Medieval Ceramics 13 (1989) 31–41.

An Analysis of Rim Fragments from 14th-century Globular Pots Excavated in Utrecht

TJEERD POT *and* HUBERT L. DE GROOT*

SUMMARY

During an archaeological excavation in Utrecht, a sealed complex of 14th-century pottery was found which contained a large number of sherds, most of which derive from globular pots. Since relatively little is known about the quantitative and qualitative aspects of this pottery, it was decided to carry out an analytical investigation of the rim fragments in particular. In view of the rather casual approach to rim sherds in pottery studies, it seemed worthwhile to adopt a more discriminating method of research which would provide as much reliable data as possible. By conducting a pilot study in order to standardise the investigation, a research protocol was drawn up. Characteristic features (variables) of the pottery were chosen and defined, methods and means of assessing them were established; the influence of the researcher was also considered.

By replicating the assessments, and moreover by having two researchers, it was possible not only to obtain reliable data but also to calculate the 'critical segment size' and the 'fragmentation factor' of rim sherds. These new concepts are considered to be applicable to research on excavated pottery in general. Some other recommendations for pottery research in general are also presented. During the analysis, the presence and absence of several inter-variable relationships was established, the former enabling a detailed quantification of the globular pots.

A comparative study of the pottery from two other waster pits showed some obvious similarities between the three populations, but also some remarkable differences, the possible causes of which are discussed.

INTRODUCTION

In the summer of 1984 the remains of several pottery kilns were found, together with many waster pits, during an excavation at Oudenoord (Bemuurde Weerd).

The municipal archives note that the first potters settled at this site, which lies in a bend of the River Vecht, at the beginning of the 14th century after being expelled from the centre of Utrecht, where their kilns were considered to be too great a risk amidst the predominantly wooden buildings of the expanding town. As more potters moved to Oudenoord, which at that time lay outside the centre of Utrecht, an industrial production centre gradually developed which was of more than local significance. Meanwhile, however, the city also expanded, and in 1398, for the same reasons as before, the potters were again forced to resettle in another, more remote bend of the river. The end date for the production centre at Oudenoord is confirmed by the 14th-century character of the pottery, and by the presence of a few sherds of imported Rhenish stoneware.

Some of the waster pits were found to contain many sherds of similar form, and the material therefore seemed suitable for statistical analysis. The primary objectives were to develop a method of research which would provide reliable data, and to calculate the quantitative and qualitative characteristics of the pottery in question. To these ends a sealed complex of sherds — one waster pit — was chosen. This contained an extremely uniform group of globular pots, densely packed with hardly any earth between them, and lacking any trace of use. The complete pots were commonly split and/or bloated, but were rarely deformed, giving the impression that they had been allowed to cool too quickly. Together with the quantity of the material (estimated at easily one cubic metre), these factors suggested that the complete contents of a kiln had misfired and had been dumped into a single pit[1].

The quantity of sherds in the pit, as in several others, proved to be so great that it was decided to collect only the rim fragments of the globular pots, and the relevant (diagnostic) fragments of the other forms present, such as rims, handles, and bases. By selecting these particular sherds, most of the information about the pottery could be recovered, and the problem of storage resolved.

PLANNING THE RESEARCH

In archaeological research it is common practice for interpretations to be based on more or less imperfect and incomplete phenomena and finds. Knowledge, spatial insight, observation and use of measuring devices are some of the ingredients that play an important role. In the specialised context of potsherds, in addition to various technological considerations, morphology and function are important and of relevance to dating, and it is often useful to reconstruct the original vessel, physically or by illustration. It is not unusual to prepare reconstructions from rim sherds in particular, even if insignificant or partly worn away, by assessing a number of variables. To assess these variables, measurement or observation is not as easy as it seems, and reliable data has to be collected under stringent conditions. Before proceeding to the results of the analysis, the three factors which form the basis of the research will be discussed; these are:

1. The material to be investigated
2. The methods and means of the investigation
3. The researcher

1. The material.

It is not within the scope of this investigation to consider the detailed technological aspects of the pottery in question, apart from noting that the slightly porous fabric of the globular pots is greyish-black through reduction. With the exception of the neck and rim, the globular pots have evidently been made by hand. The inner surface of the body up to the neck shows shallow and irregularly distributed depressions which most probably reflect the use of the potters fingertips or knuckles while shaping the pot. The outer surface has been smoothed and often shows varying traces of secondary treatment. The junction of the obviously wheel-made neck and the rim and the hand-formed body is sometimes quite smooth, but is often uneven and quite carelessly finished. The general appearance of the pots however suggests skilful forming by the potter.

The material consists of 630 rim sherds, each containing information in the form of metrical and non-metrical variables which can be considered relevant to the characterisation of the globular pots. For obvious reasons the height, maximum girth and volume of these pots cannot be assessed on rim sherds alone. Therefore the following variables were also taken into account: the diameter of the neck, the angle of the rim, the profile of the rim, the gully of the rim, the thickness of the neck, and the (secondary) treatment of the outer surface.

In general each fragment is suitable for assessment on the above criteria. Occasionally, however, a sherd proves to lack one or more of these characteristics; sometimes a variable can be assessed but the assessment is not reproducable, either because it is too small or because of some irregularity. The first deficiency can be noted directly, the latter only after repeating the assessment. The concepts of deficiency, reproducability of assessments, and reliability of data are significant and will be considered further below.

2. The means and methods of the research.

Any investigation, in particular that on a large scale, must be conducted systematically and to a standardised format. It is therefore necessary to establish a protocol in which each variable has been defined, the research criteria formulated, measuring devices and units of measurement accounted for and every action or decision to be taken described. Such a protocol ensures as consistent an investigative procedure as possible. The choice of the characteristic and non-characteristic metric and non-metric variables is based on the objective to characterise the globular pot. Some non-characteristic variables have also been introduced to obtain reliable data from the rim fragments and to trace, for eventual elimination, the non-reproducable data. These 'assisting' variables are metric and will be discussed in due course.

The protocol.

Characteristic variables	
neck diameter	metric
angle of rim	metric
thickness of neck	metric
rim profile	non-metric
rim gully	non-metric
surface treatment	non-metric
Non-characteristic variables	
segment size of rim	metric
segment size of neck	metric
registration number of sherd	non-metric

Characteristic variables.

The neck diameter must be assessed on the line passing between the body (shoulder) and the rim on the inside of the pot (Fig. 1). This diameter of the 'entrance' of the pot is preferable to that of the rim-edge, since the latter is dependant on the rim-angle, which proves to vary considerably, whereas a more constant relationship can be expected between the diameter of the neck and the capacity of the pot. The neck diameter must be measured with an accuracy up to 5mm, for which purpose a series of 90° segment moulds were made with increasing radii of one quarter of a cm. While measuring:

— the edge of the rim must be placed upside down on a horizontal plane in as stable a position as possible, after which the correct mould must be found by fitting it in, parallel to the horizontal plane

—in the case of a slight irregularity the best fitting mould has to be selected, and if two moulds prove to fit in different places the mean value must be taken. If the sherd is obviously deformed (uncommon in this material), no measurement is taken

— in case of doubt the measurements must be rounded up (sometimes after calculating the mean).

The rim angle — is the angle between the inside tangent of the rim and the vertical axis of the globular pot (Fig. 1), which is supposed to run perpendicular to the horizontal plane, and is significant with respect to the rim profile. The angle may be assessed if the fragment is placed upside down with the rim edge in the most stable position on the horizontal plane. The measurement is carried out with so-called 'adjustable triangle' and is accurate up to 1°. If the rim surface is convex, the point of contact of the tangent has to be estimated in the middle of the width of the rim. It is sometimes difficult to establish a stable position on the horizontal plane if the sherd is too small; in such cases, however precarious this may be, the most probable stable position should be looked for.

By repeating a measurement, one can establish whether or not reproducability is possible, and thus whether or not the variable in question is present. Since local irregularities in the generally coarse surface of the pot quite often cause problems, a smooth but randomly chosen spot must be marked to ensure sensible comparisons between repeated assessments.

The rim-profile is defined as the shape of the perpendicular cross-section of the rim and adjoining shoulder (see rim-angle). It is characteristic for many pots, and is often supposed to reflect the date of the object. Therefore the definition of shapes must be as detailed as possible. In this sample population, three profiles are present (Fig. 2), coded respectively 1, 2, and 3:

1 — *the rounded profile*, which is characterised by a clear angle at the inner upper side of the rim, and a rounded outer surface which runs smoothly into the neck, although sometimes a more or less pronounced kink is present above the neck.

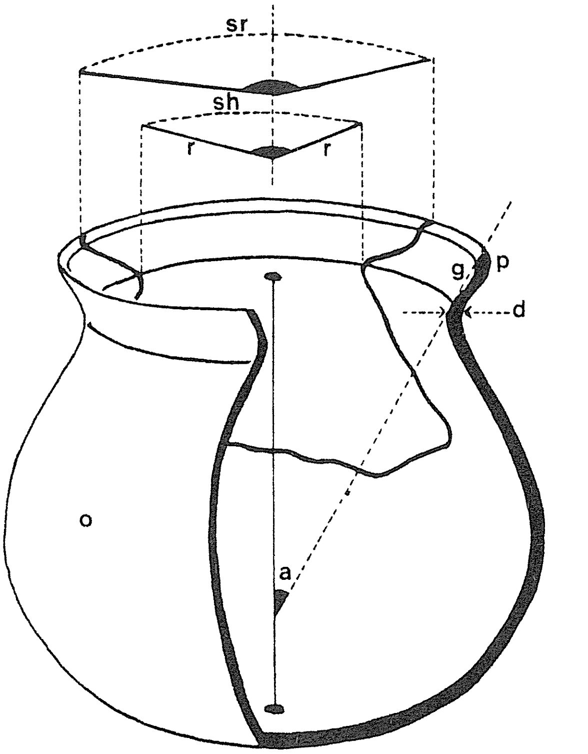

Fig. 1. Metric and non-metric variables of the globular pot: neck diameter (2xr), rim angle (a), neck thickness (d), rim gully (g), rim profile (p), surface treatment (o), neck segment (sh), rim segment (sr).

2 — *the triangular profile*, which has a sharp angle (approx. 60°) at the 'apex' of the inner upward surface of the rim and external bevel; the underside of the 'triangle' is slightly convex, after which the surface runs smoothly into the neck.

3 — *the squared or lozenge-shaped profile*, which has three angles. The first is between the inner surface and the (usually horizontal) upper surface, the second at the junction of the upper surface and the more or less vertical outer edges, and the third at the junction of that surface and the neck.

Although the illustrated examples suggest the existence of fixed angles, each type shows a variety in angle size.

The rim gully refers to the concave inner surface of the rim. If present it is usually very shallow, and taking measurements, if possible at all, makes no sense. The gully may have been non-functional, since no lids have every been found. Since eventual relationships with other variables cannot be excluded, only the presence or absence of the gully has been noted, coded respectively 1 and 2.

The surface treatment is considered to be the secondary application of grooves or scratches on the original, smoothed surface of the globular pots. The intention may have been decorative, or to aid the transfer of heat while cooking. Five types of surface treatment (globular pots viewed in an upright position) have been distinguished and coded as follows:

1 — finger wiping: smooth and shallow gullies or grooves, approximately one finger wide, and running parallel from the upper right to the lower left of the surface (Fig. 3).

2 — finger wiping: as above, but running from upper left to lower right. (Fig. 4).

3 — brush strokes (Besenstrich): more or less deep scratches, usually in horizontal, but irregularly arranged groups (Fig. 5).

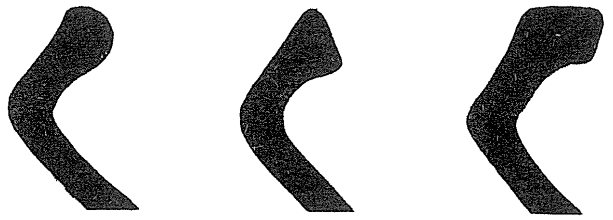

Fig. 2. Rim profiles: rounded, triangular and squared.

4 — narrow grooves: less than one finger wide, and as a rule applied at random, possibly with a small spatula; sometimes vertical, sometimes more or less diagonal (Fig. 6).

5 — a combination of roughly horizontal brush strokes, and vertical/diagonal narrow grooves, the latter applied over the first. (Fig. 7).

Non-characteristic variables.

The neck segment is the surviving part of the circumference of the neck; it is expressed in degrees (°). Assessments are linked directly to those of the neck, for which purpose each mould has been provided with a scale of 5° units. The accuracy amounts to one unit, and has to be rounded up in cases of doubt. The objective of assessing this non-characteristic variable is to establish whether any relationship exists between its size and the reproducability of the assessment of the neck diameter, and if so to calculate the critical (ie. minimum) segment size of the neck on which assessments of its diameter still prove to be reproducable.

The rim segment is the surviving part of the circumference of the rim. This is recorded in the same way as the neck segment. Recording may be linked with that of the neck segment, although obviously with a larger mould. The size of the rim segment is the determinant for the stability of the fragment when placed upside down on a horizontal plane. Stability is crucial for the assessment of the rim angle. The less stable the position of the fragment, the less reproducable the assessment of the rim angle. It might be possible to establish the critical (ie. minimum) segment size on which assessments of the rim angle will prove to be reproducable.

The fragment number, marked at random from 1 to 630, has to be considered a non-characteristic variable. This is required for the registration of the results and for recalling sherds for eventual checking.

The researcher

The researcher must consider his/her assessments intrinsically unreliable until the opposite is proven. While recording, therefore, several precautions must be taken to prove the reliability of the results, since the result of a single assessment will not as a matter of course convince the critical reader of its reliability. The only results that can be considered valid are those that prove to be reproducable. Therefore assessments must be duplicated, and moreover carried out blindly, in order to prevent any recollection while repeating the assessment. By comparing the results of repeated assessments, it is possible to establish the degree of reproducability, the *Intra-Examiner Agreement*. Non-equal assessments of a variable are also of interest; these can either be attributed to a deficiency in the sherd, or in the researcher. To eliminate the latter as far as possible, assessments must be carried out in a standardised way.

Systematic research has to be learned, practised and evaluated before application to a research programme. Even if this can be done, it is still necessary to understand that the results, though more reliable, must still be considered biased, as the individual

Fig. 3. Surface treatment: type 1.

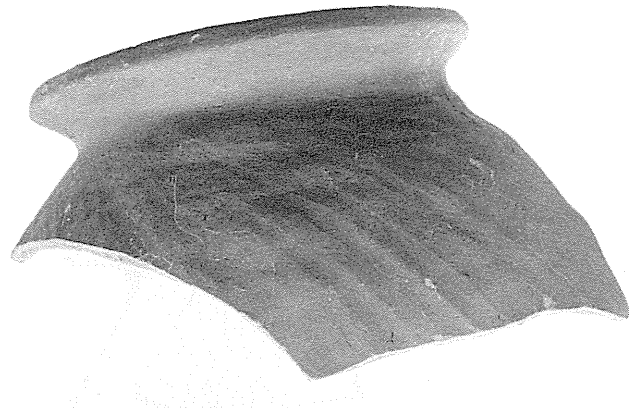

Fig. 4. Surface treatment: type 2.

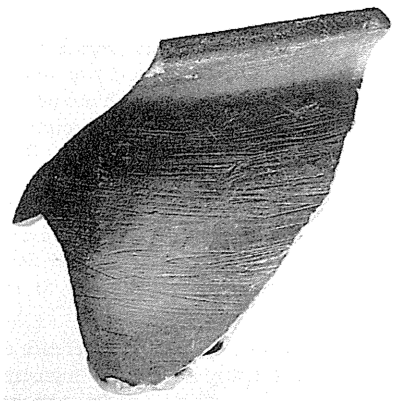

Fig. 5. Surface treatment: type 3.

Fig. 6. Surface treatment: type 4.

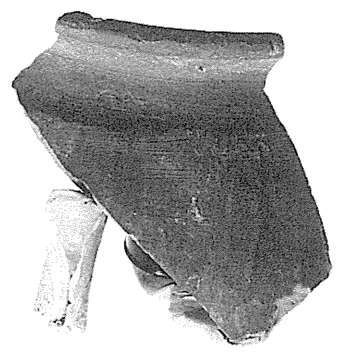

Fig. 7. Surface treatment: type 5.

abilities of the researcher, such as eyesight, accuracy etc., will influence the results. To balance this a second researcher must be introduced, and optimal reliability will only be reflected by producing both their results.

In the interests of standardisation, rather circumstantial activities were carried out before starting the definite assessments involved in this project, and the variables in question were assessed separately by the researchers on thirty randomly chosen sherds. Both series of 240 (30×8) records were compared and the differences discussed while assessing them once more together. To prevent recollection, the same assessments were carried out again one week later. *The Intra-Examiner Agreement* for each examiner could thus be established, as well as the *Inter-Examiner Agreement* between the two researchers. The latter appear to have increased considerably. Several more exercises of this kind were carried out and the calibration process gradually resulted in higher Intra- and Inter- agreements, and thus in an increasingly standardised approach to the sherds.

Finally a reference list of another series of thirty randomly chosen sherds was compiled, with 240 records upon which both researchers agreed. It was decided to reassess these sherds after every 100 sherds of real analysis. By comparing the newly obtained data with those of the reference list, any shift of standards could be stated and the researchers could make appropriate adjustments.

THE ANALYSIS

Method.

The assessments were carried out by J and T, according to the protocol and to the following schedule. Comparison (horizontal) between data of the first and second individual assessments (JI/JII, TI/TII) provides the Intra-Examiner Agreement (*intraEA*) of each investigator. Comparison (vertical) between data of both first and second assessments (JI/TI, JII/TII) provides the Inter-Examiner Agreement (*interEA*) between both researchers.

The results of the first assessments (I).

The overall disagreement between the two series of 5040 (630×8) variables to be compared amounted to 188 (3.7%). J and T agreed upon approximately three quarters of that number. In the case of disagreement, the qualification 'non-assessable' of one researcher was considered valid for the other, and the assessment of the latter was cancelled. The non-assessable phenomena proved to be equally distributed in balance between both researchers. The extreme values of 0.0 and 17.0 (Table 1) can be explained by the fact that by definition rim sherds possess profiles, but not necessarily sufficient assessable shoulder surface. The disagreement of the other variables fluctuates to some extent, and can be attributed to unfavourable fragmentation or to incidental irregularities in the material.

The InterEA per variable.

In order to compare the data of J and T, those of J were chosen as the reference.

For the metric data (Table 2), the qualifications 'more than' (>) and less than (<) therefore refer to the data of T compared to those of J. As to the non-metric data, the qualifications 'equal' (=) and 'non-equal' (≠) are valid. The percentages were calculated in relation to the available number of data (see drop out) for each variable.

neck diameter	1.3	rim profile	0.0
rim angle	6.7	surface treatment	17.0
neck thickness	0.3	neck segment	1.1
rim gully	0.2	rim segment	3.3

Table 1. The initial 'drop-out' for each variable, expressed as a percentage of the total.

		assessments						
neck diameter (unit 5 mm)	diff.	)-10	-10	-5	0	+5	+10	)+10
	n %	0.6	3.1	13.7	64.3	15.8	1.9	0.6
rim angle (unit 1°)	diff.	)- 2	- 2	-1	0	+1	+ 2	)+ 2
	n %	11.2	7.1	21.6	30.3	16.7	4.8	8.3
neck thickness (unit 1 mm)	diff.	)- 2	- 2	-1	0	+1	+ 2	)+ 2
	n %	0.0	1.1	23.1	70.1	5.7	0.0	0.0
neck segment (unit 5°)	diff.	)-10	-10	-5	0	+5	+10	)+10
	n %	2.2	3.9	18.3	56.2	12.2	4.7	2.6
rim segment (unit 5°)	diff.	)-10	-10	-5	0	+5	+10	)+10
	n %	2.0	3.4	18.4	43.0	23.5	5.1	4.6

rim gully		rim profile		surface treatment	
=	≠	=	≠	=	≠
89.7	10.3	89.0	11.0	81.6	18.4

Table 2. Inter-Examiner agreement JI/TI showing the percentages of equal and unequal assessments per variable.

variables	=	≠
neck diameter	93.8	6.2
rim angle	80.4	19.6
neck thickness	70.1	29.9
rim gully	89.7	10.3
rim profile	89.0	11.0
surface treatment	81.6	18.4
neck segment	95.3	4.8
rim segment	93.4	6.6

Table 3. The Inter-Examiner agreement JI/TI per variable (%), acceptable differences included.

variables	= (I)	= (II)
neck diameter	93.8	92.3
rim angle	80.4	83.5
neck thickness	70.1	78.0
rim gully	89.7	94.6
rim profile	89.0	90.8
surface treatment	81.6	85.4
neck segment	95.3	95.0
rim segment	93.4	91.5

Table 4. The Inter-Examiner agreement JI/TI and JII/TII per variable (%), acceptable differences included.

differences in units of measure	n	$\bar{x}$ J	$\bar{x}$ T	M J	M T
3 and more	18	54.2°	60.8°	45°	40-45°
2	31	84.5°	88.2°	80°	80°
1	194	92.4°	95.3°	85-90°	90°
0	382	94.6°	94.4°	90°	90°

Table 5. The mean ($\bar{x}$) and median (M) size of rim segments of equally and unequally assessed rim angles.

differences in units of measure	n	$\bar{x}$ J	$\bar{x}$ T	M J	M T
5 and more	40	49.9°	51.4°	45°	45°
4 and 3	54	74.6°	76.5°	70°	70-75°
2 and 1	257	97.6°	100.1°	90°	95°
0	241	97.5°	100.5°	85-90°	90-95°

Table 6. The mean ($\bar{x}$) and median (M) size of rim segments of equally and unequally assessed rim angles.

registr. nr.	neck-diam. (cm)	height (cm)	largest diam. (cm)	content (dL)
1	8.8	16.2	16.2	18.5
2	8.9	16.6	16.6	21.0
3	8.7	15.0	16.0	16.0
4	8.4	15.5	16.9	18.5
5	10.4	20.9	22.6	-
6	10.1	17.4	18.9	-
7	7.2	11.7	13.2	8.5
8	7.6	13.0	13.8	10.5
9	10.5	17.9	19.4	29.0
10	7.1	12.4	13.2	-
11	8.6	15.6	17.5	19.5
12	10.4	18.3	21.0	35.0
13	7.6	12.8	13.9	-
14	7.9	11.9	13.8	-
15	7.7	13.1	13.7	10.5
16	9.2	15.5	17.2	-
17	9.8	17.6	19.3	30.0
18	7.9	13.2	14.4	12.0
19	7.6	13.2	14.5	11.0
20	9.3	16.3	17.7	21.5
21	9.8	18.5	19.2	28.5
22	8.5	15.8	17.2	-
23	8.0	12.3	13.8	-
24	11.8	21.9	24.0	-

Table 7. Metric variables of (nearly) complete globular pots.

category	n J	$\bar{x}$	fr.f.	n T	$\bar{x}$	fr.f.
ø 70 - 95 mm (small)	176	109.4°	3.3	171	111.3°	3.2
ø 100 - 125 mm (medium small)	226	92.7°	3.9	227	92.5°	3.9
ø 130 - 155 mm (medium large)	154	85.8°	4.2	162	84.5°	4.3
ø 160 - 190 mm (large)	68	77.6°	4.6	64	74.7°	4.8

Table 8. The mean ($\bar{x}$) of neck segments in small, medium small, medium large, and large globular pots, and the fragmentation factor for each category.

	J II			T II		
diam. of neck	n abs. a	n abs. b	n %	n abs. a	n abs. b	n %
70	0.6	0.6	0.4	0.6	0.6	0.4
75	3.9			3.8		
80	5.2	9.1	5.6	5.9	9.7	6.0
85	8.5			7.5		
90	16.0	24.5	15.1	18.4	25.9	16.0
95	17.0			15.0		
100	13.8	30.8	19.0	16.4	31.4	19.4
105	13.3			13.3		
110	9.0	22.3	13.8	7.4	20.7	12.8
115	6.7			6.4		
120	9.7	16.4	10.1	8.2	14.6	9.1
125	5.9			7.2		
130	5.7	11.6	7.1	6.0	13.2	8.1
135	8.6			8.8		
140	7.6	16.2	10.0	6.7	15.5	9.5
145	6.4			6.3		
150	4.7	11.1	6.9	5.6	11.9	7.4
155	4.0			4.9		
160	5.0	9.0	5.6	4.6	9.5	5.8
165	5.0			4.0		
170	1.7	6.7	4.1	1.9	5.9	3.7
175	1.7			1.5		
180	0.7	2.4	1.4	0.6	2.1	1.3
185	0.2			0.6		
190	1.1	1.3	0.8	0.4	1.0	0.6
	162.0	162.0	99.9	162.0	162.0	100.0

Table 9. Absolute and percentage frequency distribution of 360°-neck segment (= globular pots); for each category the fragmentation factor has been taken into account

It was found that approximately two thirds of the neck diameters were assessed equally, and that the unequal data are reasonably distributed in balance. The rim angle shows the lowest interEA, possibly because of the very small unit of measure that was chosen. A relatively high interEA can be noticed for the neck thickness; however, the rather high percentage of unequal data and in particular their very unbalanced distribution are cause for concern. This high number either reflects the quality of the sherds, or the method of measuring.

The non-characteristic *neck and rim segments* show rather low inter-EA values. Neither the reasons for these low values, nor those for the unbalanced and even contrasting distribution of unequal data can be accounted for at present.

The characteristic non-metric *gully, profile and surface treatment* show relatively high interEA values; the latter is the lowest of these three variables, possibly because of the problematic distinction between images when only small surfaces are available for analysis.

In all cases the phenomenon of unbalanced distributions of unequal data can only be attributed to the researcher(s), and indicates that the calibration procedures have been unsatisfactory. It implies that, before starting the second series of assessments, attention should once more be paid to individual and mutual standardisation. The consequences of the sometimes rather alarming numbers of unequal data prove however to be less dramatic if the real significance of the differences in assessment between the researchers is analysed in more detail.

Acceptable and unacceptable differences between assessments.

As already stated, it is likely that the more substantial differences in the assessments of J and T can be attributed to deficiences in the variables of the potsherds, whereas smaller differences can be attributed to the abilities of the researchers. The latter, inherent even in the most carefully conducted assessments, increases if rather small units of measure are applied. As a result, it is justifiable to introduce acceptable and unacceptable differences between assessments. To substantiate this distinction, the applied units of measure for each variable have been related to the range between the highest and lowest values of the assessments.

For the *neck diameter*, the extreme values of the range prove to be 70mm and 190mm, the mean amounting to 130mm. If a 5% difference between assessments is considered to be acceptable, it can be calculated that a 1 unit difference (5mm) in relation to the mean value of the range amounts to 3.8%, which is evidently within the 5% limit. If calculated in more detail, in size categories of 70–110mm, 115–150mm, 155–190mm, the 1 unit difference proves to correspond with 5.5%, 3.8% and 2.9% respectively. Though slightly above the limit in the case of the smallest category, this seems to be acceptable. A difference of 1 unit is consequently acceptable in all respects.

For the *rim angle*, which ranges from 10–45°, differences of 1° and 2° in relation to the mean of the range prove to be differences of 2.9% and 5.7%. Both can be considered acceptable, but differences exceeding 2° are unacceptable.

The *neck thickness* varies from 4–12mm. It can be calculated that a 1 unit difference (1mm) in relation to the mean of the range (8mm) amounts to a difference of 12.5%. Consequently any difference between assessments can be considered a real difference and is thus unacceptable.

Identical calculations on the data of the non-characteristic *neck and rim segments* indicate the acceptability of differences up to 2 units of measure (5° and 10° circumference), which could be expected in view of the range of some tens of degrees up to 360°.

The 5% limit assumed above and the subsequent deductions will be proved to be justified in due course (Tables 4 and 5).

As a consequence of these considerations, it is possible to present an adjusted and simplified version of Table 2 (Table 3). Though this presentation solves the phenomenon of the unbalanced distribution of the remaining unequal data, it does not mean that it can be ignored. On the contrary, before starting the second series of assessments, a second extensive calibration procedure must be carried out in order to enhance individual and mutual standardisation as much as possible.

The results of the second assessment (II).

These results indicate in general that the preliminary interEA of J and T has increased considerably, apart from a slight decrease in some variables. It can also be noticed (Table 4) that the previously unbalanced distributions of unequal data have improved considerably, though not to the full extent. As for the rim angle, an almost perfect balance proves to be present. With respect to the thickness of the neck however, no improvement can be noticed. Since the intraEA of both J and T increased as well, the overall conclusion that repeated calibration, and greater experience, have resulted in as great a standardisation of assessment as possible seems to be justified. Consequently the data obtained from the second series of assessments can be qualified as the most reliable, and will be used for the objective calculations on the globular pots. There remains, however, one more general and interesting phenomenon that deserves particular attention before the calculations are made.

The 'critical segment size'.

The non-characteristic variables of *neck and rim segment* have already been introduced in the protocol with regard to the reproducability of the assessments of, respectively, the neck diameter and those of the rim angle (see above). The available series (JII and TII) of 625 records of the neck diameter have been divided according to the extent of the differences between J and T, and the mean and median values of the relevant segment sizes calculated (Table 5).

Since the differences between the respective mean values prove to be non-significant (high standard deviations because of fluctuating segment sizes), operating the median values may be preferable. It may be concluded that:

— there is a clear relationship between the reproducability of measurements of the neck diameter and the size of the relevant neck-segment. Assessments prove to be reproducable, and thus reliable, on segments of approximately 90° or more, but become less reproducable as the segment size decreases.

—in the case of differences of up to one (5mm) units of measure, the relevant segment sizes prove to be equal, which confirms the acceptability of one unit differences between assessments.

—the overall (small) difference between both researchers may be considered a reflection of their individual biases.

As for the reproducability of the measurements of the *rim angle* in relation to the size of the relevant rim segments, 595 records are available. The results of the same calculations as before are presented in Table 6. The differences between the respective mean values prove to be non-significant as well, and the following conclusions may be drawn:

—there is a clear relationship between the reproducability of measurements of the rim angle and the size of the pertaining rim segment. Assessments of rim angles prove to be reproducable on segments of approximately 90° and more, and increasingly non reproducable as the segment size decreases

—in the case of differences up to 1° and 2°, segment sizes still prove to be equal to those with no difference at all, which confirms the acceptability of differences up to 2° between assessments

— the overall difference between both examiners reflects the individual biases: T tends to assess 'higher' than J (or J 'lower' than T).

The relationship between the neck diameter and the overall size of the globular pot.

As mentioned above, the variables of height, maximum girth and volume cannot be measured on rim fragments alone. However, if a correlation between the neck diameter and one or more of these variables can be demonstrated, it should be possible to calculate the size of the globular pot indirectly. The availability of a number of complete pots provided the opportunity to verify an eventual relationship. Apart from two specimens found in the waster pit, twenty-two other pots were found during the excavation close to the pit. All were wasters, but were only cracked, and their rim profiles, rim gully and surface treatment were very similar. It was therefore thought justifiable to use these pots to assess the metric variables in question.

For the objective calculations, the measurements were this time taken with an accuracy of up to 1mm. By not rounding-off the data it was felt that the results for the following calculations would be more realistic. The diameters for both the neck and maximum circumference were calculated by taking the mean of several assessments perpendicular to one another. The volume of the pots was measured by filling them with dry sand up to the neck (see *neck diameter*), and applying a measuring glass accurate up to half a dl. The results of these assessments are shown in Table 7. Scatter diagrams have been prepared for the three relationships in question, and the respective regression equations calculated. The regression lines are shown in Fig. 8, and it is obvious that the calculated co-efficients reflect almost perfect correlations between the neck diameter on the one hand and the height, maximum diameter and volume on the other. The neck diameter is thus shown to be an essential variable of the globular pot, and to be appropriate when establishing its size. However, one important question must be considered before a quantitative reconstruction of complete pots from sherds can be carried out: do globular pots always break into a constant number of neck sherds when dropped?

The fragmentation factor.

An indiscriminate use of the neck diameter for the objective quantitative reconstruction of neck fragments into complete globular pots is only possible if, regardless of their size, pots break into the same number of neck fragments. To establish whether this is true or false, the sherds were divided into four size categories — small, medium-small, medium-large, and large according to neck diameter (see Table 8). After calculating the mean of the relevant segment sizes for each category, the fragmentation factor was assessed (dividing 360° by the mean segment value) to express the mean number of neck fragments into which globular pots of one category break.

The results in Table 8 show that the larger the globular pot, the smaller the neck fragment and the higher the fragmentation factor. Although the mean values do not differ significantly, the overall trend seems clear. In the first instance this is not surprising since fragmentation is undoubtedly related to mass and thickness. With increasing size, the mass of a pot increases exponentially in comparison to its increase in thickness. The pot therefore becomes relatively less thick, and more breakable. Since this phenomenon has been verified, it is imperative to take the fragmentation factor into consideration if quantitative reconstruction is intended.

The quantitative reconstruction of globular pots.

By applying the neck diameters to the reconstruction of complete globular pots, the primary 'drop-out' of six sherds (easily one pot) appears to be negligible. Elimination of the forty-nine deficient fragments however (Table 4: 18+31,

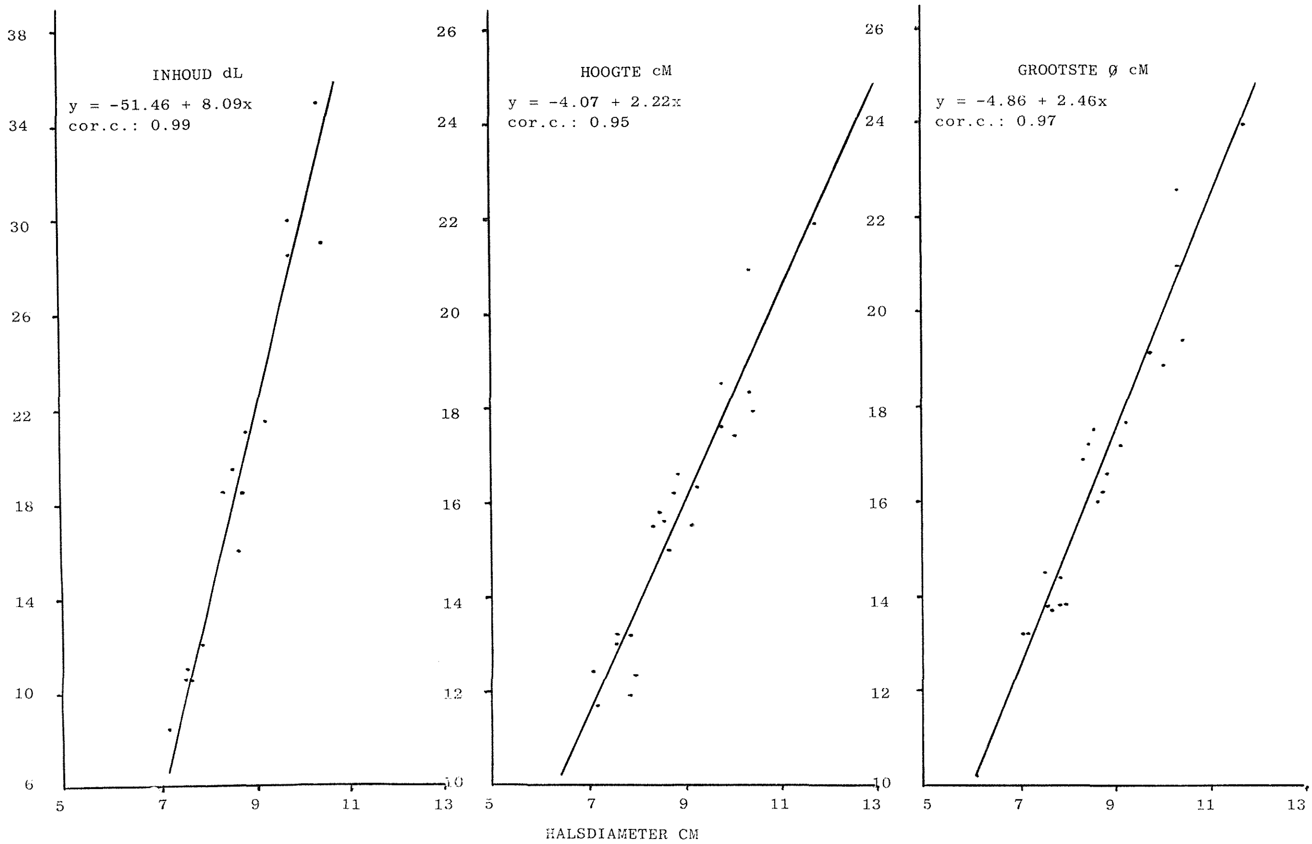

Fig. 8. Scatter diagrams and regression lines to show the relationship of neck diameter (halsdiameter) to content (inhoud), height (hoogte), and maximum girth (grootste), with equations showing the regression and correlation co-efficients.

approx. twelve globular pots) is rather high if realistic quantification is intended[2]. It was therefore decided to include these sherds because the consideration of a slightly incorrect quantification of the complete material seems preferable to a correct quantification of the incomplete material. It must be emphasised, however, that the data on the forty-nine sherds in question must be eliminated when establishing eventual intervariable relationships.

The results of these calculations are shown in Table 9. Of the categories mentioned above (Table 8), the absolute frequencies of 360° neck fragments (which equals complete globular pots) have been calculated for each diameter (n abs.a) by dividing the number of fragments by the corresponding fragmentation factor. For practical reasons the numbers of pairs of diameters (70, 75+80, 85+90 etc.) have been taken together (n. abs.b) and subsequently converted into percentages (n%). The absolute number of globular pots amounts to 162, a number which can be considered rather inaccurate. A graphic representation of the percentage frequency distribution shows the difference betwen J and T (Fig. 9). However small, it shows the non-existence of absolutely reliable results.

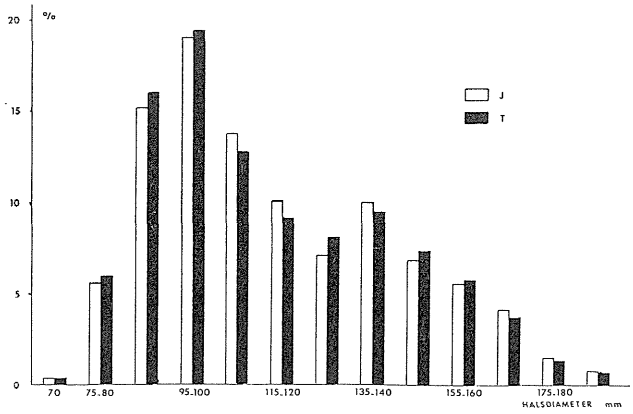

Fig. 9. Percentage frequency distribution (of both J and T) of the globular pots based on neck diameter; population I, 162 vessels.

Ø neck	number absolute		perc.	height cm	largest Ø cm	content L
70	0.6	1	0.6	11	12	0.4
75 80	9.1	9	5.6	14	15	1.3
85 90	24.5	25	15.4	16	17	2.1
95 100	30.8	31	19.1	18	20	3.0
105 110	22.3	22	13.6	20	22	3.8
115 120	16.4	16	9.9	23	25	4.7
125 130	11.6	12	7.4	25	27	5.5
135 140	16.2	16	9.9	27	30	6.4
145 150	11.1	11	6.8	29	32	7.2
155 160	9.0	9	5.6	32	35	8.1
165 170	6.7	7	4.3	34	37	8.9
175 180	2.4	2	1.2	36	40	9.8
185 190	1.3	1	0.6	38	42	10.6
	162.0	162	100.0			

Table 10. The absolute and percentage frequency distribution of globular pots (data of J only) and the approximate values of height, maximum girth and volume.

diameter of neck	rim fragments n abs.	n drop out	codes of surface treatment n: 1	2	3	4	5
70	2	0	0	2	0	0	0
75 80	26	5	9	12	2	1	2
85 90	70	13	24	24	1	12	9
95 100	87	25	12	43	9	10	13
105 110	66	15	8	36	2	9	11
115 120	44	13	5	21	1	9	8
125 130	44	10	3	11	4	12	14
135 140	58	9	4	14	7	10	23
145 150	41	10	2	12	7	5	15
155 160	36	7	4	15	1	7	9
165 170	25	3	2	10	3	6	4
175 180	10	0	2	1	0	3	4
185 190	5	0	0	4	0	0	1
	514	110	75	205	37	84	113
	(624)		(514)				

Table 11. The relationship of the neck diameter and surface treatment expressed as absolute frequencies.

neck-diam. (mm) (category)	popul. I x̄ neck-segm.	popul. I fragm. fact.	popul. II x̄ neck-segm.	popul. II fragm. fact.	popul. III x̄ neck-segm.	popul. III fragm. fact.
70 - 95 (small)	109.4°	3.3	80.8°	4.5	90.1°	4.0
100 - 125 (medium small)	92.7°	3.9	69.8°	5.2	76.1°	4.7
130 - 155 (medium large)	85.8°	4.2	60.9°	5.9	71.2°	5.1
160 - 190 (large)	77.6°	4.6	55.2°	6.5	64.3°	5.6

Table 12. The mean segment-size (x) of neck fragments and the fragmentation factor in small, medium small, medium large and large globular pots: populations I, II, and III.

neck-diam. (mm)	popul. I n abs.	perc.	popul. II n abs.	perc.	popul. III n abs.	perc.
70	1	0.6	5	2.2	3	1.3
75/ 80	9	5.6	17	7.5	17	7.6
85 90	25	15.4	42	18.6	38	16.9
95/100	31	19.1	50	22.1	70	31.1
105/110	22	13.6	37	16.4	36	16.0
115.120	16	9.9	26	11.5	19	8.4
125.130	12	7.4	22	9.7	15	6.7
135/140	16	9.9	12	5.4	13	5.8
145/150	11	6.8	6	2.7	7	3.1
155 160	9	5.6	5	2.2	3	1.3
165 170	7	4.3	3	1.3	1	0.4
175 180	2	1.2	1	0.4	1	0.4
165.190	1	0.6	0	0.0	2	0.9
	162	100.0	226	100.0	225	99.9

Table 13. Absolute and percentage frequency distribution of globular pots based on neck diameter; populations I, II, III.

Interpreting the frequency distribution for its practical significance is not easy while the numbers (percentages) are expressed as neck diameters. By converting these into height, maximum diameter and volume, the significance becomes clearer. The conversion may be carried out by means of the regression equations already quoted.

The results of the calculations, starting with the data in Table 9, column n abs.a, are shown in Table 10. They have been rounded off rather crudely in order to present whole numbers. The results have been obtained by using the data of J only. To confirm the difference between J and T once more seemed at this point superfluous.

REFLECTIONS

As noted above, there are several reasons for assuming that the material in question can be considered as the complete misfired contents of one kiln. Consequently the variety in the sizes of the globular pots may reflect the variety in the production of the potter, and thus the variety in the demand of the consumer. Seen in this context, Table 9 shows that:

—about three quarters of the globular pots have a capacity of 2 – 6 litres, of which the majority (20%) have a capacity of 3 litres.

—the number of pots with a capacity of one litre and 7 – 9 litres accounts for c.25% of the total production.

—the very small and very large pots (less than one litre and more than nine litres) together account for less than 1% of the total.

Globular pots are usually considered as cooking pots. This seems to be confirmed by the size range of the majority of the pots (2 – 6 litres), for although this seems rather large in terms of food quantities, it must be borne in mind that the volume of the pots has been assessed up to neck level, whereas in cooking the level would certainly have been lower, maybe halfway or slightly higher. It is unlikely that either the very large or the very small globular pots were used for cooking. The large pots are extremely heavy, and probably had a stationary function, such as the storage of solid food or water, the latter favoured by the slightly porous material (evaporation, cooling). The very small pots are rather exceptional; these may have been used for drinking or for the storage of dry foods such as spices.

In view of the very gradual increase in the sizes of the complete series of globular pots, it seems unlikely that production was standardised. Indeed this could hardly be expected with handmade pottery. Even if standardised lumps of clay were used, as some authors suggest, different sizes would still result. More substantial lumps of clay were probably divided by hand into more or less equal portions, depending on the size of the pots to be produced. The potter may have been able to judge by experience the amount of clay needed to produce a particular size, but the exact size would nonetheless be unpredictable.

In the attempt to calculate the space required in a kiln for 162 globular pots, several possible ways of stacking were considered. The estimated shrinkage of the pots during firing (c.15%) was also taken into consideration. The results indicate that some three to four cubic metres would have been needed. Attempts to reconstruct kilns by measuring the remains of excavated examples suggest that effective firing areas of four cubic metres were not exceptional, but that larger areas were much more common. It must be remembered, however, that some fifteen, mainly large, dishes and jugs of identically fired greyware were also found with the globular pots, which would have required an additional firing space of approximately one third of a cubic metre (see note 1).

Other intervariable relationships

Before considering other relationships, it must be remembered that near perfect correlations could be established between the neck diameter, maximum diameter, and volume. Attention still has to be paid to the (metric) neck thickness and rim angle. It is not surprising that a positive relationship exists between the neck thickness and the overall size of the globular pot. However, the correlation is less than was first expected. This may be caused by the crudeness of the junction between the body and the rim of the pots, as already noted. Large globular pots with disproportionately thin necks appear to be common.

No relationship whatsoever can be established between the rim angle and the other metric variables, and the size of the angle has obviously resulted by chance.

As for eventual relationships between the diameter of the neck, which is representative for the overall size of the globular pot, and the non-metric rim profile, rim gully, and surface treatment, forty-nine data sets have been eliminated as discussed above. No possible relationship could be established, either between the metric and non-metric variables, or within the non-metric variables, or in any combination.

There is no point in presenting all the calculations, but to illustrate the complete lack of any correlation, one randomly chosen example will be provided: neck diameter versus surface treatment (Table 11). The frequency distribution of the various forms of surface treatment with respect to the diameter of the neck clearly shows the absence of any relationship or even any trend between these variables.

To summarise, it is evident that the shape of the rim profile, the presence of the rim gully, and the nature of the surface treatment have resulted by chance, as already shown with respect to the rim angle. That the preference or specialisation of the potter has been decisive in this cannot, however, be excluded from the interpretation.

ADDITIONAL RESEARCH ON SHERDS FROM GLOBULAR POTS

The contents of two other, even larger, waster pits (II and III) on the same site provided a further opportunity to study globular pots and to investigate whether other differences or similarities could be established, based on the results of the previous analysis. The quantity and quality of the fragments again justified the assumption that each population represented the complete misfired contents from a single firing.

Apart from a wide range of red and grey wasters, both complexes proved to contain many hundreds of sherds derived from globular pots. Although uniform within each of the three populations, some differences between them could be distinguished, particularly with regard to the outer appearance of the sherds. Besides differences in colour, the quality of the surface also appeared to be different. The sherds from complexes I, III, and II became increasingly blacker in that order, although this difference could only be observed when heaps of fragments were compared side by side. The outer surfaces showed a slight but clear variation in smoothness (coarseness). Though difficult to evaluate precisely, both phenomena could systematically be proven present within each population.

Following the results of investigation I, it was decided to limit the assessment of variables to those of neck diameter, the neck segment, rim profiles and surface treatment. For practical reasons, the research was carried out by T only. His ability to record reliably could be proven by replicating assessments (blindly) on randomly chosen fragments. His results must however be considered biased as discussed above. The results of the investigations II and III are presented here without the basic calculations.

The numbers of rim sherds from groups II and III amount to 1102 and 1081 respectively, the primary 'drop-out' with regard to the neck diameter is 133 (10.7%) and 72 (6.6%). The percentages considerably exceed those of population I, but the

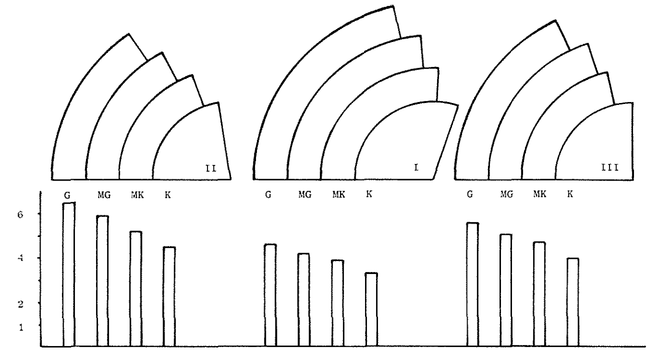

Fig. 10. The mean segment size of the neck fragments and the fragmentation factor of large (G), medium large (MG), medium small (MK) and small (K) globular pots of the populations I, II, and III.

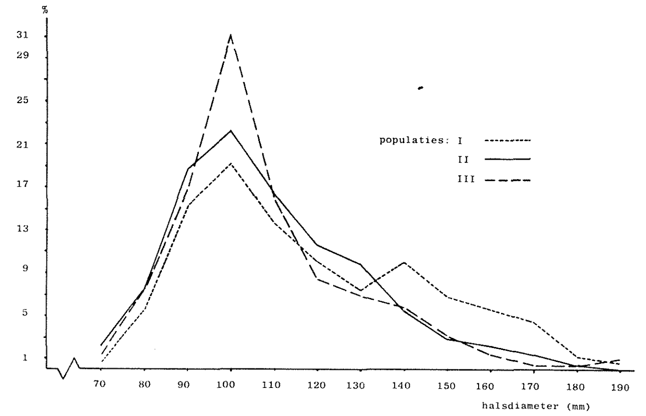

Fig. 11. Percentage frequency distributions of globular pots based on neck diameter; populations I, II, III (see Table 13).

For the reproducability of assessing the neck size in relation to the relevant neck segment, the value of the 'critical segment size' was confirmed.

The calculations of the fragmentation factors of the globular pots in groups II and III were carried out in the same way as those on group I. The values (Table 12) for the four size categories again show that the larger the pot, the higher the fragmentation factor. Though the respective mean segment sizes do not differ significantly, the general trend appears to be as obvious as in I. Statistically the trends in all populations prove to be equal, as the correlation co-efficients indicate: I vs II = 0.99; II vs III = 0.98; I vs III = 0.99. However there appears to be a remarkable difference as well. The globular pots of I, III, and II are shown (in this order) to have been broken into an increasing number of (smaller) fragments, as illustrated in Fig. 10.

The reason for this difference may be explained as follows. The level of fragmentation suffered by a pot when dropped or dumped is clearly related to the thickness and mass of the material; these variables could be proven identical in all three populations. The depth of the waster pit undoubtedly plays a rôle (gravity) as does the thickness (mass) of the covering layer of earth. Finally the dumped pottery may have been physically compressed within the pit. It is not easy to speculate on such extrinsic influences, but it seems unlikely that the subsequent effects were as systematic as they may appear. The identical proportionate fragmentation within the three populations which only differs with respect to the level, suggests an intrinsic cause within the material.

The most obvious quality of pottery, with regard to fragmentation, is its fragility or brittleness. Differences between populations of pottery in this respect are likely to be reflected in differences between their fragmentation. Physical methods of evaluating brittleness are not available, but are likely to exist. If brittleness can be evaluated, and if the above assumption can be proved true, the fragmentation factor might be an interesting parameter in pottery research. It seems to be possible to apply this parameter, although the phenomenon of brittleness itself happens to be the product of several factors, such as the quality or composition of the clay, the influences during the various stages of processing the clay, and the firing conditons within the kiln.

For quantitative reconstructions and comparative studies of substantial populations of rim sherds, the significance of the fragmentation factor seems to be indisputable, but its value must be established and taken into account. The extent of the relationship between the fragmentation factor and brittleness of the pottery remains questionable for the time being, but seems to merit further (physical) research.

With regard to the quantitative reconstructions of the rim sherds in groups II and III (Table 13), the almost equal numbers of 226 and 225 globular pots must initially be considered as coincidence. The required firing space for that number in a kiln, however, is calculated at 5 – 6 cubic metres (see investigation I), which agrees well with the estimated capacities of the excavated kilns. If the quantity of globular pots in groups II and III, plus another five pots to compensate for the 'drop-out', approximately matches the average firing space in a kiln, then perhaps the relatively low number in group I (162 globular pots) was indeed supplemented by a number of grey wares (or successfully fried pots).

The frequency distributions of the populations of globular pots I, II and III, expressed as a percentage of the whole assemblage, are presented in Fig. 11, which confirms the previously established variety and distribution in size.

RECOMMENDATIONS

1. Before carrying out research on pottery fragments it is imperative to prepare a research strategy or protocol. For standardised procedures, the relevant characteristics of the material and the methods and means of the research must be defined, and finally the abilities of the researcher must be considered.
2. Assessments on rim sherds must be carried out in duplicate and blindly. The degree of reproducability of assessments indicates whether the material can provide reliable data (eventual deficiency) or whether the assessments of the researcher may be replicated (Intra Examiner Agreement).
3. Assessments, particularly those on a large scale, must be carried out by two researchers in order to establish individual bias (Inter Examiner Agreement) and the (relative) reliability of the work. Beforehand, individual and mutual calibration procedures must be performed to prevent, as far as possible, a shift of standards during the investigation.
4. Reconstructions based on rim (neck) sherds smaller than 90° circumference have to be rejected as being pseudo-informative. In more and less developed pottery the critical 90° segment size may be supposed to have higher and lower values respectively. As a rule,

however, a minimum 90° segment size is recommended. If reconstructions on insignificant rim fragments are nonetheless attempted, the results must be presented with the degree of (un) reliability.

5. Several observations, neither on a large scale, nor systematically performed, suggest a universal applicability of the established regression equations on globular pots of different origin and dating for reasonably reliable results. In that context the frequency distribution presented seems to be practicable for comparative studies.

6. If quantitative reconstructions of the same kind are attempted, the fragmentation factors must be established and taken into account.

7. Using the shape of the rim profiles for dating globular pots is questionable. Twelve different rim profiles were found scattered across the site at Oudenoord, all of 14th-century date, but including some which until now have been considered typical of earlier centuries. For the time being, extreme care is recommended if globular pots are to be dated on rim profile alone.

Notes.

1. The pottery from the first waster pit comprises 88% globular pots, 7% grey wares, 4% red wares, 1% stoneware and tile (crudely quantified according to minimum numbers). It is likely that the globular pots and grey wares originated from the same firing process at the local production centre, the red wares and tiles from another kiln nearby. The stonewares represent imported jars which were probably used by the potters.

2. If the inadequate sherds are excluded, the percentage frequency distribution proves to remain nearly the same, which is not the case for the absolute distribution. This means that the distribution of the forty-nine deficient fragments proves to be quite balanced, as might be expected in view of the high number of fragments.

*Centre for Archaeological and Building History Zwaansteeg 11, 3511 VG Utrecht, Netherlands.

Resumé

Une fouille archéologique à Utrecht a mis au jour un ensemble clos de poteries de XIVe siècle, dont un grand nombre de tessons proviennent de pots globulaires. Leur connaissance quantitative et qualitative étant très réduites, on a décidé d'en poursuivre l'analyse à partir des fragments de lèvres. A cette fin, il a semblé bon d'adopter une méthodes de recherche plus pertinente fournissant des données les plus sures possible. Un protocole de recherche a donc été défini, ainsi que les méthodes et les moyens d'estimation et l'influence du chercheur. La duplication des estimations, menées par deux chercheurs, a permis non seulement d'obtenir des données sures, mais aussi de calculer la "taille critique des segments" et le "facteur de fragmentation" des tessons de lèvres, concepts nouveaux applicables à toutes les poteries decouvertes en fouilles. L'analyse a permis d'établir la présence et l'absence de plusieurs relations entre les variables, certaines d'entre elles ayant servi à la quantification détaillée des pots globulaires. L'étude comparative des poteries de deux autres fosses-dépotoirs a montré des ressemblances frappantes mais aussi des différences remarquables entre ces trois populations.

Zusammenfassung

Bei einer archäologischen Ausgrabung in Utrecht wurde ein grösser, geschlossener Komplex von Keramik aus dem 14. Jhd. gefunden, die grössenteils von Kugelförmigen Töpfen bestand. Weil relativ wenig über die Quantität und Qualität dieser Keramik bekannt ist, wurde es beschlossen, im einzelnem, eine analytische Untersuchung der Randfragmente vorzunehmen. Weil den Randscherben bisher in der Forschung nicht genugend Aufmerksamkeit geschenkt wurde, schien es notig zu sein, eine sehr genaue Untersuchungsmethode anzuwenden die moglichst verlässiche Daten erbringen sollte.

Ein Arbeitsstrategie wurde erstellt, um die Forschung zu vereinhalten. Charakteristische Formen der Keramik wurden ausgesucht und bestimmt. Methoden und Mittel der Auswertung wurden eingeführt und der Einfluss der Forscher wurde berücksichtigt.

Die Ergebnisse wurden überpruft von zwei verschiedenen Forscher, um die verlässige Daten zu erhalten und darüber hinaus die "Critical Segment Size" und den "Fragmentation Factor" von Randscherben zu kalkulieren. Man geht davon aus dass diese neuen Konzepte auch auf Untersuchungen von Grabungskeramik im allgemeinen angewendet werden können. Ausserdem werden andere Empfehlungen für Keramikforschung dargestellt.

Eine vergleichbare Studie mit der Keramik von zwei weiteren Fehlbrandgruben schlägt einige öffentliche Ähnlichkeiten zwischen den drei Gruppen vor, aber auch einige betrachliche Unterschiede, deren möglichen Ursachen diskutiert werden.