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Title: Letter to the editors on termite stone lines

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To the Editors,

Termite activity is ubiquitous in Australia's seasonally wet tropics, and some degree of termite disturbance is inevitable in archaeological sites across this region. Our paper specifically focused on developing guidelines for identifying situations where termite activity has been sufficient to create a stone line that mimics an archaeological horizon (Smith et al., 2020). In a critique, Williams et al. (2020) arbitrarily discount the criteria we propose for discriminating between these phenomena. Here, we respond to their comments and discuss the role of luminescence dating in identifying bioturbation by termites.

A Fine-Grained Mantle

Research on termites shows that these invertebrates selectively move sand grains <3mm in diameter, in addition to silt and clay, and that this results in a fine-grained mantle above a stone line. We do not argue, contra Williams et al. (2020), that termites are the sole cause of fine-grained mantles. We argue that a fine-grained mantle is invariably produced wherever there has been a prolonged termite activity.

Pedogenesis

We agree with Williams et al. (2020) that soil horizons are typically poorly developed in the seasonally wet tropics. However, it is well understood (Holt & Lepage, 2000) that as termites open up the fabric of a sediment, their activity facilitates a range of physical and chemical changes in soils. These include illuviation, mineral leaching, reorganization of clays, mineral authigenesis, and changes in soil structure and geochemistry. On this basis, the soil above a termite produced stone layer will have mineralogical or chemical properties that distinguish it.

Direct Evidence of Termites

Williams et al. (2020) agree that prolonged termite activity is required to form stone lines. In such cases, it is likely that direct evidence of termites—ranging from remains of galleries, fecal pellets, fragments of termite cuticle or termite corpses to clay aggregates—will be apparent in micromorphological examination of sediments. There are no grounds for expecting that archaeological deposits will differ from other sediments in this regard or that mounds (termitaria) are the default outcome of termite activity.

Time Steps

Williams et al. (2020) estimate that it takes 10,000–15,000 years for the formation of a subsurface stone line, and that these features form at the foraging limits of termites. The

corollary is that a surface (ancient or modern) must be more or less stable over a substantial period to allow a well-defined stone line to develop. If so, the presence of a paleosurface or break in sediment accumulation should be evident in luminescence ages for profiles containing deeply buried termite stone lines.

Absence of Stratigraphic Detail

We are not alone in suggesting that termites destroy or alter stratigraphy (McBrearty, 1990), including archaeological and geochemical stratigraphy. We can infer, therefore, that wherever stratigraphic details—including microlaminations—are preserved, that termite activity is unlikely to have been intensive.

Williams et al. (2020) dismiss several methods used by archaeologists to explore structure in their sites: analysis of spatial patterning, magnetic susceptibility, micromorphology, and analysis of conjoins— theorizing that evidence of structure is irrelevant, as downward “settling” of lithics and charcoal through a sediment mantle will preserve the original relationships between artifacts. They hypothesize that an archaeological assemblage can be translocated (“settle”) through a sediment column without affecting its structure. In experimental data on compaction, this effect has only been observed in short-scale displacement (10–50 mm; Andrews, 2006), where artifacts mostly followed the downward compaction of the sediments. Preservation of structure over greater translocation distances is unlikely, as it requires that “settling” operates evenly across an area and that artifacts of widely different sizes, shapes, and density move uniformly.

We agree that questions of association between archaeological materials and surrounding sediments are sharpened by luminescence dating. Evidence of association is clearly strongest wherever features such as hearths are present—and also in sites where age determinations on shell, bone, charcoal, or burnt artifacts match luminescence dates on the enclosing sediments.

Size Sorting

The field observations of Williams et al. (2020) were on open foot slopes, where removal of fine sediments has concentrated a quartz gravel present at the base of a profile. It is, therefore, unsurprising that the formation of a lag in this geomorphic context did not produce size sorting. Creation of a stone line in an archaeological profile involves more significant downward displacement of artifacts and consequently greater opportunity for size sorting. Moeyersons (1978) revealed that stone implements in consolidating Kalahari sands undergo differential displacement, depending on their size and form. Furthermore, McBrearty (1990) noted the presence of infilled termite galleries and chambers, which shows there are also grounds for expecting that small artifacts will be displaced as a part of the infilling process in addition to any displacement caused by the collapse of void spaces as a sediment consolidates.

Other than Moeyersons (1978), there are few direct data on the effects of termite consolidation of archaeological sediments. From first principles, we expect that size sorting of artifacts will be determined by (a) the heterogeneity of the parent assemblage—which can range from large grindstones and edge-ground axes to much smaller flaked stone artifacts and fine flaking debitage—and (b) by the time spent in passage within a profile.

Williams et al. (2020) hypothesize that wherever termite activity is present, an artifact assemblage will inevitably be translocated without apparent effects on its structure and will

“settle through a sediment column ... like a handful of gravel slowly sinking through a bucket of honey.” This is unlikely except at the short scale (10–50 mm), and this hypothesis is entirely without supporting data.

Overdispersion in OSL DE Distributions

Williams et al. (2020) show that near-surface churning by mound building termites broadens single-grain De distributions without creating distinct, separate age grain populations—a pattern also observed by Martin et al. (2018).

Their subsequent use of De overdispersion as the principal signature of termite activity at a site is problematic, as other vectors of short-scale (10–100 mm) disturbance will also broaden De values such as treadage, which is intrinsic to occupation surfaces. Another uncertainty is whether termite species that build subterranean nests or epigeal mounds—more usual in archaeological contexts—have similar effects to species that build large columnar mounds. Detection of termite activity by this means also requires that natural variability in microdosimetry is minimal, as noted by Williams et al. (2020). Broadening of De distributions is not the only impact of termites on a sediment profile. There is substantial evidence that termite activity also displaces sand grains. Apart from the selection of sand grains 2–3 mm, there is also field evidence of galleries infilled with intrusive sediment (McBrearty, 1990) and translocation of particles to depths >1m (Araujo, 2013; Kristensen et al., 2015; Stewart et al., 2012). Therefore, we expect a significant termite activity to be detectable as separate age-grain populations in OSL samples (Bateman et al., 2007; Kristensen et al., 2015), irrespective of whether these are evident in near-surface churning.

Zero-Dose Grains

The assumptions of Williams et al. (2020) regarding the limited movement of sand grains are unjustified. Kristensen et al. (2015) presented evidence for (i) the presence of saturated grains at the surface and (ii) mixing of low- or zero-dose grains through subsurface galleries.

In summary, we emphasize the need to use multiple lines of evidence to determine whether termite activity has been sufficiently intense to create a stone line. All the traits we list are likely consequences of prolonged termite activity associated with the creation of stone lines—irrespective of whether individual traits are exclusively produced by the action of these invertebrates.

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