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The Effects of Burrowing Activity on Archaeological Sites: Ndondondwane, South Africa

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Burrowing activity is a widely recognized source of site modification. Most taphonomic studies of burrowers emphasize their destructive aspects on the archaeological record. Excavations at Ndondondwane, South Africa, suggest burrowing activity is destructive in some ways, but may also preserve cultural behaviors. Drawing on both direct and indirect sources of evidence, we discuss how burrowing activity by rodents, earthworms, and termites can inform about pedogenic and depositional processes at archaeological sites and both preserve and destroy evidence of intra-settlement patterns and early African cultigens. Specifically, we demonstrate the limited effect of earthworms on site stratigraphy, how the localized activity of termites have preserved casts of early African cultigens, and how the ability of archaeologists to distinguish the devastating effects of rodent burrowing from remains of architectural features have permitted important inferences about social and ritual life in early African farming communities.

INTRODUCTION

In the past 20 years, it has become widely appreciated that an understanding of the nature and extent of natural and cultural taphonomic postburial processes are a prerequisite for interpreting past cultural behavior at archaeological sites. It is no longer assumed that there are direct links between the patterning of artefact and feature distributions on sites and human behavior. Many physical and biological processes that affect the movement and positioning of artefacts, ecofacts, and features within the three-dimensional context of a site, only some of which are well understood (Wood and Johnson, 1978; Butzer, 1982; Nash and Petraglia, 1987; Schiffer, 1987; Lyman, 1994; Canti, 2003). Most often, studies of postburial processes are concerned with the destruction or distortion of archaeological data. In reality, postburial processes not only destroy and distort, but also can modify and preserve evidence of past cultural behavior.

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One of the most widely recognized sources of site modification is burrowing activity. Almost all archaeological sites have some evidence of burrowing activity, and it is commonly treated as a destructive force on sites (for a recent review of bioturbation, see Balek [2002]). Burrowers either spend most of their life underground (a fossorial lifestyle), or they may live above ground using burrows for shelter, nesting, hibernation, or birthing (a semifossorial lifestyle) (Schiffer, 1987; Wülfling, 1989). Alone or in combination, both lifestyles can damage the integrity of a site’s stratigraphy and the distribution of cultural debris. However, the precise effects of different burrowing animal species on archaeological sites are poorly documented. As a result, discussions of the relationship between material cultural patterning on sites cannot proceed without considering both the positive and negative effects that burrowing animals have on the distribution and preservation of cultural remains.

Archaeologists are aware of the destructive effects caused by burrowing vertebrates, mammals, amphibians, birds, and reptiles (Wood and Johnson, 1978; Waters, 1992). During excavation, however, most archaeologists only record the highly visible disturbances caused by burrowing vertebrates (e.g., rodent tunnels). In contrast, burrowing invertebrates (insects, earthworms, and crustaceans) have received comparably less attention. This situation cannot always be attributed to archaeological negligence in terms of research design, excavation strategy, or inattention to bioturbation processes in general. Instead, it is a function of the ability of archaeologists to identify the presence of burrowing invertebrates acting on sites.

In this article, we take a somewhat different approach to the issue of postburial disturbance processes. Most taphonomic studies of burrowing activity emphasize the destructive aspects on the archaeological record (including the works cited above), while few document how burrowing animals may preserve the original horizontal and vertical relationships of cultural materials (Darwin, 1896; Johnson, 1989; Michie, 1990; Kries, 1995; Van Nest, 1997). Instead, we will show how burrowing activity is destructive in some ways, but may also preserve cultural behavior. To illustrate this point, data from the Early Iron Age site of Ndondondwane in South Africa will be presented.

THE SITE

Regional Context

Early Iron Age (EIA; A.D. 420–1050) farmers in southeastern South Africa typically established small, permanent villages on the rich alluvial soils beside lakes and rivers (Maggs, 1980a). Most EIA sites were occupied for a relatively long duration of time, often several hundred years (Maggs, 1984b, 1989). These reoccupations of the same places have created a palimpsest of flat, expansive settlements. As a result, most of the archaeological research on EIA sites in the region has focused on cultural disturbance processes as more immediate obstacles in dating archaeological sites, elucidating pan-site stratigraphic relationships, and determining the relationships between coterminous features and activities at settlements.
Ndondondwane is the type site of the Ndondondwane phase in the cultural-historical sequence of eastern South Africa (Table I). It is located on a relatively flat expanse of the northern bank of the lower Thukela River (KwaZulu-Natal, South Africa) some 200 m asl (Figure 1) on the deep well-drained red soils that predominate along the riverbanks and foot-slopes where other EIA sites are found (Maggs, 1984a, 1988; Maghumulo, 1986; van Schalkwyk, 1991, 1995). The iron-rich clayey loam soils are particularly well suited to dry-land agricultural practices, especially drought-resistant cultigens such as the cereals (*Sorghum* and the millets *Pennisetum* and *Eleusine*) preferred by first millennium farmers (Klapwijk, 1973; Maggs, 1984a, 1984b). These cereals require at least 500 mm of rainfall a year and nighttime temperatures must not drop below 15°C (Doggett, 1976; Purseglove, 1976). It is therefore likely that temperature and rainfall conditions in this area during the EIA were not substantially different than today. However, regional changes in temperature and rainfall over the past 2 millennia in southern Africa do indicate that climatic conditions were somewhat warmer and wetter in parts of the basin between ca. A.D. 500 and A.D. 700 and close to current conditions from ca. A.D. 600–900 (Tyson and Lindsey, 1992). The latter time range corresponds to the florescence of EIA habitation in the Thukela Basin. Average maximum daily temperatures in the Lower Basin vary from 19°C to 22°C between June and January, although summer temperatures in excess of 35°C are common. Winter temperatures vary between 8°C and 17°C from January to July, and light frosts can occur in the river valley bottoms (Shulze, 1982). Rainfall averages between 470 and 750 mm per year (Shulze, 1982). Most precipitation is received from rainy season thunderstorms during the summer months, mainly in March, while occasional showers and south-westerly winds typify the winters. All indications are that EIA settlements in river valleys were established in savanna-woodland. The opening of the woodlands by EIA farmers is apparent from the floral record and current vegetation distribution in the valley (Hall, 1981; van Schalkwyk, 1991): Fallow fields in the area are often quickly over-run with scrub (*Croton menyhartii*), the original sweetveld understory (*Themeda triandra*) is commonly replaced by the sparser bushveld signal grass (*Urochocha mossambicensis*), and remnant grazing lands are dominated by the pervasive *Acacia tortilis*.

The associated riverine canopy has been heavily depleted and several relict species

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**Table I. Early Iron Age chronology of the eastern lowlands in South Africa. Uncalibrated ages are summarized from Fowler (2002: Table 5.1).**

<table>
<thead>
<tr>
<th>Ceramic Phase</th>
<th>Uncalibrated Age Range (B.P.)</th>
<th>Calibrated Age Range (A.D.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mzonjani</td>
<td>1670 ± 40–1540 ± 60</td>
<td>420–590</td>
</tr>
<tr>
<td>Msuluzi</td>
<td>1460 ± 50–1275 ± 60</td>
<td>640–780</td>
</tr>
<tr>
<td>Ndondondwane</td>
<td>1300 ± 50–1100 ± 50</td>
<td>780–890</td>
</tr>
<tr>
<td>Ntshekane</td>
<td>1126 ± 45–1070 ± 50</td>
<td>890–1050</td>
</tr>
</tbody>
</table>

*Calibrated ages are given using the Pretoria Calibration Program (Talma and Vogel, 1993) based on the data of Stuiver and Pearson (1993) and adjusted for the southern hemisphere (Vogal et al., 1993).
Figure 1. Map of the Lower Thukela Basin study area and the location of Early Iron Age sites.

(Ficus sycamorus, Syzygium sp., Salix woodii, and Trichelia emetica) indicate that there was a more diverse riverine flora in the recent past. On the adjacent flat areas only isolated specimens of the deciduous marula (Sclerocarya birrea), tamboti (Spirostachys africana), and acacia (A. robusta) have survived, while on hill slopes the red bushwillow (Combretum apiculatum) dominates. The climax sweetveld community (Themeda and/or Hyparrhenia) has been mostly replaced by tufted and less palatable grasses (Aristida congesta, Sporobolus sp.) and browse-stunted acacia thicket (van Schalkwyk, 1991). As well, faunal evidence suggests that certain species, such as nyala antelope, were forced to shift the range of their habitat, and their presence during the first millennium suggests that dense riverine
woodland conditions existed (Maggs, 1995:175). Hall (1981) originally proposed that the valley slopes and low-lying areas were covered by closed savannah-woodland before the colonization of the area by EIA farmers. Only in these contexts is it clear that an opening of the river valley savannah-woodland during the EIA. All documented sites in the lower Thukela are found within 100 m of the relic canopy fringe (van Schalkwyk, 1991).

Research at Ndondondwane has established that the site contains well-preserved architectural and artefactual remains including substantive samples of both fauna and flora. During the late 1970s, excavations defined the Ndondondwane ceramics as composing a new stylistic phase in the regional Iron Age ceramic sequence (see Table I). Uncalibrated radiocarbon dates from the site indicate an occupation in the range of A.D. 650–750 (Pta-2388, 1220 ± 50 and Pta-2389, 1190 ± 50) (Maggs, 1984c). When calibrated these dates fall in the range of A.D. 879–892 (±50 years, 1 sigma) (Whitelaw and Moon, 1996). The ceramic typochronology, secured by the radiocarbon dates, suggests the EIA occupation of Ndondondwane covered the late 9th and early 10th centuries A.D. Further excavations in the early 1980s by Loubser (1985) uncovered a livestock enclosure, iron smelting, and ivory working areas near the river, and a contemporary midden to the east.

Excavations and Surveys at Ndondondwane

The most recent excavations from 1995 until 1997 expanded work in previously excavated areas and investigated new areas of the site, followed by extensive analysis of the recovered artefacts and ecofacts (Greenfield, 1996, 1997, 1998, 1999; Greenfield et al., 1997, 2000; van Schalkwyk et al., 1997; Greenfield and van Schalkwyk, in press a, in press b). The objective of these excavations was to collect spatially representative samples of data from different activity areas in an EIA settlement to test models of intrasettlement socioeconomic organization. This site was chosen for study because it was a single-phase settlement occupied for a comparatively short (< 100 years) duration of time. This has resulted in less pronounced settlement drift, or temporal and spatial changes in activity areas, which is uncharacteristic of other Early Iron Age settlements in the region (Maggs, 1984a, 1984b; Whitelaw, 1994; Lane, 1998). As such, Ndondondwane has not experienced many of the same depositional processes typical of other multiphase EIA settlements (e.g., Marker and Evers, 1976; Hall, 1981, 1984; Peely, 1987; Fowler et al., 2000). However, because the site held potential to provide a finer “picture” of both the lateral displacement and vertical superposition of cultural stratigraphy, more attention was paid to the potential effects that non-cultural post-burial processes had on the formation of the site.

A variety of complementary survey techniques for the investigation of surface and subsurface distribution of features and artefact concentrations were applied during field work at Ndondondwane. These included topographic survey, systematic surface collection, electrical conductivity survey, and soil auguring (Loubser, 1993; Greenfield et al., 2000). The aim of these techniques was to test for and...
determine in a systematic fashion the boundaries of the site, the size, depth, and nature of cultural deposits, and the possible location of features and activity areas within the site. The results of the survey efforts permitted a selection of new areas for excavation with the highest potential for recovering cultural remains.

With the new survey and excavations completed, it is now possible to define a series of spatially discrete activity areas at Ndondondwane that can be divided into two major zones (Figure 2): a central zone surrounded by an arc of peripheral activity areas. The central zone is composed of three activity areas arranged about 40 m from each other in a line from north to south: a livestock enclosure (Dung Area), a large hut floor (Transect 1), and an area (Mound Area) reserved for iron smelting, ivory working, and possibly ritual activities (with clay mask fragments, human figurines, etc.). Arranged in a rough arc to the east of the central zone, separated by a large apparently open space of some 100 m, are a series of domestic activity areas designated Middens 1–3 (Midden 4 is now considered part of Midden 2). A fourth activity area used for pottery firing and possibly preparing charcoal and iron ore for smelting is located at the southernmost end of the zone (Greenfield et al., 1997; Greenfield, 1988, 1989; van Schalkwyk et al., 1997; Fowler, 2002; Greenfield and van Schalkwyk, in press a, in press b).

Recovery Methodology

Because of nearly 5 decades of mechanical ploughing, a clearly discernible plough zone was recognized throughout the site. This horizon varied in thickness depending upon local topography and distribution of subsurface features. After clearing the hard plough zone sediments, artefacts were hand-collected within 2 × 2 m squares. Strata were excavated with regard to natural stratigraphic divisions, both within and outside features. Only in cases where the natural stratigraphy was not visible were spits of arbitrary thickness employed. This was particularly characteristic of the 2 × 2 m units (squares) opened during the 1982–1983 season, and spits were employed in the subsequent 1995–1997 seasons to discern the stratigraphic units described by Loubser (1983). In smaller test or transect trenches opened during the most recent excavations, 1 × 1 m or 1 × 2 m units were employed. In extending excavations in the Dung Area, for instance, 2 × 2 m recovery units were found to be too gross, and the spatial variability that could otherwise be seen during excavation was being lost. Consequently, there was a shift toward the use of 1 × 1 m units within the 2 × 2 m squares as the maximal recovery unit. Further, during the excavation of pits, these 1 × 1 m units were sectioned into halves. Where horizontal subdivisions within features were recognized (e.g., the Ash 1 feature in Midden 1), these were collected separately.

All the sediments in the cultural horizon or in features were dry sieved with a 3–5-mm mesh. This mesh size was extremely effective, as evidenced by the recovery of large quantities of small shell beads and microfauna. The spatial coordinates and elevations of all features and artefact concentrations were recorded, allowing for the reconstruction of the original topography of deposits and associated artefact
Figure 2. Site plan of Ndondondwane.
densities. In addition, bulk soil samples were taken from all features and from the
general cultural horizon for postexcavation flotation and sedimentological analysis
(pH, phosphate, phytolith, grain size, etc.). Two types of bulk soil samples—control
and feature samples—were recovered. The control samples were taken, regardless
of whether any carbonized or other diagnostic elements were present, in order to
help determine their distribution beyond the obvious concentrations of residues.
During analysis, the empty samples are equally important in trying to understand
distributions of cultural residues. Feature samples generally came from in and
around pits, ash deposits, and visible concentrations of carbonized remains, mi-
crofauna, or other cultural debris (e.g., beads). The latter samples were selected
in order to maximize recovery of otherwise difficult-to-collect cultural residues.
Utilizing this battery of surface and subsurface reconnaissance and excavation
techniques has made it possible to assess the impact of several burrowing species
on the nature of archaeological deposits at Ndondondwane.

BURROWING AT NDONDONDWANE

Burrowing activity at Ndondondwane was identified using both direct and indi-
rect evidence. Direct evidence came in the form of rodent burrows and *termi
natoria* (termite mounds), while ceramic ecofacts (nonartefactual organic and environ-
mental remains) provided indirect evidence. We have discussed the procedures
leading to the definition, identification and the general cultural significance of the
ecofacts elsewhere (Fowler et al., 2000), but have not explored their potential as
an indirect source of evidence for the effects of burrowing activities at the site.

Four general issues must be considered when attempting to discern the effects
of burrowing activity at archaeological sites.

1. Identification: The first issue that must be addressed is whether burrowing is
present. Disturbances due to burrowing may not always be easily identifiable.
While networks of tunnels and dens of larger burrowing taxa can be easily
distinguished by texture and color differences between ancient burrow fill
and the surrounding soils (e.g., Wilkins, 1989), collapsed burrows may not be
identified (e.g., Waters, 1986). Those of smaller burrowing taxa are even more
difficult to identify. Thus, evidence of burrowing may be difficult to detect
during excavation even if bioturbation is suspected. In many cases, burrowing
activity may only be identified indirectly during the postexcavation phase of
analysis. For example, the size sorting of artefacts in middens, with larger
artefacts in lower levels and smaller artefacts in upper levels of a deposit, has
been one way to indirectly identify burrowing activity (e.g., Bocek, 1986; John-
son, 1989). However, this situation can be further complicated when exca-
vating stratigraphically complex sites that have experienced multiple and pro-
longed occupations (e.g., Greenfield, 2000).

2. Agent: What is the burrowing species and its lifestyle? The agent can be iden-
tified in a variety of ways, including from faunal remains or, in their absence,
from remains of their lifestyle. Hints may come from the size and distribution
of burrows, soil characteristics, fecal casts, mounding, etc. (Waters, 1992:309–316).

3. Behavior of agent: Once the agent has been identified, the ethology of the burrowing species can be used to predict the nature of taphonomic modification to the site by burrowing activity. The effect animals have on a site matrix is entirely dependent upon the type, density and behavioral characteristics of the species present during and after the deposition of archaeological remains. These effects are specific to the behavior of the agent and the sedimentary matrix of the site (Waters, 1992:309–316). For example, various burrowing animals, such as rodents (Erlandson, 1984; Bocek, 1986; Johnson, 1986; Pierce, 1992; Mace et al., 1997; Aravjo and Marcelino, 2003), ants (Baxter and Hole, 1967; Lyford, 1963; Humphreys, 1981), termites (West, 1970; McBrearty, 1990), and earthworms (Darwin, 1896; Atkinson, 1957; Langmaid, 1964; Sein, 1983; Armou-Chehu and Andrews, 1994; Van Nest, 2002; Canti, 2003), differentially affect the integrity of archaeological sites.

4. Temporality: How long certain burrowing animals have been active at a site is another issue that must be addressed (Waters, 1992:314). More specifically, it must be asked whether the burrowing animals were present during initial deposition of cultural strata or did burrowing occur after the stratum was deposited. There is a need to establish a relative timeline of biotic activity at sites. The possibility of disturbance increases the longer burrowers act on soils and sediments. This causes considerable problems for archaeologists because stratigraphy and artefact typologies are the main tools used to establish how long a site was occupied and associate different deposits. The creation of artificial stratigraphic layers and the movement of phase- or period-diagnostic cultural material by burrowers may cause serious errors in interpretation. This methodological issue becomes even more pronounced when anomalous radiocarbon dates are obtained from deeply buried deposits (e.g., Taylor et al., 1986).

These issues are discussed next.

Direct Evidence for Burrowing Activities

Many burrowing animals can potentially displace cultural material and alter stratigraphy at archaeological sites in southern Africa. They can be divided into species with fossorial and semifossorial behavior. Semifossorial species spend only part of their time beneath the ground. Most commonly, burrows are used for shelter, nesting, and birthing (e.g., rodents, lizards, birds), or hibernation (e.g., snakes and beetles). In contrast, other semifossorial animals, such as termites and ants, construct large surface dwellings. Other burrowers spend most of their life underground in a fossorial lifestyle, such as earthworms, worm lizards, moles, and mole-rats. These patterns are found throughout the subtropical landscape (Wood and Johnson, 1978; McBrearty, 1990). Direct evidence of burrowing at Ndondondwane were the result of two primary agents—rodents and termites.
Rodent Burrowing

Burrows and faunal remains, both of which were commonly found during the excavations, provided evidence of rodent activity. Rodent burrows were distinguished from postholes by a variety of characteristics, including their spatial distribution, angle of penetration, depth, and the nature (including color) of the soil fill. For example, Maggs (1984c:74 and Figure 2) described a number of small holes, a few centimeters in diameter, during his excavations of the Mound Area that were animal burrows. There was a mouse still living in one. In the northeast sector of the same area, Loubser (1993:117 and Figure 6) described two shallow channels oriented in an east to west direction and several small pits (50 cm deep by 30 cm width), which contained rodent teeth and bones. In these cases, he attributed the channels and pits to rodent activity. Both Maggs and Loubser were able to distinguish the rodent burrows from structural remains (Figure 3). Both excavators identified larger channels (25 cm deep by 20 cm wide) and post-holes containing decayed wood extending some 30 cm into the red-brown, hard clayey-loam subsoil, which were the remains of a fence with lighter fill material in between (Maggs, 1984c:74; Loubser, 1993:117). Subsequent excavations in the Dung Area and in Midden 3 identified the presence of numerous rodent tunnels and burrows.

![Figure 3](image-url)
Termite Burrowing

Termite burrowing activity is visible in the form of termitaria, and both modern and ancient termitaria were found on the site. Large modern termite mounds, probably constructed by Macrotermes subhyalinus (Coaton et al., 1972) were scattered among the dense brush or at the base of trees covering the eastern half of the site. The bases of ancient termitaria were excavated in two areas of the site. Their size and vertical extent indicate that they were probably mature termitaria constructed by the same taxon. In the Dung Area at the northeast edge of the human activity zone, the base of a large termite mound extended from just beneath the plough zone deep into the sterile substrate disturbing the cultural horizons in a 2 m² area. It extended to a depth of almost 50 cm beneath the modern surface. The base of another smaller termitaria occurred in Midden 3, at the western or down slope edge of the midden. It was found within 10 cm of the surface, and was approximately 1.5 m in diameter. The total depth was not ascertained because the midden deposit was deflated and cultural remains lay only within 20 cm of the surface. While we cannot determine the precise age of these termitaria, we do know they were constructed after the EIA occupation and before the present. It is interesting to observe that both of the ancient termite mounds were located on perimeter of human activity areas. This should not be surprising since termites tend to locate their mounds near the bases of trees or stumps (Ferrar, 1982; Meyer, 1997), which might have been present near different activity areas in the settlement to provide shade.

Indirect Evidence for Burrowing Activities

Numerous unusual specimens of baked clay-rich soil were identified from the most recent excavations at Ndondondwane (n = 150). The objects fall into two morphologically distinct groups, and we have argued that they were produced by earthworm and termite activity at the site (Fowler et al., 2000). In this section, we review our analysis of the baked earthworm fecal casts and baked termite-produced plant stalk casts, and discuss their importance for understanding burrowing activity at Ndondondwane.

Baked Earthworm Fecal Casts

Included in the first group are 26 narrow, tapered cylindrical fragments of variable thickness along their extent (Figure 4a). They range from 15 to 25 mm in length, center around 6 mm in circumference, and can taper from a “head” to a “tail” often by as much as 2–3 mm. The surface coloring (reddish yellow, Munsell 5 YR 6/6 to light brownish grey, Munsell 7.5 YR 6/2), hardness (Mohs 3.5–4.0), presence of microscopic voids created by burned-out organic remains, and a sharp margin in cross section marking a black-grey “core effect” strongly indicate these objects were fired clay-rich sediment. While ferromanganese soil concretions or nodules found in the culturally sterile sub-soil do look similar to these objects, they are not as hard (Mohs 2.0) and do not have the characteristic core effect of ceramic.
objects (Rye, 1981:115–116). These properties also indicate that the objects were heated in low temperature fires, around or less than 500°C (Rye, 1981:115; Johnson et al., 1988), which were likely of long duration—a scenario where fuel was continually added to open fires, as it often is in cooking fires or in some traditional ceramic firing methods. Whatever the precise means, the firing conditions were adequate to decompose small organic constituents in the specimens, and temperatures were sufficient to make them durable by transforming the clayey soil into low-quality terracotta ceramic. The baked-soil specimens are identical with consolidated soil of unfired earthworm fecal casts, and these were identified as fired casts of fecal matter (Fowler et al., 2000).

Not all objects that fall within this morphological category were fired soil. Several similar objects were composed entirely of calcium carbonate. The calcium carbonate specimens are similar to the white calcium carbonate granules produced by earthworms (Canti, 2003:144–145). Glands attached to the esophagus of earthworms form a paste or solid granules of calcium carbonate, which are passed out with castings. They may reach sizes over 2 mm, depending on the size of the earthworm species and individual. The specimens at Ndondonwane are shaped like...
castings, and it is likely the earthworms in the area released a calcium carbonate paste that took the form of castings after being passed through the gut. Piearce (1972) has suggested the glands are most active among litter feeders, such as the large *Aporrectodea* sp., which are common in parts of South Africa. The large size of both the terracotta and calcium carbonate castings does suggest that such large earthworm species were active at Ndondondwane in the past, as they are presently (Figure 5). We suspect that casts of consolidated soil or calcium carbonate produced by *Aporrectodea* sp., and likely several other earthworm species, became incorporated in fires and were subsequently discarded in nearby charcoal/ash dumps (Fowler et al., 2000).

A general understanding of earthworm behavior yields some insight into the transformation of the fecal casts from soil to ceramic. In the process of feeding, earthworms ingest soil in order to process organic nutrients. Although vertical and horizontal movement cannot be directly linked to specific earthworms, certain species have preferred tendencies in their movement patterns (Canti, 2003). Some species of earthworms live in deep soils and tend to move vertically to and from the surface (e.g., *Lumbricus* sp.), while others live within the top 10 cm of soil and prefer horizontal movements, rising only during rains and to drop fecal matter (e.g., *Aporrectodea* sp.). When earthworms rise to the surface to deposit fecal matter, the resulting casts of consolidated soil can become incorporated in fires and/or charcoal/ash dumps. If a fire is built over the casts, they become trapped within the hot embers. The heat produced under these conditions would be sufficient to bake the consolidated soil. It is because fecal matter is deposited on the surface that it gets baked and is therefore preserved in a terracotta form. The preferred movement and other behaviors of various earthworm species can help isolate those that were present in and contributed to the formation of EIA soils and stratigraphy.

The terracotta fecal casts recovered during excavation were found at different depths and locations (Table II). Forty-five casts were found in the plough zone and one cast in the cultural horizon of Midden 3. This deflated midden had experienced recent ploughing. Because ploughing tends to dislocate objects from their horizontal context more extensively than from the vertical context (Rick, 1976; Roper, 1976), it is possible that the fecal casts in this area were not originally located in the cultural deposits and are of later or modern origin. There is no preserved evidence of cultural stratigraphy in this area, and it is difficult to assign confidently any terracotta castings found outside pits to the ancient occupation at the site. The single specimen found in the cultural horizon may also be intrusive.

A further 78 fecal casts were recovered from depths between 20 and 40 cm in the eastern part of the Dung Area (Table II). The most recent excavations have isolated two activity zones in the Dung Area: one used primarily by humans in the east and the other by livestock in the west. A stockade wall divides the two zones, and the stratigraphy in each zone is very different.

In the western livestock zone of the Dung Area (and within the livestock enclosure), four strata have been attributed to two temporal horizons (Figure 6). Each temporal horizon contains a pair of overlying loose and underlying compact dung.
Figure 5. Photograph of the large earthworm species, *Aporrectodea* sp., typical in southern Africa.
Table II. Excavated sample of ceramic ecofacts from Ndondondwane.

<table>
<thead>
<tr>
<th>Area</th>
<th>Horizon</th>
<th>Feature</th>
<th>Trench</th>
<th>Quadrat</th>
<th>Depth below Surface (cm)</th>
<th>N</th>
<th>%</th>
<th>N</th>
<th>%</th>
<th>Total N</th>
<th>Total %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dung area</td>
<td>Lower</td>
<td>Human activity</td>
<td>S1</td>
<td>SW</td>
<td>30–40</td>
<td>3</td>
<td>2.4%</td>
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<td>2.0%</td>
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</tr>
<tr>
<td></td>
<td>Middle</td>
<td></td>
<td>U5</td>
<td>SE</td>
<td>20–30</td>
<td>15</td>
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<td>58</td>
<td>46.8%</td>
<td>58</td>
<td>38.7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>V3</td>
<td>SW</td>
<td>20–30</td>
<td>2</td>
<td>1.6%</td>
<td>2</td>
<td>1.3%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dung area</td>
<td>east total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>78</td>
<td>62.9%</td>
<td>79</td>
<td>52.7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midden 1</td>
<td>Cultural</td>
<td>Open midden</td>
<td>b5</td>
<td></td>
<td>−10</td>
<td>1</td>
<td>3.8%</td>
<td>1</td>
<td>0.7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plough zone</td>
<td></td>
<td>26A</td>
<td>1</td>
<td>−5</td>
<td>19</td>
<td>73.1%</td>
<td>19</td>
<td>12.7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>25E</td>
<td>9</td>
<td>−5</td>
<td>8</td>
<td>6.5%</td>
<td>8</td>
<td>5.3%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>12</td>
<td></td>
<td>−5</td>
<td>1</td>
<td>3.8%</td>
<td>1</td>
<td>0.7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>45X</td>
<td>10</td>
<td>−5</td>
<td>37</td>
<td>29.8%</td>
<td>37</td>
<td>24.7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midden 3</td>
<td>Cultural</td>
<td>Pit 2 in midden</td>
<td>26B</td>
<td>15,16</td>
<td>−5–20</td>
<td>1</td>
<td>3.8%</td>
<td>1</td>
<td>0.7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Open midden</td>
<td>26C</td>
<td>5</td>
<td>−5–20</td>
<td>1</td>
<td>3.8%</td>
<td>1</td>
<td>0.7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>25D</td>
<td>11</td>
<td>−5–20</td>
<td>2</td>
<td>1.6%</td>
<td>2</td>
<td>1.3%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midden 3 total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>46</td>
<td>37.1%</td>
<td>69</td>
<td>46.0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transect 1</td>
<td>Cultural</td>
<td>Burned hut floor</td>
<td>A8, 9</td>
<td>80–90</td>
<td></td>
<td>1</td>
<td>3.8%</td>
<td>1</td>
<td>0.7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>124</td>
<td>100.0%</td>
<td>150</td>
<td>100.0%</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>82.7%</td>
<td>17.3%</td>
<td>100.0%</td>
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</tr>
</tbody>
</table>
The loose dung strata are mixed with ash and charcoal. The Upper Loose Dung stratum is a mix of dung, small charcoal fragments, and ash, while the Lower Loose Dung stratum includes only dung and charcoal fragments. In contrast, both compact dung strata are composed almost entirely of decomposed animal dung, but are not uniform over the entire area. The four strata tend to “bulge” somewhat in the center of the area, tapering out towards the edges of the enclosure by some 5 cm. In our observations of modern livestock enclosures, compact dung only forms where livestock tend to cluster in an enclosure, and this is often at the lowest elevation (in this case, towards the west). Thus, compact dung did not accumulate where human activity occurred.

In the eastern half of the Dung Area, uphill from the livestock zone, is where human activity is clearly attested and where the fired earthworm casts were recovered. It is termed the human activity zone of the Dung Area because there is evidence for the reworking of iron implements (i.e., charcoal and smiting slag) and the dumping of cultural debris (animal bone, pottery, etc.). It is also where meat was roasted on many occasions over a bowl-like depression, resulting in the accumulation of much ash, charcoal, and burnt bone within the depression. Three strata were found in this area (Figure 6): (1) an Upper Horizon of loose fine ash; (2) a Middle Horizon of coarser ash, mixed with bone and some charcoal; and (3) a Lower Horizon of coarse sediment, mixed with large amounts of charcoal and bone. Ceramics are abundant throughout the deposits.
The Upper Horizon in the human zone could not be stratigraphically linked to a comparable livestock impacted deposit in the livestock zone because previous disturbances (excavations) had truncated any spatial association. It is likely that such deposits are not present from evidence in trenches where the stratigraphic sequence was intact. As a result, there is no evidence of livestock impacted deposits comparable to the Upper Horizon in the eastern half of the area. However, the association of the other horizons in the human zone of the Dung Area is clearer. The Middle Horizon can be stratigraphically linked to the Upper Loose and Compact Dung horizons in the animal zone (−15−35/40 cm depth), while the Lower Horizon is linked to the Lower Loose and Compact Dung horizons (35/40−75 cm depth).

The fecal casts occur within the lower depths of the Middle Horizon (ca. 30−40 cm) and the Lower Horizon in the eastern Dung Area (ca. 35−60 cm). Each of these horizons are linked to two phases (Upper and Lower) in the development of the livestock byre. The presence of earthworm activity is documented for the entire formational history of this area of the site.

Earthworms conduct a delicate balance between temperature, oxygen, nutrition, and density requirements by moving from oxygen deprived environments or inhabiting locales where the topsoil is occasionally mixed, allowing gas by-products to escape. The activity of earthworms would not be out of place in the nutrient-rich environment of livestock byre, but it is interesting to observe that the casts are found only in the area with human activities. While the levels of carbon dioxide and other gases may have inhibited earthworm activity in the animal zone where the dung was thickest (creating an aerobic environment), particularly on the edges of the byre, this is unlikely for two reasons. First, livestock would have mixed the upper layer of the dung as they moved about the byre, thus releasing gaseous by-products. Second, earthworm fecal casts were not preserved in the livestock zone because no fires were built there.

Because earthworms tend to displace soils towards the surface when casting and not the reverse (Edwards and Lofty, 1977; Canti, 2003), it is very likely that the terracotta casts were sealed in an archaeological context concurrent with the occupation of Ndondondwane. The casts were probably burnt in the process of either cooking food or smithing iron in the human activity area of the livestock byre. Clearly, these objects provide evidence that earthworms were active in the Dung Area during the occupation (as they are currently), but the unusual relics of their presence were only inadvertently preserved by human activity in the area.

**Baked Plant Stalk Casts**

The second group of 124 objects ranges in length from 20 to 40 mm and from 5 to 19 mm in width and have characteristic striations and/or pits running along their extent (Figure 4b). They were originally thought to be and were catalogued as fragments of “figurines” because of their general similarity to the “figurine legs” reported by Loubser (1993:132−133, Figure 35). However, after closer examination,
it was realized that they are not figurines. Similar objects were found in the Riet River excavations (Dreyer, 1996:101–102, Figure 5), which fit the interstitial spaces in modern reed stalks (*Phragmites* sp.) growing near the site. Therefore, the outer surfaces of these objects are casts of the interior of the particular plant in which they formed. The Ndondondwane specimens did not match the morphological characteristics of modern reeds in the basin or the morphological characteristics of the interstitial space in modern maize stalks (cf. Freeling and Walbot, 1994). It is also unlikely that these specimens came from post-18th century maize stalks because there is no historical or ethnographic evidence for maize cultivation in this locality prior to the 1960s and the specimens are too small to have been accreted in maize and too large to be formed in millet. The objects best fit the size and shape of the interstitial spaces of sorghum stalks. We have argued that the composition and morphology of these terracotta objects represent soil baked while within the stalks of a *Sorghum* sp. stand (Fowler et al., 2000). The soil was carried up the stalk by termites while creating runnels (termite burrows). Once abandoned by the termites, these accretions remain within the stalk of the plant. If fired at sufficiently high temperature, the soil-filled stalks bake and drop to the ground.

Van Schalkwyk and Greenfield observed the results of a similar formation process during the 1995 field season at Ndondondwane. During this first field season, hollow maize stalks still standing in the southeastern area of the site from the 1993–1994 growing season were burnt off prior to survey and excavation. As the stand burned, the soil that termites had accumulated in the base of the stalks began to bake and subsequently fell to the ground among the still burning stalks and grasses in the maize stand. After being fired, the exterior of the casts permanently took on the characteristics of the interior structure of the maize plant.

We must note, however, that plant stalks could be preserved in much the same way as the earthworm fecal casts if crop stubble was collected for domestic fuel after harvest. In this case, the soil-filled stalks would be subjected to low temperature, oxygen-rich fires for a relatively long duration of time. Such a scenario would account for the differences observed in the color, hardness, and surface texture of the stalks described above, as well as where they were found. Either of these processes, which combine termite activity and heat, can preserve evidence of *Sorghum* production at sites.

The termite-produced plant stalk casts, which can now be described more properly as fired casts of *Sorghum* stalks, were recovered from two groups of contexts at the site. Sixty-five stalk casts were recovered from modern or uncertain provenance in the shallow plough zone of Midden 3, about 5 cm below the surface. These stalks were found in the same strata as the earthworm fecal casts described above. It is also possible that the stalks in Midden 3 were not originally located in the cultural deposits in the area. Other stalk casts come from stratified contexts at the site:

- the earliest cultural horizon of Transect 1 (n = 1), 80–90 cm from the surface
- the Middle Horizon (n = 61), 30–40 cm from the surface, and the Lower Horizon (n = 18), 40–50 cm from the surface, in the Dung Area

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- the Middle Horizon (n = 61), 30–40 cm from the surface, and the Lower Horizon (n = 18), 40–50 cm from the surface, in the Dung Area
● the cultural horizon (n = 3) and Pit 2 (n = 1) in Midden 3, 10–15 cm below surface
● in the cultural horizon of Midden 1 (n = 1), some 10 cm below the surface

Only the objects from these latter contexts can be placed with any degree of certainty during the occupation of Ndondondwane. We feel that the stalks of Sorghum from securely stratified contexts represent the crops cultivated by the inhabitants of Ndondondwane. The other 65 specimens from Midden 3 represent sorghum grown either during the Iron Age or more recently. Regardless of whether fields were burnt intentionally or because of wild fires, the fired sorghum stalks recovered at Ndondondwane were subsequently deposited in nearby charcoal/ash dumps located in the livestock enclosure and nearby residential middens, probably after preparing fields for a new planting season.

It is interesting to note that when these results were first presented to the South African Archaeology Association (1998), there were a number of delegates working on Iron Age sites who recognized the objects from their own field investigations. Despite this informal census, there is presently no means to establish how common these objects are at Iron Age settlements. Recent examination of ten other Ela ceramic assemblages from KwaZulu-Natal by Fowler has identified objects with the characteristics of the Ndondondwane termite-produced sorghum stalk casts (Table III). However, the large size of several objects suggests that they are not sorghum stalk casts, but are instead from more recently introduced maize plants. These observations nevertheless demonstrate that baked, termite-produced plant stalk casts occur on Iron Age sites of all ages and that termites pack soil into the stalks of many plant species.

DISCUSSION

The analysis of ecofacts and features at Ndondondwane by three research teams since 1978 has led to the identification of several different burrowing agents involved in the pre- and postabandonment biotic activity at the site. These agents have been major contributors to the pedogenic and depositional history of the site and have had both destructive and preservative effects on the condition of artifacts, ecofacts, and features. In this section, we discuss these effects and their broader implications for understanding intra-settlement organization and preservation of cultural materials.

Pedogenic Effects

The ecofacts identified at Ndondondwane provide evidence for ancient biotic activity at riverine Iron Age sites. They are an underinvestigated proxy record of the pedogenic and depositional processes affecting these settlements and similarly located sites in the sub-Saharan African. The effects of earthworms and termites on these and other archaeological sites have mainly been viewed as destructive because they change the nature of the soil they inhabit. Earthworms and termites

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Table III. Other possible occurrences of ceramic plant stalk casts produced by termite activity at Early Iron Age sites in southeastern Africa.\(^a\)

<table>
<thead>
<tr>
<th>Site Trench</th>
<th>Feature N</th>
<th>Feature O</th>
<th>Feature Q</th>
<th>Feature Q (shallow button)</th>
<th>Feature O Pit</th>
<th>Feature Q Q1 (shallow hollow)</th>
<th>Feature O Pit Contents</th>
<th>Feature Q Q1 (shallow hollow) Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Msuluzi Confluence D 4</td>
<td>Open midden</td>
<td>10–20 cm</td>
<td>Msuluzi</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ntshekane Feature N</td>
<td>Pit</td>
<td>Eroded pit contents</td>
<td>Ndondondwane</td>
<td></td>
<td>Feature O Pit</td>
<td>Eroded pit contents</td>
<td>Ntshekane</td>
<td></td>
</tr>
<tr>
<td>Ntshekane Feature Q Q1 (shallow hollow)</td>
<td>Eroded pit contents</td>
<td>Ntshekane</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Contextual data for the ecofacts from Msuluzi Confluence is discussed in Maggs (1980b) and for Ntshekane see Maggs and Michael (1976).*
consume soil and excrete or regurgitate it. Earthworms help to keep soil horizons soft, while termites make it more compact. However, the ethology of different species and the length of time they act on sediments containing cultural remains are important factors to consider when determining their impact on the integrity of the archaeological context.

The ethology of earthworms makes them greater contributors to the pedogenic processes of site formation than termites. Earthworms burrow by pushing soil aside and/or consuming the soil before them. They leave their castings either behind or on the surface. In effect, earthworms displace soil by consuming it and excreting as they move vertically and horizontally through soil horizons. The excreted soil is crumbly and helps to form the A soil horizon. They keep the A soil horizon from becoming too compact (Wood and Johnson, 1978; Stein, 1983; Canti, 2003). Since earthworms constantly pass soil material in an area through their system, they effectively churn the soil of an area over time. While some earthworm species in the region, such as the common dew worm (*Lubricidae* sp.), prefer deep soil and vertical movement, other species such as the African nightcrawler (*Eudrilus eugeniae*) or the manure worm (*Eisenia fetida*) inhabit shallower depths and tend to move horizontally (see discussions in Edwards and Lofty [1977] and Canti [2003]). Earthworms with shallow burrowing behavior were found across the site of Ndondondwane during excavations. The Dung Area stratigraphy is such that there is no substantial mixing or blending of the various strata, except at the northern edge where a termite mound was found. In this one location, the strata were obliterated by termite activity. Although earthworms were present in the eastern Dung Area of Ndondondwane, it appears that their activity did not substantially alter the archaeological stratigraphy in the area. Therefore, in addition to the large *Aporrectodea* sp., the African nightcrawler and manure worms are the best candidates for the species once active at Ndondondwane.

Unlike earthworms, termites displace soil by moving it from one place to the next in the process of constructing structures (*termiaria*). They bring fine subsoil fractions to the surface and mould structures from the soil and organic matter. During the construction of the above and below ground extensions of *termiaria*, termites consolidate the soil. Termites make a paste of soil, saliva, and a sticky solution secreted by the frontal gland. In effect, the soil and organic particles are bound together to form a dense hard matrix. The subsurface extensions of *termiaria* are often preserved on archaeological sites and are easily identified as a dense hard matrix similar to dried cement. New termite mounds are created every few years, and tend to be relocated in relatively close proximity to abandoned ones (Lee and Wood, 1971; Wood and Johnson, 1978). Therefore, termites can modify the entire soil of an area over a relatively short period of time (McBrearty, 1990).

An illustration of the effect of termites on cultural strata comes from the Dung Area and Midden 3 at Ndondondwane. The effects of constructing *termiaria*, however, are quite localized, but the cultural strata were obliterated in the parts of the Dung Area and Midden 3 where termite mounds were identified.
Depositional Effects

Beyond the mixing and movement of soil done by earthworms and termites, they also can have a profound effect upon the preservation of archaeological artefacts and features. This is particularly true of earthworms. Earthworms affect archaeological deposits in several ways, which are not necessarily mutually exclusive. They can create false artefact concentrations and stratigraphy (biostratigraphy, such as biomantles) by moving archaeological debris down to the bottom of the zone they live in (Limbrey, 1975; Butzer, 1982; Johnson et al., 1987). They bury objects by depositing fecal casts on the surface, which aids in burying cultural debris lying on the surface (Limbrey, 1975; Rolfsen, 1980; Strauss, 1981; Butzer, 1982; Stein, 1983; Canti, 2003). Some estimates suggest that earthworms can drop as much as 6600 kg of casts on a hectare of surface annually (Wood and Johnson, 1978:325, 328). Such action is capable of burying surface material rapidly, preserving its original location. Other field research shows how certain species of earthworms will blur the distinctions between different sediments and deposit boundaries, and in the process of burrowing they will directly move very small-grain materials and indirectly displace larger objects, such as artefacts (Stein, 1983:284, 286; Balek, 2002; Canti, 2003:141).

Termites also preserve the general location of artefacts. Artefacts are often “frozen” in place as termittaria are built around them. Features, however, are usually destroyed as termites bring up soil and organic material in order to create termittaria (McBrearty, 1990). They can carry soil grains and similarly sized organic materials up to the surface from only a few meters to over 180 m below the surface (West, 1970).

An equally important aspect of earthworm behavior is their ability to alter the texture and chemistry of soils. They can destroy ecofacts such as seed remains by eating them as they move through soils (Piearce et al., 1994; Stein, 1983). In some cases, this may explain the paucity of certain seed types recovered in Iron Age archaeological contexts, although, as Canti (2003:139) notes, charred seeds and other plant remains would likely be unpalatable and remain uneaten. This may also be true in sub-Saharan Africa, because carbonized plant and seed remains are preserved in site assemblages particularly when flotation was used at excavations (Read and Young, 2000). While earthworm activity is helpful for inferring soil formation, the concentration of calcareous granules produced by earthworms may also be of value to palaeoenvironmental interpretations. Their abundance in calcareous buried soils and other Quaternary deposits may help determine the relative stratigraphic positioning of ancient land surfaces in the absence of conventional data. However, the factors affecting granule production and concentration are poorly understood (Canti, 2003: 144–146).

The methods used to identify these objects should be of considerable interest to archaeologists working in southern Africa and in subtropical climatic regimes elsewhere.
where. Such objects likely form parts of many if not most archaeological assem-
blages, but have not been previously recognized. It is worthwhile to make the effort
to identify them because of the wealth of information that they can provide about
a site and its history. It is particularly important to make the effort to identify such
ecofacts, especially in areas with either a poor history of botanical recovery due
to methodology or preservation conditions. For example, at Ndondondwane, car-onized millet seeds were found among the nuts and seeds from flotation samples
identified to 38 indigenous genera (Maggs, 1984c). Despite the extensive flotation
of the ash deposits at Ndondondwane, no carbonized sorghum seeds have yet been
identified. It would appear that any potential evidence was incinerated (Jongsma,
n.d.). More broadly, only 36 Iron Age sites throughout eastern and southern Africa
dating from A.D. 500 to A.D. 1820 have evidence of preserved grains (Reid and
Young, 2000). It would appear that, even though the conditions for the preservation
of carbonized grains exist on such sites, they are not always likely to be found.
Other more indirect sources of information must therefore be sought.

Despite the fact that earthworms can move substantial quantities of soil in an
area over time, there is little evidence for the formation of overlying sediments
above the final occupation of Ndondondwane. This is simply due to the ethology
of the particular species present. Sediment was moved more laterally than verti-
cally. This is particularly visible in the Dung Area stratigraphy. There was no sub-
stantial mixing or blending of the various strata in this area, except where a termite
mound was found at the northern edge.

At this point, the best direct evidence for earthworm activity comes from the
Dung Area. It is no leap to infer the importance of earthworm activity in decom-
posing other organic debris in the middens. However, it is unknown what effect
such activity would have on the arrangement of debris within storage and refuse
pits. Potentially, such biotic activity could inhibit our ability to distinguish between
episodes of pit use and the discard of cultural debris, making it difficult or impos-
able to link the use history of different domestic middens to each other and other
activity areas in a site.

It is noteworthy, however, that little is known yet about the effects earthworms
and termites may have had in all areas of the settlement. Changes in soil texture
and color are deceptively subtle at Ndondondwane within the identified soil hori-
zons, apart from middens. Yet, in middens, where much accumulation of organic
debris is found, erosion, deflation, modern ploughing, and other taphonomic pro-
cesses often mask any direct indication of biotic activity.

Although earthworms and termites were present at Ndondondwane, it appears
that their activity did not substantially alter the archaeological stratigraphy of the
site. It appears that objects began as layers on the surface and were covered and
moved downward as a layer, a phenomenon also documented in the United King-
dom (Darwin, 1896) and at upland sites in the United States (Johnson, 1989; Kreisa,
1985, Van Nest, 1997, 2002; Balek, 2002:48). The forces of downslope erosion and
deposition of sediments on the more gently sloping terrain along the river valley
Rodents, on the other hand, substantially affected the stratigraphy of the site. However, rodent activity appears to be more concentrated in the Mound Area. This area was reserved for specialized activities associated with iron smelting (with a furnace and slag pit), ivory working (bangle manufacture), and various rituals, which have been inferred from the presence of numerous fragments of terracotta “heads” (Loubser, 1993:141–148). The mound accumulated through a shifting series of these activities. Loubser proposed a five-stage sequence. The first stage saw the construction of a house and the accumulation of two middens and other clusters of ash, stone, and daga (clay–dung mixture used in architecture). The demolition of the house marks the end of the second stage, and during the third stage a fence that possibly formed the foundation and walls of a rectangular-like structure was constructed (Loubser, 1993:117). During the fourth stage, this structure is associated with the deposition of elephant ivory and large concentrations of ash and pottery that make up the Grey Midden (Maggs, 1984c). Figurines and fragments from at least four terracotta heads were recovered from the fill of the midden. Loubser (1993:117–118) suggested that at this time the northwestern part of the fence was removed and the eastern portion shifted. The eastern and southeastern portion of the fence may have been retained for craft workers in the area as a windbreak that would have blocked the prevailing winds during the summer and winter months. In the final stage, the remaining fence was removed and an iron-smelting furnace was constructed to the west of the Grey Midden (Loubser, 1993:118–119).

Rodent burrowing is most evident in the strata associated with activity stages three and four, after the demolition of the house and before iron smelting. The plan and sections of these strata show a jumble of subterranean features (Loubser, 1993: Figure 6). Maggs and Loubser were able to distinguish rodent burrows, post-holes, and the wide, shallow channels running through the area because of differences in their shape, angle of penetration, depth, color of the soil fill, and relative spatial distribution. For instance, although the post-holes occurred at irregular intervals, they are morphologically different from rodent burrows and several contained remains similar to decomposed wood (Loubser, 1993:117).

The ability of Maggs and Loubser to distinguish the remains of this structure and associate it with large ceramic heads, figurines, ivory production debris, and ash deposits has great cultural significance. First, Loubser (1993) drew parallels between the reed and grass masks used during Venda and northeastern Sotho initiation schools, and the hollow ceramic heads found at EIA sites in the eastern lowlands. He also drew attention to the crocodile symbolism common to both the Ndondondwane heads and material culture of recent times. The initiation hypothesis proposes that social initiates in early agropastoral societies took part in highly ritualized events at which they were taught proper adult behavior and the mysteries of life, through which they symbolically attained sociopolitical maturity. Certain
parts of these rituals occur in private, usually in buildings where public access was restricted, and the structure in the Mound Area may have served such a function.

Second, such structures are typically associated with male-related activities, such as ivory- and metal-working. Large accumulations of ash in these areas are related to the "court" or "men’s assembly area" documented ethnographically (Kuper, 1980, 1982). As Huffman (1986:316) explains:

"The court midden in the Bantu Cattle culture may comprise broken beer pots, the ash from the council fire, the remains of cattle slaughtered as fines or tribute, and the remains of wild animals shared among men or given as tribute to the chief. Alternatively, the central midden may be formed by the refuse from all the families that use the court."

There is abundant evidence for assembly-area middens with large ash deposits situated away from livestock byres at Iron Age settlements (e.g., Eloff and Meyer, 1981; Denbow, 1983, 1986; Loubser, 1985, Huffman, 1986). In these settlements, the size of middens is directly related to the political importance of the site (Huffman, 1986:316), and Loubser (1985:85) has described how ash may play a symbolic role in political debate for the Kgaga by acting as "a cooling agent in 'hot' situations."

Water and ash are but two of a series of cooling agents linked to healing and fertility that are opposed to "hot," dangerous, sterilizing forces in southern Bantu-speaking societies (Fowler, 2002:345–348, 351–355). These symbolize proscriptions for behavior that are linked to the movement of men and women in settlements and the nature of the activities they undertake in different settings.

By its position in the settlement, the structure in the Mound may also be linked to political activity at Ndondondwane (Fowler, 2002:345–348). Ndebele chiefs in the northern Transvaal held secret meetings in a grass hut situated in the assembly-area or in the cattle byre (Loubser, 1981:13). The structure in the Mound Area may be the remains of such a meeting place. In addition, Whitelaw (1984:81) has also described similar features in Byre 1 at Kwagandaganda, where a depression could have served as a hearth and channels similar to the ones at Ndondondwane could have acted as a foundation for a shelter or palisade. The presence of only one cooking vessel in the Mound Area during this stage of use implies that food was eaten but not likely prepared here, and the abundant eating and serving vessels discarded along the wall of the structure may have been used for meals eaten in the structure during meetings (Fowler, 2002:347).

CONCLUSIONS

The role of burrowing animals in the development of archaeological sites is an issue that has world-wide significance. Burrowing animals can have very significant impact on the formation of archaeological sites. Yet, the effects of their lifestyle on the archaeological record are poorly documented outside of Europe and North America. While these data are useful for generalizing about burrowing animal ecology and understanding site formation where certain species have been imported into non-European or North American contexts, the effect of indigenous species outside these regions have seldom been adequately investigated.
Despite the relatively common occurrence of earthworms and termites at many archaeological sites throughout the world, it appears that the ecofacts resulting from their activity are often overlooked or otherwise considered of little analytical importance. In southern Africa, the systematic collection of artefacts and ecofacts has created an abundant material record that yields evidence of both human activities and environmental conditions at sites. Since ecofacts such as those discussed above are likely being recovered from other tropical and subtropical sites, it is quite necessary that their presence and location be noted and their significance evaluated. We have stressed that a detailed analysis of these objects provides a proxy record that can enhance our understanding of local ecological processes, archaeological site formation, and subsistence. The indirect identification of burrowing invertebrates has led to the discovery for the first time of sorghum as a cultivated grain crop at the site of Ndondondwane. Botanical analyses of carbonized seed remains had not previously identified this important staple crop at this site. It is now known that both sorghum and bulrush millet (Pennisetum typhoides) were cultivated at Ndondondwane.

Termites and earthworms are important agents of postburial and postdepositional modification of artefacts, ecofacts, and sediments. We have demonstrated how they can destroy and preserve evidence of cultural behavior. Most research on the effects of burrowing activity at archaeological sites is cast as cautionary tales. The mixing and churning of soils by animals are often viewed as barriers impeding a "correct" interpretation of past cultural activity.

In this article, we have instead shown that our experience has been rather more positive. We have demonstrated how the identification of indirect evidence of burrowing activity may inform about the formation of archaeological deposits in eastern South Africa, and how careful excavation and sensitivity to postburial site modification make it possible to offer insightful inferences of past cultural behavior despite the destructive effects of rodent activity. Ultimately, work such as this contributes towards resolving issues surrounding site formation and intrasettlement organization, which pose major problems for understanding the social and economic organization of early farming communities throughout much of sub-Saharan Africa.

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