Compositional analyses of dentate-stamped Lapita and nail-incised and applied relief pottery from Watom Island

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Introduction

This paper describes a series of compositional analyses of dentate-stamped Lapita, nail-incised and applied relief pottery from the SAD and SAC locations on Watom Island (Meyer 1909 & 1910; Green & Anson 1987; Green & Anson n.d; Specht 1968). The results of these analyses are then used to review current hypotheses concerning the role of Lapita pottery and the Lapita Cultural Complex in the peopling of Oceania. The paper also takes account of stratigraphic data at Watom's SAC and SDI locations.

Background

The discovery of sites in Western Melanesia where pottery with incised and applied-relief decoration is dominant and where only a handful of dentate-stamped sherds is present suggests that the distribution of Lapita within the Bismarck Archipelago may be less widespread than first thought (White 1992). In addition preliminary analyses of aceramic sites earlier than Lapita suggests that these sites may display traits usually associated with the Lapita colonisation (Allen & White 1989; White 1992; Green 1979).

Pottery decorated with incision and applied relief is widely distributed in the south-west Pacific (Golson 1968: 10-12; 1972: 567-576; Garanger 1971) and sometimes it overlaps chronologically with Lapita (Golson 1991: 255-256). The origins of the incised and applied relief pottery styles are still uncertain. Recently it has been suggested that it might derive from that of early (earlier than Lapita) pottery sites on the Sepik and Ramu rivers or sites in NW New Guinea dating back to as early as 5,500 BP (Goreki 1992: 33-42). The prospect that the incised and applied-relief decoration which predates Lapita may be of an early "Sepik Tradition", supports scenarios representing Lapita as one of several fashions in pottery decoration peripheral to the story of Oceania's colonisation, or simply a trade ware (Terrell 1989; 623-626)[1].

In two other models formulated to explain what may have happened to Lapita in Melanesia, the replacement of Lapita by pottery decorated with incision and applied-relief which is central. The first of these, the "Absorption Model", suggests that, as well as the Bismarcks, the Solomons, Vanuatu and New Caledonia were settled pre-Lapita by non-Austronesians, and that pottery decorated with incision and applied relief developed from a gradual merging of these people with the later Austronesian makers of Lapita.

In the second, the "Secondary Migration Model", the appearance of pottery decorated with incision and applied relief is associated with the arrival of a second group of Austronesian (Western Oceanic Austronesian) speakers into Central Melanesia (Spriggs 1992: 225-227).

The material record is being re-examined to test some of these theories. The extent to which Lapita Cultural Complex traits (Green 1979) may be continuous or discontinuous from pre-Lapita through to post-Lapita sites is being investigated (Green 1992; Spriggs 1993: 187-195). Comparative studies of the form and decoration of Lapita are also being carried out (Golson 1992) and composition analyses of Lapita and related pottery of the SW Pacific have also been undertaken to investigate their relationship (Hunt 1989; Galipaud 1990; Kirch *et al.*1991).

[1] In arguing that the material culture objects which we associate with a "Lapita Cultural Complex" may just be trade goods Terrell (1989:625) makes reference to the results of Hunt's (1989) compositional analyses of dentate-stamped Lapita pottery from Eloaue which showed some of this pottery to be exotic (See also Anson 1983).

The relevance of Waton Island pottery

Background

Watom Island has produced large numbers of Lapita sherds with dentate-stamped decoration. A classification of the Watom Lapita decorative motifs shows these to be closely related to those of Lapita sites in New Caledonia and Reefs/Santa Cruz (Anson 1986).

As well as dentate-stamped Lapita pottery, however, excavations at most Watom Island locations have also produced a considerable number of sherds decorated with nail-impressed or applied-relief decoration (Green and Anson n.d.; Anson n.d. a; Specht's 1968). The decoration of nail-impressed pottery consists of short, opposed impressions consistent with pinching. The applied-relief decoration consists of bands or large, irregular circles (Specht 1968: 28). Nail-impressed and applied-relief pottery is slipped in greyish-reds and browns which are unlike the bright red-browns common amongst plain and other decorated pottery from Watom. These pots are evidently bowls restricted at the neck (Anson 1983: 48; Anson 1994. See also Specht 1969: Pl. XI -47/m-z). The only known rim sherd (Anson 1983: Fig.XI/4) is modified beyond the notching found on plain Lapita. The incisions are broader and deeper. At the bottom of each incision there is a flattening of the ceramic paste which then protrudes outwards and inwards of the body section. More material will need to be uncovered if we are to say more about shapes. Specht (1968: 128) classified nail-impressed pottery separately from pottery decorated with applied relief. It seems, however, that they may be variants of the same group since nail impression and applied relief occur together frequently on the same sherd (Plate 2/31 & 32).

In comparing this pottery to the Lapita sherds of Watom, Father O'Reilly called it "Melanesian" (Anson: n.d.b). More recently, it has again been likened to pottery from Melanesia, namely the incised and applied-relief Mangaasi pottery (Garanger 1971: 65). Specht (1967:31), on the other hand, speculated that O'Reilly 's "Melanesian" nail-impressed and applied-relief pottery and Lapita, which he called "non-Melanesian", might represent different kinds of pottery, used and made by the same people to serve different uses, although he was unable to demonstrate a stratigraphic relationship.

Ceramic Sequence and Chronology

Recent excavations at the SAC location demonstrate that there were two Lapita cultural deposits, Zone C layers 1 & 2, underlying primary and secondary deposits of ash and more recent material. Carbon dating of these layers suggest that Lapita occupation covered a time span between circa 400 B.C. and 100 A.D. (Table 1) (Green & Anson n.d.)

PLAIN	BRUSHED	DENTATE	INCISED	NAIL IMP.	RELIEF
Layer C1 495	4 (.8%)	17 (3.2%)	6 (1.1%)	3 (.6%)	0
Layer C2 119	2 (1.5%)	9 (6.9%)	1 (.8%)	0	0

Table 1
Numbers and percentages of pottery types recovered from excavations in Zone C at Kainapirina, SAC site (DENTATE = Dentate-stamped; NAIL IMP. = Nail-impressed; RELIEF = Applied-relief).

Dating of the SAC deposits sealed in by the ashfall is provided by three radiocarbon determinations on marine shell samples and Specht's previous date on human bones.

For Zone C Layer 2 two dates are on samples from the same *Tridacna maxima* shell, from spit 2 in layer 2. One would therefore judge it not to date the first occupation features of layer 2, but the subsequent burials and stone alignment which displaced those initial activities (Green, Anson & Specht 1989). Two laboratories, Australian National University and Beta Analytic, ran radiocarbon determinations on pieces from the shell. The two statistically similar results obtained would imply an age range and intercept within one sigma of B.C. 291 (184) 113 B.C. when pooled and corrected using a Delta R ocean reservoir correction of 0.

This result is statistically compatible with the previous sample, ANU-37b, derived from a radiometric determination on a selection of human bones from the three layer 2 burials recovered by Specht (1968: 124). That result of 2420 +/-110 B.P., however, is difficult to calibrate more precisely due to a variety of factors including the uncertain effect on C12/C13 ratios of human diet. It is, therefore, appropriate to claim no more than general support from this source for a time estimate for layer 2 of between 350 BC and 50 BC, the two sigma age range for the shell date- (Green & Anson n.d.).

	Plain	Brushed	Dentate	Incised	Nail imp	Relief
LAYER C1	179 (98.2%)	1 (.6%)	1 (.6%)	0	0	1(.6%)
LAYER C2	453 (98.5%)	3 (.7%)	0	0	2(.4%)	2(.4%)
LAYER C3	245 (94.9%)	6 (2.3%)	3 (1.2%)	1 (.4%)	3 (1.2%)	0
LAYER C4	43 (76.8%)	7 (7.1%)	8 (14.3%)	1 (1.8%)	0	0

Table 2
Numbers and percentages of pottery types present in SDI location
(DENTATE = Dentate-stamped; NAIL IMP. = Nail impressed; RELIEF = Applied relief).

A date for Zone C layer 1 is provided by a partially-dissolved *Tridacna maxima* shell recovered from the base of the layer. The sample, ANU-5330, gave a radiocarbon determination of 2390 +/- 80 B.P. This, when calibrated with a marine Delta R value of 0, yields a one sigma age range and intercept value of B.C.160 (B.C.96) 38 A.D. As such, it accords well both with its stratigraphic position and the dates discussed above for layer 2. Together the three results suggest that Lapita occupation in the SAC locality covered a time span between circa 400 B.C. and 100 A.D.

The excavations at the SDI locality in the Reber-Rakival site, though of limited extent, provided a set of four securely dated pottery assemblages in Zone C layers 1-4 spaced over a 1000 years[2]. Dentate-stamped Lapita is found at its highest concentration in Zone C layer 4 at the bottom of the site and persists in much reduced proportions in Zone C layers 3 and 1 (From 800 BC to the first or second century AD) (Table 2) (Anson n.d.).

The age of the sequence of deposits at SDI was determined by dating four radiocarbon samples: one of charcoal at the base of the sealing deposits of ash and three of shell from successive occupation layers of Zone C.

A *Tridacna maxima* shell from the base of layer 4 (Beta 16 836) provides a corrected date of 914 (817) 770 BC for the initial occupation in this locality.

The compacted dark brown loam occupation layer 3 has a corrected date of 405 (365) 264 (ANU 6475) obtained from a *Trochus niloticus*.

From lenses of charred vegetation lying directly under the primary Rabaul eruption volcanic ashfall deposits, a charcoal sample (ANU 5338) provides a corrected date of 686 (726) 767 AD. The result fixes the primary ashfall from the Rabaul eruption on Watom as occuring in the one sigma age range of 650 and 850 AD, suggesting that Lapita occupation in the SDI locality ceased with the deposition of Layer 1 in the first few centuries AD. (Anson n.d ii)

Nail-impressed and applied relief pottery is absent from the earliest layers of both SDI and SAC. At the SAC location nail-impressed pottery does not appear until Zone C layer 1 while applied-relief pottery is totally absent (Table 1).

At SDI nail-impressed pottery is contemporary only with the later stages of Lapita in Zone C layers 3 and 2 when dentate-stamping is in low concentrations. The same appears to be true of pottery with applied relief decoration, which appears only in Zone C layers 2 and 1 and is contemporary with, though perhaps continues rather later than, the nail-impressed pottery (Table 2).

[2] The inference is that occupation was intermittent, recurring at intervals of 300 to 500 years, and that a series of separate layers may be distinguished, each with a different pottery content.

That nail-impressed and applied relief pottery is indeed later than dentate-stamped Lapita may need to be confirmed by larger excavations at SDI. What can be clearly demonstrated at present is the coexistence of dentate-stamped Lapita and nail-impressed pottery in the upper Zone C occupation layers of SAC (from about 150 BC to about the time of Christ) while at SDI, nail-impressed pottery is present from about 365BC and applied-relief decoration begins rather later but continues alongside Lapita until sometime in the early centuries AD.

Temporal change

In the course of excavations at SAC, a gradual change in the pottery excavated became apparent. Firstly it was observed that the pottery from Zone C layer 1 appeared to consist largely of sherds which were bright reddish and contained fewer white inclusions than the majority of pottery from Zone C layer 2, which was darker and more brown.

To look more closely at the change in the quantity of white inclusions from Zone C layer 1 to Zone C layer 2 a total of 53 sherds were selected for further analysis. The analytical technique used consisted of mineralogical point counting of these sherds in thin section. The pottery chosen consisted of plain sherds and dentate-stamped sherds.

The results of the mineralogical analysis (Green & Anson 1987; Green & Anson n.d) indicate that the white grain inclusions in the fabric of the SAC pottery consist of calcareous carbonates and plagioclase feldspars. However, while the feldspars are present in both the Zone C layer 1 and layer 2 samples, calcareous carbonates were present only in the layer 2 sample[3]. Point counting the areas at which no inclusions were found also showed that the calcareous sherds were characterised by a higher inclusion-to-clay ratio than the feldspathic sherds.

A similar result was obtained from the point counting of a small sample of sherds from spits 1, 3, 4, 5, & 6 at Specht's (1968) excavations at trench I of SAC. These sherds had been examined previously using optical emission spectroscopy. The results of this analysis confirm the results of the point counts. They show a complete lack of strontium in all but one of the sherds from the upper spits versus its presence in all the sherds of the lower two spits (Green & Anson n.d).

[3] Petrographic analysis and point counting of 10 dentate-stamped sherds from SDI robust enough to sample confirmed the presence of both modal tempers in this site; five were of the carbonaceous mode and five of the feldspathic. While most of the carbonaceous sherds were from zone C layer 4 the size and nature of the sample analysed prohibits us comment concerning the situation in zone C layers 1- 3.

Analysis of nail-impressed and applied-relief pottery

Introduction

Microprobe analysis

The composition of dentate-stamped Lapita and nail-impressed and applied-relief pottery was first studied and compared in (Anson 1983). The method utilised involved the use of an electron microprobe employing a lithium-drifted silicon X-ray EDAX analyser (Goldstein *et al.* 1984). The very high magnification afforded by the Scanning Electron Microscopy (S.E.M) component of this instrument made it possible to analyse the clay matrix composition of each sample while ignoring sand inclusions in the fabric.

The EDAX analyser was set up to record counts from the X-ray spectra of Na, Mg, Al, Si, K, Ti, Cr, and Fe. To standardise the results X-ray counts for each element in each sample were divided by the number of X-rays recorded for silicon, the least variable element in the pottery. The resulting set of eight ratios to silicon for each sample i.e. Na/Si; Mg/Si; Al/Si; K/Si; Ca/Si; Ti/Si; Cr/Si and Fe/Si, was used as the basis for sherd to sherd comparisons. It was decided to ensure that a representative analysis of each sample was obtained by doing ten twenty-second analy ses on different parts of each sample. The results were then averaged (Anson 1983: 91-136).

The clay composition of the 18 dentate-stamped sherds from the SAD location (Plate 1. 1-18) was then compared with that of six sherds decorated with nail impression (Plate 2. 19-24) and of eight sherds decorated with applied relief (Plate 2. 25-32) from the same location (Table 3 d). All of these sherds were from unstratified contexts.

To ascertain whether or not any of these samples might be indigenous to Watom, their composition was also compared to that of a clay sample from Watom, provided for analysis by J. Specht (Anson 1983: 137-173) (Table 3 a - c).

Optical mineralogy

Recently, as a check on a possible influence of post-depositional effects on the fabric of the pottery samples (Ambrose 1992), the mineralogy of sand inclusions in the fabric of a sub-sample of 21 of the sherds examined in 1983 was analysed and point-counted in thin section. To take account of the density of inclusions in the clay fabric, points at which no mineral grains were found were also counted.

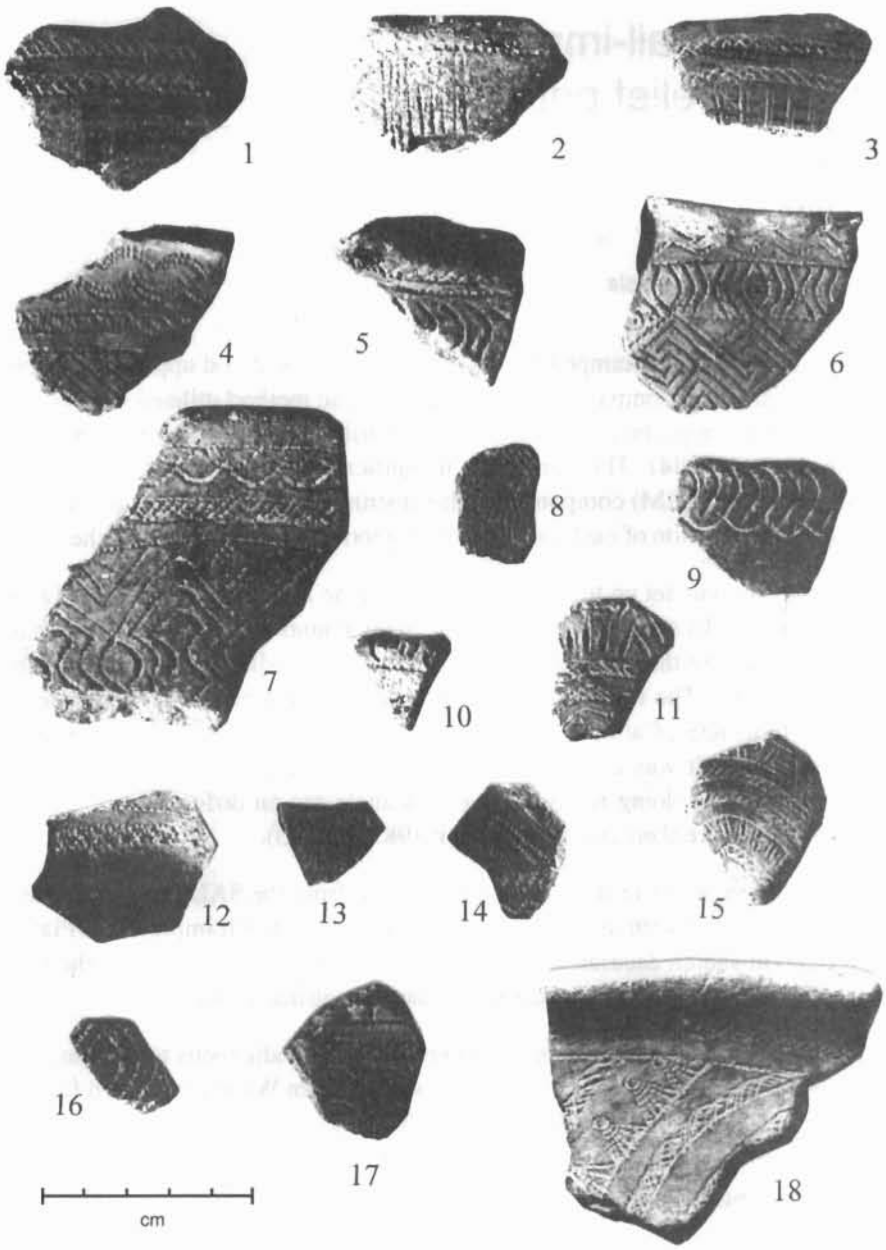


Plate 1
Watom dentate-stamped Lapita pottery sherd samples from the SAD location used in compositional analyses.

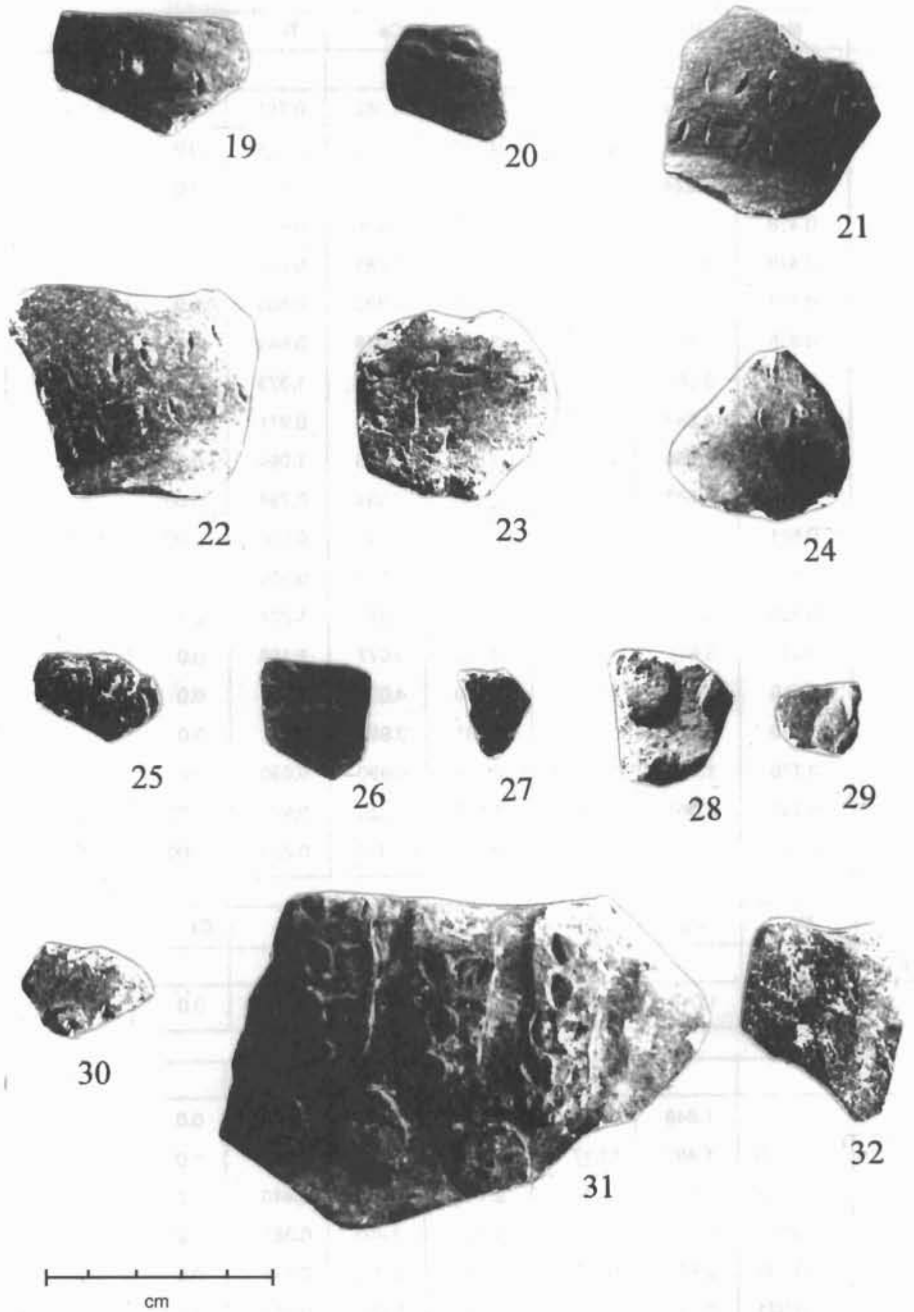


Plate 2
Watom nail-impressed (nos. 19-24) and applied-relief (nos. 25-32) pottery sherd samples from the SAD location used in compositional analyses.

	Na	Mg	Al	K	Ca	Ti	Cr	Fe
(a)								
1	0.156	2.214	47.51	2.300	3.362	0.761	0.0	4.565
2	0.283	2.297	43.12	4.279	6.812	1.446	0.0	5.607
3	1.573	6.224	63.71	3.747	5.188	1.140	0.0	8.263
4	0.438	2.456	46.13	2.098	3.936	0.695	0.0	5.777
5	0.428	2.322	44.90	1.899	5.281	0.899	0.005	5.302
6	0.571	2.323	46.05	0.929	4.833	0.688	0.0	5.388
7	0.835	3.109	46.78	3.119	4.049	0.649	0.0	6.162
8	0.352	3.067	48.67	0.816	4.918	1.373	0.0	6.311
9	0.404	4.643	50.15	2.174	4.543	0.911	0.01	5.166
10	0.417	2.650	45.11	1.601	3.913	1.094	0.002	4.849
11	0.369	2.552	42.30	2.309	4.934	0.794	0.008	5.642
12	0.681	2.799	41.58	2.106	4.590	0.686	0.008	5.430
13	0.198	2.716	47.37	1.437	5.707	0.950	0.0	5.881
14	0.523	2.611	51.07	1.324	5.952	1.224	0.0	4.312
15	0.537	3.611	47.54	2.420	5.077	1.156	0.0	6.110
16	0.116	1.467	41.23	1.710	4.696	1.121	0.0	5.311
17	0.892	6.310	41.79	1.985	3.953	0.671	0.0	7.841
18	0.176	1.755	42.00	2.023	4.990	0.680	0.0	5.872
mean	0.497	3.063	46.50	2.126	4.818	0.941	0.002	5.766
stdv	0.346	1.355	05.24	0.881	0.830	0.259	0.003	0.989

	Na	Mg	Al	K	Ca	Ti	Cr	Fe
(b)								
	0.793	1.014	35.24	1.968	6.985	1.033	0.0	5.951

(c)								
19	0.113	1.848	49.57	2.230	5.040	1.016	0.0	5.920
20	0.089	1.452	52.17	4.018	4.593	0.837	0.0	7.307
21	0.322	1.847	46.17	2.145	2.402	0.440	0.0	5.977
22	0.0	0.206	51.73	0.752	3.405	0.382	0.0	4.545
23	0.103	0.974	50.22	1.600	5.218	0.495	0.0	5.002
24	0.021	0.313	50.93	1.371	5.590	0.882	0.0	7.539
mean	0.108	1.107	50.13	2.019	4.375	0.675	0.0	6.048
stdv	0.114	0.732	02.16	1.119	1.226	0.268	0.0	1.198

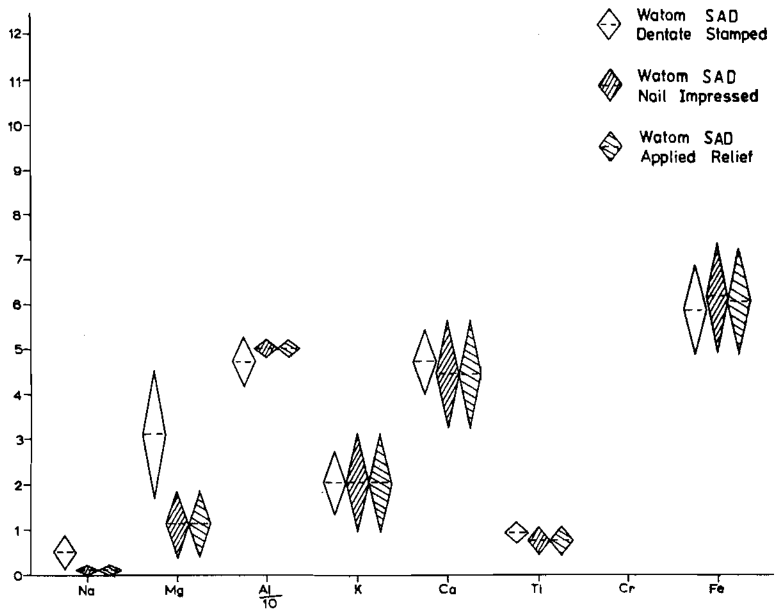
(d)								
25	0.009	0.486	50.27	2.414	4.839	1.237	0.0	5.843
26	0.024	1.268	49.07	2.691	6.168	0.759	0.0	7.242
27	0.640	0.926	53.69	2.162	5.885	0.252	0.0	5.878
28	0.559	0.498	43.41	3.856	3.935	0.982	0.0	5.251
29	0.139	2.076	48.64	3.145	5.849	0.528	0.0	6.265
30	0,767	1.592	45.85	4.106	3.328	0.749	0.0	6.801
31	0.743	1.032	53.31	2.645	5.072	1.122	0.073	6.161
32	0.766	1.816	55.16	3.542	4.026	1.250	0.0	6.115
mean	0.1456	1.222	49.93	3.070	4.888	0.860	0.009	6.195
stdv	0.339	0.587	04.05	0.707	1.047	0.355	0.026	0.608

Table 3 (suite)
Ratios to silicon calculated from averaged X ray counts obtained from Na, Mg, Al, K, Ca, Cr and Fa through Microprobe/ADAX analysis of samples of,
a. SAD location dentate-stamped pottert (Plate 1) - b. Watom clay sample -
c. SAD location nail-impressed pottery (Plate 2/19-24)
d. SAD location applied-relief pottery (Plate 2/25-32).

GROUP	PERCENT CORRECT	NUMBER OF CASES CLASSIFIED INTO GROUP		
		DENT	NAIL	RELF
DENT	88.9	16	2	0
NAIL	0.0	0	0	6
RELF	25.0	0	6	2
TOTAL	56.3	16	8	8

Table 4
UCLA BIOMED 7 M Stepwise Discriminant Analysis, Jacknifed classification of Microprobe/EDAX X ray silicon ratio data for 18 dentate-stamped, six nail-impressed and eight applied-relief samples.

In order to examine further the relationship between dentate-stamped, nail-impressed and applied-relief pottery both the chemical and physical aspects of the samples were examined. The chemical components of a sample may reflect the source of the sample. Physical aspects involve such processes as weathering and erosion, transport and deposition of the components. They may remove, concentrate or alter certain components and consequently govern the mineral assemblages of the sample which may then be classified on this basis.



I Figure 1 Microprobe/EDAX analyses composition pattern histograms: comparison of SAD location dentate-stamped Lapita, nail-impressd and applied-relief pottery samples (plotting group means and one standard deviation above and below mean).

The samples analysed consisted of 13 of the dentate-stamped (samples 1-2, 4-10, 12, & 14-18) and 8 of the nail-impressed/applied-relief pottery sherds (samples 22-23 & 25-30) previously analysed with the microprobe. Given overlaps in their decoration and the results of the microprobe analysis (see below) the nail-impressed and applied-relief pottery sub-samples were combined and treated as one group. This analysis was carried out by Yvonne Cook of the Geology Department of Otago University.

Results

Microprobe analysis

The mean values of the nail-impressed and applied-relief samples overlap those of the dentate-stamped Lapita pottery at one standard deviation for all elements. They also overlap at or near the one standard deviation level for all values obtained from the Watom clay sample, excepting the Al/Si ratio which is lower than for any of the pottery groups analysed on Watom (Anson 1983: 164-64) (Table 1 a-b).

Sampl	L	P	R	VP	VG	V	M	O
1	0	35	7	25	10	1	20	2
4	15	25	2	30	10	6	10	2
6	0	20	1	10	9	45	15	0
7	15	25	0	0	10	30	10	10
8	0	50	1	0	0	30	15	4
9	0	48	0	0	2	30	25	5
10	0	22	1	5	0	10	17	45
14	0	30	2	15	8	7	30	8
2	45	20	3	3	3	0	20	5
12	20	20	20	0	0	30	10	0
16	30	30	1	12	6	6	15	0
17	30	20	3	10	4	10	20	3
18	55	25	0	0	0	10	5	5
22	54	15	13	0	0	8	17	0
23	40	10	35	3	0	10	2	0
25	60	10	15	7	8	0	0	0
26	55	16	16	2	2	3	10	tr
27	55	20	20	0	1	1	3	tr
28	68	10	13	0	0	3	6	0
29	60	5	20	0	0	0	15	0
30	40	40	10	4	1	0	5	0

Table 5
Percentages of mineral inclusions in Watom SAD dentate-stamped (nos.1-2, 4-10, 12, & 14-18) (Plate 1) and grouped nail-impressed and applied-relief pottery samples (nos. 22-23 & 25-30) (Plate 2). Abbreviations used are as follows;
L = limestone; **P** = plagioclase; **R** = rutile + iron and titanium weathering oxides; **VP** = volcanic clasts comprising plagioclase laths; **VG** = volcanic clasts comprising glass and a variety of minerals; **V** = volcanic clasts comprising a variety of minerals **M** = mafic minerals - olivine, pyroxene, amphibole;
O = opaque metallic oxides/sulphides.

The overlap between the dentate-stamped group on the one hand and the nail-impressed and applied-relief pottery on the other is least for the Mg value (Fig. 1). An examination of the individual scores shows that 16/18 of the dentate-stamped sherds have Mg ratio values higher than 2 while 10/11 of the nail-impressed and applied-relief sherds have Mg ratio values below 2 (Table 1 a, d & e).

Optical mineralogy

Physical properties

The examination of the physical properties of the dentate-stamped and nail-incised/applied relief pottery samples suggests that while the differences between them are not large enough to be attributed to different environments of deposition the nail-incised and applied-relief sherds generally have a higher clast-to-matrix ratio.

Chemical composition

The clasts present consist of:

- Limestone. This comprises granular calcium carbonate, frequently in the form of fossils.
- Feldspar. Almost all the feldspar present is plagioclase. Where microscope identification of feldspar is equivocal some K feldspar may be present.
- Rutile and related iron-titanium weathering oxides. The exact composition of the clasts in this grouping is unknown but the group includes all colour varieties from yellow through to red.
- Volcanic clasts comprising small, euhedral plagioclase laths.
- Volcanic clasts comprising glass and glass shards with or without minor plagioclase.
- Volcanic clasts comprising a variety of components.
- 'Mafic'minerals. This groups is dominated by olivine but also includes pyroxene and possibly some amphibole.
- 'Others'. This group includes clasts found only in a very small number of samples. The most significant are opaque metallic oxides and/or sulphides. In some samples intraformational sedimentary clasts form a minor component.

Notable variations in clast abundances include: limestone; olivine; volcanic clasts of all types; opaque metallic oxides/sulphides and rutile plus iron and titanium weathering oxides. Percentages of each clast present in each of the samples are recorded in Table 4. It is evident that:

- Calcite is absent only in the dentate-stamped samples but is not absent in all the dentate-stamped samples[4].
- Volcanic clasts are abundant in 10/13 of the dentate-stamped pottery while none of the nail-impressed/applied-relief group has a content greater than 20 %.
- Olivine is abundant only in the dentate-stamped samples.
- There is generally less rutile in the dentate-stamped samples (1/13 of the of the dentate stamped group contain more than 5 % of rutile plus iron and titanium weathering oxides while 8/8 of the nail-impressed and applied-relief group exceed this amount).

[4] Given the occurrence of a temporal change in the temper type of Lapita and plain pottery at SAC from one dominated by a carbonaceous temper at Zone C layer 2 to one wherein calcite is absent or rare in the pottery of the layer 1 (see above). It may be that the absence of calcite in some of the SAD Lapita pottery may also be attributable to chronological differences in these unstratified Lapita samples.

- A high concentration of metallic oxides/sulphides occurs in some of the dentate-stamped samples.
- Plagioclase, as individual crystal fragments, is found throughout all samples but is more common in the dentate-stamped samples.

The two sample groups may thus be distinguished as follows: In the dentate-stamped pottery samples, volcanic, plagioclase and olivine clasts form the majority of the rock. Limestone is present, but only as a minor component. In contrast the nail-impressed/applied-relief pottery samples contain limestone as a significant clast component while volcanic clasts, where they occur, are a minor component (Table 5).
This may be statistically summarised in the following way: In 11 out of the 13 dentate-stamped samples the combined percentages of plagioclase, olivines, volcanics and opaque oxides/sulphides exceed 60 % of the inclusions present while none of the eight nail-impressed and applied-relief sample group approaches this figure. On the other hand, the combined percentage of limestone and rutile inclusions in all 13 dentate-stamped samples is below 60 % while seven out of the eight nail-impressed and applied-relief samples far exceed this percentage.
That calcite is absent in only some of the dentate-stamped sherds may reflect the situation at the neighbouring SAC location where pottery with calcite inclusions gradually drops out in the upper layer (see above).

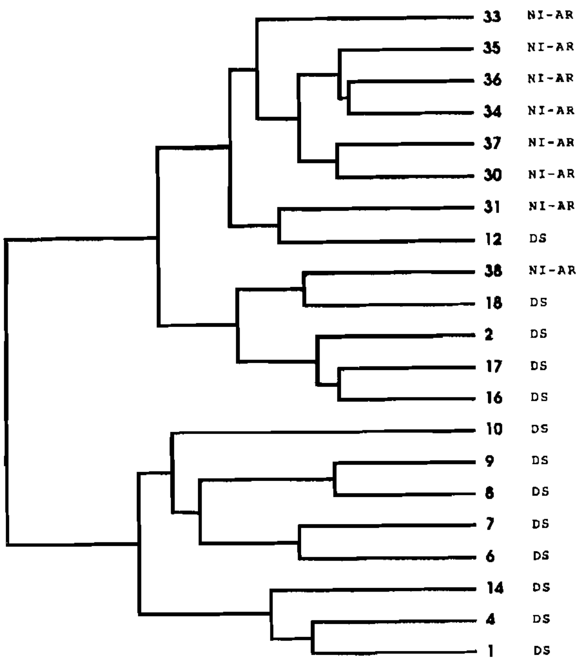


Figure 2 MV-NUTSHELL Multivariate cluster analysis dendrogram of percentages of mineral inclusions in Watom SAD dentate-stamped (nos.1-2, 4-10, 12, & 14-18) (Plate 1) and grouped nail-impressed and applied-relief pottery samples (nos.22-23 & 25-30) (Plate 2).

If there are differences between the composition of the dentate-stamped, nail-impressed and applied-relief pottery samples, the carbonaceous and felspathic nature of sand inclusions present in both dentate-stamped Lapita and nail-impressed and applied-relief samples is consistent with the plagioclase feldspar temper type which Dickinson (n.d.) inferred to be local, given its mineralogical compatibility with an origin in Watom and its preponderance amongst the sherds he analysed. This is also the composition pattern to which all 79 dentate-stamped and plain Lapita sherds analysed from the 1985 excavations at SAC and SDI conformed. The gradational nature of the parameters used to separate the dentate-stamped pottery from the nail-impressed and applied-relief samples may be to be what one might expect from potters using generally two similar clay sources.

Recently, the petrographic analysis data were analysed using multi-variate cluster analysis based on Ward's space-dilating method in the analytical package MV-Nutshell (Wright 1994). These results are in substantial agreement with the above conclusions.
If we consider the bottom branch of the tree it is evident that the classification has focused on the absence of limestone in some of the dentate-samples, setting them apart from dentate stamped pottery with limestone inclusions. An examination of the analysis scatter-grams for axes 1 and 2 of this classification, shows that this branch is characterised by low calcium values and relatively high values for volcanic inclusions.
The top branch of the tree, which includes dentate-stamped pottery with limestone inclusions is distinguished by high values of limestone and rutile.
Samples in predominantly dentate-stamped pottery sub-group lie around the centroid and so are average so far as the elements go i.e. they have no particular characterisation.
Samples in the predominantly nail-impressed and applied-relief sub-group lie in an area of the scattergram that is characterised by relatively high values of limestone and rutile and relatively low values of the other elements.

Summary of Results

While further excavations may be needed to determine whether or not nail-impressed and applied-relief pottery is indeed later than dentate-stamped Lapita, what is clearly demonstrated at present is the coexistence of dentate-stamped Lapita, nail-impressed and applied-relief pottery from about 365 BC to about the time of Christ.

Two main differences are obvious between the two groups:
- While nail-impressed, applied-relief pottery and dentate-stamped Lapita pottery appear to be local to the region of Watom, there are compositional differences between dentate-stamped pottery on the one hand and nail-impressed and applied-relief pottery on the other;
- While the composition of dentate-stamped pottery undergoes a temporal change from a type dominated by a carbonaceous temper to one where calcite is absent or rare, no such change is evident amongst the nail-impressed and applied relief pottery samples.

Conclusions

If dentate-stamped, nail-incised and applied-relief pottery were all made by the same people but for different purposes, this would entail the use and maintenance of different manufacturing technologies for each purpose[5]. The coexistence and maintenance of two indigenous pottery products might then reflect aspects of social organisation within Watom or its immediate region at this period, such as the presence of different potters from different clans with ownership rights to designs and pot making technologies. If, however, the nail-impressed and applied-relief pottery is a localised phenomenon, this need not evoke large-scale population movement scenarios.

If the nail-impressed and applied-relief pottery of Watom is part of a universal ceramic style such as Mangaasi, the following points might be made.

The positing of trade scenarios (Terrell 1989) to explain the coexistence of Lapita and Mangaasi ware in Watom are inappropriate. Here dentate-stamped Lapita, nail-impressed and applied-relief pottery appear all to be local.

To argue that the appearance of one or other of the two styles is the result of a new fashion in pottery would need one to explain why the taking up of new decoration and shapes in Watom is also accompanied by the adoption and long-term maintenance of new technology alongside the old.

As dentate-stamped, nail-incised and applied-relief pottery coexist to the end of the SAC and SDI sequences, the Watom pottery throws no light on models where the appearance of Mangaasi pottery is explained as a merging of Lapita and other traditions (Spriggs 1992: 225-227).

If the pottery produced on Watom was made by people from separate, widely-distributed ceramic traditions such as Lapita and Mangaasi, migration scenarios involving the arrival of successive groups of peoples into Central Melanesia (Spriggs 1992: 225-227) might need to be reconsidered.

[5] I would note, however, that in New Caledonia the different pots for different purposes argument has been advanced in respect of Podtanean paddle-impressed on the one hand and dentate stamped pottery on the other, because these two wares appear to have the same composition (Galipaud 1990).

Future Perspectives

To verify my results and the chronology of the nail-impressed and applied-relief pottery more material will need to be excavated and analysed. SDI, which was only test pitted, produced large numbers of pottery and it would be a good place to start. It would also be interesting to know how the results obtained at Watom might compare with analyses of Lapita and Mangaasi pottery from other sites.

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