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Investigating Underfloor and Between Floor Deposits in Standing Buildings in Colonial Australia

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Abstract
Archaeological deposits build up inside standing buildings both under and between floors and these have the potential to provide considerable information about human behavior in the past. Under and between floor spaces provide a unique depositional environment that allow the survival of rare and fragile organic materials that typically do not survive in other archaeological contexts, including paper, cardboard, fabric and other fibres, seeds, leather, and human hair and skin cells. However, they require a clear understanding of depositional processes to allow their interpretation. Experimental archaeology was conducted to understand the process of artifact deposition and the interpretation of underfloor deposits in twelve standing buildings in Western Australia. Floors were built and a range of artifacts swept across them to determine how artifacts travelled across floorboards or fell through gaps between boards. Size, shape, and angularity of artifacts were key determinants of the likelihood of deposition. Sweeping activity makes it more likely that material will be deposited around the margins of rooms, and particularly, to either side of doorways. Underfloor deposits excavated from two specific Western Australian buildings, Ellensbrook Homestead, and the York Residency Museum, are interpreted based on the results of these experiments.

Keywords Underfloor · Dust · Experimental archaeology · Taphonomy · Site formation processes · Australia

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Introduction

Historical archaeological assemblages are often derived from under and between floor deposits from within standing buildings. Despite these deposits being regularly excavated there is only a limited literature related to how they develop and taphonomic processes that impact them after deposition. In this paper we report on the results of experimental archaeology conducted to attempt to understand depositional processes for these deposits. These experiments were conducted to aid in interpretation of under and between floor deposits in twelve nineteenth-century buildings in Western Australia (Table 1, Fig. 1) which were investigated archaeologically between 2012 and 2020. We report briefly on these sites here, and we provide a fine grained interpretation of two of them as case studies: the York Residency Museum, and Ellensbrook Homestead, in order to demonstrate how a specific understanding of depositional processes is necessary for the interpretation of archaeological materials excavated from underfloor deposits. Our intention is to consider the factors that influence deposition, both deliberate and accidental, and other taphonomic impacts after deposition.

Under and between floor deposits provide important sources of information about the people who inhabited buildings in the past. We define these deposits as archaeological material (comprising matrix and artifacts), that builds up underneath floors in extant buildings with suspended wooden floors, and between ceilings (below) and floorboards (above) in multi-story buildings. Fragile organic materials that usually perish in other archaeological contexts, including textiles, paper and cardboard, human skin cells and hair, evidence of vermin and parasites, seeds and plant parts such as petals, and food remains, have a good chance of survival in under and between floor deposits. Beyond this, the matrix that artifacts are suspended is usually household dust comprising “fibres, dead skin cells, bugs, soil particles, residues of furniture, electronics and other domestic products” (Ouyang et al. 2017: 433), rather than sediment. Household dusts comprising “particulate matter from in-door and outdoor sources” (Doyi et al. 2019: 1) have the potential to contain significant amounts of chemical contaminants that build up over time and can be analyzed for past environmental information. As such, dust under and between floors in buildings should be considered an artifact in and of itself, with significant capacity to provide information about past site uses if analyzed using appropriate techniques. Household dust in an archaeological context is quite easy to recognize as it is very dry, has virtually no compaction, and is extremely motile and easily disturbed. In most cases it is necessary to excavate it using face masks and eye protection as it becomes airborne when disturbed and creates a hazard for eyes and lungs, particularly in buildings where asbestos or chemical pest control treatments have been used in the past. The motile nature of the dust means it is easily blown by winds that penetrate the underfloor space (e.g., via vents or weepholes), and consequently tends to concentrate in corners and other areas where it can be trapped. It also settles on top of joists and bearers, making a multi-layered deposit. Household dust is stratigraphically problematic, as it is so loose that heavy artifacts sink into it, meaning that site integrity can be lost. A fine grained stratigraphic assessment is key to understanding the accumulation and interpretation of underfloor deposits (see Harris 1989).

While site formation processes and taphonomy are widely discussed in archaeology (e.g., Binford 1983; Brain 1981; Dawdy 2006; Schiffer 1976, 1987), there is limited

Table 1 List of sites investigated archaeologically and shown in Fig. 1

Site Name	Building Construction Date	Date Floorboards Installed	Original Use	Modern Use
Artillery Drill Hall, Fremantle	1895	1895	Institution - military	Music venue
Ellensbrook Homestead, Mokidup	1857	ca. 1880s	Institution - mission	Heritage site open to public
Old Perth Boys School, Perth	1854	1854	Institution - school	University
Peninsula Farm, Maylands	1830	ca. 1850s	Domestic - private house	Heritage site open to public
St Bartholomew's Chapel, East Perth Cemetery	1874	1874	Institution - religion	Heritage site open to public
Strawberry Hill Farmhouse, Albany	1834	1834	Domestic - private house	Heritage site open to public
Strawberry Hill Workers Cottage, Albany	1832	1832	Domestic - private house	Heritage site open to public
Gallop House, Nedlands	1874-76	1876	Domestic - private house	Private house
Residency Museum, York	1856	1856	Domestic - private house	Museum
Fremantle Prison	1855	1855	Institution - prison	Heritage site open to public
Woodbridge House, Guildford	1884	1884	Domestic - private house	Heritage site open to public
Fremantle Lunatic Asylum	1862	1862	Institution - lunatic asylum	Art gallery

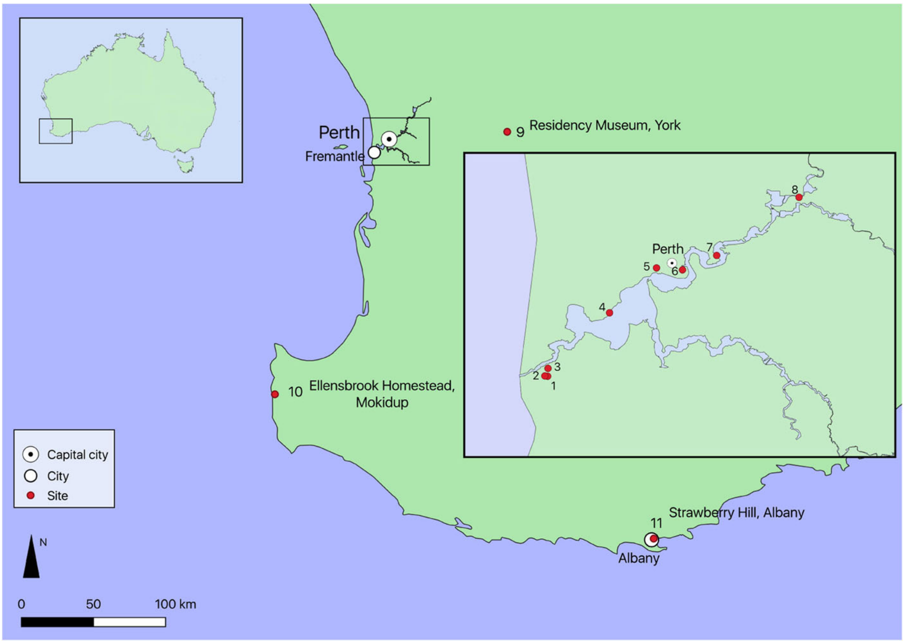

Fig. 1 Map showing location of sites. 1) Fremantle Prison; 2) Artillery Drill Hall; 3) Fremantle Lunatic Asylum; 4) Gallop House; 5) Old Perth Boys School; 6) St Bartholomew's Chapel; 7) Peninsula Farm; 8) Woodbridge House; 9) Residency Museum; 10) Ellensbrook; 11) Strawberry Hill

consideration of these in relation to underfloor deposits in historical archaeology. Casey (2004: 33) suggested this may be in part because the presence of cellars in many American buildings precludes the capacity for deposits to build up underneath floor-boards, so they are rarely encountered. However, nineteenth-century Australian buildings are less likely to have cellars, and indeed Australian research certainly shows the importance of under and between floor deposits in archaeological research (e.g., Bryant et al. 2020; Casey 2004; Murphy 2013; Winter and Romano 2019). Their interpretation requires an understanding of the construction, life span, and use of buildings. Lamotta and Schiffer (1999: 20) called this the "life history of a building," with stages of habitation (people actively using the structure), abandonment (people leaving the structure), and post-abandonment (either decay or re-use of the structure), each characterized by different depositional processes. They argued that understanding the way humans used a structure in each of these phases is crucial to understanding how deposits develop. Beyond this, Schiffer's (2010) delineation between cultural and natural depositional and post-depositional processes (what he calls C-transforms and N-transforms) has been used in attempts to understand under and between floor deposits (e.g., Mein 2012; Murphy 2013). However, Schiffer's imposition of a nature-culture divide on site formation processes can be criticized on the basis of being artificially imposed (see Antczak and Beaudry 2019), and it is clear that some site formation processes bridge that divide.

The most heavily studied artifact assemblage deriving from underfloor and between floor deposits in Australia is from Hyde Park Barracks, Sydney (see Crook et al. 2003; Crook and Murray 2006; Davies 2010, 2011, 2013a, b; Davies et al. 2014; Starr 2015), from which over 180,000 artifacts were recovered (Starr 2015: 37). While the locations of recovered artifacts were mapped using floor joists as a grid, the question of how they accumulated is poorly understood due to issues with site recording and missing paperwork. Historical records revealed that 90% of the assemblage post-dated 1848 (Starr 2015: 40–41), when new lathe and plaster ceilings were installed, providing a TAQ for the accumulation of the deposit on top of those ceilings. Spatial analysis of the recovered materials allowed interpretations of tobacco smoking behavior (Davies 2011) and religious observance (Davies 2013a) among barrack inmates, demonstrating that underfloor deposits can provide important information about past site uses.

In another study, Casey (2004) discussed underfloor deposits identified by careful excavation of demolished houses at the Rocks, also in Sydney. She concentrated on understanding the artifacts found within the deposits, rather than how those deposits formed, but suggested the following for underfloor site formation processes in domestic houses:

– They primarily occur under butt-boarded floors, with material falling through gaps between boards, and are unlikely to occur under tongue and grooved floors;
– Material can also be deposited through other gaps such as holes in the floor, or gaps between walls and boards;
– Floor coverings such as linoleum or carpets prevent material being deposited between these gaps;
– Animals such as cats and rats also impact the development of underfloor deposits by carrying in and moving around specific types of artifacts;
– Underfloor deposits within houses are spatially determined, with greater likelihood of deposits occurring in kitchens than in front rooms, and the depositional position of artifacts impacted by sweeping processes;
– Some artifacts are deliberately cached under floorboards, but the majority are accidentally deposited; and
– Specific excavation processes, including sieving, are required to recover very small objects (Casey 2004: 34).

Casey's (2004) observations primarily considered depositional and spatial location of artifactual material, as opposed to the taphonomic processes that occur under floors inside standing buildings and the likelihood of survival of fragile organic materials. In addition, Casey's contention that tongue and grooved boards limit deposition was subsequently challenged by Winter and Romano (2019: 334), who showed that such floors could be damaged over time, with the destruction of the tongues that join the boards and the subsequent opening of gaps and holes between them.

Animals that live or roam under and between floors, primarily rodents, cats, and insects, can have a significant influence on both the deposition of materials under floors, and the materials themselves after they have been deposited. Rats and other rodents build nests which contain material that they transport from other locations (Mein 2012: 62), while cats also bring prey under floors for consumption, and prey on the rodents, contributing animal bones to underfloor assemblages (Winter and Romano 2019: 335). Based on investigations of Fremantle Prison, Western Australia, Mein (2012: 98) suggested that a whole invertebrate ecology existed under and between floors, with multiple species inhabiting these spaces and preying on each other, and the humans above them. A range of insect and arachnid species were identified, including beetles, cockroaches, flies, earwigs, spiders, and bed bugs, all of which were potential contributors to underfloor deposits (Mein 2012: 64, 73–74). Termites can also significantly damage wooden structures, requiring repairs and fumigation with toxic chemicals, both of which can have implications for underfloor assemblages. Murphy (2013: 559) also highlighted water movement as a way archaeological material can enter underfloor zones, either in areas without sufficient drainage or via purpose built drains. Winter and Romano (2019: 334) demonstrated that lightweight material could be blown under floors if suitable size gaps were present at the base of walls, suggesting that such material would cluster close to external walls, lessening as the internal distance from these increases. It is also worth noting that the combination of dry underfloor areas and a dust matrix provides excellent opportunity for organic preservation. Indeed, at the majority of sites discussed here, fragile organic materials such as paper, textiles, fibers, leather, and plant materials were well preserved and survived intact for over a century (Auld et al. 2019; Bryant et al. 2020; Davies 2013b; Winter and Romano 2019).

The movement of artifacts from above to below floors specifically as a result of human actions can be broken down into accidental and deliberate depositional processes. Accidental processes such as artifacts falling between cracks in boards due to loss or sweeping is considered to have occurred at most sites and indeed, the literature tends to assume that this is how such small artifacts are deposited. Likewise, it is often assumed that larger artifacts must have entered the underfloor by being placed there deliberately. However, Green (2018) and Drummond-Wilson (2018) both suggested smaller items can also be deliberately cached by being slid between floor boards. Larger items can be cached beneath floors by lifting floorboards or making holes, and Mein (2012) interpreted a "fork with a bent prong" discovered under floors in a Fremantle Prison Cell as having been used to lever up the floor boards to allow this to happen. Documentary evidence of this practice was provided from Port Arthur, Tasmania, where convict shoemakers were caught hiding contraband under floorboards (Booth 1833). Caching behavior, or the hiding of material beneath floorboards, is seen to occur primarily at institutional sites, such as schools and orphanages (Drummond-Wilson 2018), missions (Green 2018), prisons (Mein 2012), work houses (Davies et al. 2014), and lunatic asylums (Auld et al. 2019; Bryant et al. 2020). Auld et al. (2019) and Bryant et al. (2020) reported a particularly spectacular episode of caching at the Royal Derwent Hospital in Tasmania, with large bundles of material being deposited, seemingly by a single inmate over decades. Likewise, Drummond-Wilson (2018) reported the caching of numerous toys and items valuable to children at the Perth Girls Orphanage, while Winter and Romano (2019) reported the deliberate placement of drug paraphernalia below floorboards at the Artillery Drill Hall in Fremantle. Burke et al. (2016) also discussed the caching of specific artifact types (e.g., shoes, garments, modified coins) under floors for ritual or superstitious purposes, though they note the difficulty in interpreting this behavior.

Following Lamotta and Schiffer (1999), in attempting to understand the accumulation of underfloor deposits, consideration must be given to the life span of a building, including initial construction techniques and subsequent repairs. For example, while the Brisbane Commissariat Store was originally constructed in 1829, floorboards were probably not installed until the 1860s (Murphy 2013: 551), while the Artillery Drill Hall was constructed directly over the top of a convict garden and the majority of material recovered during excavation was considered to predate its construction (Winter and Romano 2019). At both

Fremantle Prison (Mein 2012) and Hyde Park Barracks (Starr 2015), the installation of lathe-and-plaster ceilings in the nineteenth century provided a TAQ for the deposition of a between floor deposit, while at Fremantle the replacement of many of those ceilings in the late twentieth century completely destroyed any deposit before it could be excavated. At Ellensbrook Homestead at Mokidup, Western Australia, the 1920s installation of linoleum effectively sealed the deposit below (Green 2018: 13), providing a TPQ for the deposition of artifacts as a result of specific human activity. Service hatches are frequently cut in floors to allow access to install services and conduct termite inspections, and these have the potential to disturb the top of any under or between floor deposits. Finally, many archaeological investigations of underfloor deposits are conducted as a result of the need for floor repairs, which provides the opportunity or requirement for archaeological work to be conducted. In many cases these were not the first repairs undertaken, which speaks to a continual need for repair and alteration in older buildings over time. This irregular maintenance schedule also necessarily contributes to and impacts under and between floor deposits.

Underfloor Experiments

In order to improve our interpretation of underfloor deposits we sought to test how and what materials enter under and between floor spaces accidentally (we note we could not test for deliberate caching behavior). To do this we built a series of floors with different size gaps between the boards, and swept a range of materials across them, and then recorded what was deposited through those gaps.

The Floors

There have typically been two types of floorboard systems used in Australia: butt-boarded, and tongue and grooved, and the width of boards has decreased over time (Burke and Smith 2004: 184) with board width providing an approximate installation date range. Butt-boarded floor boards comprise simple timber planks laid side by side, with a potential gap between boards dependent upon how tightly they are laid. Tongue and grooved boards have a “tongue” on one side and a “groove” on the other, and the tongue is designed to fit into the groove. This means that tongue and grooved boards, when new, do not have gaps between them, although gaps can form over time (Winter and Romano 2019: 334).

Shrinkage through moisture loss also changes the aperture width between installed timber floorboards. Today the Australian Standard for modern hardwood timber floorboards (AS2796-2006) requires all timber boards to be dried to between 9–14% moisture content at the time of installation; though, of course, floorboards installed in the nineteenth century may have had higher moisture contents upon installation, and general shrinkage through moisture loss could widen gaps between boards. Additionally, very hot or dry weather can cause boards to lose moisture and shrink, opening up the gaps between them, and in extended periods of hot dry weather the moisture content can drop to as low as 4%, meaning the timbers shrink considerably as they lose moisture (Macindoe and Leonard 2012). This can significantly open the gaps between boards at certain times of the year, which then close up in cooler, wetter weather, as the timbers return to a higher moisture content.

For our experiment we used milled pine to construct three butt-boarded floors with different maximum apertures between the boards. Floor One had a maximum gap of 4 mm between boards, Floor Two 8 mm, and Floor Three 12 mm, and each floor had a surface area of at least 1 m^2. These gap widths were based on observed floors at the various sites we investigated. The floors were then laid side by side with the gaps arranged from the narrowest to widest (Fig. 2), and positioned on a large tarpaulin that had a 100 mm^2 grid inscribed on it (Fig. 3). The tarpaulin was taped to the ground surface so that the floors could be lifted after each experiment, and the distribution of artifacts mapped based on their location on the grid. As shown in Fig. 2 the sides of the tarpaulin were raised so as to ensure all artifacts were caught and accounted for. A skirting board was simulated along one side of the floors by laying a stadia rod along it. This was designed to primarily create a skirting board for Floor Two, and the gap between boards and skirting had a maximum aperture of 12 mm. The other side of the floors was deliberately left open so we could compare deposition between skirted and non-skirted sides.

The Process

A range of artifacts of different sizes and shapes, as listed in Table 3, were placed at one end of Floor One and then swept across all three floors, moving from narrowest to widest gaps. Artifacts used were ones we routinely encountered during underfloor excavations, and comprised standard domestic materials (e.g., glass shards and ceramic sherds) and specific types recovered from excavated sites (e.g., toys at the Old Perth Boys School and shells at Ellensbrook). All artifacts were deliberately placed at the

Fig. 2 Floors used in experiments (photo S. Winter)

Fig. 3 The grid used to measure depositional location with buttons as an example (photo S. Winter)

edge of the floor rather than randomly dropped. Where they were fragments of larger artifacts (e.g., from a broken bottle or plate) the entire artifact was broken in a bag and all fragments placed on the floors. The exception were stone artifacts deliberately knapped above Floor One, which we did to understand the distribution of quartz artifacts excavated from under floor boards at Ellensbrook Homestead, and whether they had been knapped in the room where they were recovered.

Artifacts were swept across rather than along boards, after which the floors were lifted, the position and number of artifacts on the underlying grid recorded, the floors cleaned of any artifacts stuck between boards, and then the experiment replicated with another artifact type.

Results: Sweeping Mechanics

This experiment used sweeping as the method for propelling artifacts across the floors, but we recognize there are numerous other ways artifacts could move across floor boards and this experiment could easily be replicated to test those methods. The mundane task of sweeping as a form of cleaning has great antiquity; for example it is pictured in Egyptian tomb frescos and described in the Christian Bible. To understand what type of brooms were available, we searched Australian nineteenth-century newspaper advertising using the National Library of Australia's Trove database and the keyword "broom." This returned over 172,000 responses demonstrating that a plethora of broom types, made from many different materials, were available for purchase. Brooms and brushes were designed for a multitude of different purposes, could be home or factory made, had bristles ranging from hard to soft, made from materials as diverse as straw, hair, and feathers, and had long, medium, and short handles. We used a short handled wooden brush with stiff hair bristles, and experimented with a range of sweeping positions, including standing, bent over, and crouching, and sweeping actions including from above in a line, or round arm from the side. Regardless of sweeping action we found that they all had a similar result, which was that the sweeping motion tended to push material in only a roughly linear direction, with some material being swept outward up to 30° from the intended direction (Fig. 4). This meant that the sweeping motion actually pushed artifacts in a 60° arc in front of the broom and as a result some of the artifacts ended up at the side of the floors, rather than passing across them from one end to the other. This also meant that many artifacts travelled across the floor at an angle <90° to the gaps, meaning they were less likely to fall through, with the majority of deposited artifacts recorded in the middle of the floors in a "linear sweep pathway" rather than towards the edges. However, artifacts that reached the sides of the floor were extremely likely to fall off, or through the gap between skirting and floor, with a percentage of nearly all artifact types being deposited in this way (see Table 3). Indeed, artifacts that encountered this gap almost all fell through and it would seem that the gap under the skirting board was more likely to have artifacts fall through it than were gaps between floorboards, if the artifact encountered it.

This explains why underfloor artifactual material is more likely to cluster at the base of walls and especially near doorways. Doorway openings are typically referred to as "sweep zones" based on the concept that people sweep detritus towards external doorways so it can be swept through them for easy discard. However, while sweeping pushes artifacts across the floor, it does not keep them all going in the same direction. While some artifacts fall

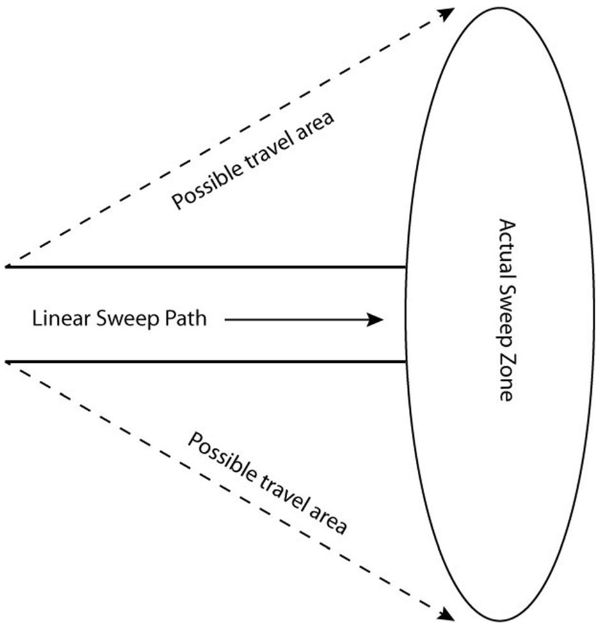

Fig. 4 Conceptual sweep zone

through gaps, others do not and are instead pushed up to 30° outside of an imagined linear pathway by the sweeping motion, rolling and bouncing until they encounter the larger gaps at the base of the walls. The motion of sweeping toward doorways suggests that artifacts are more likely to cluster at the base of a wall either side of a doorway, than in other parts of the room. Sweeping also inevitably moves dust which has settled on the boards, and in the sweeping process, that dust also encounters and inevitably falls through gaps. Sweeping then, a standard process for cleaning floors, contributes to the development of underfloor deposits as much as it helps to clean up artifacts from the surface of those floors.

Results: Size and Shape

We rapidly discovered that not all artifacts are created equal when it comes to being swept across floors. Predictably, an item could only fall through the gaps between the floors if it was narrow enough along one axis to allow it to fit between the boards. For example, an artifact that was wider than 4 mm on all axes could not fit between the boards of Floor One. However, so long as they were narrow enough on one axis, relatively large artifacts could potentially slip between narrow gaps between boards. For example, some glass shards and ceramic sherds up to 70 mm long were able to slip between the 12 mm wide gaps of Floor Three. These were not all flat, and some had considerable curvature as they derived from the wall or neck of the vessel. Where an artifact encountered a gap as wide as it, there was a possibility for it to get stuck between the boards and not fall into the underfloor. In some cases these stuck fast, but in others the vibration of simply walking over the floor was enough to dislodge the artifact and cause it to fall into the underfloor space.

The angularity of an artifact also affected how it responded to sweeping. Rounded and smooth-edged artifacts rolled and bounced across the floor more readily than flat and angular artifacts. This meant that some small, rounded, smooth artifacts bounced along the length of all three floors, never falling through a gap. Round artifacts were less likely to fall through cracks than were flat and angled artifacts. This was seemingly because flat items would easily get caught by the edges of the floorboards as they were swept across them, and a further sweeping motion then caused them to tip up and fall through the gaps. Likewise highly angular artifacts with sharp or acute angled edges also tended to "stick" on the floors rather than sweeping easily. The counter-intuitive result was that the relative flatness and presence of an acute angled edge on an artifact was a more likely determinant of deposition between boards than roundness or size. Some quite large diameter but thin artifacts were easily deposited, while smaller, rounded, or obtuse-angled artifacts were swept right the way across the floors without falling through. Cylindrical artifacts like chalk, pens, and beads had a higher chance of being swept across all boards without falling through than did flat and angular items.

Results: Deposition

As shown in Table 3, the wider the gap between boards, the more likely it was for an artifact to fall through, with the 12 mm gaps accounting for the majority of deposition and the 4 mm gaps the least. However, in the very smallest artifacts (pins, spherical beads, earthenware sherds) the 8 mm gaps accounted for the majority of deposition. These artifacts were easily small enough to fall through the 4 mm gaps but apparently rolled/bounced over smaller gaps until they reached a wider opening. The process of destroying the glass bottle, ceramic vessels, and quartzite core to produce smaller artifacts (shards, sherds, and flakes) also produced tiny fragments of material smaller than 1 mm (similar to dust). While this was not quantified, most of it fell through the 4 mm gaps during sweeping. Rolling/bouncing was clearly an issue that affected deposition of all other size artifacts. In no artifact category, regardless of size, did more than 15% of total artifacts fall through the 4 mm gap, and numerous artifact types small enough along one axis to fall through that opening, did not. This suggests that the speed the artifact was travelling across the floor, and the angle of encounter with the gap, affected its chances of falling through.

This latter aspect appears to be important, for many flat and wide artifacts had to be at exactly the correct angle to be able to slip between boards, and if that angle was not achieved by the sweeping process, they simply did not fall through. However, in all artifact types except the very largest (pens and pencils, toys, large marine shell), more than 50% of artifacts being swept across floors were deposited between boards or under the skirting boards and into the underfloor deposit. This is a significant result and shows that, where larger gaps between boards exist (i.e., >4 mm), or gaps between floor and skirting, an underfloor deposit can easily develop and build up over time simply as a result of basic floor cleaning activities.

Assessing Underfloor Deposits in Archaeological Sites

Having developed a better understanding of the mechanics of underfloor deposition, we used it to interpret archaeological material from 12 nineteenth-century Western Australian buildings (Bolton 2011; Cooper 2014; Drummond-Wilson 2018; Green 2018; Martin 2019; Mein 2012; University of Western Australia 2019; Winter 2015a, b, 2016, 2017a, b; Winter and Romano 2017, 2019). The buildings were all constructed, lived in, or used during the nineteenth century, and have areas with original in-situ floorboards (see Table 1, Fig. 1). They were all assessed for their potential to have in-situ undisturbed underfloor deposit, as well as other features; 11 were found to have viable underfloor deposits and six were subsequently excavated. Initial inspection attempted to identify household dust as the primary deposit (as opposed to pre-existing sediment), and to confirm the presence of artifacts within that deposit. The only building which was found not to have an underfloor deposit comprised of dust was the Strawberry Hill Farmhouse in Albany, which was constructed atop a natural spring and consequently had a very wet, clay/mud deposit under the floor boards. Other parameters recorded during the assessment are as shown in Table 2, which demonstrates that each individual building was subject to a unique set of depositional circumstances which impacted the make-up of the underfloor deposit. Space precludes a thorough examination here of all 12 buildings beyond what is shown in Table 2, so we discuss two specifically, as demonstrative of some broader findings.

Case Study One: Residency Museum, York

The York Residency Museum is a mid-nineteenth-century building originally constructed as the Superintendent's quarters for the York Convict Depot, then later used as the Resident Magistrate's quarters, before becoming part of the York Hospital in the first half of the twentieth century. It is located approximately 100 km east of Perth and was constructed by

Table 2 Characteristics of floorboards and underfloor deposits for investigated sites

Site Name	Excavated	Floor Board type	Skirting Boards	Service Hatches	Floor Board Damage	Blown in materials	Rodents	Caching (large artifacts)	Caching (small artifacts)	Dry Dust deposit	Good Organic Preservation
Artillery Drill Hall, Fremantle	Yes	Tongue and grooved	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ellensbrook Homestead, Mokidup	Yes	Butt-boarded	No	No	Yes	No	Yes	Yes	Yes	Yes	Yes
Old Perth Boys School, Perth	Yes	Butt-boarded	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Peninsula Farm, Maylands	No	Butt-boarded	No	Yes	Yes	No	?	?	?	Yes	?
St Bartholomew's Chapel, East Perth Cemetery	Yes	Butt-boarded	Yes	Yes	No	No	Yes	No	No	Yes	Yes
Strawberry Hill Farmhouse, Albany	No	Butt-boarded	Yes	Yes	Yes	?	?	?	?	No	?
Strawberry Hill Workers Cottage, Albany	No	Butt-boarded	Yes	Yes	Yes	?	?	?	?	Yes	?
Gallop House, Nedlands	No	Butt-boarded	Yes	Yes	Yes	?	?	Yes	?	Yes	?
Residency Museum, York	Yes	Butt-boarded	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Fremantle Prison	Yes	Butt-boarded	No	No	Yes	No	Yes	Yes	Yes	Yes	Yes
Woodbridge House, Guildford	No	Tongue and grooved	Yes	Yes	No	No	Yes	Yes	?	Yes	?
Fremantle Lunatic Asylum	No	Butt-boarded	Yes	Yes	Yes	?	?	?	?	Yes	?

convicts to a set plan as a simple brick and shingle building (Winter 2017a: 259–260), with suspended butted jarrah floor boards in all rooms, except the kitchen which had a brick floor. Approximately 2.5 m^2 of the underfloor space in one room was excavated in November 2018 when repairs to sinking floor joists were required. The excavated area (Fig. 5) was between two internal doorways under in-situ original 1850s floorboards and doorframes, and non-original skirting that was probably installed during the twentieth century. The maximum gap between boards was 4 mm at the time of excavation (early summer), although there had been some repairs to boards that indicated damage and holes larger than those gaps had previously existed.

The deposit was excavated stratigraphically identifying three dust strata comprising the underfloor deposit, sitting atop a hard clay sub-soil, interpreted as a pre-construction surface. All excavated sediment was dry sieved on site using nested 5 and 2 mm screens. It quickly became apparent that small, yet significant artifacts were being lost through the 2 mm sieves and as a result, all excavated sediment was bagged and dry sieved using micro-sieves in the laboratory. Larger artifacts that could be identified during excavation were collected and bagged by fabric type in association with their stratigraphic and spatial context.

Preliminary analysis of the material indicates the following:

Fig. 5 Excavation trench at the York Residency Museum (photo S. Winter)

- All excavated material was the result of accidental deposition with no evidence of caching. This interpretation is based on the small size of the artifacts which average 2 mm in maximum dimension and the mundane nature of items easily lost – pins, shot, small beads;
- The majority of deposition occurred spatially at either end of the trench adjacent to the doorways and along the skirting boards, suggesting sweeping towards doors;
- Delicate material that would normally not survive archaeologically was prevalent and included cotton fabric, paper, medical pills, leather, seeds, nuts, dyed feathers, human hair, and finger/toe nail fragments. Approximately 2 kg of human hair was recovered from the excavation;
- The uppermost stratigraphic layer was comprised primarily of horse chaff that appears to have been blown into the underfloor space through a sub-floor vent. This was spatially constrained and only found in-line with the vent;
- While there were apparent stratigraphical differences in the underfloor space, stratigraphy was of limited use for dating the associated artifacts. The chaff layer overlay a layer of fine dust, both of which were artifact rich. However, they predominantly only contained small and light objects such as beads and buckshot. The uncompacted nature of these two layers allowed heavier material, such as glass shards, to pass through them into the lowest strata, a heavier more compacted dust, meaning older and younger material was mixed throughout the deposit; and
- Disturbance by vermin was evident with the space under the eastern doorway filled by a rats' nest. The nest contained a variety of paper and plastic material, including Bible verse, 1970s advertising, and a 1930s stamp fragment.

Our interpretation of this deposit is that it is the result of accidental deposition with no caching evident, with additional impacts from animals and wind. Sweeping is evident with the majority of material located adjacent to doors and walls, indicating that material was more likely to enter the underfloor space this way rather than through gaps between boards.

Case Study Two: Ellensbrook Homestead

Ellensbrook Homestead is a mid-nineteenth-century building originally constructed by First Nations Noongar workers, ticket-of-leave convicts, and whalers in 1857. It underwent multiple phases of construction and demolition during its occupation, with the installation of butt-boarded flooring in the mid-1880s, which was then covered with linoleum in the 1920s (Goode et al. 2010: 18; Heritage Today 2004: 33). During this ca. 35-year period, the Homestead was used as a mission home for First Nations children, where they were taught domestic and farming skills to prepare them as servants for white settlers (Green 2018: 43).

The underfloor spaces of four rooms of the homestead were excavated in June 2017 to supplement ongoing conservation work. Of these four rooms, only two (Rooms 3 and 4) proved to have undisturbed underfloor deposits; the deposits in Rooms 6 and 7 had been removed during previous renovations and were archaeologically sterile. The excavations showed a clear stratigraphic distinction between two contexts of dusty, artifact-rich sediment, overlaying a compact surface, presumed to be earth floors.

Sediment was sieved on site using 2 mm sieves with a preliminary sorting of large artifacts, after which the sieve residues were bagged and sorted in the laboratory.

Analysis of the assemblage indicates the following:

– The assemblage accumulated through both accidental deposition and deliberate caching. Most items are between 2–10 mm on at least one axis, thus would feasibly fit between average butt-boarded floor boards. Deliberate caching of specific items including shells, flaked glass, and quartz occurred in Rooms 3 and 4. These artifacts were interpreted as having been cached due to both their size, artifact type, and spatial analysis;
– Delicate material that would not otherwise survive in the archaeological record were recovered, including fabric and cotton embroidery (Fig. 6), paper fragments, seeds, nuts, animal fur and claws, and human hair;
– Joists that supported the floor boards were laid directly on top of the previous earthen floors, meaning that it was possible to identify a clear horizon between the underfloor deposit and the earth floor below. The laying of the boards in the 1880s and the covering of floors with linoleum in the early 1920s gives a clear TAQ and TPQ for the underfloor assemblage, and datable artifacts were all within this range;
– Significant evidence of rodents was recovered but no evidence of wind penetration;
– There is historical evidence that the children in the Ellensbrook mission were not given objects beyond those needed for their basic needs and were restricted in the number of formal toys they were allowed (Green 2018: 40). Instead, they used informal toys (see Dozier 2016: 60) as play items. For example, 762 marine shells were recovered from the underfloor deposit, presumed to have been collected by the children from the nearby beach, based on letters written by the children which describe the activity of shell collecting. Shells both larger and smaller than floorboard gaps were recovered (Fig. 7). Smaller shells (n=636) may be the result

Fig. 6 Embroidered fabric recovered from the underfloor deposit at Ellensbrook (photo J. Green)

Fig. 7 Comparison of shell sizes recovered from under floors at Ellensbrook (photo J. Green)

of accidental or deliberate deposition, but 109 shells significantly larger than the gaps between average butted floorboards, and with clear aesthetic value were recovered, suggesting that they were collected and brought into the house, and then intentionally cached in the underfloor space; and

– Spatial evidence for caching is shown in the remains of an entire amber glass whiskey bottle. The majority of shards from this bottle were excavated from the southeast corner of Room 3. However, in a separate area of Room 3, two further pieces of the same amber bottle glass were found, both showing evidence of flaking. This flaked glass was spatially clearly separated from the remainder of the amber bottle shards, suggesting intentional deposition in that location. A sequence of events emerges, where a bottle was smashed and the remains cached to hide them; a single shard was selected and flaked, and later intentionally deposited elsewhere in the room to hide it. The same was seen with an assemblage of quartz flakes and debitage. Given the size and angularity of the quartz fragments, it is possible they fell between the floor boards accidentally during the knapping process. However, considering the context of the house being used as the means to remove First Nations children from their culture and train them to be members of Anglo-Australian society, traditional activities such as making stone artifacts were forbidden. Similar to the flaked bottle glass, these quartz artifacts are interpreted to have been cached, so as to hide the fact this activity was being carried out. The presence of these artifacts is evidence that the children were active agents in retaining some of their cultural heritage, as seen in other Australian missions, such as Wybalenna in Tasmania (Birmingham 1992: 176).

In this case, our interpretation is that artifacts in the underfloor deposit accumulated both accidentally as well as deliberately, with some objects being explicitly placed there by mission school inmates in order to hide specific illicit materials from supervisors. The interpretation of this caching was based on artifact size and spatial location within the rooms in which they were found. There was very little impact from vermin or wind seen in the assemblage (Table 3).

Table 3 Artifact types used in experiments and depositional results

Artifact Type	Artifact Shape	Angularity	Dimensions Axis One	Dimensions Axis Two	% through 4 mm gaps	% through 8 mm gaps	% through 12 mm gaps	% under skirting	% off end	Stuck or lost
Buttons - Circular sew through	Circular and flat	90º	14mm	1.5mm	5%	27.5%	42.5%	7.5%	7.5%	10%
Buttons - Circular sew through	Circular and flat	90º	20mm	4mm	0	7.2%	71%	7.2%	7.2%	7.4%
Buttons - Circular sew through	Circular and flat	90º	30mm	4mm	0	0	62.5%	25%	0	12.5%
Buttons - Circular shank	Circular and flat	90º	20mm	9mm	0	0	37.5%	25%	37.5%	0
Beads - Cylinders	Cylindrical	None	8.5mm	5mm	0	0	47.5%	12.5%	27.5%	12.5%
Beads - Spheres	Spherical	None	2.8mm	N/A	5%	40%	5%	15%	0	35%
Coins - Penny	Circular and flat	90º	31mm	1.7mm	0	0	72%	14%	0	14%
Coins – Ha'penny	Circular and flat	90º	25mm	1.5mm	0	0	72%	14%	14%	0
Pens and Pencils	Cylindrical	90º	130mm	8mm	0	0	17%	17%	50%	17%
Chalk	Cylindrical	Obtuse	40mm	12mm	0	0	18%	36%	36%	10%
Toys	Assorted	Acute	>12mm	>12mm	0	0	0	0	100%	0
Matches	Shafts	90º	43mm	2mm	0	9%	46%	16%	22%	7%
Pins	Shafts	Acute	25mm	0.6mm	4.5%	71%	9%	0	0	15.5%
Marine shell	Bivalve one side	Acute	<20mm	10mm	0	7.5%	65%	2.5%	10%	15%
Marine shell	Assorted	Acute	>20mm	10mm	0	0	11%	4%	81%	4%
Glass bottle shards	Assorted	Acute	Various	Various	11%*	14%	46%	0	18%	11%
Earthenware teacup sherds	Assorted	Acute	Various	Various	15%*	28.75%	22.75	5%	14%	14.5%
Stoneware plate sherds	Assorted	Acute	Various	Various	4%*	6.5%	48%	0	35%	6.5%
Quartzite flakes	Assorted	Acute	Various	Various	0%*	46%	41.25%	2.5%	10.25%	0

*Plus large amounts of dust and tiny pieces too small to count

Discussion and Conclusion

It is obvious that all artifacts recovered from beneath wooden floors had to have a way of being deposited, whether deliberately or accidentally. Unexpectedly, our intuitive guesses as to what was accidental and what was deliberate was challenged by our experiments. The physics of the movement of different shaped artifacts, and how they responded to sweeping, challenged our assumptions about exactly what was likely to be deposited below floors. In particular, artifacts seemingly much larger than the gaps between boards were able to fall through those gaps, purely as a result of the sweeping process. Beyond the results of our experiment, it was clear that post-depositional impacts such as wind and animal movements also impacted on the composition and spatiality of underfloor assemblages at the sites we investigated.

Table 4 shows a simple breakdown of the various ways artifacts can be deposited below floors. This makes a clear delineation between deliberate caching of artifacts and accidental deposition, which we prefer to a nature/culture divide. This is important, as caching reflects decisions by humans to deliberately deposit material below floors, which leads to an interpretive question of why exactly they chose to do this (which we will not explore further here). What is clear, though, is that the caching of artifacts whose smallest maximum dimension is larger than the largest available gap requires the lifting of floorboards, or accessing of the underfloor space in another way. By contrast any small item dropped on the floor could accidentally be deposited below floors and in this case would be impacted by human clean-up activity such as sweeping. The likelihood of deposition in this way is accentuated by any damage to floors opening up larger holes. Deposition by wind can only happen where wind can penetrate, and where it can, only lightweight artifacts will be affected in this way. Likewise, animals will only carry in or move materials that are useful to them, such as nesting material for rodents.

Under and between floor deposits have value in providing information about past inhabitants of buildings, but their accurate interpretation requires a clear understanding of the site formation and taphonomic processes that impact on their deposition and survival. Beyond just the "small things forgotten" (Deetz 1996) that fall through cracks and accumulate, a range of human building, cleaning, and caching behaviors impact on what materials actually make it into an underfloor assemblage to be recovered archaeologically. Construction features impact how these deposits accumulate, and a simple 4 mm difference in the width of gaps between floorboards can make a substantial difference on the likelihood of material finding its way into the underfloor. A fine grained analysis of building materials, bioturbation, and spatiality is required to

Table 4 Depositional factors – caching vs accidental

Deliberate Caching	Accidental Deposition
Small items – through gaps between boards	Falling between boards
Large items – lifting boards or people physically entering the underfloor space	Falling below skirting boards
	Falling through holes opened by damage
	Blown in from outside
	Brought in by animals

interpret underfloor deposits. Beyond that it is clear that underfloor spaces have the capacity to preserve rare and fragile organic materials that would normally perish in archaeological contexts, and that dust should be considered an artifact as much as a sedimentary matrix in which artifacts are suspended.

This study demonstrates the benefit of using experimental archaeological results for interpreting historical archaeological sites. While a thorough discussion of the breadth of experimental archaeology is beyond the scope of this paper, a review of the literature (e.g., Busuttil 2012; Paardekooper and Reeves-Flores 2014; and the extensive bibliography of experimental archaeological studies available on the EXARC.net website n.d.) suggests that it is not widely used in historical archaeology. We would argue that experimental archaeological techniques do have validity for historical archaeological projects, where an appropriate research design can be developed.

More work is clearly needed on caching behaviors and contexts within which caching is likely. However, our research so far suggests that it is far more likely to occur in institutional settings, and in places where people have an incentive to hide evidence of illicit behaviour or items that are valuable to them. Further publication of many of the sites discussed here is intended, exploring these very issues.

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