1972), Seismic surface waves, Methods Comput. Phys., 11, 217–295.

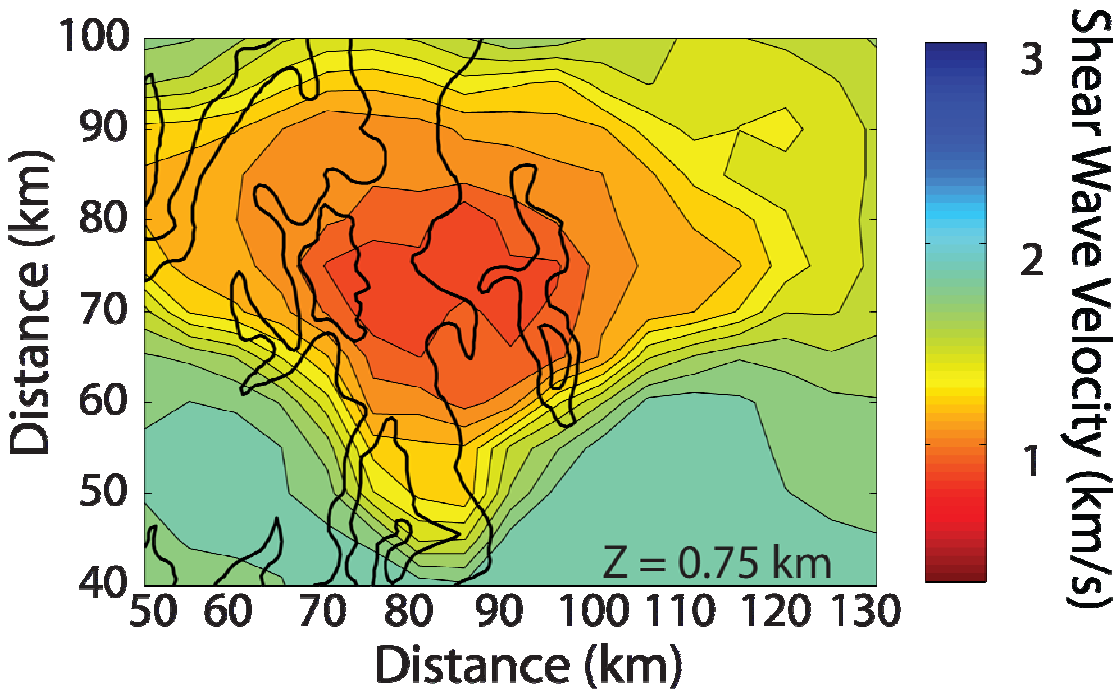

Figure 1. Shear wave velocity of the Seattle Basin at a depth of 0.75 km

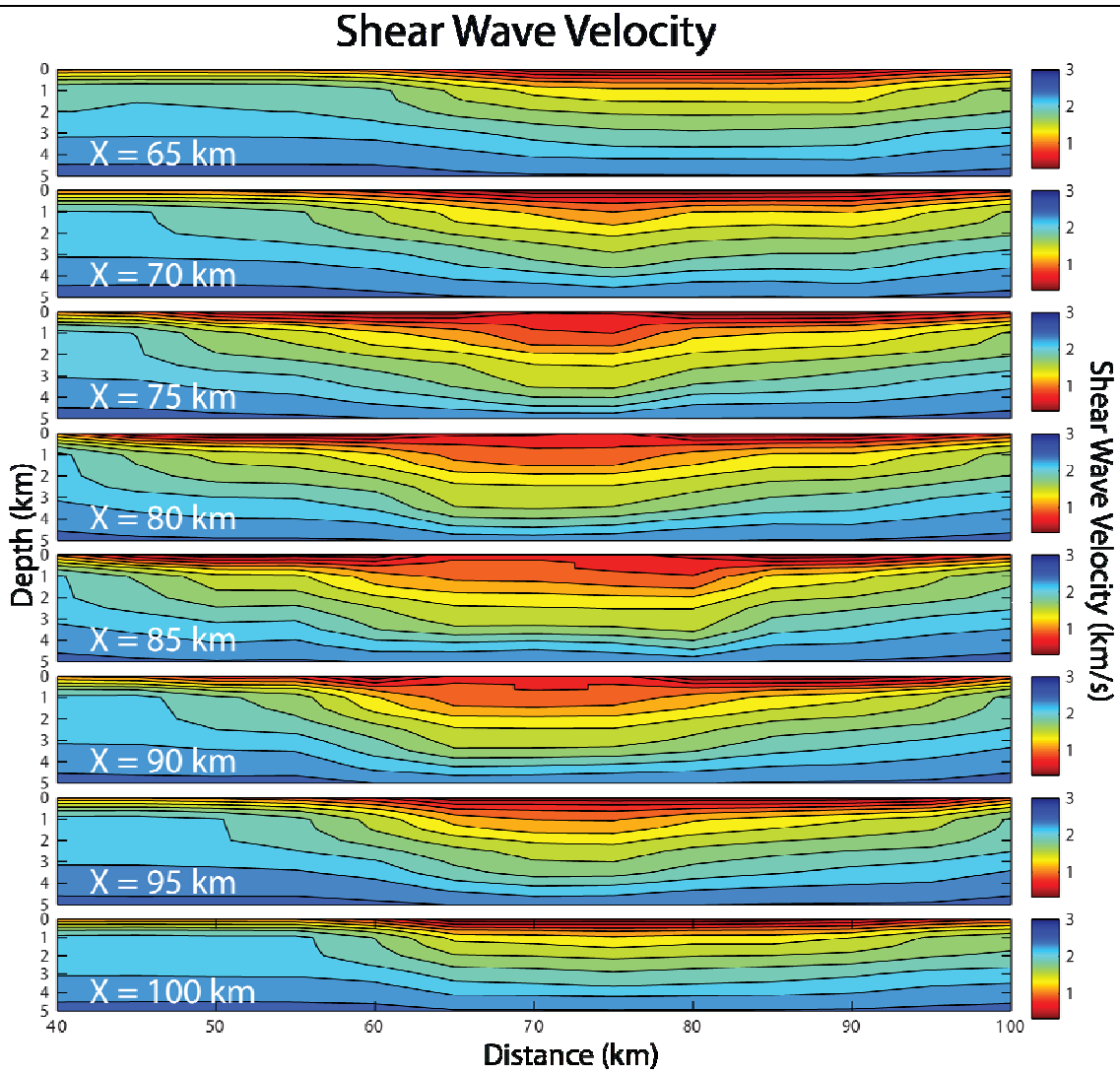

Figure 2. Shear wave velocity of the Seattle Basin in north-south vertical sections. Horizontal axes are the same as presented in Figure 1.