Can You Tell Me How the Pot Fell?

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Introduction

Focus on ceramics has been dominating research in archaeology. This constituent of the archaeological discourses derives its importance from the great potential of its material under study, as enumerated by Rice (1987:24–26). Pottery is ubiquitous, has been present for many thousands of years, and is non-perishable. It is not restricted in its association to a particular class or people, and its sherds are generally unappealing to treasure hunters who would normally leave them. In addition, there is a lot of information ceramics could tell the archaeologist by way of its manufacturing process; this idea has spawned approaches to the study of pottery based on form, decorative elements, and composition.

Ceramic remains in the archaeological record could at times be present as whole vessels, but most frequently and in many sites, they appear as potsherds. Because of this occurrence, it is apparent that the sherd has assumed the status of being the unit of examination in the study of archaeological ceramics. Research on ceramic technology, trade, gender, social organization, vessel function, political economy, ritual and ideology, and site formation process is based on vessel attributes shown in part by sherds.

Thus it is helpful to get an understanding of the circumstances and events by which sherds are produced. The processes that lead vessels into the archaeological record are some of the factors operating on the pots providing the materials from which archaeologists derive data for the various lines of inquiries.

This study examines some of the mechanical factors that may have a role in producing sherds from whole pots.

Objectives

Two independent variables in dropping, height of fall and the pot part coming into contact with hitting surface, were examined in relation to the dependent variables of potsherd number and potsherd mass. The objectives then are:

1) To determine associations between the drop height of a pot and the set of variables that include resulting number of potsherds and potsherd mass; and
2) To determine associations between pot part coming into contact with the hitting surface and the set of variables that include resulting number of potsherds and potsherd mass.

Review of Related Literature

Underlying mechanisms involved in archaeological site formation could be studied by using models. Many of these models have been constructed with the approaches of ethnoarchaeology and experimental archaeology; they have been useful in pointing out circumstances and processes by which ceramics enter into the archaeological record. This can provide good insights concerning the natural and behavioral causes involved in the deposition and the provenance of pottery. Investigations of this kind on pottery and other significant artifacts could eventually form a database for a holistic understanding of site formation processes.

Among the earliest ethnoarchaeological studies done in the Philippines was a research by de la Torre and Mudar (1982:117–146) focusing on the material culture of a rural Visayan dwelling still in use. From its attempt to determine if durable artifacts, the ones likely to be seen comprising archaeological assemblages, make up a significant part of the household, it found that at least 70% of items could be considered as such. It also advises that archaeologists should be cautious in using models for identifying activity areas because these areas are likely to be affected by disposal patterns.

Several investigators have studied disposal patterns in dwelling sites after being abandoned. The complexity of site formation, with its characteristic multifactorial dimensions and variability in artifact presentation, has been shown by the studies of Joyce and Johannssen (1993:138–163) and Brooks (1993:178–187). There are however efforts to discern possible patterns in the formation process. A project by Rotschild and co-workers (1993:123–137) involved recording household and settlement characteristics in the abandonment of a present-day Zuni village in New Mexico. The authors propose that use and abandonment processes be viewed as situated in their own places within a single continuum. With this framework and the Zuni village case, this study stresses that artifact distribution, diversity, density, and size have much to tell about the sites with regard to their degree of use and abandonment.

Tomka (1993:11–24), in his ethnoarchaeological study of agro-pastoralists in southwestern Bolivia, looked into the processes in extended site abandonment and anticipated but delayed return. By his inventory and analysis of artifacts, he discovered that delayed curation may have been a major behavior resulting in many of disposal patterns seen in extended site abandonment of pastoral residences in the area.

A number of culturally-related variables like type of site, distance to settlement core, ethnicity, population, and mobility have also been studied to determine their influence on artifact and ecofact frequencies. This was done by Kent (1993:54–73) among the San Bushmen of Botswana, where the results revealed that a major determinant of object frequencies is more the time span planned for the stay in the site than the actual length of stay. The planning component determines, according to perceived length of stay, if the artifacts to be brought in would by many or less, last long or not.

The fates to which ceramics proceed after the use they were intended for include reuse, in which the vessel continues to serve a function other than its original one; curation, sequestration from use and setting it aside in storage; and discarding the vessel. Among these, the most prevalent situations encountered by archaeologists are ceramic discard, which is likely to be seen in middens or habitation sites, and ceramic reuse oftentimes shown in burials by some utilitarian pottery having turned into grave goods.

Research on reuse behavior has been done to address problems in the determination of vessel functions and identification of activity areas that may have involved the reuse of artifacts. For instance, Deal and Hagstrum (1995) used the ethnoarchaeological approach among modern Maya and Wanka communities to build models for interpretations that consider the occurrence of reuse behaviors. Results of their work emphasize that reuse of ceramics is prevalent among societies using these artifacts; that vessels most commonly used are also those with a high frequency of reuse and discard; that the secondary function of the vessel or vessel part depends on the parts still available; and that there is a close link between reuse and provisional discard, and that these are so much related to activities of disposal and abandonment.

Investigations are also especially focused on abandonment behavior as it affects the quality and quantity of an archaeological assemblage. Lightfoot (1993:166) has summarized at least six types of behaviors that affect artifact deposition in abandonment situations:

1. *De facto refuse deposition* is the abandonment of still usable cultural materials in an activity area at a specific time;
2. *Curate behavior* is the process of taking away a still usable or repairable artifact from the area of its abandonment to be used in some other place;
3. *Lateral cycling* is the transfer of objects between users;
4. *Draw down* refers to non-replacement of artifacts when people are planning to move away;
5. *Scavenging* is getting an artifact from an area of abandonment by people living on or near the area; and
6. *Collecting* and *looting* are the taking of artifacts from the area of abandonment by non-residents of the place.

Identifying behaviors related to abandonment calls for means to measure and differentiate variability in the archaeological record caused by these behaviors and other factors. With such means, a reconstruction of the events in their possible sequence could be made. In one study concentrating on sites in Arizona, the so-called "Relative Room Abandonment Measure" was used to distinguish between early and late abandonment of activity areas, and pinpoint other unexpected behaviors that may have affected these (Montgomery 1993:157–164). It shows the data as a cross-plot of whole pot quantities and density of sherds and then comparing the patterns of a site under study with those of a "control" site.

A vessel is likely to have been discarded if the user could not find a function for it any longer. This was probably because the vessel has already changed in such a way that it could no longer show a function, like having parts of it altered or reduced. This could either come in the form of having cracked, worn out, chipped, having a hole, or having been broken, as in the case for the Kalinga village of Dalupa (Beck 2003:145). In this settlement most of the cases of ceramic damage are through breaking. With sherds from breakage or shattering being the most numerous vessel parts confronting the archaeologist, it is no wonder then that a set of investigations centered on these materials have been developing to answer questions on problems like the span of site occupation (Varien and Mills 1997), processes on settlement abandonment (Montgomery 1996), and also on residence patterns (Beck and Hill 2004).

The series of studies done on Kalinga pottery has produced reports on the subject. Longacre (1985:339–341) for instance has noted that the most commonly broken earthenpots in the Kalinga village of Dalupa are the *oppaya*, a pot for cooking meat and vegetables, and the *ittoyom*, a pot for cooking rice. He has come to a generalization that the size of the vessel is directly correlated to its length of survival.

In another study on Dalupa ceramic deposition, Beck (2003:145–148; 154–158) presents a clear outline of what kinds of damage vessels are more likely to sustain, and regarding those damaged through breakage, the more likely causes of it. Among the most numerous pots are the *oppaya* and *ittoyom*, which are mostly damaged by breakage. Causes of breakage are often pot dropping, washing, and being hit or bumped.

Because the point of breakage in most cases is considered as the point where pots end their usefulness, archaeologists have taken it then as the use-life termination of the vessel. Around this idea of ceramic use-life are studies that attempted methods of its determination and archaeological application. For instance, to obtain information on the use-life of ceramics in the Mexican village of Tzintzuntzan, Foster (1960:607–608) interviewed housewives regarding the age of vessels he observed in their kitchens. DeBoer (1985) recalled working on data for Conibo ceramics. This was done in a manner having archaeological applications, but a later and more reliable strategy was done by recording vessel loss within a certain span of years (Longacre 1985).

Aside from use-life determination are investigations on physical properties of ceramics and circumstances in their manufacture that have roles in vessel life expectancy. Foster (1960:608) cited basic strength as an intrinsic ceramic characteristic responsible for life expectancy. He considered basic strength as reflective of firing temperature height and the presence of glaze. A later study however did not find any relationship between the strength of pots and surface treatments (Longacre *et al.* 2000). Reexamination of the several variables presumed to have influence on life expectancy was also done through correlation analysis (DeBoer 1985). An inverse relationship was found between use frequency and life span, while a direct relationship showed between the logarithm of weight and use-frequency. Manufacturing cost, which was defined as "labor invested in the welding of raw materials into cultural form (ceramic vessels)," likewise showed a direct relationship with use frequency.

Breakage pattern as function of household characteristics was investigated by Tani (1994). This study supports the so-called "sherd-to-people" model (Kolb 1985:582), which states that an increase in people results in an increase in broken ceramics. Tani found that in larger households, larger cooking pots are more often used, and there are more pots broken. The higher frequency of pot breakage in larger household is likely a consequence of thermal fatigue. This has been explained by households with many members having the need to cook more food. Larger pots are often used for this purpose, and thus vessels of larger sizes are more exposed to thermal stress, rendering them weaker and susceptible to breakage.

Sherd size and deposition were tackled by DeBoer and Lathrap (1979) when they reported on ceramic discard by the Shipibo-Conibo of Peru. Sherds usually accumulate in places where breakage occurs, like household yards and trails, but factors are operating that cause modifications in sherd frequency and size. Sherds are numerous in places where people deposit the rubbish they sweep, or in lower areas of the ground surface. Meanwhile sherds were also found to be smaller in size in areas where trampling regularly occurs.

As breakage is the most cited reason for pot damage and dropping the most likely mechanism, it would be interesting to investigate the factors responsible for this. The physical variables leading to the formation of a particular set of potsherds have not received enough attention from archaeologists. This study attempts to examine the physical aspects of pot breakage resulting in the production of a particular set of potsherds about to enter the archaeological record.

Earthenware pots used in the study were obtained from Gatbuca, a barangay of Calumpit, Bulacan. Gatbuca is one of the many settlements situated on the Pampanga River delta, the southern part of the Central Luzon Plain where population density is high and the landscape is primarily devoted to rice paddy agriculture and fish farming. The fluvial character of the area is thus generous in providing the types of clay needed in the pottery-making industries of Bulacan and Pampanga provinces.

The earthenware vessels of Gatbuca were reported by Scheans (1977:87–92) as part of his survey on the different local potteries in the Philippines. These vessels consist of a vegetable or meat pot known as *balanga, paso* (flower pots), *banga* (jars for containing water for household use), and *kalang Hapon* or Japanese stoves. The tools and materials needed in making pots include the *bilingan*, a turntable made of a hollow earthenware plate placed on top of a wooden board; the *dalumi*, a cloth used for turning; *papag*, a chair where the potter sits; three kinds of paddles (*pamatil, panaglos,* and *pantakob*); *batong bilog*, or anvil stone; *dikin*, or pot rest; and the *batong pambole*, objects that are used as polishers. Other than the work of Scheans, no previous studies have yet been done on the traditional pot-making industry of Gatbuca as to people and labor involved, distributional system, and socio-cultural role of these vessels in the community.

Making a batch of *balanga*, usually numbering a few hundreds, takes about a week. A certain phase is done to all the vessels each day until the whole process is completed for all pots. The following process of pot manufacture is based on my observation in Gatbuca in August 2005:

Clay is first taken near the riverbank and brought to the house. A big lump of clay is taken and fashioned into a cone, and the fist is forced into the center of the cone's base to create a hollow. The sides of this hollowed cone is pinched for the cone to assume gradually the shape of a pot. The pot is then placed on the *dikin*. Smaller lumps of clay are formed into little coils (called *pasil*) to be plastered on the inner surface of this half-made pot to thicken the walls. The *dikin* with the vessel is placed on the *bilingan* and the latter is rotated. After dipping it in a little water, the *dalumi* is clamped at the edges of the rotating vessel to smoothen its sides. Pinching is also done to smoothen the rim. The pot takes on a more refined form and is now called *tamayok*, which is afterwards made more firm by drying. Once firm, it is set on another earthenware support called *talakdan* where it is finished to its final form by the use of paddle and anvil, and subsequently dried. Then the potter applies the *kulol* (slip), which could either be reddish or yellowish in color, with a cloth and dried again. The outer surface is polished with a plastic bottle cap (the act of *binubuling*) for the pot to acquire a smooth appearance. Finally the slip is allowed to dry and the pot taken for open firing.

Materials and Method

The following materials were used in the experiment: (1) thirty-six earthenware pots bought from one of the potters of Gatbuca, Calumpit, Bulacan; (2) digital weighing scale; (3) measuring tape; (4) sliding caliper; (5) line level; and (6) plastic bags in which to place pot sherds.

Four dimensions were measured in each of the 36 earthenware pots, which included: vessel height, rim diameter, maximum diameter, whole vessel mass. Because only the pots that were broken allowed measurements of rim thickness, side thickness, and bottom thickness, these last three dimensions were taken through random sampling only from broken pots. Vessel height was taken with a measuring tape secured to a wall and a line level placed on top of the pot that pointed to a corresponding value on the measuring tape. Rim diameter and maximum diameter were taken with a sliding caliper. A digital weighing scale was employed to get the whole mass. Rim, side, and body thickness were also taken with a spreading caliper. Pot dimensions to use, and how to measure them were derived from the book by Sinopoli (1991:61–62). Modifications were done particularly in measuring vessel height because the suggested procedure was difficult to apply on the pots in this study.

Vessels were dropped at different heights, and at varied orientations to direct a part to hit at the point of impact (see Table 1).

Difference in drop height was supposed to simulate the various heights from which pots are frequently dropped: from the hearth, shelf, and a person's head. Difference in pot part to hit ground could show if there were variations in breakage patterns due to this variable. Dropping of the pot was done on soil partly covered with vegetation litter at a place beside the Beta Way fronting Palma Hall in the University of the Philippines, Diliman, Quezon City from September 26 to 30, 2005.

After dropping, the following variables in each replicate of each treatment were recorded: number of potsherds, mass of each potsherd to arrive at the frequencies of "mass categories," and plotting the area of scatter, by measuring the distance of sherds from the area of impact. The mass of each sherd was determined using the digital weighing scale, while the measuring tape was used to measure sherd distance from the impact area.

Results and Discussion

Ceramic vessels show narrow variations in their vessel height, rim diameter, maximum diameter, vessel mass, rim thickness, body thickness, and bottom thickness (Table 2). These values show that dimensional variables of the pots were satisfactorily controlled in the experiment. These indicate, too, that the potter has been exercising craftsmanship resulting in good uniformity of the product.

Shattering did not occur on pots dropped in all of the four heights with rim hitting the ground. This resulted in maintaining the integrity of the whole pot (Figures 1 to 4). However, a single pot dropped at a height of 800 mm sustained a 9 cm fracture that ran from rim to body. Pots dropped at 300 mm with side hitting the ground did not break (Figure 5), but one had two cracks that developed from the rim directly opposite of each other. One of these ran halfway through the pot from rim to bottom, while the other was shorter, measuring 60 m. Another pot dropped at 300 mm with bottom-to-hit did not break. Shattering was observed in the rest of the treatments although one pot dropped at 800 mm with side hitting the ground only developed a 50 mm crack from rim to body.

Vessels that exhibited shattering showed a direct correlation between drop height and number of sherds produced (Figure 13). This was seen in pots with either side or bottom hitting the ground, but more so in the latter. This relationship could be explained by drop height relating to a variable that affects the number of sherds resulting from the impact. The severity of impact and its relationship to height would be illustrated in a formula concerning the conservation of energy (William *et al.* 1984:124–126), which states that the energy before and during motion is equal. This could be shown in the following equations:

(1) $PE = mgh; KE = 0$

is the situation at rest where PE, the potential energy, is the product of mass (m), acceleration due to gravity (g), and height (h), and where KE, the potential energy, is equal to 0. Just before impact, the situation becomes:

(2) $PE = 0; KE = ½ mv^2$

where the potential energy (PE) is now zero and the kinetic energy (KE) is half the product of the square of the velocity (v^2) and mass (m). Conservation of energy means that

(3) $mgh = ½ mv^2$

and it would be noticed that mass does not affect the other variables. From this equation the velocity could be derived:

(4) $v = \sqrt{2gh}$

It would now be seen that increases in height would also result to corresponding increases in velocity. Velocity is a function of impact force. It should be emphasized again that drop heights were assigned such that they simulate heights from which vessels are likely to be dropped in reality. Through this equations could height have a relationship with, and illuminate our understanding for reasons behind, the breakage pattern.

The steeper slope of the line showing relationship between the two variables in bottom-to-hit pots could be the result of a thinner bottom than side in Gatbuca pots (Table 2). It has been shown in previous studies like the one by Aronso and colleagues (1994:102–104) that thickness is a function of strength and directly proportional to it. At a certain force or load, thicker walls have a greater capacity to withstand stresses than do thinner vessel walls.

Aside from wall thickness, another possible factor that could affect occurrence or degree of shattering is the form of the vessel part coming into contact with the hitting surface. This is apparent in pots dropped with rim hitting the ground without shattering. When the inverted pot falls and comes into contact with a surface, it is essentially a dome encountering a force generated by the strong impact. This then would be explained by the structure that gives stability to domes (Bloomfield 2001:11–16). Domes derive part of their structural principles from those governing arches and vaults. In arches and vaults, a force known as the thrust is basically the resultant of two other forces; the first is the horizontal thrust created by the weight of the two piers (voussoirs) leaning on each other and the arch flatness, and the second is the weight of the arch. To render stability to the arch, the line of thrust should be in the middle third of the arch section and pier. The dome could be considered as being formed by a multitude of arches, the apices of which intersect in a common axis. The combined thrusts of this set of arches plus the circular forces present in a dome tend to develop a net of compression forces that is spread throughout the dome, making it resistant to stresses of relatively great intensity.

Another interesting observation is the one regarding the characteristic sherds resulting from breakage. It appears that particular frequencies of sherds in mass ranges are associated with the part of the pot coming into contact with the hitting surface. While a whole pot still resulted in vessels dropped with rims-to-hit (Figures 1 to 4), those with sides-to-hit produced sherds with masses falling in every range but the frequency is higher in ranges at the middle (Figures 6 to 8). The bar graphs eschew to the left in bottom-to-hit pots where most of the sherd masses fall within 1–25 grams (Figures 9 to 12). These suggest that vessel thickness and /or possibly form of the part to hit the surface is a good determinant of resulting sherd size or mass upon breakage. A thinner wall and/or a less protective form in a pot is more likely to create smaller or lighter sherds.

These results show that pot falling, breaking and sherd deposition are complicated events, and gaining a deeper understanding of the processes should consider the examination of these other variables.

Summary and Conclusions

Physical factors associated with sherd breakage like height of fall and vessel part coming into contact with hitting surface, were investigated to determine if they have relationships with resulting potsherd number, potsherd mass, and area of scatter. An experiment was thus conducted on earthenware cooking pots from Gatbuca.

Results showed that pots sustained very little or no damage when dropped with rim first to hit the ground. Breakage was seen in pots dropped with side or bottom first to hit the ground, with increasing severity as vessels were dropped at increasing heights. Pots dropped with side-to-hit exhibited a higher frequency of sherds in the middle mass range values while those with bottom-to-hit have very high frequencies in the smaller range values. These suggest that the two dependent variables examined could dictate pot breakage. Height of fall affects velocity of the pot during fall, and this in turn produces a corresponding impact force. All these three variables are consecutively related in a directly proportional manner. The production of more numerous but lesser mass sherds in bottom-to-hit pots is probably related to thickness of the pot part, in which thickness is directly proportional to resistance to stress.

Structural causes probably explain non-breakage of pots dropped with rim towards ground, wherein the combination of circular forces and lines of thrust ending up as compression forces spread throughout the pot render stability to the vessel during stresses. The production of more numerous but lesser mass sherds in bottom-to-hit pots is probably related to thickness of the pot part, in which thickness is directly proportional to resistance to stress.

The study did not show a discernible pattern between drop height, pot part hitting the ground, and sherd spatial distribution, and likewise between sherd mass and distance from impact point. If relationships are still hidden it goes to show that the event of pot breakage due to fall is one of a complex nature, probably involving a host of factors and needs to be seen in a more comprehensive manner.

Investigations of this kind are particularly useful in shedding light regarding the processes involved in sherd formation and deposition. These illustrate part of the complex series of events responsible for archaeological site formation, and warn that interpretations need to consider as much as possible all the elements and their dimensions exerting an influence on the phenomenon under scrutiny.

It may be best to treat this study as part of a series of investigations involving sequential processes that lead earthenware vessels into the archaeological record. The study assumes archaeological significance once it is stressed that various physical, chemical and cultural factors, whether they leave their traces or not in the archaeological record, may have played an important part in producing earthenware ceramic remains found in sites. Methods such as those employed in experimental archaeology and ethnoarchaeology are a way of determining the possible roles of these seemingly hidden factors.

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Abstract

Earthenware cooking pots from Gatbuca in Calumpit, Bulacan were used to test if height of fall and vessel part coming into contact with hitting surface affect sherd production upon breakage. The vessels were allotted into experimental treatments that involved dropping and breaking to see the sherds formed. Results suggest that these two variables have influences on sherd number and mass, but apparently none on sherd scatter. This follows the formula on the conservation of energy regarding freely falling bodies, in which drop height affects velocity, which in turn affects impact force, all in direct proportional relationship. Variations in sherd mass frequencies between pot parts that hit could be the result of structural differences between pot parts, but no pattern emerged between spatial distribution and other variables. Future investigations may need to consider more elements potentially influencing the event of pot breakage.

Drop Height (mm)	Rim to hit	Body to hit	Bottom to hit
300	3 pots	3 pots	3 pots
800	3 pots	3 pots	3 pots
1200	3 pots	3 pots	3 pots
1600	3 pots	3 pots	3 pots

Table 1
Experimental treatments arranged to examine effects of drop height and part of the pot to hit ground

	Vessel Height (mm)	Rim Diameter (mm)	Maximum Diameter (mm)	Vessel Mass (g)	Rim Thickness* (mm)	Body Thickness* (mm)	Bottom Thickness* (mm)
N	36	36	36	36	19	19	19
Mean	115.7778	203.0833	214.1111	884.6667	8.668421	5.394737	3.926316
Standard Deviation	4.876246	4.136	3.793	62.95849	0.873087	0.447802	0.639307
Coefficient of Variation	4.211729	2.036641	1.771538	7.116634	10.07204	8.300713	16.28262

**The value for each of the 19 pots is the average of three measurements.*

Table 2
Summary of vessel dimensions examined to ensure uniformity of pots

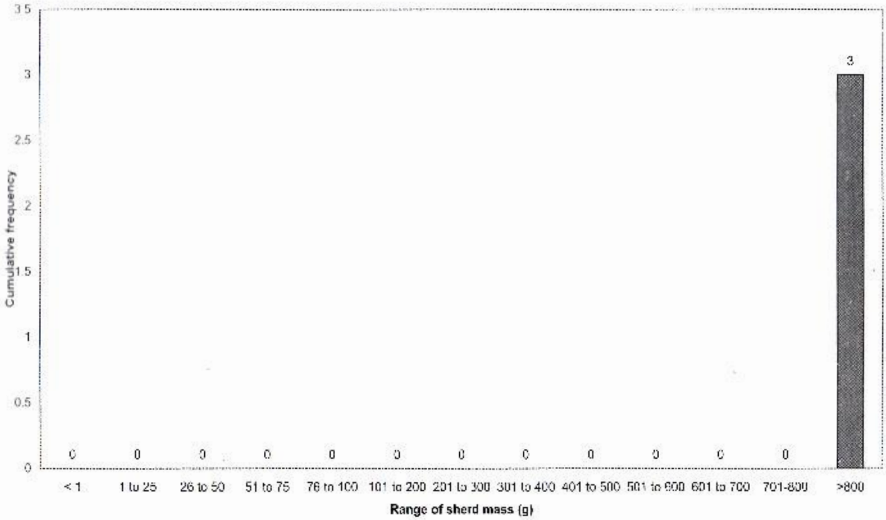

Figure 1
Sherd frequency of pots dropped at 300 mm with rim contact

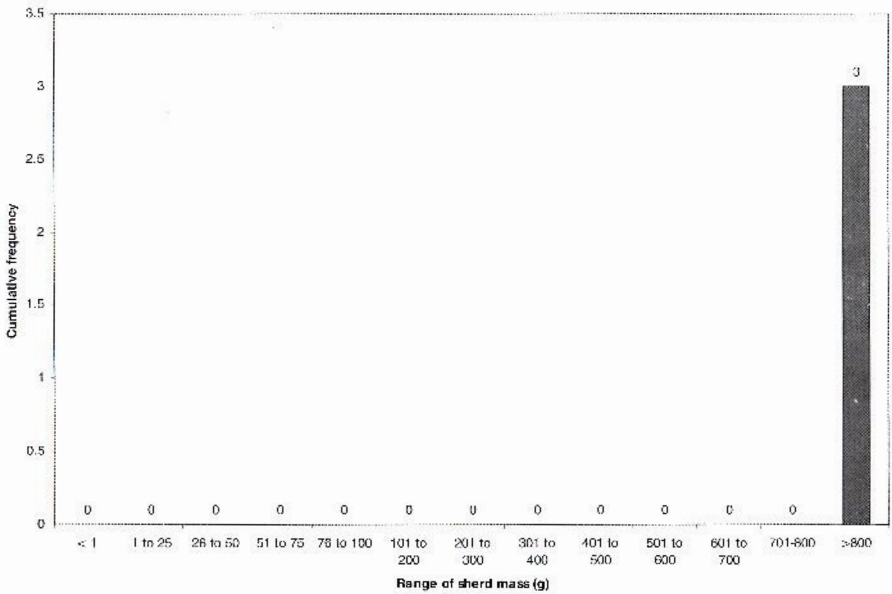

Figure 2
Sherd frequency of pots dropped at 800 mm with rim contact

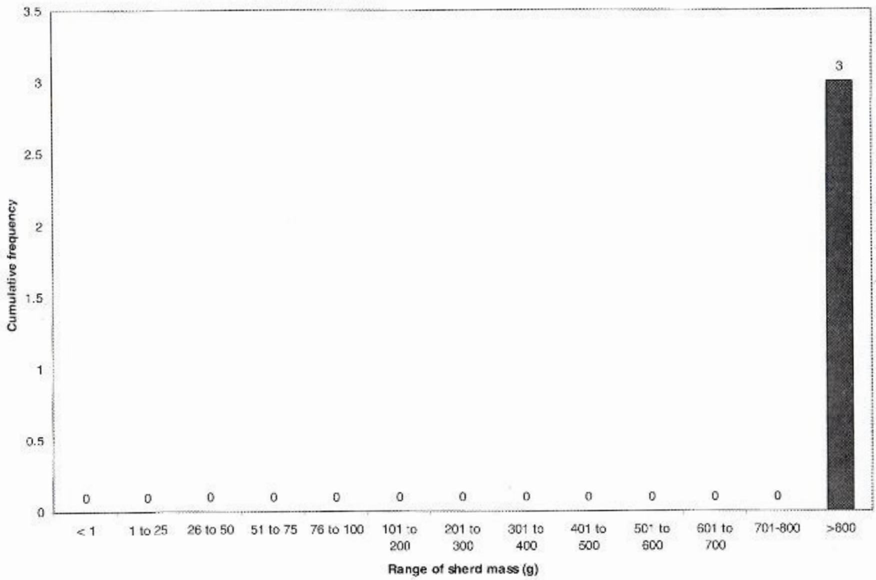

Figure 3
Sherd frequency of pots dropped at 1200 mm with rim contact

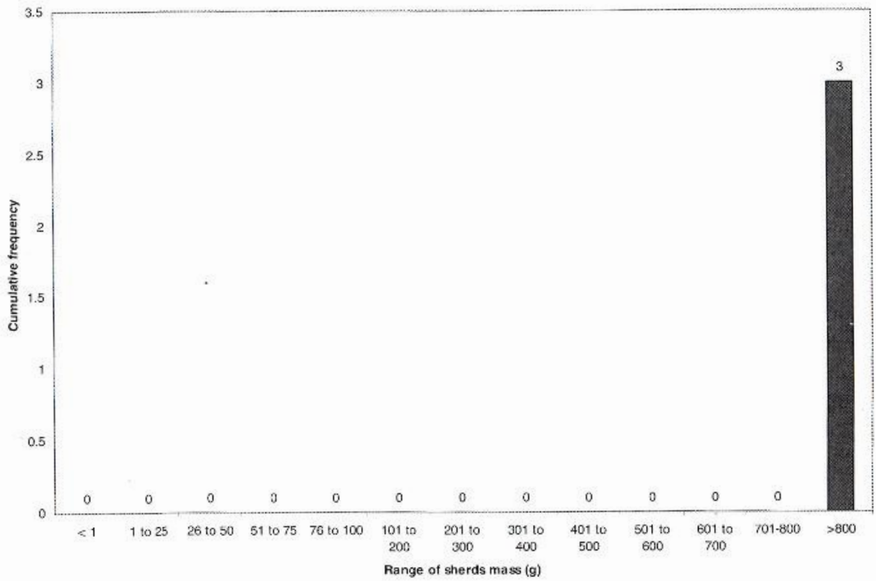

Figure 4
Sherd frequency of pots dropped at 1600 mm with rim contact

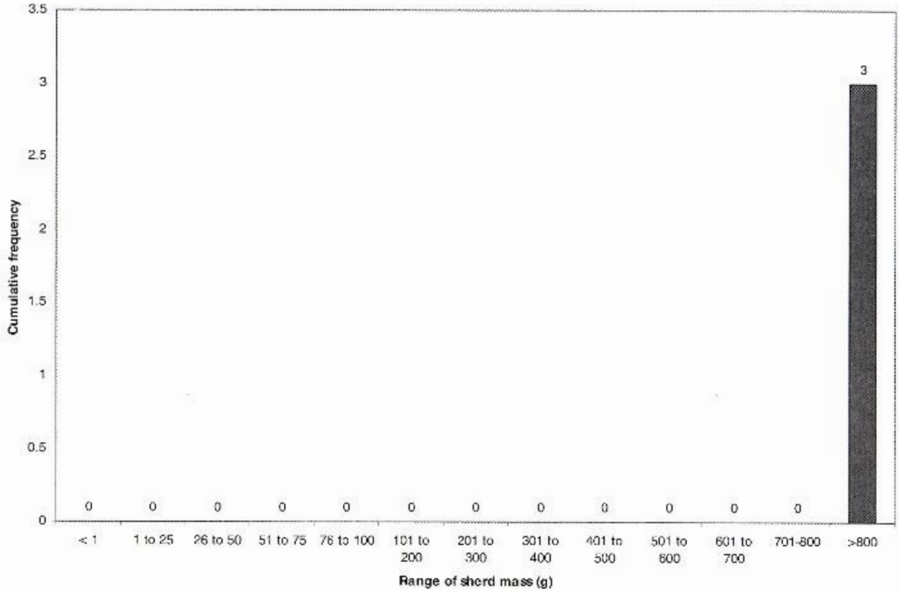

Figure 5
Sherd frequency of pots dropped at 300 mm with side contact

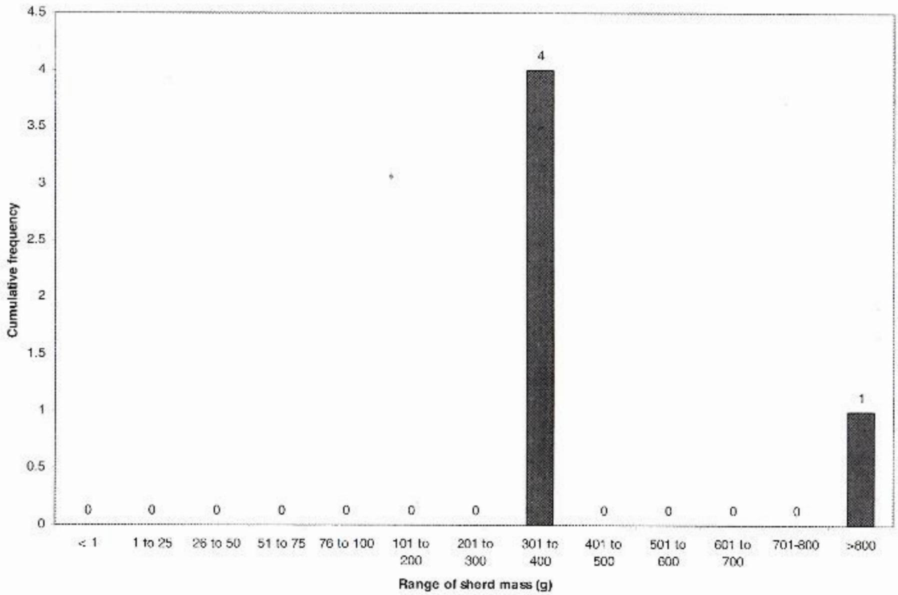

Figure 6
Sherd frequency of pots dropped at 800 mm with side contact

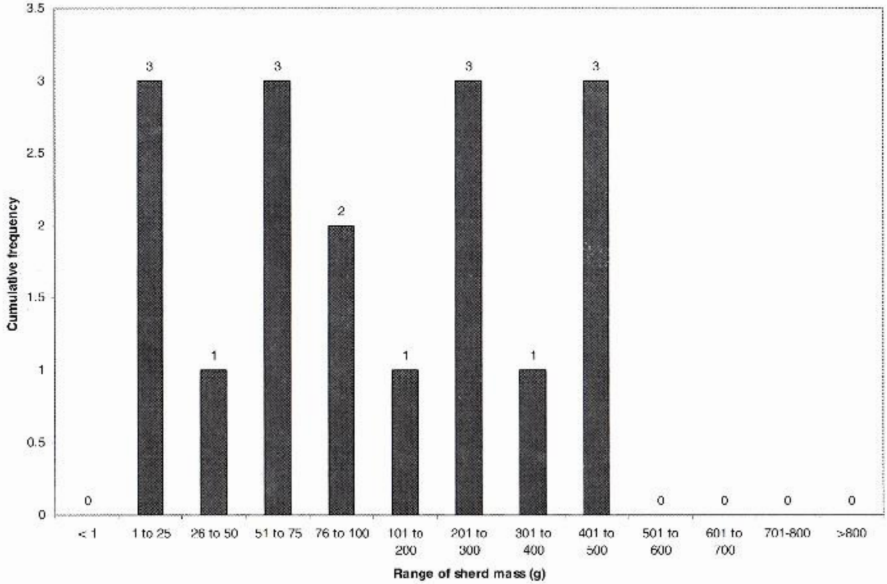

Figure 7
Sherd frequency of pots dropped at 1200 mm with side contact

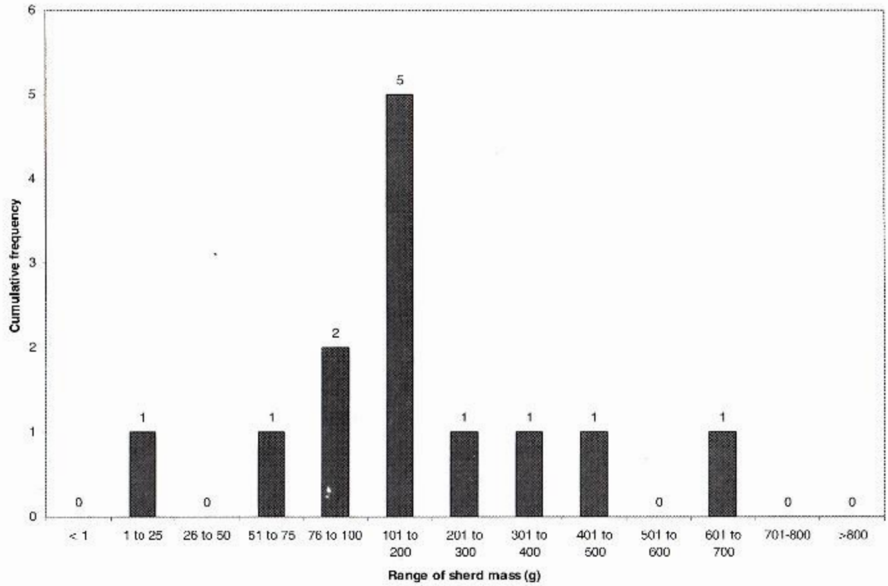

Figure 8
Sherd frequency of pots dropped at 1600 mm with side contact

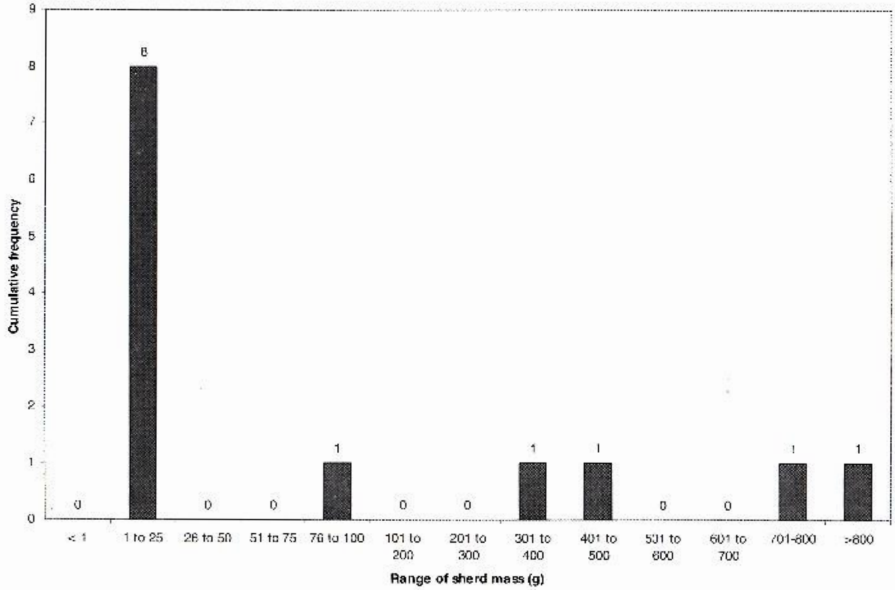

Figure 9
Sherd frequency of pots dropped at 300 mm with bottom contact

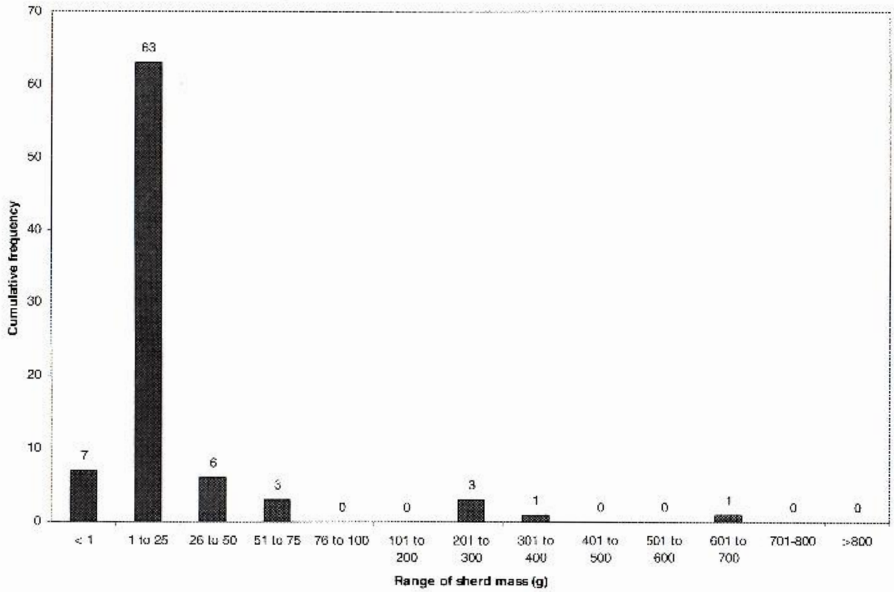

Figure 10
Sherd frequency of pots dropped at 800 mm with bottom contact

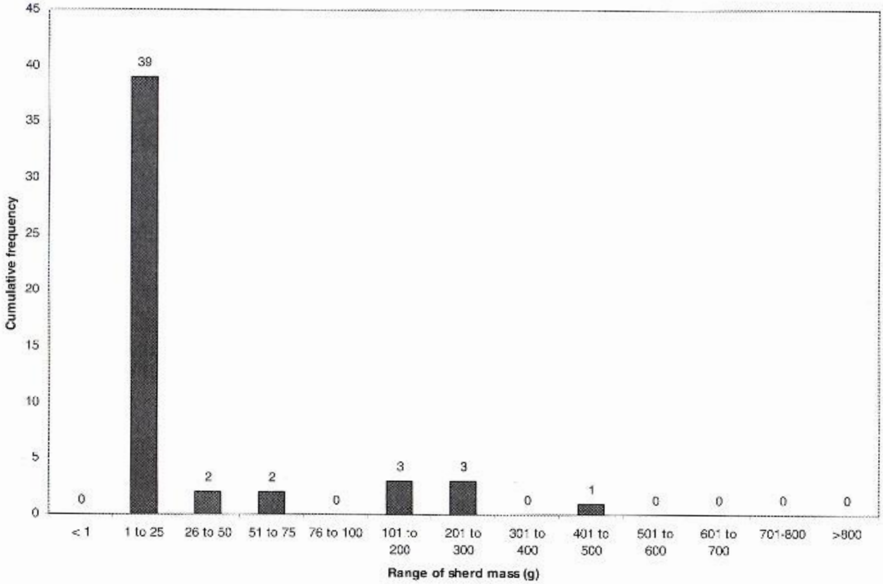

Figure 11
Sherd frequency of pots dropped at 1200 mm with bottom contact

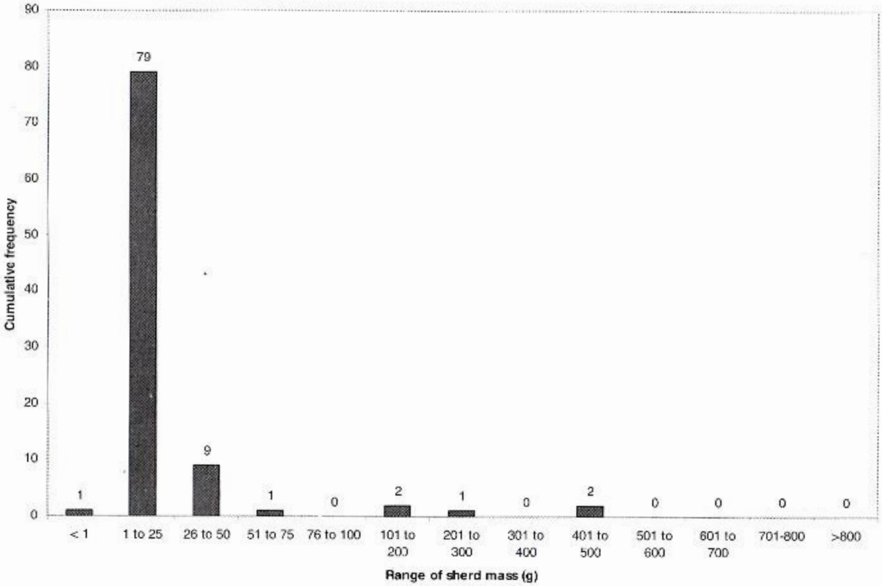

Figure 12
Sherd frequency of pots dropped at 1600 mm with bottom contact

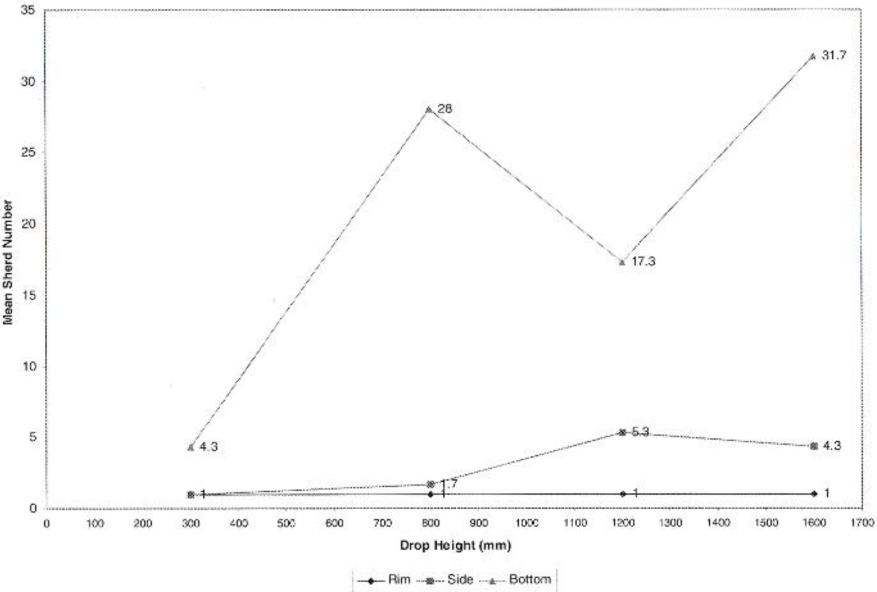

Figure 13
Relationship of drop height and mean sherd number