Comparing Piedmont and Coastal Plain near surface substructures using p-wave refraction and surface wave dispersion

DEPARTMENT OF GEOLOGICAL, ENVIRONMENTAL, AND PLANETARY SCIENCES

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Introduction

Modeling the subsurface layers and their composition can aid hazard assessment efforts. Having both p- and s-wave velocities (v_p and v_s) can provide insight into groundwater content. We probe the subsurface for v_p and v_s for two regions above and below the Atlantic Seaboard Fall Line using p-wave refraction and surface wave dispersion through a Transdimensional Hierarchical Bayesian (THB) 1D Inversion.



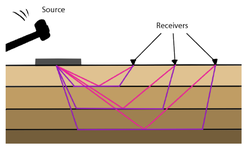
Map the showing Clarksville (Piedmont) and West Point (Coastal Plain) field sites. The Atlantic Seaboard Fall Line separates the two regions, indicating a transition from stronger, shallower bedrock in the east to unconsolidated sediments in the west.

H: Higher v_p/v_s ratios are present in West Point compared to Clarksville, indicating unconsolidated material with high porosity in a depositional environment and increased water storage.

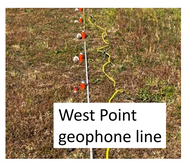
H_o: The v_p/v_s ratio does not vary between West Point and Clarksville, with no difference in water storage above bedrock.

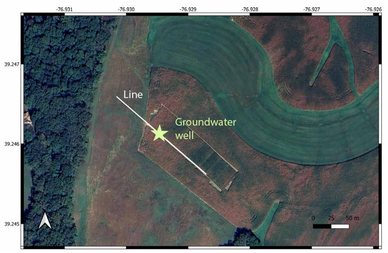
Methods: Data Collection

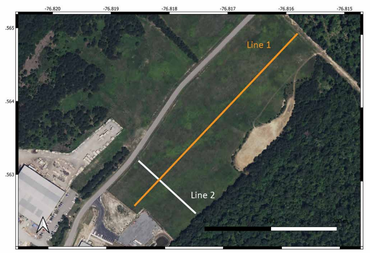
Active source seismic surveys were conducted using a vertical hammer swing as a seismic source.









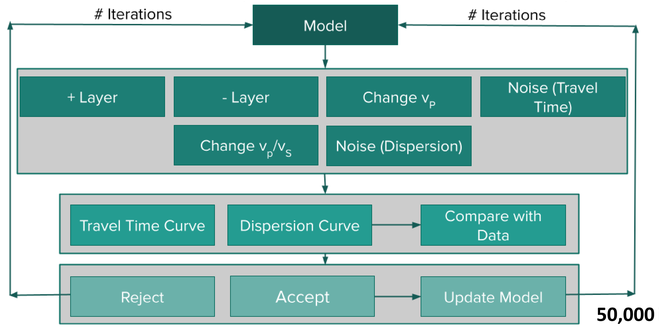


Clarksville: 132 m survey line, 4 m spacing between geophones (24 geophones, 96 m long), 12 m between shots.

West Point: 400 m & 140 m survey line, 1 m spacing between geophones and shots.

Methods: THB Inversion

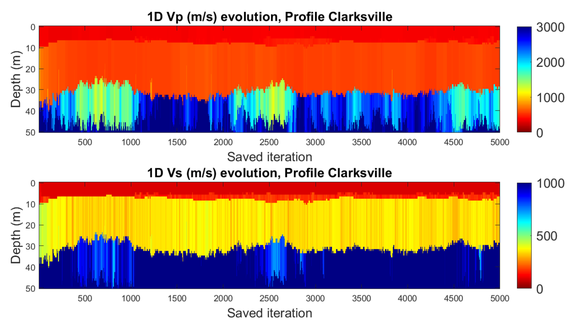
THB1D (Huang et al., 2021) was modified to propose v_p and v_s, using the v_p/v_s ratio as a prior. v_p was constrained by fitting to a travel time curve, and v_s was constrained by fitting to a surface wave dispersion curve. **Prior ranges:** v_p = 100-4000 m/s , v_s = 30-2500 m/s, v_p/v_s = 1.6-6.2

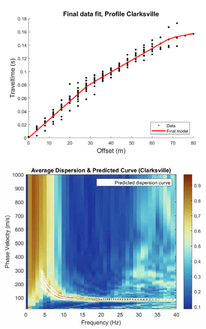


50,000 iterations

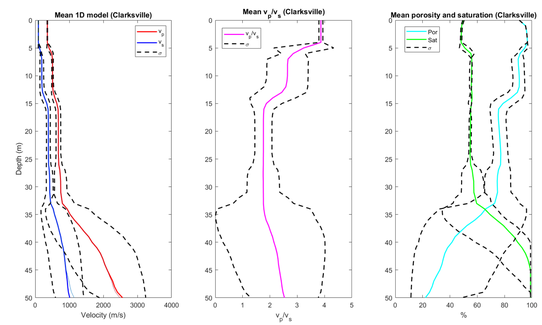
Results

Clarksville (Piedmont)



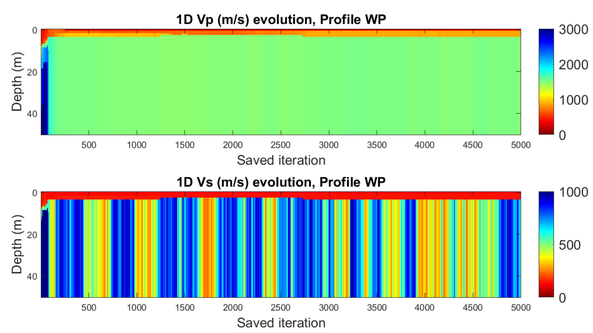


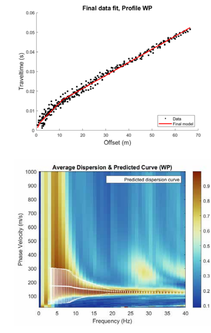
The Clarksville velocity evolution indicates that the inversion constrained 4 layers. The misfit in the travel time across the travel time curve was ~0.01 s, and the misfit in the phase velocity in the dispersion curve was ~110 m/s below 7 Hz and 25 m/s between 7 and 40 Hz.



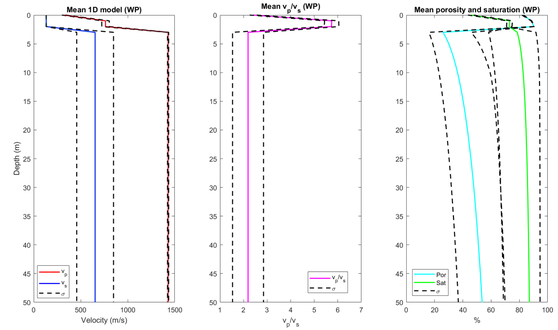
The 4 subsurface layers included a soil layer, a slightly more consolidated layer, a larger bed of consolidated sediments, and bedrock depth at ~33 m. The groundwater well along the survey line had a 12.4 m depth below the surface, which may be seen at ~12.5 m in the model.

West Point (Coastal Plain)





The West Point inversion quickly constrained v_p but not v_s below 4 m, as seen in the velocity evolution. The travel time misfit across the travel time curve was ~0.05 s, and the misfit in the phase velocity in the dispersion curve was ~250 m/s below 10 Hz and 25 m/s between 10-40 Hz.



The constrained subsurface layers included a saturated soil layer and a large bed of unconsolidated coastal plain sediments. The Surficial aquifer in West Point is at a depth of ~5 m below the surface, which may be visible in this model at ~3 m.

Conclusions

- In Clarksville, the v_p/v_s ratio was 3.9, 2.6, 1.8, and 2.1 for the 4 constrained layers (from shallowest to deepest). the bedrock depth was ~33 m, and the groundwater level was expected to be ~12.5 m below the surface and was seen in the velocity model at ~12.4 m.
- In West Point, the v_p/v_s ratio was 5.7 and 2.2 for the two constrained layers. This survey was unable to determine bedrock depth. The groundwater table level was expected to be ~5 m below the surface, but was seen in the velocity model at ~3 m.
- The West Point profile did not show bedrock, indicating that the layers are primarily soil and unconsolidated coastal plain sediments and the Coastal Plain field site can store more groundwater.
- Future work could involve implementing the inversion in 2D for regions with changing topography and/or to observe lateral variations in groundwater and improving the rock physics model for shallower layers.

References & Acknowledgements

Huang, M.-H., Hudson-Rasmussen, B., Burdick, S., Lekić, V., Nelson, M.D., Fauria, K.E., and Schmerr, N., 2021, Bayesian seismic refraction inversion for critical zone science and near-surface applications: Geochemistry, Geophysics, Geosystems, v. 22, p. e2020GC009172, https://doi.org/10.1029/2020GC009172

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