Pottery and the Pacific: the Clay Factor

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ABSTRACT

The origin of the peoples of Polynesia is closely associated with the presence of Lapita pottery, which is found in a large number of sites from New Britain to Fiji. Pottery is still made by the indigenous peoples of some of these islands. Further to the east, pottery is found in Samoa, Tonga and the Marquesas. However, the early inhabitants of these islands soon abandoned the art of making pottery.

In Fiji and many of the islands to the west, soils are formed very largely on andesite or andesite-derived alluvium, and weather to form kaolinite or smectite clays which, with the addition of suitable temper sands, can be used for the manufacture of good pottery.

In Tonga the clays are halloysitic and suitable temper sands are not available. In Samoa good temper sands can be found but the nature of the clays is such that acceptable pottery would be more difficult to make than further to the west. In the Marquesas and in Tahiti the soils are oxidic and do not contain materials from which pottery may be prepared.

Thus it is postulated that the early Polynesians abandoned their pottery techniques as they migrated into the Pacific, where it became uneconomic to manufacture usable articles because of the nature of the available raw materials.

Keywords: POTTERY, CLAY MINERALS, SOUTH PACIFIC, COOK ISLANDS, FIJI, MARQUESAS, SAMOA, SOLOMON ISLANDS, TAHITI, TONGA, VANUATU.

INTRODUCTION

Some 3500 years ago a characteristic style of pottery began to appear all across Melanesia. This pottery is referred to as Lapita, after the site where it was first found, in New Caledonia. It is probable that the makers of this pottery introduced the pottery-making technique to Melanesia, where it has persisted to the present day. These people were considered to have entered the area from the west, probably from eastern Indonesia or from the Philippines (Bellwood 1978:255). They continued to the east during the next 500 years, through Fiji to Samoa and Tonga, taking their pottery-making craft with them. It is very probable that these people were ancestors of the present-day Polynesians.

Traces of their pottery are found as far afield as the Marquesas. However, although pottery is still made in Fiji and some places further to the west, the art died out about 2000 years ago in Tonga and Samoa, while pottery in the Marquesas appears to belong to the earliest years of settlement (Sinoto 1970).

The pottery of Tonga was discussed by Groube (1971). Although pottery of probable Fijian origin was still in use at the time of the first European visitors, the great bulk of the pottery found on Tongatapu was confined to the period before about 200 BC. The nature of the sand temper of this pottery indicates that most of it was derived from a single homogeneous beach deposit of an unusual pyroxene-rich mineral sand, which could not have been found on the main islands of the Tongan group, and which was thought by Groube to have originated from Vanua Levu. Dickinson and Shutler (1974), however, considered that the temper sands could have been derived from the volcanic islands of the Tongan archipelago.

Pottery from the Marquesas is very rare. Some of it contains temper sands which could have been derived from the oceanic basaltic rocks of which the islands are formed. However, a few examples are clearly of Fijian origin (Dickinson and Shutler 1974).

In Samoa, pottery was also made in the first millennium of settlement, from 3000-2000 BP (Green and Richards 1975). It appears to have been made locally, judging by the nature of the sand temper, but has considerable stylistic affinities to the Lapita culture, widespread throughout the western Pacific at that time. The manufacture of pottery appears to have died out in Samoa some time before the third century A.D.

The reasons why the manufacture and use of pottery died out in Samoa and Tonga although it persisted and was developed throughout the western Pacific are not clear. Bellwood (1978:329) states that "Why pottery should have been discarded by sedentary populous agricultural societies is not very clear, and raw materials are not lacking except on atolls . . . While one could sit down and imagine numerous reasons for the demise of Polynesian pottery, none are likely to find acceptable proof."

After investigation of the mineralogies of the soils of some of the islands in the Pacific and studies of their potential as ceramic raw materials (Claridge 1981), it became apparent that many of them were very unsuitable as raw materials for pottery manufacture. It appeared likely, therefore, that the art of pottery manufacture was abandoned because of the poor quality of the raw materials and consequent difficulties in the manufacture of suitable articles. This paper relates the requirements for pottery clay to the resources available on some islands of the South Pacific.

RAW MATERIALS FOR POTTERY

Materials used for the manufacture of ceramic products are commonly called clays, although strictly speaking the greater part of the material may not be clay size (commonly defined as being less than 0.002 mm), and may not consist of clay minerals in the strict sense.

The principal properties required for a ceramic raw material are:

(a) That it should be sufficiently plastic to mould easily into the required shape.
(b) That it be able to retain that shape in both the wet and the dry state.
(c) That it fuse together to form a strong stable article without excessive shrinkage or deformation when heated to temperatures commonly between 900° and 1100°C.

In order to achieve these properties, the raw materials must contain sufficient clay mineral, i.e. clay-size minerals with specific composition and shape, such as kaolinite, illite, vermiculite etc. which, because of their small size, large surface areas and surface reactivity, become highly plastic when moulded with the appropriate amounts of water.

Clay minerals alone do not make a suitable ceramic raw material because they shrink and deform on drying and firing as water is lost from between the individual clay particles. It is also difficult to achieve the right degree of plasticity to form the required shape. Therefore some filler material is also required. This usually consists of sand- and silt-sized particles of some inert substance, generally quartz, although other minerals or rock fragments may be used. This filler material acts as the skeleton of the ceramic article, individual grains being held together by the clay matrix, in the wet, the dry and the fired state. This sandy material is sometimes referred to as a temper sand, especially in an archaeological context, because it is frequently added by the potter to a naturally occurring clay in order to improve its properties, and, being relatively unaltered during the firing process, may give some evidence of the place of manufacture of the pottery. In the absence of suitable sands it is possible to grind fired clay, or broken pottery to a suitable size and use it as a filler. Such material is called grog.

At high temperatures the clay minerals present undergo chemical transformations and partly fuse into a solid mass, which is water resistant and which holds the filler material together. Sometimes materials are present or are added to act as fluxes in order to lower the transformation temperature and give added strength to the finished article. Substances containing alkali cations, such as potash feldspars may be used, although commonly potassium-containing clay minerals may act as fluxes.

In primitive firing techniques such as that used at the present time in Fiji and in the Solomon Islands, kilns are not used and the pots are fired in an open fire for a short time. Temperatures during firing are probably in the range of 700-900°C. Because of the short firing time, the relatively slow chemical transformations that give rise to fired strength do not go to completion. Consequently chemical transformations on firing are not great, and many of the strength-inducing chemical transformations that occur in most pottery firings made at temperatures above 1000°C do not take place. These reactions may be induced or replaced by others in the presence of suitable fluxes, such as potassium- or sodium-containing minerals. Thus the absence of suitable fluxing material has a large influence on the strength of the finished article.

CLAY MINERALS

Clay minerals are hydrous silicate minerals that are more stable at the conditions of temperature, pressure and moisture availability prevailing at the surface of the earth than the rock minerals which have formed at high temperatures. They are formed from rock minerals in the course of weathering and soil formation that takes place almost everywhere at the atmosphere/rock interface of the earth's surface. The nature of these secondary clay minerals is related to the composition of the rocks from which they form and the environment in which the transformations take place.

In a tropical environment, rocks weather rapidly and, in general, soils on stable sites are fine-textured. Basaltic rocks, containing little or no quartz and consisting largely of plagioclase feldspars and ferromagnesian minerals transform relatively rapidly to smectites and kaolins. Andesitic rocks contain somewhat more quartz and weather to form halloysite and kaolinite clays with some residual sand- and silt-sized quartz. Some micaceous clay minerals, such as vermiculite may also be formed. Granites, containing about 30-40% quartz, with potash feldspar and muscovite micas, weather to illite, vermiculite and kaolinite, but muscovite is slow to weather, while quartz remains unaltered. Volcanic ashes, generally of basaltic or andesitic composition, consist largely of glassy fragments which weather rapidly to form the poorly-ordered clay mineral allophane, which on subsequent weathering transforms to halloysite, together with iron oxides. Under continued weathering, most clay minerals, including kaolinite or halloysite, break down to oxides of iron or aluminium, forming the bauxites or laterites which are a feature of old stable landscapes in tropical environments.

Clay minerals are also formed by the hydrothermal alteration of rocks, which takes place under somewhat higher conditions of temperature and pressure than exist at the surface of the earth, and is usually associated with volcanic activity. Hydrothermal alteration usually produces kaolinitic clays of considerable purity which are sought after for ceramics manufacture. However, such clays have a limited distribution in Fiji, Solomon Islands and Vanuatu, and appear to be absent on the islands further to the east. As far as is known, all of the pottery in the south Pacific area is made from raw materials formed by subaerial weathering processes.

The composition of ceramic raw materials varies widely. The classic whiteware body for making china consists of 50% kaolin, 25% quartz and 25% feldspar. However, for bricks, structural clay materials and coarse pottery where absence of colour is not important, other clay minerals such as illite may well be dominant and these may act as fluxes. These are also non-swelling clays, i.e. they do not expand markedly in volume when wet. Swelling clays, such as the smectites, absorb considerable quantities of water and expand markedly with a consequent very considerable shrinkage on drying. Halloysites behave very similarly to kaolinites with respect to their ceramic properties but contain considerably more water and thus cause more drying shrinkage.

Allophane contains about half its weight in water and thus its presence results in considerable shrinkage. It also, in common with gibbsite and the iron oxides, has no plastic properties and thus does not contribute to the ease in moulding a wet clay body.

From a knowledge of the clay minerals present it is possible to predict the behaviour of a ceramic raw material upon drying and firing. If the clay minerals have not been identified it is possible to predict their nature from a knowledge of the geology and the other environmental factors in soil formation.

MINERALOGY OF PACIFIC ISLAND GROUPS

WESTERN PACIFIC

West of the Tongan trench, the so-called andesite line, the dominant volcanic rocks are andesitic in composition, and have a sufficiently high silica content for some silica to crystallise. Island groups such as the Solomons, the New Hebrides, and Fiji, are formed from andesitic volcanic rocks or from sediments derived from the erosion of such rocks.

In Fiji, because of the complex geological and soil pattern (Twyford and Wright 1965), a wide range of soils, with complex mineralogies, are found. However, many soils contain considerable quantities of clay, consisting almost entirely of kaolin. Claridge (1981) reviewed the available information and concluded that suitable clays for ceramics manufacture could be found in a number of places in Fiji, and in particular in the valleys of the Rewa, Navua and Sigatoka Rivers. In these areas also, alluvial sands consisting largely of quartz are also readily available for use as tempering materials. It is probably no coincidence that pottery manufacture still persists to the present day in the Sigatoka area, where the local raw materials appear to be the most suitable of any occurring in Fiji.

The clay mineralogy of the soils of the Solomon Islands was described by Wall *et al.* (1979). Further work on the soils of the northern part of Guadalcanal was carried out by Claridge (1982), primarily with a view to locating possible resources of ceramic clays. The clay fractions of many of the well-weathered soils contained a very high proportion of halloysite or kaolinite, although others contained much smectite. In particular soils on coral or limestone sediments, but formed from superficial sediments or volcanic ash, are composed almost entirely of halloysite. Firing tests carried out on these materials showed that in their natural state they had very high drying and firing shrinkages. Because the investigation was aimed at locating clays that could be used for ceramic purposes in their natural state, no experiments on the effects of additions of sand were carried out. However, the most suitable materials were those that contained a reasonably high proportion of sand, although too much sand caused the fired clay to be very fragile and low in compressive strength. The sandiest material tested (60% sand) yielded a weak and porous product on firing, but one which showed very little distortion or shrinkage. On firing, this material did not show any marked distortion due to melting until heated to above 1100°C.

It was concluded that suitable mixtures of clay and sand could be made from some of the materials found on Guadalcanal, and elsewhere in the Solomons, from which pottery could be made. At the present time pottery is only being made on the north-western end of Choiseul Island (Ratcliff 1979), from materials which from the available information are probably a halloysite-rich clay overlying limestone and a beach sand, probably quartz-rich. However, throughout much of the Solomons similar materials could be found and the absence of pottery in the cultures of many of the island peoples must be due to historical reasons. Relics of the Lapita culture are widespread, especially on the outer islands of the group.

The islands of the New Hebrides, now Vanuatu, have been subjected to much more volcanic activity in the recent past than the Solomons or Fiji, and most of the islands are covered with basaltic ash. The soils have been described by Quantin (1975). Many of the soils are young and contain considerable amounts of allophane and, because of the great water-holding capacity of this mineral and consequent shrinkage on drying and firing, they are unlikely to be useful or suitable for any form of pottery making. However, many of the older soils are strongly weathered and consist almost entirely of kaolinite, halloysite and oxides of iron and manganese. These soils are found on the slopes of the old high islands, especially in the northern part of the group, and although they would be unsuitable in their natural state for pottery or brick-making, with the addition of a suitable temper sand, acceptable pottery could be made.

New Guinea is a fragment of continental crust with a wide range of rock types present, including sediments derived from the erosion products of granitic rocks. In many places, soil and clays suitable for pottery manufacture, with or without the addition of tempering sands, may be found (Hill 1978).

Thus it can be seen that from Fiji westwards it should always be possible to find suitable clays for the manufacture of acceptable pottery. Quality may not always be high, in terms of the standards used to judge well-fired chinaware from a clay of ideal composition, but the articles made will be reasonably durable and not require overmuch skill in their manufacture.

Tonga

Tonga appears to be a key element in the diffusion of peoples into the Pacific, especially because of the large amount of pottery associated with the early period of settlement. The main islands of the Tongan archipelago are raised coral platforms, probably having their origin in crustal upwarping associated with the nearby subduction zone of the Tongan trench. These coral platforms have been covered with a mantle of strongly weathered andesitic ash which may be up to 9 m thick (Gibbs 1976; Orbell 1971). The components of the ash, presumably originally glassy fragments, have been weathered to clay minerals, largely halloysite, and only the most resistant of the primary minerals remain in the sand- and silt-sized fraction.

To the west of the main chain of islands are a number of active andesitic volcanoes, steep-sided and difficult of access. These and other now-submerged volcanic centres were probably the sources of the ash which blankets the raised coral islands. The soils of these volcanic islands are very different from those of the main islands, and are coarse-textured and sandy, with very little clay (Orbell 1971).

Because of the brick-red colour of some of the soils of Tonga, they have been thought to have some potential as pottery or brick-making clays. Claridge and Percival (1980) carried out a series of firing tests and concluded that the clays could not be used in their natural state for the manufacture of ceramics because they exhibited high drying and firing shrinkages and consequent cracking and low strength of the finished product. The addition of grog made from fired and crushed clay lowered the firing shrinkage to more acceptable levels, but reduced the crushing strength considerably.

It is quite probable, however, that pottery with reasonable strength and shrinkage chacteristics could be made from the halloysite clays of Tonga, provided a suitable temper sand were available. However, on the main islands of the group, where clays are found, there are no outcrops of volcanic rock, and the beach sands are all coral. The only occurrences of suitable temper sands are found on the volcanic islands, which are almost uninhabited and do not have any suitable clays. Thus, in order to make pottery it would have been necessary to carry sand or clay from one island to another.

EASTERN PACIFIC

Beyond the deep trench marking the subduction zone between the Pacific and Asian plates the character of the islands changes markedly. They are all formed of oceanic basalt, usually olivine bearing and quartz free and take the form of cones or domes which have been formed over hot spots or fracture zones in the sea floor. Thus each island is isolated and rises out of an extremely deep ocean. Many of the islands were formed as the summits of these great volcanoes which protruded above the sea. The largest of these islands are the islands of Samoa and the Hawaiian islands, both of which appear to be associated with major fracture zones in the earth's crust, and both still carry active volcanoes. Other volcanoes, somewhat smaller in extent, are strongly eroded, but still steep-sided and have considerable elevation. These are the so-called "high islands". A much more commonly occurring situation is the atoll, in which the central volcano has gradually subsided so that no trace of the original volcanic cone remains, and the island is formed from coral which has built up as the central core has subsided. Such islands carry soils devoid of any silicate material. A third, more restricted class of island are the so-called "makatea" islands in which the volcanic core has been strongly eroded and deeply weathered, and then covered by a coral cap following submergence. Subsequent emergence and removal of the coral leaves an island with a central core of strongly weathered basalt, surrounded by a thick and broad coral platform. Atiu, Mauke, Mitairo, and Mangaia, in the Cook Group are of this type, while similar islands occur in French Polynesia.

Samoa

Samoa is important in the context of the movement of people into the Pacific because of the occurrence of pottery, clearly of local manufacture, in the early period of settlement of the islands. However, the available information suggests that suitable clays for the manufacture of this pottery are not widely distributed. Information on the soil pattern, weathering and the nature of the clays has been given by Wright (1963) and Claridge (1981). Because of the distribution of rocks of various ages, variations in rainfall distribution and altitudinal variations, the soil pattern is quite complex.

Because of the warm and extremely moist climate, weathering is very rapid, and most of the soils from olivine basalt are very strongly weathered. At low altitudes most of the soils consist of gibbsite and iron oxides with little kaolin and are consequently non-sticky and non-plastic. Such materials are of very little use for pottery manufacture as they are unable to be moulded, nor do they undergo suitable transformation on firing. At high altitudes the proportion of kaolin increases as the weathering intensity decreases. Around the volcanic vents in upland areas, soils formed from basaltic ash have considerable quantities of allophane and iron oxides but the former transforms rapidly to gibbsite. In general the soils of Samoa are thin and stony.

Some of the older basalt flows are somewhat more acid however, particularly on the western end of Upolu, and may be described as andesitic basalts. The soils on these rocks appear to be more plastic than most of the soils of Samoa, and contain considerable quantities of kaolin. They are relatively deep (0.5-1 m) and have a high clay content. Although no detailed firing tests have been carried out, some preliminary trials (Claridge 1981) showed that these materials could be fired to form a poor quality brick. With the addition of temper sands, pottery could be made with these clays but the indications are that quality and strength would not be high.

Cook Islands

Although no pottery is known from the Cook Islands, the soils have been investigated for their potential as ceramic raw materials (Claridge and Percival 1980) and they provide a model for the other island groups of Polynesia.

Rarotonga is a typical high island, on which the soils range from young thin soils on steep slopes, formed directly on weathering basalt, to deep ($\sim$1 m) soil formed on colluvium on the lower slopes or river terraces. The soils are all very similar mineralogically however, because the soils on the lower slopes are derived from material eroded from the steep slopes inland.

During the initial stages of weathering of basalt, feldspars and ferromagnesian minerals alter to smectite, which subsequently transforms to kaolin. Thus soils on the steep slopes where erosion is keeping pace with weathering contain a mixture of smectite and kaolin while on the lower, gentler and more stable slopes the soils consist almost entirely of kaolin. At the base of the slopes, where the finer-textured colluvium accumulates, the soils contain much more kaolin.

Clays containing much smectite have very high water-holding capacity and have large drying and firing shrinkages. Consequently they are generally unsatisfactory for pottery manufacture, although the kaolin clays would be usable if a suitable temper could be found. Temper sands are available on Rarotonga, either as sands from stream beds, or from crushed rock. Claridge and Percival (1980) found that in their natural state clays from Rarotonga were of marginal suitability for ceramics, and when attempts were made to solve problems of shrinkage and cracking by the addition of grog, the final products were of even lower strength.

The other large islands of the Cook group are makatea islands, and their basaltic cores have been deeply weathered. The soils consist largely of kaolin with considerable amounts of amorphous oxides of iron and aluminium and smaller amounts of crystalline oxides such as gibbsite, boehmite and goethite. Firing tests showed that without tempers, the clays are not satisfactory as ceramics raw materials. Because of the nature of these islands, suitable sands are not available, and it is probably unlikely that acceptable pottery could be made with the clays even if suitable tempers could be found. Thus it is unlikely that pottery could have been made on any of the makatea islands of the Cook group.

French Polynesia

The islands of what is now French Polynesia extend from close to the Equator to south of the tropic zone and thus cover a relatively wide range of climates. High islands, makatea islands and atolls are found. However, little information on the soils has been published and it is necessary to deduce the probable mineralogies of the soils from other information before the suitability of the soils as raw materials for pottery manufacture on any island can be assessed.

High islands on or about the same latitude as Rarotonga can be expected to have similar soil patterns and mineralogies. Thus it may be possible to make reasonable pottery on some of the islands of the Austral group which are slightly south of Rarotonga and have much the same climate, provided the two essential ingredients, clay and temper sand, could be associated. However, the little information that is available (Millaud 1953, Tercinier 1962) indicates that islands such as Rapa, Raivavae and Tubuai have lateritic soils and may be makatea-type islands.

Further north, Tahiti (18°S) is a high island with a soil pattern presumably similar to Rarotonga. The only soil information available is a report by Tercinier (1974), who described soils on the uplands which were completely devoid of silica, and contained a high proportion of amorphous iron and aluminium oxides, while the crystalline phases accumulating within the soil were gibbsite, magnetite and haematite. If these soils are representative of the rest of Tahiti, then weathering is obviously much more intense and has proceeded further than in Rarotonga. It is not clear whether this is due to the greater age of the weathering surface or to an increase in weathering rate. Thus it does not appear likely that suitable clays for pottery are widespread in Tahiti. However, somewhere between the young soils on steep slopes which would be very stony and with a clay fraction composed almost entirely of smectite, and the strongly weathered soils on the stable sites, it may be possible to find soils with a high clay content and with kaolin as the dominant clay mineral, from which some sort of ceramic articles could be prepared.

The Marquesas (10°S) are also high islands but are situated much closer to the equator. There appears to be little information available on the soils of the islands but if the pattern of weathering displays the same trends as seen between Rarotonga and Tahiti, most of the soils would be strongly weathered and lateritic. Therefore suitable clays would be found only on the shallow soils on steep slopes where erosion can keep pace with weathering, so that the clays would be largely kaolin or a kaolin-smectite mixture. It may, however, be difficult to separate clay from these soils, which would be extremely stony. It seems, therefore, that only a very determined potter would be able to make a usable pot, and there would be many failures.

DISCUSSION

If the current concept that the ancestral Polynesian peoples moved through the islands of Melanesia about 3-4000 years ago is correct, and they were associated with the Lapita pottery-making culture, they would have found adequate supplies of raw materials for the manufacture of pottery, especially using the technique of adding temper sands which seems to have been an integral part of their tradition. On reaching Tonga, although the resources of clay were adequate, it would have been necessary to import temper sands from the volcanic islands to the more fertile inhabited islands where the clays could be found. This would add a further level of complication to the craft, and it may have been easier to import the finished articles from Fiji.

In Samoa, although temper sands were available, suitable clays were less readily found, and as far as can be judged from the available information, not of very good quality. Thus it would have required a much greater degree of skill to make suitable articles from the available material. Eventually the art may have died out because it was considered uneconomic to manufacture articles with considerable effort, many of which were of limited use because of their fragility.

Similarly, if the early Polynesians then moved on to the Marquesas before dispersing throughout the eastern Pacific, the scarcity of raw materials and the great difficulty in preparing a satisfactory article from those that could be found, would have led to rapid abandonment of the technique. Presumably, the early settlers considered that the time and energy required to make useful pottery articles could have been better spent in other pursuits more essential to survival in a new environment. Thus within a short time all knowledge of the craft had disappeared.

When the Polynesians eventually reached New Zealand, where pottery can be made from almost any clay deposit, without even the need to add suitable tempers, they did not rediscover an art which had been a part of their ancestral cultures probably not more than a thousand years previously. It is possible, perhaps, that the discovery of pottery was one of those strokes of genius that was made only once in human history and its subsequent widespread distribution was by a combination of migration of people and cultural diffusion.

CONCLUSIONS

It is postulated that the disappearance of the art of pottery manufacture from the cultural heritage of the Polynesian people as they moved to the east was due to the increasingly unsuitable nature of the raw material once they had passed beyond Fiji. It is suggested that the time involved in the manufacture of pottery which was of low strength and limited durability was too great an investment for the return achieved. Thus, by the time the Polynesians reached lands where suitable materials were readily available, all knowledge of the art had vanished from their traditions.

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Received 15 June 1983