I am glad to review this manuscript "S- and P-wave velocity model estimation from seismic surface-waves" by Khosro Anjom et al. This work presents the application of three different surface wave methods to active-source surface wave data collected in a mining site, and estimates Vs and Vp, respectively. It's an overall good and informative paper. I have only a few comments on the details.

Dear anonymous reviewer 1,

Thank you very much for your time in reviewing our manuscript and giving useful remarks. In the following we respond to your questions and remarks.

Authors,

**Comment R1-1:** About the velocity perturbation about 7%

To be frank, i feel like the model perturbation is a bit higher. For example, let's say fig14a, the velocity perturbation of the target structure might be smaller than 15% from my guess. Authors may calculate it and prove me wrong. If it's this case, then the uncertainty from different methods is half of local anomaly of the structure which is unacceptable. I suggest authors provide the average velocity variation at different depths and different methods, and add these information into fig 18 and table 2. It will help the reader to understand the relative scales between the uncertainty associated with methods and the real variation associated with targets.

Thank you for this comment. We should clarify that no marker formation is targeted in the estimated models. The interpolated estimated VS model between 20-35 m of depth from WD and SWT methods are 12% different (Figure 9a and Figure 14a of the submitted paper), whereas the lateral variations of the models compared to the average velocity is on average 10% and 17% for SWT and W/D models, respectively. We understand your comment regarding the model misfit and lateral variations, but we have some concerns about connecting lateral variations from the models directly to the model misfit. The model comparisons were carried under many assumptions, and they were meant to show the similarity of the models and continuity of these similarities in depth. The estimated models had completely different parameterization and the comparison was carried out after the interpolation of the estimated models. The W/D method provided the estimations every 10 cm in depth and at the location of the multi-channel DCs in X and Y directions, whereas the SWT model included 300 locations equally spaced in X and Y directions and within 7 layers of 15 m thickness (only first layer 20 m). So, some level of difference in addition to difference due to methods' accuracies is expected. In Figure R1 below, we compare the results of the VS from SWT method between 20-35 m of depth (second layer) and VS from W/D method averaged between 20-35 m. In the northern part of the area, where SWT model is superimposed to WD model, the trend of the variations is well preserved. The artifacts created by the outliers of the W/D method, which is amplified by interpolation, as well as the smooth lateral transition of the SWT model are the main contributors to the model misfits. Since the SWT model is obtained from laterally constrained inversion the transition between the high-velocity and low-velocity zones is smoother, whereas W/D model provides a sharp transition zone. Using lower lateral constraints helps in sharpening the transition zones but at the cost of creating unrealistic perturbations in the model. In the revised manuscript, we will explicitly mention the impact of the lateral constraints on the transition zone, as well as the effect of model parameterization within the scheme of the three methods.

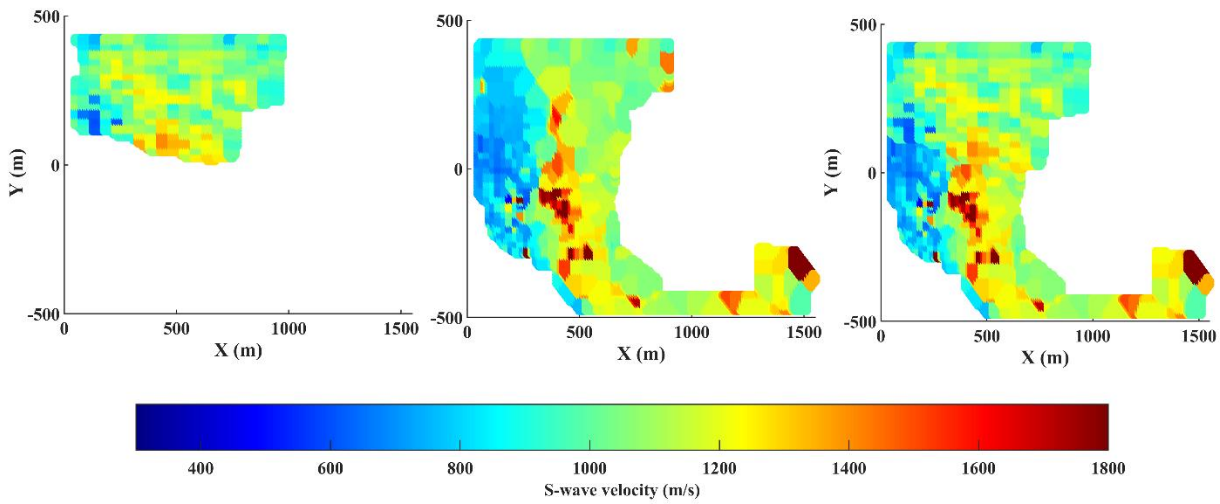


***Figure R1:*** *Comparing the S-wave velocity results from surface wave tomography and W/D for depth range of 20-35 m. a) The estimated VS from SWT. B) The estimated VS from WD. C) North zone from SWT and south zone from WD.*

**Comment R1-2:** About the data error and model error

I know it's challenging to collect high quality seismic data in area with stiff surface. figure 3 shows that the quality of the collected surface wave data is poor. Is it necessary to use some signal-enhance technical to denoise the data? I am afraid the data quality/error might be introduced into the final model error/uncertainty between different methods. because the SWT method uses only two-station pair which will definitely provide lower quality inputs than other two methods who employ the multi-channel inputs. I would expect some necessary discussions about this part.

Thank you for this comment. We completely agree that seismic data quality at stiff sites can be very challenging. Despite these challenges, surface wave analysis has proven to be a reliable tool for near-surface characterization in these sites. Comprehensive examples of surface wave methods application to hard rock sites can be found in Pileggi et al. (2011), hollis et al. (2018), Papadopolou et al. (2020), Da Col et al. (2020), and Colombero et al. (2022).

In test site of the submitted manuscript, thanks to the high energy vibroseis sources and to spectral stackings from different shot locations, we were able to obtain sufficient spectral resolution for DC picking. As you can see in the spectrum in Figure 4 of the submitted paper many shots are used to compute the final spectrum in Figure 4b, and the energy maxima shows continuity along the selected frequency band.

In the used carpet acquisition scheme, dense receiver grids were deployed, and sources were used only in accessible locations (along roads). This irregular source-receiver outline, as well as the exciting of the source in many locations, gave us a perfect opportunity for two-station dispersion measurements. In classical 3D measurements with regular source receiver locations, non-uniform azimuthal distribution is usually obtained, and the chance of stacking is reduced for many of the two-station configurations. Thanks to the source-receiver geometry created by carpet recording, we considered a high threshold for the number of stackings (at least five recordings from different shots for each of the two receivers). This way, we were able to obtain good signal-to-noise ratio in the two-station analysis even though the data were from a stiff site. Nevertheless, the spectra of the multi-channel analysis provided a better signal-to-noise ratio in the low frequencies. The distribution of the data points based on wavelength (Figure 15a of the submitted paper) reflects these challenges of the two-station method in estimating low frequencies (large wavelength) data points.  In the revised manuscript, we will include this information.

**Comment R1-3:** About the imaging point

I have no idea how the authors define the imaging points for the different methods. i guess the middle point will be taken as the imaging point for SWT, then what's the imaging point of the other two? please clarify this point.

Thank you for this comment. The W/D and LCI methods are based on multi-channel analysis. Within the multi-channel method, the computed dispersion curves are associated to the center of the multi-channel spread. Each DC is assumed to carry information about the local 1D properties beneath the receiver spread. In both W/D and LCI methods the models are estimated at the position of these local DCs and coincide with center of the receiver spread (blue square in figure 4a). Since the receiver spread is a moving squared window that is shifted by 1 receiver spacing in both x and y direction, the relevant DC and 1D models have the same density as the receiver grid.

On the other hand, tomographic inversion takes as input the dispersion curves retrieved from two receivers only. These curves show the path-average phase velocity along the path between the two receivers, and for each receiver couple in line with a source we can retrieve a DC. In this case, the retrieved model does not correspond to a single dispersion curve but belongs to a regular grid of 1D models which are estimated to invert all the retrieved two-station DCs at once. In Figure R2 below we have included for your convenience a map-view graphic scheme. On the left one path between two receivers superimposed to the grid of models, on the right we show that for each location, the model is estimated on the basis of many different paths. In the case of Aurignac data, 300 model points equally distant in x and y directions were used to build the model grid. Within the tomographic inversion algorithm, the synthetic path averaged DCs are computed as reciprocal of the average slowness along the paths discretized over the model grid. The phase velocities at the location of the discretized paths are computed by bi-linear interpolation of the phase velocities from adjacent model points (see the models in red in the plot on the left Figure R2). More information on how the paths is discretized and on how the synthetic DCs are computed for regularly spaced 1D models can be found in Khosro Anjom (2021).  In the revised manuscript, we will describe more clearly the distinction between the model structure and parameterization obtained various methods.

For the comparison of the estimated models from the three methods in the discussion of the submitted manuscript, we interpolated the models to obtain matching geometry of the estimated models in voxels of 10 X 10 X 0.1 $m^3$ in x, y and depth directions.

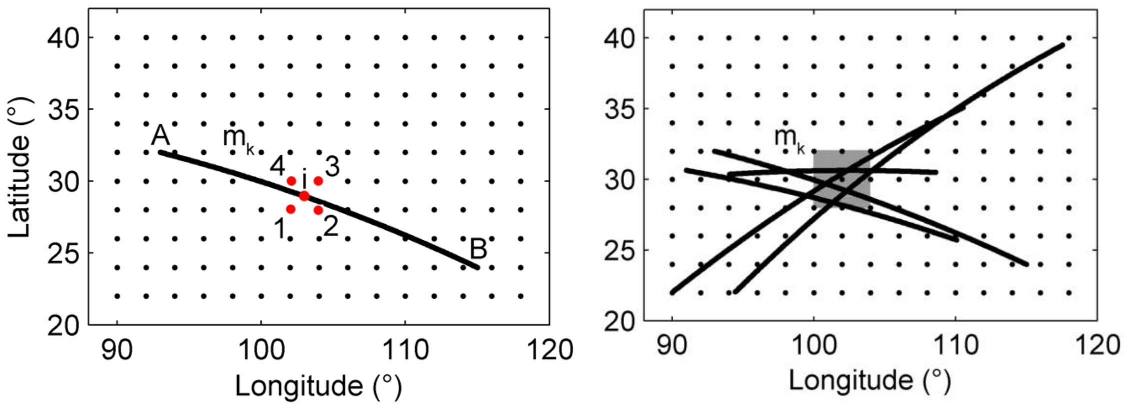


***Figure R2:*** *Schematic representation of surface wave tomography model grid definition and synthetic dispersion curve computation. a) the solid line represents the path between two stations A and B. The phase slowness of any point $i$ along the path is determined from the values at four surrounding grid points using bilinear interpolation. b) the inversion scheme links each 1D VS profile to all experimental raypaths (solid lines) crossing its neighboring area (grey area).*

**Comment R1-4:** why SWT can't provide VS model at the southern zone?

Thank you for this comment. The SWT can definitely provide a model for the southern part similar to the northern part, but we did not apply SWT to both zones due to computational capacity and memory restrictions.

Including the southern part to the surface wave tomography analysis would have meant inverting more than 3000 DCs simultaneously, given that only the north zone, which is the smaller zone, provided 1301 DCs. With more area to cover, we should have considered more model points for the inversion for a high-resolution inversion. The substantial growth in both model size and data volume would have required greater computer memory and computational capacity than what our workstations could provide. We could have under sampled the data and used a lower number of model points, but this would have impacted our study, as we wanted to perform a high-resolution inversion. As a result, we decided to focus the SWT only on the northern zone. We hope this clarifies the absence of SWT in the southern zone. In the revised manuscript, we will mention the computational constraints in performing simultaneous tomographic inversion of both zones.

**Comment R1-5:** 5. page 8, line 170, "Fig. 6b and c, as well as Fig. 6b and c, we show the", a typo!

Thank you. In the revised manuscript, we will fix this error.

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