Subsurface Structure of a Lateritic Hill: Insights from ERT & Passive Seismic at the Avon River CZO

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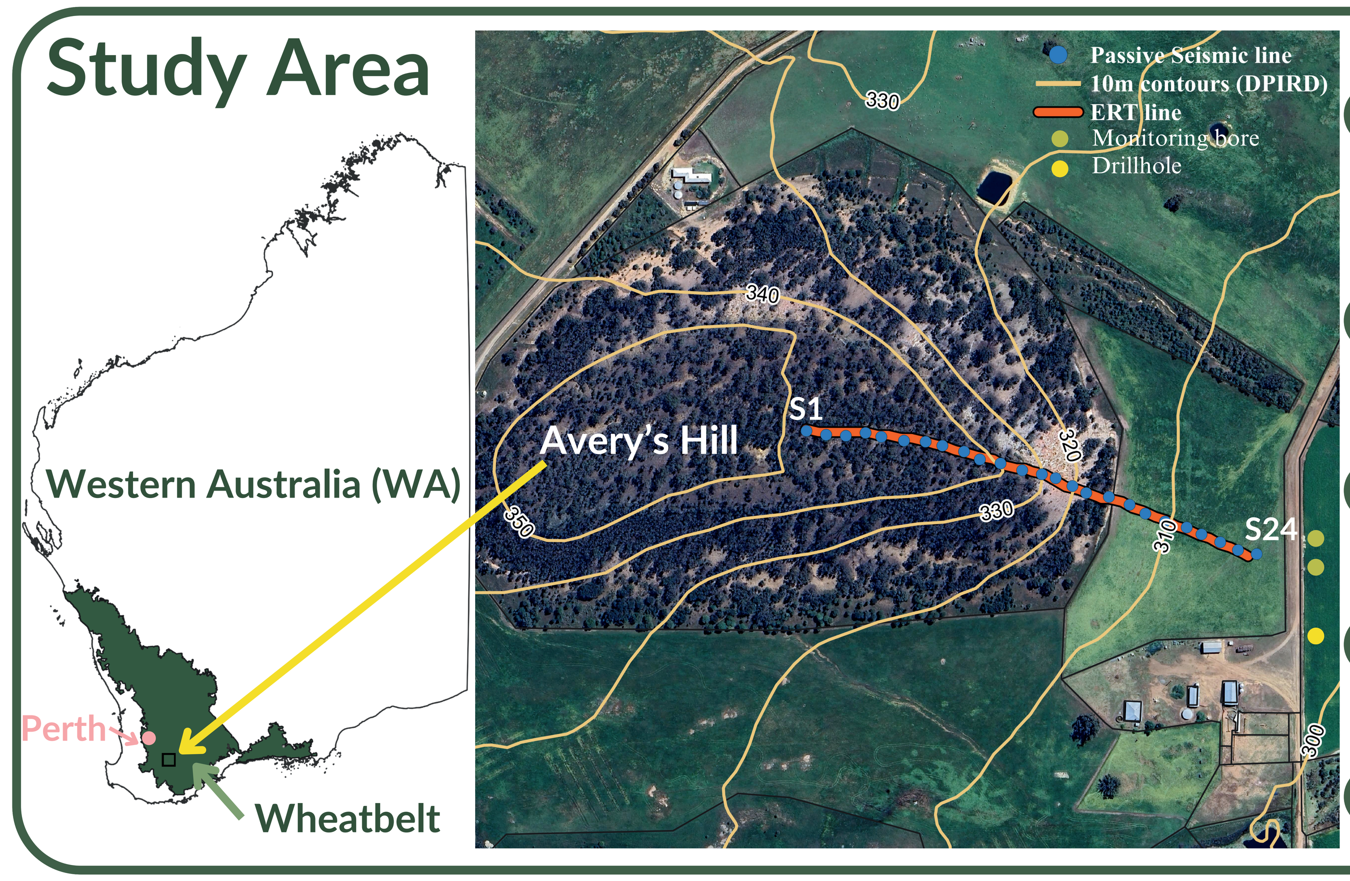
Introduction

Laterites are highly weathered soils rich in iron and aluminium oxides, formed under humid tropical conditions, and they cover nearly one-third of Earth's land surface[1]. In southwestern Western Australia, lateritic profiles developed over Archean granite and were later modified by prolonged weathering and aridification[1]. Despite their significance for hydrology, agriculture, and land management, the subsurface architecture of lateritic Critical Zones (CZ) remains poorly understood due to the difficulty of accessing and characterizing deep regolith layers[1].

Objectives

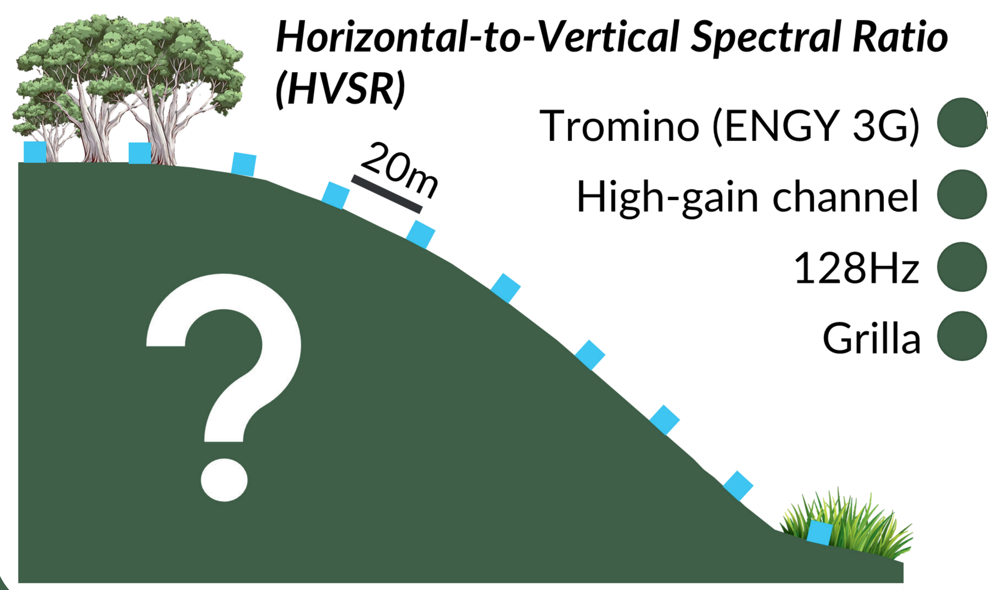
- Determine the spatial distribution of resistivity and shear-wave velocity across a lateritic hillslope.
- Interpret subsurface stratigraphy, layer thicknesses, and composition contrasts from geophysical data.
- Evaluate the role of landscape position and vegetation cover in shaping CZ.

Study Area

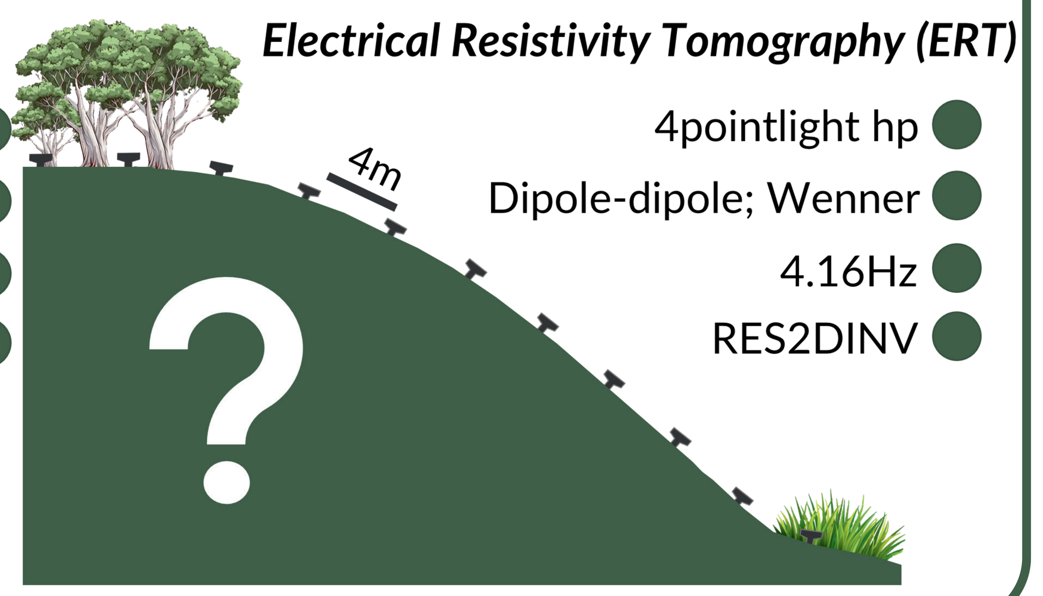


- Avery's Hill (Avon River CZO) is 120km southeast of Perth.
- Mediterranean climate; ~444mm annual rainfall, winter-dominant.
- Landscape formed ~140 Mya; prolonged weathering.
- Archean granite bedrock of the Yilgarn Craton.
- Hilltop trees; slope and foot slope pasture grasses.

Methods



- Tromino (ENGY 3G)
- High-gain channel
- 128Hz
- Grilla



- 4pointlight hp
- Dipole-dipole; Wenner
- 4.16Hz
- RES2DINV

Results and Discussion

1. **ERT Reveals Four-Layer Hillslope Structure** — ERT identified four, with an eastward-dipping layers. The surface resistive layer was thickest at the hilltop (~6m) and thinned to <1m downslope, while the deeper conductive and intermediate layers progressively thickened.
2. **Passive seismic (HVSR) supports a three-layer model** — HVSR consistently detected a soft surface layer, a soft intermediate zone, and stiff basement. The depth to the basement decreased from ~47m at the hilltop to ~26m at the foot slope.
3. **Electrical properties reflect depth and material variation** — Resistivity was highest in the upper ~5m (cemented iron duricrust), then declined sharply (sodic pallid zone). Resistivity increased again at ~20m, reflecting the transition into weathered saprolite, before a final increase at ~35–39m, marking the bedrock.
4. **Topography influences Critical Zone architecture** — Surface caps were thicker and more resistive at the hilltop, while conductive and intermediate layers were prominent downslope. Borehole observations indicate mottling and increased clay content below ~6–7m.

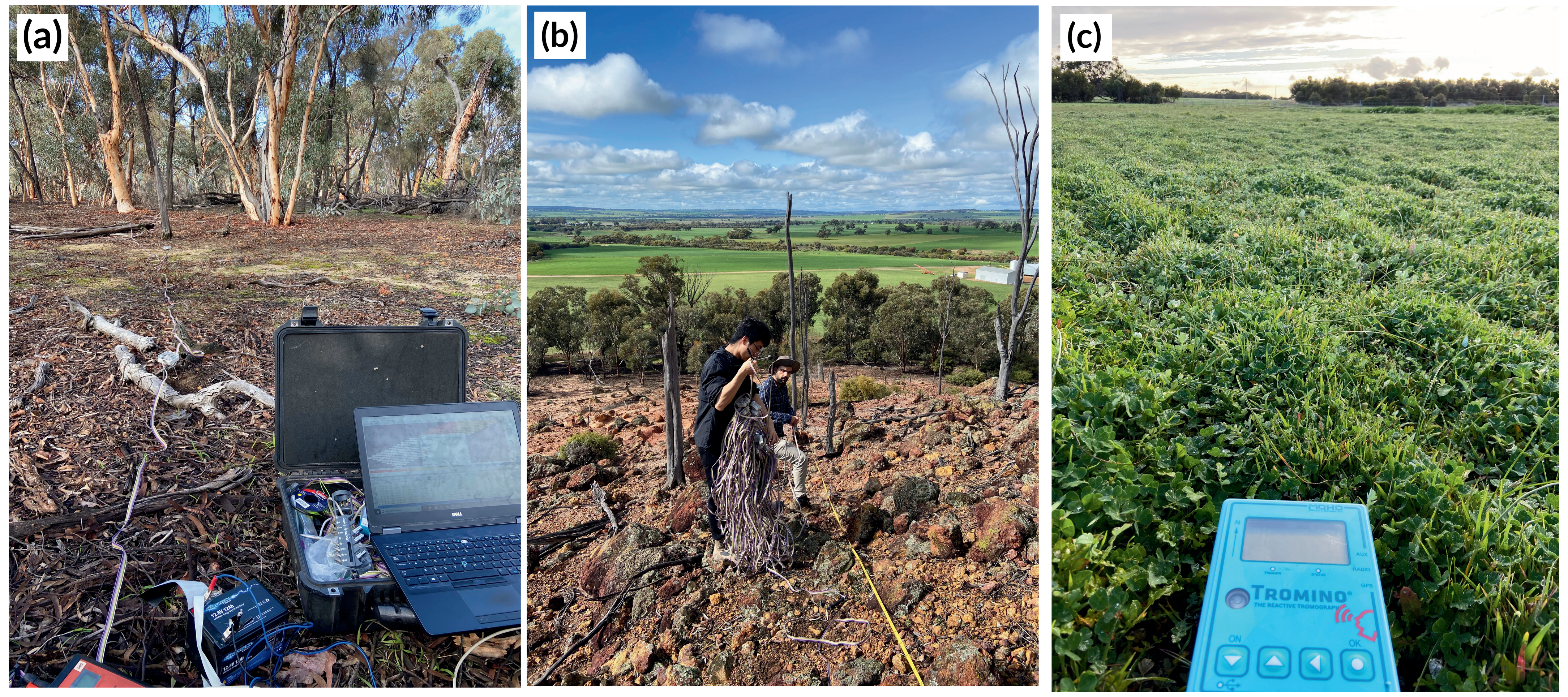


Figure 1. The ERT set-up on the hilltop plateau (a) and mid slope (b). Presented in (c) is the set-up of the Tromino ENGY 3G, the HVSR passive seismic device within the foot slope of Averys Hill.

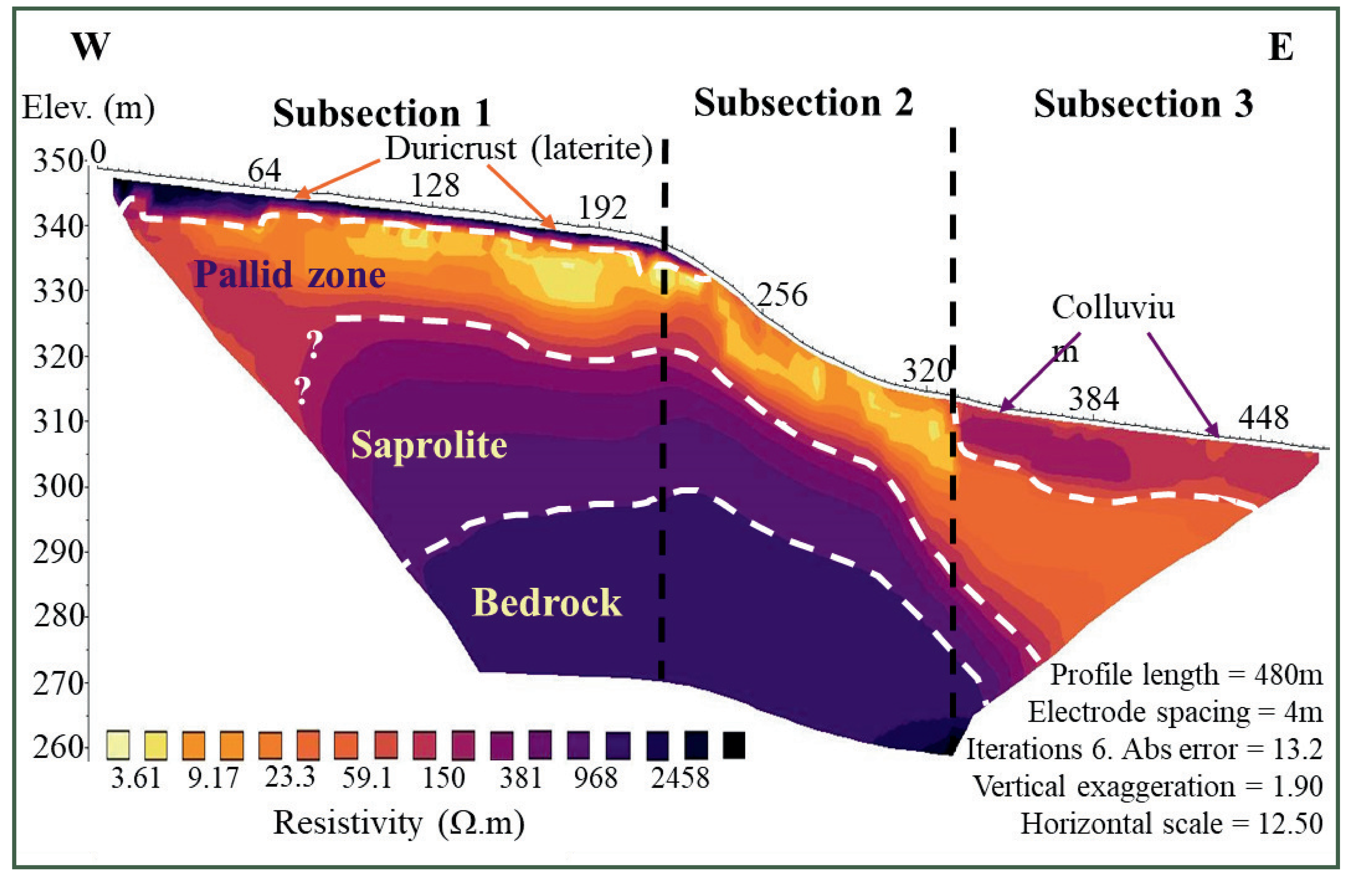


Figure 2. 2D ERT inversion model of the 480m Avery's Hill transect, oriented west-east with 4m electrode spacing using a Wenner-dipole–dipole configuration.

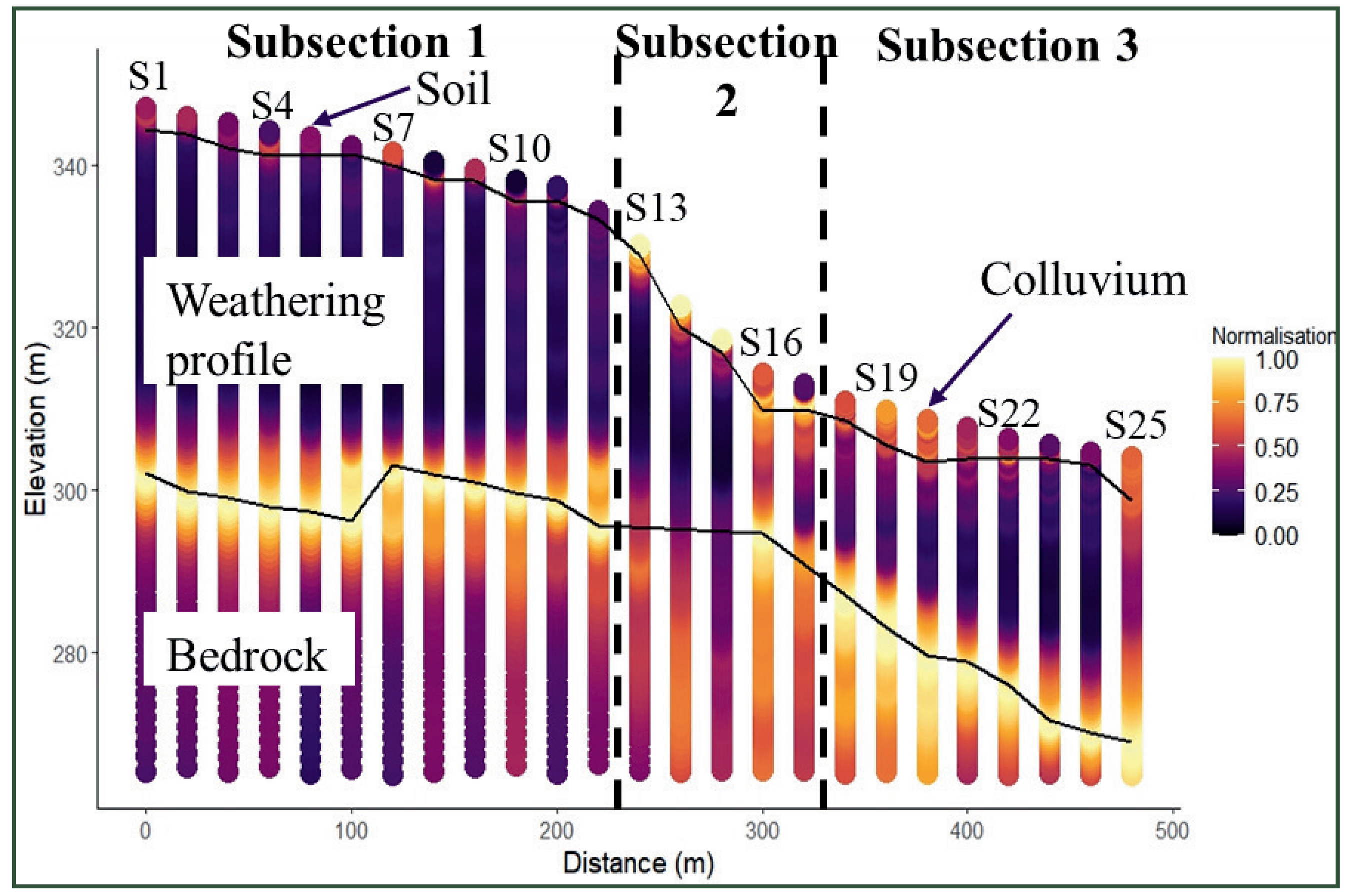


Figure 3. Normalized HVSR plots for 25 stations across the 480m Avery's Hill transect. Solid black lines indicate boundaries between soil and colluvium, the lateritic weathering profile and unweathered bedrock.

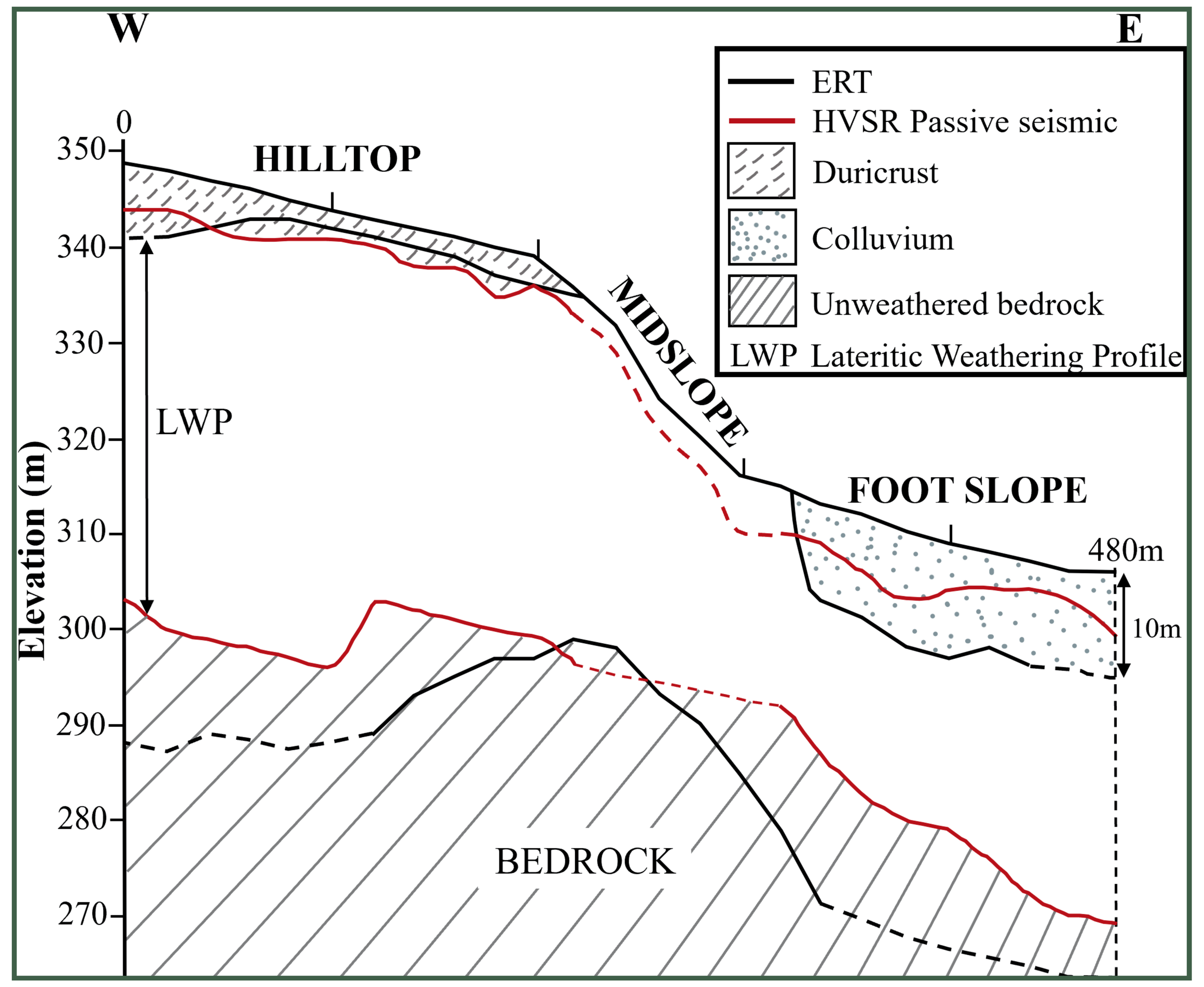


Figure 4. Schematic cross-section of Avery's Hill illustrating vertical architecture and lateral thickness variation along the 480m profile. The black (ERT) and red (HVSR) lines depict subsurface layering, with dotted sections indicating interpolated depths (ERT) and potential outliers (HVSR). The "LWP" represents the lateritic weathering profile, encompassing the pallid zone and saprolite.

Conclusions

ERT resolved four subsurface layers across the transect, while HVSR identified three. HVSR's inability to separate the sodic pallid zone from saprolite reflects limited sensitivity to subtle density contrasts in lateritic regolith. However, it more reliably identified bedrock depth where ERT was confounded by conductive clays.

References

1. Weller, J., Jakica, S., Thompson, S. & Leopold, M. (2024) Combining electrical resistivity tomography and passive seismic to characterise the subsurface architecture of a deeply weathered lateritic hill within the Avon River critical zone observatory. Earth Surface Processes and Landforms, 1–16. Available from: https://doi.org/10.1002/esp.6026

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