Integrating geoarchaeological techniques to reveal the invisible stratigraphy at Umhlatuzana rockshelter, South Africa: A grid-based approach

Femke H. Reidsma[1], Irini Sifogeorgaki[1], Ada Dinckal[2], Hans Huisman[3, 4], Mark J. Sier[5, 6], Bertil van Os[3], Gerrit Dusseldorp[1, 7]

Figure 1a

West profile indicating the grid-based sediment sample locations

Figure 1b

View of Umhlatuzana rockshelter

METHODS

Bulk sediment samples were systematically taken from the complete Western profile of the site following a grid pattern (every 15 cm), with some additional samples in the middle to increase resolution (Fig. 1). We performed:

pH analysis: to get information on the chemical balance of the sediments and preservation potential of different materials.

XRF analysis: to get information on the natural and anthropogenic elemental signal, as well as on the preservation potential of different materials.

Magnetic Susceptibility: to map changes in magnetic mineral content and related natural and anthropogenic depositional processes.

All analyses were performed under **controlled laboratory conditions** to ensure reproducibility. **Visualisation** was done using a combination of elevation plots and contour maps (pH, XRF) + bubble plots and heat maps (MS), in order to determine vertical and lateral variation within the sequence. In addition, the results were integrated with preliminary **micromorphological observations** to establish a link between the micro and meso scale.

BACKGROUND

Umhlatuzana rockshelter (Fig. 1) is an archaeological site with a nearly continuous occupation sequence spanning the last ~70,000 years, covering the **Middle Stone Age** (MSA), **Later Stone Age** (LSA), and **Iron Age**. The site yields a rich lithic assemblage and demonstrates poor bone and charcoal preservation (Sifogeorgaki et al. 2020). The Pleistocene deposits at Umhlatuzana appear homogeneous with **no macroscopically visible stratigraphic boundaries** (Fig. 1a, b). This has raised questions on the integrity of the archaeological assemblages by previous excavators (Kaplan 1990). Moreover, the sedimentation rate, taphonomic history, and the environmental context across the sequence are unclear. We aim to resolve these issues by following a **grid-based sampling approach** and integrating different geoarchaeological techniques in order to explore fine-resolution geochemical differentiations of the sediments that are macroscopically invisible.

AIMS

To shed light on the visible and invisible geochemical variation within the deposits of Umhlatuzana rockshelter, and answer questions relating to:

1. stratigraphic integrity
2. anthropogenic input
3. post-depositional processes
4. environmental change

RESULTS

The deposits at Umhlatuzana are characterised by **gradual changes** in the geochemical signal, and an **abrupt change** in values around the boundary between the Pleistocene and Holocene deposits. This change is caused by the high input of anthropogenic ash in the Holocene deposits, which is also driving the alkaline conditions in this part of the sequence (Fig. 2d). The dominant component of the Pleistocene deposits is SiO_2 deriving from **weathering of the rockshelter wall** (Fig. 2c). The Pleistocene deposits are characterised by acidic conditions, which gradually change to neutral towards the top (Fig. 2a). This change goes alongside a gradual reduction of anthropogenic input. P_2O_5 does not follow this trend, but instead shows much more lateral variation, likely related to the presence of excrement (Fig. 2b). The MS data indicate two distinct areas with different magnetic properties within the Pleistocene deposits, as well as **possible pedogenesis** around the Pleistocene-Holocene boundary. Preliminary micromorphological data confirms the homogeneous nature of the deposits and shows evidence for **small-scale mixing** related to bioturbation (Fig. 3a, b).

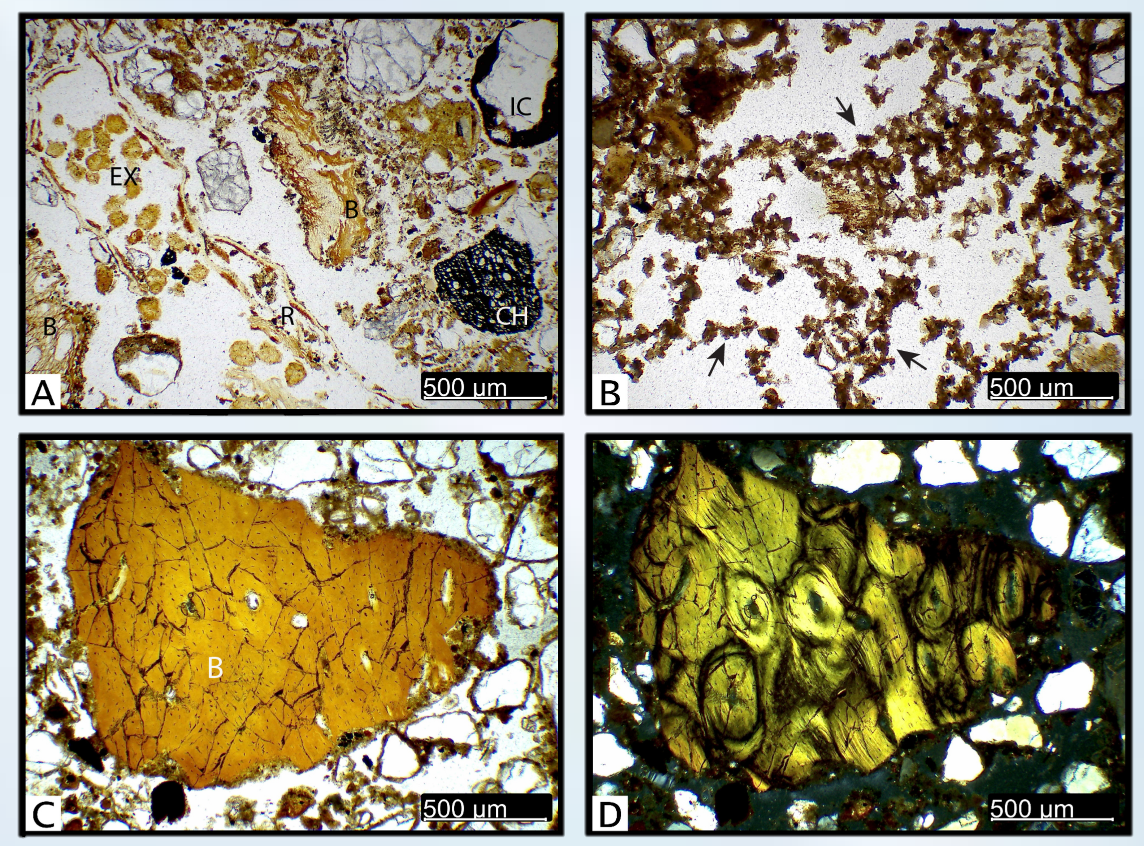
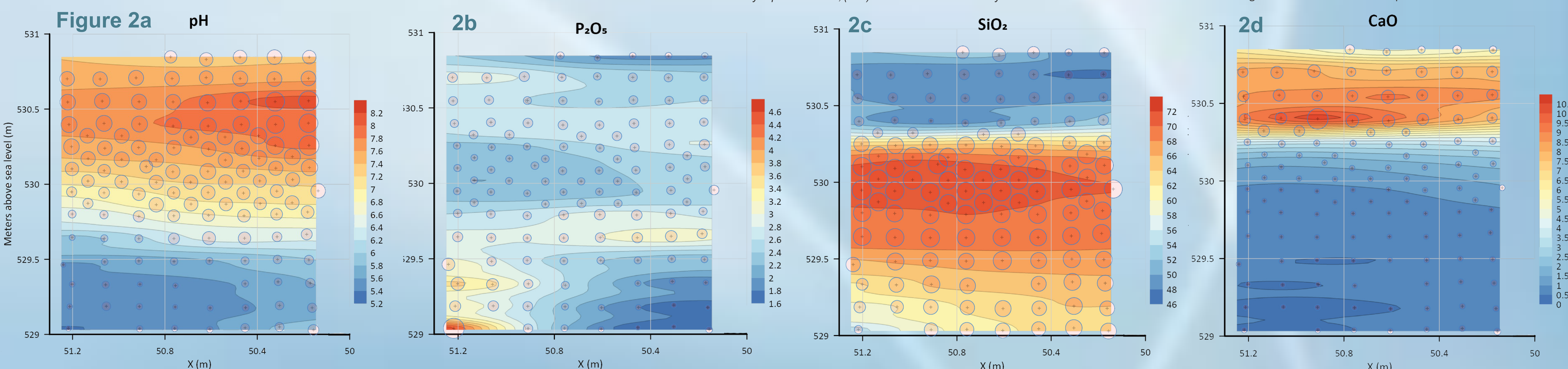


Figure 3 *Photomicrographs of sedimentary components identified in micromorphology thin sections. **A:** Degraded bone and organic (root?) tissue, including mesofauna excrements, charcoal fragment, and sand grain with iron oxide coating (PPL). **B:** Mesofauna excrements consisting of degraded organic matter (PPL). **C:** Bone fragment, with orange colours and cracking indicating heating or weathering (PPL), Group P - Group H boundary deposits. **D:** Idem, (XPL). Haversian canals are clearly visible.*



CONCLUSIONS

- The geochemical data show a gradual change indicating that **no large-scale mixing** happened at the site. Small-scale mixing related to **bioturbation** is visible in the micromorphological thin sections.
- The gradual change within the geochemical data is related to **increased geogenic and decreased anthropogenic input towards the top of the Pleistocene deposits**. The Holocene deposits are characterised by high anthropogenic input related to combustion activities.
- The preservation at the site is driven by the variation in pH, with acidic values in the Pleistocene deposits and alkaline conditions in the Holocene. The pH in the **Holocene** was **buffered** by the presence of **large amounts of ash**.
- The MS data show that within the mostly homogenous sedimentary context there are still distinctive lateral and vertical variations within the deposits, suggesting deposition of the **Pleistocene** deposits first during a **dry period**, followed by a **wetter phase**.
- The concept is **simple to execute**, **fast**, and relatively **low-cost**. The systematic approach allows for more **in-depth comparison** with other sites, once it is applied more broadly.

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[1]Faculty of Archaeology, Leiden University, NL, [2]Senckenberg Research Centre for Human Evolution and Palaeoenvironment (S-HEP), DE, [3]Cultural Heritage Agency of Netherlands, NL, [4]University of Groningen, NL, [5]National Research Center on Human Evolution, SP, [6]University of Oxford, UK, [7]Palaeo-Research Institute, Faculty of Humanities, University of Johannesburg, SA

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