# How does wetting and drying processes influence artefact distribution in expansive clay-rich soils?

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## Introduction

- Soils containing swelling clay minerals (e.g., montmorillonite) expand and contract during wetting and drying cycles, causing movement within the soil profile
- This process, known as argilliturbation, can alter artefact distributions and complicate the interpretation of archaeological deposits
- Our study investigates the influence of argilliturbation at a clay-rich sediment basin on Middle Gidley Island in the Murujuga rock art province
- Here we present an experimental study, to quantify the movement of stone artefacts following wetting and drying treatments using the local soil and other contrasting soil textures

## Site and survey

- A clay-rich sediment basin located on Middle Gidley Island in Murujuga NW W.A
- Soil shrink-swell features and desiccation cracks observed
- OSL dating of sediment core shows mixing in upper ~1.7 m
- Archaeological survey recorded medium density lithic scatter
- Dating of Melo amphora surface shell indicates Late Holocene occupation (262-2743 cal. BP)

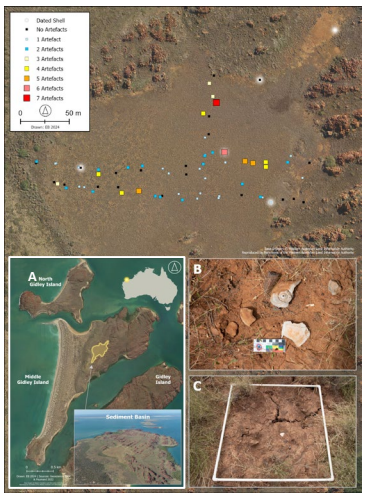


**Figure 1.** Map of Middle Gidley sediment basin showing the location of survey squares and the presence and/or absence of recorded artefacts and shell. A) Location of Middle Gidley Island in Murujuga, northwest Western Australia. Inset, aerial photograph of Middle Gidley and the sediment basin in September 2022; B) Melo amphora shell fragments recorded in a survey square; C) example of desiccation cracks.

## Argilliturbation experiment

- Six weekly wetting and drying cycles were conducted on 30 soil experiment tubs containing one of three contrasting soils types and embedded stone artefacts (small, medium or large)
- The soils used were the Middle Gidley clay-rich soil (MG Soil), a pure quartz sand (S Soil), and a mixed soil (X Soil) comprised of 25% MG and 75% S Soils by weight
- The tubs were imaged using CT-scanning before and after the experiment, and the movement of artefacts was calculated using 3D image correlation

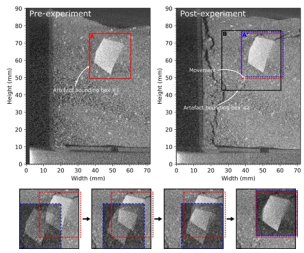


**Figure 2.** Top panel: A vertical slice through the MG-L-2 bucket 3D scan, showing an artefact pre-experiment (left) and post-experiment (right). The pre- and post-experiment artefact bounding boxes A (red, left) and B (black, right) are defined manually. The best matching location of A in the post-experiment scan is shown as box A' (blue, right), and is found automatically. The offset of A' relative to A defines artefact movement. Bottom panel: An illustration of the computational method to optimally place box A' in the post-experiment scan. The method slides box A' (blue), across box B (black), calculating the correlation coefficient between collocated pixels (voxels) at each location. This example shows a 2D slice for illustrative purposes only; the method operates in three dimensions.

## Results

- Soils from Middle Gidley sediment basin ranged from clay to silty clay loam texture and contained the swelling clay mineral, montmorillonite (Fig. 3)
- The experiment demonstrated that argilliturbation caused vertical movement (Fig. 4):
  - MG-Soil - all artefacts moved vertically upwards, from 2.3-6.7 mm (average = 4.3 mm)
  - X-Soil - all artefacts moved upwards (average = 1.2 mm) but was less pronounced
  - S-Soil - all but one artefact in the moved downwards (average = 2.0 mm)
- Movement in the horizontal plane (x-y) was less significant, but still moved by up to 3.9 mm (average = 2.4 mm) in the MG-Soil
- There was no significant difference in movement between small, medium and large artefacts, except for in the MG-Soil where large artefacts moved slightly less
- Extrapolation of movement within the MG-Soil suggests artefacts may move upwards by 2.8 cm per 100 years, based on an average of 3.9 significant wet-dry events annually
- This equates to 84 cm over 3000 years demonstrating the potential for most buried artefacts to have been concentrated to the surface over the time frame of Late Holocene occupation

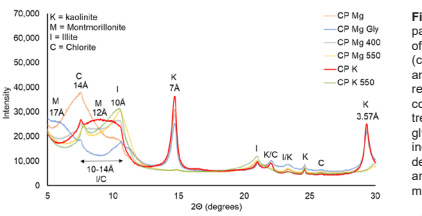


**Figure 3.** X-Ray diffraction patterns of <2µm fraction of treated MG-soil (carbonates, Fe-oxides and organic matter is removed). Analysis was completed using different treatments (MgCl, KCl, glycerol and heating) to induce clay behaviour and demonstrate expansion and contraction of montmorillonite.

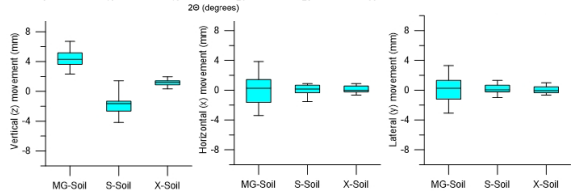


**Figure 4.** Box plots showing the range of stone artefact movement for different soil types, from left to right for vertical (dz), horizontal (dx) and lateral (dy) movement (mm), for all artefact size classes.

## Conclusions

- The argilliturbation experiment demonstrated that stone artefacts move in an upwards direction due to expansion and contraction of the soil matrix in swelling soils
- Artefacts on the surface of the Middle Gidley sediment basin may have been deposited at different times but have been pushed upwards and concentrated at the surface by argilliturbation processes
- Upwards movement due to argilliturbation in clay-rich soils, as well as sinking in sand, suggest vertical displacement is common
- The outcomes of this study highlight the potential for wetting and drying processes to disrupt stratigraphy and impact archaeological context

## Acknowledgements

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