Some general comments to the reviewers are provided, offering context for the geology and seismic interpretation, as well as motivation for the use of legacy seismic data in this study.

The 2003 D Kloof-South Deep (covering Kloof and South Deep Mine) data (Campbell and Crotty, 1990, Manzi et al., 2012a,b) have been the subject of several studies over the past 20 years, given the size of the survey area and the unique nature of the data, particularly the highly continuous seismic reflections associated with lithological contacts and the mapping of complex geological structures that cross the gold deposits. To mention a few that are relevant to this paper:

(1) Manzi (2012a,b, 2013a) reprocessed the data and computed seismic attributes to (a) delineate geological structures (faults and dykes) that cross-cut the Ventersdorp Contact Reef (gold deposit) and have the potential to migrate water and methane gas from the Transvaal Supergroup aquifers to the mining levels (~ 3 km). In Manzi et al. (2012b), the base of the 2.65–2.05 Ga Neoarchean–Paleoproterozoic Supergroup (Transvaal Supergroup) horizon (Black Reef, ~ 500 m below ground surface) and the mining horizon (VCR, ~ 3000 m below ground surface) were well imaged. The geological structures (faults and dykes) that were seismically defined at both Black Reef and VCR levels were spatially correlated with water and methane data obtained from drilling data at the mining levels. The integrated data showed a good spatial correlation (see Manzi et al., 2012b). The authors hypothesized that the water migrated from the overlying acquirers above the Black Reef (of the Transvaal Supergroup) and travelled through faults and dykes to the mining levels (within Witwatersrand Supergroup). However, due to the low resolution of the legacy seismic data in the near-surface (Manzi et al., 2012a, b; 2013a), the continuity of these structures (including the South Deep faults and dykes (especially those intruded in the fault zones)) was never investigated (see Figure 7 below of Manzi et al., 2013b). The manuscript presented here by Gomo et al. (in this special issue) attempts to provide some seismic constraints on the near-surface geology and previous interpretations: (1) the near-surface as derived from the Vs models exhibits structurally complex geology interpreted to be associated with shales, quartzites, basalts, sills, faults, and dykes. The interpretation is constrained by the geological information (surface mapping and boreholes), and (2) the Vs models, for the first time, provide some evidence that underlying structures (underground mapped and confirmed through drilling) crosscut the base of the Transvaal, meaning that they

crosscut the known groundwater aquifers within the base of the Transvaal Supergroup. The Vs model suggests that the mining level is structurally connected to the near-surface aquifers, making these geological features potential conduits for water migration (Manzi et al. 2012b).

(2) Following the work by Manzi et al. (2012a,b; 2013a) on the imaging of geological structures at the Black Reef and Mining levels, Manzi et al. (2013b) merged the re-processed 2003 reflection seismic data with other historical 3D seismic datasets (covering other mines in the Witwatersrand gold fields) to produce one continuous cube. The merged data were integrated with the geochronology data, seismic data, underground mapping data, surface and underground borehole data from the mines to build a tectonic model of the Witwatersrand Basin. The final model was constrained to the pre-Transvaal Supergroup (see Figure 2 below from Manzi 2013b), where all the structures were interpreted as pre-dating the Transvaal Supergroup. This published model will need to be revisited in the future to incorporate the new information that integrates legacy, geological information, and surface wave analysis (presented in this manuscript).

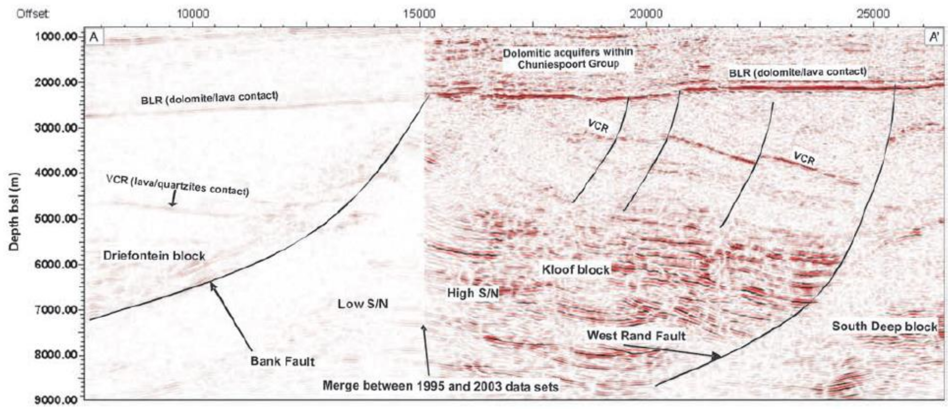

Figure 7. North–northeast regional crossline seismic section (line AA′ in Figure 6) through WUDLs, Driefontein, Kloof, and South Deep surveys. The West Rand and Bank Faults do not breach the BLR. The merge boundary between WUDLs, Driefontein, and Kloof-South Deep surveys is identifiable in the seismic section.

Figure 7, taken from Manzi et al. (2013b), show the regional structural architecture of the Witwatersrand Basin. Faults in this model pre-dates the Transvaal Supergroup.

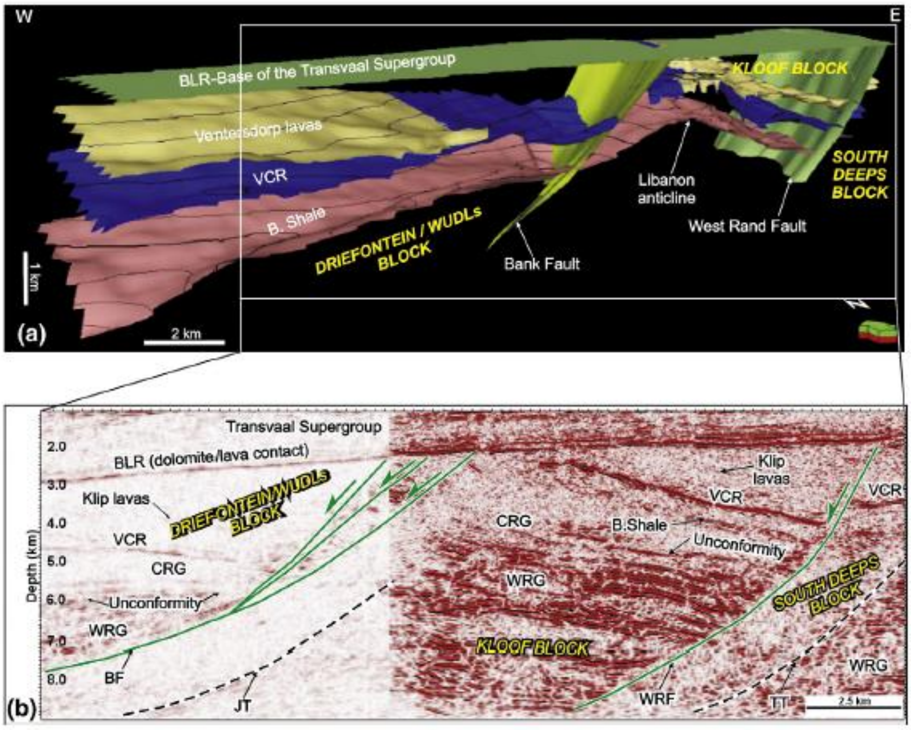

Fig. 2. Seismic model across the Witwatersrand goldfields. (a) 3D regional seismic model incorporating the BLR, Ventersdorp lavas, VCR and B. Shale. The model shows the geometry of West Rand Fault, Bank Fault and Libanon Anticline. (b) Regional crossline seismic section (line AA' in Fig. 1) through WUDLs, Driefontein, Kloof and South Deep surveys, showing WRF and BF zones and their adjacent TT and JT, respectively. WRF: West Rand Fault; BF: Bank Fault; TF: Tandeka Thrust; JT: Jabulani Thrust; WRG: West Rand Group; CRG: Central Rand Group; Klip: Klipriviersberg; VCR: Ventersdorp Contact Reef; BLR: Black Reef Formation; B. Shale: Booysens Shale.

Figure 2 illustrates the tectonic model of the Witwatersrand Basin and study area, as derived from legacy seismic data, geological information (including borehole and mapping data), and geochronological data. Major faults in this model pre-dates the Transvaal Supergroup.

(3) The work by Nwaila et al. (2020) looked at the potential to mine the Black Reef horizon at Driefontein mine (26 km west of the South Deep mine). As part of this work, the authors investigated the structural architecture of the Transvaal Supergroup (same units as those found in South Deep) using the merged legacy seismic data (Manzi et al., 2013b). The seismic data were interpreted in an integrated approach with petrography, 3D micro-X-ray computed tomography, and machine learning to characterise the ore resource and understand the structural styles within the Transvaal Supergroup. The study revealed that some geological structures affecting the Black Reef (i.e., the base of the Transvaal at a depth of 500 m) can be traced downward into the underlying, older auriferous horizons (e.g., VCR at a depth of 3.0 -4.0 km). The outcome of this research provided some clues indicating that the near-surface aquifers at South Deep require further investigation. As already mentioned, the quality of the seismic data at South

Deep was not adequate to characterise the near-surface groundwater aquifer system. The current data, in its current form, provides high-resolution imaging of geological structures from 400 m to 6,000 m depth below the ground surface. The approach of surface wave analysis presented in this paper is intended to supplement the legacy reflection seismic data, borehole data, and mine geological model, rather than compare or replace these methods – it will not be a good approach to compare them, as they are different datasets designed and implemented at the site for different scientific and mining purposes. Really, the question is simple – is there a connection between the near-surface aquifers and mining horizon levels at the South Deep mine study area? Based on the Vs model presented in this manuscript, in conjunction with the legacy data and other datasets, our interpretation is that the two systems are connected at the South Deep mine.

(4) At Kloof Gold Mine, a mine covered by the same 2003 legacy data and located about 5 km away from the South Deep mine, water and methane-gas bearing geological structures analysed through seismic data were found to connect the Black Reef level and mining VCR level (Manzi et al., 2012b). To investigate the source of water and methane gas at the mining levels along these structures, water and methane gas samples were collected along the structures for isotope analysis (Manzi et al, 2016). The isotope and geochemistry results for water indicated the mixing between meteoric/shallow aquifer water and deep hypersaline water. Similarly, there was mixing between biotic (methane from overlying aquifers) and abiotic methane (methane from the deeper crust). This provided additional evidence that the water-methane-bearing structures were transporting water/methane gas (from the surface/near-surface and the deeper part of the crust) to the mining level. Future studies at South Deep will explore similar approaches, with interpretation constraints applied to the shallow part, utilizing surface wave analysis.

(5) Tectonically, the Transvaal Supergroup (target for this study) is structurally complex and has undergone several episodes of deformation (Kinsman, 1975; Veevers, 1981; Vermaakt and Chunnet, 1994; Coward et al., 1995; Manzi et al., 2013a,b; Nwaila et al., 2022). The lithological composition and geological setting are identical to those in, and thus considered to be the result of, rift-type tectonic settings formed by stretching or thinning the continental lithosphere (Allen et al., 2015). Pre-Transvaal Supergroup, the

Witwatersrand Basin generally exhibits major listric normal faults and their related drag folds that are ascribed to the extensional tectonic Platberg Volcanism at 2754-2709 Ma (Manzi et al., 2013b, Gumsley et al., 2020). Our study area is also characterised by numerous sills and dykes that intruded at different geological ages and have been subjected to several investigations. The sills and dykes are of various ages, such as known post-Karoo dykes of pre-Cretaceous and Cretaceous age (145 - 66 Ma), Karoo dykes (150 Ma), Pilanesberg (1.30 Ga), Vredefort meteorite impact event (2.05 Ga), the Bushveld Igneous Complex magmatism (2.03 Ga), Transvaal (2.20 Ga), and Ventersdorp (2.60 Ga) (Frimmel, 2014; Fuchs et al., 2016; Frimmel & Nwaila, 2020). The post-Black Reef tectonic events likely led to the reactivation of pre-existing faults, which are clearly imaged in the legacy seismic data covering South Deep mine and other neighbouring mines (Manzi et al., 2013; Nwaila et al., 2020a). Movement along faults inevitably results in the creation of numerous microfractures, which can be observed and mapped underground (if exposed). Current mining activities can also reactivate faults and dykes (Masethe et al., 2023), promoting water infiltration, movement, and circulation, and these can also host large and damaging seismic events.

(6) In summary, at the mining level of the South Deep mine, the faults, dykes, and fractures (some observed on legacy seismic data) are well-known and constrained by the drilling data and underground mapping (where they have been exposed underground). The dykes that are seismically active are well defined by the large seismic events (by studying the strike, focal mechanisms of the seismic events). What is not known is the continuity of these structures to the shallow aquifers. Current drilling programs are focused on underground drilling; near-surface information is limited to a few historical surface boreholes. Furthermore, it is a common practice in the mining industry not to log the core in detail in the zones with no mineralisation. At South Deep, it is not surprising that the surface drill cores lack detailed information in the near-surface. For example, it is not within the interest of the mine geologists to understand the degree of weathering and fracturing of rocks that do not host mineralisation or are too far (in depth, more than 500 m) from the horizon of interest. Generally, the focus will be on lithological contact, major faults, and thicknesses. Thus, surface wave analysis attempts to characterize the near-surface geological structures (which is not well understood) and link it with the underground mining horizon (which is better understood) for current and future mine planning, development, and safety.