9

THE TO'AGA CERAMICS

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CERAMICS HAVE PLAYED a critical role in understanding prehistory in Samoa and West Polynesia. They are usually well preserved, archaeologically visible, and carry a large amount of information on variation in style (temporal and spatial), technology, function, and raw material. While ceramics have proven useful for making culture-historical inferences about Samoa and the region, they also present several interesting problems to be resolved in their own right. First, what is the nature of ceramic variability (temporal and spatial) in Samoa? Second, what kinds of change (stylistic, technological/material, and functional) occurred over the duration of ceramic production in Samoa? And third, why did ceramics disappear in Samoa after an approximate thousand-year sequence of production? In this chapter we describe the ceramic assemblage from the To'aga excavations and begin to address these questions through analyses of ceramic clay composition, technology, function, and style.

THE ASSEMBLAGE

The 1986 excavations on Ofu and neighboring Ta'u produced a total of 147 sherds (32 sherds from To'aga), and were analyzed and reported in Hunt and Kirch (1988:169-71). The 1987 field season added 1464 sherds to the To'aga assemblage. These sherds were described by Kirch et al. (1990:7-8) and are further analyzed here. Excavations in 1989 provided an additional 938 sherds to the previous total. In sum, three seasons of fieldwork at To'aga (AS-13-1) have yielded a total ceramic assemblage of 2434 sherds.

The To'aga ceramic assemblage is significant in several respects. The sherds come from a deep, well-stratified site dated with several radiocarbon determinations (see chapters 5 and 6). The assemblage spans the full duration known for ceramic production in Samoa, and consists of quantities of the pottery distinguished as "thickware" and "thinware" (see Green 1974; Holmer 1980; Clark and Herdrich 1988). Pottery from To'aga, Samoa's easternmost ceramic-bearing site, dates to the first millennium B.C. Finally, the To'aga assemblage is among the largest excavated in Samoa—only the SU-SA-3 (Green 1974) assemblage from 'Upolu is larger—and thus provides an adequate sample to assess several dimensions of variability.

The entire ceramic assemblage has been cataloged, with individual sherds enumerated. In the most general terms, the assemblage can be divided into broad classes of thickware and thinware sherds. This division of wares is based on sherd thickness, temper size, and paste texture. Such distinctions are qualitative (and somewhat impressionistic), however, and do not accurately reflect the range of variability present in the assemblage—hence the need for detailed analysis. Vessel parts include only direct rims (no necks) and body sherds, indicative of a single class of vessel forms comprising open, round-based bowls. While occurring in only minor frequencies, classes of decoration include red-slipped, carved paddle-impressed, incised, and rim sherds with notched, impressed, or crenelated lips. Frequencies of sherds by these broad classes in stratigraphic context are summarized in tables 9.1-2.

Detailed analysis of ceramics is extremely labor intensive. Observations and measurements on individual sherds can require as much as five to ten minutes each. This problem requires selecting a representative sample from the larger assemblage. In the case of To'aga, we chose excavation units with larger samples. Also, pottery was selected from excavation units to span the full temporal sequence represented at To'aga. This strategy enabled us to assess change across the full sequence of pottery manufacture at To'aga.

Sherd samples were drawn from the main areal excavation of 1987 (units 1 and 4-9, see Kirch et al. 1990 and chapter 5) and from units 27 and 28 excavated in 1990. The total sample selected for intensive analysis is 737 sherds.

The main areal excavation of 1987 (units 1 and 4-9) contained a large number of sherds (n=527) within a well-dated, stratified context. The primary ceramic-bearing occupation layers are dated (Beta-25033, 25034) to an averaged corrected range of 306-138 B.C. at one standard deviation (see chapter 6 and Kirch et al. 1990). Units 27 and 28, excavated in 1989, were selected because they provided large samples from early contexts (see chapters 5 and 6).

Based on radiocarbon dates and stratigraphic correlations, the sherds for intensive analysis can be divided into early, middle, and late periods for comparative purposes. The early ceramics, from layer III in units 1, 5-7, 9, and 28, range from approximately 1250-500 B.C. Middle period ceramics, from layer II (B and C) in units 1, 4-7, 9, 27, and 28, range from about 500 B.C. to the beginning of the Christian era. The late period sample, from layer II (A) in units 4-9 and 27, dates from the time of Christ and may span the first 200-300 years A.D. These are not "ceramic periods" or "phases," but simply represent a three-part division devised to analyze change in the sample.

The protocol for intensive analysis was designed to assess variability in raw materials, technology, style, and function. In addition to recording provenience (by unit, stratum, and level) and catalog number for each sherd, the following analytic protocol was used and observations or measurements coded for analysis (using SPSS- PC+; Norusis 1986):

1) Exterior surface treatment:
  0. eroded ("missing data")
  1. plain (untextured)
  2. wiped (striations present)
  3. puddled
  4. slipped
  5. carved paddle impressed
  6. residue obscuring ("missing data')

2) Interior surface treatment:
  (same criteria as above)

3) Orientation of inclusions ("preference") relative to vessel walls:
  1. indeterminate (i.e. no definitive long axis to grains)
  2. random orientation
  3. parallel
  4. perpendicular

4) Interior anvil casts:
  0. indeterminate ("missing data")
  1. present
  2. absent

5) Exterior paddle marks casts:
  0. indeterminate ("missing data")
  1. present
  2. absent

6) Exterior hardness (Mohs scale)

7) Interior hardness (Mohs scale)

8) Exterior surface color (Munsell):
  0. eroded ("missing data")
  1. 7.5R (& value & chroma for all modes)
  2. 5R
  3. 10R
  4. 2.5YR
  5. 5YR
  6. 7.5YR
  7. 10YR
  8. 2.5Y
  9. 5Y

9) Interior surface color (Munsell):
  (recorded same as above)

10) Oxidation/reduction pattern (using pattern template)

11) Organic residue:
  0. absent
  1. interior
  2. exterior
  3. both surfaces

12) Weight of sherd (grams)

13) Mean sherd thickness (mm, 3 measurements/3)
14) Variance in sherd thickness (mm, maximum minus minimum value)
15) Size modality of temper (Wentworth scale using grain size template, sherd viewed under 10X magnification):
    0. cannot determine temper size modality ("missing data")
    1. granule (-1 phi; >2.0 mm)
    2. bimodal granule, very coarse sand
    3. very coarse sand (0 phi; >1.0 mm)
    4. bimodal very coarse, medium sand
    5. medium sand (2 phi; >0.25 mm)
    6. bimodal medium, fine sand
    7. fine sand (3 phi; >0.125 mm)
    8. bimodal fine, very fine sand
    9. very fine sand (4 phi; >0.0625 mm)
16) Rank order of temper by material in hand specimen only (first temper by rank, second, third); materials code:
    0. indeterminate ("missing data")
    1. black trachyte
    2. green olivine
    3. gray basalt
    4. clear translucent crystals (quartz)
    5. calcareous sand
    6. ferrous peds
    7. opaque feldspathic crystals
17) Decoration technique (note: carved paddle-impressed and red slip are included under the dimension of surface treatment):
    0. undecorated (or eroded, "missing data")
    1. tool impressed
    2. incised

Rims Only

18) Rim course (angle to central vertical axis):
    1. direct
    2. inverted
    3. everted
19) Cross-section of lip:
    1. rounded
    2. square
    3. pointed
20) Rim profile (degree of thickening):
    1. none, parallel walls
    2. thinned
    3. thickened, exterior
    4. thickened, interior
21) Mean thickness of rim at lip (mm, 3 measures/3)
22) Variance in thickness of rim at lip (mm, maximum minus minimum value)
23) Estimated orifice diameter (10 cm intervals)

ANALYTIC PROCEDURES

Observation of exterior and interior surfaces allows one to determine the final finishing methods used on vessels prior to firing. Where sherds have an eroded exterior or interior surface, such observations could not be made and were coded as "missing data." Plain surfaces were simply smooth, with no other finishing techniques evident. Wiped surfaces were recognized by fine, parallel striations that were made in the clay prior to firing. Puddled surfaces, sometimes called "self-slipped" (Rye 1981:57), are those formed by wetting the surface, thus bringing the finest clay particles to the surface of the paste. This technique is recognized by textural differences on the sherd surface and in cross-section. Slip, a thin surface coating created from a fluid suspension of clay in water, commonly has a different color than the body (Rye 1981:41). Also, slip differs from the sherd body in texture. Carved, paddle-impressed surface treatment is usually produced with secondary forming using a paddle and anvil. The textured (patterned) paddle leaves a raised design on the vessel surface.

The "preferred" orientation of sand temper inclusions relates to techniques of primary forming (Rye 1981). Slab building and coiling can be detected, in part, by differences in orientation. A definitive long axis for the particles is necessary to observe orientation.

Interior anvil casts and exterior paddle (carved and plain) marks were noted as present/absent. These traits reveal the use of the paddle and anvil technique in secondary forming in the ceramic production sequence.

Hardness was measured on the interior and exterior surfaces of sherds by a scratch test using the Mohs scale. Hardness, measured on this ordinal scale, may relate to ceramic strength, raw materials, firing, and post-depositional diagenesis.

Sherd color was measured on the exterior and interior surfaces using the Munsell Soil Color Chart (1988). Ceramic color, while complex, reflects

Table 9.1
Ceramics from the 1987 Excavation Units

Unit	Layer	Thin n (%)	Thick n (%)	Rims	Red Slip	Other Sherds	Temporal Analytic Period	Total
1	IIB	2 (3)	66 (97)	10			Middle	68
	IIC	0 (0)	0 (0)	1			Middle	1
	III	2 (67)	1 (33)	0			Early	3
4	IIA	0 (0)	7 (100)	0			Late	7
	IIB	4 (44)	5 (56)	0			Middle	9
5	IIA	4 (14)	24 (86)	0			Late	28
	IIB	12 (27)	32 (73)	4			Middle	44
	III	8 (100)	0 (0)	3			Early	8
6	IIA	2 (8)	22 (92)	3			Late	24
	IIB	2 (13)	13 (87)	0			Middle	15
	IIC	17 (74)	6 (26)	0			Middle	23
	III	4 (80)	1 (20)	2			Early	5
7	IIA	1 (13)	7 (87)	1			Late	8
	IIB	5 (71)	2 (29)	0			Middle	7
	IIC	5 (83)	1 (17)	0			Middle	6
	III	4 (80)	1 (20)	1			Early	5
8	IIA	0 (0)	27 (100)	0			Late	27
9	IIA	2 (3)	67 (97)	0			Late	69
	IIB	2 (9)	20 (91)	11		Incised (1)	Middle	22
	III	1 (33)	2 (67)	0			Early	3
10	IIA	1 (25)	3 (75)	0			Late	4
	IIB	1 (50)	0 (0)	0	1		Middle	1
11	IIA	3 (38)	5 (62)	2			Late	8
	IIB	8 (8)	90 (92)	11			Middle	98
	IIC	1 (50)	1 (50)	0			Middle	2
12	III	20 (100)	0	3		Notched rim (1)	Early	20
14	IIA	7 (4)	175 (96)	10			Late	182
	IIB	10 (11)	85 (89)	0			Middle	95
Totals*		128 (15)	663 (85)	(62)				791

* Rims, slipped, and decorated sherds included with thick/thin sherd counts; eroded sherds not included in total.

Table 9.2
Ceramics from the 1989 Excavation Units

Unit	Layer	Thin n (%)	Thick n (%)	Rims	Red Slip	Other Sherds	Temporal Analytic Period	Total
15	II	1 (10)	9 (90)	1			Middle	10
	IIIA	8 (27)	22 (73)	3			Early	30
	IIIB	2 (13)	13 (87)	2			Early	15
	IIID	2 (50)	2 (50)	0	2		Early	4
16	I	0 (0)	9 (100)	0			Late	9
	II	0 (0)	3 (100)	0		Incised (1)	Middle	3
	III	12 (40)	18 (60)	2	1		Early	30
20	IIIA	4 (7)	53 (93)	4			Early	57
	IIIB	12 (9)	120 (91)	10	10	Impressed (6)	Early	132
	IIIC	10 (22)	36 (78)	3			Early	46
21	IIA	1 (25)	3 (75)	0			Middle	4
	IIB	2 (12)	14 (88)	0			Middle	16
23	IIIA	8 (13)	54 (87)	4	2		Early	62
	IIIB	32 (35)	60 (65)	10	1	Decorated (4)	Early	92
	IIIC	17 (28)	44 (72)	3	1		Early	61
24	IB	1 (33)	2 (67)	0	1		Middle	3
27	II	0 (0)	5 (100)	0			Late	5
	IIA	5 (8)	57 (92)	3			Middle	62
	IIIB	3 (30)	7 (70)	1			Early	10
28	IIA	0 (0)	1 (100)	0			Late	1
	IIB	7 (30)	16 (70)	2			Middle	23
	IIC	51 (50)	52 (50)	13	9	Impressed (1)	Middle	103
29	II	0 (0)	12 (100)	0			Middle	12
	IIIA	7 (78)	2 (22)	1			Early	9
30	II	2 (6)	32 (94)	1			Middle	34
	IIIA	11 (28)	28 (72)	6			Early	39
Totals*		198	674	(68)				872

* Rims, slipped, and decorated sherds included within thick/thin sherd counts; eroded sherds not included in total.

Table 9.4
Frequency of Sherds by Temper Size Mode(s)

Temper Size Modes	Frequency	Percent	Cum. Percent
granule	30	4.1	4.1
granule, very coarse	189	25.6	29.7
very coarse	140	19.0	48.7
very coarse, medium	114	15.5	64.2
medium	81	11.0	75.2
medium, fine	91	12.3	87.5
fine	92	12.5	100.0
Total	737	100.0	

(Valid cases = 737; Missing cases = 0)

< -1 phi) in many sherds, to particles visible only under magnification (i.e., fine to very fine sand, > 3 phi). No attempt was made to observe modes of finer (e.g., silt) particles.

Most of the sherds in the sample assemblage (86%) had a mixture of sands and contained more than one temper compositional class. Thicker sherds tended to have coarser temper and thinner sherds tended to have finer temper. Temper size correlates to temper composition ($\chi^2 = 237.21$, df = 9, $p > .0001$) in that well-rounded, calcareous sand grains are smaller than the very coarse (often angular) sand class (0 phi). Grain size and temper composition are also associated with sherd thickness. Calcareous sand temper occurs most often in thinware (73% of this temper occurs in thinware). Yet, thinware cannot be described as predominantly calcareous sand tempered because only 26% of the thinware has a predominance of calcareous sand temper. On the other hand the largest tempers, grains of glassy black trachyte, dull grey basaltic, rounded olivine, pale opaque feldspars, clear crystalline, and red ferrous, rounded grains were represented in the smallest size classes as well.

Color variability was assessed by plotting values in a scatterplot to check for trends or grouping tendencies. Bivariate plots for a three dimensional classification were achieved by plotting Munsell hue against value-chroma (figures 9.1-3; e.g., see Bishop et al. 1988). These plots reveal that color variability in the To'aga ceramics is comparable for all three time periods and for both thick- and thinwares. Sherds range from red (10R) to yellow-red (10YR) and cover an array of value and chroma. The majority of the assemblage is reddish brown or gray in color. Early ceramics include red-slipped sherds (10 R 5/6 and 2.5 YR 5/6) distinctive in coloration from the rest of the assemblage.

Although analysis showed that interior and exterior surface colors have similar distribution, the correlation on individual sherds was poor (Pearson's $r = 0.143$, $p > 0.001$). Oxidation/reduction patterns (table 9.5) play some part in this correlation, since 24% of the sherds have interior surfaces that were not fully oxidized as compared with only 3% for the exterior surfaces. As a result, more sherds have interior surfaces that are darker than their exterior surfaces. Most of the sherds (68%), however, were fully oxidized during firing.

Following analysis, the entire assemblage was inspected to check for further variation in color (or other unrecorded differences in temper, etc.). Five sherds from units 15/29/30 were anomalous in color. These sherds (5 YR 6/6 and 7.5 YR 6/3) are described respectively as reddish yellow and light brown in the Munsell system. The former group of thickware sherds (5 YR 6/6) is similar in color to the predominate color of the sherds from 'Upolu Island designated "Falemoa Tan" by Holmer (1980:114).

Sherd hardness, measured on the Mohs scale, variability in raw material, pyrotechnology, and use.

The oxidation/reduction pattern was recorded for sherd cross-sections using an inductively derived pattern template (e.g., Rye 1981:116). These patterns are indicators of the atmosphere and temperature of firing (Rye 1981:115-18).

The presence or absence of organic (carbonaceous) residue was recorded. Residues supply important clues of ceramic function.

Variation in sherd thickness has proven significant in Samoan pottery studies. Sherd thickness is estimated as a mean value from three measurements on different parts of the sherd. This mean value is a more reliable measure of sherd thickness than a single measurement (Barry 1978). Three thickness measures also provide a range expressing the variance in sherd thickness. Variance measures the uniformity or evenness of sherd thickness.

Temper was examined in terms of its rank by raw material as estimated from hand specimens only. Also, the size modality of the sand temper grains was recorded using a template produced with sand samples of varying phi sizes on the Wentworth scale. Sherds were viewed under 10X magnification. Dickinson's study of sand temper petrography offers a much more detailed and reliable (some materials are difficult to determine in hand specimen alone) analysis of a selection of sherds from the To'aga assemblage (see chapter 10).

For sherds with one or more intact surfaces, decoration technique was recorded as tool-impressed, incised, or undecorated (plain). Carved paddle-impressed and red slip, while decorative techniques, are included under the dimension of surface treatment.

Rim sherds were identified in terms of their course relative to the central vertical axis of the pot (e.g., direct, everted). The cross-section of the lip (form) and the profile of the rim, or the degree of thickening, were also classified. Finally, the thickness of each rim was measured, and orifice diameters were estimated.

Of the 737 sherds sampled for intensive analysis, 583 sherds retained both interior and exterior surfaces enabling measurement or observation of the characteristics listed above. The results of intensive macroscopic analysis are summarized and discussed below. These results, together with compositional results (below and chapter 10), provide the basis for reconstructing aspects of ceramic raw material use, production technology, style, and function.

RESULTS OF MACROSCOPIC ANALYSIS

Many of the results used for intensive analysis are summarized in tables 9.3-13. Specific characteristics that relate to material use, forming techniques, pyrotechnology, style, and function are discussed below.

The analysis of sand temper composition and grain size modality (see table 9.4) revealed the following: temper ranges in size from grains measuring approximately 2.5 - 4 mm (i.e., granules

Table 9.3
Frequency of Body and Rim sherds

Sherd	Frequency	Percent	Cum. Percent
Body	683	92.7	92.7
Rim	54	7.3	100.0
Total	737	100.0	

(Valid cases = 737; Missing cases = 0)

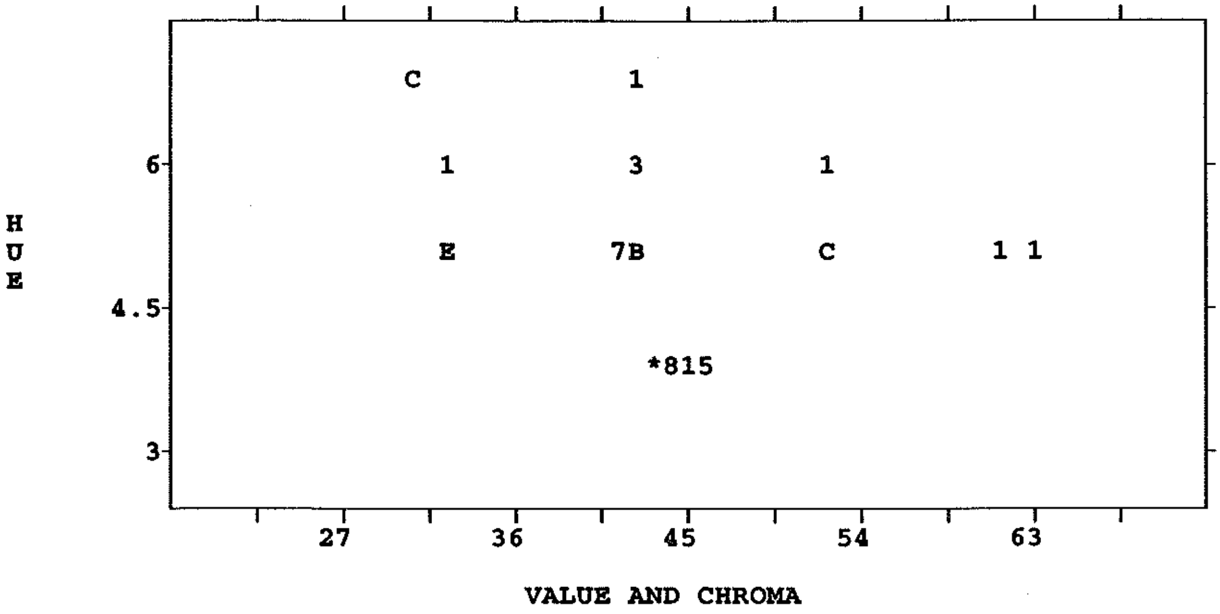

Figure 9.1 Plot of exterior sherd color (hue with value and chroma) for the late period (note to figures 9.1-3: number of cases in each position is shown in sequential order by 1-9; A-; 10-35 cases; and *, more than 36 cases).

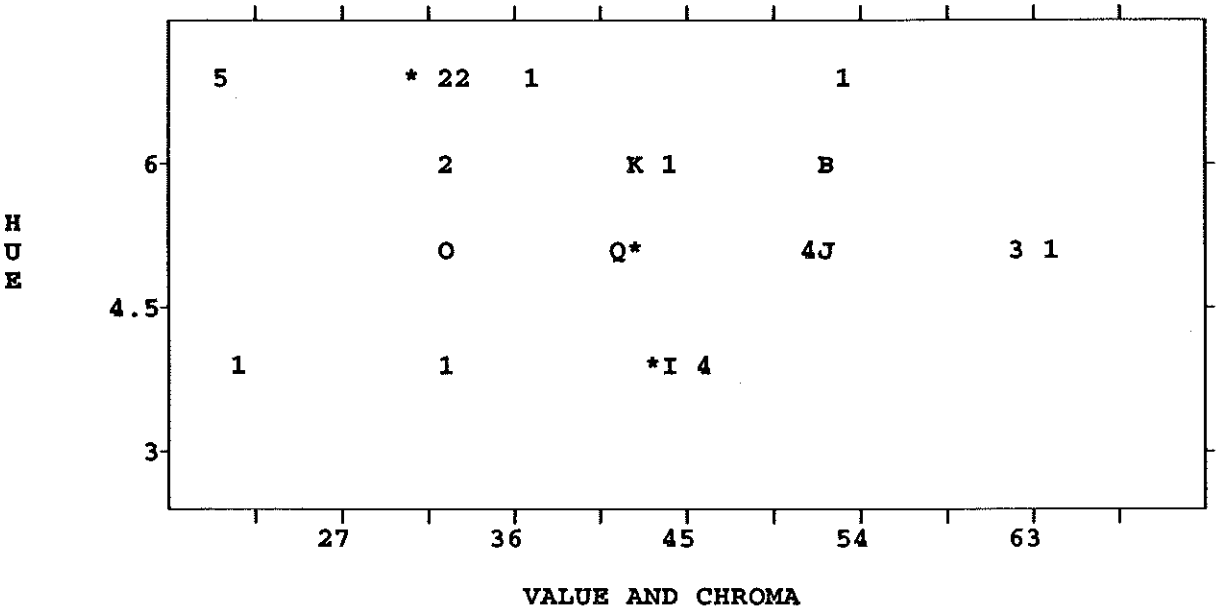

Figure 9.2 Plot of exterior sherd color (hue with value and chroma) for the middle period (see note to fig. 9.1).

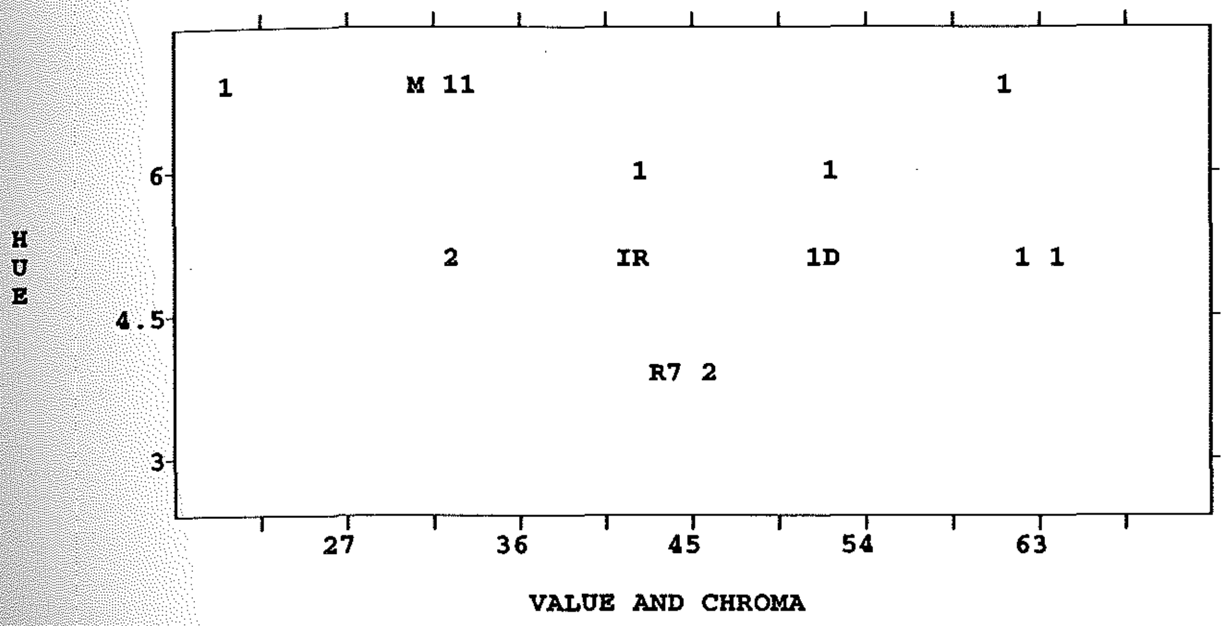

Figure 9.3 Plot of exterior sherd color (hue with value and chroma) for the early period (see note to fig. 9.1).

ranged from 2.0 to 8.0 (tables 9.6-7). This is a remarkable range of hardness, but reflects the difficulty of measuring paste hardness with a scratch test in sherds with abundant temper (which is consistently hard). Ceramic tiles manufactured from colluvial clay samples and fired in an open fire (for approximately fifteen minutes), or in the muffle furnace (500°C for fifteen minutes) were uniformly 3 in hardness. There is a strong correlation ($r = 0.8467, p > .0001$) between the interior and exterior hardness of individual sherds.

The sample analyzed ($n = 737$) had 583 sherds which retained both surfaces (i.e., non-eroded), allowing the measurement of mean thickness for each sherd. Results show that sherds range from 4.20 mm to 16.97 mm in thickness. The total sample mean sherd thickness is 9.42 mm ($\sigma = 2.84$), however the distribution is not normal, but has three modes (figure 9.4). The late portion of the sample ($n = 196$) with 140 measurable sherds, ranges from 5.60 mm to 14.55 mm in thickness. The late sample mean sherd thickness is 10.14 mm ($\sigma = 1.77$) (figure 9.5). The middle period sample ($n = 411$) with 323 measurable sherds, ranges from 4.20 mm to 16.97 mm in mean sherd thickness. The sample mean thickness is 9.97 mm ($\sigma = 3.10$) (figure 9.6). The early ceramics ($n = 130$) had 120 measurable sherds with a mean thickness of 7.09 mm ($\sigma = 1.68$). These sherds range in thickness from 4.30 mm to 14.52 mm in a somewhat normally distributed range of measurements (kurtosis 4.357, skewness 1.783), but skewed toward the thinner sherds (figure 9.7). Differences in sherd thickness are summarized by temporal-analytic periods in table 9.14.

Rims for the entire To'aga assemblage were analyzed and identified to class (see protocol). These forms are illustrated in figure 9.8. One large reconstructed sherd provided a measurable portion of a rim (9% of the estimated total) so that the diameter is reconstructed as 48 cm. About 89% of the rims are oriented 90° to a central vertical axis of the vessel. Other rims have angles approximating 80°. All rim courses are direct, with the majority (80%) having a squared lip cross section. The remaining rims (20%) are rounded in cross section.

The only decorated rims are from early contexts, comprising approximately 7% of the total. The lips of these decorated rims are impressed with narrow tools forming U-shaped notches, repeating parallel lines perpendicular to the rim, or in one case, oblique to the rim. A rim with a crenelated lip was also recovered.

Other decorated sherds are small in number. Only 30 slipped sherds and 11 other decorated

Table 9.7
Frequency of Sherds by Exterior Hardness (Mohs Scale)

Exterior Hardness	Frequency	Percent	Valid Percent	Cum. Percent
2	31	4.2	5.0	5.0
3	113	15.3	18.1	23.1
4	109	14.8	17.5	40.6
5	154	20.9	24.7	65.3
6	145	19.7	23.3	88.6
7	53	7.2	8.5	97.1
8	18	2.4	2.9	100.0
Eroded	114	15.5	Missing	
Total	737	100.0	100.0	

(Valid cases = 623; Missing cases = 114)

Table 9.8
Frequency of Sherds by Interior Hardness (Mohs Scale)

Interior Hardness	Frequency	Percent	Valid Percent	Cum. Percent
2	24	3.3	3.8	3.8
3	110	14.9	17.2	21.0
4	122	16.6	19.1	40.1
5	141	19.1	22.1	62.2
6	158	21.4	24.8	87.0
7	52	7.1	8.2	95.1
8	31	4.2	4.8	100.0
Eroded	99	13.4	Missing	
Total	737	100.0	100.0	

(Valid cases = 638; Missing cases = 99)

Table 9.5
Frequency of Sherds by "Preferred" Orientation of Inclusions Relative to Vessel Walls

Inclusion Orientation	Frequency	Percent	Cum. Percent
Indeterminate	199	27.0	27.0
Random	458	62.1	89.1
Parallel	80	10.9	100.0
Total	737	100.0	

(Valid cases = 737; Missing cases = 0)

Table 9.6
Frequency of Sherds by Oxidation-Reduction Pattern in Cross-Section

Pattern	Frequency	Percent	Valid Percent	Cum. Percent
Fully oxidized	380	51.6	67.9	67.9
Core oxidized	10	1.4	1.8	69.6
Ext. oxidized	68	9.2	12.1	81.8
Int. surf. reduced	55	7.5	9.8	91.6
Fully reduced	9	1.2	1.6	93.2
Ext. surf. reduced	14	1.9	2.5	95.7
Surfs. reduced	2	.3	.4	96.1
Ext. reduced	7	.9	1.3	97.3
Ext. surf. reduced	15	2.0	2.7	100.0
Int. reduced	177	24.0	Missing	
Total	737	100.0	100.0	

(Valid cases = 560; Missing cases = 177)

Table 9.9

Frequency of Sherds by Exterior Surface Treatment

Surface Treatment	Frequency	Percent	Valid Percent	Cum. Percent
Plain	128	17.4	20.4	20.4
Wiped	13	1.8	2.1	22.5
Puddled	481	65.3	76.8	99.4
Slipped	4	.5	.6	100.0
Eroded	111	15.0	Missing	
Total	737	100.0	100.0	

(Valid cases = 626; Missing cases = 111)

Table 9.10

Frequency of Sherds by Interior Surface Treatment

Surface Treatment	Frequency	Percent	Valid Percent	Cum. Percent
Plain	124	16.8	18.9	18.9
Wiped	14	1.9	2.1	21.0
Puddled	508	68.9	77.3	98.3
Slipped	9	1.2	1.4	99.7
Residue	2	0.3	0.3	100.0
Eroded	80	10.9	Missing	
Total	737	100.0	100.0	

(Valid cases = 657; Missing cases = 80)

Table 9.11

Frequency of Sherds by Interior Anvil Casts

Anvil Casts	Frequency	Percent	Valid Percent	Cum. Percent
Absent	85	11.5	22.3	22.3
Present	297	40.3	77.7	100.0
Indeterminate	355	48.2	Missing	
Total	737	100.0	100.0	

(Valid cases = 382; Missing cases = 355)

Table 9.12
Frequency of Sherds by Exterior Paddle Marks

Paddle Marks	Frequency	Percent	Valid Percent	Cum. Percent
Absent	54	7.3	16.1	16.1
Present	282	38.3	83.9	100.0
Indeterminate	401	54.4	Missing	
Total	737	100.0	100.0	

(Valid cases = 336; Missing cases = 401)

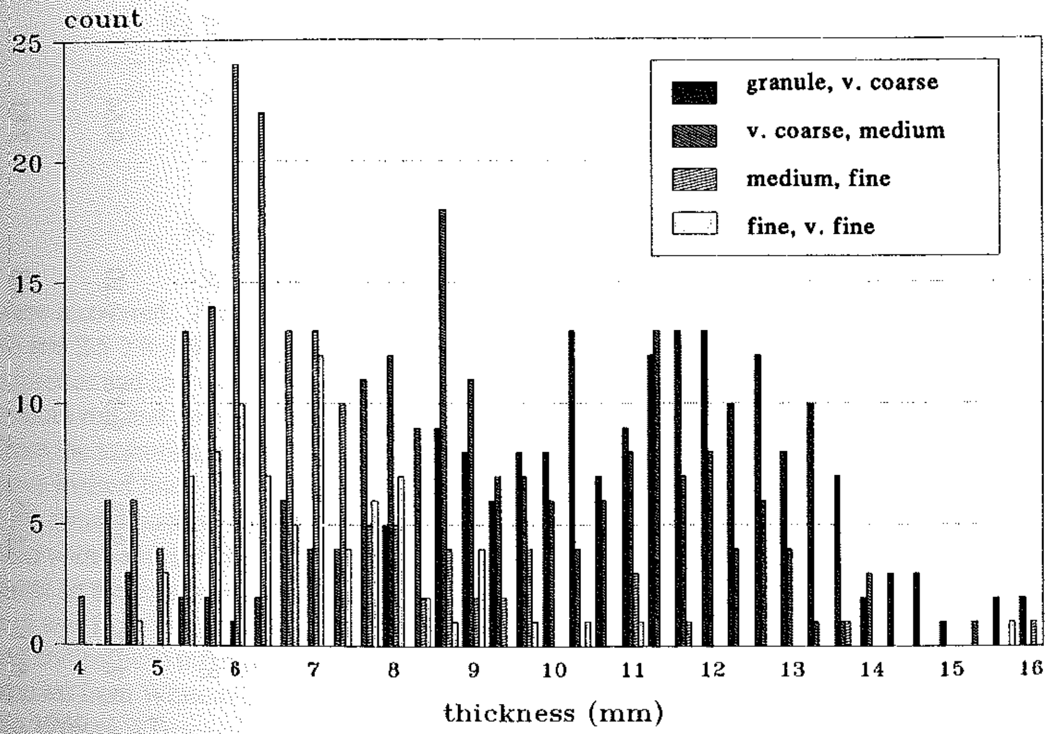

Figure 9.4 Thickness and temper size histogram for the To'aga ceramic assemblage (n = 538). Temper classes are indicated by the variable shading of the histogram bars.

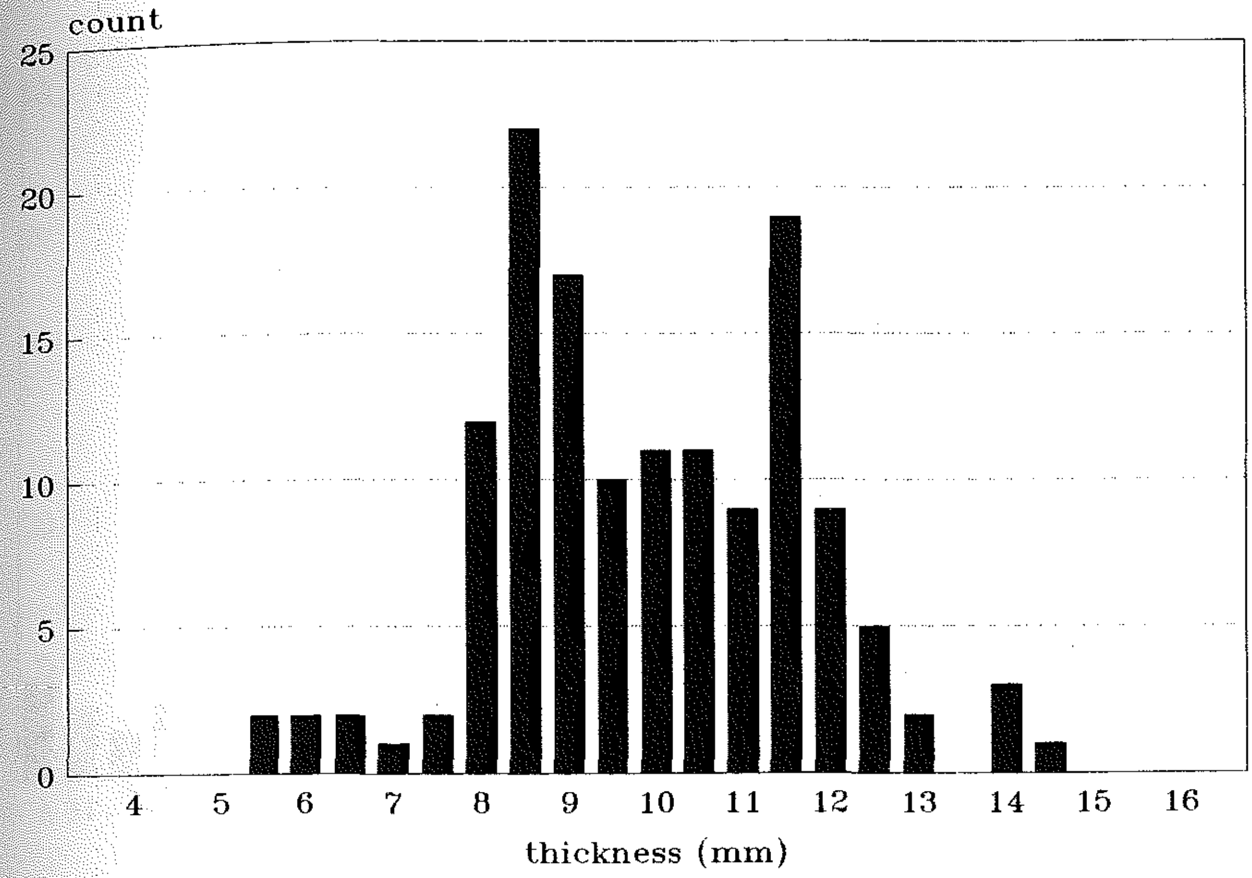

Figure 9.5 Thickness histogram for late period ceramics (n = 196).

sherds were recovered. The color of the slip is red (10 R 5/6 and 2.5 YR 4/6). This slip occurred on both the interior and exterior of the sherds and was found on both rim and body sherds. Three body sherds from the assemblage are decorated. Two sherds have incised lines, although both are small making the overall patterns indistinct. The third is a body sherd with parallel-ribbed, carved paddle impressions on the exterior surface of the vessel. This sherd was from an early context (unit 20, layer IIIB), and compares to other paddle-impressed sherds known from Western Samoa (Green and Davidson 1969:pl. 17).

All sherds recovered during excavations were examined for residue in the field, (i.e., prior to any cleaning). Ten sherds with substantial quantities of carbonized residue were discovered; seven with residue on the interior and exterior, and three on the interior alone. This residue has yet to be identified but is probably the result of cooking starchy foods (see Hill et al. 1985).

CERAMIC COMPOSITIONAL MICROANALYSIS

Analysis of macroscopic ceramic traits supports many research objectives, especially those examined here. Documenting raw material variability requires additional work, especially with respect to temper and clay of the ceramic fabric. The temper component has been analyzed and discussed by Dickinson (chapter 10). Here we present the compositional microanalysis of three clay samples and the clay portion of the ceramics from To'aga. These results allow us to address questions of clay variability (as a part of technology) and the potential for ceramic exchange in Samoa.

A sample of twenty-nine sherds was chosen for their visual differences in thickness, temper, and paste in hand section. Also, this variety of sherds came from excavation contexts that could be inferred to be of different ages (table 9.1). Age differences

Table 9.13
Frequency of Sherds by Organic Residue

Organic Residue	Frequency	Percent	Valid Percent	Cum. Percent
Absent	725	98.4	98.4	98.4
Interior surface	8	1.1	1.1	99.5
Exterior surface	3	0.4	0.4	99.9
Both surfaces	1	0.1	0.1	100.0
Total	737	100.0	100.0	

(Valid cases = 737; Missing cases = 0)

Table 9.14
Sherd Thickness Statistics by Analytic Time Periods*

Sample	Mode	Median	Mean	sd	Variance	Kurtosis	Skewness	Range	Min.	Max.
All (n=737)	7.40	9.14	9.42	2.84	8.06	-0.833	0.323	12.8	4.2	17.0
Late (n=196)	8.96	10.00	10.14	1.76	3.12	-0.171	0.004	8.9	5.6	14.6
Middle (n=411)	7.40	9.91	9.97	3.10	9.64	-1.090	0.101	12.8	4.2	17.0
Early (n=130)	6.51	6.75	7.09	1.68	2.81	4.357	1.783	10.2	4.3	14.5

* All measurments in millimeters

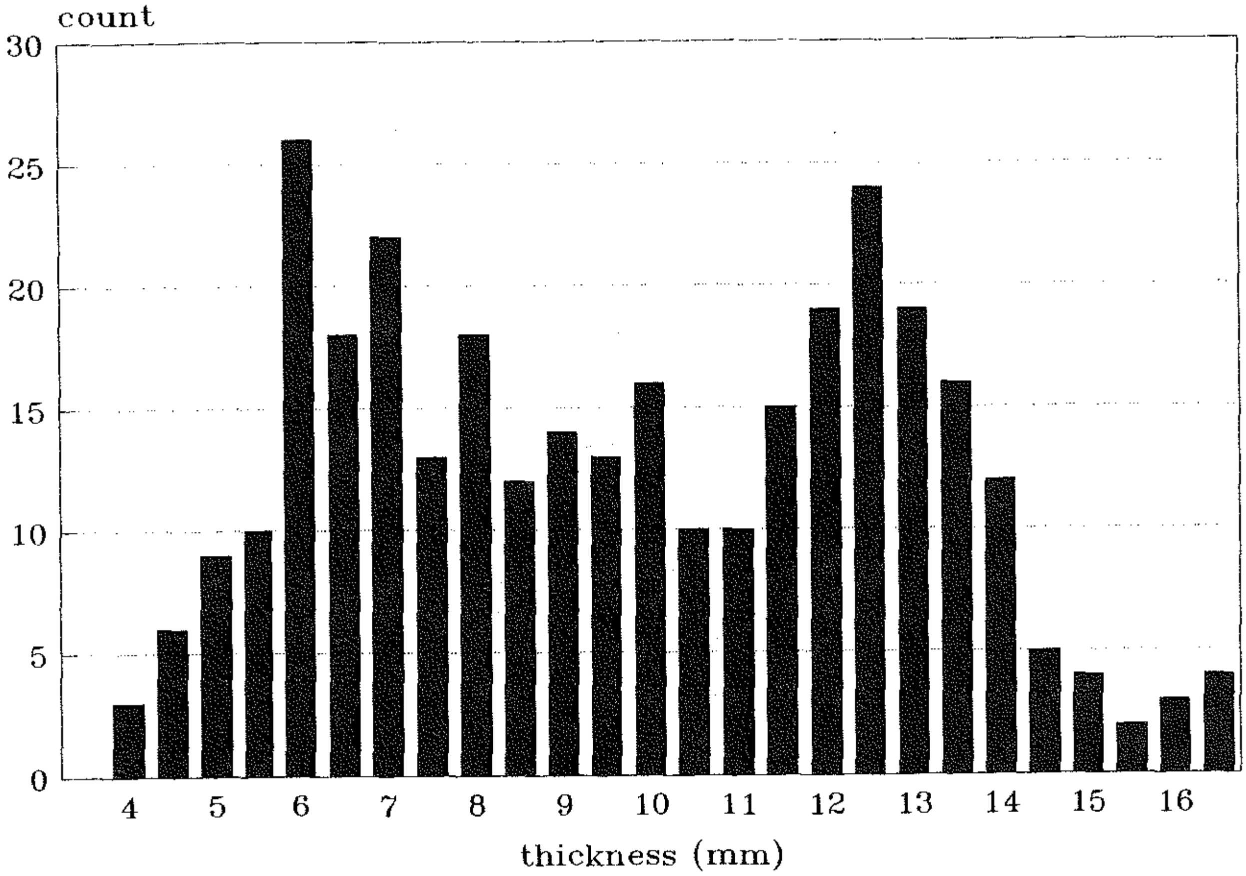

Figure 9.6 Thickness histogram for middle period ceramics (n = 411).

correspond to the analytic divisions made for the larger sample (i.e., early, middle, and late). The sherd samples were also analyzed by Dickinson (chapter 10) for their sand temper petrography. Examination of the To'aga ceramics by both sand temper petrography and elemental analysis takes advantage of the strengths of each approach (Hunt 1988).

In addition to the sherds, three clay samples were collected from colluvium near the base of the cliff at To'aga on transects 1, 5, and 9. These clays were fired in a furnace (at 500°C) for fifteen minutes to produce ceramic tiles resembling sherds. One of these clay samples (from Transect 9) was prepared in the laboratory as a fired ceramic tile (sherd). It was also analyzed by Dickinson (chapter 10) to compare "self-tempered" sherd petrography.

The elemental microanalysis was accomplished using an energy-dispersive spectrometer (EDS) integrated with a scanning electron microscope (SEM). SEM/EDS microanalysis is described in this chapter, and these results are integrated with those from the petrographic analysis. The distinct advantage of the SEM/EDS is in the selectivity afforded by the microscope component of the instrument. Using the SEM in conjunction with an x-ray analyzer, it is possible to characterize the clay matrix alone, or individual inclusions, slips, and residues (e.g., Hunt 1989). Analyses described here were conducted by one of us (TLH) on a JEOL model JSM-840A SEM fitted with a Tracor Northern energy-dispersive x-ray detector housed at the University of Washington.

Selective elemental microanalysis of pottery is possible by the coupling of an x-ray analyzer with the SEM. In the simplest terms, the SEM provides a source of electrons of appropriate energy that impinge on a sample and cause the emission of x-rays. The x-rays emitted have energies and relative abundances that reflect the elemental composition of

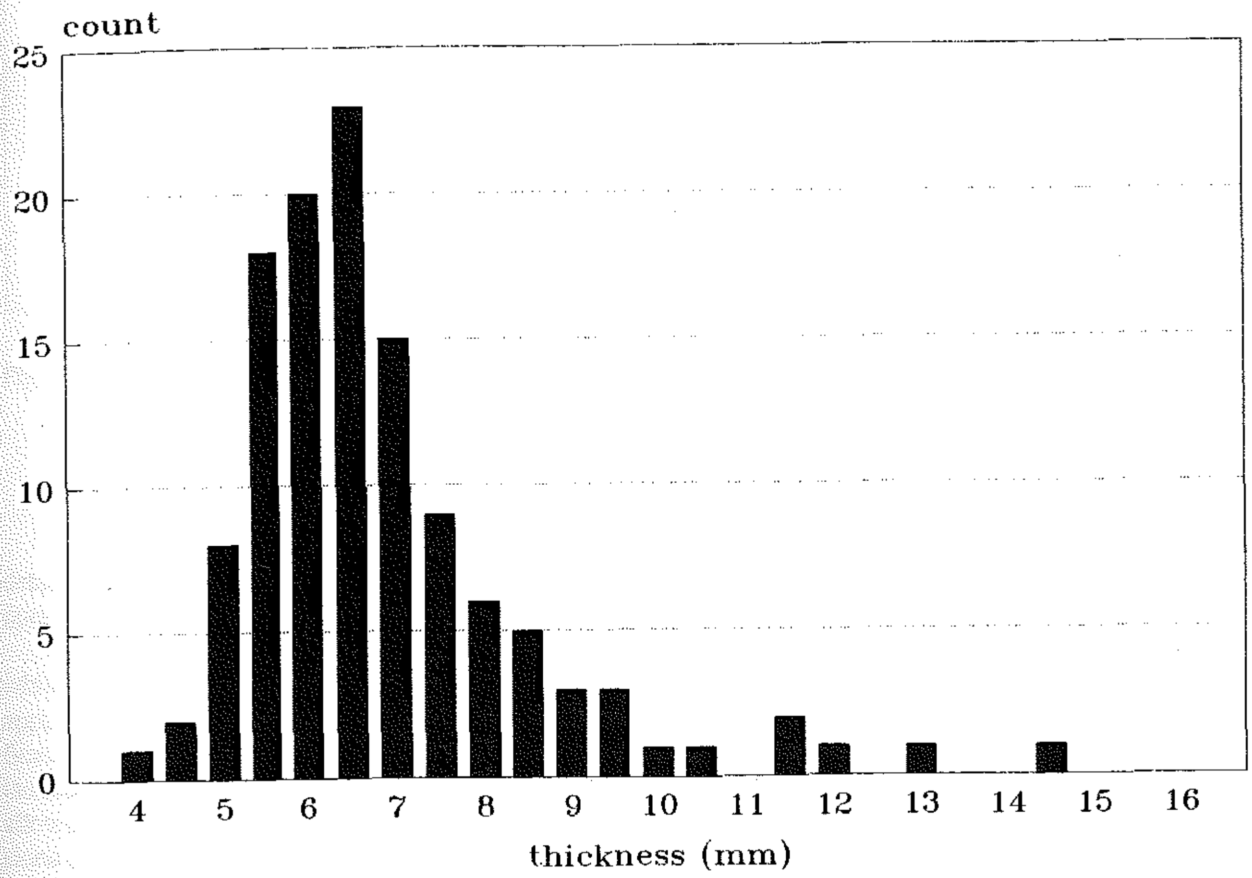

Figure 9.7 Thickness histogram for early period ceramics (n = 130).

the sample. The characteristic x-rays are detected by a lithium-drifted silicon Si(Li) crystal that—together with electronic amplifiers and signal processors—collects and electronically sorts all the energies from the x-rays emitted. Under normal operating conditions, elements with atomic numbers above 10 (Na = 11), and below 100 (Es = 99) are detectable.

The conversion of x-ray emissions into a compositional spectrum (figure 9.9) and potential quantitative data is achieved through a series of electronic components described in some detail by Postek et al. (1980) and Goldstein et al. (1981:222-24). Qualitative and quantitative analysis of the x-ray spectrum for the composition of a particular sample is complex, yet well understood (Goldstein et al. 1981:275-392). As in other recent studies, (e.g., Dunnell and Hunt 1990; Graves et al. 1990; Hunt 1989), quantitative analysis of To'aga ceramic clays used the ZAF correction method (see Goldstein et al. 1981:308). The final values calculated are quantities of elements (by weight and atomic percents) present on the cross-section surface of the sample at the point/area impinged by the electron beam. A goodness of fit between those elements quantified and standard intensities is evaluated by a chi-square test. This test provides an objective criterion to evaluate the goodness of fit for the peak-fitting algorithms used in each particular application (Goldstein et al. 1981:411-12). The analyst can judge the success or failure of x-ray collection for goodness of fit for a particular specimen on statistical criteria for each spectrum and quantitative analysis generated. All these features are available through the Tracor Northern software used.

Minimum elemental detection limits for energy-dispersive microanalysis are below 0.1% under ideal settings, and typically less than 1%, with a relative precision of 1-5% throughout the elemental range detected (Hunt 1989). Rice (1987:375) notes the general concentration range for x-ray analyses as

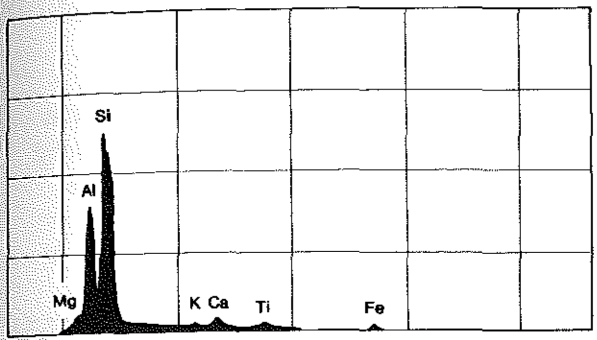

Figure 9.9 Elemental spectrum of clay composition for sherd 22 from To'aga (Univ. of Washington SEM, 27 Dec. 1989, 10KV, 1,2000X).

detection of major, minor, and trace elements (>100 ppm).

Specimens were viewed on the CRT of the SEM while undergoing x-ray analysis. An area that appeared to be only clay was selected at low magnification (30-100X) for analysis. This area was isolated by a step-wise increase in the magnification, allowing careful inspection of the region for inclusions or other anomalies. X-rays were collected from areas that appeared at higher magnification to be clay matrix only. All other specific sample preparation and analytic procedures follow those described in detail by Hunt (1989:155-59).

Twelve major and minor elements, Na, Mg, Al, Si, P, Cl, K, Ca, Ti, Cr, Mn, and Fe, were selected for analysis. These multivariate data for thirty-two specimens (sherds and To'aga clays) form the data matrix used to search for compositional structure in the To'aga ceramics.

Quantitative Analysis of Clay Elemental Data

The goal of analysis of elemental data is organizing or reducing compositional variability into archaeologically meaningful groups (Arnold et al. 1991; Harbottle 1976:42). Ideally, such groups represent discrete clay sources, and thus, the minimum number of production locales represented in the ceramic assemblage. While individual clay sources are not always distinguishable, the method has the potential to sort clays from different regions. Islands offer an especially good setting for sorting ceramic provenance because they vary in age and geologic origin. In addition, clays come from small drainages and do not mix as in continental deposits.

Sorting the clay elemental data matrix into meaningful groups generally requires deductive tests using multivariate statistics (e.g., Bishop and Neff 1989; Davis 1986). Such analyses are usually directed at inferring a probable number of distinguishable clays represented in an assemblage. Distinguishable clays might be used to infer production locales for prehistoric pottery. Some studies are successful at linking prehistoric pottery to specific (known) clay sources, either on quantitative criteria that range from ordinal tests to multivariate ones (e.g., Neff et al. 1988; Topping and MacKenzie 1988). Yet, as Arnold et al. (1991:85) have pointed out, individual clay deposits may not be easily distinguished, and in Oceania an island—or even a group of islands—as a unit of geographic space may form a single "source" in compositional space.

The To'aga compositional data matrix was analyzed for its grouping tendency with two different clustering algorithms: average linkage between groups and Ward's method (Norusis 1986). These algorithms are agglomerative and build groups or clusters from the individual specimens (sherds and clays).

Given the problems of evaluating cluster dendrograms, a rigorous solution is in the use of different algorithms. Then, only those clusters which arise independently in different analyses are considered valid, or accurately descriptive (Alenderfer and Blashfield 1984:65; Dunnell 1983:146; Sokal and Sneath 1963:166). This strategy will work in data sets in which clay groups (i.e., not necessarily individual "sources", see Arnold et al. 1991) are chemically distinctive and can be detected by statistical measures.

Discriminant function analysis was also used to examine compositional structure in the To'aga data. Discriminant function analysis offers a deductive tool for testing structure in a multivariate data set (Bishop and Neff 1989; Davis 1986; Hunt 1989). As Bishop and Neff (1989) imply, ceramic compositional data sets are complexly multivariate and require going beyond an inductive search for structure (see also Harbottle 1976).

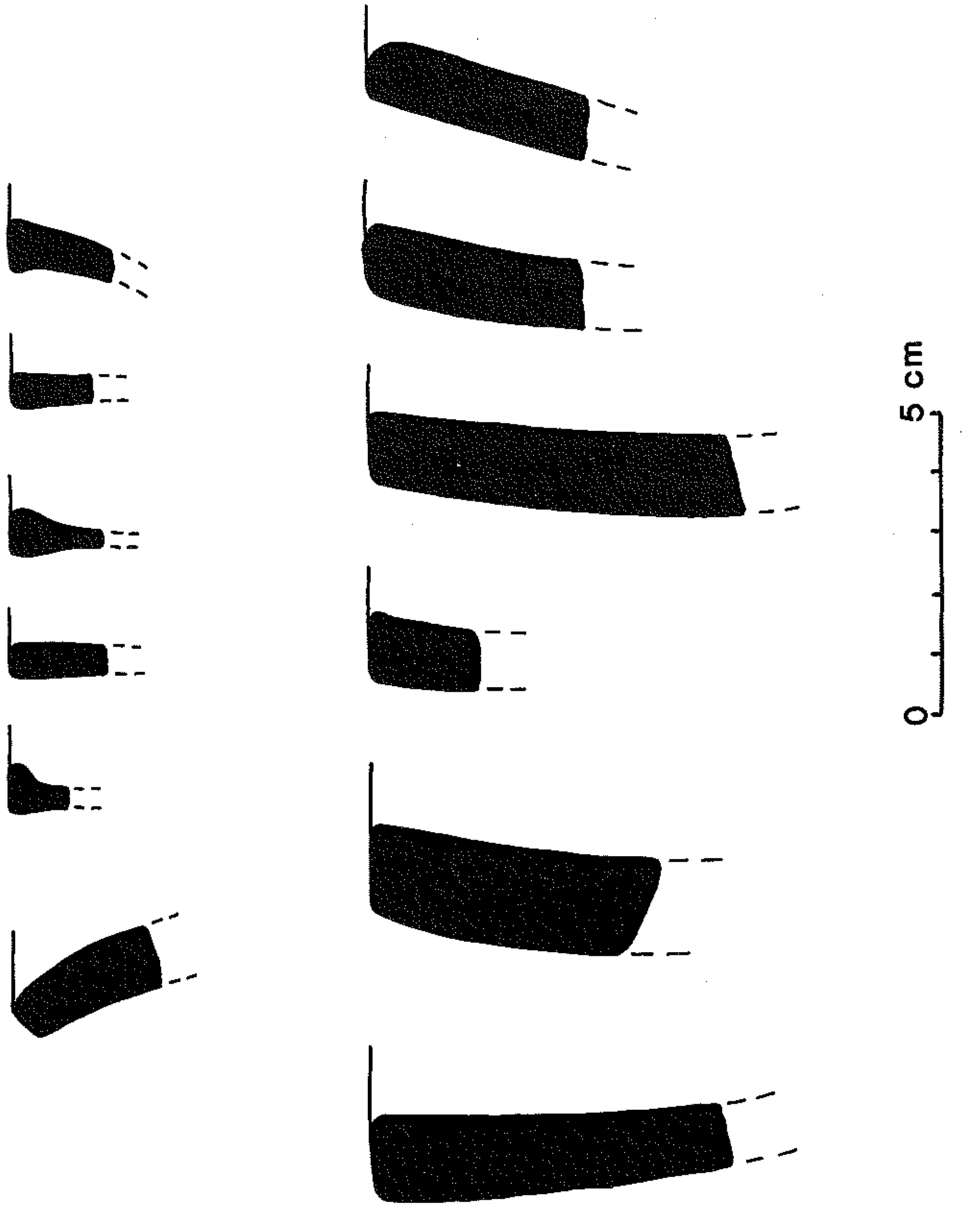

Figure 9.8 Cross sections of selected rim sherds from the To'aga assemblage.

Compositional Results

Results of these clustering procedures were plotted as dendrograms (figures 9.10-11). From these dendrograms, comparable clusters of sherds (and clay sample tiles) occurring in both solutions can be deduced. Comparison of the Ward and average linkage between group cluster dendrograms reveals four identical clusters. Table 9.15 provides summary data and results for the sample.

Cluster assignments from the two solutions (1-4, and two cases unassigned) were analyzed and plotted against first and second discriminant functions. The plot (figure 9.12) of discriminant function scores illustrates the distribution of the groups in multidimensional space.

Cluster 4 includes seven sherds of both thick- and thinware as well as the three clay samples collected from To'aga colluvium. This match suggests that local colluvial clay from To'aga was used in some pottery manufacture. The remaining three (1-3) clusters represent clay compositional groups as yet unmatched to samples from Ofu, or elsewhere. These unmatched clays are similar in composition to those of the local colluvial clay sample, and may come from other unknown sources/ source areas on Ofu, elsewhere in Manu'a, or beyond. A determination of local versus exotic provenance for the unmatched sherds would be premature; additional sampling of clays is necessary. Sherds from other islands in Samoa should also be tested for their compositional similarity to those of

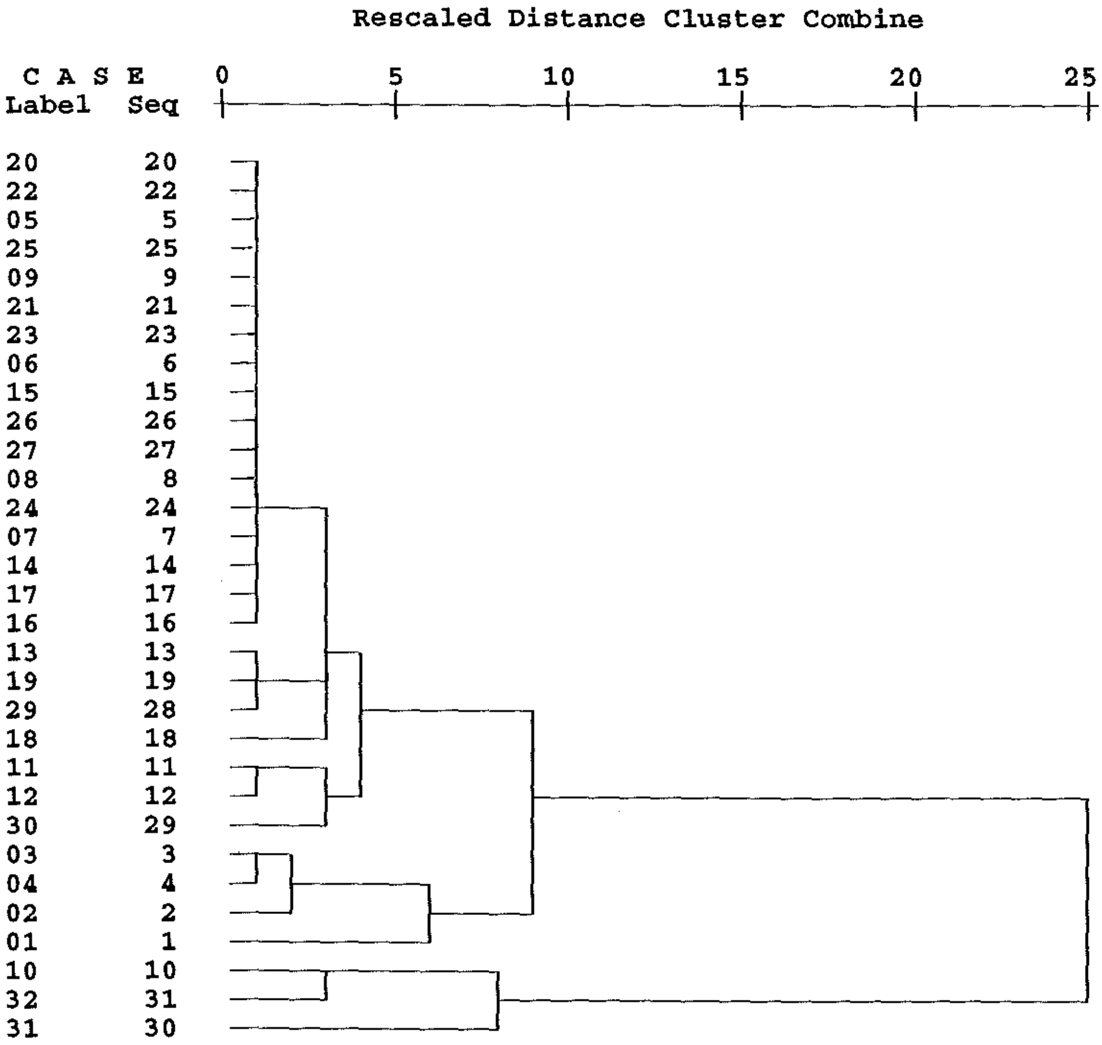

Figure 9.10 Dendrogram of Ofu pottery and clay samples using the Average Linkage (between groups) method.

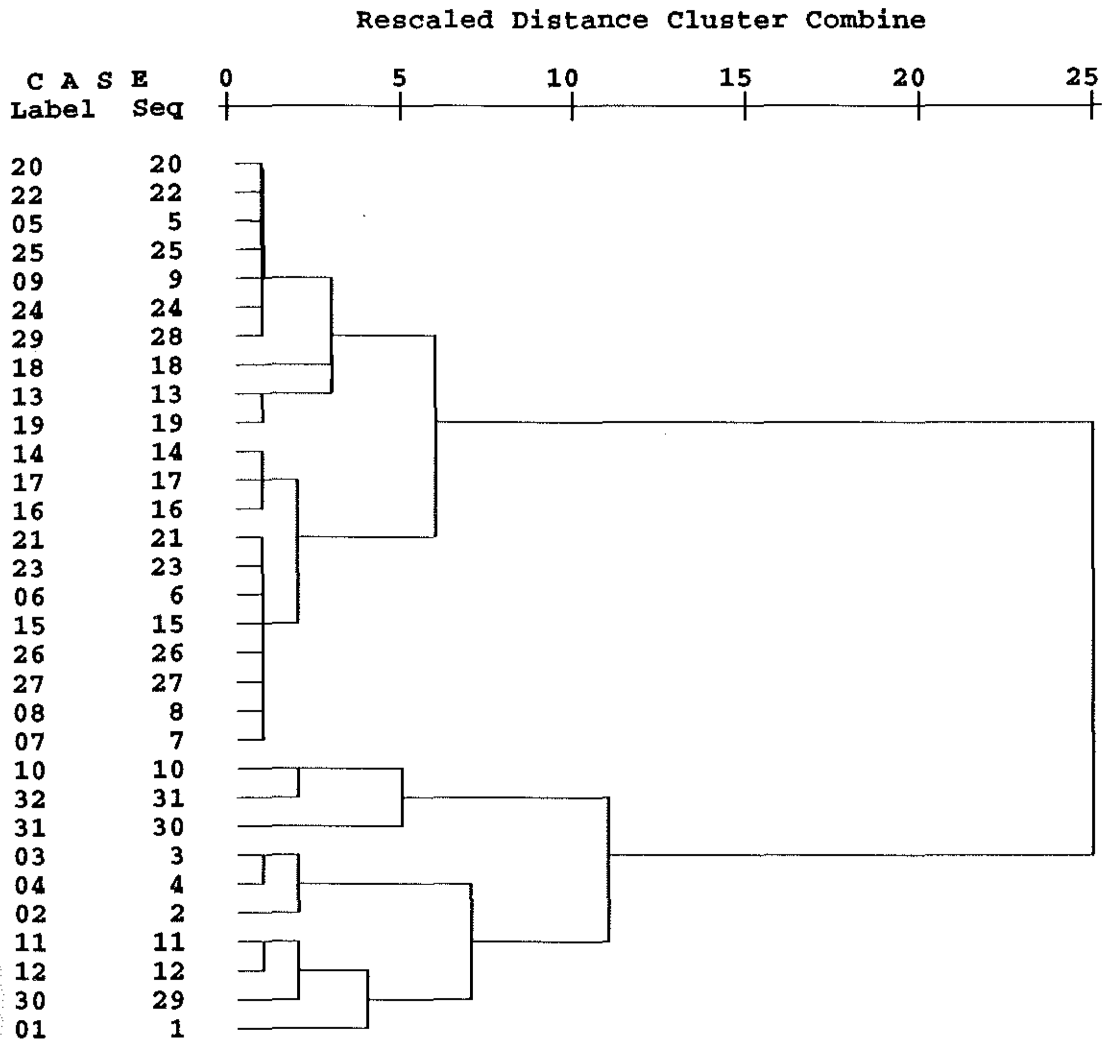

Figure 9.11 Dendrogram of Ofu pottery and clay samples using Ward's method.

the To'aga assemblage.

The association of clay compositional groups with thickware, thinware, red-slipped ware, the paddle-impressed sherd, and the three colluvial clay samples from To'aga (table 9.15) shows that thick- and thinware cannot be separated compositionally. All compositional groups are represented in thick- and thinware. Discriminant function analysis, using ware as the grouping variable, confirmed this observation. Scatterplots revealed little separation along the first and second discriminant functions (figure 9.13). The red-slipped pottery (n = 2) falls into groups 2 and 3, although a larger sample is needed to assess compositional variation in this class. The To'aga colluvial clays (in group 4) match sherds of thickware, thinware, and the carved paddle-impressed sherd.

Comparisons of ware with temper groups (table 9.15) identified by Dickinson (chapter 10) reveal that all four temper groups are represented in thickware. The profuse basaltic temper is found only in thickware, for this sample. Thinware contains sparse basaltic (temper group 2), feldspathic (temper group 3), and mixed (temper group 4) tempers (see chapter 10). The two red-slipped sherds in the sample have sparse basaltic temper. The paddle-impressed sherd and the analyzed "self-tempered" clay sample (from Transect 9 colluvium) have the mixed (temper group 4) temper, including calcareous sand. Calcareous sand in the colluvium suggests saltational transport of grains from the coast over the previously shorter distance to the colluvial deposits where mixing could

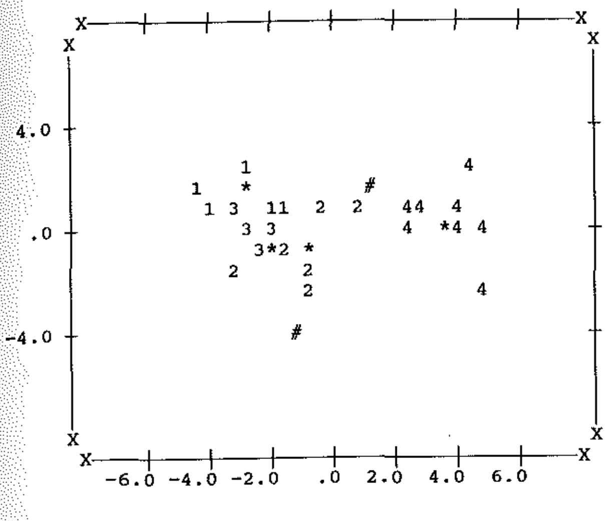

Figure 9.12 First and second discriminant function scores for analysis based on cluster (1-4) as grouping variable; * indicates group center; # indicates unclassified as to cluster.

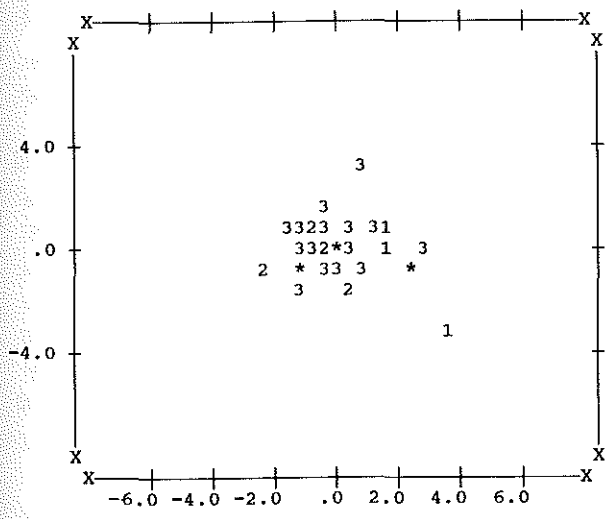

Figure 9.13 First and second discriminant function scores for analysis based on time period (early [1], middle [2], and late [3]) as grouping variable; * indicates group center.

occur naturally. Temper with calcareous sand could also represent purposeful mixing on the part of ancient potters.

The association of clay compositional groups with temper groups (table 9.15) defined by Dickinson reveals some marked correspondence. Profuse basaltic temper (Dickinson's group 1) is associated with cluster 4 (that includes the three "self-tempered" colluvial clays) more than expected by chance alone (expected = 1.7, observed = 4). Furthermore, temper groups 1, 2, and 4 occur with clay compositionally indistinct from the To'aga colluvium samples. All temper groups are associated with clay group 1. It is also noteworthy that the overall association is otherwise somewhat well dispersed. This observation suggests that in many of the specimens, temper and clay composition vary independently.

Compositional groups tabulated by their analytic time periods show a pattern of decline. Compositional variation reflected by temper groups reveals a similar pattern of decline. The early time period (1250-500 B.C.) ceramics fall into all four clay compositional groups, reflecting the greatest variety of clay (source) use. One of the clay sources in use during the early period is the local colluvial clay from To'aga, and it is in both thick- and thinware. The middle period (500 B.C.- A.D. 0) may show a decline to three clay groups, and does not include the colluvial clay from To'aga. The late (A.D. 0-300?) ceramics are only represented by the To'aga colluvial clay in thickware samples. A decline in compositional variability reflects the general simplification and homogenization of the total To'aga assemblage with time. This potential trend, however, could simply result from the smaller samples in the middle and late time periods. Additional samples must be analyzed to test a hypothesis of change in the compositional variability in the To'aga sequence.

CONCLUSIONS

Ceramics provide a critical source of information for building chronologies and inferring cultural relatedness because they vary in style. Recent advances in physico-chemical and archaeological analyses (Rice 1987) open the door to many new questions in ceramic studies. In this study, we focused on ceramics in terms of material composition and provenance, production technology, style, and function. The To'aga ceramic assemblage is particularly valuable for this kind of detailed study. The assemblage is large and comes from a stratified site where a long chronology of pottery production can be delineated. In the discussion that follows, we

Table 9.15
Sherds and Ofu Clays Selected for SEM/EDS Clay Elemental and Sand Temper Petrographic Analyses

Specimen No.	Provenience	Class	Temper Group	Clay Cluster	Period
1	Unit 6 IIa	Thick	1	4	Late
2	Unit 6 IIa	Thick	1	4	Late
3	Unit 6 IIa	Thick	1	4	Late
4	Unit 6 IIa	Thick	1	4	Late
5	Unit 6 IIb	Thick	1	1	Middle
6	Unit 6 IIb	Thick	2	3	Middle
7	Unit 6 IIb	Thick	2	4?	Middle
8	Unit 6 IIb	Thick	4	4	Middle
9	Unit 6 IIb	Thick	3?	1	Middle
10	Unit 6 IIc	Thick	2	4	Early
11	Unit 6 IIc	Thick	4	4	Early
12	Unit 6 IIc	Thick	4	4	Early
13	Unit 20 IIb	Thick	2	2	Middle
14	Unit 20 IIb	Thick	1	2	Middle
15	Unit 20 IIb	Thick	3	3	Middle
16	Unit 20 IIIa	Thin	2	2	Early
17	Unit 20 IIIa	Thick	3	2	Early
18	Unit 20 IIIa	Thick	3	2	Early
19	Unit 20 IIIb	Thin[1]	2	2	Early
20	Unit 20 IIIb	Thin	2	1	Early
21	Unit 20 IIIb	Thin[2]	2	3	Early
22	Unit 20 IIIa	Thick	2	1	Early
23	Unit 20 IIIa	Thick	2	3	Early
24	Unit 20 IIIb	Thin[3]	4	4?	Early
25	Unit 20 IIIb	Thin	4	1	Early
26	Unit 20 IIIc	Thin	4	3	Early
27	Unit 20 IIIc	Thick	2	3	Early
28	Unit 20 IIIc	Thin	2	-	Early
29	Unit 24 II	Thick[4]	2	2	Early?
30	Transect 9	Clay	-	4	-----
31	Transect 5	Clay	4	4	-----
32	Transect 1	Clay	-	4	-----

1 Square rim with an impressed lip
2 Red-slipped
3 Carved paddle-impressed (parallel rib motif)
4 "Thickware" with red-slipped exterior

offer some partial answers to the questions posed at the beginning of this chapter.

Ceramic Provenance and Production Technology

The clay microanalytic and sand temper petrographic results provide a basis for several conclusions and new hypotheses concerning ceramic provenance and production technology. Thickware, thinware, and a carved paddle-impressed sherd from To'aga can be inferred to be of local production, using colluvial "self-tempered" clay source(s) from Leolo Ridge on Ofu. Such clay(s) could be gathered near the base of the cliff at To'aga, immediately adjacent to the prehistoric occupation. Processing of such clay appears to have been minimal. The colluvial source(s) accounts for the greatest amount of pottery in the EDS/petrographic sample.

One class of pottery, the red-slipped (thinware and one thick, red-slipped sherd), does not match the local clays as presently known. The red-slipped pottery in the EDS/petro-graphic sample also contains only sparse basaltic temper (group 2). These distinctions may suggest an exotic provenance for red-slipped ware that arrived on Ofu through inter-island exchange. This hypothesis requires a larger sample to test further.

In sum, the available compositional evidence suggests at least four hypotheses that may be confirmed or falsified with additional research:

1) The decline in compositional groups (both temper and clay groups) merely reflects sample size differences for the time periods (cf. Grayson 1984, 1989; Kintigh 1989). This is, in a sense, the null hypothesis suggesting that with larger samples, the association of time period and clay or temper group will become more even (random in the statistical sense).

2) Local colluvial clay(s) provided a source for most pottery production at To'aga. Such clay(s) underwent little, if any, processing by potters. In most cases the colluvial clays could be described as "self-tempered."

3) Red-slipped pottery does not conform to the clay compositional data known for To'aga (clays and pottery). This ware, and others of similar clay-temper composition may be exotic to Ofu, and represent inter-island exchange.

4) The To'aga ceramic sequence is marked by a decline in the diversity of clays used in production (which in this case is not a product of sample size effects). This decline reflects change in the use or availability of the clay sources. Such a trend might also denote a decline in exchange, including that from other islands (see Hunt 1989; Kirch 1988, 1990).

Reconstruction of production technology is supported by the macroscopic ceramic analysis outlined above. Vessel form (bowls) and the observation of some laminar fracturing in the sherds point to slab-building as the primary forming technique. The analysis of orientation angle was designed to provide evidence for primary forming (table 9.5). However, due to the absence of grains with a definitive long-axis, and perhaps the difficulty of determining "random," "indeterminate," or "preferred orientation," the vestige of possible slab-building is not reflected in attempts to analyze particle orientation.

Secondary forming is indicated by paddle impressions (visible on 17% of the sherds) and anvil marks (present on 23% of the sherds). Two sherds show the unmistakable impression of a finger used for the same purpose.

The majority of the surface treatment is puddling (77%), a finishing technique using water and wiping to bring the finest clay particles to the surface of the paste. Wiping was also evident, occurring commonly on the rim sherds (tables 9.9-10).

Approximately 25% of the sherds in the sample display a pattern of incomplete oxidation adjacent to the interior surface in contrast to 4% with incomplete oxidation at the exterior surface. Only 2% of the sherds show little or no oxidation present. About 67% of the sherds are completely oxidized. Based on this, and other evidence described (hardness and comparison of experimentally fired-clay tiles), we suggest that pottery was fired in open conditions of temperatures reaching approximately 500-600° C. The fact that interior surfaces were darker (less oxidized), suggests that bowls were placed up-side-down for firing. This technique is similar to some documented ethnographically in Melanesia, where pottery is still made in many locations (e.g., Irwin 1985; May and Tuckson 1982).

Explaining the abandonment of pottery production in Samoa remains unresolved. Our To'aga analyses show that diversity of material use may have declined over the period of ceramic production. It could be hypothesized that changes in raw materials, for example the use of "self-tempered" colluvial clays, resulted in a ceramic product of marginal quality. This hypothesis requires additional study (e.g. see Feathers 1990).

Style

The To'aga assemblage is simple in form and carries very little decoration. Vessel parts present (direct rims and body sherds only) indicate that only forms of unrestricted orifice (bowls) were produced. There is no evidence in the To'aga assemblage of globular pots, jars, plates, or other complex vessel forms. Decorative attributes are restricted to impressing and notching on the lip, red-slip, carved paddle impression, and incision. Such a short roster departs dramatically from assemblages of comparable age from Mulifanua, 'Upolu, and from assemblages in Tonga and Fiji.

Style can be defined for analytic purposes in archaeology as traits that are free to vary independent of function (Dunnell 1978). This definition emphasizes style as governed by stochastic processes, and distributional frequencies that behave accordingly. In this perspective, thickness might be treated as a "stylistic" trait. Sherd thickness has received much attention in previous attempts to understand diachronic change in Samoan ceramics (Clark and Herdrich 1988; Green 1974; Hunt and Kirch 1988; Jennings and Holmer 1980; Kirch et al. 1990). The changing (declining) frequencies of thinware, in particular, might be a reflection of homology ("style"), and its independence from functional constraints. The frequency distributions (see tables 9.1-2) of thinware (defined as <7.5 mm) and thickware (>7.5 mm) from To'aga allow the following conclusions:

1) Thickware is present in the earliest deposits, and its abundance over time is relatively stable.
2) Thinware is never dominant in the assemblage but occurs in roughly equal percentages to thickware in the earliest deposits.
3) The presence of thinware declines in real and relative values over time but persists perhaps as long as pottery production itself.
4) Pottery declines in abundance early in the Christian era and then its production disappears entirely.

The evidence from Western Samoa is similar in many, but not all, respects. In spite of early dates for To'aga (i.e., contemporaneous with the Mulifanua Lapita site), no dentate-stamped Lapita pottery is known for this site, or elsewhere in Manu'a. This absence may be paralleled in the cases from Tikopia (Kirch and Yen 1982) and Anuta (Kirch and Rosendahl 1973) where assemblages of pottery date to early times, yet do not share the degree of decoration known elsewhere in the southwestern Pacific. Perhaps this reflects isolation from a larger interisland network that shared ideas of designs, or pots themselves. Manu'a may have simply been far enough away to incur such isolation from other islands of Samoa, Tonga, and Fiji.

Green (1974) proposed a sequence of ceramic change for Samoa. His chronological analysis from 'Upolu was based on a short occupation sequence, with radiocarbon dates ranging from 1840 ± 100 B.P. (GaK-1441) in the lowest cultural layer (V) to 1800 ± 80 B.P. (GaK-1341) in the layer (IV) above (Green 1974:115). These dates overlap at one standard deviation. When calibrated and averaged together, these two dates yield a calibrated age range at one standard deviation of A.D. 117-254 (Stuiver and Reimer 1986). Based on his analysis of over 7400 sherds, Green (1974:130) concluded that, "thin and thick ware sherds occur in association in both layers" and that over time the trend is for thickware to predominate but not totally replace thinware (1974:248). Inspection of Holmer's (1980:116) data, and his comparison to other Western Samoan assemblages, reveals a similar trend for thin- and thickware frequencies.

Function

Vessel function in the To'aga assemblage is suggested by form and the presence of residues. The single vessel form (bowls) might have served functions of storage, cooking, and serving dishes. Carbonaceous residues suggest cooking, at least in a small number of the vessels. Microanalysis for concentrations of phosphorus (P) was performed on three sherds in an experimental effort (Dunnell and Hunt 1990). These and other test case results were varied, and revealed that functional inferences based on P concentrations in pottery are unreliable

(Dunnell and Hunt 1990).

The ceramics from To'aga are among the best studied in the Samoan Islands. Addressing difficult issues beyond questions of chronology and cultural affinities demand detailed studies as we have attempted here. With regard to the questions posed at the start of this chapter, our study contributes to answers that will necessarily come from several studies of comparable detail and scope conducted with assemblages from throughout Samoa and the larger region.

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