A Case Study in Ceramic Technology: Site 26, Oundjo

Eleanor C. Casella

On the northwestern coast of New Caledonia, "8.3 miles by the west coast highway southeast of Voh and somewhat less than halfway to Koné," lies the village of Oundjo (Gifford and Shutler 1956:8). After obtaining the permission of Chief Bome, Gifford and Shutler commenced excavations at "site 26" on April 8, 1952. Faunal materials, shell artifacts, lithics, and substantial quantities of ceramics were collected, along with such historic artifacts as clay pipes and beads. Indeed, site 26 yielded six times more pottery than all the other New Caledonian excavations (Gifford and Shutler 1956:82).

In their laboratory analysis of the site 26 ceramics, Gifford and Shutler categorized the sherds into decorative "types," dividing the pottery section of their monograph into headings such as Pottery handles, Appliqué, Punctate, Chevrons, and so forth (1956:72-5). Only one short paragraph was devoted to the observable technological aspects of the Oundjo ceramics. This paper attempts to supply some of the ceramic information missing from Gifford and Shutler's report, specifically the manufacture process and ceramic technology of the Oundjo site's occupants, by providing a methodology for such laboratory investigation, and by comparing the potsherds of the deeper (and presumably older) 6-inch arbitrary levels with those of the upper levels to examine diachronic variation in ceramics. From the mixing of paste and inclusions, to the firing of the finished product, to the dumping of the broken pieces, the sherds manifest evidence from each stage in the sequence of making, using, and disposing of ceramics.

Materials and Methods

Sampling Considerations

Site 26 encompasses a large area (approximately 10 acres), and Gifford and Shutler sampled the site with three trenches, designated locations A, B, and C. They subdivided these trenches into rectangles of six by three feet, which they excavated down to underlying bedrock (Gifford and Shutler 1956:8-9). Site 26 yielded 6,783 ounces of pottery, averaging 6.44 ounces of potsherds per cubic foot of excavated matrix over the entire site (Gifford and Shutler 1956:71-82). Because of the large quantities of ceramic artifacts unearthed--well beyond the scope of my resources to study in their entirety--it was clear that I would have to develop a sampling strategy. Originally, I proposed to examine the plain body sherds from two rectangles in each of the main locations. By choosing rectangles located at opposite ends of each trench, I hoped to capture some reflection of spatial differentiation in the ceramic manufacture process. At the same time, choosing rectangles with greatest depth of deposit, I hoped to discern temporal variation. The six rectangles that fit these two requirements were: location A: A1-2/B1-2, A14-15/B14-15; location B: A1-2/B1-2, A14-15/B14-15; and, location C: D7-8/B7-8, A4-5/E4-5.

I began my examination of sherds with rectangle A1-2/B1-2, location B. In the process of acquiring data, I realized that my original sample was too large for completion within the time available. Therefore, I revised my sampling procedure by examining 50 sherds from each 6" arbitrary level, with the exception of the deepest level which only contained 18 sherds. I decided to focus on location B, A1-2/B1-2 for this project because it had been excavated to the greatest depth of all rectangles in site 26, and therefore would probably produce the most complete sample of temporal variation. In the end this research is based on a sample of 368 sherds taken from one rectangle of one trench dug from site 26. The total number of sherds from which I drew the sample, can be seen by levels in Table 1.

Table 1
Ceramic Sherd Sample Size by Level, Site 26, Location B

Level (inches)	Total number	Number sampled	Percentage of total
0-6	53	50	94
6-12	80	50	62.5
12-18	112	50	45
18-24	73	50	68
24-30	120	50	42
30-36	85	50	59
36-42	206	50	24
42-48	18	18	100
Total	**747**	**368**	**49.3**

Table 2
Presence of Anvil Impressions and Carbon Residue by Level, Site 26, Location B

Level (inches)	Impressions (%)	Residue (#)
0-6	24	4
6-12	32	6
12-18	50	9
18-24	40	6
24-30	60	12
30-36	30	6
36-42	42	4
42-48	20	0

Analytical Protocol

Based on a perusal of other ceramic analyses for southwestern Pacific archaeological sites (e.g., Kirch and Yen 1982; Kirch 1988b), a laboratory protocol was prepared listing the attributes to be examined (see Appendix C). In this protocol, the attributes were subdivided according to their stage in the manufacture process, which was the ultimate subject of this research. Measurements of average sherd thickness were taken using calipers, carefully avoiding dips or bulges due to anvil impressions. Since sherd thickness can relate to vessel function, it was thought that any temporal variation might reflect a change in the Oundjo site occupants' foodways. The presence/absence of anvil impressions on internal walls was also recorded, as an indicator of the use of paddle-and-anvil manufacture technique.

Non-plastic inclusions played a crucial part in the manufacture analysis, with type, relative amount, relative size, and general density of such inclusions all recorded. These variables were observed after making a small, fresh break on a side of each sherd using needle-nosed pliers, to control for weathering effects on the exposed surfaces. A general determination of inclusion type was made, using a coding scale that allowed for relative amounts of inclusion, the primary inclusion type occupying the first space, the secondary type following, and so on (see Hunt 1989). For example, the code "3600" denotes inclusion of primarily light minerals, with some lithic fragments present. The relative size of inclusions was visually judged under a binocular microscope, and similarly coded for density of the inclusions in the paste (Bennett 1974:84, 105).

Finally, the sherd surfaces were examined under a binocular microscope for evidence of finishing techniques. Although my protocol allowed for a potential variety of finishing methods, the sherds in the sample examined exhibited only wiping striations, and the presence/absence of those marks was recorded.

I also attempted to obtain evidence of the firing technology employed by the Oundjo occupants. The hardness of the sherds reflects the temperature and duration of firing (Rice 1987:354-355). Moh's hardness scale was used by performing a "scratch test" on the sherd surface, thereby determining the relative mineralogical hardness (Shepard 1971:114-115). The fresh breaks made on the sides of the sherds were re-examined, this time to code for relative porosity of vessel walls. Porosity depends in large part on the firing temperature, with low-fired pots retaining their porosity and remaining semi-permeable, and higher-fired pots becoming increasingly less porous until vitrification occurs and non-permeable earthenwares and stonewares develop (Rye 1981:113). Therefore, changes in the relative porosity of the sherds yield information on temporal changes in firing temperature (May and Tuckson 1982:47).

Much attention was paid to the cores produced as a result of the firing process. Eight possible core states were coded: (1) complete oxidization (or no core because the sherd was fully oxidized): (2) complete reduction (no core because the sherd was "raw"); (3) partial oxidization (with the sherd fired incompletely, so the interior was left "raw"); (4) external oxidization (dark core on internal surface); (5) internal oxidization (core on external surface); (6) partial reduction (interior fired, but cores on internal and external surfaces); (7) multiple layers of cores; and, (8) core visible at the surface with interior/exterior surfaces indeterminable (Bennett 1974:30; Rye 1981:116).

The margin between the dark, inoxidized core and the oxidized portion of the sherd also yields crucial evidence on the cooling process after firing (Rye 1981:117). A "discrete" margin results from rapid cooling--removing the pot from the fire at a designated time and cooling it at air temperature. A "blended" margin results from slow cooling, allowing heat to transfer from the oxidized part to the "raw" dark part, thereby obscuring the margin (Bennett 1974:28). Such pots are usually allowed to remain in the fire until the fuel is exhausted and the ashes cool (May and Tuckson 1982:48-9). A well defined core is a mid-state between those two margin states. Core thickness was measured visually, on a relative scale, coding by one-third increments (Bennett 1974:28). Core thickness also relates to the temperature and duration of firing, with thicker cores resulting from shorter firings at lower temperatures, and thinner cores resulting from opposite conditions (Rye 1981:119).

Use of ceramics by the Oundjo site occupants left evidence on many sherds of the site 26 ceramic assemblage. A well preserved deposit of carbonaceous residue was observed on a significant number of sherds in the sample. A log book was kept with descriptions and illustrations of those sherds. An attempt was made to record the residue patterning in relation to the sherd orientation, so that patterns that resulted from habitual use could be discerned.

Finally, post-depositional changes to the ceramic assemblage were examined by determining how weathering affected the sherds in my sample. First, the colors of the external and internal walls of the sherds were recorded according to the Munsell Soil Color Charts (Rice 1987:340-2; Shepard 1971:104-113). A note was made of any extreme changes in the average hue, value, and/or chroma of sherds between layers of the rectangle. Second, the general degree of weathering the sherd had endured was recorded, noting whether the sherd edges were jagged or smoothed, wether the surface was intact or worn, and wehther the paste was firm or disintegrating.

Results

Manufacture Process

Sherd thickness averaged at 8.38 ± 0.75 mm for the entire sample. Differences did exist between the mean thickness of sherds in the deeper levels (7-5) and the later levels (1, 2, and 3). Since level 8 contained only eighteen sherds, the mean sherd thickness and standard deviation cannot be readily compared those of the other levels. In levels 7-5 mean sherd thickness varied between 8.6-9.6 mm. Thinner walls characterize the ceramics of later levels, with the variation in mean thickness of 7.02-8.36 mm.

Evidence of primary forming techniques was noticeably lacking due to the nature of the secondary technique--paddle-and-anvil--which obscured the former. Beating the vessel walls with a paddle against a cobble anvil compacts the clay, decreasing the number of trapped air bubbles and generally increasing the strength of the vessel wall. Beating the vessels also compresses the joints of slabs and/or coils, preventing determination of primary techniques (Gifford and Shutler 1956:70). The interior surface anvil marks were therefore the only evidence left on the sherds from the forming process. Upper levels have low frequencies of these characteristic depressions on their internal walls, with levels 1 and 2 averaging 28 % (Table 2). This frequency increased sharply at level 3, and remained high through level 5, where over half of the sherds examined manifested such anvil marks. The sharp drop in the frequency of depressions exhibited in the deeper levels, although initially remarkable, was most likely due to erosion. These levels were waterlogged, and Gifford and Shutler resorted to bailing used to remove brackish water from levels 6-8 (Gifford and Shutler MS [1952]).

The non-plastic inclusions worked into the raw clay during the manufacture process primarily consisted of two classes, light minerals (such as quartz) and lithic fragments. These two classes were coded as "3" and "6" respectively. Since the inclusions were recorded by their relative abundance, four digit codes were assigned to the ceramic sherds reflecting their four most abundant types in descending order. Hence, the most common inclusion combination was predominantly light minerals mixed with an observable amount of lithic fragments, or "3600". Of the 368 sherds sampled, 61% contained predominantly light mineral inclusions, and 15% predominantly lithic fragments. However, a combination of the two materials was most prevalent, with 48 % of the sample consisting of "3600," and 13% coded as "6300." In the earlier and mid levels of the rectangle (levels 8-4), few examples of predominantly lithic fragment inclusion ("6xxx") were found to exist. However, by the top three layers, the amount increased to as many as 13 sherds per 50 sherd sample. Therefore, a change occurred in the quantity of secondary inclusions mixed into the clay paste during the initial formation phase of production.

This transformation could represent two possible changes in ceramic technology. Firstly, it could reflect a change in the source of clay utilized, an increase in lithic fragments reflecting differences both in type and frequency of natural inclusions occuring within the clay source. Conversely, the lithic increase could reflect a change in the type of non-plastic inclusions added to the clay paste during manufacture. A new and less pure source of quartz might have become preferred for obtaining inclusion material. Such a relocation could reflect transformations of the cultural landscape, such as rearrangments in local or regional exchange networks, or changing access to raw material sources. However, it is also possible that during more recent periods, less attention was paid to the "purity" of non-plastic inclusions, with a greater diversity of locally accessible inclusions mixed into the clay paste.

Other less frequent inclusions found in trace amounts included grog (crushed ceramic fragments), dark minerals, and some organic materials, which occurred at a frequency of about one sherd per sample, and were probably accidentally integrated into the paste. The frequency of grog and dark mineral inclusions followed a pattern, grog appearing in six sherds in levels 5-7, and dark minerals appearing in four sherds in levels 1 and 2. Perhaps earlier potters at Oundjo experimented by including grog as a component in a few of their inclusions, and later potters did the same with various dark minerals.

The density of non-plastic inclusions was measured against Bennett's coding scale (Bennett 1974:105). Most sherds exhibited an average density of between 10-20% inclusion-to-paste ratio. Variation exists between upper and lower levels in the frequency of this attribute. Whereas in levels 7-5, up to 66% of the sherds contained such a density range, in later levels the frequency dropped to as low as 44%. Level 8 was not included in the table because the total for the locus was only 18 sherds; however, 50% of those sherds exhibited densities of 10-20%. These statistics for this attribute show that in the late pre-contact period, potters added their non-plastic inclusions in a greater range of ratios than before.

A correlate of this trend is variation of inclusion size through the sample. Again, I used a system of coding by relative amounts to determine the two most prevalent grain sizes for the inclusions. Pottery in all layers seemed to be mainly tempered with small-to-medium particles; 83% in level 8, 78% in level 5, and 50% in level 1 followed that pattern. However, the trend decreases in frequency through time, with later levels showing some significant amounts of sherds tempered with medium to large particles. For example, 34% in level 2, and 22% in level 1 contain medium-to-large particles. In short, as the particles diversify in density, they diversify in relative size, perhaps marking an increase in ceramic experimentation in historic periods.

A final attribute relating to the manufacturing process of ceramic production is surface finish. Although the majority of sherds showed no sign of any finishing technique (over 50% in all levels) a significant minority exhibited striations on their external walls. Therefore, the ceramics were probably wiped before final firing in order to produce further compacted, smooth, and aesthetic outer surfaces (Bennett 1974:55). An unusual increase in the number of sherds exhibiting the characteristic striations occurs in level 4. This observation correlates with measurements taken on the number of eroded sherds per level, leading me to believe that mid-levels 3-5 were especially well preserved, retaining the fragile striations. Other evidence discussed later in this paper further substantiates this hypothesis.

Firing Process

Sherd hardness directly relates to the maximum temperature achieved during firing. In all eight levels, the average hardness was 3.5, interpolated from scratch tests performed with calcite (hardness 3) and fluorite (hardness 4). Because the composition of the sherds from the rectangule were shown to be relatively constant, the observed similarities in hardness are presumed to have resulted from similar firing temperatures. At 800°C, vitrification occurs in the walls of a vessel, causing hardness to increase sharply. Therefore, since the majority of the sample exhibited hardness of only 3.5, I classify the vessels as non-kiln fired terra-cotta ceramics, fired well below 800°C, probably in open air bonfires (Rice 1987:5, 356). Ethnographic studies conducted in the Pacific region support this hypothesis (May and Tuckson 1982:45-49).

Cores (the dark "raw" portions of the sherd interiors) also yield much information on the firing process. One hundred and seventy sherds had observable cores. In levels 1-6, the majority of cores (30%) displayed external oxidization, as evidenced by the darkened band of "raw" non-oxidized material at the internal wall. This core type signifies vessel orientation was with the vessel orifice down (Rye 1981:115). Significant numbers of sherds also showed evidence of total oxidization, as well as partial oxidization with the core equidistant from both internal and external walls. Level 7 marked a dramatic change in core type, with the sherds exhibiting reduction as the primary method of firing. A reduced sherd has been fired in an oxygen-depleted environment, and therefore characteristically looks dark throughout its cross section. The potter creates such an environment by waiting until the bonfire has reached a specific temperature and duration, and then extinguishing it with sand, cutting of necessary oxygen (May and Tuckson 1982:46). The vessels inside this temporary oven continue to bake in the residual heat, but do not undergo the chemical process of oxidization, and therefore remain dark black in color (Rye 1981:116). Since the examined sample of sherds changed from predominantly reduced vessels to predominantly oxidized vessels between layers 7 and 6, I infer that a change occurred in the firing technology of the people of site 26, one that may well have correlated with other cultural and/or technological changes.

Other core attributes were affected by the increase in reduction recorded in those deeper levels. Core margins are created by the rate of internal heat transfer as the vessels cool after firing. Whereas 25% of the sherds in levels 1-6 exhibited no core, due to reduction or complete oxidization, those that did primarily had blended cores. Only 8% showed the discrete margins characteristic of rapid cooling techniques. Therefore, potters of those periods allowed the fires to cool gradually, removing the pots from the embers after a relatively long period of time. Sherds of levels 7 and 8 displayed fewer cores, their reduced states leaving the cross-sections completely blackened. Of the cores that did exist, the majority were again blended.

The thickness of the cores varied little throughout the sample. Over 55% of the cores in levels 1-8 measured between one-third and two-thirds thickness of the vessel cross-section. The majority of pots were fired at low temperatures, preventing much of the wall interiors from oxidizing. Again, in levels 7 and 8, the increased rate of reduction caused the total number of sherds displaying cores to decline. However, those vessels fired by means of more "modern" technology did have predominantly one-third to two-thirds thick cores.

The increase in oxidization as the primary method of firing ceramics affected the porosity of the sampled sherds. Vessels in levels 7 and 8 were predominantly highly porous, as judged on a relative visual scale. In level 7, out of 50 sherds sampled, 64% demonstrated high porosity. However, by level 6 the percentage drops to 26%, with average porosity falling more in the medium range. Levels 1-5 continue this trend, 32% to 40% of the sherds measured having medium porosity. If a dramatic change in the firing process did occur between levels 7 and 6, as already discussed, then vessel porosity would have been affected. Since the reduction method of firing bakes the pots in residual heat, the overall temperatures reached are lower than those reached through continual firing (Shepard 1971:219). In oxidization, a chemical change occurs in the clay, porosity decreasing as temperature and duration of firing increase, until vitrification occurs (Rice 1987:5, 86). Therefore, the decrease in porosity observed in this total sample probably resulted from the development of oxidization. Although an increase in the amount of paddling done to compact and shape the vessel walls during manufacture would have caused a similar porosity decrease, I believe the decrease occurred as part of the changing firing technology between levels 7 and 6.

Patterns of Ceramic Use

A few of the sherds sampled from site 26 yielded special information on their function and use. Fifty-one sherds out of the entire sample had carbonaceous deposits on their internal surfaces. The carbon residue was unusually thick, possibly resulting from repeated boiling of heavy, sugary or starchy foods inside the vessels (such as *Dioscorea* yams?). The residue was usually thicker towards the base of the pot, although not all examples of the residue occurred on base sherds. A chemical analysis of the carbonaceous residue might provide information as to the foodways of the Oundjo site occupants.

Most levels contained six examples of residue per sample. However, in level 5, twelve sherds displayed this unusual residue: almost 25 % of the sample (Table 2). Perhaps the high frequency of residue represents a short-term change in foodways. Preparation of starchy stews or soups would easily produce thick carbonized residues during open-fire cooking. The higher residue frequency could represent an increased reliance on such starchy foods. This change in foodways could be related to environmental transformations that decreased the availability of other food types, such as over-predation of terrestrial or maritime faunal species. However, the increase in residue could also be the result of general intensification of food production by site occupants of level 5, site 26. This intensification could either be socio-ideological, resulting from increasing emphasis on wealth displays or religious festivals, or it could simply reflect a demographic increase in site occupants.

Post-Depositional Processes

Gifford and Shutler meticulously recorded site conditions in their fieldnotes as they excavated through the levels of site 26. They described location B, rectangle A1-2/B1-2, as waterlogged from levels 6-8, and thus required frequent bailing (Gifford and Shutler MS [1952]). This condition seems to have influenced weathering of the sherds. In levels 2-6, only a minority of sherds (27%) were weathered. Most sherds (70%) displayed rough edges and intact surfaces. In level 6, the first level needing frequent bailing of brackish water, the number of intact sherds begins to decrease, probably due to the waterlogged conditions. This trend intensified in deeper levels 7 and 8, where 72% to 100% of the examined sherds displayed severe weathering.

Although age probably had a role in the condition of the sherds, the firing process also affected the rate of erosion. The early reduced ceramics were naturally softer and more porous than later oxidized sherds. Hence, the samples from levels 7 and 8 weathered more completely than later ceramics. The brackish waterlogged conditions also encouraged organic growth on the walls of the sherds, which may have hastened the erosion process. This organic material produced a dramatic color change in the external and internal walls, from a Munsell hue of predominantly 5YR (red-orange & browns) to 10YR-2.5Y (olives and greens).

Middle levels 4 and 5 were especially well preserved, possibly resulting from a period of favorable post-depositional weathering conditions. These two levels contained the smallest number of weathered sherds, 20% in level 4 and 24% in level 5. The frequency of anvil impressions increased in level 4, with over 50 % of the sherds displaying the attribute (Table 2). Most importantly, the highest frequency of both carbonaceous residue and striations, attributes often highly sensitive to weathering effects, appeared in both levels (Table 2).

Conclusions

Evidence presented above seems to indicate a change in ceramic technology between levels 7 and 6. Earlier vessels were slightly thicker, and tempered with a high density of small particles of light minerals. The vessels were fired primarily by reduction, which resulted in high porosity, few firing cores, and increased post-depositional weathering. In contrast, sherds from levels 1-6 became slightly thinner, their temper consisting of slightly more lithic fragments in a greater range of densities. Particle sizes increased to medium-large by the top three levels. Externally oxidized, the vessels displayed a medium porosity range, and cores one-third to two-thirds of their cross-sections. They were allowed to cool gradually in the embers of their oxidizing bonfire. As discussed above, post-depositional effects, such as erosion and weathering, probably accentuated differences in the ceramics from levels 6 and 7, both of which Gifford recorded as saltwater-logged.

A second, more social process of transformation can be interpreted from ceramics recovered between levels 5 and 3. While earlier ceramics seem to manifest a greater degree of uniformity in their manufacture, sherds from the late pre-contact period display significant diversification in their non-plastic inclusion type, density, and size. Perhaps the greater variety of inclusions represents a period of technological experimentation, with new sources of raw materials utilized for local ceramic manufacture. However, when interpreted in light of the foodways transformations in level 5, the diversification of non-plastic inclusions could represent a decentralization of craft specialization within the community. If the increased presence of residue relates to intensification of food production for either demographic or socio-ideological reasons, one result of such intensification would be an increased demand for ceramic production, as vessels are required for food preparation, storage and display. This increased demand would decentralize the craft specialization, as more people began to manufacture ceramics. Such factors as resource accessibility and personal preference could easily create the diversification of non-plastic inclusion type, density and size manifest in ceramics from levels 4 through 1. Although outside the scope of this analysis, future testing of this hypothesis would be best done through chemical sourcing of the clay paste from ceramics of this sample, in order to determine patterns of clay aquisition.