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.

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 dispositon 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.

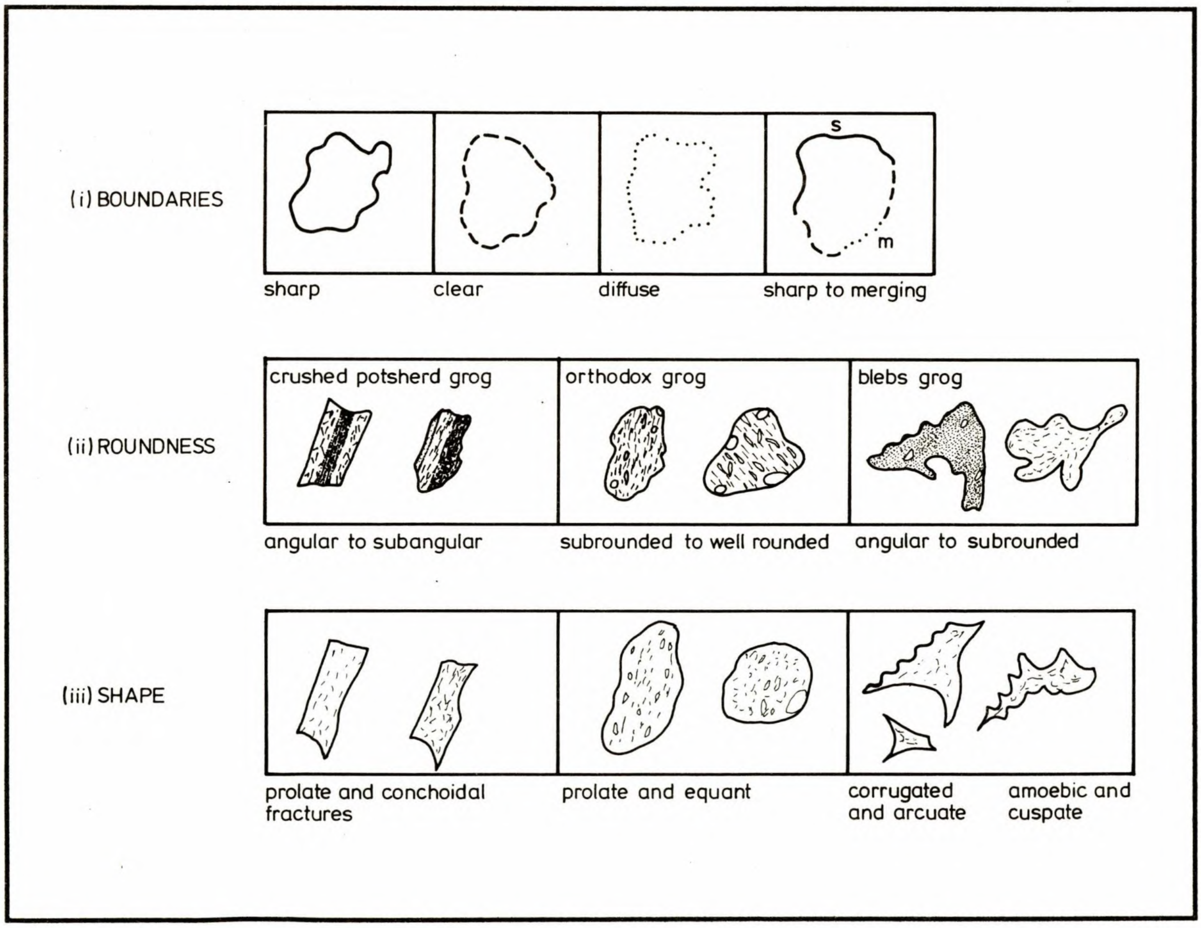

FIGURE 6.1: SELECTED PROPERTIES OF GROGS IN THIN-SECTION.

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 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 favour 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".

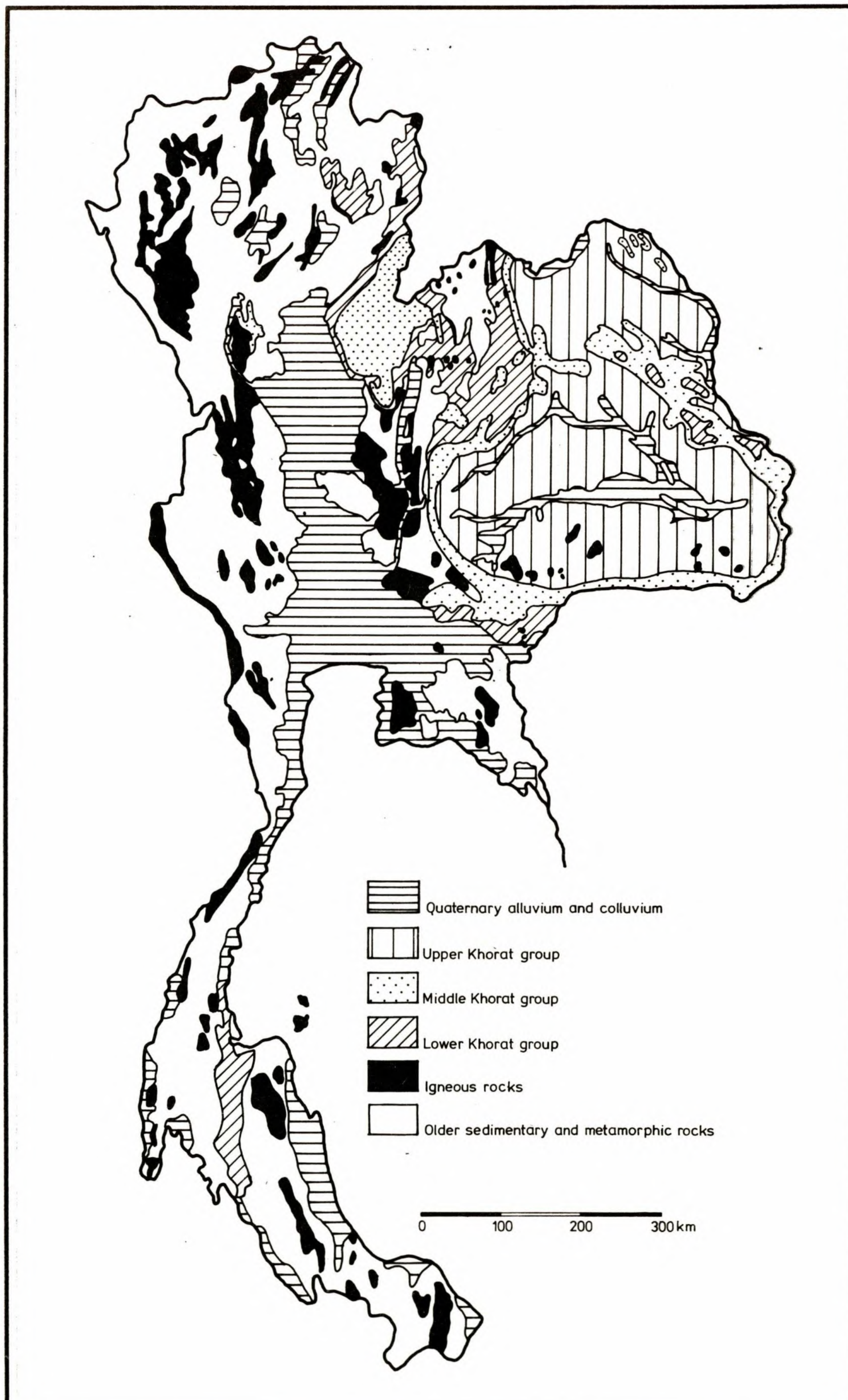

FIGURE 6.2: GEOLOGY OF THAILAND.

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.

Grogs 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 (Cruijs 1978). Subsequent epeirogeneric 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; Cruijs 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, Cruijs 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 Phanom 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, $Ca^5(PO^4)3(OH,F,C^1)$, 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 burned and crushed fresh- water sponges into clay as a temper has been reported in South American ethnographic and archaeological contexts (Krause 1911, Linnē 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 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 l 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.

Figurines 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, unlikely 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 unneccessary 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 furniture this implies that, in life, the deceased was a potter.

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 tempers but merely removed some of the very coarse nonplastic from the cooking pot clay for ornamental wares (May and Tuckson 1982:261, 264, 273). These are quantitative material variations rather than 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 fufilling 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.

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 tempers 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 conservatism 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 involve rice. Bleb temper supercedes orthodox grog in the Sakon Nakhon Basin, a sedimentary region where the latter temper endured for about one millenium (see below). The replacement 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 conservatism 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 information 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, technically 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 applies 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.

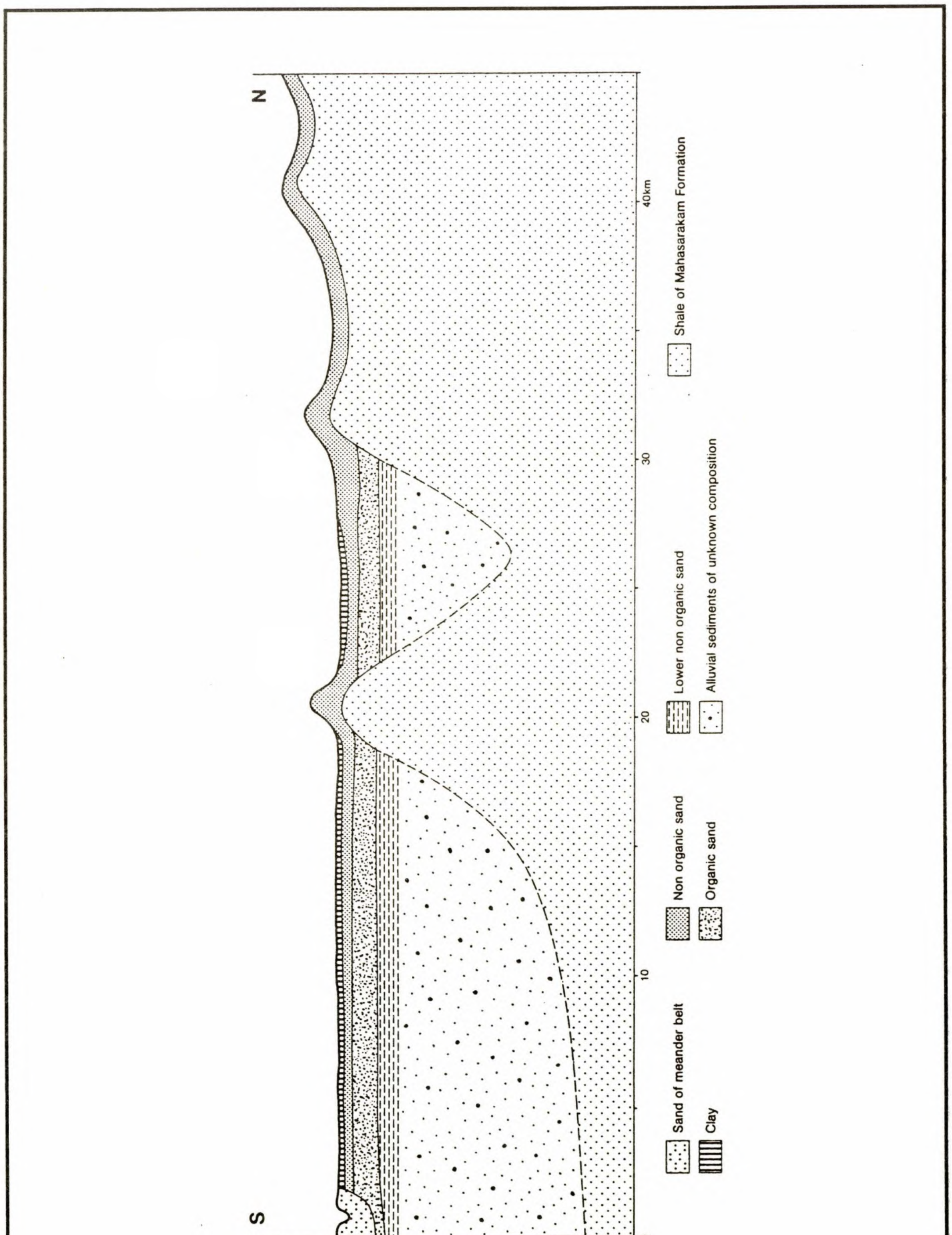

FIGURE 6.3: IDEALIZED CROSS-SECTION ACROSS TKR.(after Loffler *et al.* 1983)

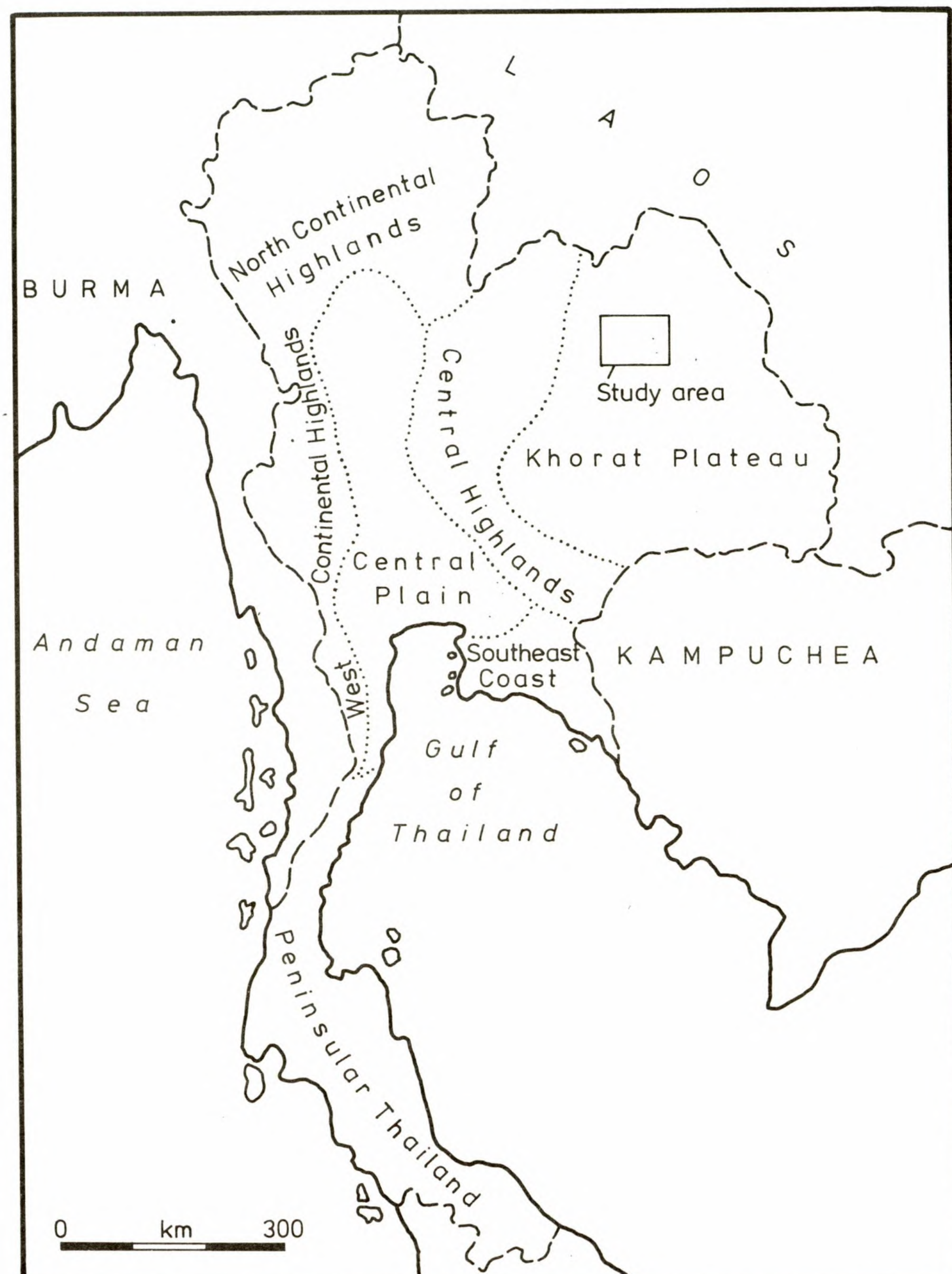

FIGURE 6.4: PHYSIOGRAPHIC REGIONS OF THAILAND (after Moorman *et al.*).

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 over-bank 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.