[Supplementary material]

Detecting and mapping the 'ephemeral': magnetometric survey of a Pastoral Neolithic settlement at Luxmanda, Tanzania

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A. Details of lithostratigraphic units (LU) identified at Luxmanda.

For additional details, see Storozum *et al*. (2021).

LU 1 (approximately 0.70–1.20m below surface). Reddish saprolite originating from degraded bedrock, which it overlies. Virtually archaeologically sterile, with artefacts occasionally entering the deposit through bioturbation associated with roots and termites.

LU 2 (approximately 0.25–0.70m below surface). The thickness, texture, and colour of LU 2 varies across the site, depending on the preservation of the overlying topsoil and the mixture of natural and anthropogenic sediments found within LU 2. The four identifiable facies (described below) are interpreted as broadly contemporary, and at all observed sections at Luxmanda there is an abrupt basal transition in sediment colour between the dark brown to grey to black LU 2 and the reddish LU 1. LU 2 is characterised by a brown silt loam formed from aeolian sediments with intermittent lenses of anthropogenic midden and ash deposits. Archaeological materials—primarily bones, lithics and ceramics—are present throughout most of LU 2, but in highly variable densities. In fact, most archaeological materials at Luxmanda are found within LU 2, in variable densities that likely reflect different activities and/or intensity and duration of activity, and potentially represent multiple phases of site occupation and reuse. A series of radiocarbon dates suggest the initial formation of LU 2 was *c*. 3000 BP (Grillo *et al*. 2018). This unit can be subdivided into four facies, with further subdivisions possible based on mineralogy, artefact density and character of archaeological material:

LU 2A is a dark, organic-rich silt. High density of artefacts, high organic matter and elevated P and C (Storozum *et al*. 2021) suggest that LU 2A is an anthropogenic deposit derived from disposal of organic matter and human and/or animal waste; the relatively high densities of archaeological material suggest that this is some combination of midden and occupation debris.

LU 2B is a grey, carbonate-rich, silty deposit with an ash-like appearance. These features, together with results of micromorphological, magnetic susceptibility and geochemical analyses (Storozum *et al*. 2021), suggest that LU 2B is derived primarily from decayed livestock dung.

LU 2C: matrix anthropogenic but distinct from LU 2A and LU 2B, with little to no ash, dung, or organic content, and containing moderate to low amounts of material culture; could result either from sparse deposition of cultural material or post depositional mixing of cultural material and other sediment.

LU 2D: similar to LU 2C but no or little material culture; matrix not anthropogenic but aeolian silt, with little to no material culture

LU 3 (approximately 0–0.25m below surface). Modern topsoil and plough zone, widely eroded across much of the site, but preserved in areas that are today reserved for grazing, where the soils have been heavily compacted and trampled by livestock. Insect and root disturbance is common.

B. Details of magnetic features at Luxmanda, and possible interpretations

M1

A region of high-range magnetic anomalies (±100nT), recorded across an area of unploughed land preserved in ploughed and cultivated fields. Appears to consist of a number of overlapping bipolar magnetic anomalies, each around 5m in diameter, covering a region around 30m wide. The excavation of granitic boulders in Units 15–17 indicate that some of the magnetic anomalies may be the result of palaeomagnetism, but the lack of similar rocks in Units 11–14 and 6–8 indicates that this is not the only cause of the magnetic anomalies in the M1 cluster. Faint magnetic readings with a similar form and size beyond the edge of the preserved land in the plough zone indicate the destruction of at least some parts of these

anomalies by modern ploughing, a point which goes against palaeomagnetism as the primary explanation for anomalies. Based on the form of anomalies and direct continuation of high to low-amplitude readings from the preserved ground into the plough zone, we hypothesise that a secondary cause of magnetic anomalies in this cluster may be archaeological thermoremanence as a result of burning, perhaps of wattle-and-daub or timber structures, although no positive evidence of burning has yet been identified during excavation. It is possible then that the M1 cluster is due to a combination of archaeological thermoremanence as a result of burning, and palaeomagnetism related to igneous rocks buried in the sedimentary matrix.

M2

Adjacent to M1 is a sub-circular region of high-range magnetic disturbance (±100nT), 7m in diameter. This magnetic anomaly maps directly onto an assemblage of buried stones and grinding stones partially exposed and first noted on the ground surface within the preserved area of unploughed land. The high-range magnetic readings suggest that these stones have some natural palaeomagnetic remanence and may therefore be igneous in nature. The principal local geological formations are apparently sedimentary eluvium and metamorphic migmatite, but volcanic lava deposits are found approximately 9km from Luxmanda at Lake Balangida. It is possible, therefore, that these stones represent artefacts brought to Luxmanda for use and deposited as a curated assemblage.

M3

A sub-circular region of high-range magnetic disturbance (±100nT), 12m in diameter. This magnetic anomaly maps directly onto an assemblage of stones partially exposed on the ground surface within a circular area of preserved land in the middle of area of ploughed fields. This feature is as yet unexcavated, but the similarity of the anomaly and context of visible assemblage to feature M2 suggests a similar cause related to an archaeological assemblage of palaeomagnetically remanent—possibly igneous stones.

M4

A linear feature in ploughed fields north of the modern road. This feature is approximately 25m in length and 10m wide, and appears to consist of a cluster of small, bipolar anomalies (±50nT) around 3m in diameter. On the basis of the different orientations of anomalies in this feature, we hypothesise that the cause of this feature may be a cluster of palaeomagnetic or ferrous artefacts of unknown origin or date. No archaeological finds were identified on the ground surface during collection in this area.

M5

A high-range dipolar magnetic anomaly (±100nT), approximately 3m in diameter, recorded in plough zone. No cause noted from surface walkover or collection. On the basis of the high-range magnetic readings, we have classed this as potentially related to thermoremanence or ferrous artefacts, but there is not enough evidence or cause to narrow this identification down at present.

M6

A high-range dipolar magnetic anomaly (±100nT), approximately 4m in diameter, recorded in plough zone. No cause noted from surface walkover or collection. On the basis of the magnetic readings, we have classed this as potentially related to thermoremanence or ferrous artefacts, but there is not enough evidence or cause to narrow this identification down at present.

M7

M7 represents a region downslope of the central survey area, containing a number of small anomalies recorded in the magnetic gradiometry survey, and a number of worked and sometimes partially burned stones observed and mapped with a GPS during pedestrian survey. The spatial coincidence of these small anomalies with surface finds particularly of stone suggests that these may be palaeomagnetic and could represent materials disturbed by ploughing activity. This hypothesis implies that this feature, although potentially related to archaeological activity upslope in the preserved pasture, does not represent *in situ* materials.

M8

A region of low-range magnetic enhancement (+25nT) with intruding (−90nT) and adjacent (−20nT) negative anomalies at the northern end of the unploughed, preserved land. Excavations recovered abundant domestic refuse correlating with the area of magnetic enhancement. We hypothesise that the magnetic enhancement of this area may therefore be due to a magnetic ‘fermentation effect’ associated with the decay of organic materials (Schmidt 2007). Excavations in the area of the negative anomaly exposed thin, slightly compacted surfaces with hearths and an associated burial. Since these hearths appear to represent the same timeframe as the midden deposits in the magnetically enhanced area, we hypothesise that the negative anomaly surrounding the area of magnetic enhancement could be related to the trapping and clumping of paramagnetic particles in exposed living surfaces prior to burial.

M9

A large, sub-circular bipolar magnetic anomaly (+35/−50nT), measuring approximately 12m across, at the edge of our survey area. It is possible that this feature, like M1, represents thermoremanence or buried palaeomagnetic materials, but since there are no surface indicators of material, it is unclear whether this is an archaeological, modern or natural feature.

M10

Feature M10 marks a cluster of sub-circular, potentially palaeomagnetic or ferrous bipolar anomalies (averaging ±40nT), and a curvilinear arrangement of adjacent positive (+15nT) and negative (−25nT) magnetic anomalies. These anomalies extend around 40m across an area of ploughed land next to the modern road. There is no indication of this feature either topographically or in the results of the surface collection, but it is possible that the near right-angle of the feature is related to recent, but relict field boundaries.

M11

This is a feature which appears to consist of a sub-circular, bipolar magnetic anomaly (±40nT) cut by a large termite mound and animal burrows. There is a spatial correlation of insect and animal activity in the eastern part of the feature with significant magnetic disturbance and higher-range magnetic readings. Similar high-range readings were noted in correlation with insect and animal burrows at three other locations across the site. We hypothesise that the burrowing may be creating a combination of enhanced magnetic sediments, and compaction of tunnel walls, which might be recorded as stronger-than-average negative magnetic readings. Further testing of this hypothesis would help identify such anomalies in future survey work.

References

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