Prehistoric Ceramics of Northeastern Thailand

with special reference to Ban Na Di

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preface

Fieldwork carried out during 1980-1981, in the Sakon Nakhon Basin of Northeast Thailand, provided most of the archaeological evidence set out in the present report. In addition, pottery recovered from excavated and/or surveyed sites spread within the Khorat Plateau, the adjacent Petchabun Highlands, and the more distant Central Plains region, has provided important comparative data. Information regarding the distribution of ceramic traditions in the area was virtually non-existent in 1980. When such conditions exist a research strategy which provides an overview of the region in question is a vital first step in orientating the data under immediate scrutiny. Hence, at David Peacock’s suggestion, it was decided to aim for an extensive corpus of pottery, from as many sites as possible, against which the primary material could be brought into focus. The comparative pottery enhanced Sakon Nakhon Basin evidence by allowing it to be set in a tempero-areal background. Such background information can give important insight into socio-economic and other cultural factors. In the present study it has allowed these processes to be brought under closer scrutiny. Fieldwork during 1985, at the neolithic site of Khok Phanom Di, contributed technological information which further bears on several inferences and conclusions within this report. These explanations particularly concern the origins of manufacturing techniques which were adopted by potters late in the Northeastern cultural sequence.

This report is a very slightly modified version of the author’s doctoral dissertation “The Prehistoric Ceramics of Northeast Thailand”, submitted to the University of Otago in 1987. The changes involve a different page format suited to double-sided publication, with running headers, and an index. It also expands and clarifies preliminary results previously published by the author in the three volume report, B.A.R. International Series 231(iii), edited by Higham and Kijingam (1984). Readers who wish to avail themselves of a detailed report which also covers the non-ceramic aspects of the 1980-81 archaeological expeditions, carried out under the auspices of the Thai Fine Arts Department’s Northeast Thailand Archaeological Project, should refer to that publication. The present volume serves as a further contribution to the 1984 three volume series, with the intention that it provide a more comprehensive cover of that investigation. It is also the author’s hope that the present report may contribute to our understanding of the prehistory of Thailand, through a consideration of Thai prehistoric ceramic artefacts. Many of the sites covered are located beyond the area covered by the 1980-81 investigation, and it has thus been possible to make available a quite broad perspective of Northeast Thai prehistory, in terms of the ceramic spectrum available at the time of publication.

At the commencement of the Sakon Nakhon Basin fieldwork, which provided both cultural and geological data, it was envisaged that any technological or petrographic information would fall under the analytical rubric so cogently promoted by earlier workers such as Anna Shepard and David Peacock. This approach seemed fitted to evidence derived from potting clays and/or ceramic artefacts. A fundamental assumption was that mineralogical evidence would provide
the yardstick for suggesting likely ceramic source areas, identifying exchange networks, detecting possible cultural changes, and exploring the integration of pottery manufacture with other socio-economic activities. One example is understanding the role of pottery in ritual behaviour, as displayed in activities considered to reflect symbolic expression. In this study the assumptions proved to be insufficient for the task at hand. They were inadequate because the material proved intractable under normal analytical procedures. Thus new techniques capable of resolving this impasse were needed.

When new research projects are initiated, particularly those involving fresh methods of inquiry, or methods which have not been applied in the area before, it is perhaps predictable that the results will not fit neatly into previous explanatory structures or "scientific paradigms". Such was the case in this study. Much of the pottery described in the following chapters was manufactured from clays which are, in standard petrographic terms, best considered "geologically non-specific". In light of this difficulty, a new approach has been adopted.

Earlier Southeast Asian studies have concentrated on pottery style. These emphasize form and design characteristics, features susceptible to transient influences. Reliance on such evidence risks misleading results. Ceramic fabrics, however, encapsulate technological and mineralogical information potentially useful in explaining cultural relationships and changes in the potter’s craft. Such information is essential if prehistoric wares are to be used for chronological frameworks, and as markers of social organisation, exchange networks and cultural changes.

Khorat Plateau geology, geomorphology and palaeoclimate are each outlined and related to Sakon Nakhon Basin potting clays. The geology is relatively homogeneous, due to its principally sedimentary composition. Materials derived from sedimentary areas can present technical problems for potters because they often require special manufacturing methods. The resultant fabrics are often distinctive. Thus both mineralogical and technological information can be identified in wares produced under these conditions. A new analytical method, which combines these data, is presented. Many prehistoric manufactures are likely to have been located in sedimentary terrain for two important reasons. First, it is estimated to form up to 80% of the earth’s crust. Second, prehistoric settlements tend to be concentrated in such terrain for socio-economic reasons unrelated to pottery factors.

The role production centres played in the distribution of ceramics is considered critical. Production is constrained by the need for reliable supplies of suitable clays and other ceramic ingredients. Quality potting clays are often restricted to small localised deposits. Pottery was often a prominent exchange item. This was partly because consumer populations were often net importers. Thus the mere presence of pottery in archaeological contexts does not guarantee in situ manufacture. These factors must be taken into consideration, therefore, when pottery is used to construct archaeological frameworks such as relative local or regional chronologies, if reliable conclusions are to result. Further, geographically explicit labels, such as “Ban Chiang Painted” or “Om Kaeo Ware”, should only be used if they genuinely define a ware’s origin. Evidence is presented which contradicts previous assumptions regarding the origins of these latter wares. Alternative explanations are given in their place.

Particular attention is paid to temper species because they are important ingredients in pottery manufacture. Since potters display marked conservatism in technological matters, tempers help identify different ceramic traditions. One Ban Na Di mortuary ware fabric, however, contained a technologically superfluous additive. This is considered to represent symbolic expression. It correlates strongly with a mortuary vessel form which is also considered ritualistic, for independent reasons. Such correlations demonstrate the need to combine...
Two temporally separated Ban Na Di ceramic traditions are detailed through analyses of potting clays, ceramic artefacts, tools associated with pottery manufacture, and the accoutrements of metallurgy. Each distinctive tradition employed different clays and fabrication techniques, and displayed different pottery styles. The local changes are considered to reflect broadscale developments of some magnitude. Theoretical models are suggested to account for these changes. They draw on material from sites within and beyond the Khorat Plateau. This evidence is used to suggest exchange networks, the presence of itinerant metallurgists, and to index the movement of pottery made under the rubric of the later ceramic tradition into an area previously lacking its associated distinctive technology. It is argued the implications of such changes are important because they heralded significant socio-economic events which markedly widened the external relationships of early Sakon Nakhon Basin communities. In addition they are thought to index the arrival of immigrant potters familiar with the new ceramic technology. It is postulated that this technology originated far to the south, ultimately beyond the margins of the Khorat Plateau. The coincidence of these new ceramics and exotic artefacts suggests that Sakon Nakhon Basin communities subsequently took part in a much expanded and more dynamic exchange network than they previously knew.

Finally, the role pottery plays in archaeological method and theory is briefly considered. As ceramic materials are rock-like in composition they are usually durable. Such durability affords pottery a degree of importance to archaeologists which may often exceed that given it by prehistoric societies. It is fortunate, however, that pottery is durable because it provides insight into cultural activities which would otherwise be unobtainable.
acknowledgements

This study is a slightly modified version of a dissertation submitted for the degree of Doctor of Philosophy at the University of Otago. The field work formed part of the Thai Fine Arts Department’s Northeast Thailand Archaeological Project. The Ban Na Di excavations were carried out under the co-direction of Amphan Kijngam, who was at that time the director of the Northeast Thailand project, and Professor Charles Higham of the University of Otago. The director of research, Archaeology Division of the Fine Arts Department, at this time, was Piset Charoenwongsa, and he played an important role in the planning and supervision of the research, which began at Ban Chiang and was carried on at other Northeastern sites such as Non Chai. The Ban Na Di expedition was supported by the Thai Fine Arts Department and the University of Otago. Funding was provided by the Ford Foundation, and the University of Otago.

The excavation directors invited the author to undertake an analysis of the ceramics, and to them I express my thanks. Fieldwork carried out during the excavation programme, aimed at locating Sakon Nakhon Basin potting clay quarries, was conducted with the support of the Fine Arts Department which provided a four-wheel drive vehicle and driver.

The New Zealand Government provided funding for pottery sorting in the Otago University laboratories. In all, thirty-five New Zealand students helped sort pottery into various categories. The government also provided temporary helpers who were trained in thin-sectioning techniques and other tasks. Over 1,000 sections were created, and the assistance of these helpers is gratefully acknowledged.

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Preface

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Chapter 1

Introduction

"The artist’s representation is .. a long way removed from truth, and he is able to reproduce everything because he never penetrates beneath the superficial appearance of anything."

Plato: The Republic:598.

It is less than two decades since Higham (1972) described Thailand as an archaeological “terra incognita”. Preliminary reports of major excavations at Non Nok Tha (Bayard 1971), and Ban Chiang (Gorman and Charoenwongsa 1976), supported by evidence from a series of smaller investigations, however, suggested that, rather than a cultural backwater (Coedes 1966), Southeast Asia, and Northeast Thailand in particular, was a cradle of very early bronze (Solheim 1968, Gorman 1978), and iron working (Bayard 1979). These metals were thought to have been exploited during the 4th millennium and by 1500 B.C respectively (Bayard 1970, Solheim 1968, Gorman and Charoenwongsa 1976). Clearly, the discovery of bronze working which ran counter to notions of a European invention (Renfrew 1973), or the presence of iron at a time it was generally considered a Hittite monopoly (Allchin and Allchin 1968:207), needed careful explanation. Unfortunately, however, detailed reports clearly setting out the provenance and confirming the stratigraphical integrity of such very early finds were lacking.

Faced with an absence of information necessary for detailed assessments of these startling possibilities, Higham and Kijingam decided to undertake a survey of sites (Kijingam et al. 1980), in a settlement pattern which included Ban Chiang, and to excavate one or more of these to gain insight into the prehistory of the region (Higham and Kijingam 1984). Thus the strategy was devised in order to resolve a hiatus in detailed knowledge. This gap extended to settlement size and distribution, social organisation and the cultural role of metallurgy. Information of this nature is a prerequisite if theoretical models designed to illuminate past cultural processes are to be formulated. An extensive corpus of pottery found in association with the metals similarly lacked sufficient study. The writer was kindly invited by Higham and Kijingam to study these wares.

From the outset, pottery has played a central role in most archaeological investigations in Northeast Thailand. Prehistoric wares form the cornerstone of chronological frameworks. Cultures have been characterised by pottery styles, and changes in style have often been directly correlated with culture change. These assumptions have often been questioned by workers elsewhere because exotic styles can be imitated by indigenous potters, thus merely fashions,
CHAPTER 1. INTRODUCTION

not cultural changes, may be involved (Peacock 1967, 1968, 1969, 1970, Shepard 1936, 1942, 1965). Because pottery was often an important item in prehistoric exchange networks, its presence in archaeological contexts, even when it forms large deposits, is insufficient reason to assume it was made locally (Shepard op. cit., Arnold 1985). To redress these problems ceramicists have considered the material pottery is composed of, its fabric, and compared this with the shape and decoration of wares (i.e. style). The origin of pottery can be suggested by identifying minerals within the fabric, and if they are distinctive enough, relating these to appropriate clay sources. Moreover some sources, promoted as likely for other reasons, can be excluded from consideration because they do not contain minerals which match those in the pottery.

The aim of the present work is to illuminate the prehistory of Northeast Thailand through an analysis of ceramics. A detailed examination of material excavated at Ban Na Di (see fig. 1.1 on page 5), provides evidence for comparison with several other excavated and surveyed Thai archaeological sites. The potential of petrographic analysis based on thin-sections of pottery will be examined with reference to the work of Shepard in the Rio Grande. This latter region features a variety of distinctive geological zones. Most of the present study area is less geologically distinctive. This is because it is located within a relatively homogeneous sedimentary plateau.

Previous ceramic studies have often successfully focussed on the uniqueness or distinctiveness of individual or related groups of pottery industries in order to characterise or categorise them. Several approaches have been employed. Style-oriented studies emphasise form and design differences. A major problem, however, is that styles are susceptible to transient influences and apparently similar wares may actually be quite different. Technological analyses include less ephemeral aspects. They rely on methods common to the natural sciences, and this allows a considerable degree of analytical rigour.

Physical phenomena generally lend themselves to a variety of classification techniques. Early technological studies, in the main, applied established geological methods. The two principal aims of such analyses are the exploration of temporal changes in the potters craft, and the illumination of possible cultural relations through material identifications and the location of their sources. Identification of different sources depends on the distinctiveness of the geological zones under examination, and an ability to discriminate precisely between them. In this respect, igneous and metamorphic zones are often more distinctive than sedimentary regions. Although exceptions to this may occur, many sedimentary regions are for sourcing purposes categorised as "geologically non-specific". Often this is because the analytical detail needed to distinguish between different zones is beyond the scope of normal research demands.

The limitations in such an approach are manifest. Unless the sedimentary region in question contains distinctive minerals or biosome it is likely to be labelled "non-specific". The extent of these indistinct sedimentary regions is unknown, but several factors make it reasonable to assume most will indeed be non-specific. Sedimentary rocks are estimated to cover between 66% to 80% of the earth's crust (Press and Siever 1974, Folk 1980, Tucker 1981). This predominance is exacerbated by a key cultural propensity reflected in prehistoric settlement patterns. Prehistoric societies display a preference for the occupation of sedimentary regions. Easier terrains, often close to waterways, were emphasised. Coastal regions and lake margins, plains and river valleys were preferred. These are principally sedimentary zones. Of course, many exceptions to such settlement patterns, and to the distribution of "geologically non-specific" sedimentary strata, exist. The overall tendency seems clear, however, in both
An examination of broad-scale geological maps will show that many regions contain sediments weathered from sedimentary strata, and it is from these sediments that potting clays are quarried. Sedentary population concentrations in fertile lowland ecotones are readily understood. These areas witnessed the intensification of agriculture and associated population increases (Flannery 1976, Redman 1978). Pottery manufacture is closely connected with agriculture, and although some potters are itinerant, making pots is a sedentary-based occupation (Arnold 1985). These factors have important implications for the technological study of prehistoric pottery.

Although detailed data are unavailable, it seems reasonable to assume that the majority of prehistoric pottery was made in "geologically non-specific" sedimentary zones. Because settlement patterns are associated with subsistence, economic, demographic and related socio-political influences (Boasrump 1965, Renfrew 1972, Redman 1976, Flannery 1976, Flannery and Marcus 1983), potters probably were often left with little choice in clay resources. Market forces, however, play an important role in the development of pottery production (Peacock 1982). In some regions, large-scale export-orientated production was concentrated in areas of high clay quality (Arnold 1985). A reliable transport system and an established exchange network are key components of this kind of production, and in prehistory they were not always available.

The quality of potting clays varies from excellent to poor (Grim 1962). Many factors affect their quality, such as mineral composition, crystallinity, plasticity and non-plastic content. Clay quality can be affected by naturally present nonplastics or those the potter adds. Most clays contain some natural nonplastics (Shepard 1956). Many require the addition of organic or inorganic material as a temper. It is important that tempers do not expand excessively as this will shatter pottery during firing. Sedimentary rocks tend to have a very wide range of expansion rates (Arnold 1985). This suggests that, in areas where clay quality is marginal, sedimentary rock fragments may often be unsatisfactory for temper. If suitable alternatives were unavailable, this could place extreme demands on the potter's skill and special adaptive techniques would be needed to transform substandard raw clays into a suitable potting material. One strategy employed by prehistoric potters involved the manufacture of artificial temper, or "grog" (Hodges 1965).

To manufacture grog, the potter is required to invest extra time and fuel resources than needed if readily available natural tempers are procurable. Thus we can be reasonably confident that grog was developed in response to a lack of local alternatives. We have noted above that this is most likely to have occurred in sedimentary regions. Once adopted, however, the grog tempering method provides a degree of resource independence. The essential ingredients needed to make pottery from imperfect clays are temper, fuel and water. Only the latter two are required, however, when expertise in grog manufacture is acquired.

This report will explore two aspects of the sedimentary source zone phenomenon. Primarily it tests the value of the "geological technique" in a region which includes large areas of sedimentary terrain. This region contains some clays which are difficult to differentiate minerallogically. Secondly, by identifying different technological responses prehistoric potters made to the demands of clay materials, the value of illuminating technical changes is considered.

We have noted that manufactured temper has been associated with the special requirements of making pottery in sedimentary regions. Evidence presented in the following chapters shows that, in prehistoric Thailand, two different kinds of grog were made. In both cases they are normally distinctive. Thus, instead of the mineralogical definition of pottery fabrics, differences in grog species allows for differentiation along technological lines. We can use this
method of distinguishing fabrics in addition to the mineralogical approach. When an indistinct mineralogy means that possible sources cannot be suggested, the technological definition can be helpful in indicating broad source areas. This is because the distribution of the two grog species is at different times mutually exclusive to certain well defined geographical regions. The distribution of these grogs, and their related technologies, changes with time.

Because some fabrics are mineralogically and technologically distinctive, it has been possible to trace the movement of exotic pottery, manufactured under the rubric of one grog tradition, into a region where only the other temper was made. This evidence has complemented geological information and allowed an assessment of cultural change through the identification of different responses to the same tempering requirements. Thus these data have provided evidence of cultural change, related to the production and exchange of pottery, and postulated movements of people, by combining two different approaches to the same technological problem. Following the introduction of the new pottery, a large-scale change in production occurred in association with a wide range of persuasive evidence for culture change, both within Ban Na Di and the surrounding region. The ceramic developments relate to many non-ceramic aspects of cultural process in Northeast Thailand and, together, they present a coherence which suggests the relationship of pottery to prehistoric communities is a subject worth recognition for the light it can shed on past societies.

Not the least of the relationships between the changes in pottery and non-pottery technology at Ban Na Di is an associated change in metal working accoutrements used in melting bronze. This is accompanied by the first firm evidence for working with iron, and probably marks the movement of people from a much larger southern region. The change also heralded participation in an expanded exchange network. Again these developments are evidenced by both ceramic and non-ceramic information.

The present report concentrates on the site of Ban Na Di within the Sakon Nakhon Basin, but sites both within the larger Khorat Basin and beyond the margins of the Khorat Plateau will also be touched on (see fig. 1.2 and fig. 1.3 on pages 6 and 7 respectively). In the next chapter we will review previous ceramic studies in Thailand with a view to bringing into focus the aims of the present work.
FIGURE 1.1: GENERAL MAP OF SOUTHEAST ASIA
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FIGURE 1.2: GENERAL MAP OF THE SAKON NAKHON BASIN
FIGURE 1.3: GENERAL MAP OF THAILAND
Chapter 2

A review of previous studies

2.1 Introduction

Former studies of prehistoric Southeast Asian ceramics share many of the inadequacies displayed by ceramic research undertaken elsewhere and upon which much prehistoric research in Southeast Asia has been based. With very rare exceptions most of these studies are concerned with aspects of pottery style. Such stylistic perspectives suffer from shortcomings inherent in the researcher’s perception when assessing physical phenomena. These influences affect all analyses which emphasize an artefact’s superficial physical appearance. In addition, they may be biased by the researcher’s natural subjectivity. Ceramic artefacts are affected by a wide variety of many physical and sociological factors. Their inter-relationships are embodied in pottery. These parameters will be discussed prior to reviewing earlier studies in order to demonstrate the need for more detailed information.

Of all artefacts available to archaeologists, pottery has probably suffered most from subjective classification. Shepard (1971:98), discussed the nature of this problem, which she termed “pottery sense”. She defined it as the “process of organisation of impressions”. Tension between objective methods and pottery sense underlies many of the inadequacies in ceramic analysis. Thus, despite rigorous efforts to be objective, attention may unconsciously be drawn to qualities defined by the immediate interests. Emphasis on readily identifiable variables, made at the expense of others, may lead to distortions in perception which amount to a process of selection by omission.

Ceramics share with lithic artefacts a high degree of durability and this has given both considerable prominence in classification studies. In practical terms, potting clays possess potential to be fashioned into an almost infinite variety of forms. By contrast, durable lithic artefacts can often only be fashioned into a limited range of forms, without an input of high levels of energy and/or technology. These limitations reflect constraints imposed by physical forces which act to shape durable rocks (Flinth and Skinner 1977). Thus dependent upon the prehistoric material under consideration, two possible parameters appear inevitable:

1. A finite range of (known, or unknown but potentially determinable) forms will exist.
2. An apparently infinite variety of forms exist.

Even with hand-crafted methods, an almost infinite variety of pottery forms are possible. In order to demonstrate this, it is necessary to consider the variables which influence pottery form.

We commence with the need to distinguish between two major parameters, those imposed by technical and those affected by socio-cultural factors. In the latter group are temporal, areal,
material, stylistic and functional constraints. Each of these is, to a varying degree, interrelated and interdependent. Temporal and areal distributions are both critically influenced by scale. For example, it would be misleading to assert that comparisons of rimforms between two cultures separated temporally was necessarily meaningful without corroborative evidence. The degree to which the cultures where temporally separated, however, affects the weight likely to be afforded any such corroborative evidence. Areal distribution is similarly affected by scale. No matter how distinctive, a rimsherd demonstrably typical of, for example, British Beaker Ware, and recovered in archaeological contexts from, say, Romano-British strata, will not be classified as anything more than a stratigraphically "mobile" artefact. It requires more than morphological association to order artefacts into a tempor-o-areal focus.

The range of forms possible is determined by the available materials in combination with the degree of technological complexity at the disposal of the potters concerned. Both are interrelated. Within these constraints, style is allowed complete freedom. That is to say, the only physical limitations to stylistic creation are those imposed by material and technological factors. Potting clay is the plastic material par excellence. Note, for example, the complexity of forms reported from burial contexts in Peru (Donnan and Mackey, 1978: passim).

Functional constraints place form analysis on much firmer ground, because here a degree of morphological uniformity may be imposed on forms intended for like end uses. Intended functions dictate the range of forms appropriate to them. Water containers for example, must be capable of efficiently containing liquid. In spite of this constraint, however, only a brief glance at a range of forms associated with any given function will demonstrate the magnitude of problems faced in function-orientated form studies. Compare, for example, cooking vessels of contemporary Northeast Thailand (often functionally connected by analogy to prehistoric examples (MacDonald 1980)), with those of the Romano-British “Dales” ware (Peacock 1982:87). Form analysis would correctly separate these vessels into two entirely different classes. This is because the significance of their forms relates to different cultural approaches to the same problem. Yet they were almost certainly designed for, and served, similar functions as cooking vessels.

The success of functional-form classification, however, is not sustainable in all cross-cultural comparisons. For example, a comparison can be drawn between Roman amphorae and vessels from archaeological contexts at Pan Po, China (Watson 1961:43, Rawson 1980:189). Although a close examination would reveal minor but diagnostic form differences, such as handle position and base shape, the close similarity between these two forms is striking. It gives rise to immense theoretical problems. Are we dealing with diffusion, invasion, parallel development, or some extremely rare coincidence? In practice such anomalies are not afforded theoretical moment without supportive or corroborative evidence.

We require additional evidence to support the isolated data provided by an artefact’s form. This may be either qualitative or quantitative. In the first instance such factors as archaeological provenance or temporal context will be questioned. The provenance of artefacts considered to be temporal mis-fits will be considered suspect. Conversely, doubtful provenance will seriously weaken any anomolous artefact’s temporal association. By definition, metallic artefacts do not belong in the Mesolithic any more than plastic belongs in the Bronze Age.

The presence of occasional “rogue” artefacts is predictable given the vagaries of post-depositional disturbances. Artefacts uncovered from even reasonably secure stratigraphic contexts, in quantity, are usually justifiably associated with the temporal if not the areal, contexts they appear to represent. Rogues occur only occasionally. Authentic representatives of the
culture under study can be expected in relative abundance. Each succeeding example of a distinctive form further reinforces both its association with the culture it is held to represent, and that culture's association with the form. This mutually reinforcing process is the essence of scientific induction. Unpredicted results cannot be accepted without further tests that confirm the initial result. In a sense this is a deductive solution to an inductive problem. By associating like forms with like, form classification proceeds in an inductive manner until some anomaly occurs. The corpus of inductively derived data is then used to test the unpredicted "rogue" against the established form class.

Such arguments are invalid. They take the following invalid logical form of deduction:

1. Many artefacts from site “X” are of this form.
2. This artefact is the same form.
3. This artefact belongs to site “X”.

The conclusion does not follow of necessity from 1. and 2. Even if 1. and 2. are true it may transpire that the artefact in question is one that was made elsewhere, either as a copy of the major form class at site “X”, or as a prototype for a site “X” major form class. Alternatively it may represent an instance of independent, parallel development.

2.2 Theoretical aspects

Insight into several basic concepts used in previous studies will be aided by a consideration of some theoretical approaches which appear to lie at the core of style analysis.

Clarke (1968, 1978), viewed most archaeological entities as being comprised of groups of entities of lower taxonomic rank. "Culture groups are clusters of cultures, cultures are clusters of assemblages, assemblages are clusters of types, types are clusters of artefacts and artefacts are clusters of attributes or traits" (Clarke 1978:35). The traditional 'sensible' grouping of objects according to prejudged unique sets of attributes that are both sufficient and necessary for group membership, is described as monothetic. Clarke argues that while monothetic groupings are common practice they are illusory, as archaeological taxonomic groups never contain individuals with identical attributes. Thus such groupings are polythetic not monothetic. That is "a group of entities such that each entity possesses a large number of the attributes of the group, each attribute is shared by large numbers of entities and no single attribute is both sufficient and necessary to the group membership" (Clarke 1978:36). Thus, in Clarke's model, the uniqueness of the monothetic group form is not practically apparent in archaeological assemblages. What we are dealing with are polythetic groups.

Clearly the key factor in either of these groups is an unequivocal definition of what is an archaeological attribute. Clarke (1978:156), promotes an "approximate" definition: " - a logically irreducible character of two or more states, acting as an independent variable within a specific frame of reference". To Clarke, attributes are restricted to "fossil behavioural elements of the level of single kind of actions, or micro-sequences of actions" (1978:154). Attributes result from and are equivalent to, "premeditated and deliberate hominid behaviour" (Clarke 1978:156).
2.3. REVIEW OF EARLIER SOUTHEAST ASIAN STUDIES

The genesis of Clarke’s behavioural approach may lie in his work on pottery style, particularly with European Beaker Ware (1962, 1967, 1970). He paid close attention to incised design elements on beakers. Designs, and design field groups, were treated statistically to generate class clusters. These were held to indicate an individual vessel’s attribute group relationship. Such attribute-derived style groups were considered culturally significant by Clarke (1970:1-8, 1978:156-158, 210-214, 252, 277).

The above definition of attribute is either explicit or implicit in many analyses of pottery style. Unfortunately it leads to most of the inadequacies imbedded in the method.

Clarke equates attributes with human behaviour and extends this to cultures, cultural groups, and larger archaeological groupings termed “technocomplexes” (1978:328). Technocomplexes are culture groups related through possessed artefact/attribute affinities. Such inductive reasoning views these affinities as ordered and regulated phenomena obeying scientifically testable “laws” of human behaviour. But they share a lack of predictive rigour displayed by sociological studies generally (Popper 1967). This gives rise to two major difficulties. First, at what scale are attributes representative of any particular cultural entity? Second, how are non-sociological data to be treated when they contradict Clarke’s essentially sociological approach?

Although attributes are demonstrably valuable delineators of large-scale technocomplexes (Clarke 1978:328-362), their validity in characterising smaller scale cultural groups is questionable. Particularly when they are used to define cultural subdivisions areally and/or temporally. Unfortunately, ceramic attributes have been extensively employed in this manner in North America (McKern 1939, Phillips et al. 1951), and in many previous Southeast Asian studies.

According to Arnold (1985), most interpretations of Central Andean archaeology rest on ceramic style distributions assumed to reflect regional culture history. But recent work suggests that these distributions give “a distorted picture of Central Andean prehistory” (Arnold 1985:94-95). This is because production was centred in relatively few locations where full-time potters engaged in year-round production. The location of these centres was determined by climatic and resource restrictions. They were facilitated, and positively reinforced, by the existence of large-scale pottery trade and exchange involving long distances. These Andean ceramic distributions reflect, not culture histories sensu stricto, but changing patterns of trade and exchange. This is an instance where questions of scale and non-sociological factors, as well as sociological, are involved.

The above discussion is not intended to suggest that style analysis has no place in studies of archaeological ceramics. It is included, however, in an effort to show that such studies, in the absence of non-stylistic corroborative evidence, are weakened by that omission.

2.3 Review of earlier Southeast Asian studies

Southeast Asian pottery studies over the past five decades share an approach often evident in both Europe and North America. This has been characterised by ontology giving way to taxonomy. Nomenclature often implied functionally oriented derivations for artefact forms. Design elements were designated to varieties or styles. Combinations of shape, design type and location on a vessel, equated with style. Before recent advances, discrete entities, such as European “Beaker Ware” (Clarke 1970, Harrison 1980), were held to denote corresponding cultural entities. With a few notable exceptions, technical analysis was ignored.

The traditional “Euro-American” approach characterises the study of Southeast Asian pottery from the early work of Quaritch-Wales to the present. Thus a stratum at Muang Phet
which revealed apparently distinctive potsherds was equated with a movement of Dvārvatī people from the Lower Chao Phraya area by Quaritch-Wales (1957). Sørensen (1972) based his analysis of the Ban Kao funerary ware on shape, surface treatment and colour. Functional inferences are reflected in his system of nomenclature. Some of the Ban Kao vessel shapes led him to draw direct parallels with Lungshangoid pottery and to postulate an overland migration route from China. The same underlying concept, that cultural relationships are clearly discernible in pottery styles, marks the criticisms of Sørensen’s work by Parker (1968). Bayard (1970) considered the Ban Kao pottery types to have reasonably close parallels with the middle period at Non Nok Tha. One vessel form, labelled “fruitstands”, he considered distinctive enough to be diagnostic. Rather than Lungshanoid, however, Bayard found closer relationship between Ban Kao and Non Nok Tha, Lopburi and Khok Charoen.

In many ways, Bayard’s approach to the rich Non Nok Tha data has influenced most subsequent studies, therefore his analytical treatments will be covered in some detail. His first impressions of the overall pottery assemblage were that a majority comprised sand-tempered, cordmarked, open-fired earthen-ware. Other types of temper and finish, such as plain or smoothed sherds tempered with rice or ground clay were considered minor categories, “very probably from imported vessels.” (Bayard 1976:146). Subsequent qualitative examination of sherds and whole vessels, however, revealed a “reasonable variety” of different tempers, forms and surface decoration. In view of these apparent variations, computer analysis, following a hierarchic taxonomy, was used. Variables included size, form, temper, surface finish, rim shape, surface treatment of rims, rim lip diameter and many metrical variables including size dimensions, sherd quantities and weights. Apart from the metrical variables, all the data were subjectively derived and heavily biased towards form and decoration.

Bayard considered funerary pottery to be of prime importance among the artefact classes recovered. He viewed vessel style and method of interment as relatively precise provenance indicators for disturbed burials. Vessel typology was used as an independent check on the phase designations of burials.

Temper is one of Bayard’s variables but it was not prominent in his classification scheme. The method of determining temper in burial vessels is not described, but non-burial sherds were examined with a low-powered binocular microscope. Eleven temper types were recognised: Sand 60.0%, sand and chaff 15.3%, fine chaff and sand 8.2%, chaff 6.2%, prepared temper 3.5%, chaff and laterite 1.7%, laterite and sand 1.7%, sand and red pigment 1.0%, crumbly sand 1.0%, laterite 1.0%, and no temper, 0.1%. Variations in temper type are listed according to chronological periods set out as generalised periods, but not specific stratigraphic units (Bayard 1977:76). This typological scheme is conceded to be arbitrary and somewhat impressionistic (Bayard 1977:65). But in a later study, which employed the same basic variables applied to a larger sample (847 vessels against less than 100), it is seen to provide a satisfactory degree of rigour (Bayard 1984:117).

Bayard (in press), has subsequently asserted that temper was included in the Non Nok Tha vessel typology. It is important to clarify whether temper was included as a variable in Bayard’s classification, because at Non Nok Tha the most comprehensive assemblage of Southeast Asian mortuary vessels was uncovered. According to Bayard (1984:90), the “final typology” is “based on reconstruction, full measurement, and computer analysis of some 847 vessels, and achieves a quite satisfactory standard of rigour.” His classification scheme involved three steps. Vessels were first grouped into six classes based on shape and base form. “Stylistic variants or types were then distinguished for each class, based on non-metrical differences in surface treatment, decoration, shape, and rim form.” The third step involved
merging of some of these "types" to produce 38 "types" within the six classes. This accounted for 799 (94%) of the total sample. The remaining vessels being "27 unique specimens and 21 Class 1 vessels lacking the basal portion". Some of the stylistic variants or "types", were considered to differ only slightly in shape or proportion. Two vessels, however, "represented actual blends of two types, and only one fell in between two of the six morphological classes". These were thus considered unique. Factor analysis, using "the mean dimensions of each type," and "based on 10 metrical variables only" confirmed the morphologically-based initial classifications (Bayard 1984:90).

None of the above steps specifically includes temper as a determinate. Although temper is listed as a "ceramic variable" (Bayard 1984:117), it is not used to differentiate either "types" or "classes". Thus in Bayard's final (1984) scheme both "classes" and "types" are presented as morphological entities. Predictably, factor analysis employing the same metrical variables used in the initial six-class classification scheme produced a clear grouping of vessels into the classes originally created for them through selecting the identical metrical factors. The utility of such predictions may be questionable because of their circular nature (Orton 1980:138-139).

Although temper appears to have been omitted from Bayard's classification calculations, it is included with a list of non-metrical variables as comparable to fabric (1984:117). Temper and fabric are here defined as two different entities. Temper is an additive deliberately mixed into plastic potting clays in order to improve their usefulness for ceramic purposes. Fabrics may be tempered or untempered. This is because some potting clays can be used without the addition of temper. Bayard groups temper with form variables (1984:117). Again, this concept is different to the definition of a pottery type used here. This is important and we will return to it later.

The only published temper/vessel association available for the Non Nok Tha funerary vessels is "an interim typology" (Bayard 1977:65-79), later termed an "interim classification" (Bayard in press). Isolated references of a general nature apart, such as "pottery tempered with chaff" (Bayard 1971:22), in the absence of any subsequent detailed temper-inclusive typology we must presume that the 1977 temper/vessel associations were also used in the "final classification" (Bayard 1984). A more complete typology is intended, however: "Temper types of the funerary vessels themselves will be published when full formal decorative analysis have been completed" (Bayard 1977:99). These treatments involve temper as it relates to the various funerary vessel "types" (Bayard 1977:65-72), although the original "types" are later termed "classes" (Bayard 1984:91). Bayard's 1977 publication clearly sets out six funerary vessel "types" "distinguished primarily by shape"...... "Within these six types a number of subtypes have been established on the basis of decoration and size (figure 4)" (Bayard 1977:65).

Type one is subdivided into six subtypes three of which (1A,1B, and 1C) are sand tempered. No temper details are given for subtypes 1D or 1F, but most of the 1E subtypes are tempered with "crushed rice chaff and some sand.." (Bayard 1977:69). Type two is subdivided into four subtypes. Subtype 11A is sand tempered; 11B is tempered with coarsely ground clay which is "lightly tempered with rice chaff;..". For subtype 11C the "temper is uniformly of silicified rice chaff and a small amount of sand". 11D is tempered with sand, and in addition "the brilliant red colour of the clay body, ... makes it seem likely that some form of red pigment was added to the clay". Type three contains only three vessels all of which are sand tempered. Type four is subdivided into four subtypes. 1VA and 1VB are listed as sand-tempered. 1VC, however, is tempered with silicified rice chaff. 1VD are simply smaller versions of the 1VC subtypes. Type five has two subtypes, both sand tempered. As with the 1ID vessels, the VB subtypes, however, appear to have had red pigment as well as sand mixed with the clay.
Type six is subdivided into two subtypes and both are sand tempered (Bayard 1977:72). In an earlier typology (Bayard 1971:43-44), the same morphological scheme as that set out above was employed, but temper is not mentioned.

“Class” and “type” are used in the final (1984) typology in place of “type” and “subtype” in the earlier (1977) “interim typology”. These substitutions refer to form criteria and are thus of no consequence to the temper/vessel associations. Perhaps significantly, “class” has often been used as a loose “mentalist” synonym denoting a widespread occurrence of style-defined pottery types (Gifford 1960, Deetz 1967). Apart from type 1D and 1E, which feature an appliqué band and nubbins respectively in the 1977 typology, the remaining 1984 types are the same as those previously labelled “subtypes” (1977), or “types” (1971:43). In each step, from “types” to “subtypes”, to “classes” comprising “types”, Bayard’s classifications have been morphological. Temper is never explicitly a criterion. Hence we need only consider the more detailed earlier (1977) publication.

Clearly the 1977 types are not subdivided into subtypes on the basis of temper. Some subtypes contain the same temper and others are not given temper categories. Indeed Bayard (1977) clearly stated that the subtypes were established on the basis of decoration and size. A detailed evaluation of Non Nok Tha fabrics could prove worthwhile, as much of the stratigraphical integrity rests on the correlations considered to be represented by the funerary vessel typology (Bayard 1977:63, 65, and 79). Further, discrete, socially stratified, groups may be identified by the presence or absence of different vessel “types” (Bayard 1984:109–116). Petrographic data could help test this hypothesis, and fabric and form associations could allow an alternative approach to the evidence. One possibility is that changes in temper species at Non Nok Tha are correlated with cultural changes. Much of the present taxonomic confusion seems to stem from a lack of general agreement regarding the definition of what constitutes a ceramic type. This difficulty may be rectified by employing the kind of approach recommended by Hulthen, and touched on below.

Concensus regarding what defines a ceramic “type”, has been reached recently in Europe (Hulthen 1974:7). This has allowed a unified methodological and theoretical approach. Yet concensus and clarification were absent less than two decades ago (Peacock 1970:380-389). A similar concept, however, had already been applied to Sudanese pottery (Adams 1964). European concensus has resulted in rewarding advances in ceramic investigations (Hulthen 1977, Howard and Morris 1981, Freestone et al 1982), undertaken within this prescriptive scientific “paradigm” (Kuhn 1962,1963). Unfortunately the European experience has not been matched in North or Meso-America. The “mentalist” approach (Arnold 1985:4–12), with its style oriented emphasis, has continued to dominate research in the Americas in spite of attempts to inculcate the kind of technological methods espoused by Shepard and others (e.g. Porter 1964, 1965). An absence of such concensus in Southeast Asia makes the urgent need for the adoption of a standardised terminology, that is both precise and appropriate, seem obvious.

Bayard’s methods closely follow those of many American practitioners. These generally either omit or emphasise superficial technological aspects of ceramic fabrics. Typically, technological “attributes” are encompassed in an all-embracing category labelled “general technology” which, together with surface treatment and vessel form (or “design style”), comprise “a class of pottery” (cf. Wheat et al 1958:34-46). A consideration of these important questions is set out in chapter three.

Insight into the selection of methods used in Bayard’s detailed stylistic analysis is increased through a consideration of Buchan’s research on assemblages derived from Higham and Parker’s excavations at Non Nong Chik. Working under Bayard’s supervision, she devoted
considerable attention to the definition of the type. She followed Ehrich (1950), and Spaulding (1960) in noting that a “type (is) defined as a group of artefacts consistently displaying a specific combination of attributes sufficient to produce a characteristic form” (Buchan 1973:15).

Defining and selecting appropriate attributes is clearly crucial. Buchan emphasised the variety of possible attributes in pottery samples, a direct result of the plastic nature of clay. The end result is a greater variety of component attributes versus a lesser degree of necessary inter-dependence between them. This means that a specific attribute combination may not always occur. The type-variety system of classification with its emphasis on ceramic type clusters is most similar to the hierarchical system chosen by Buchan, employing as it does 38 pottery variables incorporated in Bayard’s computer format. One particular variable, temper, contained 39 sub-categories derived from various combinations of four basic temper types: sand, rice chaff, laterite and prepared temper (either ground potsherds or crushed pre-fired clay balls).

It is notable that, following a detailed statistical analysis, only one pair of variables could be used for $\chi^2$ tests of association: temper types and body decoration. A definite association between the two variables was evident in the majority of results. Thus, although attributes concerned with artefact form comprise the major portion of the statistical formula, the single fabric-related attribute was equally influential statistically.

Clarke (1962, 1970), concerned with recognizing attribute groupings in his beaker ware studies, was lead by his sociological approach essentially to ignore material aspects of the pottery. Thus, Buchan includes both material and non-material attributes while Clarke does not. Yet both are interested in providing a descriptive “type” conceived as a morphological entity. Significantly, although Buchan’s attributes are clearly biased towards non-material factors, the one material attribute considered was prominent in the statistically generated results. Such studies typify the morphological and decoration emphasis that characterise style oriented research.

Faced with a pottery assemblage of c.200,000 bodysherds and 50,000 rims, Bronson (1976), considered mathematical attribute analysis too time consuming because of the huge sample size and excessive amount of apparently significant attributes. Random sampling was rejected due to the risk of ignoring unique or rare sherd types, which are potentially important if they are imported. Further, while a particular design or form attribute may have a limited temporal and spatial distribution, and is thus potentially important for documenting contact between social groups, most mathematical taxonomic systems, according to Bronson, are unable to provide appropriate weighting emphasis.

Chronology is central to Bronson’s methodology. Yet the existing system of nomenclature for the protohistoric and historic periods in the Chansen area was based on art styles and Kingdoms, such as the Funan, Dvāravatī, Khmer and Sukhothai. In consequence, in Bronson’s and Dale’s own words, “such basic procedures as pottery classification had to be started from scratch” (Bronson and Dales 1972:18). Not only did Southeast Asia lack an established system of description and classification, the Chansen material was considered not to be amenable to systems favoured elsewhere. An innovative system was therefore devised, which used terms and categories, such as “sorting class”, “specials” and “variants”. While the terminology is familiar, definitions display adaptive flexibility suited to the kind and quantity (c 66% of the sherds recovered) of the pottery analysed.

Central to the “reasonably objective” system employed is again the concept of type. Bronson’s types comprise rimsherds with at least one shared distinctive attribute. Attributes are “any single descriptive characteristic”, and a characteristic in turn “cannot be subdivided further without detailed technical examination”. Attributes, the elementary taxonomic units, are
variously combined to produce modes, types, specials, sorting classes, variants, type complexes and fabric groups.

Bronson’s treatment of the data is detailed and comprehensive within the framework outlined above. Attributes of a technical nature, such as colour, surface finish and temper appear subjectively derived, however, and form nomenclature reflects functional assumptions. Form classes are based mainly on shape and size criteria. They are limited to common whole-vessel taxa, and feature a form plus specific attribute formula definition. They also invariably include either a fabric group or temper type as an attribute. Ultimately, the ceramic phases derived from the above studies are seen to mirror cultural episodes, where long, stable periods are separated by shorter, accelerated periods of transition.

White (1986), uses a ceramic “typology”, in association with stratigraphic and radiocarbon data, with the intention of defining a relative and absolute chronology for Ban Chiang burials. She then attempts to cross-date this chronology with sequences from other sites. The relative chronology of Ban Chiang “...the ‘type site’ for the northern Khorat Plateau..” is principally based on “a detailed examination of burial ceramics and their sequential relationships” (White 1986:134). According to White, prior “...dating of the Ban Chiang sequence has been a major controversy.” (1986:133).

Again this study concentrates on style. White postpones the construction of a “formal typology” in favour of a “provisional typology” (or “pt”). She argues that postponement is necessary because of difficulty in relating marked ceramic variation to the chronology, a lack of statistical data, “...and particularly insufficient information on fabric” (White 1986:82). Thus “Types” with a capital “T” are considered to require the inclusion of technological analysis, whereas a “pt” is an artefact group whose members share a trait “cluster”. This relationship allows them to be distinguished from another group. Because the “pt” concept is specifically related to defining chronology, definitive “pt” criteria may vary (White 1986:83). Vessel morphology and size are often considered “key” definitive “traits”. Alternatively, surface treatments alone are sometimes held to be distinctive and common enough. Hence, in these cases, different vessel shapes “would unnecessarily encumber” the discussion. As morphology is not deemed to be consistently “relevant to the definition of every pt, the term ‘Form’ ...was rejected” (White 1986:83-84). Generalized size categories (small, medium and large) and functionally implicit descriptions (bowls, jars, or round bottomed pots), are combined with technological data (colour, surface decoration, construction method and fabric details), where available.

This “temporary scheme” allowed 18 pt’s to be related to 19 chronological sequences (White 1986:82-84). Thus according to White the 341 excavated Ban Chiang vessels (Hastings 1982:38-39), can conveniently be represented by 18 pt’s. Perhaps significantly 10 of the 18 pt’s include vessels for which technological data were available. These technological studies are discussed below.

White’s attributes are selected subjectively “based on extensive experience with the collection” (1986:82). Phrases such as “intuitively of immediate chronological use” (1986:81), or “The sequence proposed here makes more ‘stylistic sense’”, (1986:113-114), reflect a substantial reliance on a subjective “pottery sense”, and underline the overall approach used. Her “pt” definition, which is intended to relate distinctive artefacts with discrete archaeological units, echoes Clarke’s discussed above. It typifies the stylistic “paradigm”.

Severe constraints were imposed on White by the limited technological information available. Comparison of Ban Na Di vessel forms with Ban Chiang “pt’s” helped lead White to conclude that, in spite of a paucity of excavated data, Northeast Thailand can be characterised...
by its marked regional ceramic variability. At Ban Na Di, however, imported ceramics clearly denote external relationships. These apparently conflicting factors are thus considered irreconcilable with cultural homogeneity. Opposition between these two cultural aspects is thus seen to reflect "not isolation but more subtle socio-cultural processes" (1986:220). Paradoxically, however, according to White, intersite asymmetry in imported items disqualifies any single category as sufficient for cross-dating between sites (1986:221).

White’s use of the Ban Chiang ceramic assemblage turns on a “provisional” ceramic typology. This is promoted as a style-only typological classification. Unfortunately it is often unclear as to which definition of “type” White is referring. The limitations of ceramic styles for cross-cultural comparisons are freely admitted (White 1986:233). Hence the utility of this kind of study for assessments of cultural developments in the region is determined by the approach employed.

It is possible that the various groups of associated pt’s, and/or the pt’s themselves, may reflect any of a wide range of cultural events, either singly or in combination. For example, as with Arnold’s Andean case, these changes may reflect a change in the source of imported ceramics. Alternatively they may represent a change in local fashion preferences (cf. Watson et al. 1982). As a first step towards resolving these problems, it would seem prudent to establish whether the ceramics were the product of a local industry or, if not, to what degree they represent imported goods. White (1982:82) lists ceramic anvils, accoutrements of pottery manufacture, from both Late and Middle Periods at Ban Chiang, and hints that they may relate to a local industry. Unfortunately no further assessment of their status has been published to date.

2.4 Technological studies

Petrographic analysis of sherds from Khok Charoen using standard thin-section polarized light, as well as electron microprobe chemical determination techniques, has identified six fabric groups (Watson et al. 1982). This important study highlights the need for fine-grained analysis of prehistoric ceramics. Identification of temper and inclusions mineralogically consistent with locally available weathered volcanic rocks of acid composition provides firm evidence of local manufacture. Other implications of this work are outlined below.

McGovern (et al. 1985:104-113), conducted an “admittedly limited sampling of three periods of Ban Chiang ceramics”. Some fabrics show close parallels with the intrusive “bleb” tempered wares at Ban Na Di. This distinctive fabric is recognisable in photomicrographs included in the above publications (McGovern 1985:106, Plate 2, Vincent 1984a:694, fig 15-3B. and C.). Although the magnification levels are different (25x and 80x respectively), comparison of these photomicrographs demonstrates a close morphological similarity between the two tempers. White, however, argues for a lack of equivalence between Late Period Ban Chiang and Ban Na Di. She considers that bleb-temper is absent from Ban Chiang. According to White (1986:263), Vernon, who conducted the petrographic analysis, noted “little if any obvious plant material associated with the grog fragments. Any plant remains were found within the clay matrix”. Quite so. This complies with the association noted for other bleb-tempered fabrics. This is an important temper and we will discuss it in detail in the following chapters.

McGovern (et al. 1985), in preliminary observations based on an examination of twelve vessels, and subject to a more detailed study, assert that "although there are some similarities in vessel forms, the fabrics of Ban Na Di are clearly different from the wares included in this
study”. They argue that the Ban Chiang pottery industry “appears to have been highly conservative”. Changes in petrology, clay types, paint, slips, and fabrication techniques are held to “have been minor departures from the well-founded tradition”, but these variables also possess potential “in understanding the evolution of the industry”. Oscillations between different fabrication techniques, however, “are difficult to understand within a continuous tradition”. Such changes are postulated to be the result of “culture contact or population movements”. Finally, while the firing temperature range is held to be well defined, “more detailed analysis and/or a larger sample is desirable in resolving a number of issues”. These are observations which will be considered in the present work.

Glanzman and Fleming (1985:114-121), used macroscopic surface examination and xeroradiography of Ban Chiang vessels to assess fabrication methods. They feel “coil-and-slab” and “lump-and-slab” fabrication techniques characteristically employed by craft potters are readily detected in prehistoric pottery. These methods were “central elements” of Ban Chiang vessel fabrication. Paddle-and-anvil shaping is evident in both complete modern Ban Chiang vessels and ancient examples. The authors identify four Early Period vessels as coil-and-slab, and two as lump-and-slab, four Middle Period were lump-and-slab and one coil-and-slab, while the Late Period revealed three coil-and-slab and one vessel of uncertain fabrication. As with the previous study the sample is small (a total of 15 vessels ). Such fabrication studies, however, have considerable potential for illuminating an important aspect of prehistoric ceramic technology.

### 2.5 Ethnographic studies

Ethnographic studies offer valuable insight into the manufacture and distribution of pottery. This is relevant to the analysis of prehistoric samples if treated with caution. Unfortunately, few such studies have been undertaken in Thailand. Calder (1972) considered manufacturing processes, consumer demands, trade patterns, seasonal production, breakage patterns, replacement responses and variable end-product uses. She noted that the inhabitants of Ban Koeng saw themselves only as consumers, never as producers of pottery. Yet they were familiar with the production techniques employed at the nearby specialist potting village of Ban Mo. Excavations designed to test hypotheses related to breakage modes, and subsequent sherd distributions, provided valuable insight into deposition, transportation after breakage, and sherd wear.

Insight into production rather than consumption is provided by Solheim’s study of the southern Thai village of Sting Mor (Solheim 1964). Pottery manufacture provides the economic base of the village. The potters are female, and the manufactory utilises clay produced from “privately owned beds” situated some distance away. Sand temper is added, and a cylinder of clay is wheel formed into vessels, either completed in one stage or partly wheel-formed and subsequently shaped with a wooden paddle and fired clay anvil. Vessel fields are variously treated either with paddle impressions, stamps, or simply by being left plain. In the case of water jars, the impressions of carved paddles used in shaping are smoothed over, but stamps, which vary in motif for each potter are applied to the shoulders. Pebble burnishing and grooving are also employed. Firing is undertaken in vertical or horizontal kilns by men. The kilns are privately owned, and may be rented.

Solheim (1964) has also described the pottery making techniques of the inhabitants of Ban Nong, located c. 55 km northwest of Khon Kaen. The inhabitants arrived about two decades earlier from Khorat and Ubon respectively. Carefully selected clay is gathered by men and
women from a pond located five minutes walk away. The temper is prepared by mixing clay with rice husks into the shape of balls about 15 cm in diameter, and then after drying, firing them. During firing, they become red hot, and after firing, they are brown on the outside and black in the centre. They are then taken by women and pounded in a wooden mortar before being sieved through a 3 or 4 mm basket weave mesh. Clay is then mixed with the temper on a mat placed on the ground. While men mix the temper with the clay, women alone construct the vessels. Prepared solid clay cylinders are hollowed either with thumbs, or, in the case of large vessels, a stick, to form both solid and hollow based cylinders. These are secured on a wooden post and enlarged and evened with a rough paddle. The rim is formed by walking round the post, and using a hand-held leaf as the smoothing agent. The body of the vessel is formed using a plain paddle and anvil, and a final carved paddle application impresses a pattern on the shoulders of the larger jars. There are several different forms, and the potters are known to imitate exotic vessels. Each potter produces between 12 and 14 vessels a day, and when 200-300 have accumulated, men fire them on a raft of wood, with grass fuel heaped over them and replenished as required over a period of three to five hours. Solheim noted: “There is much flame, with generally oxidising atmosphere. The surface fires a light brown, with fire clouds common. The paste is usually brown all the way through, but in thicker portions there is often a black core remaining”. The basic economic-production unit is the family. Women make the vessels, men market them. While knowledge of potting is retained within the family and community, women coming into the village are occasionally taught potting skills.

At Ban Phan Luang near Luang Prabang, the potters gather clay from nearby fields. It is then dried, pounded and basket-sieved (Solheim 1967). This prepared clay is then water moistened and tempered with river sand until “it feels right”. Batches of pots are manufactured in stages, initially on a slow wheel. Two paddle and anvil stages complete the forming, and firing takes place on a grass fueled timber raft. No additional fuel is added during firing, which lasts between 1-1.5 hours.

Bayard (1977a) has described a further potting tradition at Ban Na Kraseng, Loei Province. He noted that clay was collected only from termite mounds. The natural occurrence of coarse sandy inclusions made it unnecessary to add tempering material, so the water-softened clay was simply pounded until uniform in texture and of acceptable consistency. Prepared cylinders of clay were hollowed by hand, then paddle beaten after the upper edge was smoothed and the rim completed. The inner rim surface was then smoothed with a bamboo stick and the shoulder area expanded with a paddle and anvil. A carved paddle and carefully selected river pebble anvil were used. Firing on a log platform fuelled by straw and bamboo lasted from two to three hours or until the vessels were glowing hot. The resultant vessels were found to be “uniform, fully oxidised, brick red in colour” and with little or no fire clouding.

2.6 Style analysis and fabric analysis

Many of the studies described above are concerned with the construction of meaningful relative chronologies both inter- and intra-regionally. This is perhaps a predictable initial response to an area little-known archaeologically. Style is emphasised in most of these approaches. Yet styles often grade imperceptibly, and style analysis alone often falls to recognise imitations of intrusive pottery, or the adaptation of foreign manufacturing techniques and styles in contrast to local innovation.

Fabric analysis, however, when clear geological parameters exist in the raw material source area, can provide firm evidence of provenance, or equally important, the exclusion of certain
areas as sources of raw material. Tempering materials afford evidence of qualitative change. One temper variety does not grade into another, and when examined petrographically, sand, grog, shell, rock or organic tempers are clearly discernible. Extreme conservatism in temper use is widespread (Shepard 1956). Thus temper can provide important information regarding pottery-making customs or traditions, particularly if one temper is preferred to other equally suitable and/or available materials.

The petrographic analysis detailed by Watson et al. (1982), the first of its kind in Southeast Asia, provided an example of the importance of fabric analysis for provenance determinations. Six fabrics are evident, 80% of the sample comprising local wares of fabric group 1. However, a meander design, derived from an exotic fabric 6 vessel, was found reproduced in simplified form on a fabric 1 pot. Watson views this as corroborative evidence of the prestige attached to the imported vessel. Clearly, a strictly style-orientated study would have failed to discriminate between these two different types.

This situation is relevant to Bayard’s 1977 analysis of the Non Nok Tha burial vessels already discussed above, because his criteria used in defining vessel types did not include temper. Thus his type 1 vessels contained either sand or rice chaff. Given the primacy afforded pottery for “establishing relationships and relative chronologies in the post Hoabinhian” (1977:59), this omission is surprising. It could also be central to the analysis as, according to Bayard, there is strong evidence for a single ceramic tradition throughout the Non Nok Tha sequence.

Table 2.1 below sets out temper types previously identified in Thailand. According to Bayard (1977), Non Nok Tha Early Period wares were tempered solely with sand. By the Late Period 50% of the pottery was chaff tempered. In view of potters’ conservatism with regard to temper use (Shepard 1956), it seems unlikely that two separate temper types would be concurrently utilized within a ceramic industry of this nature. Evidence set out in following chapters will show that rice tempered wares followed the bleb temper tradition at Non Chai, Ban Chiang Hian, Ban Na Di, Ban Muang Phruk and Non Kho Noi. Both tempers are evident throughout the Sakon Nakhon Basin sites surveyed by Kijngam et al. (1980). Rice and/or rice associated tempers appear to be generally late in this area. It is possible that a similar situation prevailed at Non Nok Tha.

Bayard’s assertion that the new temper types probably indicate increased external contact and “movement either of vessels or non-local potters” (1977:82), appears to leave out the possibility of a major cultural change. Continuities in the association of temper, form and surface treatment were actively sought (Bayard 1977:80). Because no funerary ware contained chaff or “sand-and-chaff”, and these tempers are correlated with plain wares, the latter are presumed to represent domestic pottery (Bayard 1977:81). Burial vessel descriptions, however, include types that contain these temper species. For example types 1E, 11C, and 1VC contain chaff temper (Bayard 1977:65-72). Bayard later modifies this stance by distinguishing between what are now termed “genuine” “C” and “L” vessels, and “rather crude imitations” (1984:114). The former are tempered with “sand-and silicified-rice-chaff”, the latter with sand. These “C” and “L” vessels are held to reflect “two distinct affiliative groups in Non Nok Tha Phase society” (Bayard 1984:105). Major changes in funerary wealth at the end of the Non Nok Tha Phase “could have been due to a takeover of the local authority by a larger and more complex regional entity” (Bayard 1984:116).

Petrographic examination of pottery fabrics in such studies seems worthy of consideration. Such an assessment of the Non Nok Tha funerary vessels could help define the stratigraphy.
2.6. STYLE ANALYSIS AND FABRIC ANALYSIS

by subsequent peripheral sequences of burial and/or occupation phases. Sand tempered pottery was found with the early burials. Differently tempered pottery may mark the subsequent burial/occupation phases.

Wichakana (1984a, b), used vessel rims from Ban Muang Phruk, Non Kao Noi and Ban Na Di, to construct a basic framework for the Upper Songkram Valley’s prehistoric sequence. In defining an attribute he followed the general approach used by Bronson (1976). Four attributes, rim form, rim orifice diameter and/or height, surface decoration, and “the broad characteristics” of fabrics were considered. Rim types were defined by a shared similarity of all four attributes. Tempers were identified with the aid of a binocular microscope. Nineteen temper groups were recognised, nine exclusive to Non Kao Noi. The Non Kao Noi rim assemblage is distinct from either Ban Na Di or Ban Muang Phruk.

At Ban Na Di, a dramatic change in the common types occurred at the level 5/6 interface. This coincided with a marked increase in rim types. In addition, many of these latter rims parallel rim types from the basal layer of Ban Muang Phruk. Some Ban Na Di rims parallel types from Non Chai in the Upper Chi Valley (Rutnin 1979). Thin sections of Wichakana’s rim types have been prepared by the writer and petrographic descriptions of each are summarized in appendix one.

Chantaratiyakarn (1984) undertook a similar study to that outlined above for Wichakana. This involved pottery excavated at Ban Chiang Hian, a large Middle Chi Valley site, and the related but smaller sites of Ban Kho Noi and Non Noi. One objective was to develop a regional chronology based on pottery typology. As with Wichakana’s study, temper, rim form, decoration and size are emphasized. Rim forms similar to those from Non Chai, and Non Dua in Roi Et Province (Higham 1977), were noted. This is reflected in the typological nomenclature. Ban Chiang Hian bodysherds were also sampled, and a major change noted in level 8 (c. 600 B.C.). This involved the substantial replacement of previously abundant “red on buff painted wares” by paddle impressed pottery. Wares reminiscent of “Phimai Black” (Solheim and Ayres 1979), and “Om Kaeo” (Preecha and Pukajorn 1976), and a marked development of new types occurred from levels 5/6 (c. O A.D.). Thin sections of these wares have also been prepared and examined petrographically by the author. The results are summarized in chapter eight (table 8.4).

According to Rutnin (1979), pottery from the large Middle Chi site of Non Chai was almost entirely tempered with a single temper species. Described as clay, sand and chaff, this temper is identified with 88.4% of the rimsherds and 82.3% of the body sherds. A petrographic consideration of this material is set out in appendix one and chapter eight (table 8.5).

Table 2.1 sets out in chronological order temper species documented by various workers on material from several Thai prehistoric sites. In the light of the objectives outlined above, and discussed further in chapter three, caution needs to be exercised when assessing distributions of temper species identified as attributes for essentially stylistic analyses. Categories such as sand, fibre, grog and crushed potsherds, however, help identify broad temper categories. Hence such information could provide important prima facie evidence of regional variations and/or temporal changes in ceramic technologies.
CHAPTER 2. A REVIEW OF PREVIOUS STUDIES

### TABLE 2.1: Prehistoric tempers previously identified in Thailand.

<table>
<thead>
<tr>
<th>Site</th>
<th>Temper</th>
<th>Chronology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Khok Charoen</td>
<td>granitic rock fragments- fabric grp 6</td>
<td>Period 1</td>
</tr>
<tr>
<td></td>
<td>Sand,(probably weathered volcanics)- fabric grp 1</td>
<td>Periods 2/3</td>
</tr>
<tr>
<td></td>
<td>Grog,(containing fabric 1 material)- fabric grp 2</td>
<td>Period 4</td>
</tr>
<tr>
<td>Phimai</td>
<td>fine sand</td>
<td>Tamyae</td>
</tr>
<tr>
<td></td>
<td>rice chaff</td>
<td>Phimai</td>
</tr>
<tr>
<td></td>
<td>fine to coarse sand</td>
<td>early historic</td>
</tr>
<tr>
<td>Chansen</td>
<td>mineral dominant</td>
<td>Phase 1</td>
</tr>
<tr>
<td></td>
<td>vegetable very common</td>
<td>Phase 2</td>
</tr>
<tr>
<td></td>
<td>vegetable dominant</td>
<td>Phase 3</td>
</tr>
<tr>
<td></td>
<td>vegetable dominant</td>
<td>Phase 4</td>
</tr>
<tr>
<td></td>
<td>'vegetable very common</td>
<td>Phase 5</td>
</tr>
<tr>
<td></td>
<td>mineral dominant</td>
<td>Phase 6</td>
</tr>
<tr>
<td>Non Chai</td>
<td>clay, sand and chaff</td>
<td>throughout</td>
</tr>
<tr>
<td>Roi Et sites:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non Dua</td>
<td>fibre 62%, clay 38%</td>
<td>Phase 1</td>
</tr>
<tr>
<td></td>
<td>fibre 68%, clay 23%, sand 8%</td>
<td>Phase 2</td>
</tr>
<tr>
<td>Bo Phan Khan</td>
<td>fibre 99%</td>
<td>Phase 2</td>
</tr>
<tr>
<td>Don Taphan</td>
<td>fibre 99%</td>
<td>Phase 2</td>
</tr>
<tr>
<td>Non Dua</td>
<td>fibre 31%, clay 48%, sand 19%</td>
<td>Phase 3</td>
</tr>
<tr>
<td>Bo Phan Khan</td>
<td>fibre 87%</td>
<td>Phase 3</td>
</tr>
<tr>
<td>Don Taphan</td>
<td>fibre 93%</td>
<td>Phase 3</td>
</tr>
<tr>
<td>Non Nok Tha</td>
<td>sand 92%</td>
<td>Early Period</td>
</tr>
<tr>
<td></td>
<td>sand 67%, chaff 26%</td>
<td>Middle Period</td>
</tr>
<tr>
<td></td>
<td>sand 50%, chaff 50%</td>
<td>Late Period</td>
</tr>
</tbody>
</table>

(Note: the period designations for Non Nok Tha are those given by Bayard (1977). These were later (1984:88) changed to the Phu Wiang Phase (with assumed initial occupation 3000 - 2600 B.C.), Non Nok Tha Phase (later 3rd millenium to between 500 B.C.and 200 A.D.), and after a hiatus the “parahistoric” Don Sawan Phase). Data from Watson et al. 1982 for Khok Charoen, Welch (1983) for Phimai, Bronson (1976) for Chansen, Rutnin (1979) for Non Chai, Higham (1977) for the Roi Et sites and Bayard (1977) for Non Nok Tha. In each case the dominant temper is given, and percentages rounded to the nearest number. The locations of these sites are set out in figure 2.1

### 2.7 Summary

This chapter has reviewed the principal studies into prehistoric ceramics previously undertaken in Thailand. Several were omitted either because they represent further examples of analytical methods already discussed in detail, such as Higham’s (1977) Roi Et reports, which closely follow Bayard’s approach, or because they are too general or peripheral (for example Hasting 1982, Marsh 1971; Mourer 1977, Schauffler 1976, Vallibiotama 1984, Pukajorn 1984, Vincent, Brian. Prehistoric Ceramics of Northeastern Thailand: with Special Reference to Ban Na Di. E-book, Oxford, UK: BAR Publishing, 1988, https://doi.org/10.30861/9780860545027. Downloaded on behalf of 35.160.27.221
and Wong 1982). Other work has been superceded by subsequent studies (for example Van Esterik 1973). Pottery from Khok Charoen was used by Ho (1984), for inter-site comparisons. The fabric groups identified by Freestone are linked to pottery forms. Decoration and shape, however, are given primacy.

The importance attached in the majority of these studies to the concept and analytical validity of “attributes”, as defined by European and American theorists, is central to an understanding of their general approach, the exceptions outlined above aside. We have seen that this concept was extended not only to artefacts but to cultures and cultural groups. Thus, in their endeavour to describe and explain socio-cultural similarities and differences, a disproportionate and potentially misleading emphasis has been placed by the majority of earlier workers on ceramic styles. This is in spite of ethnographic evidence that potters imitate exotic styles (Solheim 1964). Such information demonstrates the fickle nature of fashion and its powerful influence on artefact style.

In this report we will emphasise technological analysis and place importance on non-sociological, as well as sociological, influences on ceramic industries in Northeast Thailand. The formula “form plus fabric” (Hulthen 1974, Peacock pers.comm.), best describes the concept of a ceramic “type” used here. Rather than a detailed examination of decoration or morphology, the material of which pottery is composed, its fabric, will not only be emphasized but given primacy.
CHAPTER 2. A REVIEW OF PREVIOUS STUDIES

FIGURE 2.1: THE DISTRIBUTION OF SITES WITHRecorded TEMPER SPECIES
Chapter 3

Objectives and methods

3.1 Objectives

The object of this report is to illuminate the prehistory of Northeast Thailand through an analysis of ceramics from Ban Na Di and related sites within the Sakon Nakhon Basin and the upper Chi and Mun Valleys. We have noted in chapter one that these sites were examined so as to fill a lacuna in evidence regarding claims for early metallurgy. Ban Na Di was chosen for excavation because it lay close to Ban Chiang, one of the postulated very early sites containing metal, and because it occupied an environmental location shared with many surveyed sites. Test excavations indicated a material culture which included bronze and iron. Several more distant sites will be considered where they provide background data of relevance to the developments documented for the Sakon Nakhon Basin. Inclusion of these additional sites assists the theoretical model outlined below by broadening the scale of the inquiry. The potential of petrographic analysis of pottery is documented with reference to the work of Shepard (1936, 1942, 1956, 1965) in the Rio Grande.

In essence, Shepard applied established geological and statistical methods to prehistoric ceramic technology as revealed by archaeological surveys and excavations in the Rio Grande region. The result was, according to Kidder, “not only a valuable contribution to Rio Grande prehistory but an exposition, by what might be called the case system, of the role of ceramic technology in archaeological research” (Kidder 1942:ii). This assessment was later denied by Shepard (1965:62-63) when she argued that “Several distinct circumstances favored the technological study of Pecos pottery”. The first included the relationship between archaeologist and analyst which meant that the “archaeological background”, “stylistic features and relative dating of the types” were known from the outset “and throughout the study there were frequent opportunities for exchange of information and discussion with Dr.Kidder. Second, the history of the ware was exceptional because its unique decorative technique required a lead ore that was restricted in occurrence. Third, the geological diversity of the region from which the potters obtained clays, nonplastics, and pigments greatly facilitated the location of sources or source areas of these ceramic materials. Consequently, this investigation was a specific, not a general, test”. Whether or not Shepard’s Pecos investigation was a case study with general archaeological application, is central to the objectives and aims of this report. It is a question that will be tested in the following chapters.

Shepard’s research was undertaken against a background of a series of meetings, conferences and papers designed to cope with an enormous corpus of ceramic data derived from both surface surveys and excavated material. The collection of this material began in 1910
and built up to what was referred to at the Peabody Museum as a “library of sherds” (Kidder 1936:xxiv). By 1936, the combined assemblage in three Southwestern institutions represented a collection of sherds from about 12,000 sites. Further data were accumulating from other North American sites (Phillips et al. 1951). Even before sherd surveying was undertaken on a serious basis the need “for a uniform nomenclature of pottery type” (Kidder, op. cit.) was considered essential. The 1927 Pecos Conference resulted in general agreement that participants should consider “a binomial ware- nomenclature; the first name to be indicative of the locality of highest development, the second a technically descriptive term; for example, Sikyatki yellow, Mimbres black-on-white, Upper Rio Grande incised, etc.” (Kidder 1936:xxv). Further discussion followed at the 1929 Pecos Conference, and the system was adopted at the 1930 Globe Conference. Attempts to correlate ceramic categories with biological taxonomies were quickly discounted as untenable. It was, however, felt that “sound classifications and valid deductions eventually will emerge” (Kidder 1936:xxvi).

Classification of archaeological materials was considered by Kidder to be the domain of the “general archaeologist” who, however, “is not competent to carry out the detailed and highly specialized studies” essential to understanding fabric composition or firing conditions. “A little learning is, in ceramics, a very dangerous thing” (Kidder 1936:xxviii).

### 3.2 Discussion

Tension over the proper domain of the “general” archaeologist lies at the heart of many of the debates into archaeological practice and its scientific status. Archaeology is multidisciplinary, involving both the natural and social sciences. The natural sciences sometimes involve data associated with phenomena that behave in a predictable manner (Popper 1963:340), for example the sun’s motion. Its apparent movement does not provide an unequivocal explanation of its true motion or role in the solar system, however. This requires definition and explanation. Such explanations are often best articulated and simplified with the aid of a model. Scientific explanations as discoveries are “the explanation of the known by the unknown” (Popper 1972:191). Such definitions and explanations are sought by researchers in archaeology.

The rigour attached to “scientific” explanations varies according to the kind of data under consideration. Physical phenomena, the subject matter of the natural sciences, once defined and explained, exhibit properties which are predictable in terms of these definitions and explanations. Such interpretations can be relied upon because they correspond to the rules contained within the framework of the unified theory or “paradigm” (Kuhn 1962) they are embraced by. Only if the unified theory or paradigm is overthrown is this predictibility destroyed. For each such destruction a new unified theory or paradigm is created (Kuhn 1961:348-365, 1962:67-105). Hence, given general agreement as to the theoretical framework within which research is undertaken, and the rules which define and order this framework, predictions can be made with confidence.

By contrast, many explanations in the social sciences do not enjoy such predictive confidence. They cannot explain nor predict conclusively either unknown past, or future historical developments. Two important factors contribute to this lack of explanatory power. First, societies are inherently in a state of constant transformation (Renfrew and Cooke 1979). Second, these developments are in the main not repetitive (Popper 1963:340). In contrast, the solar-system-type cyclical events are determined by physical laws. Their explanation may have enhanced the predictive respectability of the natural sciences.

Societies, however, are not governed or constantly constrained by physical laws. Humans
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may act to modify their physical and/or social environment. Their actions are merely subjectively appropriate however; and historically, even if effective, only more-or-less rational. As a consequence, typical social science models need to incorporate “the rationality principle” (Popper 1967), which weakens their explanatory power. This principle effectively denies the possibility of individuals or agents acting adequately or appropriately in any given situation. To do so would require perfect knowledge of all possible variables involved in all possible instances or events. Thus actors are historically inadequate for any given situation as they see it (Popper 1967:9). Therefore, to understand their inadequate actions, we must “reconstruct a wider view of the situation than their own ”(Popper 1967:9). The social science approach involves construction of models which include typical situations or conditions. They are over-simplifications that omit much and over-emphasize much (Popper 1967:7). In order to animate such models we must accept the truth of the rationality principle but need not allow its uncertainty to destroy our models because its adoption considerably reduces their arbitrariness. It assumes the adequacy of human actions to problem-situations as we see them. Such problems are not encountered in the natural sciences.

The theoretical/methodological dichotomy between the natural and social sciences places constraints on archaeological problems where both are interrelated. This applies whether we favour a processual or historical approach. Where physical laws are involved, considerable analytical rigour can be expected. Conversely, sociological data require a different approach, and, without the utility of appropriate models, are seriously weakened by that omission. These problems, while general in archaeology, are encapsulated in ceramic studies. As Peacock (1982:173) observed “Ceramic studies are a microcosm of the discipline as a whole: the form and decoration of vessels can be a subject for the art historian, graffiti and stamps for the epigraphist, while the fabric can be analysed by the geologist, chemist or physicist”.

We may now return to the enigma thrown up by Shepard’s denial of the petrographic method’s universality. She argued that special circumstances were enjoyed in the Pecos study, because the investigation involved unequivocal evidence. Significantly, such circumstances are analogous to those embodied by the natural science’s “paradigm”. As the Rio Grande geology was variable, and clearly divided into mineralogically discrete zones, the sources of raw materials were readily determined. This evidence did not, however, identify the production sites. These owe their origins to a combination of physical and social factors.

To extract meaningful information from raw physical data, background or “contextual” archaeological information is needed. As Shepard (1965:83-84) observed, without this information, “The analytical data would have said nothing more to me than that pottery from Pecos contained a number of kinds of tempering material”. Sociological factors helped determine where the pottery was made. Shepard’s raw data comprised material amenable to analysis and interpretation within the rubric of established physical laws. Complete confidence in the petrographic and chemical results is thus warranted. Shepard’s treatment of these, however, and the archaeological data combined, involved the use of a model typically employed in the social sciences. The rationality principle is implicit in this model.

Unfortunately the clear geological variability of the Rio Grande is not ubiquitous. Often the study area will contain geologically more-or-less homogeneous terrain. These are difficult, occasionally impossible, to differentiate with standard methods. Alternatively the data may require excessively laborious and/or expensive analytical techniques. In the former cases the methodology is often labelled as inadequate (Matson 1951:273-275, Shepard 1965:62-63, Peacock 1970:382-383). Other workers argue that, because of the latter problems, the petrographic/technological approach generally should be rejected as time consuming, expensive
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and inadequate (Matson 1951:112).

Ideally we would prefer the method to be universally applicable. A major difficulty may be that in the identification of raw material sources we are dealing with singular events, whereas the overall aim of archaeological analysis is the explanation of certain kinds or types of events. Popper (1967:2) notes that "the difference between these two kinds of problem is that the first can be solved without constructing a model, while the second is most easily solved with the help of constructing a model" (italics Popper's). Thus the difficulty lies not with the petrographic method but in the formulation of a model appropriate to the available data (italics mine).

The success enjoyed by petrographic-based technological investigations stems from the explanatory rigour attached to methods involving physical laws. Shepard's Pecos study epitomises this point. Unequivocal physical evidence articulated Shepard's explanatory model. Yet this clarity is not always so readily attained, even in the physical sciences. In geological stratification studies, for example, the law of superposition cannot automatically be assumed. Thus the stratigraphic younging direction is often unclear and top-to-bottom inferences may be invalid. Many instances of tectonically overturned beds have been documented which require detailed analysis for explanation and stratigraphic correlation (Dunbar and Rodgers 1957:112). Two devices are often used to overcome such problems. The first involves increasing the intensity or detail of the study, and the second is to widen its scope. These strategies will be adopted.

Regions containing clearly differentiated geological areas can be expected to provide powerful prima facie petrographic evidence. Less heterogeneous regions may often provide equivocal petrographic information. This may require testing against other evidence or enhancement. Physical evidence, however, is normally essential to adequate interpretations and explanations. Yet petrographic information devoid of archaeological and/or sociological background knowledge is of doubtful use. Similarly, ceramic data lacking petrographic details are often highly suspect, and occasionally erroneous and misleading (Peacock 1970). Ceramic fabrics are potential sources of either physical evidence alone or in combination with sociological data. But ceramic forms encapsulate essentially sociological information only. It is axiomatic, therefore, that the formula "fabric-plus-form-equals-type" be invariably applied if the fullest possible information is to be extracted from ceramic artefacts.

Shepard assumed that the method was an essential part of the Pecos investigation because it coincided with the circumstances. Petrographic analysis, however, was only one part (albeit a very important one), in an overall model constructed to illuminate the prehistoric ceramic processes involved. It is interesting to note in this regard that while presented as "a test of petrographic analysis" the Pecos study also involved what was described as an "unique decorative technique" Shepard (1965:62-63). Clearly, sociological factors also played an important role.

Ceramics embody both social and physical phenomena. If, by some culturally determined factor, the Pecos tempers had been, for example, regionally undifferentiated organic material rather than rock, Shepard's thesis could still have been validated by the mineralogy and chemistry of the parent body and the glazes. While the inclusions may have been less easily defined and required a more fine-grained treatment, such as heavy mineral (Peacock 1967) or textural analysis (Streiten 1982:123-134), the method would have still provided sufficient useful data to articulate the overall model. In some investigations, however, petrographic analysis alone, may fail to provide sufficient data for such a result. Yet this weaker petrographic information may provide sufficient background information for valid conclusions to be drawn when associated with other pertinent information. In the absence of any unequivocal evidence, the
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Eliminative deduction lends itself to archaeological ceramic studies because, while it is often difficult, and occasionally impossible to identify the origin of ceramic materials, it is usually possible to exclude potential areas. This principle is, in a sense, articulated by negative evidence. Typical “initial conditions” in ceramic studies involve the kind of local and regional geologic terrain, the scale of the investigation, the weight given to the various elements of the data available, background or “contextual” information of the kind discussed above, and the analytical methods employed.

In ceramic studies, an understanding of the origins of archaeologically-derived material can be crucial. A ceramic artefact’s provenance may be deduced by first assuming that it was made from locally available raw material “X”. Thus, if any given ceramic artefact is local, then it would be made of “X”. Hence if it is not made of “X” it is therefore not local. When several possible sources exist these can be eliminated one by one, using the same procedure, until the correct raw material source is identified.

This kind of procedure was set out by Bacon (1620) in his Novum Organum. It became known as eliminative induction (Musgrave pers.comm.). Essentially Bacon argued that by eliminating possible causes one by one, we shall finally end up with only one possibility which is thereby established by the whole process as the true cause of X. Of course the procedure assumes that the number of possible causes of anything (or of possible hypotheses) is finite and known. For our purposes, in instances where it may be impossible to suggest a likely source, it may be useful to at least determine that the material an artefact was made from could not be locally derived. In such cases it is not necessary to gain insight into all possible derivations, but merely to establish that the material was not local. We would, however, prefer additional information, even of a general nature, regarding likely sources.

Unfortunately, in ceramic provenance studies, additional problems face us to that suggested by Bacon’s method. Elimination of, for example, igneous and metamorphic terrain as possible source regions may be a Pyrrhic victory. We may be left with a sedimentary region which presents problems of just as great a magnitude as that with which we commenced. In addition,
several manufactures could have availed themselves of different portions of what essentially, in standard mineralogical terms, is the same clay deposit. Furthermore, such production could be stylistically undifferentiated. In many studies the response to these sorts of problems has been to intensify the methodological detail or to invoke fine-grained analyses such as heavy mineral or size/texture studies (Streiten 1982). We have noted, however, that these approaches have been criticised as too time consuming or expensive. Quite so. For large geologically undifferentiated areas, economic factors may rule out such methods. In these cases the question that now presents itself is: can we satisfy both the logical and the pragmatic problems that face us? I think we can by the use of an appropriate model. This model is outlined below.

3.4 The eliminative deduction or “sieve” model

In terms of Baconian eliminative induction, if the rejection of our first hypotheses leaves us with a problem of much the same magnitude as that we started with, one option is to enumerate a further set of hypotheses. This procedure could be repeated until we discover the right one. For fabric-inclusive ceramic studies, this means the available data must be enhanced in order to make it amenable to testing in terms of the new hypotheses. Each failure means we must proceed to a higher order of investigation. Each succeeding order requires additional inputs of information and/or more complex methods of inquiry. The process thus becomes increasingly more difficult to formulate with each additional step. Eventually, some problems may prove insoluble. The key question is where to draw the line between ideal solutions and pragmatic resolutions. While we seek a perfect view it may be “better to view the scene through blurred vision than to have not looked at all” (Hanks 1972). Pyrrhic victories are victories nonetheless.

Our eliminative deductive model involves testing a series of related hypotheses. Hypotheses unable to provide conclusive explanations are passed over until all the hypotheses have been considered in turn. If none of the hypotheses is correct, the data are then enhanced. This allows the hypotheses to be reformulated. In some instances a hypothesis initially not verified will benefit from this treatment and become verifiable. Such sorting is analogous to passing the data through a sieve. The treatments are discussed below.

It should be apparent from the above discussion that the model proceeds through a series of steps. Each step involves the use of several hypotheses, some or all of which are liable to be eliminated. Thus, in effect, each step is also liable to elimination. The consequence of a step elimination is the need to assess whether “data enhancement” is practicable. Each succeeding step elimination involves further enhancement. Data verifiable using commonplace analytical methods are termed standard.

Critics of this approach may argue that enhancement procedures should continue indefinitely until all possible hypotheses are verified, rather than rely on an apparently arbitrary cessation and retreat to the “negative evidence” position outlined above. While at first glance this proposition seems to have considerable appeal, it would be prudent to note that this strategy brings with it no guarantee that any hypotheses so treated will eventually ipso facto become verifiable.

3.5 Data treatment and “enhancement” procedures

Ceramic artefacts are here approached within the rubric that “fabric-plus-form-equals-type”. Inclusion of this rule is axiomatic. The weight accorded each element is equal, yet each may
be analytically independent. Only when both are understood can the equation be resolved (cf. Shepard 1971:316). The degree to which these elements can be defined and explained varies in accordance with the available data, and conclusions stemming from analysis of them are in accordance with the physical/sociological explanatory parameters discussed above. Adequate background knowledge is essential to the overall articulation of the model.

A different but related view of “type” is detailed by Gardin (1980:62-134). Gardin suggests that physical, geometrical and semiotic properties are intrinsic, while temporal, locational and functional properties are extrinsic attributes (1980:72). Gardin commences with a provisional definition of typology as “any classification of material remains used as the basis of inferences relating to facts that are not included in the initial representation of those materials” (Gardin 1980:63). Through a process of “a systematic matching of intrinsic properties with extrinsic attributes,” (op. cit.:76), typological classifications are achieved. According to Gardin, such typologies often incorporate both compilations, where the primary objective is to present previously unpublished materials, as well as explanations of these same materials. The boundaries between these two classes of archaeological constructions, however, are not always clear.

Here we are interested in presenting both compilations and explanations of the data. In terms of the intrinsic properties recognized by Gardin, the type concept employed here can be viewed as incorporating both geometrical and semiotic properties under the form element in the equation discussed above. The equation is in Gardin’s terms “intrinsic”, while explanations in terms of the typological results may include, either implicitly or explicitly, both “intrinsic” and “extrinsic” parameters.

Many variables are incorporated within the framework of each of the fabric/form elements. For each element, these can be divided into physical and non-physical. They are approached in terms of the theoretical/methodological dichotomy evident between the physical and social sciences. The asymmetry in explanatory force between these two sciences means that variables subject to physical laws are accorded primacy. This is not to suggest that physical variables will necessarily prove more useful than non-physical, but that in the absence of any single conclusive item of evidence this asymmetry is likely to prevail.

A broad range of ceramic variables, many unique to this study, are discussed below. These are not promoted as formal or standardised classification units, nor are they required to be in terms of the model discussed above, although many have been previously employed by others in this way.

Data enhancement is achieved in three separate ways. Firstly, the scale of the inquiry may be increased. By widening the geographic area under consideration, greater geological variability is favoured. This strategy, in a sense, creates geological variability. The number of archaeological sites can also be increased, with or without increasing the study area geographically. Such sites include either occupational and/or raw material sources. Similarly, the chronological scale or range of artefact types can be increased.

Second, the detail and scope of the inquiry can be increased. For example, in fabric studies, this could involve intensive and fine-grained analyses such as electron microscopy, scanning electron microscopy or nonplastic size/texture distribution assessments. These techniques are, of course, standard geological approaches. The first enhancement step, however, acts to increase the quantity of data requiring analysis. Because of this, methods often applied to smaller scale investigations become increasingly time-consuming with scale. Some will eventually prove excessive. Thus extended databases act to limit analytical intensity for practical
Thirdly, the number of variables may be increased. This is related to the weighting procedures discussed above.

3.6 Enhancement examples

Some problems may require enhanced analysis of all the variables. Given that the choice of variables is adequate, however, this is unlikely. A typical example of the need for enhancement would arise when a particular fabric was clearly different from the material representative of a local ceramic tradition, but similar and consistent mineralogically with the regional geological terrain within which the site is located. A distinctive form may often assist to clarify such problems. The artefact’s form, however, also proved to be equivocal.

One strategy could be to widen the scale of the inquiry and thus increase both the geological territory and the amount of comparative ceramic materials. If the fabric was mineralogically consistent with the expanded terrain, but still incompatible with the increased range of fabrics examined, two likely reasons appear possible:

(i) insufficient comparative material from within the geological study region had been examined.

(ii) the fabric was exotic.

As possible sources within the study zone are increasingly eliminated, the exotic status of the fabric is statistically enhanced. It would not be possible directly to identify the fabric as exotic to the immediate geological region. It would seem reasonable, however, in the absence of evidence to the contrary, to assume that it was not local. This position is admittedly tenuous because, statistics aside, there is no evidential reason to favour one source against another. If, however, similar enhancement treatments of the artefact’s form characteristics also indicated a non-local origin, then this additional evidence would further advance the probability that the artefact was exotic. It is argued that in such instances, sufficient prima facie deductive evidence exists to allow a valid conclusion in the absence of any negating data. Such explanations are valid because they have been subjected to “rigorous tests”, are non-circular, non-ad-hoc and independently testable. The subsequent discovery of any local source would falsify this conclusion.

In order to enhance the petrographic data derived from within the Sakon Nakhon Basin, the scale of the present study area has been broadened to include geologically differentiated regions. Some of these are a considerable distance from the primary site. Similarly, a comprehensive assemblage of Sakon Nakhon Basin material surface collected from 29 sites by Kijingam et al. (1980) has been examined in order to broaden the scale of comparative data.

Use of the eliminative deduction model is a response to a study area that, unlike the Rio Grande mentioned above, is generally petrographically homogeneous. It is not promoted as infallible. The model would benefit from being subjected to “severe tests” (Popper 1972:287). The principal objectives in constructing this model are to minimise the arbitrariness of classifications or “identifications” (Peacock 1981:187), a problem that concerned Shepard (1971:312), and to organise the data in an archaeologically meaningful manner.

3.7 Production and consumption

Central to prehistoric ceramic investigations involving technological analysis is the exploration of temporal changes in the potters’ craft, the illumination of possible cultural relationships

3.7. PRODUCTION AND CONSUMPTION

through material identifications, and the location of their sources, and the characterisation of ceramic cultures. Ceramic cultures, however, may be either consumers or producers. Production is restricted by access to raw materials and climatic factors (Arnold 1985). Producers may consume their own or other production, but consumers do not produce. Because several different modes of production (Van der Leeuw 1981, Peacock 1982), and consumption (Arnold 1985), are possible, many alternatives exist. The organisation of these processes, therefore, is central to the manner groups of ceramic communities are related. An understanding of the nature of such linkages is an important objective.

Ceramic cultures fall along a production/consumption continuum. Those cultures critically dependent on production lie at one, and those dependent on consumption the other, extreme. We may anticipate that most will lie somewhere in the middle, with ceramics forming a more-or-less important cultural component. In order to make sensible the distribution of prehistoric pottery, ceramic cultures first need to be characterised in these terms. The mere presence of pottery in archaeological contexts, however, does not, in itself, allow this. Characterisation of cultures as producers and/or consumers depends critically on the proportion of local versus exotic wares present archaeologically. This may be impossible to establish precisely. It is essential, however, that production sites are accurately identified as without this information many conclusions regarding the origins of prehistoric ceramics are without foundation. An important objective here is to provide an outline of the distribution of ceramic artefacts in order to demonstrate relationships between groups of communities.

Arnold (1985:9), considers Steward’s (1955), “cultural ecological” perspective as inadequate because, apart from resources, it seems to perceive the environment as unimportant in ceramic variability. Ceramic cultures are here, however, defined in two ways. Producers involve both environmentally affected “culture core” processes and “secondary” aspects. The latter need only apply in the case of consumers. Producers are involved ecologically on two discrete but interrelated levels. Firstly, production and distribution are affected by the environment. Secondly, cultural style, a secondary factor, is influenced by both material-related production methods and consumer demands. The function and/or fashion-related preferences of consumers will intimately reflect their various cultural styles. A vital first step in characterising the nature of any ceramic culture is to establish where the pottery was produced, how it changed hands and where it was used.

As Peacock (1982:165) observed, production sites are central to several important questions. They assist “chronological evaluation,” because an understanding of “origins can be vital, particularly if the same form is made in a number of places at different times”. In contrast, “production sites can produce evidence for the contemporaneity or sequence of different forms of common origin”. Most importantly, according to Peacock, they direct our understanding of the “mode of production”.

Peacock outlines a hierarchical framework of production modes increasing in complexity from simple sporadically-produced and self-consumed household production, to more complex income-orientated entities such as “workshops”, and “manufactories”. The major difference between these entities, technological questions aside, is effectively economic.

An understanding of the Ban Na Di ceramics, therefore, is a first step towards our assessment of its position, within a web of contemporary sites, as a ceramic culture. Evidence for production is set out in the following chapters. It is variously treated with the intention of bringing into focus the different methods and modes of production evident in the prehistoric sequence at Ban Na Di and related sites.
3.8 Discussion

Many petrographic analyses of prehistoric pottery have been undertaken prior to this study. Yet few American studies have been comparable to Shepard’s pioneer Pecos investigation (Fry 1981:147). In Western Europe, however, “the field is developing into a specialised and sophisticated branch of archaeology” with a “growing interest .... in the analysis of fabrics,” (Peacock 1981:187). Shepard’s Pecos study provides not only methodological but also historical interest. This is because, in a sense, two major corollaries of this important work have strongly influenced the present research.

In the first instance, the Rio Grande investigation provides an ideal set of methodological and theoretical variables for comparison with and testing against, and this has been discussed in part above. Secondly, the influence exerted and the fate suffered by Shepard’s seminal work is germane to both the history of ceramic research and the current state of the sub-discipline in Southeast Asia. A brief assessment of these earlier research developments will help bring into focus the theoretical background behind an apparent rejection of what seemed a research strategy of great promise.

Ceramic technological studies, after Shepard, were initially held to be “essential” yet “because of the wider horizons opened by” (them) “one can hardly draw conclusions at all” (Kidder 1936:xxiii-xxiv). Shepard’s results turned the regional Rio Grande chronology on its head. In retrospect, given the impact these findings had on contemporary archaeologists, a classical Kuhnian paradigm change would seem called for. Yet it did not occur. Perhaps the reasons for this lie at the heart of the subsequent turning away from such detailed technological research in North and MesoAmerica, and ultimately, Southeast Asia. In order to illuminate this problem, it is necessary to review post-Pecos developments in North American ceramic studies and their influence on the present study area.

Following the Pecos and Globe conferences mentioned above, a series of further meetings was held. Of particular concern was the need to establish a standardised set of taxonomic definitions and terms. Classification was seen as the first step in coping with a corpus of data that was accumulating at an alarming rate. Considerable effort was accorded the definition of the most comprehensive and detailed lists of pottery “attributes”. Little attention seems to have been paid to weighting attributes, although a comparative system which featured a formula comprising “principal diagnostic traits” capable of wide comparative applicability was proposed by Gillen (1938). Pottery forms were conceived as the result of the interplay between the human “mind”, hands and principles of physics. “Qualifying attributes follow (the) traits they refer to” (Gillen 1938:27).

Such approaches have been labelled as belonging to a “mentalism” paradigm (Arnold 1985:5-19). According to Arnold, this Boasian view of ceramics was still evident in American anthropology during the 1970’s. Boas initially argued that data collection should precede generalizations, but later abandoned this approach. “His concern for mentalism and the native’s point of view led to a relativistic approach in which the units of analysis were defined differently in each culture with no cross- cultural standards of comparison” (Arnold 1985:8). Linguistics provided a basic descriptive and analytical unit, phonemes, which influenced ceramic studies in four ways. Like phonemes, ceramic types became basic descriptive units, they had a “psychological reality” for both their creators and archaeologists, and since phonemes were composed of features, so did the ceramic type.

Both the “potter’s mental template” and the “archaeologist’s ceramic type” definitions originated in the 1920’s and 1930’s, “and these concepts are still important in American archaeology” (Arnold 1985:7). “Even more important .... was the impact that mentalism had on
the lack of generalization in archaeological research" Arnold (1985:8).

In outlining the midwestern taxonomic method McKern (1939) echoes Boas's data collection, classification and generalization concepts. Classification is a means of "discovering order", and "essential trait elements" are used to demarcate discrete cultural entities. Linked traits are shared by two cultures while unshared are diagnostic as cultural determinants (McKern 1939:305).

Others followed McKern's method, but found difficulty in determining and expressing the relationships between sites in the framework of "an arbitrary taxonomic system" (Griffin 1943:335). This problem is rationalized away in later studies, which, while still following the mentalist approach, view scientific method as "a set of probabilities which lead to conclusions that are our best guesses" (Phillips et al. 1951:219). A response perhaps to the "terrifying heap" of sherds available for analysis (Phillips et al. 1951:66). Ceramic types are conceived as stylistic entities whose surface finish and decoration are constants. They are also time space fossils of cultural relationships (Phillips et al. 1951:61).

In a key review of technological studies, Matson (1951:102-116) considers shape, decoration and "recently Anna Shepard's design analysis" as characterising the "traditional" as opposed to the technological approach. Matson argues that itinerant potters, a major problem, and/or the importation of raw clays for mixing with local clays, seriously complicates physical analysis. Consequently, subtle differences in shape and decoration may constitute the primary means of import recognition. Chemical analysis, while acceptable for glazes and glasses, is a "complete waste of time" for pottery due to its heterogeneity (Matson 1951:110). Petrographic microscopy, valuable for the recognition of temper, natural inclusions and paste texture, was considered by Matson to have only limited value in differentiating between local and imported pottery. Such studies as Shepard's (1942) "classical work" are described as time-consuming, expensive, and reflecting inadequate sherd sampling. In any case, few microscopists are available and other techniques can produce results "archaeologically satisfying" (Matson 1951:111). Matson recommends examination of clean breaks by binocular microscope at 6x to 20x magnifications. This requires no special training and is indispensable for evaluating fabric texture, temper types and for firing assessments. Ethnographic evidence assists in solving firing and chemically related post-depositional problems, according to Matson, who considers the role of the potter in the community and the function of ceramics as the most important aspect of ceramic analysis.

Shepard's (1953:273-275) response is to view these criticisms of the technological method as stemming from differences between Matson's Near Eastern material and that studied by American researchers. Had Matson mainly considered American material, Shepard responded, he would not have accorded the differentiation of local and imported pottery a secondary place. Furthermore, Shepard argues, the complexities inherent in ceramics require the use of precise methods, particularly for temper identifications and firing assessments, and these should commence with petrographic data. It is important to note that, in essence, Shepard defends the method by implying that the Pecos material demanded such an approach. Thus the method had specific not general application.

An enthusiastic promotion of Matsonian "archaeologically satisfying" non-specialist techniques is implicit in many subsequent American ceramic studies. A "type-variety" concept (Wheat et al. 1958; Phillips 1958; Smith et al. 1960; Phillips 1970; Toth 1974), first applied to Mayan ceramics de-emphasized fabric analysis in favour of stylistic features. Clusters of similar types were held to reflect ceramic systems which in turn reflected cultural images.
Type clusters were related in design style or surface treatment, vessel form and “general technology”, conceived as “a class of pottery” (Wheat et al. 1958:40). Ceramic specialists are apparently now considered unnecessary because a “Fundamental requirement of taxonomic procedure is to make the analyst’s own observations useful and available to others...” (Wheat et al. 1958:42). Smith et al. (1960:332) see the type-variety system as a “first step” towards an essential standardisation of pottery analysis.

In these studies, Shepard’s Pecos research is either ignored or dismissed in passing with a wave of the hand. Spaulding (1960:60-81) outlined a statistical framework for type definition and characterisation but noted a major problem was the “proper weighting of attribute combinations” (op.cit.:81). Extensive site survey programmes produced huge pottery collections which took several years to sort and collate. Hence publications were often considerably delayed. The entire process was both labour intensive and expensive. Collation often revealed the existence of previously unsuspected new “types”. In some cases, had all the classes identified in the sample been known at the outset, a different strategy would have been applied (Phillips et. al 1951:66). In short, much of the cataloguing proceeded inductively and often simply involved the recording of data in an entirely accumulative manner. This “library of sherds” syndrome appears to have been aimed at the collection and collation of as many pottery “types” as possible in an archaeological terra incognita. Hill and Evans (1972) give a summary of typological approaches.

Definition of a key entity capable of providing data amenable to statistical analysis and the characterisation of the broadest possible range of culturally definable entities was energetically sought. Several researchers attempted to promote the concept of an artefact type as providing the answer to an unified theory of cultural characterisation and structure.

3.9 Summary

The theoretical approach to be employed involves the use of an eliminative deduction model. This is partly a response to the analysis of sites located in a relatively homogeneous geological region. Standard analytical techniques will be used where possible. When these methods prove inadequate, the data will be enhanced in various ways. Negative evidence is considered useful in suggesting likely source areas in the absence of contrary information. This is because it helps narrow the area of inquiry by sieving out irrelevant sources. Its importance increases with each application of the model.

Modes of production, distribution and consumption are key elements in determining the character of ceramic cultures. Evidence for ceramic production at Ban Na Di and related sites is set out below. A definition of the pottery “type”, which gives equal emphasis to the fabric and form is employed. This differs from definitions previously used in the area by form or style analysts. Where relevant, physical evidence is given primacy over non-physical. Production site identification is considered a key determinant in the characterisation of ceramic cultures.
Chapter 4

The study area and potting clays

4.1 Introduction

Ceramic industries employing simple manufacturing techniques of the kinds extant in Northeast Thailand today, and postulated as extending back into the prehistoric periods under question here, are closely affected by their environment. Raw materials are distributed according to geological processes (Shepard 1956), and their acquisition involves a detailed knowledge of the areal terrain. Potting clay distributions and climatic conditions can constrain clay extraction and pottery manufacture (Arnold 1985). The availability of quality materials can determine the location of production centres (Shepard 1956, Arnold 1985), and weather conditions may restrict potting to favourable climatic zones and seasons (Arnold 1985). In this chapter we will briefly examine the geography, geomorphology and climate of Northeast Thailand. The geology of the Khorat Plateau, and its implications for pottery production, will also be touched on. Finally, the clay mineralogy of 14 Sakon Nakhon Basin potting clays will be considered in detail.

4.2 Geography, geomorphology and climate

The following geomorphological outline is derived mainly from Crujjs (1964, 1978), Moorman et al. (1964), and Thiramongkol and Pisutha-Arnon (1983).

Ban Na Di is situated in the Sakon Nakhon Basin, the smaller of two located within Thailand’s northeastern Khorat Plateau (fig. 4.1). The Khorat Plateau comprises an area of about 170,000 km², and is bounded to the north and much of the east by the Mekong River. Its western, southern and southeastern natural boundaries are formed by steep escarpments of uplifted Mesozoic strata. These vary in elevation from about 250 m to 900 m above sea level (m.a.s.l.). Bordering the western plateau perimeter are combinations of sedimentary, igneous and metamorphic formations which together comprise the Central Highlands. In places these combinations are complex. This includes the 1,300 m high Phu Kradung “mesa-like outlier” (Crujjs 1978).

The plateau’s two basins have surface elevations ranging from about 100 to 300 m a.s.l. Their principal landscape features are the river terraces located in plane to gently undulating surfaces, while mounds and hills are common microreliefs (Crujjs 1978, Moorman et al. 1964). The plateau is located between 14° to 19° north, and 101° to 106° east. It gently slopes down towards the east and southeast. Stream patterns are directed principally to the east, and the major Khorat Basin is entirely drained eastwards into the Mekong River by the Mun and
Chi Rivers and their numerous tributaries. Both these rivers originate in the western hilly zones of the Central Highlands. The smaller northern Sakon Nakhon Basin is principally drained by the Songkhram and its tributaries northeastwards into the Mekong. The Songkhram originates in the Phu Phan Range. Ban Na Di falls within the Lake Kumphawapi catchment, and adjacent streams drain south into the lake which in turn discharges into the Pao River. The Pao flows south through the Phu Phan Range to join the Chi River (figs. 4.2 and 4.3).

Moorman (et al. 1964), interpreted the Northeastern (i.e. Khorat Plateau), landforms as largely alluvial in origin, the result of a series of depositional and erosional events. They argue that the plateau’s geomorphological features “are predominantly determined by tremendous alluvial deposits of the Mekong River and its tributaries” (Moorman et al. 1964:4), several such sedimentation phases being separated by erosional periods to form four main sedimentation levels (high, middle and low alluvial terraces, and the present day alluvial plain), of the existing landscape.

This widely accepted “terrace model” has recently been questioned by Loeffler (et al. 1983:123-130), who argue for essentially erosional Northeast uplands and slopes with the larger valleys representing filled-in valleys. Sedimentation “was more or less continuous following a period of pronounced incision”,”due to a rise in base level near the Mun River-Mekong River confluence”. Changing environmental conditions are held to be reflected in the character of the sediments with glacial period aeolian material “masking much of the erosional landscape with a blanket of sand”. The glacial period coincided with pronounced dryness in the Northeast due to the “greatly extended land area” during climatically induced low sea levels. “Climatic change however was not the controlling mechanism for incision or sedimentation. This was controlled by changes in base level which in turn were controlled by tectonic events” (Loeffler et al. 1983:130).

Thailand lies in the monsoon (Koppen Aw) tropical zone of Southeast Asia (Strahler 1973). Extremes in wet-dry seasons typify this zone with intermittent heavy rainfalls normally producing extensive seasonal riverplain flooding. Local annual rainfalls are affected by, and vary in accordance with, topography. Wet-season rains and resultant heavy leaching promote laterisation (Press and Siever 1974:211-212). According to Hope and Hope (1976), New Guinea montane evidence suggests that, for the last 5,000 years, the climate has been relatively stable. Sea level stability also reflects these conditions (Galloway and Loeffler 1972, Chappell and Thom 1977). These data are supported by recent Thailand montane evidence which suggests that the climate has been wet and warm for about the last 11,000 years, and that the present conditions have been experienced for at least the last 4,300 years (Hastings and Liengsakul 1983).

Arnold (1985:66-79) reports that in climates subjected to substantial rainy seasons, and consequent high humidity, ceramic industries are seriously affected. Because of excess atmospheric moisture, and/or long periods of heavy rainfall, plastic pottery fabrics often cannot be dried enough to ensure they will hold their shape. These conditions may also cause unfired pottery to crack. Firing under these conditions is hazardous, and in addition moving unfired pottery risks damage. In such conditions manufacture is not warranted and production ceases in the wet season. This regulatory effect can have important implications for the integration of subsistence and technology.
4.3 The geological setting and its implications

In this section, in addition to the sources quoted above, geological maps published by the Royal Thai Survey Department (1978, 1980, 1982, 1984), the Geological Survey Division of the Department of Mineral Resources ((DMR): 1971, 1974, 1976, 1980, 1984), and the Federal Institute for Geosciences and Natural Resources (1975, 1976, 1977, 1978, 1979, 1981), have also been considered. To date, detailed 1:250,000 scale maps covering the study area are unavailable, although they are currently in preparation (Cruis 1978:4). Such maps are available for the western plateau margins (NE 47-12, NE 47-16, ND 47-4), Mun Valley, and Central Highlands. They have all been considered, because these areas include strata relevant to the present work.

In stark contrast to the Rio Grande, Shepard’s study area, the lowlands of the Khorat Plateau are blanketed almost entirely by Quaternary sediments (Cruis 1978, and fig. 4.4). These are underlain by very thick Mesozoic sedimentary deposits of the Khorat Group (Cruis 1978). The two structural basins are without large exposures of Mesozoic bedrock. Outcrops of these rocks are usually lacking, apart from a few small and scattered outcrops of strata belonging to the Upper Khorat Group, within the plateau. The Sakon Nakhon and Khorat Basins are composed of basement Mesozoic sedimentary rocks extensively overlain by alluvium and colluvium sediments and mantles of sand of aeolian origin (Cruis 1978, Loffler et al. 1983).

Igneous rocks are absent except for Tertiary and/or Quaternary basalts which occur in the Mun River basin mainly near the southern edge of the plateau. Some high terrace gravels contain, principally Palaeozoic, remnant igneous rocks in various proportions. All are resistant or very resistant, and are thought to represent fluvial deposition from remote Central Highland sources (Cruis 1978:28).

The Phu Phan Range, which separates the Sakon Nakhon and Khorat Basins, consists of folded Mesozoic rocks of the Khorat Group (Cruis 1978). The Khorat Group contains a series of six sedimentary formations. A 1:1,000,000 scale generalized DMR map (Javanaphet 1969), shows the Phu Phan Range as comprising the Phu Phan, Phra Wihan and Phu Kradung Formations. According to Cruis (1978:35-37), the Phu Phan Range is comprised principally of the Phra Wihan, Sao Khua and Phu Phan Formations. The Khok Kruat Formation only occurs in large synclines at lower elevations, and the Upper Triassic-Lower Jurassic Phu Kradung Formation may also be present. The Mahasarakham (or Salt) Formation, which is the highest Mesozoic stratigraphic unit, has been totally removed from outcrops. The Royal Thai Survey Department (1980), in a 1:2,500,000 scale geological atlas of Thailand, show the Upper Khorat Group underlying both major basins, with Middle and Lower Khorat Groups comprising the Phu Phan Range.

Chongpan and Nares (1979), note the following associations, in descending order, for Khorat Group Formations in Changwat Petchabun (map NE 47-16). This area lies about 120 km west-south-west of Ban Na Di. The Khok Kruat contains micaceous sandstone, shale and siltstone, lime-nodule and conglomerate. The Phu Phan is comprised of a sandstone containing pebbles consisting of quartz, chert, siltstone and igneous rocks up to 5 cm in diameter intercalated with shale and conglomerate. The Sao Khua consists of micaceous sandstone and shale, and lime-nodule conglomerate. The Phra Wihan contains an orthoquartzitic sandstone with some intercalations of shale. The Phu Kradung consists of micaceous shale, siltstone and sandstone, with some lime-nodule conglomerate.

According to Cruis (1978:13), the above geomorphological and geological evidence is based on drillings, exposed outcrops and satellite remote sensing studies. He notes that the Phu Phan sandstone caps numerous mesa-like hills around the rim of the Khorat Plateau and
eroded anticlines in the Phu Phan hills. It contains resistant layers of arkosic and conglomeratic sandstones and conglomerate. These formations also outcrop along the western and southwestern margins of the plateau (Crujs 1978:14).

As the above geomorphology suggests, the Khorat Plateau was uplifted, tilted principally towards the southeast, and only slightly warped into a huge shallow basin. Apart from the Phu Phan anticlines, little deformation is apparent. According to Crujs (1978:10), Cenozoic epeirogenic movements were mainly responsible for the present plateau structure. Folding, faulting and volcanism associated with a Late Tertiary-Early Quaternary orogeny saw the replacement of igneous intrusives along the western plateau margins, and in isolated locations within the southern plateau boundaries (Crujs 1978:18,33-34).

Extensive salt deposits occur within the Mesozoic formations, although their precise distributions and/or origins are not fully understood (Crujs 1978:39-45). Outcrops of the Mahasarakham Formation, comprising mainly “siltstone, sandy shale, mudstone, evaporites (rock salt/halite, gypsum-anhydrite and potassium minerals) and minor sandstone”, are “sparse and small” (Crujs 1978:15). It is thought to form the major portion of the bedrocks of both basins. “No outcrops of solid, primary sedimentary or structural controlled salt deposits appear to exist, because, according to Gardner et al. (1967), they have been dissolved everywhere to depths of as much as 61 to 76 metres or more by deep leaching facilitated by heavy seasonal rainfall and fluctuating groundwater level that characterises the region” (Crujs 1978:39).

Geological maps and cross sections published by the Royal Thai Survey Department and the DMR (1969, 1976), show the Khorat Group as the basement structure underlying the entire Khorat Plateau. Various Khorat Group formations are shown outcropping so as to almost encircle the Khorat Basin. Minor local outcrops also occur in the northern portion of the Sakon Nakhon Basin. The overall geological structure features little displacement of the Mesozoic strata and this is typical of epeirogenic processes. It may have important implications for pre- and post-epeirogenic sedimentary deposits now present as residuum. Unfortunately, the clastic sediments of the Khorat Group have not been subjected to a detailed and systematic sedimentological study (Crujs 1978).

As noted above, detailed small scale geological maps are not yet available for much of the study area, including Ban Na Di and many related Sakon Nakhon Basin sites. Loffler et al. (1983), on the basis of 35 m deep drillings at Tung Kula Ronghai (TKR), argue for tectonic-derived pronounced incision and sedimentation, on which was superimposed climatic related sedimentation. They consider that these processes are relevant to the whole plateau. Their cores revealed a present land surface of 2-4 m thick clay to sandy silty clay, overlying fine to coarse non-organic sands which vary widely in depth but rarely exceed 8 m. Beneath this is an organically rich sand unit 10-20 m thick, C14 dated to c. 34,000 to c. 20,000 years ago. The oldest sediments were cut at 30-35 m deep, and consist of non-organic very fine to medium sands.

Hastings and Liensakul (1983:26) consider that the TKR organic sands represent a late Pleistocene deposition. It is unclear whether the TKR sediments relate to the Sakon Nakhon Basin clays. Detailed mineralogical descriptions are not given by Loffler et al. (1983). The youngest clay deposition forms a cap overlying an alluvial substratum. It is thus consistent with transported clay. There is no evidence to suggest that it results from modern sedimentation. The potting clays discussed below were quarried 1-2 m below the present land surface at most sites (fig. 4.5). They are considered to have been deposited prior to the first occupation of Ban Na Di c. 3,500 years ago.
Discussion

In a sense the Khorat Plateau represents a textbook example of geological processes where tectonism has transformed a large subcontinental Mesozoic limnic and paral sedimentary basin into a post-Mesozoic terrestrial structure (Crujs 1978). Recent data suggests tectonic activity continued during the Quaternary. In addition, climate induced environmental changes, which featured alternating drier and more humid phases, were superimposed onto these latter tectonic events. These are reflected in the present stratigraphic sediment variations (Loffler et al. 1983).

Tectonism, erosion, sedimentation and climatic fluctuations have together produced a geologically homogeneous and therefore discrete region. Clays within the plateau will reflect this homogeneity to varying degrees, dependant upon the nature of the local geology. Thus pottery made of clays derived from sources exotic to such homogeneous areas are likely to stand out because the geology is more mineralogically distinctive. Hence ceramics originating in the Phu Phan Hills, the western margins, southern igneous zone, and the Central Highlands, can be expected to be, mineralogically, clearly distinctive.

Gradational changes in the overall mineralogy should be apparent downstream from the source rock outcrops. Due to the mainly west to east internal drainage patterns, increasing quantities of distinctive inclusions should become evident the further west towards the Central Highlands the clays are quarried. Within the Sakon Nakhon Basin, sources close to the Phu Phan Range are similarly likely to prove distinctive. These distinctive mineral assemblages are unlikely to be obvious except in clays relatively close to parent rock outcrops because of rapid weathering.

Thus this huge plateau is composed almost entirely of sedimentary strata, and as the data set out below demonstrate, the associated potting clays often contain common mineral suites which are undiagnostic for sourcing purposes without intensive analysis. Several potentially rewarding methods are available to cope with such circumstances. Similar sourcing questions have been resolved using textural (Peacock 1971, Streten 1982), or heavy mineral analysis (Peacock 1967, 1970, 1973; Williams 1977). Heavy mineral analysis probably holds the best potential for the characterisation of pottery and clays not already distinguishable using standard thin-section petrography. This approach was not undertaken because the method is excessively laborious without necessarily providing clear conclusions, particularly where two differently sourced clays have been combined (Williams and Jenkins 1976). In view of the extensive scope of the present enquiry, quantitative applications of such intensive methods were considered impracticable.

The above discussion is not meant to imply that distinctive sedimentary deposits are non-existent within the Khorat Plateau. The results of a petrographic analysis of various modern Sakon Nakhon Basin potting clays, set out in chapter five, show that several are distinguishable petrographically. The X-ray diffraction data presented below complements optical evidence discussed in the following chapter. These source materials were obtained during fieldwork undertaken by the author.

4.4 Analysis of Sakon Nakhon Basin potting clays

Introduction

A total of 14 clays have been examined using standard X-ray diffraction methods. As the spectrographs set out in figures 4.10 to 4.11 show, they contain a variety of clay mineral species
in varying proportions and combinations. Several include clay minerals that hydrate excessively. Smectites, for example, are present in clays 2, 4, 10, 12 and 14. While this is only one factor in their usefulness, it suggests that overall these raw clays are therefore of varying quality as potting clays. Samples 8, 11, 13 and 14 derive from locations that were unable to be unequivocally verified as genuine sources in the field, because the original precise quarry locations were uncertain. This was due in some cases to their long term abandonment. However they have been included because they were identified by local informants as having once been exploited by potters, and all possible sources were considered as potentially crucial to the study.

Discussion

Generally potting clays containing a high proportion of kaolinite $\text{Al}_2\text{O}_3.2\text{SiO}_2.2\text{H}_2\text{O}$ are preferred by potters. This reflects both its contribution to a potting clay’s “workability”, and its strength on firing due to the chemical change promoted via the dehydration of the aluminium silicate compound to form a metakaolinite or ceramic fabric. Rigby (1948:96) describes kaolinite as the “primary constituent of china clay and fireclays”. Hamer and Hamer (1977:3-4), from a potter’s perspective, consider kaolinite as a pure clay. Disordered kaolinite, although less pure, also qualifies as a clay. According to Hamer and Hamer, however, any other mineral, mica and montmorillonite for example, does not. This concept, apparently common among potters, and until recently among many geologists (Grim 1968:14), is not accepted by clay mineralogists who have clearly established “that there are many clay materials in which there is no kaolinite present” (Grim 1968:15). While universal agreement has yet to be reached on a precise detailed classification, the basic major clay mineral groups, although some contain complex individual species and relationships, are well understood and generally accepted (Grim 1968:34, Folk 1980:89-94, Williams et al. 1982:317-324, Lewis 1984:151-157).

Kerr (1977:454), tabulates clay minerals into four groups, kaolins (kandites), including kaolinite, anauaxite, dickite, nacrite, halloysite, hydrohalloysite, and allophane, montmorillonites (smectites), including montmorillonite, beidellite, nontronite, saponite, and hectorite, illite (hydromuscovite), and palygorskites, including palygorskite, attapulgite and sepiolite, as distinct clay mineral groups. Many modern researchers include dickite and nacrite (both rare) with kaolinite (Grim 1968:38, McConchie 1978). Grim (1968:38), argues “that halloysite is distinct from kaolinite and warrants a separate specific name”. Many authors, however, (Mason 1966, Folk 1980, Tucker 1981, Williams et al. 1982, Lewis 1984), include halloysite with kaolinite. Williams et al. (1982:317-320), recognize illites, smectites, kaolinites, chlorite, gibbsite, and halloysite. An alternative classification identifies kandites (kaolinite, dickite, nacrite and halloysite), illites (illite, and the so-called hydromicas including sercite), smectites (montmorillonites), vermiculites and palygorskite. Chlorite is not included in this system (Deer, Howie and Zussman 1966:253-254). Montmorillonite is now tended to be recognized as a member of the smectite group.

The important factors for ceramic purposes are crystallinity, manner and perfection of the stacking of layers, and the number and type of chemically bound layers present in any given clay mineral. This latter factor in particular is directly related to the amount of water the clay will adsorb (Grim 1968:234-235), and crucially affects its suitability for ceramics. A schematic summary of the principle clay mineral structures is set out in figure 4.6 below.

Kaolinite has a dioctahedral structure comprising one silica tetrahedral sheet and one alumina octahedral sheet combined to form a common layer (Grim 1968:58 Fig. 4-4). These layers form sheets stacked vertically along the C crystallographic axis (Deer et al. 1966:256,
4.4. ANALYSIS OF SAKON NAKHON BASIN POTTING CLAYS

Fig. 87). Kaolinite normally is well crystalline and subject to little substitution. Within-layer sharing of atoms results in relatively few hydroxyls in comparison to other clay minerals. The layers are bound by hydrogen- or hydroxyl-type bonds (Deer et al. 1966:256, Fig. 88). The OH lattice water is lost beginning at temperatures above about 300° C with most of the dehydration occurring between about 400° and 525° C, and at about 750° to 800° dehydration is essentially complete (Grim 1968:298). The resultant loss of oxygen atoms in metakaolin almost certainly reflects a tetrahedral aluminium coordination, and it is this new structure which gives rise to the strength of metakaolin (Grim 1968:298-301). Adsorbed water (i.e. in pores, on surfaces and edges of mineral particles), is lost at little above ordinary room temperatures. For clay minerals other than well crystalline kaolinite adsorbed water is normally driven off at temperatures well below 300° C. Pore water is usually lost at 120° to 150° C. Air drying is sufficient to remove the balance of adsorbed water.

Disordered kaolinite is normally poorly crystalline with imperfections in the stacking of layers. Grim (1968:66), suggests gradations from well crystallized kaolinite to complete randomness in layer organization and populations of aluminium positions for disordered kaolinite. Substitutions, usually of titanium or iron for aluminium, only occur in poorly crystalline (i.e. disordered) kaolinite. According to Hamer (1975:100) such clay minerals form the fine and plastic portion of the so-called secondary clays (e.g. ball clays, stoneware clays and low grade fire clays).

In the case of smectites, vermiculites and the hydrated form of halloysite, the interlayer water requires temperatures of up to 400° C for complete removal. Smectites have either a dioctahedral or trioctahedral structure comprising Si-Al-Si units with the O layers of each unit adjacent to O layers of neighbouring unit (Grim 1968:79, Fig. 4-13). This results in a very weak bond. Water can readily enter between the unit layers causing the lattice to expand substantially. Dehydration of interlayer water is rapid upon heating and is probably complete at about 300° celsius. This is accompanied by a marked reduction in C axis dimensions. Rates for the loss of OH lattice water vary widely for smectites. However normal montmorillonites lose OH water rapidly from about 500° C, and dehydration is practically complete at 800° C (Grim 1968:314-315).

Smectites, illites and vermiculites are all structurally related to the micas, with illites showing the closest similarity. Micas have the same basic structure as "montmorillonite except that some of the silicones are always replaced by aluminums" (Grim 1968:93-98). The resultant charge deficiency is balanced by potassium ions located between unit layers. As a consequence micas generally contain little interlayer water. In illites this substitution occurs close to the layer surface thus preventing the ready entry of polar ions. Illites differ from the well-crystallized micas in their Al for Si substitution ratios and this gives rise to a charge deficiency reduction. Some potassium ions between unit layers may be replaced by other cations. Stacking of layers in the C direction is somewhat random and illites have smaller particles than micas. Illites lose adsorbed water rapidly below 100° C, gradually between 100° and 350° C, a large relatively abrupt loss occurs from about 350° C to 600° C, and above 600° C water is gradually lost (Grim 1968:334). The OH lattice water is gradually lost from 300° to 600° C (Grim 1968:334-335).

Smectites may contain randomly mixed cells and this results in a variety of water contents with basal spacings ranging from between about 10 to 21 Å (Deer et al. 1966:265). Hence they are often referred to as swelling clays.

Sericite is characterised principally as a degraded mica, or alternatively as a true clay mineral. Folk (1980:90), describes it as a clay mineral that is "probably just fine-grained...
slightly impure or K-deficient muscovite”. Grim (1968:42), however, objects to the definition of sericite as a clay mineral and prefers illite “for clay-mineral micas of both dioctahedral and trioctahedral types and of muscovite and biotite crystallizations”. Others, (Kerr 1977:430, 433, 461, Heinrich 1965:28, 281), consider sericite is either a hydrothermal secondary mineral or a weathered mica. Deer et al. (1966:202, 261), note that the term is “generally used to describe a fine-grained white mica which may be muscovite or paragonite”. Lewis (1984:151), argues that “illite (hydromuscovite) grades into sericite”. From a purely petrographic viewpoint, however, Williams et al. (1982), avoid the term entirely preferring to describe such material as “fined-grained muscovite” or “white mica”. In light of these variations in definition and terminology, Grim’s characterization of illite, because it refers to the chemical structure of the mineral, will be applied to chemical and X-ray clay mineral data included here. The term sericite will be used for fine-grained, optically identifiable, muscovite.

Vermiculites are often associated with muscas in mixed-layer structures. The vermiculite structure consists of an alternation of either dioctahedral or trioctahedral mica or talc-like layers and double water layers. It is similar to the smectites in that it has an expanding structure but differs in that its expansion with water is limited to about 4.98 Å (Grim 1968:104-111). Vermiculite dehydrates in steps from a normal C-axis dimension of 14.36 Å down to 9.02 Å as the interlayer water is gradually lost and the silicate stacking sequence changes (Grim 1968:108-110). When heated rapidly to about 300°C, vermiculite exfoliates with a marked expansion. If it is heated slowly up to about 250°C, however, exfoliation does not occur (Deer et al. 1966:272).

Chlorite consists of alternate trioctahedral mica-like and brucite-like layers (Grim 1968:100). Dependent on the cation present, chlorites show very little water loss prior to about 500°C, although this may vary dependent on particle size and layer orientation. After a sharp loss between 500°C to 550°C most chlorites completely dehydrate at about 850°C. A mineral with a 14 Å spacing, which expands slightly on glycolation to about 16 Å to 18 Å, has been described as a “swelling chlorite”. Such minerals probably have discontinuous brucite layers insufficient to prevent expansion on glycolation (Grim 1968:103-104). Septechlorites are closely related to chlorites chemically but structurally have serpentine-like layers with a 7 angstrom basal spacing (Deer et al. 1966:241, Lewis 1984:152).

Palygorskite, attapulgite and sepiolite have an amphibole-like double chain structure. They are not important ceramic clay minerals.

Kaolinite alone, however, does not ensure a quality potting clay because the potter also requires the clay to be “workable”. This means it must be strong, plastic and thixotropic. Hamer (1975:295), describes this latter property as the ability of clay to retain its shape while remaining viscous and thus easily worked. Grim (1968:236-238), also ascribes this property to thixotropy, although geologists may consider the term to refer to the property of some gels to become fluid when shaken (American Geological Institute 1976).

Plasticity is the property of moistened clay to be reformed when subjected to mechanical pressure, with the new form retaining its shape when the pressure is removed. This property is developed by clays mixed with a limited amount of water until readily workable. Excessive water creates a clay which is too fluid. Plasticity is primarily due to the adsorption of water by clay minerals. In potting clays it is also dependent on several other factors including the relative proportions of nonplastic and other non clay inclusions in addition to the overall clay-mineral composition. Particle size, uniformity, texture and shape influence plasticity in both clay minerals and colloidal nonplastic.
Clay-mineral composition “refers to the identity and relative abundance of all the clay-mineral components” (Grim 1968:4). It is crucial to the overall composition of the potting clay material. A quality potting clay, therefore, must include either a mixture of clay minerals or, as in the case of the lower fired wares such as biscuit and/or stoneware, a mixture of clay mineral(s) and nonplastic material. This latter component may form from 25 to 50% of the total mix.

Many commercial clay materials contain kaolinite and illite in about equal amounts, often with small additional amounts of chlorite. Montmorillonite is acceptable only in small quantities as large amounts cause catastrophic shrinkage and drying problems. Overall these clays generally display relatively low shrinkage, good plasticity and firing properties (Grim 1962:131).

### 4.4.1 Methods

In the field, spot samples of small representative areas of potting clay, weighing about 1 kg, were taken. In the laboratory, dry samples each weighing about 50 grams were immersed in 400 ml of distilled water for about 30 minutes until fully flocculated. They were then thoroughly stirred and allowed to settle for 90 seconds when the upper half of the column was decanted into another beaker. This fine fraction was allowed to settle for a further 24 hours when the excess water was decanted and the residual $< 2 \mu$ fraction was gently poured onto a glass slide and allowed to dry for at least 24 hours. The resultant dried samples were then examined in the X-Ray diffractometer employing a Cu Kα radiation at 50 KV and 20 MA.

Where initial counting produced relatively weak clay mineral peak distributions the counts per second were reduced in order to give a more well defined spectrograph. Several gave diffraction intensities of a 14 Å crystal lattice consistent with either chlorite or smectite. In these cases the samples were left in an ethylene glycol atmosphere overnight (for 16 hours), and then re-examined in the diffractometer.

A variety of preparation methods were considered prior to settling on the method outlined above. Gibbs (1971) recommends either the “smear-on-glass slide technique” or the “suction-on-ceramic tile technique”. He regards using a pipette or dropper, pouring from a beaker, the centrifuge on glass slide, as well as the centrifuge through ceramic-tile techniques as “generally unacceptable” for mounting sample material because of segregation error (Gibbs 1971:535).

Comparative tests, using three separate slides of clay 2, were undertaken to assess if any variation in the spectrograph resulted from the preparation method. This could give different proportions of coarse particles on each slide. No significant variation was evident. Care must be taken when pouring the $< 2 \mu$ fraction onto the glass slide, however, as suspensions which are too aqueous will result in a “lean” coating (i.e. lacking in sufficient solid particles for a homogeneous coating). Such heterogeneous preparations may give weak spectral peaks which could be mistaken for poorly crystalline clay minerals.

As $5 \mu$ particles fall 1 mm in about 30 seconds and $2 \mu$ about 1 mm in 4.8 minutes (Gibbs 1971:534), the decanting used is considered satisfactory. Although particles $> 2 \mu$ will probably be included in the initial decant, the second 24 hour settling period means that the $< 2 \mu$ fraction will settle last. Only the upper portion of the second preparation is used, thus a homogeneous $< 2 \mu$ coating should result.

This study is primarily concerned with the characterisation of the overall spectrum in terms of both the presence and relative proportions of clay minerals. For ceramic purposes the clay mineral composition of clay materials is of crucial importance. Thus, because these determinations were undertaken in order to assess the quality of the clay material as a potting clay, and
to complement petrographic data, the quantitative amount of individual clay species with respect to the overall sample has not been assessed. Results of the tests outlined above indicated that the pour-on-glass-slide method was suitable. Indeed Dr. A. Reay (pers. comm.), favours this method because of its simplicity and minimal experimental error.

4.4.2 Results

XRD results are set out in figures 4.8 to 4.21, and should be compared with the shrinkage tests (Table 4.2), and petrographic data set out in chapter five. A consideration of the XRD results is set out below. Samples 8, 13, and 14 were identified by non-potters as having once been quarried by potters. Because many clays potentially suitable for potting purposes occur in small localized deposits, and most require modification, it is likely that these clay materials require the addition of suitable clay minerals if they are to become viable potting materials. Thus these results highlight the need to ensure, where possible, that verified production clays are collected for analysis.

Each sample contains more than one clay mineral specie, and hence they are mixed-layer clay materials (Grim 1968:121). These are different to mixed-layer clay mineral structures which result from the interstratification of individual layers of single, or a few, alumino-silicate sheets. Mixed layer clay materials are those where, within any given naturally occurring clay material deposit, the mixture is of discrete clay-mineral particles which are not orientated in any geometrically preferred manner with respect to their clay-mineral neighbours. A deposit which contains kaolinite and smectite, for example, is a mixed-layer clay material. Mica-vermiculite and mica-montmorillonite interstratifications are common examples of mixed-layer clay minerals (Carroll 1970:38).

Where the reflections at about 14 Å have shifted following glycolation to about 17 Å the clay mineral is considered to be a smectite (Grim 1968:143). Some samples probably also contain mixed-layer clay minerals. While it is not possible to be certain, it is likely that the stable 14 Å peaks are consistent with chlorite. Grim (1968:147) notes that because of their small size, and less regular crystallinity, chlorite clay-mineral particles often give diffuse reflections, and some ordinary reflections may be absent. Chlorite is unlikely to affect the suitability of these clay materials for ceramic purposes. It should be noted that these potting clays can be divided into those which contain "swelling" clay minerals and those which do not.

In samples 1, 5, 6, 7, 8, 9, 11, and 13, no shift in the 14 Å peaks occurred, although samples 6, 7, 9, 11, and 13 display a slight decrease in spectrum height particularly at the low incident beam angles. This is probably due to the ethylene glycol producing a coating effect which has muted these signals slightly.

The spectrographs are set out below. In each case the chart speed was 20 mm per minute. The location of each clay source is set out in figure 4.7.
FIGURE 4.1: GENERAL MAP OF THE KHORAT PLATEAU.
FIGURE 4.2: THE KUMPHAWAPI STUDY AREA.
FIGURE 4.3: THE KHORAT PLATEAU.


B: Regolith formation (undifferentiated): various alluvial and colluvial sediments, colluviated residuum, alluvial middle terraces, and (dissected) erosion surfaces. Holocene and Pleistocene.

C: Basalts. Volcano remnants (cones etc.), dikes and flows. Holocene and Pleistocene.

D: Alluvial high terraces. Middle Pleistocene high terraces (containing tektites) and Plio-Pleistocene non-reworked terraces. Middle Pleistocene and Plio-Pleistocene.

E: Khorat Group, evaporite/molasse bedrock sequence comprising in descending order: Upper Cretaceous Mahasarakham Formation, Middle-Lower Cretaceous Khok Kruat Formation, Upper-Middle Jurassic Phu Phan Formation and Lower Jurassic -Upper Triassic Phu Kradung Formation.

F: Possible (non-exposed) salt dome or plug.
FIGURE 4.5: QUARRYING CLAY AT NONG I LAENG (clay site 12).
FIGURE 4.6: SCHEMATIC SUMMARY OF THE PRINCIPLE CLAY MINERAL STRUCTURES (after Tucker 1981:82.).
FIGURE 4.7: SAKON NAKHON BASIN POTTING CLAY SOURCES.
FIGURE 4.8: CLAY 1 (BAN KHAM O). 10,000 counts per second.

FIGURE 4.9: CLAY 2 (BAN PLUAI). 20,000 counts per second.
FIGURE 4.10: CLAY 3 (BAN NONG THAN). 10,000 counts per second.

FIGURE 4.11: CLAY 4 (NONG HOI KHAN). 10,000 counts per second.
FIGURE 4.12: CLAY 5 (near BAN KHAM O). 10,000 counts per second.

FIGURE 4.13: CLAY 6 (NONG SUNG, near BAN PANG NGU). 10,000 counts per second.
4.4. ANALYSIS OF SAKON NAKHON BASIN POTTING CLAYS

FIGURE 4.14: CLAY 7 (BAN NONG PHAI). 40,000 counts per second.

FIGURE 4.15: CLAY 8 (BAN MUANG (Hua Din)). 10,000 counts per second.
**FIGURE 4.16: CLAY 9 (BAN THUM).** 10,000 counts per second.

**FIGURE 4.17: CLAY 10 (NONG KHAM DIN).** 20,000 counts per second.
4.4. ANALYSIS OF SAKON NAKHON BASIN POTTING CLAYS

FIGURE 4.18: CLAY 11 (BAN LAO SUAN KLUAI). 10,000 counts per second.

FIGURE 4.19: CLAY 12 (NONG I LAENG). 10,000 counts per second.
FIGURE 4.20: CLAY 13 (BAN NA DI (Huai Wang Duan Ha)). 10,000 counts per second.

FIGURE 4.21: CLAY 14 (BAN NA DI (Nong Haeo)). 10,000 counts per second.
4.5 Summary of potting clay qualities

From the perspective of ceramic manufacture, potting clays need a range of inter-related physical and chemical qualities. The type and relative quantities of clay minerals present in any potting clay may have important effects on its quality. Variations in the quality of clay minerals may influence the overall technological processes required to produce a viable ceramic material. Of the clays described above, detailed information regarding methods of tempering are not known for samples 5, 6, 8, 9, 10, 11, 12, 13, and 14. Clays 1, 2, and 7, and possibly 12, were tempered with the bleb species of grog.

Clay 7 featured heavy rice tempering in association with the blebs. The clay was quarried a metre below a rice field to reach clay considered sticky enough. Less sticky clay was rejected as too sandy and therefore likely to crack on firing. The high proportion of clay minerals is correlated with what, in thin-section, appears to be a high silt content. Clay 3 was not tempered. It was kiln-fired into stoneware. Clay 4 was rice-tempered. The amount of temper used is not known.

Perhaps the outstanding overall feature of these clays is their mineralogical variability. This factor demonstrates the expertise required in identifying suitable raw clay deposits and preparing these clays for ceramic manufacture. It also emphasizes the skilful approach employed by potters undertaking their craft often under the most rudimentary of conditions. Samples 2 and 4 contain swelling clays, while sample 7 does not but is silty, yet, in each case, they are successfully exploited. Tables 4.1 and 4.2 below set out the quality of the unmodified clays from a potter’s subjective perspective, and the results of shrinkage tests respectively. Bisques used in the shrinkage tests measured 15 x 2.5 x 0.8 cm when formed. A 10 cm long mark was incised into their surfaces when soft to enable the shrinkage rates to be calculated (Howard 1982).

<table>
<thead>
<tr>
<th>Clay No.</th>
<th>Properties.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>moderately plastic</td>
</tr>
<tr>
<td>2.</td>
<td>moderately plastic</td>
</tr>
<tr>
<td>3.</td>
<td>short and coarse</td>
</tr>
<tr>
<td>4.</td>
<td>plastic and fine</td>
</tr>
<tr>
<td>5.</td>
<td>moderately plastic</td>
</tr>
<tr>
<td>6.</td>
<td>plastic and smooth</td>
</tr>
<tr>
<td>7.</td>
<td>short and fine</td>
</tr>
<tr>
<td>8.</td>
<td>very short and sandy</td>
</tr>
<tr>
<td>9.</td>
<td>plastic and smooth</td>
</tr>
<tr>
<td>10.</td>
<td>plastic, very fine and sticky</td>
</tr>
<tr>
<td>11.</td>
<td>slightly plastic, fine and sandy</td>
</tr>
<tr>
<td>12.</td>
<td>moderately plastic</td>
</tr>
<tr>
<td>13.</td>
<td>moderately plastic and fine</td>
</tr>
<tr>
<td>14.</td>
<td>short, fine and sandy</td>
</tr>
</tbody>
</table>

All of the bisques were fired in an oxidizing atmosphere after air-drying to the leather hard...
### TABLE 4.2: The shrinkage rates of Sakon Nakhon Basin potting clays

<table>
<thead>
<tr>
<th>clay</th>
<th>test 1. 800C</th>
<th>test 2. 900C</th>
<th>test 3. 1000C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>dry fired</td>
<td>dry fired</td>
<td>dry fired</td>
</tr>
<tr>
<td>1</td>
<td>90.5 90.0</td>
<td>90.0 89.5</td>
<td>90.0 88.0</td>
</tr>
<tr>
<td>2</td>
<td>90.5 90.0</td>
<td>90.5 90.0</td>
<td>90.0 89.0</td>
</tr>
<tr>
<td>3</td>
<td>90.0 90.0</td>
<td>90.0 90.0</td>
<td>88.5 86.0</td>
</tr>
<tr>
<td>4</td>
<td>90.0 89.5</td>
<td>90.0 89.0</td>
<td>90.0 87.0</td>
</tr>
<tr>
<td>5</td>
<td>93.0 93.0</td>
<td>93.0 93.0</td>
<td>92.5 92.0</td>
</tr>
<tr>
<td>6</td>
<td>91.0 90.0</td>
<td>91.5 90.0</td>
<td>91.5 90.0</td>
</tr>
<tr>
<td>7</td>
<td>92.0 90.0</td>
<td>92.5 92.0</td>
<td>90.0 88.5</td>
</tr>
<tr>
<td>8</td>
<td>96.0 96.0</td>
<td>96.5 96.5</td>
<td>96.5 96.5</td>
</tr>
<tr>
<td>9</td>
<td>90.5 90.0</td>
<td>90.0 90.0</td>
<td>90.0 90.0</td>
</tr>
<tr>
<td>10</td>
<td>90.0 89.0</td>
<td>90.0 89.0</td>
<td>90.0 86.5</td>
</tr>
<tr>
<td>11</td>
<td>97.0 97.0</td>
<td>96.5 96.5</td>
<td>96.0 96.0</td>
</tr>
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<td>12</td>
<td>91.0 90.0</td>
<td>92.5 91.5</td>
<td>92.0 89.5</td>
</tr>
<tr>
<td>13</td>
<td>94.5 93.5</td>
<td>95.0 95.0</td>
<td>94.5 94.5</td>
</tr>
<tr>
<td>14</td>
<td>97.0 97.0</td>
<td>97.0 96.5</td>
<td>96.0 96.0</td>
</tr>
</tbody>
</table>

After stage, following standard modern potting practice, to test their likely firing behaviour (Howard 1982). Clays 8, 11, 13 and 14 were collected unaccompanied by a potter. Significantly they displayed the least shrinkage. Clays 3, 7, 8 and 14 have little plasticity due to a disproportionate amount of non-plastics. In modern potting terminology they can be described as “short”. The shrinkage rates do not disqualify any of the clays for potting. A high proportion of non-plastics in the “short” clays is not enough to render them unsuitable, however a lack of sufficient suitable clay minerals would be critical to their use as potting material. It is likely that these clays would not fire well, given their natural composition, without modification. It should be noted that while non-plastic inclusions serve to reduce shrinkage, by coarsening and opening the texture of the material they allow the more rapid escape of gases, they may also weaken the clay by reducing the proportion of clay minerals. Thus the amount of non-plastic material a clay may accommodate is limited. The normal modern potting practice is to blend a “plastic” (i.e. high in suitable clay minerals), clay with the “short” clay (Hamer 1975:264).
Chapter 5

The petrology of Sakon Nakhon Basin potting clays

5.1 Introduction

The following potting clays were collected from quarries either in current production or utilized in living memory. Clays from sites 5, 8, 11, 13, and 14 were collected unaccompanied by a potter. The shrinkage and XRD data set out in chapter four suggest that these raw clays are of poor quality. Thus their usefulness as potting clays is uncertain. It is postulated that clays petrographically consistent with 13 and/or 14 and 10, were blended in order to produce fabric group 3 at Ban Na Di (fig. 7.22, appendix one, and Table 5.1 below).

Each clay was fired at 50°C increments from 700°C to 1050°C, in an oxidising atmosphere, and then thin-sectioned. Thus eight sections of each clay have been examined. Prior to covering with a glass slip, the sections were etched with hydrofluoric acid fumes and then stained successively with sodium cobaltinitrate, a 5% barium chloride solution, and finally with a near-saturated amaranth solution. The latter two chemicals stain plagioclase feldspar red, the first stains potassium feldspar yellow. A full description of the procedure is set out by Norman (1974). Lewis (1984:144-145) gives an alternative method. Staining assisted in identifying fine to very fine sand-sized feldspars. Roundness and sorting have been visually estimated. Colours represent firings to 1000°C recorded under the Munsell notation system.

Point counting has helped differentiate sources through the quantification of their various nonplastic contents. The Glagolev-Chayes method (Galehouse 1971:385-407) was used. The results are set out in Tables 5.1 and 5.6. These should be treated as a guide only because the difficulties encountered in evaluating sedimentary fabrics (Lewis 1984:66-67), are increased in ceramics for two important reasons.

First, the mixing of nonplastics in clays is not always homogeneous. Heterogeneous mixing may be natural, or promoted by “wedging”, a process designed to exclude air prior to firing. Therefore some areas often contain less nonplastics than the overall average, but other areas contain more. These differences are often not easily discernible, or readily accommodated, in ceramic thin-sections.

Second, a wide variation in nonplastic size range is common both within and between clays. It is often difficult, therefore, to decide optimum magnification levels. Magnifications too low may mean that important cryptocrystalline inclusions are not discernible, and thus erroneously counted as clay matrix. These nonplastic particles are often important to the potting mixture. They perform a different role, however, to clay minerals (see chapter four).
An 100x magnification was adopted as this allowed for the recognition of silt-sized non-plastic particles. In Table 5.1 phytoliths, diatoms and unidentifiable fragmentary microfossils have been grouped together. Table 5.2 sets out the relationships between spicules, fragmentary fossils including diatoms, and phytoliths. Spicules and phytoliths are treated separately. No attempt has been made to identify diatoms or phytoliths. A detailed examination of microfossils lies outside the scope of the present study.

Heavy minerals have been examined in thin-section and washed samples. Tourmaline, zircon, and rutile have been identified optically. This is a restricted suite. Many grains occur as silt-sized particles. This is probably common to heavy minerals in most sediments (Blatt et al. 1980:306). Their size means they can be difficult to identify. Zircon, tourmaline and rutile are probably present in most, if not all, Khorat sediments. ZTR percentages are often useful in determining the maturity of terrigenous sediments and sandstones (liwHubert 1962).

Local concentrations of heavy minerals may be generated by chance depositional conditions such as tectonic and sea level stability. Such asymmetry may require intensive sampling to allow interpretation. In addition, weathering-induced differential destruction, particularly in more tropical climates, may also pose serious interpretive problems (Blatt et al. 1980:286, 305-309). Rutile, for example, while very stable in sedimentary environments, may merely reflect regional weathering conditions rather than distance from, or abundance in, igneous source rocks (Blatt et al. 1980:252-257). Results set out below suggest that for the present sourcing and petrogenetic purposes intensive heavy mineral techniques are unwarranted. This is not intended to suggest that heavy mineral analysis would not be useful, but that present analytical techniques are excessively laborious, and thus impractical, in studies which involve large quantities of pottery from many sites.

Recognition of some potentially important silt or smaller sized minerals initially caused some difficulty. At the standard 30 μ thin-section thickness they may be masked by the clay matrix. Calcite, for example, is often present as a drusy sparite or a micritic scatter. Some threads of flakey “white mica” are a similar dimension. Thus both are readily disguised by the fabric matrix. Such minerals may only be visible if the thin-section is thinner than normal. This also applies to many heavy mineral particles, especially zircon and rutile.

5.2 Results

The overall composition of each clay is described below. Tables setting out the relationships between important minerals are given to provide an overall outline. Clay compositions and mineral associations help in the interpretation of the clays’ geological paragenesis.

(a) Tables

Table 5.1 sets out point counts of the major components. In each sample 500 points were counted. Although some inclusions occasionally failed to register, each is present, at least in trace amounts, in all clays. In clay 3, the most outstanding example, only two spicule fragments were noted in the eight thin-sections. They did not register in the point counts.
TABLE 5.1: Point counting analysis of major components

<table>
<thead>
<tr>
<th>Clay</th>
<th>Matrix</th>
<th>Quartz</th>
<th>Kspar</th>
<th>Fe</th>
<th>Spicules</th>
<th>Microfossils</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>68.8</td>
<td>24.8</td>
<td>0.2</td>
<td>4.0</td>
<td>0.8</td>
<td>0.2</td>
</tr>
<tr>
<td>2</td>
<td>81.0</td>
<td>10.2</td>
<td>0.0</td>
<td>3.0</td>
<td>0.6</td>
<td>5.2</td>
</tr>
<tr>
<td>3</td>
<td>70.8</td>
<td>22.8</td>
<td>0.6</td>
<td>5.8</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>4</td>
<td>80.2</td>
<td>13.2</td>
<td>0.0</td>
<td>3.8</td>
<td>1.2</td>
<td>1.6</td>
</tr>
<tr>
<td>5</td>
<td>61.4</td>
<td>30.0</td>
<td>1.6</td>
<td>2.8</td>
<td>1.0</td>
<td>3.2</td>
</tr>
<tr>
<td>6</td>
<td>86.2</td>
<td>9.6</td>
<td>0.0</td>
<td>0.0</td>
<td>1.0</td>
<td>1.2</td>
</tr>
<tr>
<td>7</td>
<td>91.8</td>
<td>3.6</td>
<td>0.0</td>
<td>2.8</td>
<td>0.4</td>
<td>1.4</td>
</tr>
<tr>
<td>8</td>
<td>62.6</td>
<td>36.2</td>
<td>0.8</td>
<td>0.2</td>
<td>0.2</td>
<td>0.0</td>
</tr>
<tr>
<td>9</td>
<td>82.2</td>
<td>6.8</td>
<td>0.0</td>
<td>2.4</td>
<td>4.8</td>
<td>3.8</td>
</tr>
<tr>
<td>10</td>
<td>78.6</td>
<td>5.2</td>
<td>0.2</td>
<td>5.2</td>
<td>7.6</td>
<td>3.2</td>
</tr>
<tr>
<td>11</td>
<td>75.0</td>
<td>23.4</td>
<td>0.4</td>
<td>1.2</td>
<td>0.8</td>
<td>0.0</td>
</tr>
<tr>
<td>12</td>
<td>65.2</td>
<td>18.8</td>
<td>0.4</td>
<td>2.0</td>
<td>11.2</td>
<td>2.4</td>
</tr>
<tr>
<td>13</td>
<td>75.0</td>
<td>23.8</td>
<td>0.0</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>14</td>
<td>65.0</td>
<td>33.6</td>
<td>0.2</td>
<td>0.4</td>
<td>0.2</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Notes: All chert varieties were counted with quartz. Fe includes limonite and all other hydrous ferric iron compounds. Plagioclase is only rarely present (see Table 5.6 below).

Spicule, diatom and other unidentified microfossils, and phytolith proportions are given separately in Table 5.2 below. They are important in assessing possible paragenetic variabilities.

TABLE 5.2: Relationships between microfossils
(expressed as percentage of total sample).

<table>
<thead>
<tr>
<th>Clay</th>
<th>Spicules</th>
<th>Diatoms etc.</th>
<th>Phytoliths</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.8</td>
<td>0.2</td>
<td>0.0</td>
</tr>
<tr>
<td>2</td>
<td>0.6</td>
<td>3.0</td>
<td>2.2</td>
</tr>
<tr>
<td>3</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>4</td>
<td>1.2</td>
<td>1.6</td>
<td>0.0</td>
</tr>
<tr>
<td>5</td>
<td>1.0</td>
<td>0.8</td>
<td>2.4</td>
</tr>
<tr>
<td>6</td>
<td>1.0</td>
<td>1.0</td>
<td>0.2</td>
</tr>
<tr>
<td>7</td>
<td>0.4</td>
<td>1.0</td>
<td>0.4</td>
</tr>
<tr>
<td>8</td>
<td>0.2</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>9</td>
<td>4.8</td>
<td>2.8</td>
<td>1.0</td>
</tr>
<tr>
<td>10</td>
<td>7.6</td>
<td>1.8</td>
<td>1.4</td>
</tr>
<tr>
<td>11</td>
<td>0.8</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>12</td>
<td>11.2</td>
<td>1.4</td>
<td>1.0</td>
</tr>
<tr>
<td>13</td>
<td>0.4</td>
<td>0.0</td>
<td>0.4</td>
</tr>
<tr>
<td>14</td>
<td>0.2</td>
<td>0.2</td>
<td>0.4</td>
</tr>
</tbody>
</table>
Quartz, in a variety of forms, is prominent throughout, and monocrystalline quartz always dominates. Many grains display overgrowths. Chert is also ubiquitous. Both are highly diagnostic of sedimentary authigenic processes (Folk 1980, Tucker 1981). Many monocrystalline, and most polycrystalline, quartz grains display undulose extinction. This is occasionally intense and results in extinction shadows which sweep across the grain in a radial fashion when the stage is rotated more than 5° (Folk 1980:72). Igneous and metamorphic quartz may each feature this phenomenon. Their abundance and type, when coupled with the species of heavy minerals present, however, suggests many may have a metamorphic origin (Tucker 1981:44, Folk 1980:95-97). Table 5.3 below sets out quartz and chert components.

### TABLE 5.3: The quartz and chert component

<table>
<thead>
<tr>
<th>clay</th>
<th>overgrowths</th>
<th>poly quartz</th>
<th>chert</th>
<th>quartz %+</th>
<th>shape</th>
<th>sorting</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>several</td>
<td>9.09</td>
<td>17.53</td>
<td>24.8</td>
<td>A-SR</td>
<td>M-P</td>
</tr>
<tr>
<td>2</td>
<td>few</td>
<td>14.54</td>
<td>7.14</td>
<td>10.2</td>
<td>A-R</td>
<td>M-P</td>
</tr>
<tr>
<td>3</td>
<td>few</td>
<td>1.81</td>
<td>9.09</td>
<td>22.8</td>
<td>A-SR</td>
<td>P</td>
</tr>
<tr>
<td>4</td>
<td>several</td>
<td>14.54</td>
<td>16.20</td>
<td>13.2</td>
<td>A-SR</td>
<td>M</td>
</tr>
<tr>
<td>5</td>
<td>rare</td>
<td>9.09</td>
<td>5.84</td>
<td>30.0</td>
<td>A-SR</td>
<td>M</td>
</tr>
<tr>
<td>6</td>
<td>few</td>
<td>1.81</td>
<td>0.64</td>
<td>9.6</td>
<td>A-R</td>
<td>P</td>
</tr>
<tr>
<td>7</td>
<td>v. rare</td>
<td>10.90</td>
<td>1.94</td>
<td>3.6</td>
<td>A-SR</td>
<td>M</td>
</tr>
<tr>
<td>8</td>
<td>none</td>
<td>1.81</td>
<td>6.49</td>
<td>36.2</td>
<td>A-SR</td>
<td>M</td>
</tr>
<tr>
<td>9</td>
<td>rare</td>
<td>1.81</td>
<td>5.19</td>
<td>6.8</td>
<td>A-SR</td>
<td>M</td>
</tr>
<tr>
<td>10</td>
<td>few</td>
<td>5.45</td>
<td>1.29</td>
<td>5.2</td>
<td>A-SR</td>
<td>M</td>
</tr>
<tr>
<td>11</td>
<td>many</td>
<td>10.90</td>
<td>6.49</td>
<td>23.4</td>
<td>A-R</td>
<td>P</td>
</tr>
<tr>
<td>12</td>
<td>few</td>
<td>9.09</td>
<td>20.77</td>
<td>18.8</td>
<td>A-R</td>
<td>P</td>
</tr>
<tr>
<td>13</td>
<td>many</td>
<td>7.27</td>
<td>0.64</td>
<td>23.8</td>
<td>A-R</td>
<td>P</td>
</tr>
<tr>
<td>14</td>
<td>few</td>
<td>1.81</td>
<td>0.64</td>
<td>33.6</td>
<td>A-R</td>
<td>P</td>
</tr>
</tbody>
</table>

Notes: Quartz %+ refers to the total point counted quartz fraction. This includes mono- and polycrystalline varieties and chert. The overgrowth quantities are subjective estimates. Chert and polycrystalline quartz quantities are given as percentages of the quartz count not as percentages of the overall non-plastic fraction. Shape, sorting and the total quartz fraction are included for convenience.
**5.2. RESULTS**

### TABLE 5.4: Shape, sorting and maximum size of nonplastics.

<table>
<thead>
<tr>
<th>clay</th>
<th>quartz %+</th>
<th>shape range</th>
<th>sorting</th>
<th>max size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>24.8</td>
<td>Angular/subrounded</td>
<td>Moderate/poor</td>
<td>0.55mm</td>
</tr>
<tr>
<td>2</td>
<td>10.2</td>
<td>Angular/rounded</td>
<td>Moderate/poor</td>
<td>0.50mm</td>
</tr>
<tr>
<td>3</td>
<td>22.8</td>
<td>+++ Angular/subrounded</td>
<td>Poor</td>
<td>0.50mm</td>
</tr>
<tr>
<td>4</td>
<td>13.2</td>
<td>Angular/subrounded</td>
<td>Moderate</td>
<td>0.60mm</td>
</tr>
<tr>
<td>5</td>
<td>30.0</td>
<td>+++ Angular/subrounded</td>
<td>Moderate</td>
<td>0.25mm</td>
</tr>
<tr>
<td>6</td>
<td>9.6</td>
<td>Angular/rounded</td>
<td>Very Poor</td>
<td>1.20mm</td>
</tr>
<tr>
<td>7</td>
<td>3.6</td>
<td>Angular/subrounded</td>
<td>Moderate</td>
<td>0.40mm</td>
</tr>
<tr>
<td>8</td>
<td>36.2</td>
<td>++ Angular/subrounded</td>
<td>Moderate</td>
<td>0.50mm</td>
</tr>
<tr>
<td>9</td>
<td>6.8</td>
<td>+++ Angular/subrounded</td>
<td>Moderate</td>
<td>0.30mm</td>
</tr>
<tr>
<td>10</td>
<td>5.2</td>
<td>Angular/subrounded</td>
<td>Moderate</td>
<td>0.40mm</td>
</tr>
<tr>
<td>11</td>
<td>23.4</td>
<td>Angular/rounded</td>
<td>Poor</td>
<td>0.70mm</td>
</tr>
<tr>
<td>12</td>
<td>18.8</td>
<td>Angular/rounded</td>
<td>Poor</td>
<td>0.65mm</td>
</tr>
<tr>
<td>13</td>
<td>23.8</td>
<td>++++ Angular/rounded</td>
<td>Poor</td>
<td>0.90mm</td>
</tr>
<tr>
<td>14</td>
<td>33.6</td>
<td>++++ Angular/rounded</td>
<td>Poor</td>
<td>0.50mm</td>
</tr>
</tbody>
</table>

Notes: ++++ rarely well rounded  
+++ rarely rounded  
++ mainly angular  
+ total quartz fraction including mono and polycrystalline as well as chert varieties.

### TABLE 5.5: Heavy minerals and metamorphic quartz.

<table>
<thead>
<tr>
<th>Clay</th>
<th>Zircon</th>
<th>Tourmaline</th>
<th>Quartz “twins”</th>
<th>Stretched</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.10mm</td>
<td>0.04mm</td>
<td>several</td>
<td>?</td>
</tr>
<tr>
<td>2</td>
<td>0.13mm</td>
<td>0.10mm</td>
<td>several</td>
<td>?</td>
</tr>
<tr>
<td>3</td>
<td>0.10mm</td>
<td>0.05mm</td>
<td>several</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>0.15mm</td>
<td>0.10mm</td>
<td>several</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>0.03mm</td>
<td>0.03mm</td>
<td>several</td>
<td>?</td>
</tr>
<tr>
<td>6</td>
<td>0.06mm</td>
<td>0.08mm</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>0.08mm</td>
<td>0.07mm</td>
<td>several</td>
<td>?</td>
</tr>
<tr>
<td>8</td>
<td>0.08mm</td>
<td>0.14mm</td>
<td>rare</td>
<td>-</td>
</tr>
<tr>
<td>9</td>
<td>0.08mm</td>
<td>0.08mm *</td>
<td>rare</td>
<td>-</td>
</tr>
<tr>
<td>10</td>
<td>0.03mm</td>
<td>0.03mm</td>
<td>rare</td>
<td>0.40mm</td>
</tr>
<tr>
<td>11</td>
<td>0.22mm</td>
<td>0.04mm</td>
<td>several</td>
<td>?</td>
</tr>
<tr>
<td>12</td>
<td>0.10mm</td>
<td>0.15mm +</td>
<td>several</td>
<td>0.50mm</td>
</tr>
<tr>
<td>13</td>
<td>0.10mm</td>
<td>0.03mm</td>
<td>several</td>
<td>-</td>
</tr>
<tr>
<td>14</td>
<td>0.10mm</td>
<td>0.12mm</td>
<td>several</td>
<td>-</td>
</tr>
</tbody>
</table>

Notes: *
- many very fine
+ numerous
? probably metamorphic

The above values are maximum grain size in millimetres for heavy minerals. Quartz “twins” refers to composite grains with sharp twin-like boundaries which have been formed as the result of strain and subsequently annealed during the final stages of metamorphism (Williams et al. 1982:332). Stretched metamorphic follows Folk’s genetic classification (1980:69-72). Particular attention has been paid to the orientation of microcrystals.
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TABLE 5.6: Feldspars and weathered nonplastic proportions.

<table>
<thead>
<tr>
<th>clay</th>
<th>total + quartz</th>
<th>weathered</th>
<th>“fresh”</th>
<th>kspar +++</th>
<th>plagioclase +++</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>24.8</td>
<td>50%</td>
<td>50%</td>
<td>0.22</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>10.2</td>
<td>50%</td>
<td>50%</td>
<td>0.10</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>22.8</td>
<td>50%</td>
<td>50%</td>
<td>0.10</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>13.2</td>
<td>50%</td>
<td>50%</td>
<td>0.20</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>30.0 mainly fresh</td>
<td>-</td>
<td>1.15</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>9.6</td>
<td>50%</td>
<td>50%</td>
<td>0.28</td>
<td>0.06</td>
</tr>
<tr>
<td>7</td>
<td>3.6</td>
<td>50%</td>
<td>50%</td>
<td>0.25</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td>36.2 mainly fresh</td>
<td>-</td>
<td>0.20</td>
<td>0.10</td>
<td>-</td>
</tr>
<tr>
<td>9</td>
<td>6.8</td>
<td>50%</td>
<td>70%</td>
<td>0.16</td>
<td>-</td>
</tr>
<tr>
<td>10</td>
<td>5.2 ++ 50%</td>
<td>50%</td>
<td>0.18</td>
<td>0.07</td>
<td>-</td>
</tr>
<tr>
<td>11</td>
<td>23.4</td>
<td>50%</td>
<td>50%</td>
<td>0.18</td>
<td>0.05</td>
</tr>
<tr>
<td>12</td>
<td>18.8</td>
<td>60%</td>
<td>40%</td>
<td>0.08</td>
<td>-</td>
</tr>
<tr>
<td>13</td>
<td>23.8</td>
<td>60%</td>
<td>40%</td>
<td>0.10</td>
<td>0.09</td>
</tr>
<tr>
<td>14</td>
<td>33.6</td>
<td>50%</td>
<td>50%</td>
<td>0.42</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Notes: + total quartz fraction including mono and polycrystalline as well as chert varieties
++ none heavily weathered
+++ values for feldspars are maximum size in millimeters.

(b) Clay descriptions

Many inclusions are common to all the clays. Important qualitative variations will only be described in detail when first encountered. Except for clay 10, monocrystalline quartz dominates the nonplastics. Quartz is described in detail for clay 1. The more salient features only are given subsequently.

Several heavy minerals are evident. Zircon, tourmaline, rutile, hematite, limonite, and micas have been noted. Many are probably ubiquitous as minute, optically undiagnostic, particles in thin-section. Hence only those readily detected, or highly diagnostic of source rocks, have been considered. Terms used to describe features common to many quartz grains have the following meanings: cracks are shallow valley shaped features to grain surfaces, fissures are deep narrow features, and fractures traverse the entire grain to leave narrow gaps.

Clay 1.

A texturally immature silty pink (7.5YR/7/4) clay. The clay matrix is dull, and this corroborates XRD results which indicate the presence of mixed-layer clay minerals.

Monocrystalline quartz dominates the nonplastic inclusions. It is principally anhedral, but the origin of many grains is reflected in their euhedral shape. Many are strained and undulose extinction is common. Several grains contain vacuoles often as trails. Quartz ranges in size from coarse sand to fine silt, being poorly to moderately sorted, and angular to subrounded in form. Overgrowths are common (fig. 5.1), and some grains have several well-developed crystal faces (Tucker 1981:56, fig. 2.44). Occasional quartz grains are wholly or partly encased in a red-brown iron oxide probably hematite (Birkeland 1974:86; Kerr 1977:227). Hematite can
also be identified in hand specimen. Earthy, ochreous, and giving a red streak, it is mainly scattered throughout as sand-sized irregular nodules or pellets.

**FIGURE 5.1: MICROPHOTOGRAPH OF QUARTZ OVERGROWTHS.**

Monocrystalline quartz with either fractures, pits, crevices or rough, sometimes puckerred surfaces, is common. Many grains show weathering to edges. Often fissures have been penetrated by dark red-brown limonite. This limonitic “staining” often delineates subrounded to rounded subsequently overgrown “host” grains. One angular grain is cemented to a chert grain which displays mosaic pin-point extinction. Both mono and polycrystalline grains are occasionally intensely strained. “Twins” are prominent (Williams et al. 1982:332). Composite grains, in which microlites behave as “negative” crystals and extinguish in the opposite position to the host grain, are common (Carozzi 1960:41). The microlites appear to be siliceous. Many grains have inclusions, and/or vacuoles, either abundant, diffusely scattered throughout, or as well defined trails (Folk 1980:69-72).

Polycrystalline quartz falls into several varietal groups. They are discussed in descending order of frequency. Group 1 includes many medium sand sized grains which show distinct internal sutures between crystal boundaries. Extinction ranges from slightly to strongly undulose (Folk 1980:72). The internal crystals are either roughly equant or comprise one or more larger crystals bounded or intermeshed by smaller ones. These sutured grains suggest authigenic silica cementing of very coarse silt to very fine sand. They are best described as quartzite although their paragenesis is uncertain. The clarity of crystal boundaries grades from clear to invisible. In the latter case individual crystals are only apparent when the microscope stage is rotated under crossed polars and the internal crystallographic structure is revealed.

Group 2 polycrystalline quartz grains are composed of either roughly equant, or slightly
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subsequent anhedral crystals, with clear unsutured boundaries. These are either irregular or almost straight. Extinction tends to be moderately undulose or inclined. Several entire polycrystalline grains are partially overgrown. In rare cases “normal” quartz crystals are interspersed with one or more grains of mosaic microcrystalline chert.

Group 3 grains are comprised of irregular elongate, subsequent and roughly parallel, larger crystals sometimes with many smaller crystals randomly distributed between them. Crystal boundaries are often crenulate. Extinction is always strongly undulose or distorted. Individual crystals generally approximate parallel crystallographic orientation, although some entire grains are severely contorted. This contrasts with groups 1 and 2, where crystals tend to be randomly distributed. Sharp boundaries between neighbouring sectors which each differ in extinction by a few degrees, plus internal strain suggests that these grains are metamorphic in origin. Group 3 grains are of fine sand size.

Chert is present in three forms, microquartz, chalcedonic quartz and megaquartz. The latter can be identified in composite grains. The former two varieties occur either as individual or composite grains (Folk 1980:79, Tucker 1981:210). Overall, cherts are mainly subrounded, but some are angular or rounded, of very coarse silt to medium sand size. Microquartz chert is composed of a finely crystalline equant mosaic with pin-point extinction. Megaquartz chert crystals are larger, up to fine sand size, often with unit extinction. Chalcedonic chert has fibrous crystals. These often display a radiating arrangement, some forming wedge-shaped or mammillated structures which are subrounded to rounded and up to medium sand size (Tucker 1981:210-211). Many grains are markedly graded. Some include both micro and megaquartz. A few composite grains also include wedge shaped chalcedonic and mosaic chert arrangements. Within chalcedonic mammillated quartz internal sector boundaries move sequentially into extinction as the microscope stage is rotated.

All of these cherts are diagnostic of an eroded older sedimentary source (Folk 1980:80). They probably represent the weathered remains of a chalcedonic cement pore filling. Such cements are characteristically associated with quartz arenites. The microquartz, megaquartz and chalcedonic quartz could all derive from such a source (Tucker 1981:211, fig. 9.1).

Calcite is principally dispersed sparsely throughout the clay matrix as a micrite (Tucker 1981:116), or microcrystalline irregular grains of up to 0.01 mm. It occasionally occurs as very fine sand sized euhedral crystals, or in groups of irregular sized euhedral crystals. These often display multiple twinning.

Potassium feldspar is rare, angular, and of very fine to fine sand size. No plagioclase feldspar was present.

Both tourmaline and zircon are prominent, but not numerous. Tourmaline is angular, either bladed and euhedral, or corroded and anhedral, to very coarse silt size. Zircon principally occurs as angular, very fine sand sized, detrital grains. A few grains are euhedral.

Hematite occurs as red to dark brown semi-opaque round pellets of medium sand size. They often contain angular silt sized quartz inclusions (see also above and clay 2).

Fragments of fresh water sponge spicules are rare. These spicules have kindly been identified for the writer by Professor F.W. Harrison, head of biology, Western Carolina University, as belonging to the genus Ephedratia meyenii. Harrison reports that these sponges are presently found in the region. The genus was probably abundant in the Mesozoic (Bergquist 1978). They occur in each of the clays examined. Diatoms and phytoliths are rare.

Phytoliths are ubiquitous in Sakon Nakhon Basin clays. An analysis of their origins lies outside the scope of the present work. A very brief summary of the major types noted is necessary, however, because some are considered to represent deliberately added rice plant
remains in some ceramic fabrics (Appendix one). Some inclusions are optically consistent with rice phytoliths. In shape, subrounded to rounded, birefringence and refractive index (less than 1.54 determined by Becke line test), and size, 5 to 10 μ, they parallel siliceous depositions within rice leaf and husk (Yoshida et al. 1962). Phytolith quantities vary widely between clays, and as they never exceed 40 μ in diameter, they may easily escape detection in thin-section, if they are rare. Given that rice cultivation is currently widespread, their presence in modern sediments is predictable. Phytoliths in the Sakon Nakhon Basin clays are probably related to earlier processes, however, because these are excavated as much as 2 metres below the present land surfaces.

Twiss et al. (1969:109-114), include a morphological classification of grass phytoliths, both class 3 (panicoid), and 4 (elongate), are present in the above clay sample. Brydon et al. (1963:476-477), describe and illustrate shard-like silicified plant astersclereids of similar shape and optical properties to inclusions noted. Wilding and Drees (1973:647-650), illustrate (Fig. 1-f), opaline bodies which are also similar to inclusions observed in Sakon Nakhon Basin clays. None of these are like the rice phytoliths described by Yoshida et al (1962), or the inclusions referred to as rice phytoliths in the Sakon Nakhon Basin clays.

Clay 2.

A texturally immature silty (10YR /8/4) clay. Mica is evident in the XRD spectograph. Detailed optical examination revealed very fine sand sized bleached biotite. Biotite often alters to chlorite or vermiculite (Kerr 1977:439-440), and soils may contain vermiculite (Battey 1972:276). The 14 ÅXRD peak discussed in chapter four could represent a vermiculite. This is equivocal because of similarities with smectite (Grim 1968:104-113). Alternatively, mixed-layer clay minerals, possibly involving vermiculite, may be present (see chapter four).

Micritic and microcrystalline to finely crystalline calcite (Folk 1980:164), is diffuse through-out the clay matrix as a mosaic of numerous clusters of euhedral or subhedral crystals. The diagenesis of freshwater calcareous cements often involves the reprecipitation, as calcite, of dissolved aragonite from, for example, ancient undolomitized limestones (Tucker 1981:130). These are chiefly described as “drusy sparites” (Tucker 1981:126-127). Calcite is common in recent sediments (Folk 1980:98).

Monocrystalline quartz is mainly anhedral but some grains are subhedral. It spans from silt to medium sand size. A few grains are strained. Several display undulose extinction. A few include overgrowths. One authigenic (?) grain has overgrown a sponge spicule. Several contain vacuoles, some as trails. Several have fractures, cracks and micro pits. Some show crescentic marks. Many grains are deeply weathered. In a few limonite has penetrated into cracks and fractures. One grain contains a 0.05 mm long euhedral tourmaline inclusion.

Polycrystalline quartz is prominent. Group 1 is rare, group 2 common, and group 3 is well represented. Most grains display undulose and/or inclined extinction often with clear crystal boundaries. These grains have crystals that are mainly uniform in size with irregular, rarely sutured, boundaries. Some grains have unclear crystal boundaries, and most of these are subquart. A few grains with clear crystal boundaries contain numerous vacuoles often as trails.

Microquartz, megaquartz and chalcedonic chert as described for clay 1 are present. Two composite grains are evident. One is part mosaic, part chalcedonic. The other is chalcedonic, part wedge and part mammillate.

A red to dark brown iron oxide compound, probably hematite, or the hydrous oxide goethite, occurs in various forms. They are probably weather-induced precipitates (Birkeland 1974:66-68). They occur as dense, almost opaque, pellets or as a stain which lightly coats the clay
matrix (Folk 1980:99). Rock fragments, cemented by dark red-brown hematite or goethite, are present in two forms. One form is angular of a very coarse sand size. The other rock fragment is well rounded ooid-like of granule size. Both contain angular, silt to fine sand sized, quartz inclusions. In some, iron encases angular to rounded single grains of quartz to form, fine sand sized, ooid-like pellets.

Potassium feldspar occurs as subangular to subrounded very fine to medium sand. At 100x magnification no potassium feldspar registered during point counting. It formed 0.4% of the sample at 200x. No plagioclase feldspar was evident.

Zircon, of very fine sand size, is mainly detrital. One euhedral grain is 0.13 mm long. Angular tourmaline of the same size is also present.

Sponge spicules occur in minor amounts, but diatoms and phytoliths are relatively abundant.

Clay 3.

A texturally immature micaceous (7.5YR/7.5/6) clay. The overall appearance of the matrix, in thin-section, is of numerous flakes of fine muscovite or “white mica”. These, and rare fine sand sized grains of kaolinite, are probably derived from the weathering of feldspar. Fine, sand-sized muscovite pseudomorphs of potassium feldspar, identified provisionally by their “dusty” appearance and blocky shape (Tucker 1981:45), also rarely occur. Kaolinite and weathered muscovite may measure < 30 μm in cross section thus, at normal thickness, they can be disguised by the matrix. Slightly thinner sections revealed the “white mica” abundance.

Monocrystalline grains clearly dominate the quartz fraction. They are mainly anhedral, but some are subhedral, and many display undulose extinction. Cracks, fissures and fractures are common. Many grains are weathered. This shows on the surfaces and interstices of cracks, but limonitic weathering is rare. Overall, they range widely between well weathered to relatively fresh. Fresh grains tend to display straight extinction. A few strained grains contain diffuse vacuoles. Some grains show overgrowths, and one has a microcline tourmaline intergrowth.

Polycrystalline quartz is extremely rare. Only one weathered group 2 grain of fine sand size was observed.

Chert is mainly mosaic, with a few chalcedonic and one composite grain. All are angular to subrounded of fine sand size.

Calcite is not prominent, only occurring as sparse, micritic, and mainly anhedral, crystals.

Ferruginous inclusions are numerous to abundant. They fall into two distinct groups. In both, grains range in shape from angular to rounded, and in size, from fine sand to very fine pebbles. One group is texturally and mineralogy consistent with the overall clay fabric. These generally contain quartz, mica and chert inclusions, of silt to fine sand size, although some single grains of quartz, of up to medium sand size, are partially or totally iron-encased. The cement appears to be an authigenic chemical precipitate of hematite or goethite. It is red to dark brown and often almost opaque. It also occurs as discrete pellets of up to medium sand size.

The second group is black and opaque, mainly without, but often with, silt-sized inclusions. Inclusion-rich examples in the first group often give the appearance of sand or siltstone fragments. It is likely, however, that they represent the clay fabric cemented by chemical precipitates. Where this ferruginous material has subsequently been subjected to dehydration and hardening, it is best described as laterite, in contrast to the hematite/goethite discussed above (Birkeland 1974:114-115). Dehydration cements these latter minerals into the rigid network of crystals. This hardness characterises laterite. Dehydration may be promoted by forest clearance (Birkeland 1974:op. cit.).
Potassium feldspar is rare, angular, of very fine to medium sand size. Some grains may be weathering to muscovite or kaolinite. Plagioclase feldspar was not present.

Detrital, sometimes angular, zircon and tourmaline, of very fine sand size, is rare. Sponge spicule fragments, diatoms and phytoliths are each extremely rare.  

\textit{Clay 4.}

A texturally immature silty (5YR/7/6) clay. Monocrystalline quartz is mainly anhedral, a few grains are subhedral. Undulose extinction, cracks, fractures and micro pits are common. In several cases limonite has penetrated fractures, but weathering to edges and internal surfaces is generally rare. A few grains contain vacuoles. These are usually diffuse and rarely as trails. Several grains have overgrowths. One has acicular microlitic inclusions of rutile (?).

Polycrystalline quartz of groups 1 and 2 is prominent, and of group 3 rare. One composite, very fine sand-sized grain is cemented to mosaic chert.

Chert is common, angular to subrounded, mainly mosaic, and never exceeds medium sand size. Chalcedonic chert is fine sand size. Graded chalcedonic, and composite mosaic/chalcedonic grains are both evident.

Potassium feldspar is represented by a few angular, very fine sand sized grains. No plagioclase feldspar was evident.

Micritic calcite can be prominent or sparse. It is either concentrated in small isolated patches, or as diffuse crystals. In clay 4, it is often barely discernible in some thin-sections, but obvious in others.

Zircon and tourmaline grains are anhedral, angular to fine sand size and rare.

Hematite, or goethite, pellets and angular lumps occur as a semi-opaque reddish brown precipitate. They are few and never exceed coarse sand dimensions.

Sponge spicules and diatoms are well represented. Phytoliths are rare.  

\textit{Clay 5.}

A texturally immature and very silty (10YR/8/3) clay. The XRD spectrograph indicates the presence of poorly crystalline clay minerals. Overall there are few nonplastics of > silt size. They display little mineralogical variability.

Monocrystalline quartz is mainly anhedral, but sometimes subhedral. Grains generally range in size from very fine silt to very fine sand. Most are fresh. Undulose extinction is common in the few fine sand-sized grains. Weathering to edges, fractures or fissures is uncommon. Internal surfaces rarely include limonite. Overgrown grains are rare. A few have diffuse vacuoles.

Polycrystalline quartz is moderately well represented. It includes groups 1 and 2 grains. These are angular to fine sand size. One grain is intensely strained and may belong to group 3.

Significantly, although sparse, all three varieties of chert are present. Mosaic and chalcedonic cherts range in shape from angular to subrounded. They never exceed very fine sand size. Mammillated grains, displaying sector extinction, are subrounded and of fine sand dimension.

Potassium feldspar is angular, to fine sand size, and is poorly represented. Plagioclase feldspar was not present.

Calcite occurs in two forms. First as numerous to abundant micritic crystals which are spread diffusely throughout the fabric. Secondly, a few isolated euhedral crystals, which measure up to fine sand size, are also present. A composite grain, composed of euhedral calcite on anhedral quartz, suggests the calcite may derive from a silica calcite sandstone cement (\textit{Williams et al., 1982:339-341}). Drusy sparites are common forms of calcitic sedimentary

Hematite, or goethite, is mainly present as a few angular to subrounded pellets of up to very fine pebble size. One rounded ooid-like grain is of fine pebble size. It encases spicules, potassium feldspar, and silt-sized quartz grains, all of which are consistent with the composition of the overall fabric.

Zircon and tourmaline are rare. They occur as detrital, angular to subangular, grains of very coarse silt size.

Sponge spicules are rare and fragmentary, diatoms rare, and phytoliths relatively abundant.

Clay 6.

Another texturally immature and silty (10YR/8/3) clay. Many quartz grains have extensive, and apparently fresh, fractures.

Monocrystalline quartz is mainly anhedral, but some grains are subhedral. Many grains show undulose extinction. Weathering to surfaces, and the interstices of fissures and fractures, is common. The latter often contain limonite. Some grains have micro pits. A few have overgrowths. Vacuoles are rare.

Polycrystalline quartz is extremely rare. Only one group 2 grain, of medium sand size was observed. It had been overgrown by authigenic quartz. One medium sand-sized grain has an intergrowth of zircon.

Chert is also extremely rare. Only one grain of subrounded, very fine sand-sized chalcedonic chert was observed.

Potassium feldspar is angular to subrounded, from coarse silt to medium sand size, and rare. Plagioclase feldspar is extremely rare. Only two coarse silt-sized grains were noted.

Calcite rarely exceeds 0.05 mm. It takes two forms. First, as a diffuse micritic “dust” throughout the fabric. These crystals are generally anhedral. Secondly, one very fine subrounded pebble (2.25 mm), is composed of calcite-cemented, fine sand-sized, quartz grains. One of these quartz grains appears to have authigenically overgrown a sponge spicule. The calcite crystals, within the pebble, range from silt to fine sand size. They are euhedral or subhedral and often twinned. A thin band of clay matrix adjacent to this pebble forms a darker "corona". The pebble is probably authigenic to the sediment and not detrital. Similar calcite aggregates are common within the interstices and on the surfaces of prehistoric potsherds, which suggests they represent authigenic deposits.

Zircon and tourmaline occur as rounded, detrital, grains of very fine sand size.

Fragmentary spicules, diatoms and phytoliths are rare.

Clay 7.

This is a texturally immature (10YR/7.5/4) clay. A sharp variation in texture is evident between individual thin-sections. Some are silty. Others are substantially micaceous. In these latter sections the particles are preferentially orientated so that as the microscope stage is rotated the majority of field of view sweeps in and out of extinction in broad parallel bands.

Monocrystalline quartz is mainly anhedral. A few grains are subhedral. Several have undulose extinction. In many this is very strong. Vacuoles are present as diffuse scatters in a few grains. Fractures, and weathering to edges and internal surfaces are rare. Only one grain displays overgrowths.

Polycrystalline quartz is principally of the group 1 variety, with irregular-sized crystals and boundaries. These grains are angular and from very fine to fine sand size. One subangular fine sand-sized may belong to group 3, but this is equivocal.

Chert is chalcedonic only, and very rare. It is angular and of very fine to fine sand size.

Potassium feldspar is rare, and angular to subrounded. It ranges in size from very fine sand
to fine sand. Plagioclase feldspar is absent.

Calcite abundance varies markedly between sections. The crystals are micritic. Never prominent, they often occur in dense, approximately 10 mm to 30 mm diameter, isolated patches. In addition to these aggregations, individual crystals may also be spread diffusely through the matrix. They are mainly anhedral, but occasionally euhedral.

Hematite, or goethite, is present as angular to well rounded precipitates of up to medium sand size. Its abundance varies considerably between sections, from rare to numerous.

Zircon occurs as angular, very coarse silt to very fine sand sized, detrital grains. It is very rare.

Tourmaline is represented by a single fragmented, euhedral, very fine sand-sized grain. Fragmentary spicules, diatoms and phytoliths are rare.

Clay 8.

This clay is texturally immature. As with clay 5, clay minerals are poorly crystalline. Although grain size distribution ranges from fine silt to medium sand the median is 0.084 mm (n = 30, S.D. = 0.04, V = 0.001). Thus the majority of grains are of fine sand size. No hematite, or goethite, is apparent. A reddish yellow (5YR7/8) matrix, however, suggests the presence of cryptocrystalline ferruginous minerals.

Monocrystalline quartz clearly dominates the nonplastics. In general they have fresh surfaces. Although a few fragmentary euhedral grains were noted, no overgrowths were observed. Many grains display intense undulose extinction. Grains with small cracks or complete fractures are numerous. Many contain negative crystals, suggestive of an igneous source (Folk 1980:69). A few have micro pits, or vacuoles. The latter are mainly diffusely distributed but in some grains they occur as trails. Weathering, either with or without limonite to surfaces, is common.

Polycrystalline quartz is rare. Only a few group 2 grains were noted. They were angular and of fine sand size. The single group 1 grain observed contained "white mica" inclusions.

Chert is rare. It is restricted to mosaic or chaledonic, very fine to fine sand-sized, grains. These are mainly angular but a few are subrounded. One composite grain grades between mosaic and chaledonic.

Plagioclase feldspar is angular to subrounded, and from very fine sand to medium sand size. One grain is overgrown, suggesting a sandstone source (Tucker 1981:58). Plagioclase feldspar is present as a single angular, very fine sand-sized, detrital grain, and an almost euhedral fine sand-sized grain. Both have very clear polysynthetic twins. Symmetrical extinction angles of 5° and 12° respectively, although insufficient for application of the Michel-Levy method, suggest a sodium-rich composition.

Calcite is present as a diffuse, mainly micritic, aggregate of different shapes and sizes. It is numerous to abundant. A few fragmentary or intact euhedral plates reach fine sand size. Most calcite occurs as tiny euhedral crystals.

Zircon is rare. It occurs as angular, very fine sand-sized, detrital grains.

Tourmaline is present as rare, anhedral, very fine to fine sand-sized, detrital grains.

Fragmentary sponge spicules, phytoliths and diatoms are rare.

Clay 9.

A texturally immature silty (10YR7.5/6) clay.

Monocrystalline quartz displays mainly undulose extinction. Weathered grains, some with surfaces stained by limonite, are rare. Grains with vacuoles or overgrowths are also rare. These two factors suggest this may be a well weathered, mineralogically mature, fabric. The overall
5.2. RESULTS

Quartz fraction is low.

Polycrystalline quartz is extremely rare. Only two grains were noted. One belongs to group 2, and the other possibly to group 1.

Chert is similarly rare. Both mosaic and chalcedonic varieties, angular to subrounded, and from very coarse silt to fine sand size, are present.

Potassium feldspar occurs as very coarse silt to fine sand-sized, subangular to subrounded, grains. Plagioclase feldspar is not present.

Calcite is prominent but not abundant. It is principally scattered throughout the matrix as diffuse micritic individual crystals. There are also some fine sand-sized anhedral crystals. The abundance of calcite varies widely between sections, and it may be masked in thicker sections by the clay matrix.

Hematite, or goethite, is present either as subrounded, very fine sand to medium sand-sized pellets, or as a staining to clay-sized particles.

Zircon occurs as heavily weathered, to coarse silt size, detrital grains. It is rare.

Tourmaline is well represented by anhedral, coarse silt-sized, detrital grains.

Sponge spicules are numerous, rarely intact, but many are only slightly fragmented. Diatoms and phytoliths are prominent.

**Clay 10.**

A texturally immature and moderately micaceous (10YR/7.5/6) clay.

Monocrystalline quartz is almost entirely anhedral, with rare fragments of euhedral grains. Many grains are fractured. Undulous extinction is common, and grains with diffuse vacuoles are prominent. Several grains are weathered, but none heavily. In many grains both external and fracture surfaces have limonite stains. A few are free of limonite. Only a few overgrowths were noted. One grain has cryptocrystalline mica (?) inclusions.

Polycrystalline quartz is very rare. It ranges in size from fine to medium sand, and is either angular or subrounded. Each of the three groups is represented by just one grain. Crenulated crystal boundaries are absent from the group 3 grain. It is, however, very heavily strained into subparallel bands. Such stress bands characterise quartz derived from some varieties of mechanically strained metamorphic rocks (Williams et al. 1982:503-504).

Chert is rare. It is represented by a few mosaic, and one mammillated chalcedonic grain, with sector extinction. All were angular, and of fine sand size.

Potassium feldspar ranges in size from very fine to fine sand, and from angular to subangular in shape. It is rare. Plagioclase feldspar is angular and represented by very fine sand-sized grains, and is also rare.

Calcite occurs throughout the matrix. Many dense patches contain aggregates of mainly micritic crystals interspersed with larger euhedral crystals. These patches are usually about 0.25 mm in diameter. Euhedral platey crystals, of very fine sand size, are scattered throughout the fabric. A few, fine sand-sized, anhedral, crystals occupy voids. In each case these crystals suggest an orthochemical origin.

Hematite, or goethite, is scattered through the fabric. It appears to have precipitated into subrounded, or rounded, pellets and areas of stained clay. These are up to fine sand size.

Zircon and tourmaline, from coarse to very coarse silt size, are both present as detrital grains. They are rare.

Sponge spicules are numerous to abundant. Many are only slightly imperfect, and several are intact. Fragments tend to be well preserved. Diatoms and phytoliths are numerous.

**Clay 11.**

This texturally immature clay is dominated by silt to coarse sand-sized nonplastics. It is a
brownish yellow (10YR/7.5/6).

Monocrystalline quartz is mainly anhedral, often subhedral, and abundant. Overgrowths are numerous. Many grains show severe strain with undulose extinction being common. Several have fractures, and micro pits. Grains which have been heavily weathered mainly to internal surfaces and edges are few. Heavy weathering with limonite to fractures and external surfaces is common. Several grains have diffuse vacuoles and in a few vacuoles occur as well defined trails. Some of these grains are extensively strained. Negative crystals are common. A notably wide range of surface textures, from crisp and fresh to heavily weathered, is represented.

Polycrystalline grains are relatively rare. All three groups are present as angular, fine to medium-sized sand. One grain was heavily weathered. Another group 2 grain is severely strained.

Chert is also rare. It mainly occurs as mosaic, very fine to fine sand-sized, angular to subrounded, grains. Also present is angular chalcedonic chert, of very fine or medium sand size.

Potassium feldspar occurs as very fine to fine sand of angular to rounded shape. It is rare. Plagioclase feldspar is extremely rare. Only one rounded, very fine sand-sized, grain was detected.

Calcite is scattered lightly throughout some sections as diffuse micritic crystals. It is not generally prominent.

Hematite, or goethite, occurs apparently as a precipitate. It is often present as rounded, but with some well rounded, pellets of mainly fine sand, but also up to coarse sand size.

Zircon is rare. It ranges in size from very fine to fine sand. Tourmaline and rutile are extremely rare, angular, and of very coarse silt size.

Sponge spicules and phytoliths are well represented. Diatoms are not prominent.

Clay 12.

Another texturally immature and silty (10YR/7.5/6) clay, it contains the highest density of sponge spicules, tourmaline and chert encountered in the sample.

Monocrystalline quartz is dominated by anhedral grains, but many are subhedral. Many grains are strained, undulose extinction being common. Fractures and micro pits are prominent. Several grains are weathered, but only a few have limonite coatings to such surfaces. Internal fracture surfaces, and weathered external grain surfaces are commonly limonite free. Vacuoles, which are either diffuse or occur as trails, are rare. Grains with acicular inclusions of tourmaline are also rare. These inclusions are up to 0.025 mm long. One quartz grain contains a prismatic tourmaline intergrowth 0.02 mm wide by 0.07 mm long. Quartz grains with overgrowths are common. Some apparently authigenic subhedral grains, however, do not display overgrowths. A wide range of shapes are evident. They vary from angular to rounded. Some are almost well rounded.

Polycrystalline quartz is not abundant. All three groups, however, are present. They range in size from fine to medium sand. They are all angular and one is heavily weathered. A group 3 grain, probably metamorphic in origin, is stretched and granulated (Folk 1980:69-72).

Chert, both mosaic and chalcedonic, is prominent. Both varieties range from very coarse silt to fine sand in size, and from angular to subrounded in shape.

Potassium feldspar is rare, angular, and of fine sand size. Plagioclase feldspar is absent.

Calcite is scattered thinly throughout the fabric as anhedral micritic crystals. Euhedral micritic crystals surround a few quartz grains. Many voids are full of authigenic euhedral plates and anhedral crystals, of up to very fine sand size.
Hematite, or goethite, occurs as angular to rounded pellets and clay stainings, of mainly very fine, but also up to medium, sand size. Anisotropic black laterite is present as well rounded very coarse sand. A pore filling of micritic calcite crystals in some cases bounds the laterite-clay-matrix interface. A few quartz grains are encased in ferruginous material. This has produced ooid-like shapes.

Zircon is rare, detrital, and from very coarse silt to very fine sand in size. Tourmaline is well represented. It occurs mainly as angular to rounded, detrital grains. These are of coarse silt to fine sand size. In addition, several acicular rods ranging from 0.05 mm to 0.07 mm in length are present. One euhedral crystal, with rhombohedral terminals, measured 0.05 mm in length.

Sponge spicules are abundant. They are often well preserved. Diatoms and phytoliths are numerous.

Clay 13.

A texturally immature, (10YR/7.5/4), clay.

Monocrystalline quartz is mainly anhedral, often subhedral. Many grains are strained. Undulose extinction is common. Several grains have fractures or micro pits. Weathering to internal and external surfaces, either with or without limonite staining, is often present. Many grains contain numerous, but diffusely spread, vacuoles. Overgrowths are common. A few grains contain tourmaline inclusions (fig. 5.2).

**FIGURE 5.2: TOURMALINE INCLUSION IN A WELL-ROUNDED QUARTZ GRAIN.**

Polycrystalline quartz is not prominent. A few group 2 angular, very fine to coarse sand-sized, grains were noted. A group 3 grain, probably metamorphic in origin, is stretched and granulated (Folk 1980:69-72).

Chert is rare. It is represented principally by angular to subrounded, fine to medium sand-sized, mosaic grains. One composite grain, which is graded between mosaic and chalcedonic, and one ordinary chalcedonic grain were also noted.
Potassium feldspar is a minor component. Although none were recorded during point counting, several angular, very fine to fine sand-sized, grains were observed. Plagioclase feldspar is very rare. Two angular grains, one of very coarse silt and the other of very fine sand size, are present. Symmetrical extinction angles suggest a sodium-rich composition.

Calcite generally occurs as a numerous scatter of micritic crystals throughout the fabric. In places this may be abundant. Its presence is highly variable, however, and some sections have little. A few larger, often euhedral, platey crystals of up to fine sand size also occur.

Hematite, or goethite, is represented by several angular to rounded pellets, or clay stainings, of up to fine sand size. One rounded grain, of very coarse sand size, contains several quartz grains. The ferruginous material in this latter grain is dense, and mainly opaque in thin-section. It grades from brown to black and is thus optically consistent with a hematitic ironstone (Williams et al. 1982:415). This material may thus represent the dehydrated goethite and hematite characteristic of laterite (Birkeland 1974:114).

"White mica" is present as threads up to 0.05 mm long. It is very rare.

Zircon is also rare. It occurs as angular, very fine sand-sized, detrital grains. Tourmaline is of coarse silt size and very rare.

Fragmentary sponge spicules, diatoms and phytoliths are rare.

Clay 14.

A texturally immature (10YR/7.5/4) clay.

Monocrystalline quartz is substantially as for clay 13. It has slightly fewer grains with overgrowths. One grain has a subhedral tourmaline intergrowth 0.08 mm long.

Polycrystalline quartz of group 2, and mosaic chert are each represented by a single fine sand-sized grain.

Potassium feldspar is again minor. It ranges from very coarse silt to medium sand in size, and in shape from angular to subangular. Three angular, very fine to fine sand-sized, grains of plagioclase feldspar were noted. Their symmetrical extinction angles suggest a sodium-rich composition.

Calcite is not abundant. It is present as a diffuse scatter of micritic crystals in most thin-sections.

Ferruginous minerals are the same as described for clay 13.

Several grains of zircon were noted. It occurs either as angular, very coarse silt or very fine sand. Tourmaline, of the same dimensions but usually bladed rather than granular, is rare.

Sponge spicules, diatoms and phytoliths are rare.

### 5.3 Summary and concluding remarks

Sakon Nakon Basin clays can be characterised by a dominance of minerals derived from older sedimentary sources. They are reworked sediments. The sponge spicule deposits are consistent with transported clay. There is no evidence to suggest they result from modern sedimentation (see also chapter four). Given the depth that the potting clays are quarried, even if they relate to the latest deposition of sediments documented by Loffler et al. (1983), they predate the occupation of Ban Na Di. The nonplastics are mineralogically mature, but their texture appears immature. A full textural analysis is beyond the scope of the present work. Although the shape and sorting of nonplastics have been estimated in thin-section, these, along with the surface textures of grains and fabric composition, suggest textural immaturity. According to Folk's (1980:26) sediment scheme, the clays can be considered sandy (> 10% but < 50% nonplastics). Sediment fabrics with a high matrix component suggest textural immaturity.
5.4. MINERALOGICAL ZONES

(Tucker 1981:20). Older sedimentary source sediments may have a “generally low” textural maturity (Folk 1980:140). Differences in textural and mineralogical maturities are common in sediments, and this is related to their sedimentation history (Williams et al. 1982:328).

The Sakon Nakhon Basin regional geology is reflected in the clay mineralogy. Thus the clays contain reworked sedimentary minerals, often with much chert. The quartz fraction in these clays displays a wide variation in surface texture. Much is fresh and displays little evidence of weathering. These clays can be conceived as being compositionally immature. They will increase in maturity with distance from source and variations in weathering. Because of this, a textural definition of maturity is preferred.

The mineralogical maturity of the Sakon Nakhon Basin clays is characterised by a lack of all but the stable and ultrastable heavy minerals (Hubert 1971:459), in association with cherts and quartz overgrowths. Detailed maps are not available for the area. As Mesozoic strata are thought to underlie the entire plateau, however, we can anticipate that the same rocks are present and exposed in the Phu Phan Range (Cruijs 1978). The Mesozoic strata is comprised of the Khorat Group. According to Javanaphet (1969) the Phu Phan Range includes the Phu Phan, Phra Wihan and Phu Kradung Formations, and these form part of the Khorat Group. Exposures of these Formations, which border the Petchabun Range and western plateau margins, have been geologically mapped.

Chongpan and Nares (1979), note that the Phu Phan Formation contains a pebbly sandstone. The pebbles consist of quartz, chert, red siltstone and igneous rocks up to 5 cm in diameter. They are intercalated with shale and conglomerate. The Phra Wihan is comprised of an orthoquartzitic sandstone with some intercalations of reddish-brown and gray shale. The Phu Kradung comprises micaceous shale, siltstone and sandstone, with some lime-nodule conglomerate. Thus the Sakon Nakhon Basin clays are readily understood in terms of the regional geology.

5.4 Mineralogical zones

In terms of the nonplastic components of the clays described above, four mineral zones are evident (fig. 5.3).

Micaceous zone

Two quite highly micaceous clays are restricted to a small zone bordering the northern margins of the Phu Phan Range. In clay 3, muscovite is generally present as sericite threads. It occasionally occurs as sericitic inclusions in both mono- and polycrystalline quartz. The association of muscovite pseudomorphs of potassium feldspar, sericite threads and kaolinite, in clay 3, suggests deeply weathered potassium feldspars. Bleached biotite and associated vermiculite occurs in clay 2. It lies upstream of clay 3. These two clays are the only samples containing “large” optically identifiable micas (Folk 1980:86).

Micas in the remaining Sakon Nakhon Basin clays are mainly cryptocrystalline. Clays 6, 7, 9, 10 and 11 gave mica reflections in the XRD spectra (chapter four). Clay 10 is the only one of these which is moderately micaceous in thin-section. It includes a few threads of “white
CHAPTER 5. THE PETROLOGY OF SAKON NAKHON BASIN POTTING CLAYS

Sponge spicule zones

Sponge spicules occur in relative abundance in two small zones. One lies close to the western edge of the basin. This zone includes clays 9 and 12. The other zone is represented by clay 10 at Nong Kham Din.

Plagioclase feldspar zone

Plagioclase feldspar is restricted to a small slightly elevated area which extends towards the northwest from the Phu Phan Range just north of Lake Kumpawaphi. This zone is about 10 km wide and stretches 25 km towards the basin interior. Ferruginous minerals are poorly represented. The plagioclase feldspar zone encloses Ban Na Di.

Ferruginous zone

Ferruginous minerals follow the above zoning pattern, but in reverse. They are poorly represented towards the centre of the basin and tend to be most numerous near its margins.

5.5 Paragenesis

An understanding of paragenetic processes which effected the present clay distributions is important to one of our primary objectives: the sourcing of prehistoric ceramic fabrics. Only a very brief outline is necessary.

It is likely that four principle geomorphological processes have been responsible for the present Sakon Nakhon Basin clay deposits. Epierogenic uplift, tectonic folding and faulting, climatic change during the Pleistocene, and recent humid weathering conditions have combined to produce the present landscape. Each of these is interrelated.

The various quartz species, including cherts, are derived from weathered silica-cemented quartzarenite sandstones or orthoquartzites (i.e. unmetamorphosed quartz-cemented quartz arenites (Williams et al. 1982:559)). These reworked sediments are almost ubiquitous. Overgrowths are only absent in clay 8, which is located in a high portion of the basin. Polycrystalline quartz and chert both diminish in abundance with distance from outcrops of the Khorat Group. Igneous quartz can probably be sourced to the sandstone pebbles of the Phu Phan Formation. The lime-nodule conglomerates of the Khorat Group, plus allochemical constituents probably account for the calcareous minerals. The Phu Kradung Formation probably supplied the micas prominent in clays 2 and 3.

Thus three different sedimentary mineral groups are present:

1. allochemical: represented by spicules, phytoliths, diatoms and some calcite.
2. terrigenous: represented by reworked sediments, including weathered, chemically-cemented sandstones and igneous quartz.
3. orthochemical: represented by calcareous, and ferruginous minerals.

It is anticipated that the differentiation evident in Sakon Nakhon Basin clays will also prevail in the larger Khorat Basin. Given the broadscale regional lithofacies, however, many clays may be very similar to those set out above. Clay from the Chi Valley has been briefly examined for comparison. It also contains some reworked sedimentary minerals, but little chert...
or polycrystalline quartz. Spicules are well represented. Potassium feldspar and ferruginous precipitates are rare, and zircon and tourmaline very rare. Many quartz grains indicate severe stress.

FIGURE 5.3: SAKON NAKHON BASIN MINERAL ZONES.
Chapter 6

The identification of production centres

“although technological and stylistic studies are closely interdependent, we cannot rate one as more important than the other, since they furnish different kinds of information”.

Shepard (1942:232).

Consideration of Shepard’s pioneer work in the Rio Grande will, in the first instance, provide a testable model for the present work. Her approach involved a petrographic analysis of ceramic fabrics and their comparison and quantification with pottery forms. Particular reference was made to tempers and surface treatments. She was able clearly to demonstrate intensive trade/exchange networks hitherto either unknown or the subject of conjecture. This enabled temporal changes to be understood in detail. As a result, substantial reformulation of the regional chronology was required. It had previously been erroneously based on changes in ceramic styles. In essence two important factors were considered in detail by Shepard:

(i) the various technologies involved were subjected to a fine-grained analysis. Thus changes in individual manufacturing traditions were detected and readily compared with other regionally-associated traditions.

(ii) the identification of pottery production centres.

Both of these factors are interrelated. They are important to an understanding of prehistoric ceramic cultures. Without this knowledge we may easily be deceived that the mere presence of pottery is consistent with its manufacture on site (Shepard 1942:177). Even large quantities of pottery cannot be taken as prima facie evidence for in situ production.

Production centres may be identified by defining the proportions of local against foreign material present in any site or ceramic district. Ceramically independent sites or districts should contain mainly local tempering material, and a small percentage of foreign material. Temper species may be defined by either mineralogical or technological criteria. An understanding of the magnitude of an indigenous industry provides insight into important cultural questions (Van der Leeuw 1981, Peacock 1982). It helps define the industry’s production character and related technological complexity. These reflect sociological and economic influences. Many of these questions are interrelated with, and articulate, other cultural variables.
Renfrew (1972: 22,37) pointed out that changes in technology as a subsystem may precipitate change in other subsystems, often to their mutual enhancement. This can have important consequences for cultural processes (Flannery 1968, Hammond 1976, 1977).

The above discussion is not meant to imply that such changes are necessarily evolutionary, in an orthodox lineal or straight-line-trajectory sense, or that they represent or reflect important cultural changes. In some cases, particularly those involving small-scale production, manufacturing changes may have little effect (May and Tuckson 1982). These are probably minor exceptions, however, and it seems safe to assume that for most production centres, manufacturing changes reflect important underlying cultural changes. Unfortunately our present knowledge of Southeast Asian production centres is so scant that to attempt to redress this paucity in a stroke risks self-deception and misrepresentation. Yet such is the importance of production site identification that we must start somewhere, even if this means reaching out from a position of almost total darkness.

The characterisation of local ceramic technologies is a first step in making regional comparisons. These provide information important in identifying production centres. Recognition of these centres may be vital in developing relative chronologies, understanding variations in local technologies, modes of production and patterns of exchange. In the Rio Grande study, their illumination led to the discovery of dynamic changes both inter and intra regionally with time.

Fabric characterisation was central to Shepard’s analysis. Particular attention was paid to the petrographic identification and categorisation of temper species, and microchemical analyses of glaze paints (Shepard 1942:135). A critical assumption being that while potters are notoriously fickle in their adoption and/or adaption of exotic or innovative designs or styles, they display an almost unswerving conservatism in their approach to technological matters (Shepard 1942:177). Recent ethnographic studies support this conservatism. Potters often enjoy indulging in new fashions (May and Tuckson 1982:199). Innovations include minor variations of traditional designs or styles when these are socially acceptable (May and Tuckson 1982:218-220). Perhaps these serve to provide relief from the customary mundane, and necessarily repetitive, preparation and construction processes. Commercial incentives, however, usually exert more immediate influences (May and Tuckson 1982:229, 237, 289). Primarily, in Shepard’s view, changes in temper species can reflect major cultural changes. This is because, although style changes are readily achieved, technical changes risk serious production failure.

Three questions arise from this reliance on “temper-typing”. Firstly, can tempers always be clearly identified? Second, are they always geologically, and by extension archaeologically, meaningful? Thirdly, are we justified in assuming they are always treated in the conservative manner suggested by Shepard?

We will begin by considering the first two questions from a geological perspective, because that is an approach favoured by proponents of the petrographic method (cf. Shepard 1936, 1942, 1956, 1965; Peacock 1970, 1982:169). The third question requires the scrutiny of both ethnographic and archaeological data.

Fabric petrology, if distinctive rocks and minerals are present, helps suggest the origin of a ware. When the temper is composed of these materials further information is available. Shepard (1942:134) argued that the identification of such tempers indicated the geographical area a ware was made in, its principal production centres, the volume and direction of trade, centres of stylistic development and the chronological position of types.
CHAPTER 6. THE IDENTIFICATION OF PRODUCTION CENTRES

Technological analyses, according to Shepard, involve three principles: "adequate sampling, exact and detailed technological analysis, and correlation of archaeological and technical data" (1942:226). In some instances correlating temper data with other ceramic properties, such as colour and firing characteristics, can also assist in characterising wares. These values, however, were applied to tempers exhibiting clear geological affinities.

In stark contrast to the Rio Grande, the Khorat Plateau is a relatively undifferentiated geological region. The potting clays discussed in chapters four and five clearly emphasize this point. Therefore, in view of this indistinct geological terrain, we may need to extend our enquiry beyond the constraints imposed by a strictly mineralogical "temper-typing" approach in order to identify production centres. A similar strategy was employed by Shepard (1948:101-102), even when mineralogically distinctive tempers were the outstanding identification criteria. As she later observed: "Our primary problem, therefore, is to evaluate the properties and decide how much time we are justified in devoting to them" (1956:101).

6.1 Ceramic production evidence

Ceramics embody both physical and non-physical evidence. We will initially restrict our discussion to physical data but need to retain the option to cast our net wider if necessary. Since our primary task is to identify production centres, we commence with an assessment of physical production evidence.

Most technological studies are confined to evidence provided by pottery alone. Little direct attention seems to have been paid to the tools used to manufacture pottery, such as ceramic anvils. Except, of course, as they are reflected in technological factors discoverable in the pottery itself, such as residual impressions left over from vessel forming (Shepard 1956: 59-60, 185, 394), and in Thai contexts Glanzman and Fleming (1985:114-121)). Intrusive pottery identification was considered by Shepard to be concerned with either the importation of completed ceramic wares or exotic raw materials (1956: 336-341). Although forming and decorating equipment is sometimes considered in detail, it does not usually appear to be often considered for provenance purposes. Presumably this is because it is nonceramic or cannot be linked to its source for some other reason. Ceramic anvils, however, could provide prima facie evidence useful in tracing the movement of potters from one production area to another.

A variety of physical evidence is available from the sites under investigation here. It can be conceived of as being either primary or secondary. The former is direct, involving information regarding the physical environment. Secondary evidence, however, is indirect and often merely implied, such as prestige accorded to potters in a ceramic manufacturing centre. Such prestige may be reflected in the disposition of wealth in funerary assemblages (Vincent in press).

6.2 Primary evidence

Ceramic artefacts, raw, and industrial associated materials, are all primary physical evidence. Raw materials can be either unprocessed or processed to varying degrees. Some raw materials are reconstituted artefacts. Crushed pottery, for example, is often used as a temper. Industrial associated evidence embraces both ceramic and non-ceramic accoutrements, such as tools and moulds. It also incorporates firing fuels and/or firing remains, artefact construction and decoration evidence such as residual joining, shaping and surface finishing marks, and evidence...
for the blending of clays.

(i) Temper

Temper is any material deliberately added to plastic clays before firing in order to improve their ceramic qualities. It is often the most important item of primary physical evidence and falls into two groups, natural and artificial. Natural tempers include geologically derived materials such as rock fragments, sand, ash, silt, and biogenetic products. Modern biological materials, either faunal or floral, are also used. In addition, clay deposits may contain wood, shell, diatoms, phytoliths, sponge spicules and foraminifera, as well as other faunal and floral remains. These may be paleontological or modern. Clastic and organic nonplastics in raw clays are of course not tempers, but natural deposits. As fractions of the parent ceramic fabric, however, they may be equally helpful in identifying clay sources. They are particularly important when present as major and distinctive components. Although they are often clay-sized, their chemical and thermal response differs from clay minerals.

Care needs to be exercised in distinguishing between natural or purposely added inclusions as the characterisation of these different species may provide important cultural insights. This applies equally to such nonplastics as rock fragments (Whitbread 1986:79-88), or the remains of volatile plant material such as rice husks (Yen 1982; Vincent 1984b). Rice husks and/or straw may be accidentally incorporated into plastic potting clays during quarrying or manufacturing processes. Many modern Sakon Nakhon Basin potting clays, such as the Ban Nong Phai clay (site 7 fig. 4.7), are quarried from beneath rice fields. Hence the exclusion of plant material is impracticable, even if desired. When ceramic and crop subsistence activities are interrelated, and undertaken in close proximity, the unintentional inclusion of plant fragments into plastic clays is almost inevitable. Thus the presence of rice remains in prehistoric fabrics, whether accidental or deliberate, may provide prima facie evidence of close relationships between subsistence and technology. This point is important and we will return to it later.

Artificial tempers are manufactured. They may be materials originally intended for other uses, or purposely prepared as fabric additives. Crushed potsherds may be either unintentional and/or deliberate inclusions. Prefired and subsequently crushed clay ball temper (“chua”) is an example of purposely manufactured temper. Both are usually categorized as grog by most ceramicists, and that definition is also used here. According to Bayard (pers. comm.), “chua” means “a substance added to cause a change”. This Thai word is also used for yeast or leavening in baking. A unique kind of manufactured grog has been previously described by the writer as “blebs” (Vincent 1984b). In thin section, liwbleb temper can be clearly differentiated from other prefired clay grog, as opposed to potsherds, by both its shape and association with rice remains. A different kind of crushed clay grog, however, is also present in many prehistoric fabrics. This grog does not possess the characteristic bleb shape. It was probably widespread within the Khorat Plateau prior to the first appearance of bleb temper (Vincent 1984b). This kind of grog has also been reported elsewhere (Whitbread 1986). For these reasons it is here referred to as orthodox grog. Thus three different subspecies of grog exist, each of which can be distinguished petrographically:

(i) crushed potsherd grog either the crushed remains of once entire ceramic artefacts, and/or pottery which is the result of firing failures, often termed “wasters”.

(ii) orthodox grog (crushed prefired clay which does not normally contain temper). Although exceptions to this maxim may exist, by definition they will never contain rice remains as the tempering agent.
(iii) *bleb grog* crushed prefired clay which has been purposely tempered with rice plant remains, normally featuring varying amounts of rice husk, prior to its initial firing.

Rice husk added to the prepared clay balls accounts for the distinctive shape of the bleb subspecies of grog. Its shape gives rise to its name. Although the balls are rice-tempered, crushing disintegrates the mixture and any surviving unburnt rice is dislodged. This is probably because rice acts to weaken the composition, and fracture planes coincide with its distribution. The disintegrated particles, comprising rice remains and ceramic material, are together mixed with additional raw potting clay to form the final plastic preparation. Therefore, although rice husk impressions are common to the grog, the parent body, not the grog particles, characteristically contains rice husk.

Figure 6.1 illustrates selected properties of the above grogs. In addition, some of those used by Whitbread (1986:80 table 1) for the description of argillaceous inclusions are included for comparison. Care needs to be exercised when identifying these grog subspecies in thin section, and the cautionary tale set out by Whitbread (1986:79-88), with regard to argillaceous material is equally pertinent when analysing Southeast Asian ceramics.

![FIGURE 6.1: SELECTED PROPERTIES OF GROGS IN THIN-SECTION.](image)

Several modern bleb-tempered fabrics of known composition have been examined, both in hand specimen and thin-section, for comparative purposes. Modern bleb temper characteristics coincide with those observed in prehistoric ceramics. Hence we can be confident that the
6.2. PRIMARY EVIDENCE

criteria set out above for bleb temper are correct. These ethnographic data not only allow confidence in the bleb petrographic definition, but also provide direct evidence of the production processes involved. Bleb temper is currently used by many potters in Northeast Thailand, but its regional extent is not understood in detail. The distribution of modern tempering methods appears somewhat heterogeneous. Immigrant potters today tend to bring their methods with them. This may account for the apparent heterogeneity. The practice clearly supports Shepard’s temper conservation thesis. A detailed description of each grog subspecies appears in appendix one.

Even a cursory glance at a geological map of Thailand as a whole (figs. 6.2, 6.4, and 4.4), and the Central Plain and Khorat Plateau regions in particular (Thiramongkol 1983:6-23), demonstrates that large areas are composed of sedimentary materials. Much is alluvium and colluvium. Data presented previously (Vincent 1984b), and expanded here, show that many of the clays available in these regions are not suitable for pottery production in an unmodified state. This is predictable, as raw clays often require processing before they are suitable for pottery (Grim 1962, 1968, Hamer 1975). Normally this involves the addition of temper in order to reduce excessive shrinkage during forming and firing. A wide variety of naturally occurring suitable material is often locally available. Many have previously been identified with handcrafted pottery production elsewhere (May and Tuckson 1982, Shepard 1956).

Hodges (1965:121), in considering pre-Roman European pottery, suggested that the traditional use of grog may indicate it was originally developed in an area that lacked locally suitable mineral or organic tempers. This situation was rare in Europe. Therefore, the grog-tempered bell beaker ware, for example, could have been developed in an area without mineral tempers, such as the “loess lands”. Beaker pottery, in contrast with “the vast majority of Neolithic wares in Britain”, was almost invariably grog-tempered. Hodges implied that tradition may dictate a continued preference for grog even when other suitable tempering materials become available.

In Thailand, grog temper may represent a response to a lack of natural tempers suited to the raw potting clays. It is perhaps significant that Khorat Plateau clays feature either mixed-layer clay minerals and/or a high proportion of silt-sized nonplastic material. The Sakon Nakhon Basin raw clays probably often lack an adequate proportion of clay minerals to tolerate additions of fine sand to sand-sized temper. Granule-sized nonplastic temper, however, could reduce the proportion of clay minerals needed to achieve a satisfactory aggregate. Granules could also fulfill the important function of allowing chemically unbound water to escape rapidly, and reduce shrinkage, although this does not appear to be generally excessive (Table 4.2). Sufficiently strong ceramics were produced from such an aggregate at Ban Na Di. When pottery production forms a vital cultural component, a local paucity of suitable natural materials may favor manufacture of artificial temper. Grog could have originated in the sedimentary regions of Northeast Thailand prior to the availability of reliable supplies of suitable alternatives, for example rice by-products. This is, of course, speculation. Evidence set out in following chapters, however, could be interpreted as supporting such a sequence.

Grog in ceramic fabrics has been fired twice. Thus fabrics containing grog composed of the same raw clay as the parent body contain twice fired clay. It has experienced a primary firing as prepared clay balls, followed by a second pottery firing. Grogs, dependent on respective firing temperature, can be either “hard” or “soft” (Hamer 1975:150). Those previously fired to temperatures lower than the parent body firing are soft. Hard grogs are first fired to temperatures above the final body firing. Grogs, as with their parent ceramic bodies, may be tempered or untempered.

Untempered grogs should not be confused with either “clay temper” or “clay pellets".
6.2. PRIMARY EVIDENCE

The former is unfired, and therefore plastic, clay, either accidentally included as dry lumps, or deliberately added by the potter during manufacture. Clay pellets are formed by a wide variety of natural processes, and along with clay temper may be difficult to identify in thin-section. A major problem is that with hand-formed fabrics localised variations in moisture content may create small dry lumps during preparation processes. This produces a heterogeneous fabric with lumps of relatively dry material isolated within the moister containing material. When fired, the lumps may be indistinguishable from natural inclusions. Whitbread (1986:83-84) discusses some aspects of clay temper and pellets in detail. Selected properties observed in Southeast Asian fabrics are set out in figure 6.1.

Firing alters clay mineral chemical bonds (Grim 1968), and modifies the overall structure of potting clays. Thus, dependent on the firing temperature, the amount of unbound and bound water able to be adsorbed is greatly reduced or eliminated completely. Temperatures of over 1000° C. have been recorded for open firings (Lauer 1972, 1974, Irwin 1977). This would produce initial vitrification in many clays (Maniatis and Tite 1978, 1981). Firing test results for Sakon Nakhon Basin clays are set out in chapter seven. They suggest temperatures up to a maximum of 950° C, and as low as 700° C were common at Ban Na Di.

Artificial grog manufacture may imply some knowledge of clay mineral properties. The initial firing renders an unsatisfactory raw clay into a useful temper. Such grog is less susceptible to shrinkage, even when refired within a parent matrix of the same clay. This method, in a sense, is a kind of "self-tempering". It only requires one resource to be extracted from the environment. Given that most raw clays require tempering, potters using such grogs are less reliant on local resources than others without the necessary skills. This independence could further reinforce their inherent technological conservatism. Thus potters familiar with artificial grog may be less likely to change their temper concept than others. Khorat Plateau evidence supports this conservatism, because in spite of an availability of alternative materials, grog traditions endured. Within the Sakon Nakhon Basin, for example, some contemporary production sites used grog but others preferred rice temper for clays of similar ceramic quality.

Artificial and natural inclusions can be indistinguishable in thin-section (Whitbread 1986). The comparison of fabrics whose composition and manufacturing history are known, with pottery of uncertain fabrication, however, provides important information. The method is particularly valuable for characterising artificial grog tempers in thin-section. Their manufacturing history can thus be established.

Grog may contain any of the natural and/or artificial inclusions listed above in combinations which make identification difficult. We need not rely on one form of petrographic evidence, however, or infer that because some argillaceous inclusions are difficult to characterise, the identification of grog tempers is hazardous. It is not. Shepard (1971:97-100), noted that observing and handling large quantities of pottery develops a "pottery sense", by which she meant a "process of organization of impressions" (1971:97-100). This referred mainly to hand specimen studies, but they equally apply to petrographic microscopy. "It is not simply a matter of familiarization through repetition. It is seeing continuous variations and their limits, and recognizing associations and discontinuities" (Shepard 1971:98). As with potsherds, so with argillaceous inclusions in thin-section. The optical comparison of known with unknown fabrics allows positive identifications. It also allows confidence in defining the limits of optical variations displayed by argillaceous inclusions.

Ceramic data may provide insight into nonceramic cultural aspects. Bleb temper, for example, suggests a close relationship between subsistence and technology because it is associated with rice husks. A consistent use of rice husk in quantity cannot be regarded as a whimsical
aberration, because any temper selected must be reliable in two ways. First, as a ceramic component, it must be technologically dependable. Second, because temper plays a central role in the overall pottery manufacturing process, it must be readily available. A key factor in the choice of a temper is the existence of a consistently reliable supply. The use of rice husks for temper indicates a close relationship between subsistence and technology. It also suggests that this valuable source of food was exploited on a permanent basis. Whether as a cultigen, or an abundant and readily harvested wild plant, is yet to be established. In either event an intimate knowledge of the plant seems obvious. Ceramics containing rice show an overall increase with time in the Khorat sites examined. These data are set out in the following chapters.

(ii) potting clays

Many potting clays can only be sourced to large areas of homogeneous strata. Thus they cannot be readily identified with specific geological terrain in an archaeologically meaningful way. Clays derived from broadscale outcrops of sedimentary rocks, for example, are often indistinct (Peacock 1970:379). Most sites under investigation here are located within a large plateau which displays little obvious geological variation. Fortunately, several helpful details are apparent. The available geomorphological data, summarised below, are discussed more fully in chapter four.

The Khorat Plateau is extensively blanketed by Quaternary sediments. Outcrops of distinctive rocks are mostly lacking apart from small scattered exceptions. The entire plateau is probably underlain by basement Mesozoic sedimentary rocks (Cruiks 1978). Subsequent epeirogenic processes have caused only moderate warping of the internal structure. Erosion and sedimentation, either as glacial-related aeolian deposits or surface and river eroded valley infill, have probably been the major land forming agents during this period (Moorman et al. 1964; Cruiks 1978; and Loffler et al. 1983).

Using data from 35m deep cores, Loffler et al. (1983:126) suggest an idealized stratigraphy for Tung Kula Ronghai (TKR) in the central Mun River Basin (fig. 6.3). This site is centrally located in the southern Khorat Basin, therefore the results are considered applicable to the entire Khorat Plateau (Loffler et al. 1983:123). A sequence of five sediments were encountered. Clay is present in the alluvial sediments. It forms the youngest strata as a cap overlying alluvial substratum. Thus it almost certainly represents transported clay. Data set out in chapter five suggest that the Sakon Nakhon Basin potting clays are reworked sediments derived from older sedimentary source rocks. Thus, in terms of current evidence, the clays can be considered to be geological. There is no evidence to suggest that they result from modern sedimentation. At TKR the clay layer is 2-4m thick.

Many of the Sakon Nakhon Basin potting clays contain distinctive biological deposits (chapter five). For sourcing purposes the most important of these are the skeletal remains of the fresh water sponge *Ephydatia meyeni*, kindly identified for the writer by Professor F.W.Harrison, head of the department of biology, Western Carolina University. Harrison reports that this species is presently found throughout the region. Sponge spicules of the genus *Ephydatia* were first reported by Lamarck (1802:374) from both Miocene and Holocene contexts near and within Lake Baikal.

For sourcing purposes, we must discriminate between modern and geological sediments as each could contain *Ephydatia meyeni* spicules. Field observations indicate that the potting clays are presently quarried from geological deposits. The modern sediments appear to be deficient in clay minerals and over represented by silt and plant material. Clays derived from
Tertiary, Mesozoic or even Paleozoic Periods are widely exploited for pottery (Grim 1962:130-133). Recent sediments are less likely to contain much kaolinite as illites and chlorites appear first in leaching conditions (Grim 1962:41-44). Very Ancient sediments, however, contain mainly illites and chlorites, as smectite and kaolinite disappear in sediments of increasing age (Grim 1968:554). Clay-mineral formation processes are generally slow (Krauskoff 1967:187-196), but may be very rapid in tropical conditions (Grim 1968:523).

(iii) Sakon Nakhon Basin potting clay sources

To assess the potential of raw potting clays for sourcing prehistoric ceramic production their mineralogical composition will be summarized here. Detailed petrographic descriptions of each clay are set out in chapter five. This evidence should be compared with ceramic petrographic data from prehistoric sites located both within and beyond the plateau margins (appendices one, two and three).

Clays from 14 currently or recently-used quarries have been tested for shrinkage and firing properties. Each has also been fired and examined in thin-section. The clay mineral composition of each has been determined by X-ray diffraction. The results are set out in chapter four. The unmodified "workability" of each clay has been subjectively tested by a professional potter. These results are given in Table 4.1. Each clay was also prepared into bisques to test their shrinkage characteristics (Howard 1982:147-150). The results are listed in Table 4.2, and should be read in conjunction with the petrographic data.

Apart from sponge spicules and clay minerals, Sakon Nakhon Basin potting clays are not generally distinctive in thin-section. A full sedimentological analysis is beyond the scope of this work. Further, particularly in light of the regional geology, it seems likely that such data would be more useful in suggesting the paleoparagenesis of the clays, than in providing direct sourcing evidence. We need to discriminate between different potting clay sources. Compared to the broadscale distribution of the plateau’s sediments, (Moorman et al. 1964), the potting clays are highly localised. We need, therefore, to emphasize factors likely to provide sourcing evidence.

The often close mineralogical similarities displayed by the clays brings with it disadvantages and advantages. On one hand, the lack of obvious variability within the immediate study area is restrictive, yet this disadvantage brings as compensation one important advantage. Although the region appears to have a relatively undifferentiated mineralogy, it is encompassed almost entirely by more distinctive rocks (Javanaphet 1969, Crujjs 1978, Gliessman 1983). The resultant large scale variability is marked. This situation can be extended to the entire Khorat Plateau. Thus, although some pottery within the region can be difficult to characterise and differentiate in thin-section, material derived from outside the plateau should be distinctive. Local wares from Khok Charoen (Watson et al. 1982), for example, contain volcanic rock fragments. Pottery from Nong Nok Chik, Non Nok Tha, Khok Ph anom Di and several Loei sites have been examined by the writer in thin-section. In each case the material is distinctive. Thus material exotic to the present study area usually stands out with crystal clarity.

In terms of sorting and angularity of nonplastics, each clay can be classed as texturally immature after Folk’s (1980:26, 100) scheme for sandy clays, and sediments with >5% clay. In the fired bisques, excluding silt-sized and aphanitic material, nonplastics vary from about 10% to 40%. They range from coarse sand to fine silt in size, and are mostly angular to subangular or subrounded in shape, and poorly to moderately sorted. Quartz, mainly mono-, but with some polycrystalline grains is present throughout. Quartz overgrowths and various cherts diagnostic of a reworked, mineralogically mature sedimentary source are common. Potassium feldspar
occurs throughout in minor amounts. Plagioclase feldspar is restricted to a small area lying between the Upper Songkhram and Kumpawaphi catchments. Heavy minerals are zircon, tourmaline, and rutile. Tourmaline and then zircon being the most abundant. Nearly all the heavy minerals, with the most common exception being zircon, are aphanitic. All the clays contain phytoliths. Some probably derived from rice plants (Yoshida et al. 1962). Diatoms are also present in some clays.

Initial petrographic analysis (Vincent 1984a), suggested “collophane”, a broad term for the cryptocrystalline mineral component of apatite, Ca₅(PO₄)₃(OH,F,C₁), was present as numerous silt-sized grains in both clays and ceramic fabrics. Subsequent electron microprobe analysis, however, has eliminated collophane from consideration. The grains are optically consistent with plant phytoliths (Brydon et al. 1963; Twiss et al. 1969; Widing et al. 1973). In view of the almost ubiquitous presence of rice agriculture throughout the plateau (Moorman et al. 1964), rice phytoliths are to be expected. Iron-rich clay lumps, hematite and goethite are common and calcite occurs in varying proportions in many of the clays, principally as cryptocrystalline material.

Three petrographic characteristics distinguish these clays in thin-section. They are sponge spicules, mica and plagioclase feldspar. Sponge spicules are present in each clay, but in varying quantities. The clay mineral matrices, of both clays and ceramic fabrics, can be separated into three different groups. In one the birefringence is micaceous, another is moderately micaceous, and the third is silty and dull. Shepard (1956:30) describes the former phenomenon as “micaceous sheen”. The clays and ceramics examined from within the plateau are generally only moderately micaceous. This contrasts with micaceous fabrics derived from external geological formations. Ceramics from Non Nok Tha and Non Nong Chik for example, which are located in the Phu Kradung Formation, contain distinctive, highly micaceous, matrices. The Phu Kradung strata contains micaceous shale, sand and siltstones. One group of Sakon Nakhon Basin clays, however, is also distinctively micaceous.

The origin of spicules in ceramics is of archaeological importance. The addition of previously burnt and crushed fresh-water sponges into clay as a temper has been reported in South American ethnographic and archaeological contexts (Krause 1911, Linné 1925, 1965, Serrano 1950). Selkirk and Adamson (1982:197-210), assessed the utility of microfossils for archaeological reconstructions. They infer that fresh-water sponge spicules (megascleres), found in 2000-year-old pottery associated with Sudanese White Nile sites, represent purposely crushed sponges added as temper. This is because sponge remains are abundant and “organic details that could not have survived natural death” are preserved.

The above ethnographic reports establish the use of burnt sponge remains for temper. Thus, when ancient fabrics of unknown fabrication contain spicules, it may seem reasonable to infer that they were deliberately added as temper. The Sakon Nakhon Basin clay deposits, however, incorporate spicules as natural inclusions. To infer that spicules are temper from their presence in ceramic fabrics would, therefore, be unwarranted without supportive information. Hence care should be exercised when defining their origins. Simpkins and Allard (1986:108) noted sponge spicules in Orange series ceramics from South Carolinian coastal sites dated to c. 1700 B.C. Unfortunately they do not discuss their status, and consequently it is unclear whether they are natural inclusions or deliberate additives. Thin-sections of the fired clay bisques and modern Ban Pluai pottery show that spicules survive forming and firing in excellent condition.

Spicule concentrations in the modern Sakon Nakhon Basin clays vary widely. At Nong Hoi Khan three separate samples were taken, each over 20 m apart. They indicate no intra-site variation in spicule concentrations. Study beyond the scope of the present work is needed.
6.2. PRIMARY EVIDENCE

to establish the precise origin of sponge spicules. Their status as geological, not modern, deposits is indicated by field observations. It is common for potters to reject the top metre or so of clay as "not sticky enough". At Ban Nong Phai (site 7 fig. 4.7), the upper metre of soil and clay was rejected. In spite of this, however, the production clay is short and fine (Table 4.1). In this case the older underlying clay contains few spicules. The Nong 1 Laeng (site 12 fig. 4.7) clay was excavated from a depth of over 2 m (fig. 4.5). It contains abundant spicules.

We may also gain some insight into the spicule distributions from archaeological evidence. Clays from all the known modern quarries within a 50 km radius of Ban Na Di have been analysed. Prehistoric pottery from sites within and beyond the Khorat Plateau have been examined in thin-section and their petrographic characteristics noted (chapters seven to ten, and appendices one to three). The Ban Na Di ceramics have provided detailed information regarding vessels, ceramic potters' anvils, metallurgical crucibles and furnaces, jewellery moulds and unfired clay figurines. These data are discussed fully in chapter seven. We need only briefly to consider it here.

Primary evidence clearly demonstrates that ceramic artefacts were manufactured in situ, throughout the occupation of Ban Na Di. The founding ceramic tradition was replaced, about halfway through the sequence, by another. We will confine our discussion to the earliest, and commence by contrasting vessel with figurine fabrics. Most early local wares belong to fabric group 1. This fabric is tempered with "orthodox" grog, and has a moderately micaceous matrix which contains numerous spicules. This fabric, along with local fabrics 2 and 4, is mineralogically compatible with modern Nong Kham Din clay (site 10 fig. 4.7). Vessels were probably fired in the open, on a bonfire or raft, in a partially oxidising atmosphere which often left a few "fire clouds" (Shepard 1956), blackened surface areas created during firing by pockets of reducing atmosphere. The comparison of modern clays fired to known temperatures with the prehistoric pottery indicates firing temperatures in the range 700-950°C.

Figrurines were treated entirely differently. In contrast to the local ware vessels, figurines were not fired nor were they tempered. The prehistoric figurines were modelled from material petrographically readily identified with local Ban Na Di clay. This clay is short, fine and sandy with few spicules. As the XRD results set out in chapter four show, it is not micaceous, and is poorly crystalline. Experiments with figurines modelled from the Ban Na Di clay indicate they were merely air-dried. Subjective hardness and cohesion tests demonstrate that the replicas are fragile. These modern replicas mirror the prehistoric examples in hand specimen. Their colour, texture and density appear the same.

Nong Kham Din, the nearest quarry, lies 6 km from Ban Na Di (fig. 4.7). Its clay is moderately micaceous. The nonplastics are dominated by spicules. Excluding clay sources without sufficient spicules, there are only two other possible sources. One is 42 km, the other 50 km from Ban Na Di, unlike distances when quality clay is available nearby. Arnold (1981:34-36) reports that 82% of 85 pottery communities surveyed obtained clay from within 7 km of their production sites, "and this distance probably represents the upper limit of the maximum range of exploitation."

In addition to figurines, the local clay was mixed with Nong Kham Din clay and then used in pottery manufacture. The evidence for blending is discussed fully in chapters five and seven. Only a limited number of vessels contain the blended fabric group 3, and this is probably due to shrinkage problems. The differential use of local clay in figurines suggests that the exotic clay was conserved for artefacts which demanded quality clay. This strategy is continued throughout the sequence in other artefacts. It implies that the imported clay was considered more valuable than the readily available, but inferior, local resource. A predictable
response to raw materials, whose source lay at some distance. Clearly a non-local source supplied the spicule-bearing clay.

When the quarries were surveyed traditional production was extant, although in decline. Because local informants possessed an intimate and detailed knowledge of the region, however, sources that had been abandoned even several generations earlier were readily identified. Pottery has only recently been subjected to competition from aluminium cooking vessels (Calder 1972). Hence it seems likely that all potentially useful clay sources were in production within living memory. All have been analysed and only Nong Kham Din qualifies both petrographically and economically as the early source.

The petrographic differences observed between Ban Na Di and Nong Kham Din clays are also present between the prehistoric figurine and pottery fabrics. The former has very few fragmentary spicules while in the latter they are numerous. The air-dried and fragile figurines were employed as mortuary furniture, artefacts deliberately buried presumably with the intention of leaving them undisturbed. If so, they would need to remain intact only for the duration of the funeral ritual. It would be unnecessary to fire or temper them.

Ritual symbolism could explain the preference for local clay in figurines but this seems unlikely. A special type of mortuary vessel was often included as furniture alongside figurines in several burials (Kijngam 1984:397-399). These “goblets” feature a modified version of the earliest local fabric. In addition to the “orthodox” grog of fabric group 1, the goblets of fabric group 2 contain varying amounts of rice husk. Fabric 2 correlates with goblets almost exclusively. This suggests they were designed for ritual purposes. It would be surprising, therefore, if figurines were fabricated from a different material for ritual reasons. The figurines often included fragile parts such as finely pointed cattle horns (Kijngam 1984:116-117), which would have presented firing difficulties.

Thus economic and technological factors would favour the use of local clay for figurines that did not require the strength of pottery. The absence of satisfactory local potting clay, combined with the transport costs attached to importing quality raw material, would promote conservation. This conservatism shows that the variations observed between modern clay deposits also existed from the first occupation of Ban Na Di. Thus archaeological and geological evidence are mutually supportive.

The above discussion is not intended to imply that Khorat Plateau clays or ceramic fabrics can be categorised simply by the presence or absence of sponge spicules. More than one factor must be taken into account. Even geologically heterogeneous regions with relatively distinctive countryrock, for example, may present difficulties. This is because mineralogically distinctive areas bring no inherent guarantee of localised distinctiveness. Thus, some relatively distinct, but homogeneous, strata may extend over considerable areas.

### 6.3 Secondary Evidence

Secondary physical evidence reflects the socio-economic influences that pottery exerts on ceramic cultures. Many aspects of this influence are often only implied. Some factors, however, are explicit. Subsistence versus prestige values demonstrate this dichotomy. Estimates of pottery production as a proportion of the overall economy, for example, can be explicitly expressed. By contrast, social status may be implied by differential access to rare or high quality wares. Social ranking, for example, has been implied from the asymmetry of prestige ware distributions in mortuary contexts (Bayard 1984, Higham 1984). When manufacturing accoutrements are inferred as funerary furnishing this implies that, in life, the deceased was a potter.
6.3. SECONDARY EVIDENCE

Production intensity can be implied from the proportion of such practitioners in the total population, given that the mode of production is understood. Such information has important implications for the identification of production centres.

Standards of expertise in ceramic production are often gauged using style-related aesthetic evaluations (cf. van Esterick 1973:89). They are also clearly revealed in levels of technical complexity, or the integration of methods with other technically intensive industries, such as metallurgy. Characterisation of these aspects permits regional and inter-site comparisons. They may also imply their degree of cultural imbeddedness. Technical changes following the arrival of immigrant potters, for example, could imply that the recipient tradition previously possessed a lower level of expertise compared with the donor industry. Given the inherent conservatism potters tend to display over technical matters, it seems safe to assume that inferior foreign techniques would not be adopted in the face of superior local methods.

Drawing on Mexican ethnographic data, Foster (1965:43-61) considered that a potter’s social position tends towards the lower end of the scale. Thus, the majority of potters in “peasant societies” are “artisans not artists”. Foster considered that market conditions, particularly the tourist market, and not artistic motives, was important in the maintenance of production stability. This affected stylistic and technological change. “Under conditions of little technological and stylistic change, pottery-making techniques are available to all members of a village who wish to know them... Under conditions of rapid change, pottery-making secrets appear, known to only a few people. At such times disappearance of a particular style or technique can more easily occur than during periods of little change” (Foster 1965:59). In Foster’s experience, “without unusual stimulus”, potters rarely showed much interest in other potters’ work.

May and Tuckson (1982:211-212) note a different sociological emphasis in the Sepik region, however, where status is accorded potting expertise. Thus, skilfully constructed sago storage pots and decorated ceremonial or “ritual clay objects” give males a degree of status. “Only very successful men” ... “favoured by the supernatural in all aspects of their achievements - carving, pot-making, hunting, planting, dancing and singing - can rise to the fourth and highest stage of initiation”. In addition, as individual vessel designs have supernatural associations, “two pots having the same design but made by different potters will have different names” (May and Tuckson 1982:266). It is relatively rare, however, for potters to be accorded high status in Papua New Guinea. This relates more to institutions or related initiations than to skill recognition, although it is unclear whether this was always so.

Irwin (1977, 1978), argues that the late, florescent, “Mailu” ceramic period “represents a single sociologically and spatially homogeneous tradition,” an “industry so standardized it could be the work of a single pottery” (1978:411). In 1890 Mailu was the largest and most influential village. It monopolized the local ceramic industry and articulated two integrated trade networks which stretched 125 km along the coast. According to Irwin, the Mailu Period society exhibited “incipient” social stratification. It is difficult to imagine that potters in such a society did not receive special recognition for skills upon which their society’s vigour depended.

Based on ethnographic evidence, Arnold (1985:196-198) argues that the status a potter may achieve depends on the hierarchical structure of the society they live in. Low status, therefore, may reflect the dirty nature of potting, or else the susceptibility of potters to economic exploitation. High status is accorded relatively profitable production and/or trade. The production of pottery highly valued because of some special connotative or purely artistic quality also brings status recognition. According to Arnold, in societies with a hierarchical structure, status depends on a sexual division of labour and production demands, provided the
population is stable. In agricultural societies, male potters who depend on the production of low value wares are likely to have low status. In such societies, however, because the female production supplements primary subsistence activities, females will occupy relatively higher social positions. Satisfied demands for "mythical, religious or social structural symbols" accord potters high social positions (Arnold 1985:198).

Such sociological factors underscore the need to look beyond immediate technological questions in order to gain insight into underlying cultural processes. Each ceramic tradition is embedded within a culture. Thus modes of pottery production may help characterise the sociological structure of prehistoric societies. Secondary evidence can give us occasional glimpses into status relationships. Because ceramic production is closely interrelated with many other cultural variables, primary and secondary evidence together have the potential to illuminate such important cultural questions as exchange and social organisation. At Khok Phanom Di, for example, the status attached to potters in their lifetime is suggested by an outstandingly rich interment. A differentially rich individual was interred with a comprehensive assemblage of pottery and equipment. This included manufacturing accoutrements, partly processed raw material and pottery of outstanding quality. Such evidence may allude to important questions, such as status, exchange, subsistence and technological integration, which help both generate and sustain ceramic technologies sensu stricto.

Sepik and Mexican potters both responded to the stimulus of tourist markets by producing wares specifically designed to meet these demands (Foster 1965, May and Tuckson 1982). This did not, however, involve a change of technology. The single underlying theme that unites potters is an intense reluctance to change their technological framework. Their methods of clay preparation, vessel fabrication and firing, in particular, are subject to extreme conservatism. This conservatism, of course, is the key to Shepard’s "temper typing" assumptions, but it may be misleading.

The widespread technological conservatism of potters may lull us into believing that pottery production always features a restrictive, essentially limited, technological repertoire. Not necessarily so. Potters may be conservative only to the extent that they tend not to take up new methods at the expense of traditional, and thus consistently reliable, techniques. A range of related, but technically different, methods may be used. Darvill and Timby (1982:75), for example, note that at Purton, Wiltshire, Roman potters employed three related, but different, fabrics. Arnold (1981:32-33) observes that functional constraints often dictate the temper species used, and/or their pre-fabrication treatments, when available resources require processing in order to produce the desired ware. May and Tuckson (1982:30-31) record that three of the Sepik production centres studied used different clays for ornamental as opposed to utilitarian vessels. Coarse fabrics are used for cooking pots and fine for ornamental wares.

Clearly, the manner in which potters vary clay preparation will affect the resultant fabric composition. Shepard’s "temper type" thesis is not invalidated by the above fabric treatments, however, for two important reasons. First, the variations noted relate to practical restrictions placed on fabrics due to the type of pottery under production. Hence decorative wares require fine textured fabrics devoid of coarse particles. Conversely, cooking-pot fabrics benefit from a degree of open-texture in order to reduce thermal shock fractures, although other factors also influence their responses to repeated temperature changes (Rye 1976). Second, although the Sepik potters, for example, employed different clays for different wares, their methods of processing each clay remained the same. They did not use different temps but merely removed some of the very coarse nonplastic from the cooking pot clay for ornamental wares.
6.4. FINAL COMMENTS AND CONCLUSIONS

qualitative technical changes.

Even under stress, potters adhere to traditional methods of clay preparation. Lauer (1974), for example, reports that, for economic reasons, Amphlett Island potters boycotted a traditional Fergusson Island clay source. This source was replaced with new, but inferior, clays. They experimented with blending clays but at no stage used temper, even though the major problems with the new clays were shrinkage and cracking. In view of such evidence, it seems reasonable to assume that tempering would have improved them. Amphlett potters, however, had no tempering tradition and hence no knowledge of its utility. Tradition-bound, their pottery deteriorated dramatically. This impasse was only resolved when the traditional source again became economic. Production was then resumed in the established way with the preferred potting clay.

Secondary physical evidence also involves the transmission of symbolic expression. Ritual expression is often associated with iconography incorporated into ceramic forms, with particular emphasis focused on the embodiment of symbolic designs (Renfrew 1972:426-42). The structure of design elements and patterns have often been characterised, like language, as information carriers (cf Arnold 1985:157-165). Such perspectives, however, ignore the physical composition of ceramics. These can also be a medium for symbolic expression, including that associated with ritual. Inquiries into symbolic expression which emphasize design may overlook the medium with which the message is transmitted. Thus, extrasomatic information may be incorporated into the ceramic fabric itself. These materials can be considered as modes of communication sui generis. Unfortunately, however, their symbolic message may often be disguised because they mimic purely physical functions. Hence they may be misinterpreted as fulfilling a solely physical role. May and Tuckson (1982:136, 210-218 and 291), for example, report taboos and ritual associated with raw clay, paint and pottery manufacture. Clay and paint can have material, symbolic and magical value. They may, therefore, often play dual functional and symbolic roles.

R ritual wares may sometimes contain unorthodox manufacturing modifications. Thus, technically unnecessary materials may be incorporated because they fulfill an important symbolic function. From a strictly technological view, therefore, this is aberrant behaviour. When modifications involve the pottery fabric they may have important technological implications. If temper is affected, we need to determine whether symbolic expression or technological variations, which may reflect cultural change, are involved. The validity of the thesis that temper change indicates cultural change, in these cases, rests on a holistic characterisation of the tradition under scrutiny. Of course, we cannot anticipate such a total understanding given the complex nature of ceramics and societies. This is not a counsel of despair. Provided mundane, or in other words, profane, local production is understood, deviations from "normal" manufacturing techniques should be detectable.

6.4 Final comments and conclusions

Production centres or districts can be defined through the proportion of local versus exotic pottery present. Provided the geological terrain is distinctive enough, local fabrics can be identified by their mineralogical associations. As potters are technically conservative, and sometimes use mineralogically identifiable tempers, Shepard successfully employed a "temper typing" sourcing method. All tempers, however, are not readily traced to geological sources. The "temper typing" thesis must therefore be qualified. We need to clarify several points.

Manufactured tempers may be useful for identifying production districts if they can be
readily identified and their method of manufacture is distinctive. The distribution of such
temper in discrete, mutually exclusive, regions could provide *prima facie* sourcing evidence
of value. Before considering this further, some technological definitions require evaluation.
The first concerns temper definition. The blending of clays to improve their quality is a form of
tempering. Blending can act to control shrinkage and cracking by determining the proportions
of nonplastics and clay minerals present. It may also assist in improving other qualities such as
workability and plasticity. May and Tuckson (1982:310) document one strategy which involves
the blending of three different clays. Mixing an unsatisfactory short and weak clay with a
highly plastic and therefore also weak clay, can often produce a satisfactory mixture (Hamer
1975:264).

Second, although Shepard’s application of the “temper typing” method is not universally
valid, the key assumption that potters are technically conservative, is. Hence any change in
temper species is potentially significant. The use of grog temper suggests development within
a sedimentary terrain which lacked suitable alternative local materials. Once adopted, grog
temper affords resource independence in sedimentary regions naturally deficient in suitable
tempering materials. This independence may further reinforce the inherent technological con-
servatism potters display.

Grog tempers can be characterised in terms of their method of manufacture, even if they
are mineralogically ambiguous. Bleb grog, for example, has a distinctive shape due to the use
of rice in the manufacturing process. “Orthodox” grog has a different shape. It does not in-
volve rice. Bleb temper supersedes orthodox grog in the Sakon Nakhon Basin, a sedimentary
region where the latter temper endured for about one millenium (see below). The replace-
ment of one grog tradition by another is significant for two important reasons. Firstly, no
functional requirement would dictate such a change. Any change in the face of an established
successful method, which was unnecessary for technical reasons, is clearly the result of non-
technological factors. Secondly, in the bleb temper example, the magnitude of the technical
change is increased because bleb manufacture is more complicated than the orthodox grog
method. This is because it requires the inclusion of an additional material. Technical con-
servatism would mitigate against the adoption of a more complicated method in opposition to
a simpler, proven, procedure. Thus such changes may suggest the influence of one ceramic
tradition, and *ipso facto* one culture, upon another. As with other tempers, the magnitude of
these kinds of changes may be critically significant.

Clearly, then, manufactured (or “artificial”), tempers can furnish different kinds of infor-
mation than natural tempers. When the former are distinctive, and can be traced to discrete
zones, they may also be useful in suggesting general source areas. Such information, of course,
can be utilized in conjunction with mineralogical data. If artificial tempers are to be used in
this way they must be unequivocally related to ceramic technology. Thus we first need to
discriminate between two different classes of additives in ceramic fabrics. Temper relates to
manufacturing requirements, and is dictated by the physical properties of the clay. The other
class, unlike temper, is symbolic. Thus it may be technically superfluous. This may present
special classification problems. Provided a tempering tradition is understood, however, tech-
nically orthodox inclusions should be distinct from symbolic additives. This is because the
latter will be unnecessary, *ipso facto*, for tempering purposes. If the majority of local wares
are tempered with orthodox grog, for example, but a minority, which in other respects are the
same, also contain a further additive, then this is *prima facie* evidence of symbolism.

If we accept that potters are technologically conservative, the “temper typing” thesis ap-
pplies to all temper species equally. Only some species, however, will be readily sourced.
Other than geologically and technically distinctive materials, biological and botanical remains are also potentially useful for suggesting origins (Cooper 1982:161). For example, if shell temper is used and the shell derives from a species with a restricted habitat.

It is important to keep in mind that fabric identifications “can proceed on several levels” (Riley 1982:4). Several disparate but related items of ceramic and non-ceramic archaeological data, when integrated, may transform apparently insignificant evidence into meaningful information. Broad scale technological change, in both ceramic and cultural senses, is evident in a shift from one grog production technique to another throughout much of the Sakon Nakhon Basin. The reasons behind this change can be inferred from the ceramic and archaeological evidence combined.

Evidence from Khok Phanom Di, a pre-metallic site about 20 km inland from the present Gulf of Siam coast, suggests occupation was probably confined to the period c. 3,000 B.C. to c. 1,500 B.C. (Higham et al. 1987). It lies beyond the Khorat Plateau on the edge of the Central Plain (fig. 6.4), a large sedimentary region. This location is significant for two reasons. Firstly, in terms of grog temper, it is located adjacent to sedimentary deposits. Thin-sections of pottery from the earliest levels reveal bleb temper. These fabrics are exotic to Khok Phanom Di. Their overall composition suggests a derivation from the surrounding regional sedimentary terrain. Secondly, the earliest postulated production of bleb temper within the Khorat Plateau is later than 500 B.C. (Vincent 1984b). Although, as evidence set out in chapter eight shows, the first bleb-tempered fabric appeared in the Chi Valley c. 1300 B.C.. This fabric, however, is probably exotic. Orthodox grog is later replaced by blebs at many Sakon Nakhon Basin sites.

At Ban Na Di, the earliest ceramic tradition is replaced by one featuring the production of bleb tempered wares. This change took place c. 100 B.C.. Associated with the bleb temper tradition are many new forms and different construction methods. Industrial accoutrements, raw clay source, burial ritual and metallurgy also change. When primary and secondary physical evidence synchronise in this manner, cultural changes of some magnitude are indicated. These data are discussed further in the following chapters.
FIGURE 6.3: IDEALIZED CROSS-SECTION ACROSS TKR. (after Loffler et al. 1983)
6.4. FINAL COMMENTS AND CONCLUSIONS

FIGURE 6.4: PHYSIOGRAPHIC REGIONS OF THAILAND (after Moorman et al.).
Chapter 7

The ceramic traditions of Ban Na Di

7.1 Archaeological summary

Ban Na Di is located less than 20 km from Ban Chiang (Gorman and Charoenwongsa 1976, White 1986). It is situated near low terrace soils (Moorman et al. 1964), at the confluence of two small streams. This is a typical environmental relationship shared with many other prehistoric sites recently surveyed in the Kumpawaphi area (Kijngam et al. 1980). For some of its prehistory, the site was occupied contemporaneously with Ban Chiang (White 1982, 1984, 1986). Radiocarbon determinations, derived from secure and stratigraphically unambiguous contexts, imply an occupation sequence spanning the period from c. 1500 B.C. to after c. 200 A.D., according to the excavators (Higham and Kijngam 1984:29-32).

Eight stratigraphic levels have been identified at Ban Na Di (Higham and Kijngam 1984). The earliest three, (levels 8 to 6), contained superimposed inhumation burials with numerous thin sand lenses interspersed between them. These lenses are apparently derived from overbank floodwaters. The excavators have subdivided this early mortuary phase (MP1) into three successive subphases 1a-c. A second mortuary phase (MP2) is ascribed to level 4. MP2 is less well represented, comprising only five child jar burials. Evidence for bronze casting spans levels 8 to 4. Bronze casting clearly becomes intensive, however, with the creation of level 5. Iron initially appears in level 7. This is fugitive, however, and can readily be explained by post-deposition disturbance. Higham (1987:145), considers 500-400 B.C. as a reasonable date for the origins of early iron-working in Southeast Asia. The first clear indications of iron-working at Ban Na Di derive from level 5 (Kijngam 1984:91). The excavators’ proposed chronology is set out in Table 7.1 below.

Ceramic materials occur throughout the entire sequence. They include what seem to be utilitarian and ornamental wares. One hundred and thirty four vessels were associated with mortuary ritual. Animal figurines modelled from clay were also interred as funerary furniture. Accoutrements used in pottery manufacture and bronze-working were uncovered. This equipment includes ceramic anvils and metallurgical apparatus, the latter including moulds, crucibles and furnace remains. A total of 263 rimforms and 147 vessels have been examined, along with ceramic rings, bow pellets and several perforated sherds. Fabric associations are summarized in appendices one to three. Ceramic artefacts from levels one and two have not been analysed, except in rare instances, as this portion of the stratigraphy is considered by the excavators to post-date 1550 A.D.
7.2 Ban Na Di Ceramic Traditions

The Ban Na Di pottery can be separated into three groups, funerary and occupation context wares, and industrial ceramics. Non-ceramic clay figurines and furnace remains are also present. Each of these aspects will be considered. We will examine burial, occupation and industrial fabrics and consider the relationships between these fabrics and artefact forms. Interments during the earliest mortuary subphases derive from stratigraphic contexts of exceptional clarity. Therefore we commence with an examination of burial fabrics.

(a) “Whole” vessels

Eleven burial context fabrics have previously been partially described (Vincent 1984b). Some of these have been modified in the light of subsequent, more detailed, evidence. Along with a further four fabrics, they are described in Appendix one. Whole vessel fabrics, including those stratigraphically equivalent with the burial phases, are also summarized in Appendix one. No vessels were recovered from phase 3 burials, thus burial fabric groups relate to mortuary phases 1 and 2 only. Mortuary phases 1a to 1c will be considered first. Figures 7.1 to 7.6 illustrate the stratigraphy of Ban Na Di, the site layout, and selected burials respectively.

FIGURE 7.1: STRATIGRAPHIC CROSS-SECTION OF BAN NA DI.
Figure 7.2: Site Plan of Ban Na Di.
FIGURE 7.3: (a) SELECTED BAN NA DI BURIALS. (burials 7 to 14).
FIGURE 7.4: (b)SELECTED BAN NA DI BURIALS. (burial 35).
FIGURE 7.5: (c) SELECTED BAN NA DI BURIALS. (burial 7).
7.3 Mortuary phase one

Fabrics during mortuary phase 1 can be conveniently divided into three groups:

(i) grog tempered
(ii) rice tempered
(iii) sandy fabrics occasionally containing relatively minor amounts of grog or grog-like argillaceous material

We have noted that grog can be subdivided, according to the criteria given in chapter six, into orthodox and bleb subspecies. Fabric groups 1, 2, 3, and 4 all contain orthodox grog morphologically similar to that shown in figures A.1 and 6.1. Each is considered a product of the earliest ceramic tradition (Appendix one). They are grouped according to technological characteristics which are reflected in the quantity of grog, plant material, quartzose sand and spicules in each fabric. Table A.1 (Appendix one) sets out the vessel fabrics, forms, mortuary
phases and likely source. Form categories are derived from Higham and Kijngam’s (1984:306-309) factor analysis. Therefore they need to be considered in conjunction with fabrics. The validity of these form categories, for comparative purposes, is here considered to be restricted to MP1 Ban Na Di pottery, the ceramic tradition the majority of them represent. An example of each form category is illustrated below (figs. 7.7 to 7.21). In each of the illustrations a is at the top.
FIGURE 7.7: BAN NA DI "WHOLE" VESSELS (a: pot 5, form 1a. b: pot 9, form 1b. c: pot 6, form 1c.).
FIGURE 7.8: BAN NA DI “WHOLE” VESSELS (a: pot 30, form 2. b: pot 34, form 2.).
FIGURE 7.9: BAN NA DI "WHOLE" VESSELS (a: pot 108, form 3. b: pot 135, form 4.).
FIGURE 7.10: BAN NA DI "WHOLE" VESSELS (a: pot 95, form 5. b: pot 97, form 6. c: pot 109, form 6. d: pot 96, form 7.)

FIGURE 7.13: BAN NA DI "WHOLE" VESSELS (a: pot 39, form 14a. b: pot 37, form 14b.).
FIGURE 7.14: BAN NA DI "WHOLE" VESSELS (a: pot 44, form 14c. b: pot 47, form 14c. c: pot 48, form 14c.).
FIGURE 7.15: BAN NA DI “WHOLE” VESSELS (a: pot 86, form 15. b: pot 128, form 16.).
FIGURE 7.16: BAN NA DI "WHOLE" VESSELS (a: pot 92, form 17. b: pot 123, form 18.).
FIGURE 7.17: BAN NA DI "WHOLE" VESSELS (a: pot 113 and lid, form 19.).
FIGURE 7.18: BAN NA DI "WHOLE" VESSELS (a: pot 114 and lid, form 19.).
FIGURE 7.19: BAN NA DI "WHOLE" VESSELS (a: pot 115 and lid, form 19.).
FIGURE 7.20: BAN NA DI “WHOLE” VESSELS (a: pot 116 and lid, form 20.).
"Whole" vessels are those with sufficient surviving portions to form a substantial cross-sectional outline of the intact pot. Once whole vessels have been thus defined, rimforms are valuable as diagnostic representatives of whole vessel forms. Of the total 147 whole vessels, 146 have been assigned fabrics. The fabric of Pot 47 displays close similarities to fabric group 7, although it cannot readily be associated with this group without further more detailed analysis. The "whole" vessels include 133 from burials and 13 from occupation levels. Table A.2 (Appendix one), sets out mortuary and occupation level vessel fabrics in chronological order. Tables A.3 and A.4 (Appendix one) show the distribution of MP1 local ware fabric groups and exotic fabric groups respectively.
Evidence set out below shows that two ceramic traditions are mutually exclusive to MP1 and MP2. Therefore pottery derived from either occupation levels or burial contexts, during each mortuary phase, are here considered together in terms of their respective stratigraphic associations. The combined number of whole vessels comprised of fabric groups 1, 2, 3, or 4 amounts to 85.22% of the total MP1 assemblage. In thin-section all are compatible with the Nong Kham Din clay (site 10), except for fabric 3 which differs in nonplastic proportions. The overall appearance is similar, but quartz increases at the expense of the spicule count in fabric 3. Direct comparisons of pottery with clay are not entirely valid because they involve raw versus processed materials. Fabrication techniques, for example, may redistribute nonplastics in pottery unevenly. Forming operations can cause a loss of finer particles, and disproportionately reduce the original clay matrix component. Thus direct comparisons can only be regarded as approximations.

Point counting of six fabric group 3 vessels give the following values: matrix component $X = 70.26\%$ (S.D: 7.59, V:48); quartz $X = 23.10\%$ (S.D:7.59, V:47.02); spicules $X = 1.8\%$ (S.D: 0.63, V:0.33). Values for a fabric group 1 vessel are set out in Table 7.3 below. They are: matrix component 66.6%, quartz 4.8%, spicules 8.8%. The fabric group 1 constituents match closely those of Nong Kham Din clay (clay 10, Table 5.1 chapter five, and appendix one). Fabric group 3 is clearly different. Nonplastic and clay matrix components for the Sakon Nakhon Basin potting clays are set out below (fig. 7.22). A 50/50 blend of each Ban Na Di clay with clay 10 is included for comparison. Clays 10 and 13, when blended, give nonplastic ratios of: matrix 76.8%, quartz 14.5%, spicules 4%. For clays 10 and 14 the values are: matrix 71.8%, quartz 19.4%, spicules 3.9%. Fabric group 3, in terms of nonplastic proportions, closely matches a blend of local with Nong Kham Din clay. Nong Sung clay is the only other likely source. This clay, however, lacks sufficient spicules and can thus be excluded from consideration.
7.3. MORTUARY PHASE ONE

FIGURE 7.22: THE NONPLASTIC COMPONENT OF SAKON NAKHON BASIN POTTING CLAYS.

One vessel, (pot 35, fig. 7.23), displays characteristics which are informative. This data relates to the composition of fabric group 3 and fabrication details which apply to most MP1 whole vessels. As a guide to fabrication methods, Table A.5 (Appendix one) gives a summary of cordmarking on whole vessels. Pot 35 was interred with burial 36 along with pots 15, 16, 39 and 40. The former two pots contain fabric group 1 material. Pots 39 and 40 are “goblets”. They contain fabric 2 and 1 respectively. It is important to note that pot 35 does not seem to have been used prior to interment. Apart from post-deposition adhesions of calcium and iron, it is in pristine condition. Note also the vertical shrinkage crack. An equatorial join between the moulded lower section and upper paddle and anvil construction is clearly evident in the wall opposite the crack. This construction method dominates local wares. It is discussed further below. Note that the crack extends from the rim to just beyond the equatorial join, thus it traverses the major join between the upper and lower fabrication stages. Such vertical cracks are symptomatic of the addition of excessive amounts of nonplastic material, either as temper or the incorrect blending of short and plastic clays (Hamer 1975:78). In form and method of construction, pot 35 is clearly associated with vessels containing fabric group 1 or 2 material.
The data set out above suggest that pot 35 represents the result of a local blending failure. In addition, evidence for deliberate conservation of imported Nong Kham Din clay is set out below. This information, when considered together, strongly supports the notion that local and imported clays were blended to produce fabric group 3. The blending strategy would conserve a valuable exotic resource. Notably, this fabric is confined to forms 1a, 1b, 3, and 4 vessels, all of which are probably utilitarian wares. Petrographic and construction evidence both support a local origin for fabric groups 1 to 4.
7.3. MORTUARY PHASE ONE

Fabric group 1 dominates local wares. Fabric groups 2, 3 and 4 are essentially modifications of fabric group 1. We have seen that fabric group 3 is a technological variation probably related to the conservation of imported clay. Fabric groups 2 and 4 form a continuum. They closely correlate with forms 14a, b, and c “goblets” (Higham and Kijngam 1984). This form corresponds with Sørensen’s fruit stands (“tou”, Sørensen 1967:75), Watson’s pedestal bowls (1968:304), and Bayard’s “type 4b footed bowls” (1977:67). Of the 29 examples, 27 (93.1%), contain local fabrics. The exotic vessels are restricted to form category 14c. The single local ware 14c goblet (pot 44), differs in detail to the two exotic forms (pots 47 and 48). Pot 44 has an “S” twist cordmark and a rounded base edge termination, pots 47 and 48 cordmarks are “Z” twist, and their base edges terminate in a square edge (fig. 7.14). Fabric groups 2 and 4 increase with time (Table A.1 Appendix one). They form 30% of MP1a local wares, 30.23% of MP1b, and 40.38% of MP1c. Two local ware goblets occur in MP1a, 10 in MP1b, and 13 in MP1c mortuary contexts. Goblet fabrics are set out in Table 7.2 below.

<table>
<thead>
<tr>
<th>Fabric</th>
<th>Form 14a</th>
<th>14b</th>
<th>14c</th>
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<tr>
<td>1</td>
<td>1</td>
<td>2</td>
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<td>2</td>
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<td>-</td>
<td>1</td>
</tr>
<tr>
<td>n vessels</td>
<td>4</td>
<td>22</td>
<td>3</td>
</tr>
</tbody>
</table>

Note: pot 47 (see Table A.1 appendix one).

As with fabric group 3, fabric groups 2 and 4 are tempered with orthodox grog. They can be distinguished from fabric group 1, however, by the presence of rice remains. It is important to note that these two inclusions were separate additives. Rice remains or impressions are essentially absent from the grog. This contrasts sharply with bleb temper where rice impressions are common. Thus the rice was not involved in the grog manufacture. The only difference between fabric group 1 and the goblet fabrics is the addition of rice. There is thus no obvious technical requirement for its presence. Goblets, therefore, both in terms of fabric and form, represent a special type of ware. Accurate quantification of the proportion of rice remains in fabric groups 2 and 4 is difficult because of problems with thin-section sampling. Further, it is difficult to assess whether rice was included accidentally in some cases during manufacture. We can anticipate that, in communities where rice was exploited for subsistence, it would be difficult to exclude it from pottery even if desired. Thus apart from goblets, forms 1b, 1c, 2, 3, 4 and 10 also contain fabric group 2 material.

The following fabric group 2 and 4 form correlations are evident: form 1b:7.14% (n = 13), form 1c:33.33% (n = 12), form 2:14.28% (n = 7), form 3:40% (n = 5), form 4:2.5% (n = 28), form 10:100% (n = 1). Form 10 is represented by Pot 99. This vessel was placed over the abdomen of burial 18. The fabric groups 2 and 4 correlations for all goblets, however, is 88.88% (n = 27). Clearly, goblets are closely correlated with fabrics containing rice remains.

Vessels of similar form have been postulated as ritual (Weinberg 1965:195), or ceremonial wares (Rawson 1980). When both fabric and form are associated in this manner we can be confident that this is prima facie evidence of importance. The use of forms and/or colours
as a symbolic means of communication is described by Harris (1986:126) as “graphic isomorphism”. These systems, he argues, convey pictorial messages independently to script at a basic level of communication. Thus graphic forms can act as a mode of communication sui generis. Visually independent communication systems are ideally suited to ritual symbolism. In the case of specially prepared and designed mortuary vessels, it is possible that we may be encountering a powerful system of visual communication. In the absence of evidence to the contrary, however, “goblets” are here inferred to represent a mortuary ware of ritual significance.

Prior to considering fabrication and firing details, we need briefly to discuss the optical properties of fabric groups 1 to 4 because these relate to the method of construction and clay origin. In polarized light, the matrices of MP1 local ware fabrics display a moderately birefringent sheen. Shepard associated this with the abundant presence of mica in low-fired pottery, and described it as a “golden or silvery cast” (1956:30). In Ban Na Di fabrics the birefringence is seen to best effect when the microscope stage is rotated between crossed polars. It is probably due to the effects of both clay mineral orientation and matrix texture. Clay mineral flakes tend to lie nearly parallel to the plane of pot surfaces. This results from clay preparation processes, and the mechanical effects of shaping (Hamer 1975:63). The effect is most prominent in oxidised surface “herringbone” zones where closely packed, fine lath-like micaceous particles are randomly orientated. It tends to be masked by reduction.

Similarly, in shales, a principal cause of fissility is the tendency of clay mineral flakes to lie almost parallel to bedding planes. Thin-sections cut normal to stratification present these flakes on edge. As both extinction position and slow vibration direction parallel the apparent flake elongation, the whole thin-section tends to show aggregate positive elongation. When rotated between cross polarizers, an entire thin-section may extinguish in two principal directions. If the clay particles are more randomly oriented “the appearance of a thin-section does not vary appreciably when rotated between cross polarizers, and it does not tend to extinguish preferentially in any two directions.” (Williams et al. 1982:321).

Most prehistoric Khorat Plateau wares were probably shaped by the paddle and anvil method. Potters used mainly cord-wrapped or carved paddles. Observation of thousands of sherds suggests that, even when a smooth finish was required, these paddles were probably used as the main shaping instrument. Plain paddles were probably reserved for the final smoothing process. Paddles with a rough surface distribute wet clay more efficiently during forming, because they impart more surficial force given the same mass. This is because serrated versus plane surfaced paddles concentrate the impact force within a smaller area given the same mass and effective area of impact.

Thin-sections cut perpendicular to pot walls often reveal some aggregate sorting. Larger nonplastics tend to concentrate in the centre. In modern vessels, paddle and anvil shaping results in differential sorting and finer constituents are concentrated towards wall surfaces. This is due to mechanical forces, and the water-born transportation of very fine particles through pores in the plastic fabric. Much of this finer fraction often sticks to the potter’s hands and tools. Thus pots may retain proportionately more nonplastics than the parent raw clay.

Depending on the amount of carbonaceous material present in unfired pottery, and firing atmosphere conditions, pottery fired in the open is often not fully oxidised (Shepard 1956:75-94). In thin-section, most MP1 local ware fabrics have a reduced central core. Only the surface 1mm or so of vessel walls are oxidised and the majority have reduced interior surfaces. Exterior surfaces are generally oxidised, often with “fire-clouds” (Shepard 1956). Many rims are almost entirely reduced. This is often interrupted by oxidised “flares”. Internal reduction and rim
flares strongly suggest these pots have been fired upside down. Where oxidisation is complete the micaceous sheen is apparent. Oxidised zones near surfaces often display a “herringbone” effect, due to a random orientation of closely packed, fine lath-like particles of mica.

Nong Kham Din clay is consistent with fabrics groups 1, 2 and 4. It is postulated that it also formed a component of blended fabric group 3 along with local clay. Nong Kham Din clay is moderately micaceous and also contains numerous spicules. Thus it is unique among the clays studied. Table 5.2 (chapter five), sets out the relative quantities of spicules for each Sakon Nakhon Basin clay. The proximity of sources is also of prime importance in the acquisition of raw materials. Nong Kham Din and Nong Sung (clay 6), each lie about 6 km from Ban Na Di (fig. 4.7). Arnold (1985:38- 51), reports that for geodesic walking distances, out of 111 cases tabulated from ethnographic sources, 84% of quarries were located within 7 km of the point of production, and this “probably represents the upper limit of the maximum range of exploitation”, but the preferred exploitation territory probably occurs at 1km.

In addition to the mineralogical evidence discussed above, we can exclude Nong Sung as the MP1 clay source for several other reasons. Firstly, ceramic anvils composed of clay mineralogically compatible with Nong Kham Din are exclusive to MP1. MP2 anvils, however, contain Nong Sung clay. In each case the anvils are associated with the contemporary local ceramic tradition. Thus fabric group 1, which dominates MP1 wares, is also the major MP1 anvil fabric. Similarly, fabric group 12 dominates both MP2 wares and anvils (Tables A.1 and A.13 Appendix one). Secondly, MP2 is associated with a different ceramic tradition. A simultaneous change in technology and clay source is associated with this transition. Nong Kham Din clay is replaced by material mineralogically compatible with the Nong Sung clay. This clay was used for both anvils and vessels (Tables A.13 and A.1 Appendix one). Thirdly, differential use of each clay is evident during both mortuary phases. Thus MP1 crucibles are composed of Nong Sung clay (Table A.14 Appendix one). MP1 figurine fabrics (Table A.6 Appendix one), however, contain untempered and unfired Ban Na Di clay. During MP2, crucibles contain the latter clay (Table A.14 Appendix one). Thus local clays were employed where ceramic quality was unimportant during MP1, and for crucibles opposed to pottery during MP2. The poor quality of the local, versus imported clays, (chapters four and five), suggests this was a purposeful act of conservation. It reinforces and helps corroborate the geological evidence which demonstrates that the better quality clays were exotic. Non Sung clay is important because it not only spans both traditions, but is also associated with imported wares. We will return to it later.

In both fabric and form, vessels containing fabric groups 1 to 4 inclusive are compatible with a single ceramic tradition. This homogeneity is further strengthened by a distinctive fabrication method. During MP1 a practice of forming the lower hemisphere of medium to large bowls on a mould dominates. Excluding miniatures, 84 local fabric vessels are sufficiently complete for analysis. Of these, 76 (90.48%), are unequivocally mould-made. The method is revealed by a prominent, usually straight, equatorial join and positive cord impressions to the interior lower hemisphere. Upper interior hemispheres, in contrast, are smooth with a generally undulating surface. The undulations are consistent with a series of joined coils (Glazman and Fleming 1985:115). They appear to have been added to the preformed moulded base. Although erosion prevents an accurate assessment, most of the remaining vessels were also probably moulded. Very few appear to have been made from either slabs and/or coils.

Ethnographic data are available for a moulding technique which would satisfy the Ban Na Di evidence, of which pot 35 (fig. 7.23) is a typical example. Foster (1960:205-214), describes
a technique employed by potters at Alcatlan, Mexico. The moulds, over which several forms are shaped, are vessels constructed robustly enough to withstand the strains generated during the manufacturing process. These moulds are essentially vessels thicker and heavier than normal, and feature striated exterior surfaces. One mould may serve as the base for several different final products. This parallels the Ban Na Di tradition where small spherical bowls (such as forms 1 and 2), and goblet bowls (forms 14a, b and c, figs. 7.7, 7.8, 7.13 and 7.14), are all mould-made, and of similar size and shape.

The method involves kneading a previously mixed quantity of clay into a flat pancake on a mat. This is then placed over the bottom of an upturned mould. The sheet of clay is patted with a paddle until uniform, trimmed and removed, thus forming the lower half of a pot. The upper portion is completed when the moulded section is sufficiently dry to support further material. As Foster pointed out, fragments of broken moulds in archaeological contexts would probably be overlooked due to their similarity with actual vessels. Thickness and density are characteristic however, and at Ban Na Di several dense sherds 10-12 mm thick were recovered from MP1 levels, although not actually associated with interments. Mortuary phase 2 vessels are not mould-made.

7.4 Firing temperatures

Ethnographic studies (Shepard 1956, Solheim 1964, Bayard 1977a) allow insights into the firing parameters in ceramic technology as practiced by household or individual workshops employing relatively simple production methods. In assessing firing temperatures, information regarding the type and likely duration of firing is important. Ethnographic and technological analyses are here combined with the intention of bringing into focus the fundamental variables involved in prehistoric firing methods.

We commence with the need to qualify and quantify a range of variables that affect ceramic firing procedures and their final product. These include the nature of vessel fabrics prior to firing, the atmosphere throughout the firing sequence, and the length of firing. The manner in which vessels are fired (singly or in multiples), and the method of stacking also have some influence on the final results (Shepard 1956:74-75).

At Ban Kham O, (Vincent 1984b), pots are fired on a bamboo raft packed with rice straw. The pots are placed upside down, without straw in between them, and then covered with straw for firing. Fired pots display generally oxidised exterior surfaces and slightly reduced interiors. Fire clouds cover up to 10% of the exterior surfaces of most pots. Raft firing is common in many modern Northeast Thai manufacturies, but firing durations vary from approximately two to five hours (Solheim and Bayard op. cit.), and possibly longer, with generally oxidising atmospheres.

It is possible to infer with reasonable confidence that the early mortuary phase local wares were mostly fired upside down in a generally oxidising atmosphere for the following reasons. Of the 85 pots suitable for assessment (miniatures and form 14 bases are excluded), only 8.24% are substantially oxidised internally and externally. The outstanding firing-related features of the remaining 91.76% are their oxidised exterior surfaces (if fire clouds occur they are minor), and their substantially blackened interior surfaces. A marked tendency towards increased blackening is noticeable towards upper portions and rim interiors. This could derive from colloidal carbons, contained in sooty smoke trapped within the upturned pot during firing, penetrating the fabric pores and creating permanent “smudging” (Shepard 1956:88). This is unlikely, however, given a generalised oxidising atmosphere. Alternatively the atmosphere
within the vessel could be reducing.

Stacking round-based pots upside down on a firing raft reduces the risk of catastrophic toppling and breakage when the inflammable supports are consumed. During firing the irregular surfaces created by burnt fuel would probably admit some oxygen into the insides of vessels. It is likely, however, that the pot’s internal atmosphere would be extensively reducing. Significantly, in kiln firings where vessels are not placed directly onto the fuel, the danger of toppling is minimised, particularly where loading allows adequate support. Thus kiln firings of vessels stacked upright in an oxidising atmosphere could be expected to produce oxidised interior and exterior surfaces.

Recorded temperatures for the type of raft firings outlined above are not presently available. Shepard (1956:78) records open firing temperatures up to 940° C for dung fuels and notes 1000° C is rarely attained in direct open-air firings. Lauer (1971:73) records a maximum of 920° C for dry wood and coconut leaf fronds. A firing duration of about one hour applies in both cases. May and Tuckson (1982:47) tested the firing ranges of 32 Papua New Guinea clays. The lowest vitrification temperature was 1100° C, but most were 1200° — 1250° C. They note that “the top temperatures reached in open firings are between 900° C and 1000° C”. Irwin (1977) recorded a maximum temperature of 1018° C on Mailu Island, but most ranged from between 900° to 950° C. From prehistoric contexts, Meacham and Solheim (1980) report temperatures of up to 975° C for Non Nok Tha layer 7 sherds, and up to 1200° C (but as low as 800° C) for Phimai sherds. Their results were based on thermal expansion measurements (Tite 1969).

In considering firing temperatures achieved by MP1 Ban Na Di potters, we commence by assuming that valid assessments of the firing behaviour of clays used in prehistory are possible provided that the same clay used in prehistory can be obtained and fired to known temperatures under known conditions, and that the firing conditions used in prehistory can be established and replicated.

It follows that if the same material and methods are used, the same or similar results can reasonably be expected. Of course it is not practically possible to replicate precisely either the ceramic fabric or the firing conditions used in prehistory, but it is possible to approximate them.

Nong Kham Din clay (clay 10), has been fired in an electric muffle kiln to sequentially higher temperatures in an oxidising atmosphere. Bisques, measuring 15 x 2.5 x 0.8 cm, were fired at the increasing rate of 100° C/hour. The kiln was preheated to 150° C and the bisques air-dried for seven days prior to being fired at 50° C increments to temperatures ranging from 700° C to 1150° C. Although an unlikely procedure in prehistory, slow firing is considered appropriate in test conditions to minimise cracking and deformation. To prevent thermal shock the bisques were allowed to cool in the kiln (Howard 1982:147).

Chips with clean fracture surfaces were removed from each bisque, suitably coated, examined and photographed in a scanning electron microscope at X1000. This followed Maniatis and Tite (1978, 1981) who used a combination of chemical and physical techniques to assess original firing temperatures of prehistoric sherds. They noted that a reducing, opposed to an oxidising, atmosphere lowered the temperature at which various vitrification structures formed by c. 50° C for non-calcareous clay. Calcareous clays (those normally containing >6% calcium oxide), developed glassy phases associated with vitrification later than non-calcareous clays dependent on the clay texture and temperature intensity. Between 1050°-1150° C the amount of glass in calcareous clays rapidly increased and continuous vitrification similar to that displayed by pottery made from non-calcareous clay occurred. The firing atmosphere effects noted above
were less pronounced for calcareous clay pottery. Maniatis and Tite's method involved identifying the type of clay used, fineness of its texture, and then estimating from observed vitrification structures displayed by prehistoric sherds in-the-received-state and after re-firing at known temperatures. They identified four temperature related stages: no vitrification (NV), initial (IV), extensive (EV), and continuous vitrification (CV). Each stage developed dependent on firing atmosphere and calcium oxide content. Initial vitrification structures (smooth isolated areas or filaments of glass) were similar for both non-calcareous and calcareous clays and typically developed at 800° - 850° C in an oxidising atmosphere. At higher temperatures the quantities of glass increased and the structures developed were critically dependent on both clay type and firing atmosphere. A variety of bloating pores were produced, each characteristic of, and dependent on, the clay type, firing atmosphere, temperature achieved and rate of firing.

In view of the comprehensive assessments of open firings undertaken by Shepard and others noted above, temperatures in the upper range 800° - 950° C were anticipated. Thus in terms of Maniatis and Tite's findings, neither clay type nor firing atmosphere were considered critical. Petrographic examination revealed authigenic calcite deposits, at times very extensive, both as surface adhesions or networks of interstitial veins within the pottery fabrics, apparently resulting from post-depositional ground water effects. It is important to note that these chemical changes are probably accelerated by tropical conditions. Silica and calcite-cemented sand is also present as surface deposits on some sherds. In potting clays calcium has a "potent tendency to reduce the vitrification range" (Grim 1962:124). When pottery is fired in reducing conditions this converts Fe³⁺ → Fe²⁺ and this increases the fluxing potential of the iron particularly when calcium is present (Edwards and Segnit 1984:73). Both of these minerals are present in the Sakon Nakhon Basin potting clays analysed in chapters four and five.

Grim (1962), notes that fluxes cause the development of amorphous glassy material at relatively low temperatures. Fluxes are much more effective either as part of the clay mineral or as adsorbed ions (Grim 1962:124). Smectites and vermiculites have a high cation exchange capacity (1962:30). Initial high temperature phases depend largely on the structural character of the clay minerals present, later high temperature phases depend more on the total composition "these generalities apply, of course, to clay minerals which do not contain considerable extraneous fluxes" (Grim 1962:96). Thus refiring highly calcinated sherds in an oxidising atmosphere risks misleading results. Hence Nong Kham Din clay fired at known temperatures was compared with sherds as received.

Figures 7.24 a to d illustrate the following vitrification stages and related firing temperatures. Pot 112 is oxidised to exterior (5YR/6/4) and interior (5YR/7/4), but has post deposition stains probably derived from calcium, and manganese, which is also a highly migratory element (Shepard 1966:871). In an earlier work (Vincent 1984b), it was stressed that this figure represented the maximum degree of vitrification observed in fabric group 1. Furthermore, as both the grog and parent matrix of fabric group 1 are mineralogically compatible with clay 10, it is reasonable to expect a similar firing response for both materials. Comparison of modern clay and fabric group 1 SEM photomicrographs suggested temperatures in the range of 1000° C to 1100° C were possible as maxima. These postulates are further clarified below.

Several points need emphasising. First, given the kind of industry under consideration, it seems unlikely that temperatures in excess of 1000° C could have been regularly exceeded. Second, in making assessments of ancient sherd thermal responses, a lack of precise understanding of the clay mineral composition is a major difficulty. Grim (1962:96, 108-111) reported that different clay mineral species respond variously. Mixed-layer clays further complicate these responses. Third, the effects of post depositional calcium, as a fluxing agent, are
also unclear (Grim 1962:96). Fourth, potsherds may have a slightly increased calcium content due to the effects of processing discussed above. Thus direct comparisons of raw and fully processed clays may also be slightly misleading.

As a check on the modern with ancient comparisons, fabric group 1 sherds were re-fired to 1050° C and soaked at that temperature for 20 minutes. Their colour changed from 5YR/5/2 to 5YR/6/8. Figures 7.24 a and b illustrate as-received and fired states. The as-received photomicrograph displays some glassy phases, but not extensive, and is thus considered as in the initial vitrification stage. An extensive amount of bloating pores consistent with continuous vitrification is evident in much of the re-fired sherd, although fig. 7.24 c, another view of the same re-fired sherd, shows less bloating and vitrification structures. These compare with those observed in other as-received sherds (fig. 7.24 d). This is pot 112 as received previously published in Vincent (1984b:fig 15-6, D).

In an attempt to resolve the fluxing question, additional pieces of the same potsherd were left in simmering hydrochloric acid for 90 minutes. These sherds were thin-sectioned and checked for any residual authigenic interstitial calcite. As substantial amounts remained, the sherds were left for 2 hours in boiling HCl, and the sherds were again thin-sectioned. Although less prominent, calcite was still well represented. The calcium is clearly very difficult to remove and this problem remains unresolved.

McGovern et al. (1985:106) used the SEM method in assessing the ancient firing temperatures reflected in Ban Chiang “ware types”. They concluded that “uniformly low temperatures (c. 500° C-700° C)” were represented. Given that at least some of their fabrics are composed of local potting clay, and this seems highly likely, comparison of photomicrographs from both sites suggests the Ban Na Di wares were fired to higher temperatures. These data, combined with the evidence set out above for Ban Na Di fabric group 1 wares, indicates that temperatures somewhere between the two were probably the norm for Ban Na Di potters.

Conservatism is called for when direct evidence, such as experimental or field firing temperature data, are lacking. Based on the information provided above, we may reasonably assume that at Ban Na Di firing atmospheres would have been reducing for much of their duration. The influence of calcium is uncertain. Given its ubiquity in Sakon Nakhon Basin clays, however, it may also have been a factor. Thus it is prudent to allow for the effect of both calcium and reduction. If we allow 50° C for each, a maximum temperature of 950° C seems probable. This is reinforced by some local ware sherds (fig. 7.25 e, (pot 127) and f, (pot 104)), which display fewer vitrification structures. Figures 7.25 g and h illustrate clay 10 fired to 1050° and 1100° respectively. Keeping the firing atmosphere and calcium allowances in mind, these sherds suggest even lower temperatures. At 950° C, the postulated maximum firing temperatures compare with those ethnographically recorded for open firings discussed above.
FIGURE 7.24: VITRIFICATION STRUCTURES IN BAN NA DI MP1 LOCAL WARES (from left to right, top: a, b, lower: c, d. x1000 magnifications)

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FIGURE 7.25: VITRIFICATION STRUCTURES IN CLAY 10 AND BAN NA DI MP1 LOCAL WARES. (from left to right, top: e, f. lower: g, h. x1000 magnifications)
7.5 Mortuary Phase Two vessels

Five stratigraphically contemporaneous infant burial urns, each with an enclosing lid, make up the MP2 sample (figs. 7.19 and 7.20 and 7.21). One urn and its lid (pot 116, fig. 7.20), contains a fabric previously ascribed to fabric group 1 (Vincent 1984b). The remainder (figs. 7.17, 7.18, 7.19 and 7.21) are composed of bleb-tempered fabric 12, a fabric group not represented in the earlier burial phases (Table A.1 Appendix one). The presence of an orthodox grog fabric, which characterizes MP1, in MP2 contexts has rightly been questioned by White (1986:311-312). A more precise interpretation of fabric associations is now possible, following the quantification of non-plastic inclusions, and a detailed analysis of Sakon Nakhon Basin clays. Two bleb-tempered burial urn lids have been compared in thin-section with a MP1 pot of fabric group 1 and pot 116. Point counted values for the major constituents are set out in Table 7.3 below.

<table>
<thead>
<tr>
<th>Pot No.</th>
<th>matrix</th>
<th>Quartz</th>
<th>Kspar</th>
<th>spic</th>
<th>grog</th>
<th>Fe.</th>
<th>voids</th>
<th>pm*</th>
<th>ph+</th>
</tr>
</thead>
<tbody>
<tr>
<td>117 lid</td>
<td>59.4</td>
<td>6.0</td>
<td>0.2</td>
<td>0.8</td>
<td>14.4</td>
<td>0.0</td>
<td>9.2</td>
<td>8.0</td>
<td>2.0</td>
</tr>
<tr>
<td>115 lid</td>
<td>60.8</td>
<td>6.0</td>
<td>0.4</td>
<td>1.0</td>
<td>16.6</td>
<td>0.0</td>
<td>9.4</td>
<td>4.0</td>
<td>1.8</td>
</tr>
<tr>
<td>116</td>
<td>80.2</td>
<td>5.8</td>
<td>0.2</td>
<td>2.8</td>
<td>8.0</td>
<td>0.0</td>
<td>1.6</td>
<td>0.0</td>
<td>1.4</td>
</tr>
<tr>
<td>4</td>
<td>66.6</td>
<td>4.8</td>
<td>0.0</td>
<td>8.8</td>
<td>9.6</td>
<td>5.4</td>
<td>4.4</td>
<td>0.0</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Notes: * plant material (mainly rice husk).  
+ phytoliths.  
Values are expressed as percentages of total.

The non-plastic constituents of the two bleb-tempered pots, (115 and 117), are compatible with vessel 116. The fabric group 1 specimen (pot 4), however, contains orthodox grog, the same temper species as pot 116. Pot 116 has no plant material or ferruginous minerals and few spicules. Nong Kham Din clay is consistent with pot 4, but not the bleb-tempered vessel fabrics or pot 116. These latter fabrics are constitutively compatible with clay 6 from Nong Sung (chapter five).

Because pot 116 is tempered with the same grog species as fabric group 1 vessels, the dominant tempering technique of early ceramic traditions in the Sakon Nakhon Basin, and detailed analysis of clay samples had not been completed, it was initially not recognised as being different. Pot 116 and its lid contain fabric group 16 material. This fabric provides an important link between early orthodox grog-temper and later bleb-temper traditions. It occurs in anvil fabrics during both mortuary phases at Ban Na Di. The parent matrix is clay 6, the parent material for MP2 bleb wares, and the bleb-tempered anvils discussed below. Thus although Ban Na Di, and as the data set out below demonstrates, much of the Sakon Nakhon Basin as well, witnessed a major change in traditional ceramic production techniques, fabric group 16 endured unaltered.

Firing temperature assessments have not been undertaken for MP2 wares as this lies outside the scope of the present work.
(b) Figurines

Nineteen clay animal figurines from MP1 burial and level 7 occupational contexts have been examined, (fig. 7.26, and Table A.6 Appendix one), ten in thin-section. The latter figurines were modelled from clay petrographically compatible with material local to Ban Na Di (clay 13). In hand specimen each figurine has similar clay characteristics. It seems reasonable, therefore, to extend the petrographic data to them all. The figurines are soft, fragile, (< 3 on Moh’s scale), and crumble easily. Notably none survived intact. Replicas were modelled by the writer from clay 13, and air-dried. They are the same colour, (10YR.5.5/2), with a similar texture and cohesiveness to the prehistoric figurines. These properties contrast with those of the fired local wares, which are durable.
The prehistoric figurines were not tempered or fired. If they were designed specifically for mortuary ritual, such a composition would be appropriate. This is because, as funerary furniture, they would only require sufficient strength to survive the duration of the interment rituals. Such a highly specialized use of local clay, which had a limited ceramic usefulness due...
to its poorly crystalline clay mineral component, (chapter four), helps corroborate the notion of conservation associated with imported quality clay. This motive is also suggested by the blending of local and imported clays in fabric group 3 discussed above. Thus it seems that any opportunity to conserve this exotic resource was readily taken.

Eight figurines were painted with a red iron oxide solution, probably derived from hematite, (Birkeland 1974:67, 86). Another figurine had received a sealant coat of what appears to be a resinous material. Fingerprints and pinched surfaces are often clearly visible which suggests they were hand-modelled. A sharp instrument has been used to model eyes, nostrils and the nose of the human figurines (fig. 7.26).

7.6 Occupation Fabrics

Post deposition disturbances, such as postholes and midden pits, can mean that secure stratigraphic contexts for non-burial pottery are rare. The clarity of flood lenses at Ban Na Di has afforded a secure provenance for grave goods, and allowed precise chronological divisions. These circumstances are not accorded the non-burial pottery. A sampling strategy is required, therefore, which provides a degree of contextual rigour to material of less certain provenance.

Peacock (1982:172), warns that probabilistic sampling risks inadvertent selection of deposits dominated by residual material, and the exclusion of potentially primate samples derived from excavated contexts. Such situations favour judgemental sampling. They may also lie behind the widespread practice of selecting rimsherds as representing the broadest, and most readily recognisable, range of pottery "types". This strategy has proved successful in previous studies, (Kidder op. cit., Shepard op. cit., Rutnin op. cit.), however it includes one serious shortcoming.

Rimform classification studies are heavily biased in favour of selection for exotic wares. Thus rare and/or novel individual members of the sample are emphasized at the quantitative expense of more common varieties. This bias can be briefly demonstrated by comparing the proportions of Ban Na Di MP1 local ware pots to exotic vessels in two ways (Tables 7.4 and 7.5). First, the different proportions with respect to form categories are compared, and second, with respect to the total sample. Mortuary phase 2 and non-burial vessels are excluded.

| TABLE 7.4: Proportions of exotic MP1 burial pot forms. |
|-----------------|----------|----------|-----------------|------------------|
| Phase | n pots | n forms | n exotic forms | % of exotic forms |
| la    | 11     | 3       | 1               | 33.00            |
| lb    | 49     | 14      | 3               | 21.42            |
| lc    | 63     | 13      | 9               | 69.23            |
The implication of selecting for form variants rather than for form-plus-fabric types is that it clearly biases the sample in favour of form or stylistic variety. Thus exotic wares will be disproportionately represented. This is predictable because in a sense exotic is synonymous with novel, and variation orientated studies are, therefore, biased towards the exotic. Of course a range of factors influence the presence or absence of exotic items in any given archaeological context. What is promoted here is that if exotic items are present as individuals in a class of artefacts that includes substantial numbers of locally produced artefacts of the same class, then the bias discussed will prevail.

(a) Rimsherds

Definition of discrete forms allows primary differentiation but risks the bias mentioned above. Unfortunately this bias is exacerbated by the propensity of potters to copy novel forms. In contrast to fabric types, which can be expected to reflect the potter’s inherent technological conservatism, forms are often copied. Such pottery may spread across fabric boundaries. Thus, a single form may exhibit both local and exotic fabrics. With whole vessels, nuances in surface finish and construction methods usually allow copies to be recognized. The situation with rims, however, is less clear. Often only a small portion is available, and plainware rims commonly exhibit little variation in shape. Therefore, correlations between complexity and a single fabric group, or simplicity and more than one fabric group, is selected with increasing sample size.

Table A.7 (Appendix one) sets out the rim fabrics following Wichakana’s (1984:223-290) form categories and nomenclature for levels 8 to 3 inclusive. Representative examples of each form are set out in figures 7.27 to 7.44. White (1986:311) argues that the “US” (for “Upper Songkhram”) designation which precedes Wichakana’s rim categories is geographically incorrect in the case of Ban Na Di, and presumably other sites within the Pao and hence Chi river drainage system. Any attempt to alter Wichakana’s system along these lines would lead to a less descriptive term, however, because we are dealing with cultural entities. We particularly need to discriminate between Chi Valley sites and those within the Sakon Nakhon Basin. This northern basin is usually conceived by geomorphologists as being bounded by the Phu Phan Range. Thus it includes the Kumphawapi zone (Crujjs 1978:8-9, Thiramongkol 1983:14). Ban Na Di is located in this latter zone.
FIGURE 7.27: THE BAN NA DI RIMFORMS FROM LEVEL 8. Scale 1:2
FIGURE 7.28: THE BAN NA DI RIMFORMS FROM LEVEL 7. Scale 1:2
FIGURE 7.29: THE BAN NA DI RIMFORMS FROM LEVEL 7. Scale 1:2
FIGURE 7.30: THE BAN NA DI RIMFORMS FROM LEVEL 6. Scale 1:2
FIGURE 7.31: THE BAN NA DI RIMFORMS FROM LEVEL 6. Scale 1:2
FIGURE 7.32: THE BAN NA DI RIM FORMS FROM LEVEL 6. Scale 1:2
FIGURE 7.33: THE BAN NA DI RIMFORMS FROM LEVEL 6. Scale 1:2

FIGURE 7.34: THE BAN NA DI RIMFORMS FROM LEVEL 5. Scale 1:2
FIGURE 7.35: THE BAN NA DI RIMFORMS FROM LEVEL 5. Scale 1:2
FIGURE 7.36: THE BAN NA DI RIMFORMS FROM LEVEL 5. Scale 1:2
FIGURE 7.37: THE BAN NA DI RIMFORMS FROM LEVEL 5. Scale 1:2
FIGURE 7.38: THE BAN NA DI RIMFORMS FROM LEVEL 5. Scale 1:2
FIGURE 7.39: THE BAN NA DI RIMFORMS FROM LEVEL 4. Scale 1:2

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FIGURE 7.40: THE BAN NA DI RIMFORMS FROM LEVEL 4. Scale 1:2
FIGURE 7.41: THE BAN NA DI RIMFORMS FROM LEVEL 4. Scale 1:2
FIGURE 7.42: THE BAN NA DI RIM FORMS FROM LEVEL 4. Scale 1:2
FIGURE 7.43: THE BAN NA DI RIMFORMS FROM LEVEL 3. Scale 1:2
FIGURE 7.44: THE BAN NA DI RIMFORMS FROM LEVEL 3. Scale 1:2
Some exotic rimsherd fabrics are not fully described as such detail lies outside the scope of the present work. This applies particularly to fabrics considered to originate from sedimentary terrain, and which are not readily associated with Sakon Nakhon Basin potting clays. Many, however, are readily understood in terms of these clays. They have been allocated probable sources with varying degrees of confidence. Thus, these latter fabrics are readily related to general areas. Those of less unequivocal association are followed by a question mark. It is stressed that Tables A.1 to A.11 (Appendix one), can be regarded as approximations only. Further, the stratigraphic contexts of occupation level rimforms should be treated with caution due to the post-depositional disturbances discussed above. Therefore, *in situ* funerary wares are given stratigraphic primacy over occupation level rimforms.

We can be confident, however, that the rim fabric plus form associations are meaningful because they reflect pottery types *sensu stricto*. Thus the associations set out in Appendix one can be considered acceptably secure. The histograms set out below (fig. 7.45 to 7.46), summarize distributions of exotic vessels and rimform fabrics detailed in Tables A.1 and A.7 (Appendix one), and the temporal distribution of orthodox grog and bleb-tempered rims considered local to Ban Na Di. It is important to note that the distribution of exotic fabrics originating outside the Sakon Nakhon Basin closely follows that of local Ban Na Di bleb wares. Exotic “whole” vessel distributions correlate with the exotic rim tendency up to level 5. In combination, these data corroborate the overall rim type distributions. They are mutually supportive, and point to a major change at the level 5/6 interface. A concurrent major stratigraphic discontinuity in mortuary vessels underscores the rim type changes. At the same time, funerary furniture and mortuary ritual also undergo a comprehensive range of changes (Higham and Kijngam 1984). Several other ceramic artefacts have been examined. Comments regarding the origins of exotic rims apply equally to these artefacts as well.
FIGURE 7.45: THE DISTRIBUTION OF EXOTIC FABRICS AT BAN NA DI.
(Shaded area represents exotic wares, totals are outlined.)
FIGURE 7.46: THE DISTRIBUTION OF ORTHODOX AND BLEB GROG AT BAN NA DI. (Upper: totals for site. Lower: Ban Na Di local wares.)
(b) Ceramic “rings”

Several fragmentary artefacts, apparently fashioned as rings or bracelets with round or oval cross sections, were recovered. A small representative sample has been thin-sectioned.

<table>
<thead>
<tr>
<th>TABLE 7.6: Ban Na Di ceramic “ring” fabrics.</th>
</tr>
</thead>
<tbody>
<tr>
<td>level</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>7</td>
</tr>
<tr>
<td>7</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>4</td>
</tr>
</tbody>
</table>

Note: + untempered Ban Na Di clay 13.

(c) Ceramic “ladles”

Only one ladle fragment (cat. 1357 L8 A3/A4 30) has been examined. It is composed of a fabric tempered with orthodox grog. Its origin is uncertain. The parent matrix is consistent with a Sakon Nakhon Basin source.

(d) “Bow” pellets

Abundant small ceramic pellets, probably used with a pellet bow as missiles, occur throughout the sequence. They range in size from about 12 mm to 23 mm in diameter. Those composed of local clay have a high proportion of nonplastics and their hardness (>5 on Moh’s scale) and cohesiveness suggests they were fired. None of the pellets rendered in Ban Na Di clays was tempered. Level 4 revealed an orthodox grog tempered non-local pellet. A fabric group 12 pellet was recovered from level 2. The fabrics are summarized in Appendix one, Table A.12.

7.7 Industrial Fabrics

(a) Ceramic anvils

The paddle and anvil technique remains a principal means of vessel forming in modern north-eastern Thai pottery production and ceramic anvils are still common. Of the 23 anvils recovered at Ban Na Di none was firmly associated with burials. Twenty-one have been thin-sectioned. Their fabric associations and suggested provenance are summarized in Table A.13 (Appendix one).

Eight, (61.53%) of the 13 MP1 anvils examined are composed of fabric group 1. Three (23.07%), contain clay 3. Thus they have eastern Sakon Nakhon Basin affinities. One anvil (7.69%) has a fabric which probably relates to the western Sakon Nakhon Basin margins. The other is composed of fabric group 16 material, which contains clay from nearby Nong Sung. The MP1 anvil forms, (Higham and Kijngam 1984:154-157), can be subdivided into two groups. These correlate with local against exotic fabrics. A typical fabric group 1 anvil is illustrated below, (fig. 7.47) along with cats. 1850 and 858, which contain fabric groups 10...
and 16 materials respectively. These latter anvils differ in shape to the majority of fabric group 1 forms. A single fabric group 1 anvil, (cat. 1851), however, is similar to the fabric group 16 example.

(b) Crucibles

Twenty six fragments of ceramic crucibles have been thin-sectioned. Their petrographic characteristics are summarized in Table A.14 (Appendix one). Several crucibles have bronze slag and/or metal adhering to inner surfaces. In some crucibles, this has also penetrated into the ceramic fabric. Cross sections reveal two clearly different mineralogical portions within such modified crucibles. Peripheral areas tend to be consistent with “normal” pottery ceramics. Areas adjacent to the metal, however, in many cases have been modified, presumably by heat during use. Mullite is present in these latter areas, and this indicates that they were subjected to relatively high temperatures (Rigby 1948, Grim 1962-99-100). A sample Ban Na Di crucible is illustrated in figure 7.48 below.

Fabrics presumed to have partially changed during bronze casting operations, (Seeley and Rajpita 1984:109), were compared with more extensively affected samples. This provided background data useful in assessing their unmodified ceramic properties. Detailed studies of industrially modified crucibles are of course properly the province of metallurgists, and clearly lie beyond the scope of the present work. Fabric identifications, however, may provide insights into important cultural factors outside metallurgical questions sensu stricto. Thus we may note that, with one possible exception, prior to level 5, crucibles were not fabricated from local clays 13 or 14. Most (17 (80.95%), of the 21 examined), were tempered with orthodox grog. Three were rice tempered. Six crucibles are composed of fabrics consistent with MP1 fabric groups 1 or 2. Two of the earliest crucibles parallel a very early occupation level 8 rim fabric, which may derive from within the plagioclase feldspar zone relatively close to Ban Na Di. One crucible has clear mineralogical associations with clays located east of Ban Na Di, close to the Phu Phan Range. This crucible contains sand of a quartze composition. Numerous chert, many potassium and several plagioclase feldspar grains are present in the sand.

Three level 5 crucibles have been examined in thin-section. Two contain untempered Ban Na Di clay. The other is composed of fabric group 13 material, a fabric group considered to originate in the eastern Sakon Nakhon Basin.

(c) Jewellery moulds

Eleven “clay” moulds were recovered, one from level 6, nine from level 5, and one from level 4 (Higham and Kijingam 1984:82). These have been examined in hand specimen only. Of particular interest are moulds presumed to have been involved with the manufacture of bronze bracelets. In cross-section, two distinct materials are visible. An inner, very fine, portion, which often bears fine negative impressions of positive engravings, and an outer encasing coarse shell. The inner component is 1-2 mm and the outer 4-10 mm thick. Some fragments are intact in section, thus it is probable that the cire perdue method, employing either wax or a low melting metal, was used. Ball (pers comm.), describes a method which may explain the process used at Ban Na Di. First, a completed template is dipped into a fine slurry of levigated clay, and then carefully allowed to dry. Second, when leather hard, the initial coat is manually covered with a thicker covering of a coarser clay preparation such as commonly used in pottery manufacture. After a further appropriate period of air drying the mould is ready for casting.
(d) Furnace fragments

Four furnace fragments have been examined in thin-section. One (cat. 472), incorporated a sherd tempered with orthodox grog. The fabric of this sherd is consistent with a Sakon Nakhon Basin source. The largest furnace fragment (cat.955, fig. 7.49), measures 130 mm x 92 mm x 56 mm. It has woven mat impressions on one surface. Two further fragments (cats.916 and 1472), were examined. The former has a partial hand imprint. All of the furnaces were constructed from local clay. Compared to figurine and modern clay samples, however, the furnace fragments are dense with a high proportion of nonplastics. Their composition suggests they were either derived from a slightly different local source than the one the figurines and modern clays were quarried from, or that a preparation technique was used which selectively reduced the clay matrix component. During MP1, only one furnace was uncovered in level 7.

(e) Miscellaneous artefacts

Perforated sherds are present from level 6 at Ban Na Di, and in layers 4, 6 and 7 at Ban Chiang Hian. Such sherds have often been associated with rice steaming. Calder (1972:14) describes similar looking vessels from Ban Koeng as alkali filter pots. Until more complete vessels are available, the precise role of perforated vessels is conjectural. Their provenance and suggested sources are set out in Table 7.7 below.

<table>
<thead>
<tr>
<th>level</th>
<th>fabric</th>
<th>catalogue No.</th>
<th>suggested source</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>12</td>
<td>1503</td>
<td>Ban Na Di</td>
</tr>
<tr>
<td>4</td>
<td>blebs</td>
<td>307</td>
<td>Non Chai?</td>
</tr>
<tr>
<td>4</td>
<td>blebs</td>
<td>1508</td>
<td>Non Chai?</td>
</tr>
</tbody>
</table>

Five rod-like ceramic artefacts, measuring 30 to 40 cm long, by 12 to 18 mm in diameter, were recovered. Each has one pointed end, and is rounded in cross section. A level 7 sample, (cat. 719), has been examined in thin-section. It is composed of dense, but otherwise untempered, fired local clay.

7.8 Final comments and summary

Clearly, the ceramic evidence from Ban Na Di is complex. Only the more salient aspects require discussion at this point. First, two different indigenous ceramic traditions are reflected in the MP1 and MP2 funerary wares. During MP1 manufacture was apparently conducted under the stress of a lack of quality local clay. This led to blending, and the use of local clay in artefacts which did not require a quality ceramic composition. Although affected by this shortcoming, MP1 potters retained their basic tempering method. Modifications were restricted to supplementing imported clay with local material, and to the addition of rice to their basic potting mixture. This was apparently added for ritual purposes. Unfortunately we are unable to examine in detail the MP2 mortuary ritual, except to note that infant burial urns make their first appearance. These contain a technologically different temper from that of the earliest tradition. The MP1 method of vessel fabrication featured the use of moulds. This
CHAPTER 7. THE CERAMIC TRADITIONS OF BAN NA DI

technique was not used in constructing the MP2 burial urns. They were built up from slabs or slabs and coils.

Surface decoration also differs between MP1 and MP2 wares. A majority of MP1 vessels were cordmarked. Miniatures aside, of the 100 vessels sufficiently intact for analysis, 99 were finished in this way. We have noted that this finish, when a paddle and anvil are used for forming, is less demanding than a smooth surface. In contrast to MP1, however, from level 5 onwards smoothed, and red painted or slipped, surfaces dominate (Table B.8 Appendix two). The MP2 burial urns reveal that a plain instrument was used to smooth over underlying cordmarks. This two-stage process preceded a wide variety of painted decoration. In comparison with MP2 rimforms, the MP1 repertoire is very limited. The later production appears to be more developed. Therefore it was probably conducted under different socio-economic conditions. These were apparently more intensive. External relationships, in terms of exotic rim types, involved a much expanded exchange network.

Funerary, occupation and industrial ceramics all demonstrate that a major discontinuity was associated with the replacement of the MP1 tradition by a new one which involved the manufacture of bleb tempered pots. A different clay source was exploited for pottery. This same source, however, probably provided the clay for MP1 crucibles. It is present in anvils during both periods. We have also noted that the changes in pottery manufacture was accompanied by changes in clays and fabrics used in metallurgy. The transition from the MP1 to the new ceramic and metallurgical traditions is marked by technical discontinuity. Several external relationships, however, continued as before. This is reflected in imported materials and a maintenance of technological connections with the eastern Sakon Nakhon Basin region. Such continuity suggests that some existing socio-economic links were maintained and other, perhaps new, relationships are strengthened.

Wares tempered with orthodox grog are present throughout the sequence. During MP1 they were locally manufactured and varied in composition only through the addition of rice. Rice is positively correlated with what are probably ritual vessels. When ceramic strength was not important an inferior local clay was substituted for a quality imported clay normally used for pottery. Figurines, some small artefacts and furnaces contain local clays. “Bow” pellets and crucibles suggest that this practice probably spans both traditions.

Ceramic anvils relate directly to pottery manufacture. They are, therefore, essential items in a potter’s equipment. It seems likely that potters would make their own anvils and identify with them. If so, anvils possess potential as sensitive indicators of cultural changes. At Khok Phanom Di several individual anvils and cylinders of prepared clay were incised with distinctive marks. If such “potters’ marks” denote individual ownership, this concept is reasonably extended to the Ban Na Di anvils. The movements of individual potters, perhaps by way of marriage exchange, are potentially traced through the mobility of anvils. We can also anticipate that changes in ceramic traditions should also be accompanied by a change in potters’ equipment. These are sensitive prima facie indicators of culturally significant processes.

Although the Ban Na Di sample is small, several pertinent points are obvious. First, a clear dichotomy is evident between the distribution of anvil fabrics on each side of the level 4/5 interface. Second, although a variety of exotic fabrics are represented, only one anvil is consistent with a source external to the Sakon Nakhon Basin. An isolated Chi Valley anvil might reasonably be equated with marriage exchange. In this instance, however, we are also presented with a comprehensive range of related developments. And in each instance they correlate with each other. Thus the changes from orthodox to bleb grog at Ban Na Di closely matches changes in the spectrum of imported pottery. Similarly, increases in exotic wares,
which during MP1 emphasize the Sakon Nakhon Basin, are by level 5 strongly influenced by Chi Valley imports. And by level 4 both regions are virtually equally represented in the exotic ware spectrum.

Mortuary vessels are conclusive both in terms of fabric and provenance. Again they are mutually exclusive to MP1 and MP2. Unfortunately, however, they are absent from level 5. In order to resolve this omission, we have been able to focus on rim sherds, crucibles, anvils and several other ceramic artefacts. The first, rim fabrics, clearly support a change at the level 5/6 boundary. Although bleb-tempered rims occur in level 6 and 7, the quantity is small and readily explained by in situ artefact mobility, a familiar phenomenon in Southeast Asian prehistoric sites, where human and animal disturbances, such as posthole digging and bioturbation, are common.

Crucible fabrics are equally important in illuminating the transition at level 5. During MP1 bronze workers avoid using local clay for crucibles. Conversely, however, they use local clay in the construction of their furnaces. There is no evidence to suggest that this strategy was altered during a period of over a millennium. The situation changed dramatically in level 5 with the appearance of the first crucibles made from untempered local Ban Na Di clay. It coincides with the disappearance of the principal MP1 crucible fabric. Admittedly this is a small sample. It is stressed, however, that these accoutrements are key components of a vital industry. The following chapter will outline a model designed to account for temporal changes at Ban Na Di and related sites.
FIGURE 7.47: CERAMIC ANVILS FROM BAN NA DI. (upper: cat. no 858; middle left: cat. no 1851; middle right: cat. no 1850; lower: a typical local anvil form).
FIGURE 7.48: A BAN NA DI CRUCIBLE.
FIGURE 7.49: A FRAGMENT OF FURNACE FROM BAN NA DI.
Chapter 8

A model to account for temporal change

It is now necessary to consider sites with a wide geographic distribution in order to bring into focus evidence for cultural change at Ban Na Di. Sakon Nakhon Basin sites will be considered first, followed by the Khorat Basin, and finally data available from areas external to the plateau. Although many fabrics have been examined in thin-section, a detailed consideration of each is beyond the scope of the present work. Fabric descriptions will, therefore, be confined to general statements. Particular attention will given to temper varieties. Further details will be provided only when essential to demonstrate specific points of interest. Intra- and inter-regional comparisons are necessary if temporal changes in technology are to be identified, because they may involve broadscale processes. As many sites as possible have been examined with the aim of constructing a basic temporal and areal framework. Site names are listed in Table B.1 (Appendix two). The prehistoric ceramics derive from 16 excavations and 32 surveyed sites which were surface collected. All of the excavated pottery has been analysed in thin-section. In 15 cases, surface collected pottery has been considered in hand specimen, the remainder were studied in thin-section. Thin-sections of pottery from 5 modern manufactures have also been examined for comparison.

8.1 Surface collected Sakon Nakhon Basin pottery

Sherds collected from 29 intensively surveyed Sakon Nakhon Basin sites, (Kijingam et al. 1980), have been analysed (fig. 8.1). A summary of fabrics and temper types is set out in Table B.3 (Appendix two).

The distribution of surface collected fabrics is summarized in Table 8.1 below. The data is based on an analysis of 78 sherds, 26 in thin-section.

<table>
<thead>
<tr>
<th>fabrics</th>
<th>sand ?</th>
<th>orth. grog</th>
<th>blebs</th>
<th>rice</th>
<th>vitrified</th>
</tr>
</thead>
<tbody>
<tr>
<td>sherds</td>
<td>1</td>
<td>20</td>
<td>26</td>
<td>25</td>
<td>5</td>
</tr>
<tr>
<td>sites</td>
<td>1</td>
<td>18</td>
<td>24</td>
<td>25</td>
<td>5</td>
</tr>
</tbody>
</table>

The sampling strategy employed (Kijingam et al. 1980:81) involved collecting “at least 40 sherds” and “rimy bases and decorated body sherds were preferred to badly worn or plain
ware.” Thus the bias discussed in chapter 5 is probably inherent in the sample because stress was placed on certain specimens. In addition, the collection was further sampled by the writer for fabric variation. We can be reasonably confident, therefore, that a wide range of fabrics is represented.

### 8.2 Excavated Sakon Nakhon Basin fabrics

In addition to Ban Na Di, smaller excavations were carried out at Ban Muang Phruk and Non Kao Noi (Higham and Kijngam 1984).

**(a) Ban Muang Phruk**

Each of the 93 rimforms, identified by Wichakana (1984b), has been examined in thin-section. The rimform fabric distributions, following Wichakana’s system, are summarized in Table B.4 (Appendix two). Radiocarbon determinations were not obtainable at Ban Muang Phruk because no securely provenanced charcoal was encountered. Based on rimform comparisons, however, the excavators have dated the initial occupation period to c. 100 B.C. The petrographic data support this proposal. The Ban Muang Phruk fabric distributions are summarised in Table 8.2 below. Each rimform is illustrated in appendix two.

<p>| TABLE 8.2: The chronological distribution of Ban Muang Phruk fabrics. |
|--------------------|------------------|----------------|----------------|---------------|</p>
<table>
<thead>
<tr>
<th>level</th>
<th>orth. grog</th>
<th>blebs</th>
<th>rice</th>
<th>other</th>
<th>Phimai?</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1</td>
<td>22</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>23</td>
</tr>
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<td>14</td>
<td>3</td>
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<td>-</td>
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</tr>
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<td>3</td>
<td>-</td>
<td>10</td>
<td>10</td>
<td>-</td>
<td>1</td>
<td>21</td>
</tr>
<tr>
<td>2</td>
<td>-</td>
<td>3</td>
<td>23</td>
<td>1</td>
<td>4</td>
<td>31</td>
</tr>
<tr>
<td>Notes: blebs ? are included in the blebs count. total: 93</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**(b) Non Kao Noi**

Again, no radiocarbon determinations are available. Forty nine sherds have been analysed in thin-section (Table 8.3).

### 8.3 Excavated Khorat Basin fabrics

**(i) Chi Valley sites**

Pottery from excavations at four Chi Valley sites has been examined in thin-section. Two of these sites, Ban Chiang Hian and Non Chai, are large. They probably covered c.39ha and c.28ha respectively (Chantaratiyakarn 1984a), although the precise size of Non Chai is uncertain (Bayard et al. 1986). Ban Kho Noi and Non Noi are small, the latter covering only 100m x 70m (Kijngam et al., 1980:40).
8.3. **EXCAVATED KHORAT BASIN FABRICS**

(a) **Ban Chiang Hian**

Based on radiocarbon results from Ban Chiang Hian and Ban Kho Noi, Chantaratiyakarn (1984:579), proposed the following chronology for Ban Chiang Hian: layer 11, c. 1300-900 B.C., layers 9-10, c. 900-600 B.C., layers 6-8, c. 600-1 B.C., layer 5, c. 1-500 A.D.. A total of 115 sherds, sampled by Chantaratiyakarn, have been examined in thin-section. Most are rimforms. Table 8.4 below, sets out their chronological distribution.

Two anvil fragments were recovered at Ban Chiang Hian, and this suggests pottery was produced on site. Some rimforms have a similar shape and surface decoration to Non Chai and Roi Et examples (Chantaratiyakarn 1984:592).

(b) **Ban Kho Noi and Non Noi**

Both sites are located on a tributary of the Chi River less than 15 km from Ban Chiang Hian (fig. 8.2). Ban Kho Noi and Non Noi ceramics are considered by the excavators to be closely related to those of Ban Chiang Hian (Chantaratiyakarn 1984:583,601). Both excavations were small, exploratory test projects. Some rimsherdb fabrics are petrographically consistent with samples from the Roi Et sites excavated by Higham (1977). Their source is uncertain. A Mun Valley derivation, however, is quite possible because they compare with a major Roi Et fabric group. A total of 36 sherds, mainly rims, have been thin-sectioned and examined optically. Tables B.5 and B.6 (Appendix two), set out chronological distributions of Ban Kho Noi and Non Noi fabrics respectively.

(c) **Non Chai**

This large site occupies a nodal position in the Upper Chi Valley from which access to the Sakon Nakhon Basin was direct and easy (fig. 8.2 and 4.4). It was occupied from c. 400 B.C. to c. 200 A.D. (Bayard et al. 1986), and thus spans the period of transition from level 7 through to level 5 at Ban Na Di. Detailed assessments of temper and surface finish, under Bayard’s direction, were carried out by Rutnin (1979). Examples of each surface finish class, identified by Rutnin, have been thin-sectioned. The fabric distributions are set out in Table 8.5 below.

The frequency percentages given in Table 8.5 were determined by Rutnin, and are expressed as proportions of the entire sample. It should be noted that outcrops of the Khorat Group, which also help form the Phu Phan Range, lie a few km to the west. The two grog-tempered fabrics with biotite have an overall similarity to clay 3 in the Sakon Nakhon Basin. Their mineral associations and hand specimen appearance, however, clearly set them apart from any Sakon Nakhon Basin pottery examined. The Non Chai bleb-tempered fabric groups are different from Sakon Nakhon Basin fabrics both in thin-section and hand specimen. A preliminary fabric assessment has been previously published (Vincent 1984b).

Most of the fabrics are bleb-tempered. They are from red painted or slipped sherds which were concentrated in layer 3. It is important to note that Rutnin’s temper class “clay, sand and chaff” equates with this bleb temper. It comprises 88.4% of the rimsherds and 82.3% of the body sherds she examined under a low-power binocular microscope (Rutnin 1979:93). Non Chai provides important positive evidence to the temporal model set out below. We will return to it later. Each of the following sites is shown in figure 8.2.
(ii) Mun Valley (lower)

Type sherds identified by the excavator from Don Taphan and Non Dua have been analysed. This material can be related to the third excavated Roi Et site, Bo Phan Khan. Each of these sites is located on tributaries of the Mun River. The excavators proposed the following chronology, based on radiocarbon dates and ceramic styles: phase 1, c. 500 - 1 B.C., phase 2, c. 1 B.C. - 700 A.D., and phase 3, c. 700 - 1000 A.D., (Higham 1977).

Higham (1977), who used similar temper and surface finish categories to Bayard and Rutnin, noted that rice-tempered wares dominate at each site. These include a particularly distinctive sgraffito ware, dubbed “Roi Et” by Higham, after the province in which it was first recognised. Sand-tempered pottery became prominent late in the sequence. A thin white ware is also late. At Non Dua a “clay” temper is associated with the early levels (Higham 1977). A selected range of wares representing the above sequence has been examined in thin-section. On the basis of hand specimen evidence, Higham noted that rice temper was early, “clay” rare, and sand was late in the sequence. Their chronological distributions are set out in Table 8.6 below.

None of the Roi Et fabrics is petrographically comparable to those from Sakon Nakhon sites.

“Roi Et” ware

Each of the twenty sherds examined was composed of a fabric consistent with a sedimentary terrain. A notable feature is the numerous to abundant presence of fresh water sponge spicules. All the specimens were tempered with rice husk.

When still plastic, the exterior surfaces of “Roi Et” ware appear to have received a three stage sgraffito treatment. First they were cord-marked, and then a red (10R/4/4 to /6) slip or paint was applied. Finally, a series of horizontal parallel lines were carefully incised into the soft surface with a square-ended instrument. The lines are less than 1 mm deep, about 10 mm wide and 30 mm apart. Where incised, the vessel walls are oxidised a bright pinkish white (7.5YR/8/2). The smooth internal surfaces were also coated with a slip or paint. These vary from partly oxidised to reduced.

(iii) Mun Valley (upper)

Seven sherds from four sites in the Phimai region have been examined in thin-section. Six are considered by the excavator as “typical Phimai tradition chaff-tempered”, and the other similar to Roi Et “white ware” (Welch pers. comm.). Each of the former sherds is tempered with rice husk. Without a detailed investigation of local clays, they are geologically non-specific. The latter sherd is quartzose with an abundance of fresh water sponge spicules and a silty matrix. This ware is very similar in hand specimen to the grog-tempered “thin white” Don Taphan ware discussed above. Petrographically, however, it is different.

The excavator (Welch 1985), basing his conclusions on ceramics, proposed the following chronology: Tamyae phase c. 1000 - 600 B.C., Prasat phase c. 600 - 200 B.C., Classic Phimai phase c. 200 B.C. - 300 A.D., Late Phimai c. 300 - 600 A.D., Sema c. 600 - 950 A.D. Late historic periods have been omitted. According to Welch (1985:229-238), the above dates are tentative. The chronological distribution of sherds, their provenances (Welch pers comm.), and fabrics are summarised in Table 8.7 below.
FIGURE 8.1: SAKON NAKHON BASIN ARCHAEOLOGICAL SITES.
CHAPTER 8. A MODEL TO ACCOUNT FOR TEMPORAL CHANGE

TABLE 8.3: The chronological distribution of Non Kao Noi fabrics.

<table>
<thead>
<tr>
<th>level</th>
<th>orth.grog</th>
<th>blebs</th>
<th>BND 9</th>
<th>rice</th>
<th>Phimai?</th>
<th>none</th>
<th>stoneware</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>12</td>
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<td>-</td>
<td>-</td>
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<td>4</td>
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<td>-</td>
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<td>-</td>
<td>-</td>
<td>11</td>
</tr>
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<td>1</td>
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<td>1</td>
<td>14</td>
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</tbody>
</table>

Notes: + level 4: 3 specimens and level 2: 1 specimen are as for Ban Chiang Hian LXI and LX ordinary grog fabrics.
++ 3 specimens are as for Chi Valley blebs.

TABLE 8.4: Ban Chiang Hian fabrics.

<table>
<thead>
<tr>
<th>level</th>
<th>orthodox grog</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>micaceous</td>
</tr>
<tr>
<td>11</td>
<td>7</td>
</tr>
<tr>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>-</td>
</tr>
</tbody>
</table>

Notes: one additional level 10 fabric has Roi Et similarities.
+ three level 6 and all level 5 sandy grog fabrics may have igneous associations.
FIGURE 8.2: THE DISTRIBUTION OF ARCHAEOLOGICAL SITES CONSIDERED.
### Table 8.5: The chronological distribution of Non Chai fabrics.

<table>
<thead>
<tr>
<th>layer</th>
<th>phase</th>
<th>surface finish</th>
<th>temper</th>
<th>frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>1</td>
<td>“red painted on black”</td>
<td>blebs +</td>
<td>1.33</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>“red slipped and polished”</td>
<td>grog ++</td>
<td>0.29</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>“red slipped with applique”</td>
<td>grog ++++</td>
<td>0.17</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>“black painted on buff”</td>
<td>blebs</td>
<td>0.14</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>“plain”</td>
<td>grog &lt;</td>
<td>22.37</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>“carved paddle, red slip”</td>
<td>blebs ? +++</td>
<td>7.47</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>“red painted on buff”</td>
<td>rice ? &lt;&lt;</td>
<td>6.69</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>“painted with applique”</td>
<td>blebs</td>
<td>0.92</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>“carved paddle, painted”</td>
<td>blebs</td>
<td>54.68</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>“carved paddle, smoothed”</td>
<td>rice</td>
<td>0.41</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>“cord-marked”</td>
<td>rice</td>
<td>5.43</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>“impressed”</td>
<td>rice</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Notes: blebs + fabric is similar to “Roi Et white” (Higham 1977).
+++ bleached biotite, plagioclase feldspar and brown siltstone are present.
< biotite, brown siltstone, and phlogopite (?) are present.
+++ this grog is difficult to categorise as the fabric is dense. It probably represents a plastic clay. Several rice husk fragments are also present.
<< a dense sandy oxidised fabric with a light amount of rice husk “temper?” It has “Roi Et white” overtones.

### Table 8.6: The chronological distribution of Roi Et fabrics.

#### Non Dua:

<table>
<thead>
<tr>
<th>phase</th>
<th>level</th>
<th>temper</th>
<th>excavators’ category</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16</td>
<td>orth.grog +</td>
<td>“smoothed plain”</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>rice ++</td>
<td>“white ware”</td>
<td>1</td>
</tr>
</tbody>
</table>

#### Don Taphan:

<table>
<thead>
<tr>
<th>phase</th>
<th>level</th>
<th>temper</th>
<th>excavators’ category</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>28</td>
<td>rice +++</td>
<td>“Roi Et ware”</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
<td>rice +++</td>
<td>“coarse ware”</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>7b</td>
<td>rice +++</td>
<td>“white slipped”</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>4e</td>
<td>orth.grog +++</td>
<td>“thin white”</td>
<td>1</td>
</tr>
</tbody>
</table>

Notes: + a sandy fabric with a different mineralogy to earlier fabrics. It has possible igneous associations.
+++ a similar mineralogy to the above fabric but lightly tempered with rice
+++ parent body is consistent with a sedimentary source.
++++ moderately micaceous matrix.
### TABLE 8.7: The chronological distribution of Phimai fabrics.

<table>
<thead>
<tr>
<th>Site</th>
<th>section No.</th>
<th>date</th>
<th>temper</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ban Suai</td>
<td>C1</td>
<td>0 A.D.</td>
<td>rice husk +</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>C3</td>
<td>0 A.D.</td>
<td>rice husk +</td>
<td>1</td>
</tr>
<tr>
<td>Ban Tamyae</td>
<td>C2</td>
<td>500 B.C.</td>
<td>rice husk +</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>C4</td>
<td>400 B.C.-100 A.D.</td>
<td>rice husk +</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>C5</td>
<td>post 0 A.D.</td>
<td>rice husk ++</td>
<td>1</td>
</tr>
<tr>
<td>Ban Prasat</td>
<td>C7</td>
<td>no data</td>
<td>rice husk +</td>
<td>1</td>
</tr>
<tr>
<td>Non Ban Kham</td>
<td>C6</td>
<td>200 B.C ?</td>
<td>sand ? +++</td>
<td>1</td>
</tr>
</tbody>
</table>

Notes: + moderately micaceous matrix  
++ silty matrix  
+++ it is unclear whether this fabric is tempered.
8.4 Excavated Central Highland fabrics

(i) Pa Sak Valley

Freestone recognised six fabric groups at Khok Charoen (Table 2.1), (Watson et al. 1982). Type samples of fabric groups 1 to 5 inclusive have been examined in thin-section. None bears any significant resemblance to any of the Khorat Plateau fabrics discussed above. According to Freestone, fabric group 6 contains fragments derived from an epidotized granitic rock. Thus all of the Khok Charoen fabric groups can be discounted from our consideration of Khorat Plateau wares.

(ii) The Phu Wiang region

Bayard (1984:88-89), assumes a date 3000 - 2600 B.C. for the initial settlement of Non Nok Tha, "and a date between 500 B.C. and 200 A.D. for the end of the Non Nok Tha Phase". According to Bayard (1977:84), the Non Nong Chik and Non Nok Tha temper groups are substantially the same. Type specimens selected by Bayard for both sites have been examined in thin-section. In each case the fabrics are different to any previously discussed from Khorat Plateau sites. Most are readily understood in terms of the local geology. Several include igneous minerals. At Ban Na Di, two MP1 vessels (pots 62 and 64) are probably derived from near this area. Non Nong Chik fabrics examined from levels 8-5 (inclusive), are sandy and probably untempered. Fabrics from levels 1-3 are composed of a petrographically similar material. It is important to note that these are tempered with rice husk. Levels 1-3 at Non Nong Chik post-date the Non Nok Tha phase.

(iii) The Pa Mong survey area

Bayard (et al.), conducted a site survey in the Loei region. Representative sherds surface collected from the Loei area sites of Non U Mung, and Non Na Nong Khong, and from Ban Tak Det in Laos (Bayard 1980), have been examined in thin-section. In each case the fabric displays a clear igneous association.

(iv) Excavated Loei sites

Sherds from two recent excavations in Loei province (Rutnin pers.comm.), have been examined petrographically. These include four representative vessel sherds from Noen Phrik (Phrik Mound), and one burial associated sherd from Tham Pha Phim (Pha Phim Cave). Each of the vessel sherds belong to the same fabric group. It contains fragments of a weathered volcanic rock, probably a rhyolite. This is readily understood in terms of the regional geology. The rock fragments are probably natural inclusions.

The Pha Phim Cave sherd represents a different fabric group. Also igneous, in this case the mineralogy suggests a granitic or granodioritic source. This fabric is mineralogically equivalent to "Nga Ngua Buff", pottery surface collected from Non Na Nong Khong (Bayard 1980:70).
8.5 Khok Phanom Di

Over twelve hundred thin-sections of “whole” burial vessels, rimforms, ceramic anvils, prepared clay cylinders and modern clay samples have been examined. The implications of bleb tempered wares in the Khok Phanom Di assemblage are discussed below.

8.6 Temporal interpretative model

The evidence presented above is necessarily detailed due to the nature of the study area’s regional geology. This detail is central to the model outlined below. It has also been provided in the hope that it will stimulate the acquisition of further information on ceramics, and thus lay the ground for more precise alternative models. It is recognised the evidence could be interpreted differently to that in the proposed model. Further, it is stressed that the present model is considered the most appropriate only in terms of the current information.

We will approach the evidence from two directions. First, evidence considered peripheral to our purpose will be excluded. Second, a series of temporally sequential events will be correlated in order to provide a coherent chronological framework for Ban Na Di. This means that some changes in remote parts of the Khorat Plateau, and indeed beyond, will be considered.

To help bring into focus the likely origins of changes in Sakon Nakhon Basin pottery traditions, such as that evidenced by the dichotomy between MP1 and MP2 at Ban Na Di, we can reasonably exclude the Central Highland zone. This is because pottery from there either includes igneous minerals or displays a different sedimentary petrology to the Sakon Nakhon Basin clays. They contrast with the fabrics which dominate the known Sakon Nakhon Basin sites. For the origins of these changes, therefore, we must identify another sedimentary source zone.

At Ban Na Di, 4 of the 8 rimforms from the basal occupation level reveal a fabric mineralogically consistent with a source within the surrounding plagioclase zone. It is tempting to view this ware as having accompanied the initial settlers. Such a source would help explain the strong ties with Eastern Sakon Nakhon Basin traditions which are documented in anvils, crucibles, MP1 burial vessels and rim fabrics. It is an association which continued throughout MP1. It is also possible, however, that this early fabric represents some other event, such as the first attempts at exploiting clays close to Ban Na Di.

Vessels made from exotic fabrics were imported throughout MP1 (fig. 7.45). A clear dominance of Sakon Nakhon Basin sources is evident in both whole vessel and rim fabrics. One MP1c burial vessel (pot 65) has a possible Khorat Basin origin. Two vessels are consistent with a Petchabun piedmont source. One (pot 64), is from MP1b, the other (pot 62), from MP1c. The high value attached to this ware is suggested by a local copy represented by a MP1c vessel (pot 63). Although this vessel is very similar to pot 62 in form, surface finish and construction details are different (Table B.7 (Appendix two)). Exotic pottery from the Central Highlands is rare. Thus, this local reproduction is corroborative evidence of the prestige attached to exotic wares for mortuary furniture. It also reinforces the evidence from anvil and crucible fabrics of clear external relationships beyond the immediate environs. It is possible that such exotic wares were sent as mortuary gifts from more remote affines. Exchange networks involving prestige pottery are another mechanism for the circulation of exotic pottery. The rarity of pottery from the Central Highlands, however, suggests minimal contact of either kind. This contrasts markedly with the prominence of exotic wares derived from Sakon Nakhon Basin.
sources. Pottery production was important to the inhabitants of Ban Na Di throughout the sequence. This is reflected in the importation of quality clay, and the blending or differential use of local materials during both MP1 and MP2. Thus production persisted in the face of a lack of suitable local clay.

Cultural relationships, in terms of the ceramic technologies involved, illuminate two distinctive emphases. During MP1, a close association with what appear to have been Eastern Sakon Nakhon Basin pottery traditions dominates the external relationships. Anvils fashioned using nearby clay 6, and clays consistent with eastern sources over 50 km distant, hint at the presence of immigrant potters. Exchange alliances, involving marriage partners and the residential movement of individuals, is one mechanism which might help explain these factors. Mortuary vessels, occupation rimforms and industrial accoutrements all point to a close association with Eastern Sakon Nakhon Basin societies. The intensity of these links increased steadily throughout MP1.

Asymmetry between intensifying inter-regional associations and undeveloped intra-regional potentials may point to mechanisms which acted in unison to enhance some relationships but conserve others. It seems reasonable to infer that if societal adaptations vary because they relate to different environments, these will be reflected in broader cultural aspects. These may relate more to subsistence and technology, however, rather than to secondary cultural aspects such as pottery. Therefore pottery may often not be markedly distinctive even when it relates to cultures with different lifestyles. This factor could explain the lack of close connectivity between the Central Highlands and Sakon Nakhon Basin communities in terms of the exotic pottery spectrum at Ban Na Di.

Physical isolation, rather than cultural differences, may have initially hampered southern influences on the northeast. With the settlement of Non Chai, however, a pivotal location between north and south was filled. Whether this single event ultimately provided a catalyst for the subsequent northeastern developments is unclear. We will discuss the likely effects of this question in the final chapter.

Relationships beyond the Sakon Nakhon Basin throughout MP1 appear to have been limited. Commencing with the deposition of level 5, however, a series of dramatic and comprehensive changes are obvious. In terms of imported wares, the Eastern Sakon Nakhon Basin influence is initially weakened, and then almost replaced by Khorat Basin ceramic traditions. In concert with the initiation of this change, a tempering tradition relatively recent to the Upper Chi Valley suddenly penetrated the Sakon Nakhon Basin.

Subsequent to changes in the indigenous pottery tradition at Ban Na Di, late in the 1st millenium B.C., relationships with the southern cultures develop in quantity and depth at the expense of established Sakon Nakhon Basin relationships. Ceramics from the Chi Valley in the first instance, and by c. 200 A.D., together with Mun Valley wares, increase at the expense of Eastern Sakon Nakhon Basin pottery. By c. 500 A.D. ceramics originating in the Khorat Basin exceed, for the first time, exotic Sakon Nakhon Basin wares. Equally important, however, are the concurrent changes in industries interrelated with pottery production. We can defer an examination of these factors until chapter nine, and confine our present inspection of the evidence to that directly involved with pottery *sensu stricto*. A key question is the origin of bleb-tempered wares during the period preceding the level 5 change in the local pottery tradition. Clearly, the prime candidate is Non Chai. Both temper species and mineralogy are distinctive enough to rule out any of the alternatives.

Rutnin (1979) noted that the majority of bleb-tempered sherds were from red-painted or slipped wares, which concentrated in layer 3 at Non Chai. Similar wares characterise level 5
8.6. **TEMPORAL INTERPRETATIVE MODEL**

at Ban Na Di. This surface decoration contrasts sharply with MP1 treatments, as Table B.8 (Appendix two), shows. The implications of this correlation for “Ban Chiang Painted Ware” are examined in chapter ten.

Bleb-tempered pottery is predominant among basal Ban Muang Phruk wares. If the earliest levels are subdivided into lower and upper portions, however, a clear dichotomy between the surface finish of rimforms is evident. Table 8.8 below, illustrates this.

**TABLE 8.8: Ban Muang Phruk: The surface treatments of early rims.**

<table>
<thead>
<tr>
<th>level</th>
<th>spits</th>
<th>red slip/paint %</th>
<th>plain %</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>21 - 19 +</td>
<td>22.22</td>
<td>77.77</td>
<td>9</td>
</tr>
<tr>
<td>5</td>
<td>18 - 16 +</td>
<td>72.72</td>
<td>27.27</td>
<td>11</td>
</tr>
</tbody>
</table>

Note: + inclusive

Rutnin reported that at Non Chai plain wares were the second most common surface finish, comprising 22.37% of the total. They concentrate in the upper two layers and retain the early temper species (Rutnin 1979:119-121). None of the lower level 5 Ban Muang Phruk plain rim types occur at Ban Na Di, but several are morphologically similar. For example compare BND US 58 with BMP US 192 (Higham and Kijngam 1984:36, 55). Of the eleven upper level 5 Ban Muang Phruk rim types, six match level 6, and five match level 5 specimens at Ban Na Di.

This early emphasis on plain surfaces might be explained by a lack of local raw materials or knowledge of them. Suitable raw materials for red pigments are locally available, however, so this is unlikely. In view of potters’ capacity to copy, imitation of local preferences may have been a stimulus, particularly if the Ban Muang Phruk inhabitants were a minority group. This site may have been an early forerunner of a much larger movement of people from the Khorat Basin, because the plain surface finish soon gave way to the preferred treatment evident in the Non Chai slipped or painted bleb wares. This interpretation is, of course, speculative.

The movement of people using a range of different pottery manufacturing methods into the Sakon Nakhon Basin from the south is a possibility which gains explanatory force when a wider view is taken. A summary of known ceramic sequences, using “temper-typing” in a very general way, reveals a temporal regularity in potting tradition changes within the Khorat Plateau. This began in the south and progressed northwards. It is unnecessary, for the present, to determine whether the Khorat sites were manufacturing centres, although all or many may have been. We need not presume so. Our purposes are here served if we can establish that the fabrics were consistent with the regional sedimentary terrain. Furthermore, added support would come, if they were consistent with the Khorat Plateau geology, if we could categorise their temper species in terms of areal and temporal distributions.

The difference between Khorat Basin fabrics and Sakon Nakhon Basin wares is in most instances apparent. Accepting for the moment that “fibre and clay” or “chaff with grog” equates with blebs, this temper may have been present at Roi Et, (Higham 1977:111-137), and Phimai, (Welch 1985:199-203), by the middle of the first millenium B.C. This information is, unfortunately, tenuous without detailed petrographic evidence. To resolve this dilemma, we need now to cast our net still wider.

Pottery excavated at Khok Phanom Di (fig. 1.1), includes bleb-tempered wares. These are present throughout occupation levels, in burial fabrics, and in one of the many ceramic anvils. Blebs are associated with a wide range of fabrics. Some are related to fabrics whose parent
bodies are consistent with clays examined from within the large tract of sedimentary terrain surrounding the site. But in each case they appear exotic. Such marked fabric variability suggests bleb temper was regionally widespread (Vincent 1987). We have already noted, in chapter six, that grog may be closely associated with sedimentary terrain. Khok Phanom Di is pre-metallic, and occupation was probably confined to the period 3000-1500 B.C. (Higham et al. 1987:148).

At Ban Na Di, the first bleb-tempered fabric occurs later than 1000 B.C. It is consistent with a Chi Valley derivation. At Ban Chiang Hian, blebs are represented by two rimsherds and one bodysherds. Each has a red painted or slipped band. Their fabrics, although consistent with a sedimentary source, differ from both the postulated local wares and those from the other Khorat sites already discussed. The rims have both been classed “TYPE BCH 2” an “infrequent type” by Chantaratiyakarn (1984:593-594). Their provenance suggests a late first to early second millennium date. In figure 8.3 they are compared with rimforms US58 from Ban Na Di and US192 from Ban Muang Phruk.

![Figure 8.3: Comparison of Ban Chiang Hian, Ban Na Di and Ban Muang Phruk Rimforms. (Upper row: “TYPE BCH 2”)](image)

Current background evidence, viewed in combination with the areal and temporal distributions of bleb-temper, suggests an early origin outside the Khorat Plateau, followed by a gradual movement within the plateau from south to north. Thus it seems reasonable, at this stage, to view the movement of bleb wares into the Sakon Nakhon Basin as the culmination of a generalized process which originated far to the south beyond the plateau’s borders, probably about two or so millennia prior to its initial introduction into Ban Na Di.

Khorat Plateau ceramic industries may be traced through a series of temper changes which
together give an orthodox grog-blebs-rice sequence. To what extent this system can be generalised awaits future analysis. It is stressed, however, that this proposal does not exclude localised variations. Rice temper, for example, is present from the lowest levels at Ban Na Di. Its widespread use throughout the Sakon Nakhon Basin *in quantity*, however, was probably late. At Ban Chiang Hian the bleb-tempering method may not have been adopted. It should be noted, however, that this very large site was extensively fortified with moats and ramparts (Kijngam *et al.* 1980:41).

It should be clear by now that the proposed temporal model argues for a series of general trends. These were superimposed onto a mosaic of, often probably locally circumscribed, ceramic technologies, each falling under the rubric of a specific ceramic tradition. Similar general trends may characterise diffusion of new methods, either with or without population movements. Hence the Sakon Nakhon Basin sequence may have mirrored, in microcosm, several more widespread events. In the following chapter we will consider in detail the stratigraphic discontinuity at Ban Na Di. This may help illuminate the processes involved, and allow some insight into the kinds of effects the events postulated above may have had on local populations.
Chapter 9

The level 5/6 interface at Ban Na Di

A major stratigraphic break is evident in Ban Na Di at the level 5/6 interface. In pottery, this change is characterised by the replacement of the founding orthodox grog-tempering tradition with another highly distinctive technology. A different and more sophisticated range of pottery types is evident. Whereas during MP1 wares are rarely slipped or painted, the new assemblage is dominated by this surface treatment. The new ceramic tradition is accompanied by many changes in other aspects of material culture as well as mortuary ritual, but faunal and floral remains suggest a continuity in subsistence strategies throughout the prehistoric occupation (Higham and Kijngam 1984:698-701).

Deposition of lower level 6 material saw the last use of the excavated area for burials belonging to MP1. Evidence for in-situ bronze casting as well as the first recovery of iron slag were found in level 5 (Higham and Kijngam 1984:29).

If we are to account for these developments, it is important to establish whether a hiatus occurred between the end of level 6 and the beginning of level 5. We may address this question through a comparison of levels 8-6 with levels 5-3 pottery and industrial ceramics. Ceramic artefact groups which span the period in question are of special interest. The principal source of pottery during MP1 is from secure mortuary contexts, but the levels 5-3 wares derive mainly from occupation areas. Correlation with evidence from other Sakon Nakhon Basin sites, however, could be expected to corroborate that from Ban Na Di.

A central objective of the present study has been to consider a wide temporal and areal framework. If the model set out in chapter eight has achieved its objective, it will have shown that generalised processes underlie the changes at Ban Na Di. During MP1, very few exotic fabrics originated outside the Sakon Nakhon Basin. This emphasis changed markedly during the period levels 5-3 were laid down, when imports from the Khorat Basin become increasingly dominant. The MP1 local pottery manufacture is characterised by an orthodox grog tradition, but during the subsequent period, a bleb grog tradition is established. These developments mirror, at least partially, changes of a much broader nature which permeated the Sakon Nakhon Basin.

Temporal distributions of exotic fabrics provide insight into changing cultural relationships. When local changes occur in concert with regional changes, their role as information carriers is increased. If technological innovation accompanies such events, an enhancement of inter- and intraregional diversity is favoured. According to Renfrew (1972, 1975) growth in endogenous and exogenous exchange favours societal cohesiveness and the rise of central places. To explore these processes, we need to discriminate between local change and external influences at Ban Na Di.

Although the available data do not allow a detailed understanding of these latter events, a
broad outline of external relationships is apparent in the technological developments already noted. These probably influenced much of the immediate region and are interwoven with the Ban Na Di sequence. Thus bleb-tempered wares dominate the earliest levels at Ban Muang Phruk. This dominance is secured later at Non Kao Noi following a first occurrence of Chi Valley fabrics. These sequences match the change at Ban Na Di, the magnitude of which is confirmed by surface collections. These suggest that bleb-tempered wares became widespread throughout the Kumpawaphi and Upper Songkram region. In addition, a marked growth in interregional exchange is evident.

Ban Na Di burial vessels from mortuary phases 1 and 2 are both petrographically and stratigraphically distinct, but no burials were found associated with level 5. To help resolve this lacuna we will turn to other evidence. We should first note, however, that four of five mortuary phase 2 infant burial urns were made of local bleb wares but the fifth contains fabric group 16 material. This gives a secure stratigraphical association of old and new ceramic traditions.

Fabric group 16 material also occurs in one level 7 and two level 5 anvils. This continuity reinforces the close association between Ban Na Di and Nong Sung suggested by the funerary urns. In level 5, for the first time, both local pottery fabrics and imported anvils are rendered in Nong Sung clay. Yet the imported anvils represent the old tempering method, while the local pottery follows the new bleb tradition. Overlying the local changes pottery and anvils of the old tradition continued to enter Ban Na Di, a clear signal that the manufacture of bleb-tempered pottery did not replace the long-established Sakon Nakhon Basin ceramic traditions completely.

Temporal distributions of Sakon Nakhon Basin wares after level 6 also support assimilation rather than replacement. During level 6, no such bleb-tempered wares are evident. They make their first appearance in level 5, when they almost equal wares tempered with orthodox grog. Significantly, level 5 also demarcates the first dominance of local bleb-tempered wares at Ban Na Di. Equally important is a rapid decline of Sakon Nakhon Basin blebs during level 4, coupled with the reinstatement of orthodox grog dominance. This suggests other Sakon Nakhon Basin manufacturies continued production unaffected by the new developments.

We need now to reflect on the above evidence in terms of the relative similarity between the tempering methods of the two ceramic traditions. Their responses to the requirements of processing clays derived from sedimentary contexts fell under the same technological rubric: both employed a grog temper. Thus both ceramic traditions are likely to have carried out production in similar environments in terms of the temper chosen. Given the higher energy input involved, potters are unlikely to opt for grog temper unless suitable alternatives are unavailable. These circumstances favour an origin in sedimentary regions which lack readily exploitable tempering materials. This is not meant to imply simple environmental determinism, but argues for a logical adoption of circumscribed technical methods in the absence of any viable alternative. If potters wish to carry out pottery manufacture, the only possible alternatives are importation or the adaptation of materials through their modification. This latter response is, of course, reliant on technological knowledge and expertise.

If cultures which share generally similar environments also share similar cultural adaptations, their exploitation of these habitats may also be similar. If so, this compatibility is likely to have enhanced diffusion and the subsequent assimilation of new, improved, techniques. According to Houghton and Wiriyaromp (1984:401), the human remains display only slight evidence of biological change between mortuary phases 1 and 3. The ceramic evidence does
not contradict these data. Conversely, the almost complete failure to develop further the potential western links can be explained by the same theoretical constructs. Thus the adaptation to the western piedmont is unlikely to match closely that to the sedimentary basins of the Khorat Plateau.

Rim fabrics changed markedly at the level 5/6 boundary. Nine local bleb-tempered rim-forms occur in level 6, few enough to be explained by human and animal activities such as posthole excavation or bioturbation. A review of fabric distributions should help redress any imbalance between doubtful stratigraphic integrity opposed to statistical rigour. We will consider exotic rims and industrially related fabrics.

In spite of probable mixing between levels, the frequency distribution histograms set out in figure 9.1 show trends in the incidence of exotic rims. These are reinforced by “whole” vessel distributions. It is recalled that exotic fabrics will be disproportionately represented due to the bias discussed in chapter seven.

Exotic fabrics increased steadily from level 8 until level 4, when they declined sharply. Exotic wares from Sakon Nakhon Basin sources almost mirror this increase, but clearly suffer heavily from the level 4 decline. Fabrics from outside the basin, however, jump dramatically at level 5. They continue to increase throughout level 4 and 3. In spite of the sharp overall reduction of imported wares from level 4 onwards, the considerable increase in Khorat Basin imports continues unaffected. Khorat Basin wares more than double in level 5, just as Sakon Nakhon Basin wares begin their decline. These dramatic events gain increased significance set against both a long period of import conservation and the increased distance Khorat Basin wares were transported.

“Whole” vessel fabrics corroborate the levels 8-6 increase in Sakon Nakhon Basin imports. Exotic vessels follow the same temporal frequency distribution pattern displayed by the levels 8-6 occupation wares. This validates the initial tendency of increased proportions of exotic wares but with emphasis on Sakon Nakhon Basin rather than Khorat Basin pottery. Thus it seems reasonable to view the overall shape of the exotic rim frequency distributions as meaningful. Further corroboration is available from industrial fabrics.

Ceramic anvils relate directly to both production and the practitioner. They are thus potentially sensitive indicators of fine grained as well as broader cultural changes. At Ban Na Di, a clear dichotomy is evident between the distribution of early and mortuary phase 2 local fabrics. Each is mutually exclusive to the stratigraphic zones either side of the level 4/5 interface. A variety of exotic fabrics are also represented. With one level 4 exception, (cat. number 387), they are all consistent with Sakon Nakhon Basin clays. This latter anvil is composed of a fabric which is consistent with a Chi Valley derivation.

Early period crucible fabrics do not contain local clay, yet it was used to construct a level 7 furnace. This changes in level 5 when two crucibles manufactured from untempered local clay appear. This first evidence for use of local clay in crucibles coincides with the disappearance of the major early crucible fabric. Crucibles are components of an important industry, thus it would be difficult to dismiss these changes as the result of whim. If so, they occurred in the face of a tradition spanning over a millenium, and unnecessarily risked crucible failure. The use of local clay for a level 7 furnace increases the likelihood that experimentation with its use in crucible fabrics took place. If so, it is possible these were unsuccessful because casting procedures during MP1 ruled out its use. The possibility that contact with Eastern Sakon Nakhon Basin metallurgists continued, beyond the level 5/6 interface, is suggested by the presence of crucibles both in level 7 and within level 5 (cats.1371 and 1730 respectively).

Clearly, major changes in the combined pottery data are independently corroborated by
key industrial evidence. Even when viewed in isolation, many individual changes are highly informative. Coherence is present between each of the key ceramic aspects examined. These correlations are unlikely to have been coincidental. Interpretation of this information naturally involves important cultural questions.

Three processes seem to be central to the changes documented within the Sakon Nakhon Basin. First, they appear to form part of broad scale developments which probably originated beyond the southern boundaries of the Khorat Plateau and culminated in Northeast Thailand. Second, we can reasonably anticipate that an intensification of exchange relationships between the Chi Valley and the Sakon Nakhon Basin provided a catalyst for an increase in technological and cultural interaction. Such exchanges could have favoured the diffusion of people manufacturing in the bleb-temper tradition into the Sakon Nakhon Basin. Thirdly, subsequent to the widespread introduction of the new technology, methods previously extant over much of the region continue to be favoured by some Sakon Nakhon Basin pottery manufactories but not others.

At the point when level 5 at Ban Na Di started to accumulate, production of ceramics employing techniques peculiar to the early tradition seems to have continued without pause in some Sakon Nakhon Basin centres. Others changed to the new tradition. Previously unoccupied sites were also settled by people at least utilizing extensively, if not manufacturing, the new ware. During this period at Ban Na Di, the material culture intensified dramatically in range and complexity, and iron slag first occurred (Higham and Kijngam 1984). Accoutrements associated with metal casting at Ban Na Di changed after more than a millenium of continuity.

The introduction of these new technologies into the Sakon Nakhon Basin seems to have had an uneven effect on the existing manufacturing and related exchange infrastructure. It apparently complemented rather than superseded the existing ceramic exchange frameworks. The transformation of ceramic methods at Ban Na Di was complete, and the ceramic spectrum from Non Kao Noi suggests that this change was repeated at other production sites. At Ban Na Di close links with the Eastern Sakon Nakhon Basin continued. This region is adjacent to tin deposits in Laos, a key raw material in bronze production. Thus the existing Sakon Nakhon Basin exchange networks are maintained and intensified. This intensification is repeated in the Khorat Basin exchange network, which previously recorded a steady, but less intensive, development. Intensified exchange networks require increased organisation and hint at population increase. Population growth and subsistence expansion are recurrent but not sufficient, conditions for the development of stratified societies (Dumond 1972). It seems reasonable to assume, however, that the assimilation of new and improved technologies would consequently stimulate accelerated change.

The mechanisms underlying these changes are clearly likely to be complex and it may be unwarranted to speculate too far, without a more detailed understanding of the parameters involved. In summary the following processes are suggested for the Khorat Plateau:

(i) the broadscale changes in ceramic technology were superimposed onto existing traditions.
(ii) exchange-induced diffusion of new technologies from south to north.
(iii) assimilation of these innovations occurred, usually along with population movements, into new regions.

Since the evidence could be interpreted in several ways, we need not argue for direct expansion of centralised polities nor as yet reject such models. Until both a clear chronological framework and further production and technological evidence is available, it may be prudent...
to view the many and varied competing models as conjectural and refutable. This comment is designed to accommodate what could well have been a mosaic of local responses to the conjectured processes. It would help explain, for example, why the inhabitants of the large fortified site of Ban Chiang Hian do not seem to have taken up the new bleb-temper technology.

In the Sakon Nakhon Basin, a variety of site occupation strategies were adopted during the period of infiltration. Some sites, such as Ban Muang Pruk, were occupied for the first time. Non Kao Noi and Ban Na Di had been previously inhabited. Perhaps the clinching factor which points to a mid-sequence hiatus at Ban Na Di is the sharp discontinuity in existing ceramic manufacture, coupled with a clear continuity in external relationships which involve metallurgy within level 5. Thus a close association with key external relationships was maintained without any noticeable disruption. This apparently smooth transition, however, occurred in concert with major changes in the technological framework of two important industries.

Throughout the sequence, ceramic production proceeded under stress due to the inadequacy of local raw materials. Such circumstances magnify any risks attached to the exploration of alternative clay sources. What factors mitigated during MP1 in favour of one clay for pottery and another, probably similarly distant, for crucibles is unclear. Certainly, social relationships alone need not take precedence. The MP1 clay source at Nong Kham Din is yet to be exhausted. We can be reasonably confident, therefore, that the level 5/6 discontinuities, when taken in conjunction with the ceramic data, provide strong prima facie evidence of a hiatus between level 6 and the inception of level 5. Metallurgy also involved exotic ceramic materials. Their presence underlines strong Eastern Sakon Nakhon Basin associations. A continuity of contacts with this region suggests raw material dictates were given precedence. Thus it is reasonable to assume a reliable source of clay would not have been needlessly passed over. Immigrants taking up residence in a populated settlement can reasonably be expected to acquire local knowledge of such an important clay source quickly.

In the following chapter we will proceed with a review of two problems directly related to the shortcomings inherent in pottery analyses which emphasize style. In each case the stylistically distinct ware concerned has important implications for both regional and inter-regional chronologies.
FIGURE 9.1: THE DISTRIBUTION OF FABRICS AT BAN NA DI.
Chapter 10

The "Om Kaeo" and "Ban Chiang painted" ware problems

Two distinctive kinds of surface decoration were encountered at Ban Na Di among exotic wares. One involved incised and/or incised and slipped or painted surfaces, the other featured painted designs only. The first variety has often been categorised as "Om Kaeo" ware after the site wares of this surface finish were first recognised. Similarly, it has been common practice to equate the painted wares with Ban Chiang where this surface finish was prominent. Because both kinds of wares have often been used as chronological "markers", and they have been postulated as having had a relatively wide distribution, their wider context needs to be considered.

10.1 The "Om Kaeo" problem

Many of the problems which beset stylistically orientated characterisations of Southeast Asian ceramics can be summarized through the analysis of pottery often labelled "Om Kaeo". Since the discovery in 1972 at Ban Om Kaeo (Preecha and Pukajorn 1976), of globular cord-marked vessels with decorated fields, almost any similarly decorated sherd has been categorised "Om Kaeo". The decoration consists of intricately incised and slipped or painted fields often ingeniously arranged. Ban Om Kaeo lies about 1 km from Ban Chiang.

When a "wealth of this pottery" was recovered at the latter important site, the excavators, Gorman and Charoenwongsa, "almost" designated a single phase "Om Kaeo". They note that "various renderings of this technique exhibit one common feature - the design motifs so carefully incised on the buff background are later filled with highly contrasting red pigment" (Gorman and Charoenwongsa 1976). Characterised by curvilinear and geometric designs, the ware was "probably the most distinctive " and considered "highly diagnostic" (Gorman and Charoenwongsa 1976:20-21). In the light of this report, perhaps predictably, such decorated wares were often used for intersite chronological correlations (Bayard 1987, White in: Bronson and White 1984, Higham and Kijngam 1984). Subsequent reconstruction of Ban Chiang vessels has revealed considerable variety, and recently these wares have been used to help designate three phases in a revised Ban Chiang chronology (White 1986:240-245, 279).

White has pointed out that the term is now so "broadly and imprecisely applied" to render it meaningless for stylistic crossdating. She notes that the lumping of these vessels together on the basis of "incised and painted designs" (i.e their mode of surface decoration), "caused considerable confusion" (1986:245). Yet in spite of this, specific distinctive (sic) forms may
be diagnostic, White argues. Recognition of this problem epitomises the shortcomings of style-oriented classification.

As with “Om Kaeo”, so it is with many other style-derived groupings of prehistoric Thai ceramics. Almost any heavily reduced, burnished ware has been labelled “Phimai Black” (Solheim and Ayres 1979), because many such sherds were recovered at Phimai. Bronson and White (1984) refer to the “Black Ware” phase at Phimai. Similarly “Ban Chiang Painted” could be almost any red painted or slipped sherd, particularly when it has spiral or circular designs. “Nong Bua Buff” (Bayard 1980), refers to an oxidised ware surface collected from Nong Bua in the Pa Mong region. “Roi Et ware” and “Roi Et white” have been discussed above. Categories such as “red slipped and burnished”, “red-on-buff painted”, “incised and painted”, “beaker forms”, “curvilinear incised”, and “black to grey burnished and incised” have been employed to define important chronological sequences. These terms are as broad and imprecise as “Om Kaeo”.

At Ban Na Di, the presence of “Om Kaeo” sherds generated much excitement amongst some archaeologists prepared to use these distinctive, and hence apparently easily identified, sherds as chronological markers. Bayard (1987:119-121) placed considerable stress on their provenance and used them directly in correlations of Sakon Nakhon Basin and Chi Valley sequences, and, by implication, with Non Nok Tha. This propensity of Southeast Asian workers to correlate surface decoration with momentous archaeological events extends to single vessels, particularly those with a distinctive style. White (1986:269), for example, used a single distinctive vessel at Ban Tong to help correlate the Ban Chiang chronology.

In order to test the validity of using incised and painted or slipped wares for correlating relative chronologies, a sample of twenty-four sherds with “Om Kaeo” decoration from levels 6 and upper level 7 at Ban Na Di have been examined. They represent six different fabric groups. Twelve belong to fabric group 6 and three to fabric group 9. These groups have been previously identified with the “whole” vessel assemblage (Appendix one). The remaining fabrics will be discussed in general terms only. A summary of surface finish details is set out in Table C.1 (Appendix three). Many sherds are weathered, making determinations of colourant bonding impracticable. As they cover the complete range of surface finishes represented, sherds composed of fabric groups 6 and 9 material only will be considered in detail.

Fabric group 6 sherds vary slightly in colour but are principally a reddish brown (5YR/6/3). All are dense and usually oxidised. A few have slightly reduced cores and two (including O19 fig. 10.1), are substantially reduced to internal surfaces. Figures 10.1 to 10.7 illustrate the range of decorative designs. Four principal modes of decoration are evident. Plain, cord-marked, incised and slipped or painted surfaces are employed. Backgrounds are mainly smooth, but often display residual cord impressions indicative of a two-stage forming process. Unmodified cord-marking sometimes acts to emphasize fields. Incised designs, either with or without a paint or slip, may be curvilinear or geometric. One sherd appears to copy a Phu Wiang motif (sherd O3 fig. 10.2).

10.1. THE "OM KAEO" PROBLEM

Fabric group 9 sherds (fig. 10.3) are a pinkish grey to grey (5YR/7/2 to 5YR/5/1) with fields of meticulously painted geometric panels or ribbons. The paint is a red (10R/4/6 to /8) iron oxide, probably hematite. It readily scrapes off to reveal a homogeneous smooth substrate, indicative of post-firing application (Shepard 1971:168-178). This contrasts with fabric 6 colourants which are chemically bonded.

Four further fabrics, two mineralogically consistent with Sakon Nakhon Basin sources and one with the Western Piedmont, are also present. The latter fabric is petrographically comparable with a Non Nong Chik sherd kindly identified by Bayard as representative of his Non Nok Tha "soft sand" temper category. Although sandy, it is lightly tempered with rice husk. Its highly micaceous matrix and distinctive nonplastic mineralogy are probably characteristic of the Phu Wiang region. An angular medium-sized sand, dominated by mono- and polycrystalline quartz, with several grains of chert and plagioclase feldspar, subrounded coarse sand-sized grains of hematite, with angular fine sand-sized quartz inclusions, brown biotite, accessory tourmaline, and rare quartzofeldspathic igneous rock fragments comprise the parent body. As a few composite grains of chert-cemented monocrystalline quartz are also present, a micaceous sandstone source is indicated. It is possible that some intermingling of weathered igneous country rock has also occurred. Although further work is required on this fabric, it is clearly distinct from the Sakon Nakhon Basin clays. Non Nok Tha and Non Nong Chik are located within the Phu Kradung Formation. Sherds composed of this fabric are illustrated on the following page.
Two sherds (O1 and O3 fig. 10.4) contain the Phu Wiang fabric. They are dense and oxidised red (2.5YR/5/6). The former has red infilled fields probably consisting of an unbonded iron oxide paint.

Three other sherds are composed of material mineralogically similar to fabric group 15, but lack iron-rich ooid-like inclusions, and this distinguishes them from the latter fabric group. A Sakon Nakhon Basin source outside the plagioclase zone is indicated, and an origin northeast of Ban Na Di seems likely. The fabric is moderately micaceous and tempered with orthodox grog (figure 10.5).

**FIGURE 10.5:** "OM KAEO" WARE AT BAN NA DI: SHERDS O24 AND O42. Scale 1:1.

Sherd O42 is reduced throughout (2.5YR/2.5/0) with red (10R/4/8) probably unbonded painted fields. Residual cord-marks are visible beneath the incised and painted area. Sherd O24 is oxidised (2.5YR/6/4). Note the angle of cord-marking application.
Sherd O38 (fig. 10.6) is characterised by an orthodox grog temper. The parent matrix is composed of material compatible with clay 5, a source near to Ban Chiang and Ban Om Kaeo (fig. 4.7). Note that sherd O38 is oxidised (10YR/8/3 to 7/3). The dark fields are red (10R/4/6). Note the vertical cordmarks, a characteristic apparent in many of the published Ban Om Kaeo vessel forms.

Three further sherds are heavily tempered with rice husk. Carbon released from the husk during firing probably affected the associated extensive reduction. The parent body contains very few nonplastics. These are mainly microcrystalline quartz, which is rarely greater than silt size. None exceed fine sand dimensions. A few ferruginous grains are also evident. In polarised light the fabric is moderately micaceous. It is geologically non-specific. Figure 10.7 illustrates rice tempered sherd O7. An oxidised (2.5Y/6/4) external surface area 1mm deep masks a heavily reduced (2.5Y/4/0) body. The fields are red (10R/4/6). Two sherds not illustrated are incised only.

FIGURE 10.7: “OM KAEO” WARE AT BAN NA DI: SHERD O7. Scale 1:1.
Clearly, the manufacture of incised and painted wares was not restricted to a single production centre. Of the six types set out above, only one, sherd O38, is likely to have originated from Ban Om Kaeo. Yet the design motifs, particularly those depicted on sherds O24, O42, O20, and O25 (figs. 10.5 and 10.3), duplicate Ban Om Kaeo forms. Such copied forms often confuse style-orientated analyses. Conversely, however, imitations may provide important information regarding prestige or regional cohesiveness. Thus the prestige attached to traded wares is emphasized through local copies. A different sociological focus, intersocietal cohesiveness, is demonstrated when fashionable contemporary designs are regionally adopted. We may reasonably expect that the intensity of such processes will be indicated by the quantity and quality of such production, particularly if it cuts across local technological and stylistic traditions.

A homogeneous mode of decoration, if associated with design elements which together create popular forms, suggests close relationships between regional production centres. If such production also spans several different pottery traditions, then these conditions strengthen the notion of close regional connectivity within the Sakon Nakhon Basin. In this respect fabric groups 6 and 9 are particularly informative. Together they link both level 7 and mortuary subphases 1b and 1c at Ban Na Di with Ban Chiang MP VII. This is because at Ban Na Di, in addition to "whole" vessels, six rimforms (Appendix one) which contain either fabric are paralleled at Ban Chiang during the Middle Period (White 1986:239-240). One Non Kao Noi level 3 rim is also composed of fabric 9 (Table 8.3 chapter eight). It would be unwise to stretch this latter comparison too far on the basis of a single rimform, however, and caution is warranted until further data are available.

It seems reasonable to view "Om Kaeo" wares as representing a popular regional type during the period prior to the inception of level 5 at Ban Na Di, where they are obviously rare. A paucity of a regionally distributed ware may be associated with "a period of first appearance or imminent disappearance of a type" Shepard (1971:336). It may be significant in this respect that at Ban Na Di fabric groups 6 and 9 are clearly concentrated below the level 5/6 interface in both mortuary and occupational contexts. The incised and painted or slipped wares seem to have enjoyed widespread popularity during the millennium or so prior to the arrival of the new blem temper ceramic tradition from the south. Unlike the orthodox grog-tempering method, however, the style does not appear to have survived beyond the major change to a new range of styles rendered with a different mode of decoration. The succeeding "painted" wares in turn are subsequently evident over much of the region. This phenomenon typifies the kinds of changes which may be precipitated by the diffusion of a different pottery tradition with its associated new methods and styles. In the following section we will assess problems related to "Ban Chiang Painted" pottery, a distinctively decorated ware well known publicly.

10.2 The "Ban Chiang Painted" problem

Ban Chiang is probably best known by art historians, style analysts, and the general public for its outstanding pottery. The so-called "Ban Chiang Painted" wares have stimulated worldwide interest among art collectors (van Esterick 1973:75). According to White (1982:28), it was this "red-on-buff pottery which gave the site its early renown." Three important studies of Ban Chiang pottery have recently been undertaken. Glanzman and Fleming (1985:114-121) consider vessel fabrication methods, McGovern et al. (1985:104-113) fabric petrology, and White (1986) undertook a major style analysis. Our attention here is concentrated on "Ban Chiang Painted" ware.
Stratigraphically, it was encountered “above the incised-and-painted pottery” initially associated with Phase IV (Gorman and Charoenwongsa 1976:24). White (1986:279) revised this chronology and places “incised and painted” pottery into three new phases (Early Period V, Middle Periods VI and VII). White sandwiches a ceramically undefined phase, (Middle Period VIII), between the succeeding “red-on-buff painted” phase (Late Period IX). This latter phase, originally characterised by “Ban Chiang painted” (Gorman and Charoenwongsa 1976:23), is now defined by a stylistic “provisional type” (pt-16), by White (1986:100-102), who dates the period to 300-1 B.C.(1986:279). Thus Late Period IX is partly contemporaneous with the Ban Na Di level 5/6 interface.

Late Period vessels, according to White, can be grouped “on the basis of surface treatment”, differences in “coil-and-slab” construction techniques in comparison with Early Period vessels, a paucity of plant material compared with previous periods, and the presence of green hornblende. This latter point is important and we will return to it later.

According to Hastings (1982:38-39), over 300 pots (341 are inferred in caption 2), were recovered from Ban Chiang. Of these, all funerary ceramics have since been fully examined “and most have been reconstructed” White (1986:61). This has allowed White to identify major stylistic groups, each characterised by a specific vessel or vessels. Eighteen were considered in detail by White (1986:61, 279). Two are assigned to Late Period IX (LP IX). Both are categorised “Late Period provisional type 16 (Group J)” (White 1986:102). McGovern et al. analysed one LP IX and three LP X vessels. Glanzman and Fleming consider three of these.

To date, no data are available regarding the areal distribution of specific vessels in the various burials concerned. This information would determine individual mortuary assemblage structures, and allow comparison of individual wealth. Variety, and the differential presence of quality wares, helps to delinate the “shape” of individual burial vessel assemblages. Vessel quality as well as quantity may both be measures of the deceased’s rank and status. Although this information is unavailable, the Late Period “provisional types” are considered by White to represent styles distinctive enough to define burials stratigraphically associated with this phase.

Asymmetry in funerary furniture between individual graves could symbolise, in mortuary ritual, the social structure of a society. It could act to distinguish relationships in living populations such as those involved in social stratification. The differential access to “prestige” wares has thus been used to demarcate social structure through assessments of relative wealth (Bayard 1984, Higham 1984). Differentially “rich” burials, depending on whether the apparent wealth is ascribed or inherited, could suggest social ranking (Peebles and Kus 1977). Exotic items, including pottery, imply prestige (Renfrew 1972:42) and differential access to prestige goods implies social stratification (Fried 1967, Dumond 1972, Renfrew 1975).

Access to exotic prestige goods requires a trade or exchange system which in turn entails organization. The intensity of this exchange activity correlates directly with the degree of social organization involved (Renfrew 1975). The distribution of any prestige ware relates to social and economic levels of activity. A key component in the identification of trade/exchange networks involving pottery requires an assessment of regional resources and production centres. In order to bring “Ban Chiang Painted” ware into a regional perspective we need to distinguish between the technological and mineralogical information available for the Ban Chiang sample. We can then look for any correlations with the known Sakon Nakhon Basin clay mineralogy and “Ban Chiang Painted” sherds from Ban Na Di and other regional sites.
McGovern et al. (1985:105-106) divided their petrographic analysis into two parts. Predominant inclusions were identified in thin-section and point-counted. Subsequently "the presence/absence of heavy mineral accessories (e.g. green hornblende, hematite, etc.), which were poorly represented in thin-section, was assessed by inclusion analysis of disaggregated 25 mg. samples." The major inclusions identified were quartz, grog and plant material, most of which was "easily recognizable as parts of rice plants." A photomicrograph (Plate 2) of "quartz-tempered grog inclusions" within the fabric of vessel BC-9 (McGovern et al. 1985:106) appears to illustrate reduced blebs. Clearly it is important to establish the identity of these inclusions. For if they are blebs then we have prima facie evidence that Ban Chiang was affected by the broadscale changes in Sakon Nakhon Basin pottery production documented above.

White (1986:263), however, reports that the petrologist who undertook the thin-section analysis (Dr. William Vernon, McGovern et al. 1985) did not recognize any grog resembling blebs. But, according to White he noted "little if any obvious plant material associated with the grog fragments. Any plant remains were found within the clay matrix". This association is consistent with the relationship noted for blebs. Only a few grog fragments actually include rice husk. Rice husk in the clay matrix, however, is one of the defining criteria set out in chapter six. Blebs were first described by the reader (Vincent 1984b:669-670) as associated with rice husks. The association was not described in detail, thus it may have been unclear whether the husk was within the grog or the parent matrix.

If we put aside, for a moment, the question of temper specie identification, what ceramic evidence regarding the affiliations of "Ban Chiang Painted" ware do we have? First, the temper specie is grog. Second, the surface decoration involves a red "paint". A clear correlation is evident between bleb temper and "painted" wares at Non Chai and Ban Muang Phruk (Rutnin 1979, Wichakana 1984). At Ban Na Di, 86.6% (n = 112) of bleb tempered rims were treated this way. Conversely, orthodox grog is correlated with unpainted wares. Surface-collected assemblages from 29 Sakon Nakhon Basin sites include 24, (82.72%), with bleb-tempered pottery. All three excavated sites revealed abundant bleb-tempered ware. This raises the percentage of sites with bleb wares to 84.37%. Obviously, the distribution of bleb tempered wares was widespread, if not ubiquitous, throughout the region. In view of this ubiquity it may be unwarranted to reject the notion that they were also present at Ban Chiang during the Late Period.

In the absence of compelling evidence that bleb-tempered wares were not present during the Late Period at Ban Chiang, we will assume it also played a part in the exchange network discussed in chapters eight and nine. We may recall this was evidenced both by a long tradition in exotic material movement within the region and a rapidly developed pottery exchange system with the much larger Khorat Basin. We will proceed in the knowledge that our sample is comprehensive. We are fortunate that it includes modern pottery of known composition for comparative purposes. Petrographic information of this kind greatly assists with the identification of argillaceous inclusions. Without these data, blebs could be difficult to detect. Thus the writer is confident, in terms of the published photomicrograph discussed above, that the Late Period "Ban Chiang Painted" ware fabric represented is bleb-tempered. The origin of "Ban Chiang Painted" ware, however, is not as secure.

We need not confine ourselves to temper species in searching for the likely source of "Ban Chiang Painted" ware at Ban Chiang. For this we can turn to mineralogy. In this respect the evidence is unequivocal. McGovern et al. (1985:109) report that in each Late Period vessel examined petrographically, green hornblende is present in association with grog temper. Our examination of Sakon Nakhon Basin clays has revealed that Ban Chiang lies outside the
plagioclase zone (fig. 5.3). Dry samples (45 grams) of each clay from both sources adjacent to Ban Chiang were first washed with water and then boiled in 10% dilute hydrochloric acid to produce a clean sand and silt sample. This was examined under a binocular microscope at 65x magnification. A detailed scan of about 10,000 grains in each sample failed to reveal hornblende. Of course it is possible hornblende is so poorly represented that this method failed to reveal the mineral. The mineralogical maturity of each of the 14 Sakon Nakhon Basin clays, however, makes this most unlikely.

Both the potting clays adjacent to Ban Chiang contain quartz varieties diagnostic of mineralogically mature reworked quartzarenites (chapter five). According to Krynine (1942:545-546), light and heavy mineral assemblages are usually similar in their degree of maturity. Orthoquartzitic sandstones, such as the Phra Wihan from which the reworked quartzes were probably eroded, are almost exclusively composed of ultrastable quartzes, zircon, tourmaline and rutile (Hubert 1971:460). Unstable heavy minerals such as hornblende are therefore unlikely to occur in clays 1 or 5 (Hubert 1971:459). In view of this information it seems unlikely that the so-called “Ban Chiang Painted” pottery considered by McGovern (et al.) was manufactured at Ban Chiang. Before leaving the important question of origin, we shall try to refute this explanation as a test of its validity.

Typical arguments against the technological identification of intrusive pottery, which rests on exotic material recognition, are that insufficient local resources have been investigated to rule out the existence of the given raw material; or alternatively, that although the raw materials are not locally present, they may have been imported. Thus merely the raw clay, and not the pots, may have been exotic (Shepard 1971:337). If we demand an absolute knowledge of all the region’s clay resources, we need no further test. Our argument is destroyed because no such information is available, or ever likely to be. We cannot even aspire to a thorough knowledge of local or regional resources as native potters have. Yet this is no counsel of despair. Our “crucial tests” should not ignore a major portion of the hypothesis, and we must remember that we are not dealing with raw materials in isolation, but in a specific archaeological context.

What does the archaeological context of “Ban Chiang Painted” ware tell us? Judging from the available data, 341 vessels were recovered from Ban Chiang covering a period of nearly 4000 years, with the Late Period forming c. 600 years (White 1986:279). Fifteen of a total one hundred and twenty five burials have been provenanced to the Late Period. Extrapolating burial vessels from burials this gives an estimated 41 pots for the Late Period, few enough for all to be exotic even if pottery was locally produced. Evidence for local production is scant. Glanzman and Fleming (1985:116) noted impressions possibly attributable to anvils, but give no information regarding whether any anvils were found at Ban Chiang. The only firm evidence for pottery production at Ban Chiang is four ceramic anvils; one is undated, one dated to c. 100 - 300 B.C., and two c. 300 B.C.- A.D.200 (White 1982:76). These dates, in White’s revised chronology, are consistent with Late Period IX and X.

According to White (1986:83), Late Period surface treatments are “sufficiently distinctive and common” to provide satisfactory classification evidence. Unfortunately, shape is not a criterion in White’s “provisional types” (pt’s). In addition, it is unclear what this classification refers to as it is often confused with “type” sensu stricto. This point apart, it is “key burial ceramics” which are emphasised by White (1986:84). Late Period painted vessels were interred with six burials and “the red-on-buff style of pottery (pt-16) is found on a number of vessel shapes” (White 1986:323, 108). We can proceed no further for the present, as only limited technical and “no statistical information” is available (White 1986:233). She notes (1986:85), however, that anvils were used throughout the sequence, but unfortunately does not explain
this observation. She also observed (1986:263, 314), that the presence of iron, blue glass beads, and the “increased use of red paint” at Ban Na Di and Ban Chiang supports their contemporaneity, and that the broad dispersion of “certain pottery styles and technologies” may reflect the presence of specialized manufacturing centres.

In order to bring into focus the regional context of “Ban Chiang Painted” pottery, we need now to summarise archaeological and technological evidence from Ban Chiang and beyond. First, we have little direct evidence for in situ pottery manufacture at Ban Chiang. According to White (1986:28), the total area excavated is 130.8 m², compared to 65 m² at Ban Na Di (Higham and Kijngam 1984:37). Twenty three anvils were recovered at Ban Na Di, only four are reported from Ban Chiang. Even allowing for statistical effects involved in the sampling nature of excavations, a clear discrepancy is obvious. Recent data from a postulated major pottery manufacturing centre at Khok Phanom Di suggests the inclusion of accoutrements as funerary furniture is an important component of mortuary ritual in such societies (Vincent 1987). If such a response can be generalised, the prehistoric inhabitants of Ban Chiang were unlikely to have been specialised potters. As White has suggested (1986:313-316), we may need to look further afield for such specialised production.

Second, we have firm evidence of longstanding regionality in pottery exchange, the movement of potters between different clay source areas, and prima facie evidence of the existence of itinerant metallurgists (chapter seven and appendix one Table A.14, crucible 1371). At Ban Na Di, the differential use of local versus imported clays for figurines, and the evidence for blended clays in mortuary vessels, demonstrates that manufacturing was sometimes carried out under adverse conditions. Access to quality clays is critical for satisfactory pottery production and is restricted by their natural distribution. Such differential resource access favours craft specialisation (Renfrew 1972, 1975, Redman 1978). Craft specialisation in turn provides stimulus for social ranking.

Third, after the level 5/6 interface at Ban Na Di, a major new type of ware was widely distributed throughout the region. This new bleb-tempered pottery did not totally replace the previously dominant product, but appears to have been assimilated into a new configuration which involved both production and consumption. Here, surely, are the hallmarks of an intensive and dynamic process of cultural change, based on a “deviation amplification” (Flannery 1968), involving the injection of a new ceramic technology into an existing pottery manufacturing tradition which involved a regional exchange system. Under this milieu, access to high quality pottery rendered in the new style, such as “Ban Chiang Painted” wares, could help confer prestige. Sites which occupied a nodal position in the exchange network are likely to have benefited from this, particularly if an organizational role was involved (Haggett 1975). Accessibility to resources, and node connectivity, are important factors in such regional networks. Ban Chiang occupies a pivotal location intermediate between the major, metallurgically important, eastern region of the Sakon Nakhon Basin and the smaller Kumpawaphi region which links the northern and southern portions of the Khorat Plateau.

According to Kijngam’s et al. (1980), mathematical model, a site hierarchy is absent in the Kumpawapi area. A major difficulty with this approach is lattice distortion over time (Haggett et al.1977:106). We simply have no adequate information regarding contemporaneous site sizes. Factors affecting size during one period may later become meaningless. Static analyses fail to cope with this problem. Ban Chiang, while not a central place in terms of its size, may well have been nodal because of its geographic location. It was occupied early in the known regional sequence, and, to date, sites revealing greater material wealth have not been identified within the Sakon Nakhon Basin. Thus, in terms of present archaeological information, we
cannot dismiss its importance.

Christaller’s theory places importance on the role of central places in providing or distributing sought after, or “central”, goods and services. They characteristically occupy geographically nodal locations in exchange networks. Thus Ban Chiang could reasonably be conceived of as a net importer of high quality goods. This would not necessarily exclude the possibility of some local utilitarian pottery production (Arnold 1985). When the lack of pottery accoutrements, relative material wealth and centrality of Ban Chiang are considered in combination, it is predictable that pottery such as “Ban Chiang Painted” wares were imports.

Eleven sherds, categorised by the Ban Na Di excavators as “Ban Chiang Painted”, have been examined in thin-section. Seven fabrics representing three temper species, orthodox grog, blebs, and rice are present. These are summarised in Appendix three.

Three bleb-tempered sherds display a surface decoration stylistically compatible with White’s “pt-16” (1986:Fig.13a.). Two are illustrated in figure 10.8. The parent fabric is consistent with clay within the plagioclase zone. The presence of composite mosaic/chalcedonic and mammillated chert grains suggest a source close to the Phu Phan Range.
Sherd O29 is oxidised to surfaces. Colours: interior 10YR/7/4, exterior field background 10R/5/3, curvilinear design and frame 10R/4/3. Sherd O37 is slightly reduced. Colours: interior 10YR/4/1, exterior field background 10R/5/6, design 10R/4/3. Two separate coats of an iron oxide based paint have probably been applied, although self-slip could be involved in the case of O37. An oxidised sherd (O40 not shown), has a 10YR/7/6 unpainted background and a 10R/4/4 painted design.

One sandy, bley tempered sherd (fig. 10.9) is petrographically similar to Chi Valley fabrics.
The surface 1 mm of sherd O30 only is oxidised. Colours: exterior background 2.5YR/6/6, design 10R/4/6, (probably an iron oxide). The interior background is coloured 2.5YR/6/6. A thin 10R/4/8 line at the upper interior fractured rim remnant suggests that this sherd represents the remains of a painted rim. Sherd O34 (fig. 10.10) is composed of fabric 12 material. The exterior 1 mm of sherd O34 is oxidised. Colours: exterior background 7.5YR/7/4, design 10R/5/6, (probably an iron oxide). The interior is coloured 7.5YR/3/0.
10.2. THE “BAN CHIANG PAINTED” PROBLEM

Sherd O32 (fig. 10.11) is bleb-tempered. Level 6 rimform US 56 also contains this fabric (appendix one). No plagioclase is evident, diatoms are prominent and spicules are rare. Polycrystalline quartz, mosaic chert, zircon and tourmaline also occur. The parent matrix is moderately micaceous. This mineral association suggests a Sakon Nakhon Basin source close to clay 4 (chapter five).

FIGURE 10.11: “BAN CHIANG PAINTED” WARE AT BAN NA DI: SHERD O32.

Scale 1:1
The exterior 1 mm of sherd O32 is oxidised. Colours: exterior background 5YR/6/3, design 10R/4/6, (probably an iron oxide). Interior red paint 10R/4/4, unpainted surface 5YR/3/1. An oxidised sherd (O31 not illustrated) has a 5YR/7/3 background with a 10R/4/8 design similar to sherd O37.
Rice husk temper in association with a moderately micaceous, geologically non-specific, matrix which contains mostly quartzose nonplastics characterises the fabric of sherd O28 (fig. 10.12). The exterior 1 mm of sherd O28 is oxidised. Colours: exterior background 7.5YR/7/4, design 10R/4/6 (iron oxide?). The interior is coloured 7.5YR/3/0.

Scale 1:1
Two further rice husk tempered fabrics (not illustrated) are present. The first (sherd O33), has an oxidised (7.5YR/7/2) exterior surface, to 1 mm depth, with a (10R/4/4) painted design similar to O37. All the interior is painted (10R/4/3). The parent matrix is consistent with clay 10 (chapter five). Sherd O36 has a moderately sandy matrix containing a principally quartzose nonplastic suite. It probably derived from an Eastern Sakon Nakhon Basin source. Surfaces are oxidised to 1 mm in depth (7.5YR/7/4), and two thin parallel lines are coloured 10R/4/8. Orthodox grog has been used to temper sherd O35 (fig. 10.13). The parent matrix is not, in terms of the present work, geologically specific. The outer surface has been burnished prior to receiving the painted design. Note also that the exterior 1 mm of sherd O35 is oxidised. Colours: exterior background 5YR/7/4, the design contains a 10R/4/6 iron oxide. The interior is coloured 7.5YR/3/0.

Scale 1:1
In terms of pottery types, and hence probably manufacturing centres, the regional nature of “Om Kaeo” wares is repeated again in “Ban Chiang Painted” wares. Suitable potting clays, according to local informants, are locally restricted. This is a pattern which is probably quite common in many countries worldwide (Grim 1962). A regional distribution of small, locally confined deposits, would favour the development of production centres. We have noted a marked variation in potting clay composition in the Sakon Nakhon Basin sample. Access to known high-quality clays may have accentuated the value of this resource and intensified the process of craft specialization (Arnold 1985).

Inter- and intra-regional exchange networks are both reflected in the exotic fabric spectrum at Ban Na Di. This increased both in extent and intensity with time. Restricted clay resources, specialised production and exchange networks appear to have been interrelated. Together they may have helped produce a degree of regional cohesiveness. From a ceramic viewpoint, it may be useful to characterise the resultant pottery distribution pattern as representing a mosaic of pottery users and producers. We have already noted that modes of pottery production can vary widely (Peacock 1982). The distribution of “Om Kaeo” and “Ban Chiang Painted” wares, their exceptional technical and aesthetic quality, and value as mortuary furniture, suggests they were in demand and that specialist production centres acted to supply that demand.

If Ban Chiang during the Late Period was a manufacturing site, with local potters producing “Ban Chiang Painted” wares, the two nearby clay sources adjacent to Ban Kham O could have readily supplied their needs in terms of clay quality. In terms of our present understanding of the local geology, however, the only Late Period IX and X vessels examined petrographically to date were not fabricated from either of these clays. They contain clay mineralogically inconsistent with a local derivation. This is because clays within the Upper Songkram catchment are not known to include hornblende. In the light of this evidence it seems most likely that these vessels were imported. The alternative explanation, that the clay was imported, appears untenable because suitable clay sources were locally available.

What proportion of Ban Chiang pottery was imported is yet to be determined. Resolving this question may require additional technical information of the kind already provided. The present practice among Southeast Asian researchers of grouping pottery together into a single taxon, on the basis of surface decoration, seems likely to promote further confusion if continued. Terms such as “Phimai Black”, “Nong Bua Red”, “Roi Et ware”, “Om Kaeo” and “Ban Chiang Painted” should not be used by serious scholars of prehistory. Recent ceramic research in South America, Africa and Europe has reinforced Shepard’s earlier findings that the presence of pottery, even in abundance, in prehistoric sites is insufficient cause to presume they were locally manufactured. Although much of the pottery uncovered at Ban Chiang may have been the product of local potters, until further information is available, it seems unwarranted to continue with such a broad and imprecise term as “Ban Chiang Painted”.

Chapter 11

Concluding remarks and future prospects

The principal aims of a technological analysis of ceramics are the exploration of temporal changes in the potters' craft, and the illumination of possible cultural relations through material identifications and the location of their sources. In this work particular attention has been given to clay sources, temper, fabric mineralogy, vessel construction including firing and fabrication, and to non-pottery ceramics related to pottery and metallurgical industries. The long period of occupation and clear stratigraphic contexts of mortuary wares and industrial features at Ban Na Di, coupled with a comprehensive and geographically extensive sample of comparative pottery, have provided an opportunity to investigate these variables.

A model, which combines both technical analysis and aspects of archaeological data related to both physical and sociological factors, has been employed to bring into focus aspects of prehistoric ceramic production in Northeast Thailand. Evidence for broadscale changes in ceramic traditions, possibly originating beyond the southern borders of the Khorat Plateau, in addition to extensive exchange networks, has been presented. Such networks are indicated both within the Sakon Nakhon Basin and between it and Chi Valley sites. All possible clay sources were sought with the help of local informants. Suitable sources are few and locally restricted in extent. The Ban Na Di clay is only suitable for a limited variety of uses. For pottery making, a blended composition of local and quality imported clays was often used. Artefacts less demanding in utility were often rendered in local clays, thus conserving valuable imported raw materials.

Recognition of mineralogically distinctive materials plays a central role in technological analysis. About 70% of the Earth's terrestrial surface is sedimentary in origin (Tucker 1981:1). As most sedimentary deposition occurs in continental areas, local geology, relief and climate determine the kind and quantity of material deposited. When exploited clays were derived from sediments adjacent to distinctive country rock, the potential of petrographic analysis is likely to be increased. Such regions, however, are anticipated to be poorly represented, compared with regions where sedimentary country rock dominates, in view of the overall proportion of sedimentary terrain mentioned above.

The natural distributions of distinctive source rocks, likely to provide clear associations for sourcing purposes, may often be limited to areas outside those of immediate concern. This problem may not be as elusive as it at first appears, however, as methods are available with the potential to solve such problems. Our most pressing problem, however, probably concerns deciding what depth of analytical intensity is appropriate to the problem at hand. This question is likely to be a recurring one, for, apart from the natural distributions of indistinctive materials, pottery production sites have a tendency to concentrate in such regions (Arnold 1985). This bias will act further to exacerbate the disproportionate occurrence of sedimentary deposits.
We may anticipate, with respect to pottery production, that many prehistoric settlements were located in sedimentary regions. This is because the lowlands and waterways suited to irrigation and transport are key agricultural resources. It applies equally to irrigated cereal and inundation rice cultivation (Sherratt 1980). In Eurasian contexts, the rise of large urban populations may be related to plough agriculture (Goody 1976), and the development of intensive exchange of “secondary products” (Sherratt 1981). We noted that an increase in pottery exchange between the Khorat and Sakon Nakhon Basins developed with time, but accelerated markedly with the adoption of bleb-tempering within the latter basin.

Rice remains are always present in some ceramic fabrics at Ban Na Di. Chang and Loresto (1984:384) considered that kernels from level 7 at Ban Na Di could be of the cultivated type. Evidence for possible plough agriculture has been presented by Higham (1975), Kijngam (1979), and Higham and Kijngam (1979). They later modified this stance for two reasons: because socketed bronze ploughshares, common in the Red River Valley during this period, are not present, and evidence suggesting an expansion into land suitable for ploughing in the Middle Chi region is also not available (Higham and Kijngam 1984:721-722). Current data, however, suggests that some form of intensive rice cultivation could have been conducted by at least level 7 at Ban Na Di. At Ban Chiang the large gastropods *Pila polita* and *Pila ampullacea*, which are sensitive indicators of prevailing environmental conditions, significantly become rare after Early Period levels. *P. polita* requires permanent water and no longer survives naturally. *P. ampullacea* survives the dry season by aestivating and exhibits a monsoon-regulated breeding cycle. Paddy field environments would therefore presumably favour *P. ampullacea*. Ploughing, and paddy bank rebuilding, may have so reduced this species that intensive collecting was unprofitable (Higham and Kijngam 1979). Evidence that animals were used for traction is provided by the comparison of prehistoric Bovidae phalanges with modern draught animals, this indicates that *Bubalus bubalis* from these levels at both sites were as robust (Higham and Kijngam 1979, 1984:355).

Pottery production methods are more compatible with sedentary than with mobile lifestyles, so we may anticipate that most pottery production was undertaken in regions favouring permanent settlements, as opposed to areas unsuited to year-long habitation. Climatic extremes can affect production schedules (Arnold 1985). Rice cultivation is seasonally regulated (Geertz 1968). As has been noted, the above seasonality may also regulate pottery production. Seasonally wet-dry climates, such as the monsoon conditions presently experienced in Thailand (Koppen Am), restrict production to relatively dry portions of the year (Arnold 1985:78). If wet monsoons reflect present equatorial and tropical conditions (Strahler 1973:177), stable sea levels (Galloway and Loffler 1972:27), and glacial activity both suggest they typify the climate in the region for at least the last 5,000 to 8,000 years (Hope and Hope 1976).

Integration of pottery production with rice cultivation is a “deviation amplifying situation” (Flannery 1968), which may have important implications for the intensification of a stable subsistence strategy, related interactions with technology, and the development of ranked societies. Wet rice agriculture is a particularly stable and durable system with a marked ability “to respond to a rising population through intensification” (Geertz 1968:32). Even with the most intense population, the system does not break down. Once adopted, the paddy system lends itself to numerous improvements; for example transplanting, ploughing, weeding, and improved irrigation or drainage. Adoption of paddy rice agriculture turns on the necessary technology and a commitment to an agricultural lifestyle. The more developed the system becomes, the less likely are the cultivators to abandon it, even though this may lead to extreme human impacts (Geertz 1968:33). According to Geertz, unlike swidden agriculture, soil fertility...
has no long-term effect on crop yields. Water plays a paramount role by transporting nutrients, nitrogen fixing algae, and promoting chemical and bacterial processes. Water is more important than soil type.

Societies are essentially conservative, and social factors regulate population growth (Renfrew 1972:487). Innovations are only likely to be accepted when traditional technological and subsistence strategies are no longer adequate. Once established, a fully developed paddy-wet-rice system can be maintained to give optimal production levels by the input of technological skills. Expertise, not sheer energy, is needed (Hanks 1972:155-161). The nature of paddy-fields: clearly defined boundaries, locations adjacent or in relation to neighbours' fields, locational quality variations (ease of clearing, embankment construction and overall working), drainage and water availability, distance from storage and habitation areas, and the capital investment of labour, all enhance the concept of individual ownership, the accumulation of equity and social differentiation.

Bayard (1984a:161-168), has proposed four general periods (GPs) of regional social and economic change for northeast Thailand as a whole. Period A (3500-2500 B.C.) is characterised by “at least semi-sedentary agricultural communities ... with noticeable but fairly weak social ranking.” Period B (2500-1800 B.C.) witnessed the appearance of bronze technology, and increased, but still “simple-ranked”, social ranking. Period C saw both iron technology and intensive wet-rice farming introduced during the “mid-first millenium B.C. with a more marked increase in ranking”. Period D, followed shortly after the commencement of the present era, with either incipient state formation, or complex chiefdoms and a development of “true states” by the fusion of indigenous entities and Indian “socio-political and religious concepts”. This scheme has been accepted by regional specialists (Higham and Kijngam 1984:710; White 1986:278). Welch (1985:229), however, argues for a separate Mun Valley chronology; but Wilen (1987:110), mainly on the basis of ceramic styles, views Nam Phong piedmont “culture history” as corresponding to GP's B and C. Recent debates (Bayard 1987, Higham 1987), have been mainly concerned with chronological detail rather than overall structure.

If the general phase chronology is correct, and if pottery production played a significant role in socio-economic factors, and acted as an index of the importance of exchange networks, changes in ceramic assemblages should be related to more general cultural change. We have noted in chapter two that pottery style analysis has been used extensively to characterise various prehistoric changes and relative chronologies. We can now compare these findings with technological information.

Because to date technological data have, with few exceptions, been generally neglected, a strategy designed to overcome this deficiency has been adopted. Although intensive petrographic techniques are essential for precise technological analysis, methods which need excessive work, without necessarily providing unequivocal results, have been avoided. Heavy mineral analysis, for example, may give misleading results when ceramic fabrics are composed of blended clays from different sources (Williams and Jenkins 1976). In view of the Ban Na Di results, which show blending was employed, this method could only have been applied with considerable caution. In essence, therefore, intensive geological techniques have not been emphasised. This allowed an extensive range of technological questions covering the maximum possible number of sites to be considered. Thin-sections and other standard geological techniques have allowed a geographically extensive range of sites to be compared with the more intensively examined Ban Na Di ceramic traditions and Sakon Nakhon Basin clays.

The strategy of contrasting intensive analysis of local data with extensive comparative...
material has allowed an overview of broadscale developments which span the plateau as a whole. These bear directly on major changes which influenced Ban Na Di and the Sakon Nakhon Basin. Petrographic evidence has illuminated two major facets of technological inquiry. Mineralogical data point to likely raw material source areas. Although much of the sample derives from relatively indistinct sedimentary strata, a process of elimination has enabled mineralogically irrelevant regions to be excluded from consideration where these are distinctive. As a corollary to examining pottery within a large-scale sedimentary setting, however, detailed information regarding a temper species specifically related to such terrain has been uncovered. It gives important insight into socio-economic questions and bears directly on processes underlying changes reflected in the General Periods discussed above.

We need now to reflect on several key components related to sedimentary terrain adaptations which bear on the development of complex societies. First we will review ceramic evidence. Hodges (1965) has suggested that grog temper development may represent a response to a lack of locally available alternatives. He notes that in Europe it is associated with sedimentary areas. In Thailand, two different sub-species of grog are evident, both related to such terrain. Rice husk is added to one but not the other. Prior to its first appearance within the Khorat Basin, this bleb grog occurs at Khok Phanom Di. Bleb-temper later becomes prominent in the Chi Valley (c. 200-100 B.C.). By c. 100 B.C., its production replaces a substantial portion of pre-existing orthodox grog traditions in the Sakon Nakhon Basin. This change occurred following a period of gradually increasing representation in wares imported from Chi Valley sources at Ban Na Di.

Apart from the more immediate cultural implications of such a change, an important technological question arises: why reject a successful and longstanding method for another process almost identical in expenditure of preparation effort, and identical in ceramic effectiveness? From a technological perspective this change seems unwarranted, particularly as tempering materials must fulfill the two critical criteria of functional reliability and consistency of supply. We must look beyond technology for answers to such a radical change.

We have examined a range of ceramic artefacts at Ban Na Di and noted the earliest indigenous pottery tradition was replaced by a different one. The temper species of both were similar, differing only in the addition of rice husk. Rice husk, however, is present throughout the sequence in pottery fabrics. Vessels of potentially ritual significance aside, rice husk is incidental to the earliest Ban Na Di pottery tradition. While available, it was not used for temper. Why? Two possible reasons seem relevant. First, the extant tempering tradition could have been adopted prior to a reliable supply of rice husk becoming available. Second, although rice husk later became available, and other Sakon Nakhon Basin potters used it as a single element, potters familiar with using orthodox grog were not stimulated to change to another method, a response consistent with their inherent conservatism in technological matters.

The concept of using pre-fired clay as temper embraces both grog methods. Bleb-temper being a modified variety. The step from orthodox grog to blebs is a small one, involving only the mixing of rice husk into the balls prior to their initial firing. A reliable supply of rice, however, is essential. The scale of bleb ware production suggests rice surpluses were available. In this respect it is important to contrast the relatively minor amount of purely rice-tempered Sakon Nakhon Basin wares in the Ban Na Di sample prior to the influx of bleb wares. These could easily represent localized exploitation of what White (1984:28) has termed “non-cultivated rice”, or alternatively the non-plough method of broadcasting (Hanks 1972). The broadscale incidence of bleb wares, and their prominence alongside orthodox grog in the Sakon Nakhon Basin fabric spectrum, strongly suggests that bleb-tempering potters were implanted
into a pre-existing pottery manufacturing province. This would not rule out the adoption of bleb-tempering by some innovative local potters. Such an event seems unlikely, however, unless potters practicing bleb-tempering implanted their method among them.

What kinds of stimulation are likely to induce practitioners in a technologically complex craft to change unnecessarily a key component of their industry? Given the sociological imbeddedness of pottery production in ranked societies (May and Tuckson 1982), it seems reasonable to assume that changes in social organization would be the most likely source of such a stimulus. This kind of change is consistent with emulation of externally derived exotic prestige artefacts, which confer status and promote or enhance social ranking (Renfrew 1975). This is, of course, speculative, but it may fit the evidence. The association of bleb-tempered anvils and pottery at Ban Na Di, the predominance of these wares at Ban Muang Phruk from its inception, and their extensive regional distribution, however, provides direct evidence that another more pervasive process affected much of the Sakon Nakhon Basin. On the basis of these data, the diffusion of people from a region which produced bleb-tempered pottery is clearly indicated. We have seen that this type of pottery is earlier present in the southern alluvial basins and plains. It occurred in quantity at Non Chai, a major site occupying a strategic position (figs. 4.4 and 8.2). A natural corridor runs north directly into the Sakon Nakhon Basin giving easy access to the Kumphawapi and Upper Songkhram areas.

If diffusion was substantially responsible for the changes evident in ceramic production, we can anticipate changes in the sociological framework. Ritual, subsistence and technical aspects of societies are sensitive to such influences. We can expect morphological changes in recipient societies, not obliteration by the donor group. The resultant structure should retain aspects of both groups. The transition should be heralded by an increase in exotic artefacts, and culminate in the substitution of obsolete techniques and the introduction of novel artefacts and ideas. If the process involved neither imposition nor implantation (Renfrew 1975), but assimilation, it suggests that pre-conditions existed which acted to enhance such a transition.

Higham (1984:72-86), has argued for moderate “lineage ranking”, and “little if any supra-village authority structure” on the basis of Ban Na Di remains during mortuary phase 1 (MP1). He compared the burial wealth of two postulated different social sub-groups (A and B), mainly in terms of non-ceramic artefacts, and found that area B burials were consistently richer through time. Although in area A later burials were richer than earlier ones. We can test these findings against whole vessel data previously unavailable. A total of 18 exotic vessels are present as funerary furniture, 1 in phase 1a; 6 in 1b; and 11 in 1c, (appendix one). The phase 1a burial is disturbed (Kjngam 1984:397). Proportions of exotic to total vessels are: for phase 1b area A has 5:16 (31.25%), B has 1:20 (5%); for phase 1c area A has 7:28 (25%), and B has 4:12 (33.33%). A 5 year old child in phase 1b area B was interred with 8 vessels, 1 is exotic. Its fabric is consistent with a Sakon Nakhon Basin source. A 2 year old in phase 1c area A had 3 vessels, 1 consistent with a Chi Valley source. They are the only non-adult interments with exotic vessels. Overall, the number of burials with vessels varies little with time: phase 1a has 9:15 (60%), 1b has 15:21 (71.42%), 1c has 14:24 (58.33%). Burials with exotic vessels, however, increased markedly: 1a has 1:9 (11.11%), 1b has 4:15 (26.66%), and 1c has 6:14 (42.85%). This is a very small, but important sample. It corroborates the overall tendency of exotic wares to increase with time, and if we include Higham’s evidence, it supports the notion that ranking was present. It also suggests a steady increase in exotic exchange throughout the period.

Exchange networks during MP1 at Ban Na Di, as reflected in the exotic pottery spectrum,
CHAPTER 11. CONCLUDING REMARKS AND FUTURE PROSPECTS

were extensive, but concentrated towards the Eastern Sakon Nakhon and Khorat Basins. Important copper and tin sources lie beyond the former region. Exotic stone and marine shell help underline the extensive nature of exchange network participation (Higham and Kijngam 1984:702). The latter could derive from the Gulf of Siam or, perhaps via Mekong River exchange networks, from further afield. The quantity of Chi Valley pottery imports increased steadily during late MP1. A significant expansion in this exchange coincides with the advent of local bleb production. This is achieved at the expense of Sakon Nakhon Basin imports. Substantial elements of the pre-existing orthodox grog traditions in this latter region survive these developments apparently unaffected. These data, coupled with the level 5/6 ceramic discontinuity at Ban Na Di, argue for an influx of people with strong Chi Valley links who maintained close ties with their region of origin. Their settlement of the Sakon Nakhon Basin appears to have supplemented pre-existing occupation areas. It may also have expanded settlement along new habitats, such as flood-prone lake margins.

Sherrat (1980:313-330) reported that the plough formed an integral component of lowland water-exploiting agriculturalists in the Nile, Indus and Tigris/Euphrates alluvial basins. It may be recalled that Ban Na Di is situated near stream confluences on a low terrace, a location shared with many other early GP A and B sites. White (1982:30) observed that modern wet-rice cultivation is often carried out with a hand tool and without a water-buffalo-drawn plough. Without a plough, however, it is unlikely that the full benefits of water control could be gained. Thus, in order to ensure successful wet-rice cultivation, soils rich in nutrients, which are located close to perennial streams, would present advantages for pre-plough agriculturalists. The early restricted concentration of Sakon Nakhon Basin sites follows patterns noted by Sherrat (1980:316) "of early agrarian systems in the western Old World". In this latter region, and most of Europe, introduction of the plough saw extensive land clearance, increased livestock numbers, and brought a shift in focus to drier areas.

Bronze technology was familiar to the first settlers of Ban Na Di, and the first evidence of iron working occurs in level 5 in the form of slag. Higham and Kijngam (1984) associate the transition from GP B to GP C with the appearance of this slag and many associated changes. These include burial ritual, abandonment of the early cemetery, which became a bronze working area, and the first appearance of clay rollers and rice "steamers". Bronze was first introduced to Ban Chiang and Non Nok Tha after initial occupation, probably c. 2,000 to 1500 B.C. At Ban Chiang, a change in burial ritual, along with associated material culture and technological differences, marks the change from Middle to Late Periods. Thus, according to Higham and Kijngam (1984), this GP B to GP C transition parallels events at Ban Na Di.

Iron and intensive wet-rice farming are key components of GP C. Yet, according to Higham and Kijngam (1984), metal may not necessarily be crucial to population increases attendant upon "expansionary settlement" of the Kumpawaphi and Upper Songkhram regions by Chi Valley immigrants who were accustomed to a more developed ranking. This is because no bronze or iron plough tips are evident in the Khorat archaeological record, but they are common in contemporary Vietnamese contexts, and another wet-rice technique is available. The method is known as ratooning. It uses floating rice and is particularly suited to areas prone to gentle flooding to which some rice varieties are intolerant. Ratooning does not require plough cultivation. More extensive production associated with the introduction of this method could have provided sustenance for a sudden influx of Chi Valley peoples possibly under the threat of warfare. Although fisioning from the periphery of developing Chi Valley chiefdoms "involving steady but peaceful infiltration" could have been absorbed by the local population, the sharp break in the Ban Na Di sequence "make this seem unlikely" (Higham and Kijngam
Whether the transition from GP B to GP C in the Sakon Nakhon Basin was peaceful or not, in terms of the ceramic spectrum, it was substantial, and at Ban Na Di, complete. If warfare played a vital role, it seems unlikely that total annihilation resulted as pottery fabrics characteristic of GP B continue into GP C. Again, the retention of earlier socio-economic variables, such as bronze metallurgy and important associated exchange networks, tend to support a process of assimilation as the ultimate result of the transition. For example, although the technology associated with bronze casting at Ban Na Di changes, early exchange relationships appear to have been maintained and probably strengthened. More complex methods, such as high tin alloys and clay moulds, the latter paralleled at Non Chai, were introduced (Higham and Kijingam 1984:688-700). Close ties are maintained with the Eastern Sakon Nakhon Basin region, however, which lies closer to key raw materials. A crucible fabric suggests this region may have provided itinerant metallurgists. Chi Valley relationships, however, strengthen at the expense of those of the Sakon Nakhon Basin. Notably, Chi Valley pottery imports show a steady increase with time. The process is orderly, without any sign of a major temporal discontinuity such as that which marked the transition at Ban Na Di. Transformation of the social form is implied by post-transition changes in exchange networks, this is an evolutionary process which suggests an intensification of social organisation (Renfrew and Cooke 1979). Systemic evolution prior to the transition point may have set the scene for revolutionary processes of the kind envisaged by Higham and Kijingam (1984). The resultant metamorphosis incorporated aspects of both the recipients’ and donors’ traditions.

External relationships show a clear shift in emphasis from intra-regional to inter-regional after the transition from GP B to GP C at Ban Na Di. In addition to retaining important links with the Eastern Sakon Nakhon Basin bronze industry network, a vigorous new relationship is opened up with a much larger Khorat Basin system. This latter development gave access to exchange networks of an entirely different magnitude. Iron was introduced, and c. 200 A.D., the first glass beads appear at Ban Na Di. Glass beads replace shell and stone jewellery common throughout levels 6-7. Their specific gravity suggests an Indian origin (Pilditch 1984:78). In addition, ceramic seals in the form of either incised rollers or stamps first occur (fig. 11.1).

Examples of stamps similar to figure 11.1c were recovered from Chansen by Bronson (1976:29). He considered that they resembled “Funan” finds at U Thong on the Chao Phraya Plain and at Oc Eo in the Mekong River Delta. It is important to note that each seal at Ban Na Di bears a different design. This is repeated at Ban Chiang (Gorman and Charoenwongsa 1976:22; White 1982:46, 75, 88). Such exclusivity implies that the intended function was not related to manufacturing processes such as imparting patterns onto other materials. For if so, we can reasonably expect to find several of the same design. As some were broken, replacements would be needed, and fashionable designs are likely to have had wide currency. Unique designs suggest special purposes. The size and rarity of these artefacts precluded thin-sectioning. A ceramic composition is apparent in hand specimen. Experiments with plastic clay demonstrated that they readily impart an excellent impression when pressed firmly into the surface, and provided the clay is not sticky, a clean separation is easily achieved. Clay tablets with negative impressions are unknown in Southeast Asian archaeological contexts. The durability of unfired clay in these situations is unclear, however, even given that they were relatively intact when discarded. It should be noted that the Lerna sealings were subjected to fire (Caskey 1955, 1958). This probably ensured their survival.

The Ban Na Di seals could be tokens (Folan and Hyde 1980), but this seems unlikely in view of their form. The possibility that they were a means of denoting individual ownership
FIGURE 11.1: THE BAN NA DI CERAMIC SEALS (a: top left; b: top right; c: second top row; d: third top row; e: bottom.)
gains strength when the value of prestige goods, such as glass, are considered. As exotic items, such as marine shells and pottery, predate seals, material value alone is unlikely to have been a sufficient cause. Thus, if the seals were used to denote ownership, it seems unlikely that they related to goods freely available on an open market. They could, however, have acted as symbolic information carriers which helped reinforce close social relationships enjoyed by those who were privileged to direct participation in an extensive economic redistributive system.

Lamberg-Karlovsky (1975) reports that such a system existed in early third millenium Mesopotamia. In this latter case trade in luxury carved chlorite bowls is involved. Lamberg-Karlovsky suggests that the successful maintenance of long-distance trade in luxury items points to strong sociopolitical control. He also notes that the distribution of distinctive seal types overlaps that of equally distinctive ceramic types (1975:363). It would be unwise to push comparisons with Mesopotamian city-state trade networks too far. On the other hand, we should not draw back from attempting to explain the association of two artefact groups unique to GP C in the Sakon Nakhon Basin. To do so would be an omission. In seals and the GP C highly decorative bleb-tempered wares we also have a coincidental association. It extends from Non Chai, where glass beads are abundant during phase 3, to Ban Na Di and Ban Chiang. On the basis of present data, however, it excludes Ban Chiang Hian and Non Nok Tha.

Schauffler (1976:27-37), excavated small test squares at Don Klang, Ban Phak Top and Ban Tong. The former is close to Non Nok Tha, the latter two lie near Ban Chiang. Serious looting had damaged each site and the results can only be treated with caution. Glass beads were recovered from Don Klang and “clay rollers” from Ban Tong. Such tantalizing glimpses fall short of the kinds of evidence needed for valid inferences to be drawn, and until Northeast Thailand is further explored it would be misleading to formulate models based on them. Conclusions should be drawn on the basis of clear evidence, although this need not be comprehensive (Higham and Kijingam 1984:710).

Function aside, the presence of seals and glass beads in association with iron argues for inclusion in a much broader exchange network which included prestige items. They also help link Ban Na Di with LP Ban Chiang. Bronze technology, and a range of associated jewellery is similarly correspondent (Higham and Kijingam 1984). It is clear that we are dealing not only with different technologies and more reliable agricultural methods but also a more complex level of social organization. As Hanks (1972) observed for rice cultivation, the important variable is not so much which particular strategy is preferred, although these are influential, but the level of expertise applied. Social changes, not natural forces, may be crucial socio-economic stimuli.

Restricted access to desired resources promotes competition and when this involves improvements to land individual ownership concepts are commonly invoked. In plough societies “diverging devolution” underscores this concept (Goody 1976). We have noted, however, that while ploughing would extend wet-rice into marginal dry areas, the plough-less ratoon method has also been suggested for the Chi Valley, Kumphawapi and Upper Songkhram. This derives from Wheatley’s (1983) interpretation of the 3rd century A.D. Chinese reference “Sow (or plant) in one year (and) reap for three”, which is to suggest ratooning was practiced in the flood- prone Transbassac. A practice which is only suited to certain zones, required special skills and could have opened up previously unexploited areas. This hypothesis, if true, involves systemic processes of comparable effect to the introduction of ploughing. Individual ownership of triennial crops and preferential access to prime sowing or planting locations would
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provide a comparable stimulus.

These events take on further significance when we consider the relative significance of Ban Na Di. It is unlikely to have occupied a nodal position in the regional exchange network, in terms of both its geographic location and lack of valuable raw material resources. It was certainly not a central place in terms of relative size (Kijngam et al. 1980, Higham and Kijngam 1984). Pottery manufacture could have only been carried out under the stress of a local absence of suitable clay. Thus it is unlikely to have been an important production centre, and as such a net exporter of pottery in any economically significant manner. Overall, it is reasonable to portray Ban Na Di as a typical small autonomous village located outside the mainstream of regional socio-economic interaction.

We have noted in chapter seven that MP2 pottery incorporated a much increased range of techniques and construction expertise. An extensive repertoire of vessel shapes is reflected in rimforms, and skilled use of paint in surface decorations is evident. Compared with the comprehensive MP2 assemblage, the founding tradition is clearly inferior in both manufacturing and variety of design. In both fabric and form, these new locally produced wares mirror in many respects Non Chai pottery. Perhaps even more important are the technological implications reflected in such overall quality. It is unlikely such expertise could be developed in areas lacking quality raw materials. This requirement clearly hindered potters of the early local Ban Na Di tradition. Production centres with access to quality clays are in a position to increase output when and if the occasion arises. Thus it seems reasonable to assume that a relationship of this kind would favour the quantitative and qualitative florescence of ceramic production. Positive feedback with other subsystems, such as subsistence, is therefore enhanced by these factors (Arnold 1985). This kind of interaction has been promoted as catalytic to the multiplier effect (Renfrew 1972).

Aspects of Goody’s (1976) diverging devolution model coupled with Sherratt’s (1980) secondary products revolution proposals are socio-economic factors which may have important consequences when substantial ceramic production is associated with land-owning or controlling agriculturalists. Positive feedback between wet-rice agriculture and export-orientated pottery production typifies the kinds of interactions between subsistence, technology and related increased social complexity, which characterised the development of ranked societies elsewhere (Adams 1960, 1966, 1975, Dalton 1975, Johnson 1975, Renfrew 1975, Renfrew and Cooke 1979, Sabloff and Lamberg-Karlovsky 1975).

Prestige quality wares were imported throughout the Ban Na Di sequence. During MP1, they are mainly represented by the same or similar types of incised and painted wares which characterise the Ban Chiang Middle Periods, although equally masterful examples, such as pots 95 and 96, are also present. Both these wares are consistent with Sakon Nakhon Basin sources. In addition to high quality, rarity may also have signalled prestige. Wares from a distant igneous region, and of unusual form, were copied. This corroborates the importance of exotic pottery as prestige goods.

With the inception of blem-tempered production the presence of high quality wares at Ban Na Di, and probably throughout the Sakon Nakhon Basin, increased dramatically. During the Late Period at Ban Chiang, exquisitely painted probably blem-tempered vessels became popular as mortuary furniture. Different fabrics indicate that several manufactures were simultaneously producing wares decorated in this style. Such popularity reflects the prestige accorded this ware. This is a response noted elsewhere following the introduction of exotic pottery (Shepard 1942). In the present case, the first appearance of the ware is followed by a postulated movement of people into a region which previously did not produce it. The rise
in popularity appears to have accompanied the influx of immigrants. This suggests that the
popularity was a result of either novelty and/or it reflects a change in social organization en-
gendered by the dominance of a new social order. Production of quality wares can be expected
to give exchange advantages.

White (1986:313-315) has argued that a change in the “socio-cultural” scene may have
resulted in rapid movements of people. Another explanation for temporal changes in ceramic
technology, according to White, is that manufacturing and distribution structures could have
changed. She gives as an example a change from “each village manufacturing most of its
own vessels to specialized pottery villages manufacturing for a region”, this could explain the
“broad dispersal of certain pottery styles and technologies”.

We have noted that production is critically dependent on the local availability of raw mate-
rials. In view of the highly localised nature of suitable potting clays, it seems unlikely that less
favourably situated villages could produce surpluses. In many instances, villages are likely to
have been not producers but net consumers. Production centres specializing in pottery manu-
facture would have provided the major influence on the ceramic spectrum. It is these centres
which will provide the key to temporal and areal distributions of prehistoric pottery.

Identification of production centres can be anticipated to provide insight into important
cultural variables including the evolution of complex societies though the feedback mecha-
nisms mentioned. Production centres are dependent on the availability of raw materials. Thus
they are likely to be favourably situated with respect to quality clay sources, distortions pro-
duced by efficient transport systems, such as waterways, aside. Wares emanating from them
help contribute to the articulation of exchange networks. They affect relative chronologies
and important processual factors such as socio-economic organization. An understanding
of pottery exchange intensity is a primary step towards illuminating relative chronologies. A
lack of clear understanding of mechanisms which generate pottery distributions seriously risks
unwarranted assumptions. Assumptions, for example, which regard the relative proportions of
pottery through time as valid inferences in establishing relative chronologies, should be treated
as suspect unless a detailed understanding of where such pottery originated from is available.

Intensive analysis of production centres is likely to prove rewarding for the above reasons.
We have seen that, although some distinctiveness is evident between different Khorat Plateau
clays, they can often be expected to be generally indistinctive due to the nature of local country
rock. For this reason it may sometimes be necessary to include intensive techniques. Blending
renders heavy mineral analysis unreliable for comparisons of clays with ceramic fabrics. Produc-
tion centres are more likely to utilize non-blended clay, however, because by definition they
should enjoy adequate supplies of quality clays. These will often not require modification be-
yond the addition of standard temper. Heavy mineral analysis is suited to these circumstances.

Mineral identifications are central to sourcing the origins of wares. Elimination of unrel-
ated mineral zones helps narrow the area of enquiry. This strategy may also be applied to
differences in technologies. For example, variations in grog temper. Pottery containing ortho-
dox grog can usually be distinguished from wares with bleb-temper. Provided these tempers
are first identified in thin-section, examination with a low-power binocular microscope should
suffice in most instances. When compositional parameters are fully understood, this can be
undertaken by those unfamiliar with petrographic techniques. These temper distinctions, when
dealing with large sedimentary regions, can provide significant prima facie evidence.

A principal objective of this report has been to illuminate the prehistory of Northeast Thai-
land through an examination of a range of ceramic artefacts. Adoption of a standard termi-
nology, which is both precise and appropriate is urgent and critical for meaningful future
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discourse. Pottery types should include fabric and form considerations. Because they are potentially diagnostic of whole vessels, rimforms are important and should receive close attention. When correlated with fabric, they allow assessments of the relative proportions of types. The identification of exotic wares, which may often comprise a small percentage of a ceramic assemblage, is thus enhanced. At Ban Na Di, exotic vessels were copied by local potters. In view of this propensity to imitate novel designs or styles, it is necessary that both the fabrics as well as forms are subjected to detailed study.

Regions which display a distinctive geology are best suited to petrographic analyses, particularly when fabrics which derive from such areas contain diagnostic rock and mineral inclusions. Under these conditions, suggested sources are less ambiguous than those proffered for more homogeneous regions. Even in difficult areas, however, it is often possible to identify exotic wares. An intensive examination of clays and modern comparative materials helps distinguish between different source zones and manufacturing methods. This is particularly valuable when potting clay sources and fabric compositions can be understood in terms of the local regional geology and manufacturing methods respectively. These are important questions and ones which should be addressed in future studies.

Ceramic analysis has the potential, not only to illuminate temporal production changes and cultural relationships through material identifications, either by locating or excluding likely sources, but also to address such questions as exchange, social organisation and related cultural change. Production centres are vital to many aspects of pottery analysis, even when production is conducted under adverse conditions and is essentially aimed at internal consumption. Related manufacturing techniques may often indicate a regional homogeneity derived from social cohesiveness. This kind of association has often been attributed to stylistic similarities. Exclusive style-oriented assumptions, which are invalidated when styles are imitated, are not comparable with inferences drawn from the essentially intransient influences of technology. We have seen that these may be as equally widespread as pottery styles. The two, however, can not be assumed to be correlated, although they often may be.

Pottery, of course, forms just one component of prehistoric endeavour. Durability may act to impart undue bias and prominence to ceramic artefacts. We must, therefore, not promote pottery beyond its true function and meaning as cultural detritus. Pots never equal people. Clay is the plastic medium par excellence, however, and this allows a measure of human expression not afforded by many other artefacts. Symbolic expression, favoured contemporary styles, social unity and economic development are all reflected in ceramic preferences. Ceramics also embody evidence of considerable importance to the identification of exchange networks and relative levels of technological development. We are fortunate indeed that such artefacts are durable. Their relative abundance in Southeast Asian prehistoric contexts demands careful analysis if misleading avenues of inquiry are to be avoided. Ethnographic data greatly enhanced the identification of the bleb temper. Our attention to ethnographic information is likely to give rewarding results when correlations with archaeological data are evident. Valid conclusions rest on the acquisition of worthwhile information gathered from aspects of ceramic manufacture that give meaningful results. In this respect the mode of production is an important indicator of socio-cultural associations. Designs or art forms commonly fall under a specific stylistic rubric. This is not a limiting factor because individual styles may be rendered in a wide variety of materials and techniques. Cubism, for example, retains its form whether oils, water paint, or charcoal are applied to canvas, wood, or paper by hand or machine. Ceramic modes of production, however, are constrained by the kinds of materials and technology available. Technological strategies, therefore, can be expected to relate directly to

locally available materials and technical expertise. Access to exchange networks and transport facilities will act to enhance technological development through the input of new ideas and materials.

Finally, ceramics should be approached both from intensive analytical directions, and as a means of bringing together broad syntheses of disparate sociological relationships. Together, these relationships articulate processes central to the dynamic forces whose manipulation have characterised temporal changes in human societies. We should not allow ourselves to be bogged down by the gathering of more and more data, so that we feel constrained and reluctant to formulate bold new hypotheses or models based on available evidence. Ceramics represent one of the most important human inventions. We should organise our approach to pottery with the knowledge that although it forms only a small, occasionally unimportant, component of human expression, the information it may contain is worth careful consideration. This is a dedication that is warranted, not for any intrinsic satisfaction, but in view of the valuable conclusions to which it may lead.
Appendix One

The ceramic fabrics of Northeast Thailand

A.1 The petrology of Ban Na Di “whole” vessels

A total of 147 vessels have been examined (chapter seven). Detailed descriptions of the different fabrics identified are set out below.

A.2 Mortuary Phase One fabrics

(a) local wares

Fabric groups 1 to 4 inclusive are categorised primarily in terms of *technological* variations in temper. Fabric group 3 is considered to comprise a blended mixture of a plastic with a short clay. Clay preparation of this kind, in a sense, is a form of tempering. It acts to increase the proportion of nonplastics in the mixture.

Fabric group 1.

The parent matrix is comprised of a clay petrographically consistent with Nong Kham Din (sample 10, chapter five). Its most distinctive features include a moderately micaceous matrix, few nonplastics, and numerous sponge spicules.

Fabric group 1 is tempered with “orthodox” grog (figures 6.1 and A.1) below. It is usually comprised of the same constituents as the parent ceramic body, although it may often be free of large inclusions. The matrix of both often appears argillaceous in thin-section. Orthodox grog is angular to subrounded in shape. It ranges in size from very fine to very coarse sand. Coarser nonplastics often tend to be concentrated within a central core, a narrow portion of which is often reduced, at times heavily. The fabric is usually oxidised to a shallow depth (about 1 mm), in from vessel surfaces. These areas are dominated by finer particles, an artefact of paddle and anvil construction. Any oxidised micaceous particles display a characteristic sheen. These particles, when randomly mixed, give a distinctive “cross-hatched” effect. Voids are rare.

In contrast with the fabric group 12 “bleb” temper discussed below, “orthodox” grog does not incorporate rice husk. In many Khorat Plateau fabrics, including strictly sand-tempered wares, it is common for isolated fragments of rice husk occur. These are considered “incidental”, because they were probably not added deliberately. Orthodox grog may, in very rare instances, display husk impressions to exterior surfaces.
Fabric group 2.

Mineralogically, this group appears the same as fabric group 1. Three variations, however, set it apart ceramically. In addition to orthodox grog, plant material is also present in varying amounts. Isolated rice husk impressions to the exterior surface of grog fragments, rare husk remains within the parent fabric, and numerous to abundant rice phytoliths are all indicative of its presence. This addition of rice remains distinguishes fabric group 2 from fabric group 1.

In overall composition, fabric groups 1, 2, and 4 form a continuum. The principal variables are grog and a plant material, probably rice straw and husk. Husk is mainly represented by remnant impressions. Two factors mitigate against defining sharp boundaries between each fabric, and each can be very difficult to differentiate.

First, rice was probably present throughout the sequence at Ban Na Di and Ban Chiang (McGovern et al. 1985:110). Further, a particular tempering material is only likely to be selected if its availability is highly reliable. It is important to note that phytoliths are ubiquitous in Sakon Nakhon Basin wares. Although common to many grasses, the abundance of phytoliths consistent with rice strongly suggests this plant formed a key subsistence component from the first occupation of the basin. Given that rice was environmentally more-or-less ubiquitous it would be almost impossible to exclude its by-products, even if desired, from potting clay.

Second, the same exclusion problem effects clay lumps in the potters manufacturing environment. Such lumps can be difficult to discriminate from grog particles in thin-section (Whitbread 1985). Fabric group 4, for example, which features abundant voids and some plant material, probably comprising rice husk and straw, also includes a few grog-like particles.

The colour of fabric groups 2 and 4 is a dark charcoal grey. Generally only external surfaces are oxidised to a minute depth. Such surficial oxidation indicates the atmosphere was not reducing when firing was completed (Shepard 1971). The internal fabric colour is most probably due to a very high proportion of carbonaceous particles derived from combusted plant material.

Fabric group 3.

A 50/50 blend of Nong Kham Din clay with either of the two Ban Na Di clays would give a nonplastic to clay matrix ratio consistent with fabric group 3 (figure 7.22 and Table 5.1 chapter five). All of the minerals noted for clays 10, 13 and 14, are present in varying amounts. Plagioclase feldspar is rare. Fabric group 3 probably represents a two-stage, or blended, mixture. It is postulated that the plastic Nong Kham Din clay was first mixed with the short Ban Na Di clay. This mixture was then tempered as for fabric group 1.

Fabric group 4.

A relative abundance of voids, probably representing the vacated sites of plant material, and a paucity of grog set this fabric group apart. It is closely related to fabric group 2, but has much less grog. Rice phytoliths are prominent, but husk impressions are not obvious which suggests mainly straw was added. Only two vessels are involved.

Comment

The above four fabric groups are closely related. It must be stressed that, fabric group 3 apart, the variations noted are often slight. Because of this, variations within vessels were sought, and pot 37 was sectioned in three places to check fabric homogeneity. Although a degree of variation was apparent, it appeared less than the variation between fabric groups. Hence it was decided to separate fabric groups 1, 2 and 4. Because potting clay preparations are not completely homogeneous some overlapping between these three fabric groups is possible.
(b) exotic wares.

(i) Sakon Nakhon Basin fabrics.

Fabric group 5.

This fabric group consists of a rice-tempered material which is mineralogically compatible with clay from Nong Sung (sample 6, chapter five). In contrast with Ban Na Di MP1 fabrics, the rice husk is distinctive and free of straw. In addition, the fabric is fully oxidised, and dense, apart from a few voids or inclusions representing combusted or remnant carbonized husk. Plagioclase feldspar is present as rare, very fine sand grains. Nong Sung lies within the plagioclase feldspar zone (figure 5.3).

Fabric group 6.

This fabric group is dense, and mainly fully oxidised. It is comprised of a sandy clay which has been tempered with orthodox grog. The clay has a relatively high quartz content. Compaction, a relatively high clay density, and oxidation combine to mask the grog in thin-section. In hand specimens, however, cut and moistened surfaces readily reveal its presence. None of the Sakon Nakhon Basin clays sampled matches the fabric group 6 mineralogy precisely. The association of a micaceous matrix, few spicules or ferruginous minerals, plagioclase feldspar, and weathered quartzarenite rock fragments suggest a source to the east near the Phu Phan Piedmont. The rock fragments comprise diagnostic chert-cemented monocrystalline quartz grains. The presence of coarse silt-sized plagioclase feldspar suggests it originates either from or near Ban Lao Suan Klua (clay 11, chapter five).

Fabric group 8.

Fabric group 8 has close mineralogical and textural similarities with clays 2 and 4 (chapter five). This suggests a source near or within the upper catchment of the Songkhram river. The fabric is fully oxidised, and very dense. This makes any argillaceous inclusions difficult to detect in thin-section. When cut surfaces are moistened, however, grog is visible under a hand lens. Two nearly identical vessels, of outstanding quality, are the sole representatives of this fabric. Because of their quality and rarity extra care was taken when removing tabs for thin-sectioning. Although each vessel has the same orthodox grog-tempered fabric, differences are apparent. Thus pot 95 includes several fragments of rice husk. Pot 94, however, has no obvious husk, but phytoliths and several ferruginous pellets, absent from pot 95, are present. These differences are probably due to sampling variations.

Fabric group 9.

Very distinctive isotropic, or partially isotropic, grains, of either argillaceous rock fragments or orthodox grog, characterise this fabric group. Its parent matrix compares mineralogically with clay 2 (chapter five). The argillaceous inclusions are of coarse sand to granule dimension, usually sub-rounded to rounded, but occasionally angular. In plane polarized light they often merge completely with the surrounding matrix. Some contain abundant microfossils. Diatoms, spicules and phytoliths are present in a broad range of highly variable combinations. In many, however, microfossils are often absent or poorly represented. In some mudstones, such as shales, microfossil variability typically results from rhythmic laminations which characterise lacustrine sedimentation (Tucker 1981:92).

Even when non-plastics are entirely absent, the isotropic charateristics are maintained. Thus in plane polarized light no morphological or textural variation is discernible between the area occupied by the inclusions and the surrounding matrix. Yet under crossed polars they become prominent with clearly defined boundaries. Their isotropic characteristics vary from
A.2. MORTUARY PHASE ONE FABRICS

almost complete to moderately birefringent. This could result from the preferential orientation of clay minerals as artefacts of a prepared grog. When the fragments are orientated in thin-section so that they are viewed parallel to the C crystallographic axis of the mineral constituents (i.e. the section is cut normal to the C axis), the isotropism, or near isotropism, is explained (Grim 1968:426-428), Williams et al 1982:321-324.

Solheim (1964), reports a grog variety which is derived from crushed and sieved pre-fired clay balls. Fissility may be imparted during clay preparation to these balls. If so, they would probably tend to shear preferentially along the “bedding” lines. This would create grog elongate in the “bedding” direction. Sorting within the confines of vessel walls during paddle and anvil construction would favour a longitudinal grain orientation. Thus the internal grog stratification would lie normal to the thin-section plane.

Alternatively, the inclusions may represent fragments of shale weathered from the Phu Kradung Formation. A clear understanding of the origin of these inclusions requires information regarding their nature. It seems unlikely that this can be established without samples of either raw clays or fabrics of known composition for comparison.

Fabric group 10.

Abundant rice husk and straw characterise this fabric group. Mineralogically it shows a close similarity with clay 3 (chapter five). The clay matrix is micaceous, and ferruginous minerals and chert are present.

Fabric group 11.

Mineralogically, the constituents of fabric group 11 are very close to those of clay 6 (chapter five). It is slightly more micaceous, however, and lightly tempered with orthodox grog. Incidental rice husk is also present.

“Eastern” Sakon Nakhon Basin fabrics.

Each of the following fabric groups has a micaceous clay matrix, spicules are always rare, and their overall mineralogies suggest they originate in, or close to, the eastern micaceous zone (figure 5.3). Thus either clays 2, 3, or 4, or some similar unsampled material may be involved. A detailed investigation of each micaceous fabric group is beyond the scope of the present study. A major difficulty is that rocks of the same Formations outcrop both to the west and east of the northern basin. An intensive analysis, such as that undertaken on the Sakon Nakhon Basin clays (chapter five), is required before proveniences for these fabrics can be suggested with confidence. The current assessment is based on a comparison of potting clays and fabrics from several northeastern sites. It is considered sufficient for our present purposes, therefore, to place only those fabrics which are considered to have affinities with the micaceous zone described. Some adjustments may be necessary in the light of future investigations. Fabric groups 8, 9, and 10 discussed above, and some “Om Kaeo”-style pottery (chapter ten) also fall into this group.

Fabric group 13.

This fabric group is characterised by an orthodox grog temper contained within a distinctive ceramic body. The parent material contains iron-rich inclusions. These are either ooid-like or angular. Spicules are often prominent within the grog. Mineralogically, the parent matrix is compatible with clay 3 (chapter five).

Fabric group 15.

Iron-rich, ooid-like, coarse sand-sized inclusions are again present, but in this instance they are less prominent than in fabric group 13. The matrix, which is only moderately micaceous,
suggests a source near to clay 3. This, and an orthodox grog temper, characterises fabric group 15.

(ii) non-Sakon Nakhon Basin fabrics.

Fabric group 7.

Close associations with ceramics of the Petchabun peidmont are suggested by a highly micaceous matrix and igneous minerals. This fabric group is composed of a sandy clay which has been lightly tempered with orthodox grog. The igneous minerals clearly place it outside the Sakon Nakhon Basin. Measurements of the plagioclase feldspar using the Michel-Levy method suggest a basic igneous source (Vincent 1984b). Plagioclase feldspar is represented by a few individual grains, and rare rock fragments. Comparative sherds, from sites both deep within and bordering the Petchabun Range, have also been examined. Micaceous sandy fabrics from Nong Non Chik are very similar petrographically.

Compared to the Sakon Nakhon Basin clays, fabric group 7 has a more prominent feldspar representation. Potassium feldspar is more numerous, and generally fresher and larger. It measures up to coarse sand size. Plagioclase feldspar occurs with orthoclase in what appear to be highly altered volcanic rock fragments. Although strained monocrystalline quartz dominates, some sand grains are quartzo-feldspathic, and others feature quartz with weathered brown mica inclusions. A pale green hornblende also occurs as fine sand-sized detritus. These latter minerals suggest a granitic source may be involved. Volcanic and plutonic rocks are extensively exposed upstream of Nong Non Chik in the northern Central Highlands.

Reworked sedimentary minerals are also present in small quantities. Some quartz grains display overgrowths. A few very fine sand-sized grains of mosaic chert grains are present. They are subrounded. Freshwater sponge spicules and phytoliths are rare. Similarities with Non Nong Chik fabrics, coupled with the presence of minerals common to sedimentary terrain, make it reasonable to postulate that this fabric originated from the western margins of the Sakon Nakhon Basin, possibly in a zone intermediate between the Petchbun Piedmont and the basin sensu stricto.

Fabric group 14.

For sourcing purposes, the constituents of this fabric are geologically non-specific. Its principle characteristics in thin-section are an orthodox grog temper and a moderate amount of rice husk. There are few nonplastics, which never exceed fine sand size. They are dominated by monocrystalline quartz which is often strained. Unsutured polycrystalline quartz, of fine sand size, potassium feldspar, mosaic chert, and detrital tourmaline, each of very fine sand size, and spicules, are rare. Phytoliths are numerous.

In hand specimen the fabric is texturally the same as rice tempered pottery from Ban Suai and Ban Prasat. Welch (1985:203), reports that grog-tempered pottery dominates the early Tamyae tradition. Fabric group 14, therefore, may represent local Phimai clays tempered with orthodox grog, and possibly rice husk. The Phimai region is cloaked with Quaternary to Recent alluvium and eluvium, (Javanaphet 1969), therefore an indistinct mineralogy is predictable. Fabric group 14 is heavily reduced throughout. The construction details of the single vessel which represents this fabric, such as a low helix angle cord twist and a non-moulded forming process, also set it apart from Ban Na Di local wares. Until a more detailed petrographic study of Phimai pottery has been undertaken this fabric can only be accorded provisional status.
A.3 Mortuary Phase Two fabrics

Fabric group 12.

A highly distinctive grog characterises this fabric group. In thin-section, it ranges in shape from sharply angular to bleb-like. This descriptive term has been used previously (Vincent 1984b). The grog has been manufactured by crushing fired clay balls which have been heavily impregnated with rice husk. Rice not combusted may be disaggregated during the crushing process. A modern example from Ban Pluai (clay 2, chapter five), is included for comparison with prehistoric blebs (figure A.2 below). Figures A.3 and A.4 illustrate prehistoric blebs in hand specimen. Figure A.5 shows rice husk within a bleb grog fragment in thin-section.

In their most distinctive form, blebs closely parallel the arcuate shards of glass in typical vitroclastic textures such as those of vitric tuffs (Williams et al. 1982:263 fig 9-2. A). These latter shards are also the result of comminution. They derive from vesiculated vitric ash. It is this connotation which is alluded to in the descriptive term employed, because in a sense, the rice husk forms small bubbles in the clay. When crushed, the clay balls tend to fracture along vesical planes formed by the combusted rice. Thus, in this respect, the processes involved in manufacturing this artificial temper are effectively analogous to natural processes. Arcuate and corrugated faces, due to rice husk impressions and fracture planes, are common. Many grains have an amoebic-like shape in thin-section. Their distribution within the ceramic fabric is probably best described as poikiloblastic (Williams et al. 1982:440, fig 16-1. C), a term considered appropriate because pottery is in a sense a metamorphic rock. Bleb temper of course refers specifically to a technological process, and many different fabrics feature them. Its presence, without specific geological or distribution evidence, provides no direct sourcing information. In this case, of the clays sampled, the parent body of fabric group 12 is composed of material consistent with clay from Nong Sung (clay 6, chapter five).

Fabric group 16.

The parent matrix of this fabric group is compatible with Nong Sung clay (sample 6, chapter five). It is tempered with orthodox grog. The fabric is dense and includes few nonplastics. These are mainly spicules, quartzose grains or ferrigenous opaques. The major constituents have been point-counted and compared with MP1 fabric group 1 and MP2 fabric group 12 (see Table 7.3 chapter seven). Although the temper is consistent with MP1 Ban Na Di local wares, fabric group 16 occurs in level 7 and 5 anvils during MP1 and MP2 (Table A.13 below).

A.4 Whole Vessel fabrics

FIGURE A.1: ORTHODOX GROG IN THIN-SECTION. 125x magnification.
FIGURE A.2: MODERN (left) AND PREHISTORIC BLEBS (right) IN THIN-SECTION. 125x magnification.

FIGURE A.3: PREHISTORIC BLEBS IN HAND SPECIMEN.
FIGURE A.4: PREHISTORIC BLEBS IN HAND SPECIMEN.

FIGURE A.5: PREHISTORIC BLEBS WITH RICE IN THIN-SECTION. 100x magnification.
### TABLE A.1: Ban Na Di “whole” vessel fabrics.

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TABLE 1 continued: The Ban Na Di “whole” vessel fabrics.

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<th>phase/level</th>
<th>suggested source +</th>
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<td>16</td>
<td>1b</td>
<td>Ban Na Di</td>
</tr>
<tr>
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<td>1a</td>
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</tr>
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<td>8</td>
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<td>1c</td>
<td>Ban Na Di</td>
</tr>
<tr>
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<td>4</td>
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</tr>
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<td>14b</td>
<td>1c</td>
<td>Ban Na Di</td>
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<td>4</td>
<td>1c</td>
<td>Ban Na Di</td>
</tr>
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<td>Ban Na Di</td>
</tr>
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<td>140</td>
<td>1</td>
<td>9</td>
<td>L7</td>
<td>Ban Na Di</td>
</tr>
</tbody>
</table>

Notes: + The sources listed accord with the fabric descriptions set out above.
++ see chapter seven for a discussion of form categories.
note a: Pot 47 cannot be readily associated with a particular source. Although it has similarities with fabric group 7, it requires further detailed analysis to substantiate this. It can, however, be considered exotic to Ban Na Di.

TABLE A.2: The chronological distribution of “whole” vessel fabrics.

<table>
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<td>-</td>
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<td>-</td>
<td>-</td>
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<td>Totals:</td>
<td>64</td>
<td>39</td>
<td>11</td>
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TABLE 2 continued: The chronological distribution of “whole” vessel fabrics.

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<th>phase</th>
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<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
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<th>16</th>
<th>n</th>
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<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>1a:</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>1b:</td>
<td></td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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</tr>
<tr>
<td>1c:</td>
<td></td>
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<td>2</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>7</td>
</tr>
<tr>
<td>2:</td>
<td></td>
<td>-</td>
<td>-</td>
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<td>Totals</td>
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<td>4</td>
<td>2</td>
<td>9</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>21</td>
</tr>
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</table>

Note: Fabric groups 1 to 4 inclusive are MP 1a to 1c local wares. Fabric group 12 is a mortuary phase 2 local ware.

TABLE A.3: The mortuary phase 1a to 1c whole vessel fabrics.

<p>| MP1 whole pots: % of local vs exotic fabrics. |</p>
<table>
<thead>
<tr>
<th>LOCAL fabrics: no. of pots</th>
<th>% of total</th>
<th>% of local</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>64</td>
<td>47.05</td>
</tr>
<tr>
<td>2</td>
<td>39</td>
<td>28.67</td>
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<tr>
<td>3</td>
<td>11</td>
<td>8.08</td>
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<tr>
<td>4</td>
<td>2</td>
<td>1.42</td>
</tr>
<tr>
<td>Subtotals:</td>
<td>116</td>
<td>85.22</td>
</tr>
</tbody>
</table>

TABLE A.4: The mortuary phase 1a to 1c whole vessel fabrics.

<table>
<thead>
<tr>
<th>EXOTIC fabrics: no. of pots</th>
<th>% of total</th>
<th>% of exotic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sakon Nakhon</td>
<td>17</td>
<td>12.50</td>
</tr>
<tr>
<td>Petchabun</td>
<td>2</td>
<td>1.47</td>
</tr>
<tr>
<td>Khorat Basin</td>
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<td>0.73</td>
</tr>
<tr>
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<td>20</td>
<td>14.70</td>
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</table>
A.4 Cord-marks on vessels

The cordmarking twist terms used in Table A.5 below, follow Osborne and Osborne (1954). The exterior walls on moulded pots are cordmarked vertically, or near vertically, and then partially smoothed. This is particularly noticeable at the base. Interior surfaces below the equator are cordmarked with positive impressions. Above the equator they are smooth. Below the equator the interior surfaces are even, above they are undulating. These undulations usually follow parallel lines which suggest that the upper portion of the vessels have been added as sequential rings. The interior cordmarks are usually obvious, although some vessels are eroded making assessments difficult. Often a clear equatorial join suggests that the lower hemisphere of such vessels have been moulded.

### TABLE A.5: The cordmarks on Ban Na Di “whole” vessels.

<table>
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<tr>
<th>pot</th>
<th>twist</th>
<th>width (mm)</th>
<th>application</th>
<th>interior/ exterior</th>
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</thead>
<tbody>
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<td>1</td>
<td>Z</td>
<td>2.5</td>
<td>vertical</td>
<td>exterior only</td>
</tr>
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<td>2</td>
<td>Z</td>
<td>2-3</td>
<td>horizontal*</td>
<td>exterior only</td>
</tr>
<tr>
<td>3</td>
<td>Z</td>
<td>1.2++</td>
<td>vertical and horizontal</td>
<td>exterior only</td>
</tr>
<tr>
<td>4</td>
<td>Z</td>
<td>1.2</td>
<td>vertical and horizontal*</td>
<td>exterior only</td>
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<tr>
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<td>Z</td>
<td>1.2++</td>
<td>vertical and horizontal*</td>
<td>both +++</td>
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<tr>
<td>6</td>
<td>Z</td>
<td>1.2</td>
<td>vertical*</td>
<td>both</td>
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<tr>
<td>7</td>
<td>Z</td>
<td>0.6</td>
<td>cross-hatched all over</td>
<td>exterior only</td>
</tr>
<tr>
<td>8</td>
<td>S</td>
<td>1.0</td>
<td>special - see note 1</td>
<td>both</td>
</tr>
<tr>
<td>9</td>
<td>Z</td>
<td>1.0</td>
<td>cross-hatched all over+</td>
<td>exterior only</td>
</tr>
<tr>
<td>10</td>
<td>Z</td>
<td>1.0</td>
<td>vertical and horizontal*</td>
<td>both</td>
</tr>
<tr>
<td>11</td>
<td>S</td>
<td>0.8</td>
<td>vertical or diagonal*</td>
<td>both</td>
</tr>
<tr>
<td>12</td>
<td>S</td>
<td>0.8/1.5++</td>
<td>vertical and horizontal+</td>
<td>both</td>
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<td>0.75</td>
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<td>1.0</td>
<td>diagonal*</td>
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<tr>
<td>15</td>
<td>Z</td>
<td>1.2/2++</td>
<td>vertical and horizontal*</td>
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<td>16</td>
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<td>exterior only</td>
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<td>vertical/horizontal/diagonal*</td>
<td>both</td>
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<td>vertical/horizontal/diagonal*</td>
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<td>29</td>
<td>S</td>
<td>1.0</td>
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### TABLE 5 continued: The cordmarks on Ban Na Di “whole” vessels.

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<td>31</td>
<td>Z 0.8/0.5</td>
<td>vertical</td>
<td>both</td>
</tr>
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<td>32</td>
<td>Z 1.2</td>
<td>vertical and diagonal</td>
<td>exterior only</td>
</tr>
<tr>
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<td>Z 1.2</td>
<td>diagonal (smoothed over)</td>
<td>exterior only</td>
</tr>
<tr>
<td>34</td>
<td>Z 0.8</td>
<td>vertical to diagonal*</td>
<td>both</td>
</tr>
<tr>
<td>35</td>
<td>Z 1.2</td>
<td>vertical and diagonal*</td>
<td>both</td>
</tr>
<tr>
<td>36</td>
<td>Z 1.0</td>
<td>vertical to diagonal*</td>
<td>both</td>
</tr>
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<td>37**</td>
<td>Z 1.0</td>
<td>vertical and diagonal*</td>
<td>both</td>
</tr>
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<td>38**</td>
<td>Z 1.0</td>
<td>vert to diagonal (smoothed)</td>
<td>both</td>
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<td>39**</td>
<td>Z 1.8+++</td>
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<td>exterior only</td>
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<td>40**</td>
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<td>vertical*</td>
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<td>vertical</td>
<td>both</td>
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<td>vertical</td>
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<td>both</td>
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<tr>
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<td>diagonal (smoothed)</td>
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</tr>
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<td>vertical</td>
<td>exterior only</td>
</tr>
<tr>
<td>49**</td>
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<td>vertical</td>
<td>exterior only</td>
</tr>
<tr>
<td>50**</td>
<td>Z 1.2</td>
<td>cross-hatched</td>
<td>both</td>
</tr>
<tr>
<td>51**</td>
<td>Z 0.8</td>
<td>vertical</td>
<td>both</td>
</tr>
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<td>Z 1.0</td>
<td>vertical and horizontal*</td>
<td>both</td>
</tr>
<tr>
<td>53**</td>
<td>Z 1.0/2.0</td>
<td>vertical and horizontal</td>
<td>both</td>
</tr>
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<td>54**</td>
<td>Z 1 to 2</td>
<td>cross-hatched</td>
<td>both</td>
</tr>
<tr>
<td>55**</td>
<td>Z 0.8/3.0</td>
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<td>both</td>
</tr>
<tr>
<td>56**</td>
<td>Z 1.0</td>
<td>vertical</td>
<td>both</td>
</tr>
<tr>
<td>57</td>
<td>Z 1.0</td>
<td>vertical and diagonal*</td>
<td>both</td>
</tr>
<tr>
<td>58</td>
<td>Z 1.0</td>
<td>vertical/horizontal/diagonal*</td>
<td>both</td>
</tr>
<tr>
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<td>Z 1.0</td>
<td>vertical*</td>
<td>both</td>
</tr>
<tr>
<td>60</td>
<td>Z 1.0</td>
<td>vertical*</td>
<td>both</td>
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<td>vertical</td>
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<td>Z 0.8</td>
<td>diagonal*</td>
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</tr>
<tr>
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<td>Z 1.2</td>
<td>diagonal*</td>
<td>exterior only</td>
</tr>
<tr>
<td>64</td>
<td>Z 0.8</td>
<td>diagonal*</td>
<td>exterior only</td>
</tr>
<tr>
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<td>Z 1.0</td>
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<td>exterior only</td>
</tr>
<tr>
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<td>no data</td>
<td>- base only available</td>
<td></td>
</tr>
<tr>
<td>67**</td>
<td>as for 66</td>
<td></td>
<td></td>
</tr>
<tr>
<td>68**</td>
<td>Z 1.0</td>
<td>vertical and diagonal</td>
<td>both</td>
</tr>
<tr>
<td>69**</td>
<td>Z 0.8</td>
<td>base only</td>
<td></td>
</tr>
<tr>
<td>70**</td>
<td>as for 66</td>
<td></td>
<td></td>
</tr>
<tr>
<td>71**</td>
<td>Z 1.0</td>
<td>vert.(ext) x-hatched (int)</td>
<td>both</td>
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<td>---</td>
<td>---</td>
<td>---</td>
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<td>72**</td>
<td>Z</td>
<td>1.2</td>
<td>base only</td>
</tr>
<tr>
<td>73**</td>
<td>no data</td>
<td>- top of bowl only</td>
<td></td>
</tr>
<tr>
<td>74</td>
<td>Z</td>
<td>0.6+/-1.5</td>
<td>vertical and diagonal</td>
</tr>
<tr>
<td>75</td>
<td>Z</td>
<td>0.8/2.0</td>
<td>vertical and diagonal</td>
</tr>
<tr>
<td>75a</td>
<td>no data</td>
<td>- small fragment</td>
<td></td>
</tr>
<tr>
<td>76</td>
<td>Z</td>
<td>1.0</td>
<td>vertical</td>
</tr>
<tr>
<td>77</td>
<td>Z</td>
<td>0.6</td>
<td>cross-hatched</td>
</tr>
<tr>
<td>78</td>
<td>Z</td>
<td>0.8</td>
<td>vertical</td>
</tr>
<tr>
<td>79</td>
<td>Z</td>
<td>0.8</td>
<td>vertical*</td>
</tr>
<tr>
<td>80</td>
<td>S</td>
<td>0.8 and 1.5</td>
<td>cross hatched diamond pattern</td>
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<tr>
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<td>Z</td>
<td>0.8/1.5</td>
<td>vertical and horizontal*</td>
</tr>
<tr>
<td>82</td>
<td>Z</td>
<td>1.0</td>
<td>vertical</td>
</tr>
<tr>
<td>83</td>
<td>Z</td>
<td>1.0</td>
<td>vertical</td>
</tr>
<tr>
<td>84***</td>
<td>Z</td>
<td>1.2</td>
<td>vertical</td>
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<tr>
<td>85***</td>
<td>Z</td>
<td>0.6</td>
<td>vertical and diagonal*</td>
</tr>
<tr>
<td>86***</td>
<td>Z</td>
<td>1.0</td>
<td>vertical to diagonal</td>
</tr>
<tr>
<td>92**</td>
<td>Z</td>
<td>1.0</td>
<td>vertical</td>
</tr>
<tr>
<td>93</td>
<td>Z</td>
<td>remnants only 0.2/0.8</td>
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<tr>
<td>96</td>
<td>Z</td>
<td>1.0</td>
<td>vertical (partly smoothed)</td>
</tr>
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<td>97</td>
<td>Z</td>
<td>1.0</td>
<td>horizontal to diagonal</td>
</tr>
<tr>
<td>98</td>
<td>Z</td>
<td>1.5</td>
<td>diagonal</td>
</tr>
<tr>
<td>99</td>
<td>Z</td>
<td>1.5</td>
<td>vertical to diagonal</td>
</tr>
<tr>
<td>100</td>
<td>S</td>
<td>1.2</td>
<td>vertical and diagonal crossed</td>
</tr>
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<td>101</td>
<td>Z</td>
<td>1.0</td>
<td>vertical (base missing)</td>
</tr>
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<td>102</td>
<td>S</td>
<td>0.8</td>
<td>near vertical (base missing)</td>
</tr>
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<td>Z</td>
<td>1.0</td>
<td>vertical (base missing)</td>
</tr>
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<td>104</td>
<td>Z</td>
<td>1.0</td>
<td>vertical (base missing)</td>
</tr>
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<td>105</td>
<td>Z</td>
<td>1.2</td>
<td>vertical</td>
</tr>
<tr>
<td>106</td>
<td>Z</td>
<td>1.0</td>
<td>vertical (base missing)</td>
</tr>
<tr>
<td>107</td>
<td>Z</td>
<td>2.0/4.0</td>
<td>cross-hatched both</td>
</tr>
<tr>
<td>108</td>
<td>Z</td>
<td>1.5/1.5</td>
<td>horizontal and near vertical</td>
</tr>
<tr>
<td>109</td>
<td>Z</td>
<td>1.2</td>
<td>vertical (partly smoothed)</td>
</tr>
<tr>
<td>110</td>
<td>Z</td>
<td>1.0</td>
<td>vertical and near horizontal</td>
</tr>
<tr>
<td>111</td>
<td>Z</td>
<td>2.0/1.0</td>
<td>vertical and near horizontal</td>
</tr>
<tr>
<td>112</td>
<td>Z</td>
<td>1.3</td>
<td>near vertical</td>
</tr>
<tr>
<td>113</td>
<td>Z</td>
<td>2.0</td>
<td>vertical (partly smoothed)</td>
</tr>
<tr>
<td>113a</td>
<td>Z</td>
<td>2.0</td>
<td>vertical (113 lid)</td>
</tr>
<tr>
<td>114</td>
<td>Z</td>
<td>2.5/0.5</td>
<td>vertical (partly smoothed)</td>
</tr>
<tr>
<td>114a</td>
<td>Z</td>
<td>2.0/1.0</td>
<td>vertical (114 lid)</td>
</tr>
<tr>
<td>115</td>
<td>Z</td>
<td>2.0/1.0</td>
<td>vertical (partly smoothed)</td>
</tr>
<tr>
<td>115a</td>
<td>Z</td>
<td>2.0/0.4</td>
<td>vertical (115 lid)</td>
</tr>
<tr>
<td>116</td>
<td>Z</td>
<td>2.0/1.0</td>
<td>diagonal (partly smoothed)</td>
</tr>
</tbody>
</table>
TABLE 5 continued: The cordmarks on Ban Na Di "whole" vessels.

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>116a</td>
<td>Z 1.5/0.5 vertical (partly smoothed)</td>
<td>exterior only</td>
</tr>
<tr>
<td>117</td>
<td>no data</td>
<td>vessel eroded exterior only</td>
</tr>
<tr>
<td>117a</td>
<td>Z 1.5/0.8 vertical</td>
<td>exterior only</td>
</tr>
<tr>
<td>118</td>
<td>Z 1.2 vert. and diag. (base missing)</td>
<td>exterior only</td>
</tr>
<tr>
<td>120</td>
<td>Z 1.2/1.5 vertical and diagonal crossed</td>
<td>both</td>
</tr>
<tr>
<td>121</td>
<td>Z 0.7/2.0 vertical and diagonal*</td>
<td>both</td>
</tr>
<tr>
<td>124</td>
<td>Z 0.7 vertical/few diagonal</td>
<td>exterior only</td>
</tr>
<tr>
<td>126</td>
<td>Z 1.2 and 1.5 special - see note 4</td>
<td>both</td>
</tr>
<tr>
<td>128</td>
<td>Z 1.2 vertical</td>
<td>both</td>
</tr>
<tr>
<td>129</td>
<td>S 2 to 4 cross-hatched</td>
<td>exterior only</td>
</tr>
<tr>
<td>131</td>
<td>Z 1.2? vertical (heavily smoothed)</td>
<td>exterior only</td>
</tr>
<tr>
<td>132</td>
<td>Z 1.2 and 1.0 vertical* special-see note 4</td>
<td>both</td>
</tr>
<tr>
<td>133</td>
<td>Z 1.2 vertical</td>
<td>both</td>
</tr>
<tr>
<td>134</td>
<td>Z 1.0/1.5 vertical (base missing)</td>
<td>exterior only</td>
</tr>
<tr>
<td>135</td>
<td>Z 0.8/1.0 vertical (base missing)</td>
<td>exterior only</td>
</tr>
<tr>
<td>136</td>
<td>Z 0.4 vertical and diagonal*</td>
<td>both</td>
</tr>
<tr>
<td>137**</td>
<td>Z 1.0 vertical</td>
<td>both</td>
</tr>
<tr>
<td>138</td>
<td>Z 1.3/2.0 vertical (base missing)</td>
<td>exterior only</td>
</tr>
</tbody>
</table>

Notes: * denotes exterior basal region displays random or "cross-hatched" cordmarking.
++ denotes average width.
+++ denotes interior cordmarks extend from base to rim/body junction.
+ denotes cordmarks are mainly vertical at and/or above equator.
** denotes vessel is a goblet, and, unless specified, only the bowl portion is discussed.
*** denotes miniature goblet.

note 1: The spaces between cord impressions are unusual in that they exceed the maximum diameter of the cordmarks. Most cordmarking features spaces between cordmarks which are equal to, or less than, the cord diameter. On pot 8 the spaces measure approximately 4 mm on average. Cordmarks below the equator are either vertical or horizontal, but above are cross-hatched. Subsequent examples of width between cordmark spacings are indicated thus: cord diameter/space diameter.

note 2: For pot 18 the distribution and orientation of the cordmarks is the same, or very similar, to both interior and exterior surfaces. As this vessel was partly moulded, it is likely that the same potter constructed both mould and pot.

note 3: Cord diameters to internal and external surfaces for pot 25 are identical and notably wide. As with pot 18 this suggests the same potter constructed both mould and vessel.

note 4: Two different cord mark patterns are present. This suggests two different paddles were used.
### TABLE A.6: The Ban Na Di burial figurines.

<table>
<thead>
<tr>
<th>provenance</th>
<th>level/phase</th>
<th>cat.</th>
<th>form</th>
<th>fabric</th>
</tr>
</thead>
<tbody>
<tr>
<td>F6 Burial 40</td>
<td>1a</td>
<td>1438</td>
<td>cattle</td>
<td>clay 13 *</td>
</tr>
<tr>
<td>F6 Burial 40</td>
<td>1a</td>
<td>1439</td>
<td>cattle</td>
<td>clay 13 *</td>
</tr>
<tr>
<td>F6 Burial 40</td>
<td>1a</td>
<td>1440</td>
<td>cattle</td>
<td>clay 13 *</td>
</tr>
<tr>
<td>F6 Burial 45</td>
<td>1a</td>
<td>1383</td>
<td>cattle +&lt;sup&gt;+&lt;/sup&gt;</td>
<td>local clay **</td>
</tr>
<tr>
<td>F6 Burial 45</td>
<td>1a</td>
<td>1384</td>
<td>cattle +</td>
<td>local clay **</td>
</tr>
<tr>
<td>F6 Burial 45</td>
<td>1a</td>
<td>1387</td>
<td>cattle</td>
<td>clay 13 *</td>
</tr>
<tr>
<td>F6 Burial 46</td>
<td>1a</td>
<td>1437</td>
<td>cattle</td>
<td>clay 13 *</td>
</tr>
<tr>
<td>F6 Burial 47</td>
<td>1a</td>
<td>1418</td>
<td>cattle</td>
<td>clay 13 *</td>
</tr>
<tr>
<td>F6 Burial 47</td>
<td>1a</td>
<td>1405</td>
<td>elephant</td>
<td>clay 13 *</td>
</tr>
<tr>
<td>F6 Burial 47</td>
<td>1a</td>
<td>1401</td>
<td>cattle</td>
<td>clay 13 *</td>
</tr>
<tr>
<td>F6 Burial 47</td>
<td>1a</td>
<td>1396</td>
<td>cattle +</td>
<td>clay 13 *</td>
</tr>
<tr>
<td>F6 Burial 47</td>
<td>1a</td>
<td>1270</td>
<td>cattle</td>
<td>clay 13 *</td>
</tr>
<tr>
<td>F6 Burial 47</td>
<td>1a</td>
<td>1388</td>
<td>cattle +</td>
<td>local clay **</td>
</tr>
<tr>
<td>F6 Burial 47</td>
<td>1a</td>
<td>1389</td>
<td>cattle +</td>
<td>local clay **</td>
</tr>
<tr>
<td>F6 Burial 47</td>
<td>1a</td>
<td>1396</td>
<td>cattle</td>
<td>local clay **</td>
</tr>
<tr>
<td>F6 Burial 47</td>
<td>1a</td>
<td>1397</td>
<td>cattle +</td>
<td>local clay **</td>
</tr>
<tr>
<td>F6 Burial 47</td>
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<td>1399</td>
<td>cattle +</td>
<td>local clay **</td>
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<tr>
<td>F6 Burial 47</td>
<td>1a</td>
<td>1401</td>
<td>cattle +</td>
<td>local clay **</td>
</tr>
<tr>
<td>F6 Burial 38</td>
<td>1b</td>
<td>1419a</td>
<td>cattle +</td>
<td>local clay **</td>
</tr>
</tbody>
</table>

**Notes:**
- * thin-sectioned
- ** hand specimen
- + red paint
- řesin ?
A.6 Ban Na Di rimform fabrics

The rimform fabric tables set out in the following pages relate to both the Sakon Nakhon Basin potting clays, an analysis of which is detailed in chapters four and five, and the various ceramic fabric groups discussed above in this appendix. Further discussions of potting clays and ceramic fabrics are to be found throughout the main body of the report, and in appendices two and three. Appendix two includes surface collected Sakon Nakhon Basin fabrics, Ban Muang Phruk rimform fabrics, and illustrations of the Ban Muang Phruk rimforms. Each of these sections should be read in conjunction with the evidence set out in the above chapters.
### TABLE A.7: The Ban Na Di occupation level rimform fabrics.

<table>
<thead>
<tr>
<th>rimform level</th>
<th>section</th>
<th>fabric</th>
<th>suggested source</th>
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</thead>
<tbody>
<tr>
<td>US 18 8</td>
<td>684</td>
<td>* BND ? plagioclase zone</td>
<td></td>
</tr>
<tr>
<td></td>
<td>685</td>
<td>3 Ban Na Di</td>
<td></td>
</tr>
<tr>
<td></td>
<td>686</td>
<td>3 Ban Na Di</td>
<td></td>
</tr>
<tr>
<td></td>
<td>687</td>
<td>* BND ? plagioclase zone</td>
<td></td>
</tr>
<tr>
<td>US 19 8</td>
<td>hand specimen</td>
<td>3? Ban Na Di</td>
<td></td>
</tr>
<tr>
<td>US 20 8</td>
<td>676</td>
<td>* BND ? plagioclase zone</td>
<td></td>
</tr>
<tr>
<td></td>
<td>677</td>
<td>* clay 7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>678</td>
<td>* BND ? plagioclase zone</td>
<td></td>
</tr>
<tr>
<td>US 21 8</td>
<td>679</td>
<td>* BND ? plagioclase zone</td>
<td></td>
</tr>
<tr>
<td></td>
<td>688</td>
<td>3 Ban Na Di</td>
<td></td>
</tr>
<tr>
<td></td>
<td>689</td>
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<tr>
<td></td>
<td>690</td>
<td>3 Ban Na Di</td>
<td></td>
</tr>
<tr>
<td>US 22 8</td>
<td>680</td>
<td>* clay 7</td>
<td></td>
</tr>
<tr>
<td>US 23 8</td>
<td>682</td>
<td>13 East Sakon Nakhon Basin</td>
<td></td>
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<tr>
<td>US 24 8</td>
<td>683</td>
<td>1 Ban Na Di</td>
<td></td>
</tr>
<tr>
<td>US 25 8</td>
<td>681</td>
<td>* BND ? plagioclase zone</td>
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</table>

#### level 7:

<table>
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<th>section</th>
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<th>suggested source</th>
</tr>
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<tr>
<td>US 18 7</td>
<td>709</td>
<td>1 Ban Na Di</td>
<td></td>
</tr>
<tr>
<td></td>
<td>710</td>
<td>10 clay 3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>711</td>
<td>1 Ban Na Di</td>
<td></td>
</tr>
<tr>
<td>US 19 7</td>
<td>691</td>
<td>11 clay 6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>692</td>
<td>13 clay 3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>693</td>
<td>13 clay 3</td>
<td></td>
</tr>
<tr>
<td>US 20 7</td>
<td>721</td>
<td>* BND ? plagioclase zone</td>
<td></td>
</tr>
<tr>
<td></td>
<td>735</td>
<td>1 Ban Na Di</td>
<td></td>
</tr>
<tr>
<td>US 21 7</td>
<td>699</td>
<td>* BND ? plagioclase zone</td>
<td></td>
</tr>
<tr>
<td></td>
<td>708</td>
<td>* BND ? plagioclase zone</td>
<td></td>
</tr>
<tr>
<td>US 23 7</td>
<td>694</td>
<td>13 clay 3</td>
<td></td>
</tr>
<tr>
<td>US 26 7</td>
<td>715</td>
<td>6 clay 11 ?</td>
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<tr>
<td></td>
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<td>6 clay 11 ?</td>
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<td>6 clay 11 ?</td>
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<tr>
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<td>904</td>
<td>6 clay 11 ?</td>
<td></td>
</tr>
<tr>
<td>US 27 7</td>
<td>713</td>
<td>9 clay 2 ?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>903</td>
<td>9 clay 2 ?</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:** * orthodox grog.

The fabric * BND ? plagioclase zone, may represent an early adaptation of local clays, or derive from a nearby non-local source. Its core is heavily reduced and open with numerous phytoliths suggesting plant material, and some rice husk is present.
### TABLE 7 continued: Ban Na Di occupation level rimform fabrics.

<table>
<thead>
<tr>
<th>rimform</th>
<th>level</th>
<th>section</th>
<th>fabric</th>
<th>suggested source</th>
</tr>
</thead>
<tbody>
<tr>
<td>US 28</td>
<td>7</td>
<td>712</td>
<td>*</td>
<td>see O 27 uncertain provenance</td>
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**Notes:** * orthodox grog.

The fabric * BND? plagioclase zone, may represent an early adaptation of local clays, or derive from a nearby non-local source. Its core is heavily reduced and open with numerous phytoliths suggesting plant material, and some rice husk is present.

For further details regarding ‘O’ series fabrics see chapter ten and Tables C.1 and C.2 (appendix three).
TABLE 7 continued: Ban Na Di occupation level rimform fabrics.

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Note: * orthodox grog.
For further details regarding 'O' series fabrics see chapter ten and Tables C.1 and C.2 (appendix three).
TABLE 7 continued: Ban Na Di occupation level rimform fabrics.

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Note: * orthodox grog.

For further details regarding ‘O’ series fabrics see chapter ten and Tables C.1 and C.2 (appendix three).
TABLE.7 continued: Ban Na Di occupation level rimform fabrics.

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Note: * orthodox grog.

** gog is different to parent body.

For further details regarding ‘O’ series fabrics see chapter ten and Tables C.1 and C.2 (appendix three).
A.5. BAN NA DI RIMFORM FABRICS

TABLE 7 continued: Ban Na Di occupation level rimform fabrics.

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Note: * orthodox grog.

** grog is a different clay to the parent body.

*** grog is probably either clay 13 or 14.

The fabric * BND? plagioclase zone, may represent an early adaptation of local clays, or derive from a nearby non-local source. Its core is heavily reduced and open with numerous phytoliths suggesting plant material, and some rice husk is present.

For further details regarding ‘O’ series fabrics see chapter ten and Tables C.1 and C.2 (appendix three).
TABLE.7 continued: Ban Na Di occupation level rimform fabrics.

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Note: * orthodox grog.
TABLE.7 continued: Ban Na Di occupation level rimform fabrics.

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Note: * orthodox grog.
*** grog is either clay 13 or 14.
+ Phimai (C5), and Ban Chiang Hian (BCH 1151) LVI fabrics are similar in thin-section to this fabric.
++ a Ban Chiang Hian LVI fabric (BCH 1129) is similar in thin-section to this fabric.
numbers within brackets are thin-section references.
TABLE 7 continued: Ban Na Di occupation level rimform fabrics.

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Note: * orthodox grog.

** matrix is similar to a late Nong Nok Chik sherd.

*** grog is probably clay 13 or 14.

+++ as for Non Chai layer 3 blebs, and BCH (1011) LIX fabric.

numbers within brackets are thin-section references.
### TABLE.7 continued: Ban Na Di occupation level rimform fabrics.

<table>
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#### level 3:

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*Note:* * orthodox grog.

Numbers in brackets are thin-section references.
TABLE 7 continued: Ban Na Di occupation level rimform fabrics.

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<td>Phimai?</td>
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Note: * orthodox grog. Numbers in brackets are thin-section references.
TABLE A.8: The distribution of BND occupation level rimform fabrics.*

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<th>MP1 wares</th>
<th>MP2 wares</th>
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<td>-</td>
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<td>32</td>
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<td>21</td>
<td>9</td>
<td>32</td>
<td>56</td>
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<td>16</td>
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Notes: + fabrics 1 to 4 inclusive.
++ fabric 12.

TABLE A.9: The distribution of exotic Ban Na Di rimform fabrics.*

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<th>% Mun</th>
<th>% Petchabun</th>
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TABLE A.10: The distribution of Ban Na Di rimform grog tempers.*

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<td>28</td>
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<td>16</td>
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<td>21</td>
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* see notes below A.11.
### TABLE A.11: The distribution of Ban Na Di rimform rice tempers.

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Notes to Tables A.8 to A.11:
- Level 8: One form has local and Sakon Nakhon Basin (SN) fabrics.
- Level 7: Five forms are of uncertain provenance. Two forms have local and SN fabrics. One form has two SN fabrics and another has three.
- Level 6: Four forms have local and SN fabrics. One has local and Chi valley, and one form has two SN sources.
- Level 5: Fourteen SN orthodox grog, and twenty bleb fabrics are hand specimen assessments. Seven orthodox grog, two rice, and two bleb hand specimens are of uncertain origin.
- Level 4: Two rice tempered hand specimen forms are of uncertain provenance. Five forms have local and SN fabrics. One form has Petchbun and SN fabrics. Three forms have local and Chi Valley fabrics. Four forms have SN and Khorat Basin fabrics. Fourteen bleb and four orthodox grog tempered forms are of uncertain provenance.
- Level 3: Two forms have local and Chi Valley fabrics, and one form has SN and Chi valley fabrics. Four rice, six bleb and one orthodox grog tempered forms are of uncertain provenance.
A.7. BAN NA DI BOW PELLET, ANVIL AND CRUCIBLE FABRICS

A.7 Ban Na Di bow pellet, anvil and crucible fabrics

<table>
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Notes: * orthodox grog, non-local fabric.
++ fabric may be an untempered blend of clays 10 and 13.
### TABLE A.13: The Ban Na Di ceramic anvil fabrics.

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<td>6</td>
<td>* ++</td>
<td>605</td>
<td>A2 23</td>
</tr>
<tr>
<td>6</td>
<td>* SN (?)</td>
<td>556</td>
<td>A3 17</td>
</tr>
<tr>
<td>5</td>
<td>16</td>
<td>156</td>
<td>A3 13</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>268</td>
<td>A4 17</td>
</tr>
<tr>
<td>5</td>
<td>16</td>
<td>180</td>
<td>A4 14</td>
</tr>
<tr>
<td>4</td>
<td>12</td>
<td>464</td>
<td>A2 17</td>
</tr>
<tr>
<td>4</td>
<td>12</td>
<td>421</td>
<td>A2 16</td>
</tr>
<tr>
<td>4</td>
<td>blebs +++</td>
<td>387</td>
<td>A4 12</td>
</tr>
<tr>
<td>4</td>
<td>12</td>
<td>137</td>
<td>A2 13</td>
</tr>
<tr>
<td>2</td>
<td>rice+</td>
<td>50</td>
<td>A1 4</td>
</tr>
</tbody>
</table>

**Notes:**
- * orthodox grog.
- + probably clay 6.
- ++ probably clay 3 region
- +++ probably Chi Valley.
- SN (?) probably from the western Sakon Nakhon Basin margins.
TABLE A.14: The Ban Na Di crucible fabrics.

<table>
<thead>
<tr>
<th>level</th>
<th>fabric</th>
<th>catalogue</th>
<th>provenance</th>
<th>metal/slag present</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>* clay 6? +</td>
<td>1186</td>
<td>A4 39</td>
<td>yes ++</td>
</tr>
<tr>
<td>8</td>
<td>* (note a)</td>
<td>1230</td>
<td>A4 40</td>
<td>no</td>
</tr>
<tr>
<td>8</td>
<td>* (note b)</td>
<td>1173</td>
<td>A4 37</td>
<td>yes ++</td>
</tr>
<tr>
<td>8</td>
<td>rice clay 6?</td>
<td>1313</td>
<td>A2/A3 38</td>
<td>yes +++</td>
</tr>
<tr>
<td>8</td>
<td>* clay 6?</td>
<td>1314</td>
<td>A2/A3 39</td>
<td>no</td>
</tr>
<tr>
<td>8</td>
<td>* clay 6?</td>
<td>1064</td>
<td>A3 42</td>
<td>yes</td>
</tr>
<tr>
<td>8</td>
<td>* clay 6?</td>
<td>905</td>
<td>A2 46</td>
<td>no</td>
</tr>
<tr>
<td>8</td>
<td>* clay 6?</td>
<td>1434</td>
<td>A3/A4 40</td>
<td>yes</td>
</tr>
<tr>
<td>8</td>
<td>* clay 6?</td>
<td>1056</td>
<td>A3 41</td>
<td>no</td>
</tr>
<tr>
<td>8</td>
<td>1 (note b)</td>
<td>1226</td>
<td>A4 39</td>
<td>yes</td>
</tr>
<tr>
<td>7</td>
<td>* (note a)</td>
<td>901</td>
<td>A4 30</td>
<td>no</td>
</tr>
<tr>
<td>7</td>
<td>* clay 6?</td>
<td>989</td>
<td>A3 38</td>
<td>no</td>
</tr>
<tr>
<td>7</td>
<td>* clay 6?</td>
<td>-</td>
<td>A3/A4 24</td>
<td>yes</td>
</tr>
<tr>
<td>7</td>
<td>sand (note c)</td>
<td>1371</td>
<td>A3/A4 30</td>
<td>no</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
<td>11 8</td>
<td>F6 11</td>
<td>no</td>
</tr>
<tr>
<td>7</td>
<td>* clay 6?</td>
<td>1097</td>
<td>F6 11</td>
<td>yes **</td>
</tr>
<tr>
<td>7</td>
<td>rice clay 6?</td>
<td>1294</td>
<td>A2/A3 34</td>
<td>yes +++</td>
</tr>
<tr>
<td>7</td>
<td>1 (note b)</td>
<td>1360</td>
<td>A2/A3 36</td>
<td>yes</td>
</tr>
<tr>
<td>7</td>
<td>2 (note b)</td>
<td>756</td>
<td>A1 32</td>
<td>yes</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>1779</td>
<td>A3/A4 22</td>
<td>no</td>
</tr>
<tr>
<td>6</td>
<td>rice (note d)</td>
<td>-</td>
<td>A2 24</td>
<td>no</td>
</tr>
<tr>
<td>5</td>
<td>BND clay ***</td>
<td>403</td>
<td>A1 19</td>
<td>yes</td>
</tr>
<tr>
<td>5</td>
<td>BND clay ***</td>
<td>532</td>
<td>A1 18</td>
<td>no</td>
</tr>
<tr>
<td>5</td>
<td>13</td>
<td>1730</td>
<td>A3 16</td>
<td>no</td>
</tr>
</tbody>
</table>

Notes: * orthodox grog + this fabric is composed of either clay 6 or a material of similar composition. ++ a fine to medium-sized sand of quartzose composition is sandwiched between the bronze detritus and crucible body. +++ the quartzose sand is intermingled with detritus, mullite and other unidentified mineral phases. This suggests that the hot metal has partly replaced the ceramic fabric. ** carbonised rice husk is also encapsulated within the detritus *** untempered.

(a) the fabric "** BND? plagioclase zone" is as for the material identified in level 8 rimforms.
(b) the presence of mullite indicates that this fabric was heat affected. Although it lacks many early local ware characteristics spicules are abundant and surviving nonplastics suggest fabric group 1 or 2.
(c) this fabric is heavily tempered with an angular, fine to medium sized, and well sorted, sand comprising mainly mono- and polycrystalline quartz. Chert is also prominent, mostly as mosaic, but also as composite and mammillated grains. Potassium feldspar and plagioclase feldspar are also well represented. Zircon and ferruginous opaques occur as accessory minerals. This assemblage strongly suggests a source within the plagioclase zone close to the Phu Phan Range (see chapter five).
(d) an unknown fabric, possibly derived from local clay.
Appendix Two

"A great variety of inclusions have been found in prehistoric pottery ..., the material used depending both upon the custom of the potter and what was afforded by her environment."

Shepard (1936:405).

B.1 Introduction

Particular emphasis is given to technological evidence. Excavated and surface collected pottery from several related sites both within and beyond the Khorat Plateau has been examined (figs. 1.1, 8.1 and 8.2). Most are located within the plateau sensu stricto. Table B.1 summarizes their archaeological status and methods of data treatments.

Site numbers follow Kijngam et al. (1980) for Kumphawapi and Mahasarakham regions, and Bayard (1980) for the Pa Mong region. Capital letters refer to sites not previously codified.

B.2 Catalogue of Sites

The following tables list prehistoric and modern sites both within the Khorat Plateau and the Central Highlands. In addition the Khok Phanom Di ceramic assemblage has also been considered. For a preliminary statement on the fabrics from the latter site refer to the ceramic section contributed by the writer in Higham et al. (1987).
TABLE B.1: Catalogue of sites examined.

(i) Sakon Nakhon Basin.

<table>
<thead>
<tr>
<th>Site No.</th>
<th>Site.</th>
<th>Status</th>
<th>Analytical method.</th>
</tr>
</thead>
<tbody>
<tr>
<td>64</td>
<td>Non Rong Rian</td>
<td>surface</td>
<td>thin-section</td>
</tr>
<tr>
<td>65</td>
<td>Ban Phan Don</td>
<td>surface</td>
<td>hand specimen</td>
</tr>
<tr>
<td>67</td>
<td>Ban Non Nam Tiang</td>
<td>surface</td>
<td>thin-section</td>
</tr>
<tr>
<td>68</td>
<td>Ban Muang Phruk</td>
<td>excavated</td>
<td>thin-section</td>
</tr>
<tr>
<td>76</td>
<td>Non Khi Jing</td>
<td>surface</td>
<td>hand specimen</td>
</tr>
<tr>
<td>77</td>
<td>Ban Khon Sai</td>
<td>surface</td>
<td>hand specimen</td>
</tr>
<tr>
<td>78</td>
<td>Ban Phai Chan</td>
<td>surface</td>
<td>thin-section</td>
</tr>
<tr>
<td>79</td>
<td>Ban Don Kaen</td>
<td>surface</td>
<td>hand specimen</td>
</tr>
<tr>
<td>84</td>
<td>Ban Lao Mak Ba</td>
<td>surface</td>
<td>hand specimen</td>
</tr>
<tr>
<td>86</td>
<td>Ban Nong Khok Kok</td>
<td>surface</td>
<td>thin-section</td>
</tr>
<tr>
<td>88</td>
<td>Ban Lao Suan Khuay</td>
<td>surface</td>
<td>thin-section</td>
</tr>
<tr>
<td>89</td>
<td>Ban Yang</td>
<td>surface</td>
<td>thin-section</td>
</tr>
<tr>
<td>90</td>
<td>Ban Chit</td>
<td>surface</td>
<td>thin-section</td>
</tr>
<tr>
<td>91</td>
<td>Ban Hua Nong Khlong Charoen</td>
<td>surface</td>
<td>hand specimen</td>
</tr>
<tr>
<td>92</td>
<td>Ban Don Kok</td>
<td>surface</td>
<td>thin-section</td>
</tr>
<tr>
<td>93</td>
<td>Ban Na Di</td>
<td>excavated</td>
<td>thin-section</td>
</tr>
<tr>
<td>94</td>
<td>Ban Tan Dieo</td>
<td>surface</td>
<td>hand specimen</td>
</tr>
<tr>
<td>95</td>
<td>Ban Hua Nong Yang</td>
<td>surface</td>
<td>hand specimen</td>
</tr>
<tr>
<td>97</td>
<td>Non Kao Noi</td>
<td>excavated</td>
<td>thin-section</td>
</tr>
<tr>
<td>102</td>
<td>Ban Tha Muang</td>
<td>surface</td>
<td>hand specimen</td>
</tr>
<tr>
<td>103</td>
<td>Non Noi</td>
<td>surface</td>
<td>hand specimen</td>
</tr>
<tr>
<td>105</td>
<td>Non Si Phu</td>
<td>surface</td>
<td>hand specimen</td>
</tr>
<tr>
<td>118</td>
<td>Ban Kha Wua</td>
<td>surface</td>
<td>hand specimen</td>
</tr>
<tr>
<td>120</td>
<td>Non Na Bo</td>
<td>surface</td>
<td>hand specimen</td>
</tr>
<tr>
<td>121</td>
<td>Ban Muang Pang</td>
<td>surface</td>
<td>thin-section</td>
</tr>
<tr>
<td>130</td>
<td>Ban Ya</td>
<td>surface</td>
<td>thin-section</td>
</tr>
<tr>
<td>131</td>
<td>Ban Kho Tai</td>
<td>surface</td>
<td>thin-section</td>
</tr>
<tr>
<td>132</td>
<td>Non Ban Nad</td>
<td>surface</td>
<td>thin-section</td>
</tr>
<tr>
<td>133</td>
<td>Non Ban Bua</td>
<td>surface</td>
<td>thin-section</td>
</tr>
<tr>
<td>138</td>
<td>Ban Mak Ba</td>
<td>surface</td>
<td>hand specimen</td>
</tr>
<tr>
<td>140</td>
<td>Ban Chiang Wae</td>
<td>surface</td>
<td>hand specimen</td>
</tr>
<tr>
<td>A</td>
<td>Ban Phak Top</td>
<td>surface</td>
<td>thin-section</td>
</tr>
</tbody>
</table>
### TABLE.1 continued: Catalogue of sites examined

(ii) Khorat Basin.

(a) Chi Valley.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>142</td>
<td>Ban Kho Noi</td>
<td>excavated</td>
<td>thin-section</td>
</tr>
<tr>
<td>150</td>
<td>Non Noi</td>
<td>excavated</td>
<td>thin-section</td>
</tr>
<tr>
<td>161</td>
<td>Ban Chiang Hian</td>
<td>excavated</td>
<td>thin-section</td>
</tr>
<tr>
<td>B</td>
<td>Non Chai</td>
<td>excavated</td>
<td>thin-section</td>
</tr>
</tbody>
</table>

(b) Mun Valley (lower).

<table>
<thead>
<tr>
<th>Site</th>
<th>Location</th>
<th>Status.</th>
<th>Analytical method.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>Non Dua</td>
<td>excavated</td>
<td>thin-section</td>
</tr>
<tr>
<td>D</td>
<td>Bo Phan Khan</td>
<td>excavated</td>
<td>thin-section</td>
</tr>
<tr>
<td>E</td>
<td>Don Taphan</td>
<td>excavated</td>
<td>thin-section</td>
</tr>
</tbody>
</table>

(c) Mun Valley (upper).

<table>
<thead>
<tr>
<th>Site</th>
<th>Location</th>
<th>Status.</th>
<th>Analytical method.</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>Phimai</td>
<td>excavated</td>
<td>thin-section</td>
</tr>
</tbody>
</table>

(iii) Central Highlands.

(a) Petchabun.

<table>
<thead>
<tr>
<th>Site</th>
<th>Location</th>
<th>Status.</th>
<th>Analytical method.</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>Kok Charoen</td>
<td>excavated</td>
<td>thin-section</td>
</tr>
</tbody>
</table>

(b) Phu Wiang.

<table>
<thead>
<tr>
<th>Site</th>
<th>Location</th>
<th>Status.</th>
<th>Analytical method.</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>Nong Non Chik</td>
<td>excavated</td>
<td>thin-section</td>
</tr>
<tr>
<td>I</td>
<td>Nong Nok Tha</td>
<td>excavated</td>
<td>thin-section</td>
</tr>
</tbody>
</table>
B.3 SAKON NAKHON BASIN SURFACE COLLECTED FABRICS

TABLE 1 continued: Catalogue of sites examined.

(c) Pa Mong.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>J</td>
<td>Phrik Mound</td>
<td>excavated</td>
<td>thin-section</td>
</tr>
<tr>
<td>K</td>
<td>Pha Phim Cave</td>
<td>excavated</td>
<td>thin-section</td>
</tr>
<tr>
<td>L45</td>
<td>Non U Mung</td>
<td>surface</td>
<td>thin-section</td>
</tr>
<tr>
<td>L71</td>
<td>Non Na Nong Khong</td>
<td>surface</td>
<td>thin-section</td>
</tr>
<tr>
<td>V1</td>
<td>Ban Tak Det (Laos)</td>
<td>surface</td>
<td>thin-section</td>
</tr>
</tbody>
</table>

In addition the following modern fabrics were examined:

**Sakon Nakhon Basin:**

- Ban Chiang
- Ban Phu

**Pa Mong:**

- Ban Na Kraseng
- Non U Mung

**Mahasarakham:**

- Ban Mơ

**TABLE B.2: Schedule of sites examined.**

<table>
<thead>
<tr>
<th>Region</th>
<th>excavated</th>
<th>surface</th>
<th>modern</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sakon Nakhon Basin</td>
<td>3</td>
<td>29</td>
<td>2</td>
</tr>
<tr>
<td>Khorat Basin</td>
<td>8</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Central Highlands</td>
<td>5</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td><strong>Totals:</strong></td>
<td><strong>16</strong></td>
<td><strong>32</strong></td>
<td><strong>5</strong></td>
</tr>
</tbody>
</table>

B.3 Sakon Nakhon Basin surface collected fabrics
<table>
<thead>
<tr>
<th>Site No.</th>
<th>analytical method</th>
<th>temper</th>
<th>fabrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>64</td>
<td>thin-section</td>
<td>rice</td>
<td>micaceous reduced</td>
</tr>
<tr>
<td></td>
<td>hand specimen</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>65</td>
<td>hand specimen</td>
<td>?</td>
<td>stoneware</td>
</tr>
<tr>
<td>67</td>
<td>thin-section</td>
<td>rice</td>
<td>sandy/micaceous, oxidised</td>
</tr>
<tr>
<td>76</td>
<td>hand specimen</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>77</td>
<td>hand specimen</td>
<td>blebs</td>
<td></td>
</tr>
<tr>
<td>78</td>
<td>thin-section</td>
<td>*</td>
<td>moderately micaceous</td>
</tr>
<tr>
<td>79</td>
<td>hand specimen</td>
<td>blebs</td>
<td></td>
</tr>
<tr>
<td>84</td>
<td>hand specimen</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>86</td>
<td>thin-section</td>
<td>blebs?</td>
<td>sandy, moderately micaceous</td>
</tr>
<tr>
<td>88</td>
<td>thin-section</td>
<td>*</td>
<td>abundant spicules (clay 10)**</td>
</tr>
<tr>
<td>89</td>
<td>thin-section</td>
<td>blebs</td>
<td>sandy</td>
</tr>
<tr>
<td>90</td>
<td>thin-section</td>
<td>rice</td>
<td>reduced</td>
</tr>
<tr>
<td>91</td>
<td>hand specimen</td>
<td>rice</td>
<td></td>
</tr>
<tr>
<td>92</td>
<td>thin-section</td>
<td>*</td>
<td>micaceous</td>
</tr>
<tr>
<td>94</td>
<td>hand specimen</td>
<td>* ?</td>
<td></td>
</tr>
<tr>
<td>95</td>
<td>hand specimen</td>
<td>blebs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>hand specimen</td>
<td>rice</td>
<td></td>
</tr>
</tbody>
</table>
### TABLE.3 continued: Sakon Nakhon Basin surface collected fabrics.

<table>
<thead>
<tr>
<th>Site No.</th>
<th>analytical method</th>
<th>temper</th>
<th>fabrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>102</td>
<td>hand specimen</td>
<td>* ?</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>hand specimen</td>
<td>stoneware</td>
<td>-</td>
</tr>
<tr>
<td>103</td>
<td>hand specimen</td>
<td>blebs</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>hand specimen</td>
<td>rice</td>
<td>-</td>
</tr>
<tr>
<td>105</td>
<td>hand specimen</td>
<td>*</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>hand specimen</td>
<td>blebs</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>hand specimen</td>
<td>rice</td>
<td>-</td>
</tr>
<tr>
<td>118</td>
<td>hand specimen</td>
<td>sand ?</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>hand specimen</td>
<td>blebs</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>hand specimen</td>
<td>rice</td>
<td>-</td>
</tr>
<tr>
<td>120</td>
<td>hand specimen</td>
<td>*</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>hand specimen</td>
<td>blebs</td>
<td>**</td>
</tr>
<tr>
<td></td>
<td>hand specimen</td>
<td>stoneware</td>
<td>-</td>
</tr>
<tr>
<td>121</td>
<td>thin-section</td>
<td>blebs</td>
<td>**</td>
</tr>
<tr>
<td></td>
<td>hand specimen</td>
<td>rice</td>
<td>-</td>
</tr>
<tr>
<td>130</td>
<td>thin-section</td>
<td>*</td>
<td>sandy, m. micaceous, reduced</td>
</tr>
<tr>
<td></td>
<td>thin-section</td>
<td>blebs</td>
<td>sandy, m. micaceous, oxidised **</td>
</tr>
<tr>
<td></td>
<td>thin-section</td>
<td>rice</td>
<td>sandy, m. micaceous, reduced</td>
</tr>
<tr>
<td></td>
<td>thin-section</td>
<td>blebs</td>
<td>micaceous reduced **</td>
</tr>
<tr>
<td>131</td>
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<td>blebs</td>
<td>sandy, moderately micaceous</td>
</tr>
<tr>
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<td>*</td>
<td>moderately micaceous **</td>
</tr>
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<td></td>
<td>thin-section</td>
<td>rice</td>
<td>reduced</td>
</tr>
<tr>
<td>132</td>
<td>thin-section</td>
<td>*</td>
<td>micaceous few nonplastics</td>
</tr>
<tr>
<td></td>
<td>thin-section</td>
<td>blebs +</td>
<td>micaceous few nonplastics</td>
</tr>
<tr>
<td></td>
<td>thin-section</td>
<td>*</td>
<td>sandy/micaceous</td>
</tr>
<tr>
<td></td>
<td>thin-section</td>
<td>rice</td>
<td>silty</td>
</tr>
<tr>
<td></td>
<td>thin-section</td>
<td>*</td>
<td>micaceous</td>
</tr>
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<td></td>
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<td>micaceous</td>
</tr>
<tr>
<td>133</td>
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<td>blebs +</td>
<td>moderately micaceous, reduced **</td>
</tr>
<tr>
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<td>blebs</td>
<td>spicules/micaceous **</td>
</tr>
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<td></td>
<td>thin-section</td>
<td>rice</td>
<td>micaceous ** + +</td>
</tr>
<tr>
<td>138</td>
<td>hand specimen</td>
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</tr>
<tr>
<td></td>
<td>hand specimen</td>
<td>blebs</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>hand specimen</td>
<td>rice</td>
<td>-</td>
</tr>
<tr>
<td>140</td>
<td>hand specimen</td>
<td>rice</td>
<td>-</td>
</tr>
<tr>
<td>A</td>
<td>thin-section</td>
<td>blebs</td>
<td>sandy, moderately micaceous</td>
</tr>
</tbody>
</table>

**Totals:** 29 sites, 78 sherds (26 thin-sectioned).

**Notes:** * orthodox grog. ** exterior surface red painted/slipped.

+ few blebs with abundant rice.

++ surface decoration consists of a red painted or slipped design comprised of spirals or concentric rings and circles. This kind of ware has often been categorised as ‘Ban Chiang Painted’.
### B.4 Ban Muang Phruk Rimforms

**TABLE B.4: The Ban Muang Phruk rimform fabrics.**

<table>
<thead>
<tr>
<th>rimform</th>
<th>level</th>
<th>spit</th>
<th>temper</th>
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<tbody>
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<td>16</td>
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</tr>
<tr>
<td>US 56</td>
<td>5</td>
<td>16</td>
<td>blebs **</td>
</tr>
<tr>
<td>US 65</td>
<td>5</td>
<td>18</td>
<td>*</td>
</tr>
<tr>
<td>US 74</td>
<td>5</td>
<td>18</td>
<td>blebs</td>
</tr>
<tr>
<td>US 78</td>
<td>5</td>
<td>16</td>
<td>blebs **</td>
</tr>
<tr>
<td>US 84</td>
<td>5</td>
<td>18</td>
<td>blebs **</td>
</tr>
<tr>
<td>US 87</td>
<td>5</td>
<td>18</td>
<td>blebs **</td>
</tr>
<tr>
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<td>5</td>
<td>17</td>
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</tr>
<tr>
<td>US 108</td>
<td>5</td>
<td>18</td>
<td>blebs</td>
</tr>
<tr>
<td>US 110</td>
<td>5</td>
<td>16</td>
<td>blebs **</td>
</tr>
<tr>
<td>US 164</td>
<td>5</td>
<td>17</td>
<td>blebs **</td>
</tr>
<tr>
<td>US 190</td>
<td>5</td>
<td>21</td>
<td>blebs</td>
</tr>
<tr>
<td>US 191</td>
<td>5</td>
<td>21</td>
<td>blebs ?</td>
</tr>
<tr>
<td>US 192</td>
<td>5</td>
<td>21</td>
<td>blebs ?</td>
</tr>
<tr>
<td>US 193</td>
<td>5</td>
<td>16</td>
<td>blebs</td>
</tr>
<tr>
<td>US 194</td>
<td>5</td>
<td>21</td>
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</tr>
<tr>
<td>US 195</td>
<td>5</td>
<td>17</td>
<td>blebs ?</td>
</tr>
<tr>
<td>US 196</td>
<td>5</td>
<td>21</td>
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</tr>
<tr>
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<td>5</td>
<td>20</td>
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</tr>
<tr>
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<td>17</td>
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</tr>
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<td>blebs **</td>
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<td>20</td>
<td>blebs</td>
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</tr>
<tr>
<td>US 174</td>
<td>4</td>
<td>15</td>
<td>blebs</td>
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<td>15</td>
<td>blebs</td>
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<td>4</td>
<td>10</td>
<td>blebs</td>
</tr>
<tr>
<td>US 203</td>
<td>4</td>
<td>15</td>
<td>blebs **</td>
</tr>
<tr>
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<td>15</td>
<td>blebs **</td>
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## TABLE 4 continued: The Ban Muang Phruk rimform fabrics.

<table>
<thead>
<tr>
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</thead>
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</tr>
<tr>
<td>US 205</td>
<td>4</td>
<td>15</td>
<td>blebs</td>
</tr>
<tr>
<td>US 207</td>
<td>4</td>
<td>14</td>
<td>rice</td>
</tr>
<tr>
<td>US 208</td>
<td>4</td>
<td>14</td>
<td>sand ? +</td>
</tr>
<tr>
<td>US 209</td>
<td>4</td>
<td>14</td>
<td>rice</td>
</tr>
<tr>
<td>US 210</td>
<td>4</td>
<td>14</td>
<td>rice</td>
</tr>
<tr>
<td>US 212</td>
<td>4</td>
<td>14</td>
<td>blebs</td>
</tr>
<tr>
<td>US 213</td>
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<td>blebs</td>
</tr>
<tr>
<td>US 216</td>
<td>4</td>
<td>13</td>
<td>blebs</td>
</tr>
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<td>13</td>
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<tr>
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<td>Non Chai</td>
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<td></td>
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</tr>
<tr>
<td>type 2AA</td>
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<tr>
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<td>3</td>
<td>8</td>
<td>rice ***</td>
</tr>
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<td>US 119</td>
<td>3</td>
<td>8</td>
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</tr>
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<td>US 178</td>
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<td>8</td>
<td>rice</td>
</tr>
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<td>US 211</td>
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<td>8</td>
<td>blebs</td>
</tr>
<tr>
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</tr>
<tr>
<td>US 217</td>
<td>3</td>
<td>8</td>
<td>rice ++</td>
</tr>
<tr>
<td>US 219</td>
<td>3</td>
<td>9</td>
<td>blebs</td>
</tr>
<tr>
<td>US 220</td>
<td>3</td>
<td>9</td>
<td>blebs</td>
</tr>
<tr>
<td>US 221</td>
<td>3</td>
<td>9</td>
<td>rice ***</td>
</tr>
<tr>
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<td>3</td>
<td>8</td>
<td>rice ***</td>
</tr>
<tr>
<td>US 223</td>
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</tr>
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<td>7</td>
<td>blebs</td>
</tr>
<tr>
<td>US 226</td>
<td>3</td>
<td>5</td>
<td>rice (Phimai ?)</td>
</tr>
<tr>
<td>US 227</td>
<td>3</td>
<td>7</td>
<td>blebs</td>
</tr>
<tr>
<td>US 228</td>
<td>3</td>
<td>7</td>
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</tr>
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<td>3</td>
<td>7</td>
<td>rice</td>
</tr>
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<td>7</td>
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<td>3</td>
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<td>5</td>
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</tr>
<tr>
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<td>2</td>
<td>6</td>
<td>rice</td>
</tr>
<tr>
<td>US 233</td>
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<td>6</td>
<td>rice ++</td>
</tr>
<tr>
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<td>2</td>
<td>6</td>
<td>rice ++</td>
</tr>
<tr>
<td>US 235</td>
<td>2</td>
<td>6</td>
<td>rice ++</td>
</tr>
<tr>
<td>US 236</td>
<td>2</td>
<td>6</td>
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</tr>
<tr>
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<td>2</td>
<td>6</td>
<td>rice +</td>
</tr>
<tr>
<td>US 238</td>
<td>2</td>
<td>6</td>
<td>rice ++</td>
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TABLE 4 continued: The Ban Muang Phruk rimform fabrics.

<table>
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<tr>
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<th>level</th>
<th>spit</th>
<th>temper</th>
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</thead>
<tbody>
<tr>
<td>US 239</td>
<td>2</td>
<td>6</td>
<td>rice (Phimai ?)</td>
</tr>
<tr>
<td>US 240</td>
<td>2</td>
<td>5</td>
<td>rice (Phimai ?)</td>
</tr>
<tr>
<td>US 241</td>
<td>2</td>
<td>5</td>
<td>blebs</td>
</tr>
<tr>
<td>US 242</td>
<td>2</td>
<td>5</td>
<td>rice ++</td>
</tr>
<tr>
<td>US 243</td>
<td>2</td>
<td>5</td>
<td>rice</td>
</tr>
<tr>
<td>US 244</td>
<td>2</td>
<td>5</td>
<td>blebs</td>
</tr>
<tr>
<td>US 245</td>
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<td>5</td>
<td>rice</td>
</tr>
<tr>
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<td>2</td>
<td>5</td>
<td>rice ++</td>
</tr>
<tr>
<td>US 247</td>
<td>2</td>
<td>4</td>
<td>rice (Phimai ?)</td>
</tr>
<tr>
<td>US 248</td>
<td>2</td>
<td>4</td>
<td>rice (Phimai ?)</td>
</tr>
<tr>
<td>US 249</td>
<td>2</td>
<td>4</td>
<td>rice</td>
</tr>
<tr>
<td>US 250</td>
<td>2</td>
<td>4</td>
<td>rice</td>
</tr>
<tr>
<td>US 251</td>
<td>2</td>
<td>4</td>
<td>* and plant material</td>
</tr>
<tr>
<td>US 252</td>
<td>2</td>
<td>4</td>
<td>rice ***</td>
</tr>
<tr>
<td>US 253</td>
<td>2</td>
<td>4</td>
<td>rice ++ ***</td>
</tr>
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<td>US 254</td>
<td>2</td>
<td>3</td>
<td>rice ***</td>
</tr>
<tr>
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<td>3</td>
<td>rice</td>
</tr>
<tr>
<td>US 256</td>
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<td>3</td>
<td>blebs</td>
</tr>
<tr>
<td>US 257</td>
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<td>rice ++ ***</td>
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<td>2</td>
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<td>rice ++ ***</td>
</tr>
<tr>
<td>US 259</td>
<td>2</td>
<td>2</td>
<td>rice ++ ***</td>
</tr>
<tr>
<td>US 260</td>
<td>2</td>
<td>2</td>
<td>rice ++ ***</td>
</tr>
<tr>
<td>US 261</td>
<td>2</td>
<td>2</td>
<td>rice ++ ***</td>
</tr>
</tbody>
</table>

Notes: * orthodox grog.
** sandy blebs Chi Valley?
+ Ban Chiang Hian LVI.
++ sandy with rice temper.
*** rice, the fabric is reduced throughout.

B.5 Ban Kho Noi and Non Noi fabric distributions
TABLE B.5: The chronological distribution of Ban Kho Noi fabrics.

<table>
<thead>
<tr>
<th>level</th>
<th>mod.</th>
<th>micaceous</th>
<th>sandy</th>
<th>‘Roi Et’</th>
<th>blebs *</th>
<th>rice</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>3</td>
<td></td>
<td>4+</td>
<td>5</td>
<td>2</td>
<td>-</td>
<td>16</td>
</tr>
<tr>
<td>2</td>
<td>-</td>
<td></td>
<td>1+</td>
<td>1</td>
<td>-</td>
<td>1++</td>
<td>6</td>
</tr>
</tbody>
</table>

Notes: + as for Ban Chiang Hian sandy grog: rimforms MC 5, MC 6, MC 8, BCH 10 and Non Chai II BB.
* rimforms BCH 2b and Non Chai class 2 type cc.
“Roi Et” fabrics include rimforms Non Chai class I type A BCH 42, MC 4 and Non Chai class 2 type AA.
++ rimform MC 9.

TABLE B.6: The chronological distribution of Non Noi fabrics.

<table>
<thead>
<tr>
<th>level</th>
<th>mod.</th>
<th>micaceous</th>
<th>sandy</th>
<th>sand</th>
<th>‘Roi Et’</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>3</td>
<td>-</td>
<td>5</td>
<td>1</td>
<td>-</td>
<td></td>
<td>6</td>
</tr>
</tbody>
</table>
FIGURE B.1: BAN MUANG PHRUK RIMFORMS. Level 5. Scale 1:2.
FIGURE B.2: BAN MUANG PHRUK RIMFORMS. Level 5. Scale 1:2.
FIGURE B.5: BAN MUANG PHRUK RIMFORMS. Level 2. Scale 1:2.
FIGURE B.6: BAN MUANG PHRUK RIMFORMS. Level 2. Scale 1:2.
TABLE B.7: The construction and surface finish of Pots 62 and 63.

<table>
<thead>
<tr>
<th>Pot 62</th>
<th>Pot 63</th>
</tr>
</thead>
<tbody>
<tr>
<td>rim constructed as continuum of vessel wall</td>
<td>rim attached separately to upper wall surface</td>
</tr>
<tr>
<td>“Z” twist cord marks:</td>
<td>“Z” twist cord marks:</td>
</tr>
<tr>
<td>helix angle 35°</td>
<td>helix angle 49°</td>
</tr>
<tr>
<td>diameter 0.75 mm</td>
<td>diameter 1.2 mm</td>
</tr>
<tr>
<td>red painted design</td>
<td>no painted design</td>
</tr>
<tr>
<td>wall thickness 3 mm (av.)</td>
<td>wall thickness 5 mm (av.)</td>
</tr>
</tbody>
</table>

exterior wall colour 2.5YR/5/4 7.5YR/6/4

Notes: Pot 62 cordmarks have a low applied angle of inclination (30°). On pot 63 this is much higher (60°). A series of 17 red dots, about 10 mm in diameter and 15 mm to 35 mm apart, circumscribe the upper body margin and a red line (10R/4/4) marks the extreme rim edge. Not mould made, it is oxidised apart from small fireclouds to the base. It dates to mortuary phase 1c.

Pot 64 contrasts with pot 62 in several respects. It is completely reduced (2.5YR/2.5/0), and cordmarks extend almost to the upper rim edge. The rim is modelled as an extension of the walls in a single construction operation. Cord diameter (<0.75 mm) and angle of inclination (30° to 45°) are similar to pot 62. This vessel is earlier and dates to mortuary phase 1b.

TABLE B.8: The surface decoration of rims at Ban Na Di.

<table>
<thead>
<tr>
<th>level</th>
<th>temper</th>
<th>red slip/paint</th>
<th>% plain</th>
<th>% total</th>
</tr>
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<tbody>
<tr>
<td>8</td>
<td>*</td>
<td>-</td>
<td>8</td>
<td>100.00</td>
</tr>
<tr>
<td>7</td>
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<tr>
<td>6</td>
<td>*</td>
<td>3</td>
<td>16.66</td>
<td>15</td>
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<td>*</td>
<td>2</td>
<td>33.33</td>
<td>4</td>
</tr>
<tr>
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<td>7</td>
<td>blebs</td>
<td>2</td>
<td>100.00</td>
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<td>89.47</td>
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<td>3</td>
<td>blebs</td>
<td>14</td>
<td>73.68</td>
<td>5</td>
</tr>
</tbody>
</table>

Note: * orthodox grog.
Appendix Three

C.1  Incised wares at Ban Na Di

The following table summarizes the surface finish characteristics of incised and painted or slipped sherds at Ban Na Di. Sherds such as these have often been categorised as “Om Kaeo”. A discussion the these sherds is set out in chapter ten.
TABLE C.1: The surface finish of “Om Kaeo” sherds at Ban Na Di.

**fabric group 6:**

<table>
<thead>
<tr>
<th>T.S. No.</th>
<th>plain</th>
<th>cordmarked</th>
<th>incised</th>
<th>incised/painted</th>
<th>colours:body fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>O5</td>
<td>x</td>
<td>+</td>
<td>-</td>
<td>x</td>
<td>5YR/6/4 10R/6/4</td>
</tr>
<tr>
<td>O8</td>
<td>x</td>
<td>-</td>
<td>x</td>
<td>-</td>
<td>5YR/6/3</td>
</tr>
<tr>
<td>O11</td>
<td>x</td>
<td>-</td>
<td>-</td>
<td>x</td>
<td>5YR/6/3 10R/5/4</td>
</tr>
<tr>
<td>O12</td>
<td>x</td>
<td>-</td>
<td>-</td>
<td>x</td>
<td>5YR/7/4 10R/6/4</td>
</tr>
<tr>
<td>O14</td>
<td>x</td>
<td>++</td>
<td>x</td>
<td>(slip 5YR/7/3)</td>
<td>5YR/6/3</td>
</tr>
<tr>
<td>O15</td>
<td>x</td>
<td>++</td>
<td>x</td>
<td>(slip 5YR/7/3)</td>
<td>5YR/6/3</td>
</tr>
<tr>
<td>O16</td>
<td>x</td>
<td>-</td>
<td>-</td>
<td>x</td>
<td>5YR/5/3</td>
</tr>
<tr>
<td>O17</td>
<td>x</td>
<td>-</td>
<td>x</td>
<td>-</td>
<td>5YR/5/3</td>
</tr>
<tr>
<td>O18</td>
<td>x</td>
<td>++</td>
<td>x</td>
<td>(slip 5YR/7/3)</td>
<td>5YR/6/3</td>
</tr>
<tr>
<td>O19</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>-</td>
<td>5YR/6/3</td>
</tr>
<tr>
<td>O26</td>
<td>x</td>
<td>++</td>
<td>x</td>
<td>(slip 5YR/7/3)</td>
<td>5YR/6/3</td>
</tr>
<tr>
<td>O27</td>
<td>x</td>
<td>-</td>
<td>x</td>
<td>-</td>
<td>5YR/6/3</td>
</tr>
</tbody>
</table>

**fabric group 9:**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th>x</th>
<th>5YR/7/2 10R/4/6</th>
</tr>
</thead>
<tbody>
<tr>
<td>O20</td>
<td>x</td>
<td>-</td>
<td>-</td>
<td>x</td>
<td>5YR/5/1 to 7/2      10R/4/8</td>
</tr>
<tr>
<td>O22</td>
<td>x</td>
<td>-</td>
<td>-</td>
<td>x</td>
<td>5YR/7/2 10R/4/8</td>
</tr>
</tbody>
</table>

**Phu Wiang fabric:**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th>x</th>
<th>2.5YR/5/6 10R/4/6</th>
</tr>
</thead>
<tbody>
<tr>
<td>O1</td>
<td>x</td>
<td>-</td>
<td>-</td>
<td>x</td>
<td>2.5YR/5/6</td>
</tr>
<tr>
<td>O3</td>
<td>x</td>
<td>-</td>
<td>x</td>
<td>-</td>
<td>2.5YR/5/6</td>
</tr>
</tbody>
</table>

**Sakon Nakhon Basin fabric:**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th>x</th>
<th>x</th>
<th>2.5YR/6/4 10R/4/8</th>
</tr>
</thead>
<tbody>
<tr>
<td>O24</td>
<td>x</td>
<td>x</td>
<td>-</td>
<td>x</td>
<td>2.5YR/3/0 *        10R/4/6</td>
</tr>
<tr>
<td>O39</td>
<td>x</td>
<td>+</td>
<td>-</td>
<td>x</td>
<td>2.5YR/2.5/0 *      10R/4/8</td>
</tr>
</tbody>
</table>

**Notes:**

++ the cordmarks are remnants from a secondary smoothing process.

* the cordmarks have been fully covered by a smooth slip.

* reduced.

x present.

- absent.
TABLE 1 continued: The surface finish of 'Om Kaeo' sherds at Ban Na Di.

<table>
<thead>
<tr>
<th>T.S. No.</th>
<th>plain</th>
<th>cordmarked</th>
<th>incised</th>
<th>incised/painted</th>
<th>colours:body</th>
<th>fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>O38</td>
<td>x</td>
<td>x</td>
<td>-</td>
<td>x</td>
<td>10YR/8/3 to 7/3</td>
<td>10R/4/6</td>
</tr>
</tbody>
</table>

Rice tempered fabric:

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>O6</td>
<td>x</td>
<td>-</td>
<td>x</td>
<td></td>
<td>2.5YR/6/4</td>
<td>-</td>
</tr>
<tr>
<td>O7</td>
<td>x</td>
<td>-</td>
<td>-</td>
<td>x</td>
<td>2.5YR/6/4</td>
<td>10R/4/6</td>
</tr>
<tr>
<td>O13</td>
<td>x</td>
<td>-</td>
<td>x</td>
<td></td>
<td>2.5YR/5/4</td>
<td>-</td>
</tr>
</tbody>
</table>

Notes: + the cordmarks are remnants from a secondary smoothing process.
++ the cordmarks have been fully covered by a smooth slip.
* reduced.
x present.
- absent.

The above data given is of a very general nature only. It should be read in conjunction with chapter ten, the fabric descriptions set out in appendix one, and the Sakon Nakhon Basin clay descriptions discussed in chapters four and five.
# C.2 Painted Sherds at Ban Na Di

TABLE C.2: A summary of painted ware fabrics at Ban Na Di.

<table>
<thead>
<tr>
<th>T.S. No.</th>
<th>level</th>
<th>temper</th>
<th>fabric</th>
<th>suggested source</th>
</tr>
</thead>
<tbody>
<tr>
<td>O28</td>
<td>6</td>
<td>rice</td>
<td>non-specific</td>
<td>unknown</td>
</tr>
<tr>
<td>O29</td>
<td>6</td>
<td>blebs</td>
<td>clay 11 ? +</td>
<td>plagioclase feldspar zone</td>
</tr>
<tr>
<td>O30</td>
<td>6</td>
<td>blebs</td>
<td>sandy</td>
<td>Chi Valley ?</td>
</tr>
<tr>
<td>O31</td>
<td>6</td>
<td>blebs</td>
<td>mod. micaceous</td>
<td>Sakon Nakhon Basin ? ++</td>
</tr>
<tr>
<td>O32</td>
<td>6</td>
<td>blebs</td>
<td>mod. micaceous</td>
<td>Sakon Nakhon Basin ? ++</td>
</tr>
<tr>
<td>O33</td>
<td>6</td>
<td>rice</td>
<td>sandy ++</td>
<td>Sakon Nakhon Basin ?</td>
</tr>
<tr>
<td>O34</td>
<td>6</td>
<td>blebs</td>
<td>12</td>
<td>Ban Na Di</td>
</tr>
<tr>
<td>O35</td>
<td>6</td>
<td>*</td>
<td>sandy ++</td>
<td>Eastern Sakon Nakhon Basin ?</td>
</tr>
<tr>
<td>O36</td>
<td>6</td>
<td>rice</td>
<td>sandy ++</td>
<td>Sakon Nakhon Basin ?</td>
</tr>
<tr>
<td>O37</td>
<td>6</td>
<td>blebs</td>
<td>clay 11 ? +</td>
<td>plagioclase feldspar zone</td>
</tr>
<tr>
<td>O38</td>
<td>6</td>
<td>blebs</td>
<td>clay 11 ? +</td>
<td>plagioclase feldspar zone</td>
</tr>
</tbody>
</table>

**Notes:**
- + a more detailed analysis is required before a precise association can be given. The fabric matrix is consistent with a source near the Phu Phan Range within the plagioclase feldspar zone.
- ++ no plagioclase feldspar is present.
- * orthodox grog.

When considering the above table, reference should be made to appendix one for detailed descriptions of the ceramic fabrics, and to chapters four and five which discuss the Sakon Nakhon Basin clay petrology.
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