Near-surface characterization and delineation of water conduits at South Deep Gold Mine, South Africa

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The article presents an alternative approach to inferring the potential mining issues at depth by characterising and evaluating near surface properties. Central to this approach is the hypothesis that specific structural features, such as dykes, foster a seismically detectable connection between shallow aquifers and deeper mining zones.

While conceptually compelling and potentially valuable in mine planning and risk assessment, the integration of 3D shear-wave (Vs) velocity models with legacy P-wave reflection data, though innovative, raises questions regarding dataset quality and compatibility.

Observations/comments:

Strengths

The study effectively combines newly acquired MASW seismic datasets with legacy P-wave reflection data, demonstrating a creative approach to multi-scale geophysical integration.

The work is clearly motivated by the need to reduce deep mining hazards, by linking geological structures such as dykes and fracture zones to deep mining issues.

The authors succeed in extracting new value from older seismic records, offering novel geological interpretations

The authors demonstrated very competent approach to analysis of surface waves using sub-optimal seismic data. The geophysical investigations are combined with an exhaustive geological literature.

The geophysical results are interpreted against a well-researched and expansive geological framework to strengthen conclusions.

Comments/questions

MASW: Claimed depth of investigation of 360 m seems to be justified with very few data points (Fig. 8).From most of the displays provided the maximum depth appears to be around 200-220m, which is more likely to be the case, based on the acquisition parameters and the spread length over which surface waves could be traced on the low-res images provided.

Fig.8 phase velocities are reasonable. The inverted velocities go to 5000 m/s, seems much to high at depths of 200-300 m. Pretoria complex: Vp (5.0-6.5 km/s), Dolerite intrusions 6.0-6.8 Km/s. Hence Vs higher than 3.8 km/s can hardly be expected.

See for example Altindag, R. (2012), *Correlation between P-Wave Velocity and Some Mechanical Properties*

And Kgaswane et al., 2012, Shear wave velocity structure of the Bushveld Complex, South Africa; *Tectonophysics.*

MASW or P and S-waves:

The objective of the article is to document the use of MASW technique to characterise the near surface and connect the anomalies found to the issues encountered at the mining depth level.

Receiver spacing of 10m risks spatial aliasing of surface waves. A frequency–wavenumber (F-K) analysis of both the newly acquired and legacy datasets would significantly strengthen the validation of the applied methods. If remedial steps were taken to mitigate aliasing risks, they should be documented to increase the confidence in the findings.

It remains unclear why P-wave refraction arrivals, which are visibly present in the provided shot records, were not incorporated into the geophysical analysis. Integrating these data with shear-wave profiles would offer a more robust inversion framework. Furthermore, by linking P- and S-wave velocity models, the authors had the opportunity to compute additional elastic parameters, particularly Poisson's ratio, which could enhance aquifer characterization.

Figures and data presentation

Figure 4 shows Rayleigh waves that are barely visible and limited to a spread length of approximately 200 m. Based on standard MASW practices, this propagation range does not support the claimed investigation depth of 360 m, especially when employing 5 Hz geophones and assuming realistic shear wave velocities for the site.

Moreover, the vibroseis source utilized in the survey is known to produce relatively weak surface wave energy. Its long-duration sweep increases the risk of mixed wavefields, which may affect dispersion curve extraction.

Figure 6 exhibits well-developed P-wave refractions extending across the full 2 km spread. Surface waves appear to be present, at best over 200m length, and/or spatially aliased. The small display scale and low resolution of the field data images severely hinder a proper assessment of wavefield characteristics in both Figures 4 and 6.

To allow for accurate interpretation of all wave types, significantly improved display quality is necessary. I recommend that representative shot records from both the new and legacy surveys be shown independently, without additional overlays, so that readers can assess signal quality and wavefield content with greater clarity.

Figure 13 suggests that the legacy data may have undergone excessive (signal-to-noise ratio) SNR enhancement, potentially resulting in an overly smoothed image that masks subsurface discontinuities. If access to the raw legacy dataset is possible, reprocessing it with modern imaging techniques could yield a significantly different structural interpretation. Moreover, the reprocessing may bring more clarity in the near surface, possibly up to 200 m depth.

Lows in Vs at the position of interpreted dykes could be related to the computations since dolerite dykes are likely to have a higher velocity than the surrounding rocks.

Recommendations

The investigative approach is conceptually appealing yet suffers from poor presentation of field data. High-quality visual displays are crucial for transparent interpretation. This needs to be corrected.

I believe that the analysis would be strengthened by incorporating P-wave refraction tomography, given that refraction images already span the full spread length.

F–K (frequency–wavenumber) plots should be included to assess the integrity of surface wave sampling and verify spatial aliasing.

The stated depth of investigation needs more rigorous justification. I recommend including a brief overview of MASW methodology and the commonly accepted rule of thumb for depth estimation.

The geology chapter could be much more concise and related to the analysis shown. Geological referencing is way to extensive for a little benefit to the reader.