3

Methodology

Introduction

The 2009 excavation at An Sơn consisted of a large assemblage of ceramic sherds in the occupational layers, some complete or reconstructable vessels in burial contexts and the dense pottery scatter of Trench 1. The morphological and decorative attributes of the ceramics were assessed by examining the entire 2009 assemblage. Since no fabric analysis has previously been conducted on the An Sơn ceramic assemblage, a broad approach has been adopted to uncover the variety of ceramic fabrics, inclusive of both rare and more common rare fabrics. The sampling strategy for the fabric analysis has been designed to characterise the ceramic fabrics over time and to encompass the variety of the assemblage.

The methods described here outline the excavation and sampling strategies used to obtain the ceramic sample from the 2009 An Sơn excavation. The methods for assessing morphology, decoration and fabric of the entire ceramic assemblage are explained, together with the macroscopic and microscopic methods used for close examination of a sample for fabric analysis. This chapter presents the methods for the study of the An Sơn chronological sequence and the different uses of space on site. For the ceramics, it discusses the methods for assessing the function of pottery vessels, standardisation in certain forms, and for the comparisons of forms, decoration and fabrics between An Sơn and other sites, together with the statistical procedures applied to conduct these analyses.

Methods of excavation and ceramic analysis at An Sơn

Excavation strategy at An Sơn, 2009

While the ceramics from the 2009 excavation are the primary focus of this study, a 1997 excavation revealing earlier layers with different ceramics from those present in 2009 are referred to in this monograph. The 1997 Trench 1 was excavated into the top of the mound to a depth of 4 m. The stratigraphy consisted of three main units, with Unit 2 containing a large number of thin and alternating alluvial silt floors and occupation layers (Nishimura and Nguyễn 2002). Some areas of the mound had been levelled by 2009, and the western side had been terraced away from the road to create a steep slope that was 5 m high to the top of the mound. The southern side of the mound had been terraced at an earlier date. The eastern side had been levelled and excavations had previously taken place in this area in 2004 and 2007.

The previous excavations in 2004 and 2007 at the eastern side of the mound revealed extended burials (Văn *et al.* 2008; Phạm 2006). One of the main intentions of the 2009 excavation was to locate more burials, and three long trenches were laid out adjacent to the still open 2004 and 2007 excavation trenches. Trench 1 was 3 x 12 m, Trench 2 was 5 x 5 m and Trench 3 was

2 x 10 m. The trenches were divided into 1 x 1 m squares for recording purposes and were labelled according to an alphanumeric system (Figure 3.1). A 2 x 1 m test square was also excavated into the western side of the mound, where it had been terraced back from the road.

The different trenches presented various usage and depositional contexts that are important for deducing the functions of particular ceramic vessel forms and different areas of the site. Trench 1 intersected the southeastern corner of the mound at square C1, and contained overlapping and sloping deposits that extended away from the mound. These are interpreted as discard layers. Trench 2 also consisted of an independent set of sloping layers that were truncated by recent earthmoving activities. The layers sloped away from a cooking area in the northeast corner of the trench. Trench 3 was largely internally unstratified with clay and small sherd contents thought to be the result of run-off from the main mound during heavy rainfall. A similar run-off effect with clay and small sherds was evident at the southern end of Trench 1. Trench 3 did not provide much archaeological information, except for a cluster of pottery vessels in the basal layer.

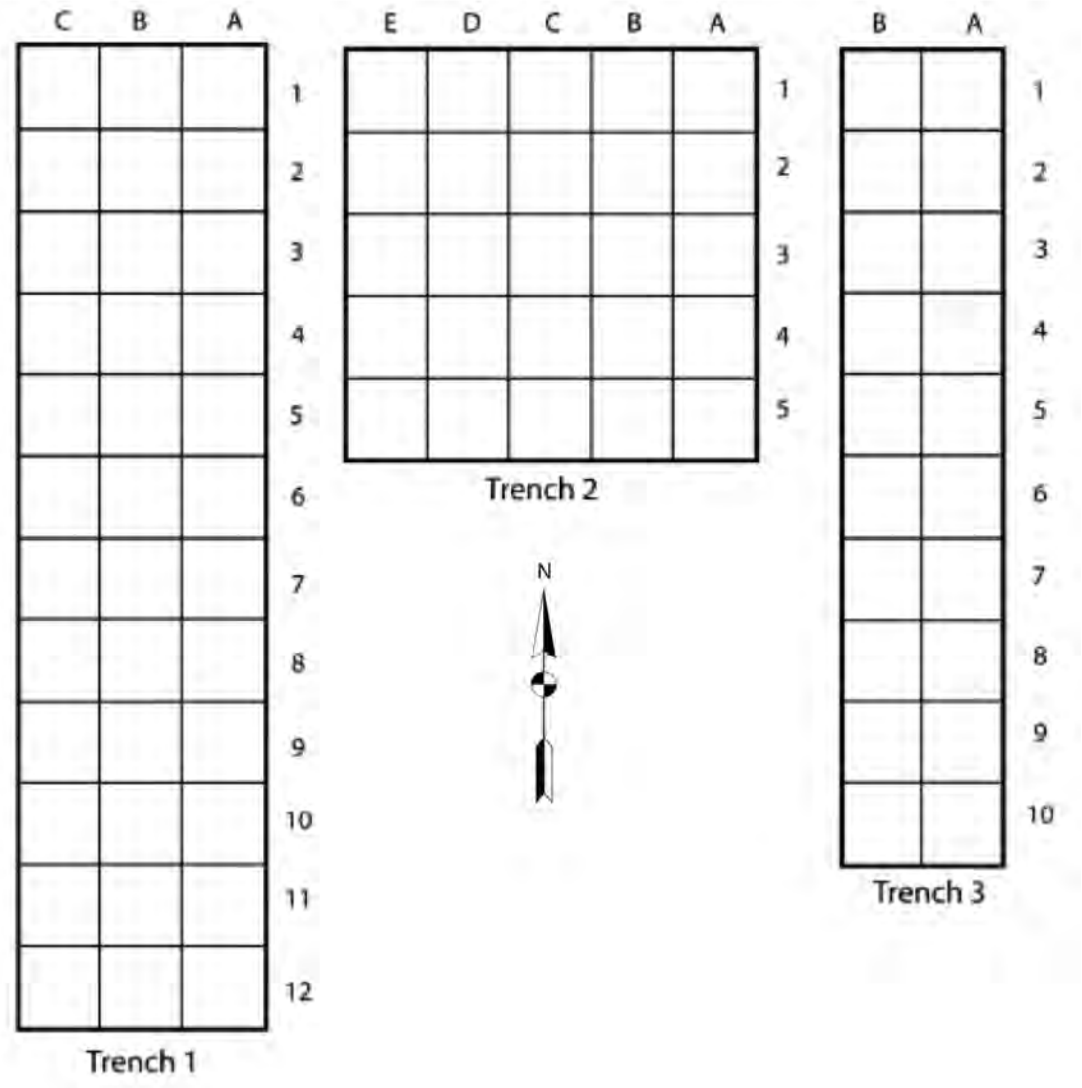

Figure 3.1. Schematic diagram of the three trenches of the 2009 excavation to display the applied alphanumeric system. Each square is 1 x 1 m. This diagram does not correspond to the layout of the site (see Chapter 4).

Source: C. Sarjeant.

Trenches 1 and 3 were excavated in 10 cm spits. The fifteen excavated spits of Trench 1 were translated into eight separate stratigraphic layers, as were the thirteen spits of Trench 3 (see Chapter 4). Trenches 1 and 3 were excavated to the basal alluvium, at a depth of 1.5 m. The complex nature of the lenses in Trench 2 meant that fifteen stratigraphic layers were identified, and 10 cm spits were excavated within these layers (see Chapter 4). The basal alluvium was present in Trench 2 at a depth of 1 m. The western Test Square was excavated in 10 cm spits and the spits were labelled according to depth. The Test Square was excavated to a depth of 2.6 m.

The ceramic assemblage of An Sơn

Before sampling for fabric analyses, a full assessment of the ceramic sherds and vessels that were excavated in 2009 took place. This initially involved dividing the ceramics into basic categories. As this was a large task, it was completed by a team: Bùi Chí Hoàng, Nguyễn Kim Dung, Đặng Ngọc Kinh, Nguyễn Khải Quỳnh, Nguyễn Khánh Trung Kiên, Lê Hoàng Phong, Nguyễn Phương Thảo, Nguyễn Mạnh Quốc, Trần Thị Kim Quy, and myself. The complete or partially complete vessels from deposits and burials were kept separate from the sherds that underwent the sorting process (Figure 3.2). *Tempers* were identified macroscopically, to the best of the team's abilities, into sand or fibre tempered. The 'other' tempers were identified by myself in initial sorting and kept aside for further analysis. *Components* were simply divided into rim or body sherds. The rim sherds also included foot rims, while body sherds also included stems/pedestal stands. All rim and foot rim sherds were kept aside for rim form categorisation. *Surface treatments* were separated into plain, cord-marked/comb incised/lines impressed with a carved paddle (henceforth called 'paddle linear impressed'), and other decorated rim and body sherds. All of the decorated sherds were kept aside for further analysis.

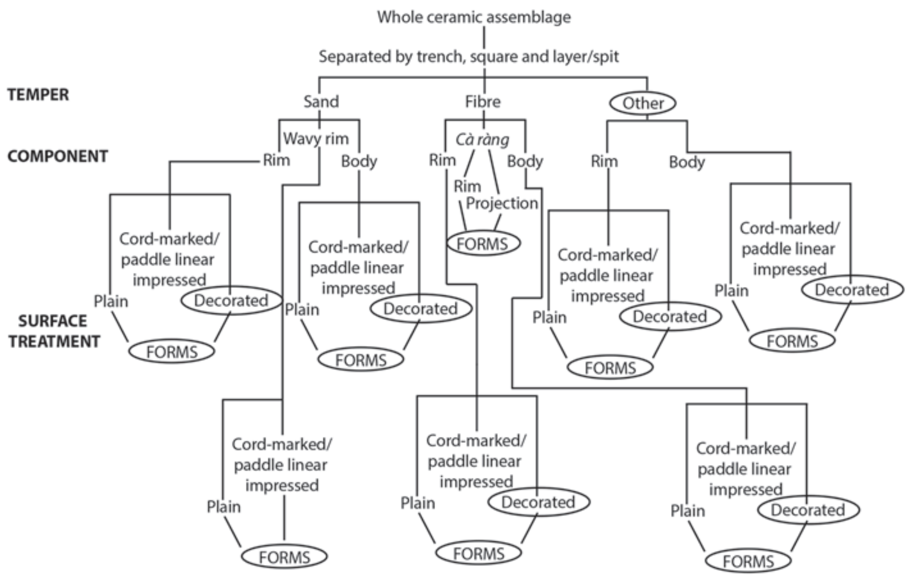

Figure 3.2. Initial sorting of ceramic sherds. The circled categories of ceramic sherds were subjected to further analysis.

Source: C. Sarjeant.

The weight and total number of sherds in each spit were recorded. Both the sand and fibre tempered sherds were counted as rims, wavy rims, cord-marked body sherds, plain body sherds, other decorated rim and body sherds, and foot rims. The fibre tempered *cà ràng* (stove/earth oven cooking vessel) sherds were counted as rims, body sherds, and tripod projections sherds. After these preliminary counts, the circled categories shown in Figure 3.2 were subjected to further analysis.

Sampling the ceramics

The ceramic sample from the 2009 excavation was selected with the aim of characterising the sequence of ceramic technology at An Sơn. The deepest and clearest stratigraphic sequence observed in 2009 was in the 1 x 1 m square closest to the mound, C1, in Trench 1. Sherds were selected for fabric analysis from square C1, in order to consider changes in the ceramic technology over time. Additional sherds were collected from the base of the Test Square and the 1997 excavation, since these earliest layers contained ceramics that were distinguishable from that in the later layers (Nishimura and Nguyễn 2002). These sampled excavation units were deemed representative of the overall ceramic assemblage at An Sơn.

The analysis of morphology and decoration involved assessing the entire assemblage that was excavated in 2009. Close attention was given to the ceramic forms excavated from the Trench 1 squares A1, A2, B1, B2, C1 and C2, because these squares contained clear mound-edge stratigraphy, and Trench 2 indicated coking activities using earth ovens.

The sherds for fabric analysis from square C1 were selected from each spit to include the different rim forms, components, fabrics and surface treatments (i.e. rim sherds, body sherds, sand tempered sherds, fibre tempered sherds, 'other' tempered sherds, plain sherds, cord-marked sherds, decorated sherds, etc.) that were represented. This reflected a stratified random sampling strategy (Drennan 1996: 87). The initial selection process resulted in about 10–20 sherds from each spit, depending on how many sherds were excavated. It was noticed that few wavy rimmed vessels (class D) were present in Trench 1 square C1, and a sample of class D sherds from other trenches for the fabric analysis was acquired. The 10–20 sherds from each spit of Trench 1 square C1 were reduced in number before removal from Vietnam due to weight restrictions in transportation. Therefore, ten sherds were selected randomly from each set of sorted sherds: five sand-tempered, five fibre-tempered. The 'other' fabric sherds were kept in the sample, adding to the ten sherds for some spits of Trench 1 square C1. Class D (wavy rimmed) ceramic sherds and basal layer sherds from the Test Square and the 1997 excavation were also kept for analysis.

Once in Australia, the number of sherds from Trench 1 square C1 had to be reduced further for laboratory analysis, owing to the time and cost of SEM-EDX analysis. In most cases this was limited to two sherds per spit (one sand, one fibre, plus 'other' tempered sherds). While the sample chosen for fabric analysis was small, the fabrics from An Sơn appeared macroscopically homogeneous. A microscopic examination of various sherds prior to sampling indicated there was homogeneity in the clay matrix compositions of the primary temper groups of sand and fibre.

The sample chosen for fabric analysis from Trench 1 C1 included 40 sherds. Each spit was sampled with two to seven sherds, based on the above criteria (one sand, one fibre, plus 'others'). Additional sherds were sampled from other squares of the 2009 excavation to encompass the variety of fabrics, forms and decoration. These included a further six sherds. Thirteen sherds from the lowest layers of the Test Square and from the 1997 excavation were also sampled. Two surface sherds were studied in the preliminary analysis of fabrics. To confirm local ceramic manufacture nine clay samples were collected for comparison with the pottery fabrics: three unfired samples close to the Vàm Cỏ Đông River channel near An Sơn and six fired clay samples from 2009 archaeological contexts.

Further comparative samples were analysed to confirm the local manufacture of the An Sơn ceramics, including some from other sites in southern Vietnam sites, northern Vietnam and other areas of Southeast Asia. The wide dispersal of the selected sites was necessary to show major relationships and differences in the ceramic fabrics. The majority of the samples were surface finds but they had characteristics of neolithic earthenwares comparable to those at An Sơn. A total of 21 sherds were sampled from nine sites.

The collection of the clays and the samples from other sites was arguably haphazard, but it illustrates the need for further analysis of clays and ceramics from other sites in southern Vietnam. Access to comparative material for fabric analysis was problematic. It was the original intention to acquire provenanced sherds from other southern Vietnam sites, but this was not possible at several museums in southern Vietnam. Such a study must wait until another site is excavated in the region with a similar approach to the An Sơn ceramics.

A list of the samples chosen for fabric analysis, their identification numbers for the statistical analyses, forms, surface treatments and Munsell colours are presented in Appendix A with their temper group (as presented in the analysis of Chapter 6, Part I).

Method for the analysis of morphology and decoration

Morphology and decoration were studied differently when assessing the complete/reconstructed vessels on the one hand and the ceramic sherds on the other. The initial sorting process that has been previously outlined (Figure 3.2) meant that the rim and decorated sherds were set aside and ready for the next analytical step. The complete and reconstructed vessels were photographed and drawn to show the profile and surface treatment. Measurements of rim diameter, rim length, rim thickness, body thickness, height, and foot rim diameter were taken, and temper was identified macroscopically.

Once the rim sherds had been separated from the body sherds, the rims were categorised according to form (see Chapter 5). The variations in rim forms were drawn to scale and any associated surface treatments recorded. Decorated sherds were separated to allow for rubbings and photographs to be taken. Variation in decoration was recorded according to mode of decoration and whether decorations occurred in isolation or in combination. The decorative modes included cord marking, comb incision, paddle linear impression, burnishing, linear incision, geometric incision, spiral and wave incision, punctate stamping, roulette stamping, red painting or slipping, and white lime infill.

As described above, close attention was given to the rim forms from the basal layers of the 1997 excavation and Trench 3, from squares A1, A2, B1, B2, C1 and C2 of 2009 Trench 1, from 2009 Trench 2, and from the Test Square. These areas were identified as important for understanding the stratigraphy and chronological sequence of the site, and the functional uses of different areas of the site.

The more common rim forms were targeted for further measurements and fabric analysis (including concave rim form A2a, forms B1a and C1b, and the wavy and serrated rimmed vessels, class D; see Chapter 5). The measurements of these rim forms included rim diameter, rim length, rim thickness, angle from rim to rim termination, body thickness, and height of vessel when present. Other measurements were taken when relevant. These more frequently observed rim forms and their measurements were applied to a study of standardisation in the An Sơn assemblage (see Chapter 7).

Method for the analysis of fabrics

Ceramic petrography has been a central focus of analytical work and has been integrated with both macroscopic and chemical analysis in many studies. Manual SEM (scanning electron microscopy) with linked EDX (energy dispersive x-ray spectrometry) is routinely used in the analysis of ancient ceramics (Knappett *et al.* 2011; Spataro 2011; Tomber *et al.* 2011). Like any method however, it does have limitations: SEM-EDX cannot differentiate between minerals with very similar chemistry and a complementary technique is required, such as XRD (x-ray diffraction). D.P.S. Peacock (1977; in Knappett *et al.* 2011) has advised against conducting elemental studies without knowledge of the macroscopic and microscopic properties of the ceramic assemblage. The macroscopic analysis requires looking at the overall sherd assemblage and a representative sample is then selected for microscopic analysis in thin section in order to identify local fabric groups, working from the local geology and clay sources. SEM may also be applied in order to provide a chemical analysis for an understanding of local or non-local ceramics. A number of different analytical techniques are required to provide the appropriate degree of resolution, although there are advantages in applying methods that retain the mineralogical and textural qualities of the fabrics, such as SEM-EDX, which was utilised in the analyses for this monograph (Knappett *et al.* 2011).

Application of SEM-EDX in recent studies of archaeological ceramics

SEM-EDX has been applied in other ceramic studies in a similar way to that presented in this monograph. For instance, SED was used on neolithic ceramics from south-eastern Europe (Spataro 2011) because the fabrics concerned were often not homogeneous, and had coarse inclusions and porous structures. The SEM-EDX analyst is able to select areas for chemical analysis that are less affected by the presence of mineral temper, and the inclusions can be analysed individually. Petrographic analysis is often conducted on thin sections in combination with SEM in order to characterise the matrix according to clay composition (for example, calcareous or non-calcareous), and to identify vitrified, fossilised and other properties. Inclusions can be identified according to colour, composition, grain size, frequency, rounding and sorting, and can also be used to determine provenance of raw materials (Spataro 2011).

Characterisations of fabrics can include variables such as temper choices, degree of vitrification and firing temperatures. A study of the ceramics from the Alcantara River Valley in northeastern Sicily applied polarising microscopy, x-ray diffraction and SEM (Belfiore *et al.* 2010). Firing temperatures were studied with vitrification structures observed with SEM. This study applied the following methods: petrographic analysis by polarising optical microscopy, micro-morphological analysis by SEM (vitrification and equivalent firing temperatures), x-ray diffraction spectra, x-ray fluorescence of major, minor and trace elements, and SEM-EDX spot analysis of mineral phases for volcanic tempers and lavas. SEM-EDX offers 'detailed information on their chemical composition,' and the SEM results supported the XRD analysis (Belfiore *et al.* 2010: 444).

Testing of SEM-EDX with QEMSCAN® has been conducted by researchers in the Aegean (Knappett *et al.* 2011). QEMSCAN is an automated approach to SEM-EDX, that is, a computer controlled SEM developed for image analysis and mineral analysis by the mining industry. The method is operator independent, apart from the initial selection of the operating mode and the beam stepping interval. QEMSCAN is a bulk chemistry method that is based on the measured modal mineral abundance and the estimated mineral chemistry. The fine grained and amorphous mineral phases and grains/inclusions and matrix/groundmass are all measured together in a single analysis and at the same resolution to provide quantitative data. Despite the importance of introducing elemental analysis after macroscopic and microscopic studies, the integration of all of these techniques can be difficult. According to Knappett *et al.* (2011), this can be remedied somewhat by QEMSCAN, through its combination of textural and mineralogical data based on elemental spectra. It is possible to characterise materials accurately when the rocks and sediments are unaltered, but this is not always the case with fired materials, and additional data are needed on the chemistry of each mineral phase (Knappett *et al.* 2011).

Tomber, Cartwright and Gupta (2011) applied SEM-EDX to a study of Indian Ocean region ceramics that incorporated rice husk (*Oryza sativa*) fabrics. They identified the exact particles that were added as temper as rice spikelet fragments (husk) and stems. Fragments of Poaceae family, i.e. grasses, were also presentbut could not be identified to species due to their fragmentary state. The study employed petrographic, biological and SEM methods. The high variability in the fabrics led to the conclusion that the ceramics were made in small-scale production settings. It may be argued that the presence of rice chaff temper indicates an economic reliance on rice and that it was readily available. However, the technological significance of using this type of temper should not be underestimated, particularly for the use of pots that are under thermal shock during cooking (Tomber *et al.* 2011).

While basic macroscopic and microscopic methods were employed in my research, manual SEM-EDX was also applied. This method was chosen because of my previous experience with the instrument (Sarjeant 2008). Furthermore, SEM-EDX has been recognised as a useful technique for identifying both tempers and clay matrix groups in earthenwares with micrographs and chemical compositional data, thus providing mineralogical and chemical analyses (described further below). I would suggest that, given more time and finances, supplementary samples be included in such an analysis with the addition of comprehensive petrographic study and an analysis of trace elements, which would complement the fabric analyses in this monograph.

Method of SEM-EDX analysis

Macroscopic analysis was conducted on all sherds to separate them into basic fabric groups in the field: sand or fibre tempered. This separation was conducted macroscopically or with low magnification to identify tempers, and recorded for squares A1, A2, B1, B2, C1 and C2 of Trench 1, Trench 2, the basal layers of Trench 3, the Test Square, and the basal layers of 1997 excavation. The macroscopic groups were expanded to include lateritic and shell tempered fabrics. These four major groups (sand, fibre, laterite and shell) then required microscopic analysis, and sherds were sampled from representative areas of the site.

The samples that were collected for fabric analysis were recorded with the following information: rim form (if known), vessel component (body or rim), surface treatment and decoration, macroscopic observation of the fabric, and the Munsell colour of the exterior surface and interior fabric (see Appendix A). The sampled sherds were prepared for SEM-EDX analysis: each sherd was cut and impregnated in a 25 mm circular epoxy resin block with the flat surface of the sherd exposed at the top of the block. The resin blocks were polished with diamond paste to create a flat, polished analytical surface. Note that the texture and structural integrity of the sherd sample remains intact as no crushing of the sample takes place. All of the samples were prepared by Tony Phimphisane or John Vickers in the Research School of Earth Sciences at The Australian National University.

Once this preparation was completed, the samples that were ready for microscopic study were analysed with a lit Zeiss stereoscope, and photographs were taken with the attached camera, an AxioCam ERCc5. The following features were recorded: visual identification of temper, colour of sand grains, size of sand grains, density of sand grains, and colour and texture of the clay matrix. These observations are important for a comprehensive SEM-EDX analysis. The samples were then carbon coated, which ensures conductivity when the sample is in the SEM.

SEM combines a compositional measurement over a range of depth at 1 μm or approximately 10,000 atom layers, therefore SEM is considered a bulk rather than a surface analysis technique (Newbury *et al.* 1986: 244–245). My study utilised the ability of SEM to provide analyses of the sand grains separately from the clay matrices. No bulk analyses were conducted of large areas that may include both temper and clay; these were analysed separately. Therefore, manual SEM-EDX was preferable to the aforementioned automated SEM-EDX with QEMSCAN. Electron microscopy provides separate chemical analyses of the clay matrix and minerals rather than the blend of both that most other techniques provide when samples are crushed in preparation. The smoothly prepared sample can be moved under the electron beam for spot analysis. The obtained chemical results allow the grouping of sherds on the basis of chemical similarity into groups called Chemical Paste Compositional Reference Units (CPCRU) (see Summerhayes 2000: chapter 4).

The sherds were analysed using a JEOL JSM-6400, a regularly calibrated scanning electron microscope with an EDX attachment in the Electron Microprobe Unit, Research School of Biology, The Australian National University. The JEOL JSM-6400 is optimised for quantitative x-ray analysis. Machine conditions used a negative potential of 15 keV accelerating voltage and a constant current of 1nA. In this study, micrographs were taken and EDX quantitative analyses were conducted. Backscatter micrographs were taken at magnifications of x20, 50, 100 and 600 with SpectrumMono software. The x600 micrograph was taken to show the texture of the clay matrix. The micrographs aided the identification of grains and matrix areas with different textures and greyscale colours that were to be selected for EDX quantification.

The EDX quantitative analysis was presented by means of ZAF matrix correction by stoichiometry and all elements were combined with oxygen (valency -2) in a calculation based on 6 anions per formula. The EDX of an SEM is typically applied to measure the characteristic x-rays of major elements (>10 weight %), whereas WDS (wavelength dispersal spectrometry) is used to measure minor elements (<10 weight %). The sample is analysed non-destructively and when flat, polished samples are analysed the accuracy is usually 1–2% of the amount present of a given element (Goldstein *et al.* 2003: 12). The EDX analyses the x-rays emitted by the sample when the electron beam is targeted at the sample in an SEM. Each element has x-rays that are characteristic of the atomic structure which appear as peaks and quantities in EDX analysis that can be identified when compared with reference peak data (Goldstein *et al.* 2003: 356). The JEOL JSM-6400 EDX is linked to Oxford Link ISIS software to identify the characteristic x-rays according to known reference standards (the commonly observed element standards are shown in Table 3.1) and is sensitive down to boron. The combination and concentration of different elements can be used for mineral identification. Each EDX analysis was conducted for 100 seconds livetime.

Two different modes of EDX analysis took place. The first was conducted on the non-plastic sand grains. It is possible to select specific areas for analysis with the SEM since the entire area of analysis appears on the monitor. A spot can be analysed up to x300,000 magnification. This ensured accurate mineral identification and characterisation of specific grains and spots within the ceramic fabrics. Similar principles applied to the analysis of the second component, the clay matrix. Five representative areas of the clay in each sample (areas not inclusive of sand grains that were potentially added temper grains) were selected for EDX analysis. Once again, the area of analysis was observed visually on the monitor. The magnification depended entirely on the sample: some sherds had smaller sand grains than others and some sherds were densely tempered, so the clay matrix analysis of these had to be conducted at a higher magnification. While grain analyses were conducted up to x300,000 magnification, the clay matrices were usually analysed between x500 and x7000 magnification. The elemental oxides of sodium, magnesium, aluminium, silicon, phosphorus, sulfur, potassium, calcium, titanium, vanadium, manganese and iron were analysed. Other elements were added when peaks were identified in grain analyses, e.g. zircon.

Table 3.1. Standards for JEOL JSM-6400 EDX at the Electron Microscopy Unit, The Australian National University. Only the frequently analysed elements of the ceramic samples included.

Element	Standard	Date
Na	albite ($NaAlSi_3O_8$)	26/06/2009
Mg	MgO	26/06/2009
Al	albite ($NaAlSi_3O_8$)	07/04/2009
Si	sanidine ($KAlSi_3O_8$)	26/06/2009
P	$NiPS_3$	03/07/2009
S	PbS	16/04/2009
Cl	NaCl	31/07/2008
K	sanidine ($KAlSi_3O_8$)	26/06/2009
Ca	diopside ($CaMgSi_2O_6$)	26/09/2008
Ti	TiO_2	25/06/2009
V	pure V	31/07/2008
Mn	pure Mn	31/07/2008
Fe	Fe_2O_3	11/05/2009
Zr	pure Zr	05/02/2009

Source: The Australian National University Electron Microscopy Unit lab manual.

Identifying tempers from compositional data and micrographs

Tempers must be distinguished from natural non-plastic inclusions in ceramic fabric characterisations. Non-plastic inclusions are the components of a ceramic fabric that are not the clay paste, and include natural and human-added inclusions. Tempers are non-plastic additives added by potters to improve the ceramic fabric in forming and firing. While it may seem straightforward to analyse a non-plastic grain within a ceramic fabric with the SEM-EDX since the readings offer compositional data that relates to known minerals, differentiating the non-plastic natural inclusions from tempers can be difficult. It is important to consider what materials occur naturally in clays. Organic materials, pottery sherds, igneous, sedimentary and metamorphic rock fragments, coarse sands and pumice are common tempers. Grain sizes and relative abundances of the non-plastic grains aid the confirmation of tempers. The abundance of natural quartz in clays and its use as a sand temper can make differentiation difficult. Fine silt quartz is common as a natural inclusion, whereas coarse, waterworn quartz grains are likely to be temper additives. Coarse grains may be present naturally but waterworn grains do not occur naturally in clays (Shepard 1965: 161–162).

Visual observations aided the selection of different grains for analysis. The non-plastic inclusions that were analysed with the EDX were identified as minerals utilising reference materials (Severin 2004; Deer *et al.* 1992). Some of the non-plastic inclusions were not identifiable minerals, and their compositions represented calcareous and phosphate materials, such as shell and bioclasts. Organic plant materials could only be analysed visually, as the EDX cannot read botanical remains. Temper groups were established from the identified non-plastic inclusions that were manually added by the potters (see Chapter 6, Part I).

Statistical methods for clay matrix compositional data

Compositional data and the selection of elements

Using the EDX data from the clay matrix analyses, multivariate statistics were applied to identify clusters and to define CPCRUs. A primary aim in the quantitative elemental characterisation of pottery is to define groupings that make chemical and archaeological sense (Summerhayes and Allen 2007: 111–112). Compositional data are relative, so if one element increases in value, others will decrease. In order to make the matrix data comparable between different samples, and to obtain averaged compositional data for each sample, the raw data were normalised. Thus, the compositional data totalled to a constant value (100%). The data were always positive, between 0 and 100 (Pawlowsky-Glahn and Egozcue 2006). The EDX analysis produced negative values when a particular element was undetectable and these were rounded to zero to avoid affecting the statistical analyses.

Some of the analysed elemental oxides were undetectable across most of the samples. The selection of elements to include in statistical analyses requires consideration with regard to the absence of certain elements in the samples. The compositions can also be affected by environmental conditions, including post-depositional effects, which have the potential to alter the chemical composition of archaeological ceramics. This has been particularly noted for the concentrations of phosphorus (Freestone *et al.* 1985). In the samples from An Sơn, the concentrations of SO_3 and V_2O_5 were very low and consistently undetectable, so it was appropriate to exclude these elemental oxides from the statistical analyses. Additionally, there are problems with including MnO in statistical analyses of compositional data. Anna Shepard (1966) has identified manganese as highly migratory, and cautions against including it. These four elements are assessed in bivariate plots and by principal components analyses (PCA) in Chapter 6 to establish whether they should be included in further statistical analyses. The remaining elemental oxides, MgO, Na_2O, Al_2O_3, SiO_2, K_2O, CaO, TiO_2 and FeO were all important components of the clay matrices that were included in the statistical analyses.

If certain elements are excluded from the statistical analysis, a sub-composition is adopted and the values must be re-normalised. There have been concerns over the habitual use of inappropriate methods of statistical analysis for compositional data, specifically for compositional and sub-compositional data (Pawlowsky-Glahn and Egozcue 2006). Some researchers question this concern, given that 'reasonable and interpretable results arise from the application of conventional techniques' (Pawlowsky-Glahn and Egozcue 2006: 2). However, there have been methods developed for compositional data that illustrate how log ratios can be used to acknowledge the relative magnitudes and variations of the components that are necessary to analyse compositional data. Log ratios transform the data from a simplex space, i.e. compositional data in a restricted space in which the values are only between 0 and 100, to Euclidean real space which is applied to conventional multivariate statistical analyses, like PCA (e.g. Pawlowsky-Glahn and Egozcue 2006; Aitchison *et al.* 2002; Aitchison 1986).

To prepare the compositional data for statistical analyses, each set of data for each analysed area was examined for errors (low total values or inconsistencies with the other readings). Each matrix area was normalised to a total of 100%, inclusive of only the elements that were to be analysed in the subsequent statistical processes. Once normalised, the multiple matrix area readings were averaged to give a single set of compositional data for each sample. The averaged values were applied to a log ratio transformation. The log ratio was applied against one of the common and least variable elemental oxides in the clay matrices, aluminium oxide. The basis for the selection of Al_2O_3 for the log ratio transformation is presented in Chapter 6. The above calculations can be summarised as:

$N[x] = 100(x/\sum x)$

Normalised value of each element of each reading = (element compositional value/sum of compositional values for reading) multiplied by 100

$\mu[x] = \sum N[x]/n$

Mean value of each element of each sample = sum of normalised element compositional values of each element of each reading/number of readings for each sample

$\log(\mu[x]/\mu[Al_2O_3])$

log (mean value of each element of each sample/mean value of Al_2O_3 of each sample)

where x is the compositional value for an element of a reading, n is the number of compositional readings for one sample, N is the normalised value for a compositional value (the sum of all normalised compositional values for each reading is 100), and μ is the mean compositional value of all of the readings for a sample.

Log ratio transformed values were used for all statistical analyses for the clay matrix data (PCA, hierarchical cluster analysis and canonical variate analysis).

Principal components analysis (PCA)

The compositional data from SEM-EDX analysis produced values for each analysed elemental oxide, resulting in a large number of variables. PCA was employed to reduce the variables into principal components. From the PCA, compositional groups and clusters can be identified to determine which ceramic samples are the most and least chemically similar to each other. It is common practice to apply PCA to compositional data, as a dimension-reducing technique for the multiple elemental variables. In PCA, the elements are reduced to principal components, which can then be plotted against each other to identify compositional groupings. Michelaki and Hancock (2011) report the need to formulate bivariate plots before leaping into PCA or CLR-PCA (centred log ratio-principal component analysis) plots to identify elements that may diminish the chemical variation. It may only be necessary to include a few of the elements in a PCA. Bivariate plots are explored in this monograph before PCA to identify the variables that have the most weight in the variability exhibited in the PCA (Chapter 6).

Two main difficulties exist in the application of compositional data in PCA. The first is the curvature that may be displayed by compositional data, and this nonlinear data is applied to linear PCA. Therefore a method of PCA needs to be used that will accommodate both nonlinear and linear data. The second difficulty is the use of a Euclidean sample space in PCA when the compositional data are simplex, and Aitchison (1983) proposed that log ratio transformations overcome these difficulties.

The PCA itself reduces the elemental variables into a few manageable dimensions to show the chemical elements that are highly associated to each other. PCA was conducted to transform the compositional data into three principal components in this analysis. The first principal component exhibits the most variability within the compositional data, while the second exhibits the second most variability, and so on. PCA was completed to three principal components in this study. A percentage of variation for each component is given in PCA. The weighting of the variation of each principal component is dependent on the elemental variables that exhibit the greatest variation amongst the latent vectors, known as loadings. The PCA produces values for each sample with a first, second and third principal component that can be plotted to reveal clusters and outliers. The CPCRUs are identified from the clusters. Outliers may be removed from the PCA in order to clarify the samples that group together, as strong outliers in a biplot may cause the remaining samples to cluster tightly in comparison to the outlier.

The bivariate plots, log ratio transformations and PCAs were conducted with GenStat software for the analyses shown in Chapters 6 and 7. PCA biplots and plots of the first three principal components (or dimensions) are presented in this monograph. The biplots show the variability of the ceramic samples in relation to specific elements, while the PCA plots show the variability of the ceramic samples in relation to the PCA loadings. A table of the PCA loadings for each analysis is also provided for the first three principal components, inclusive of the total percentage variability for each principal component in parentheses. The loading values in bold in the table indicate the elements that contribute the greatest variability to the PCA plots.

Hierarchical cluster analysis

PCA can be supported by cluster analyses. Cluster analyses illustrate homogeneous groups or clusters in a dataset. Hierarchical agglomerative clustering was employed, in which each sample is viewed as an individual. Samples are then successively grouped into clusters until there is a single cluster. Average-linkage hierarchical clustering is most frequently applied in archaeology and the resulting dendrograms, while not always easy to understand, are often a realistic representation of the data. Clusters can be discerned from the dendrogram by 'cutting' the dendrogram at a single or several points based on the groupings that result (Baxter 2003: 92–95). Various clustering methods were investigated and the average-linkage method was most consistent with the PCA and therefore applied in this study.

The hierarchical cluster analyses were conducted with GenStat software for the analyses shown in Chapters 6 and 7. The cluster analyses are presented with dendrograms and interpretive tables to identify the groups when cut at a logical specified point on the plot.

Canonical variate analysis (CVA)

Canonical variate analysis (CVA) is a form of canonical correlation analysis and is a suitable multivariate statistical method for dealing with the simultaneous analyses of several sampling levels (e.g. from different stratigraphic layers) (Reyment 2006). CVA is essentially a PCA of the group mean vectors. Like PCA, CVA is a dimension-reducing technique that transforms a multivariate dataset into two or more dimensions. However, *a priori* information about the dataset can be implemented and the differences between these *a priori* groups are maximised in CVA. CVA can be used when the dataset includes three or more *a priori* groups, while discriminant analysis is applied to only two groups. PCA and CVA biplots are directly analogous (Hammer and Harper 2006: 100; Tofallis 1999; Greenacre and Underhill 1982: 205).

The ability to input *a priori* archaeological groupings, such as sites, layers or vessel forms, in a statistical analysis provides the opportunity to validate whether the chemical compositional data have any relationship to other archaeological knowledge. This is an exploratory technique and it is applied in this monograph on several occasions. In relation to the clay matrix compositional data, CVA plots are formulated to investigate the compositional relationship between groups based on separate sites (An Sơn, Cù Lao Rùa, Đình Ông, Giồng Cá Vồ, Lộc Giang, Hòa Diêm, Ban Non Wat, Mán Bạc, Đa Bút and Cồn Cổ Ngựa), on the stratigraphic layers at An Sơn, the tempers in the An Sơn ceramic fabrics, the vessel forms at An Sơn, and pottery versus clay fabrics at An Sơn.

The CVAs were conducted with GenStat software for the analyses shown in Chapters 6 and 7. The CVA results are presented as biplots to show the variability of the first two dimensions in the CVA plots that follow. Many of the CVA plots are shown with 95% confidence circles around the specified *a priori* group mean. A table of the CVA loadings for each analysis is also provided for the first two or three canonical variates, inclusive of the total percentage variability for each canonical variate in parentheses.

Methods for contextualising An Sơn ceramic production

The original aims of this monograph (Chapter 1) were to contextualise the An Sơn ceramic assemblage within the neolithic of southern Vietnam. This section describes the methods used to understand how the An Sơn assemblage, with specific analyses related to the ceramic sequence, the usage of different areas of the site based on the material culture evidence, and the nature of ceramic production on site. Methods for comparing An Sơn with other sites in southern Vietnam and elsewhere in mainland Southeast Asia are discussed.

An Sơn ceramic production

Sequence and spatial distribution of the ceramic assemblage

The sequence and chronological relationships (the vertical positioning) of the different ceramic forms applied the data from the morphological and surface and fabric analyses of the sherds. The sequence was assessed by separating the ceramics into their originating cultural layers when possible, rather than spits. The clearest sequences were derived from Trench 1 and the lowest layers of the Test Square. The sequences of vessel morphology and surface treatment are outlined in Chapter 5, while those of temper choices and clay matrix chemistry are presented in Chapter 6.

The spatial distribution (the horizontal positioning) of the different ceramic forms over the site was informative with respect to the function of specific forms. This analysis primarily focused on the sherds from Trench 2, since the stratigraphy offered a series of roughly contemporaneous layers (see Chapter 4) with multiple forms of archaeological evidence existing alongside the sherds themselves. The results of the spatial distribution of ceramic forms are discussed in Chapter 5.

Ceramic production and standardisation

Studies of specialisation, standardisation, distribution and other issues relating to the organisation of production are underdeveloped in mainland Southeast Asian ceramics research. There is increased understanding of the way in which pottery is produced, thourgh studies of raw material selection, forming, decoration and use (all of which require more attention in Southeast Asian prehistory but are steadily developing). It is appropriate to expand on this research to understand the organisation of pottery production. The social status and identity of potters, and of groups associated with potting, along with the organisation of production may be inferred by examining ceramic evidence in terms of context, concentration, scale and intensity (see Costin 1991).

Direct evidence for ceramic manufacture is rare in the archaeological record, but debris from manufacture and unfinished items can be compared to finished products to assess these questions. Craft specialisation can be inferred when a high intensity, low scale, low concentration occupation is practiced, and when one type of vessel made in a standardised manner may be more common than others. Standardisation is an indirect way to infer specialised production, if vessels are made in a uniform way. Standardisation is one of the easiest variables to deal with in the study of ceramic production organisation. However, ceramics are subjected to a great deal of variation in manufacture and the variation evidenced in ceramic morphology may be the result of many factors (Costin 1991).

To begin an analysis of pottery production organisation at An Sơn, I conducted a study of standardisation across the major ceramic forms. Following this I undertook a more thorough study of the common and distinctive forms of ceramics: A2a, B1a, C1b and D1a. With little direct evidence for production areas at An Sơn, much of the discussion about specialisation, context, concentration, scale and intensity has to be derived from indirect evidence. The standardisation study involved focusing on morphology and dimensions. The dimensional measurements were assessed with a PCA, a hierarchical cluster analysis and a CVA (as previously as described), and with coefficient of variation (described below), in order to identify which vessels were similar within a particular vessel form group. These results can lead to the inference of the degree of standardisation and, with other indirect evidence, may provide information about specialisation and organisation in pottery production at An Sơn.

Coefficient of variation (CV)

Dimensional measurements are frequently tested statistically for variability with the coefficient of variation (CV) to deduce whether the sample is less or more variable, i.e. more or less standardised (Roux 2003a; Eerkens and Bettinger 2001; Foias and Bishop 1997; Costin and Hagstrum 1995; Blackman *et al.* 1993; Junker 1993). The CV calculation is:

CV = standard deviation/mean

All CV values are expressed as percentages in this monograph (i.e. the above calculation multiplied by 100).

Without an independent scale, it can be difficult to deduce the level of variability when comparing different assemblages. However, Eerkens and Bettinger (2001) have tested CV to identify a constant that represents the highest degree of standardisation at 1.7% and the lowest degree of standardisation at 57.7%. The higher the CV, the more variable and less standardised the sample. Studies have shown that full-time specialists manufacture products with a CV between 5 and 10%, while part-time producers manufacture small, household-level products with a CV of 15% (Foias and Bishop 1997; see also Blackman *et al.* 1993; Longacre *et al.* 1988). Issues arise in the calculation of a CV when archaeological groupings of a ceramic assemblage include a variety of sizes, which result in high coefficients of variation (as observed in Longacre *et al.* 1988). It may be beneficial to divide these groups into finer classes according to size, for example, to produce different results where the coefficient of variation is smaller (Kvamme *et al.* 1996).

The CV values were calculated with GenStat software and are summarised in plots in Chapter 7. The CV calculations consider variation within different vessel/rim forms and across different provenance contexts. The analysis of the A2a, B1a, C1b and D1a forms include PCA, cluster analysis, CVA, and CV calculations for the dimensional attributes. Decorative attributes were added to the study of standardisation of the A2a form with CV calculations, and the fabric attributes are provided with a PCA of the clay matrix compositional data. Closer examination of the dimensional, decorative and fabric attributes of these forms was undertaken in order to show changes in homogeneity and variability over time, and in different contexts, in the manufacture of these common vessel forms at An Sơn.

An Sơn in context

Southern Vietnam

Correspondence analysis (CA)

Past comparative research between sites in southern Vietnam, and Southeast Asia in general, has relied upon broad descriptive and illustrated presentations of data. The final statistical analysis employed in this monograph, a correspondence analysis, aims to establish a systematic and intensive method for comparing the ceramics and other material culture from different sites. Systematic comparative studies typically employ statistical methods and there is greater confidence in the results when such methods are utilised (see Smith and Peregrine 2012). A correspondence analysis (CA) is an exploratory analytical technique that is essentially a principal component analysis for tables of counts. A CA results in a graphical plot of the relationship between the rows and columns of a table (Baxter 2003: 137). A CA is used for categorical rather than continuous data.

The process of accumulating data for the comparative analysis involved identifying which sites contained 'Neolithic' material culture, particularly sufficient information about the ceramics, to compare with the material from An Sơn. This required a detailed collection of information about the comparative sites from reports and my own observations of collections where possible. Given the variable nature of the available information about archaeological sites in southern Vietnam, limited data are available and this analysis is based solely on photographs, illustrations and personal observations. Some descriptive information from English, French and Vietnamese documentation was also utilised, however, these documents posed problematic differences in identification and terminology. Each material culture variable was scored as present (1) or absent (0) in the neolithic occupation of each site. Accurate quantitative data were not available for most sites and so this binary approach was implemented for the statistical analysis. The correspondence analysis resulted in values for a number of dimensions, of which two were then plotted. The correspondence scores for the sites and variables were plotted to identify the sites that are most similar or different in terms of material culture, and also the material culture variables that resulted in these similarities and differences.

The sites of Bến Đò, Cù Lao Rùa, Cầu Sắt, Cái Vạn, Bình Đa, Rạch Núi, Đa Kai, Lộc Giang, Suối Linh, Rạch Lá, and Đình Ông were included in the comparison with An Sơn. Gỗ Cao Su and Rạch Rừng also had neolithic occupation, but insufficient information was available to include these sites in the comparative study (Table 3.2). Many sites have been excavated or surveyed in the past in southern Vietnam, but the available reports are sometimes limited to descriptive and pictorial information rather than analysis. The implementation of a correspondence analysis is aimed at utilising even the limited information from these sites. Without future excavation or survey (which is often not possible due to site destruction), few sequence and occupation details can be deduced from these previously reported sites. To relate the chronology of the analysed sites to the sequence at An Sơn, the material culture at An Sơn was divided into early, middle and late phases of occupation.

The correspondence analyses were conducted with GenStat software. Two plots are presented for each analysis, one of the material culture variables and one of the sites. The presence and absence of the analysed variables at each site are listed in Appendix B. The scale on these plots indicates the variability of the sample.

Table 3.2. Sites in southern Vietnam with neolithic sequences included in the comparative study with An Sơn. All sites included in comparative analysis except Gỗ Cao Su and Rạch Rừng.

	Location	Date (uncalibrated dates calibrated with OxCal 4.1.7 IntCal09 to 95.4% probability) (Reimer et al. 2009; Bronk Ramsey 2010)	Location of studied material culture	References
Bến Đò	Ho Chi Minh City	c. 3000 BP (no radiocarbon dates) (Fontaine and Delibrias 1974)	N/A	Phạm 1977; Fontaine 1975, 1972
Bình Đa	An Bình ward, Biên Hòa city, Đồng Nai Province	3180±50 BP (Nishimura, Nguyễn and Nguyễn 2009) 3555–3267 cal. BP	Đồng Nai Provincial Museum, Biên Hòa	Nishimura 2002; Nishimura and Vương 1997; Phạm and Nguyễn 1993
Cái Vạn	Long Thành district, Đồng Nai Province	Neolithic and metal age occupation (no radiocarbon dates)	Đồng Nai Provincial Museum, Biên Hòa	Nishimura 2002
Cầu Sắt	Bình Lộc village, Xuân Lộc district, Đồng Nai Province	Neolithic material culture (no radiocarbon dates)	Đồng Nai Provincial Museum, Biên Hòa	Hoàng and Nguyễn 1977; Hoàng, Nguyễn and Phạm 1976
Cù Lao Rùa	Thạnh Phước village, Tân Uyên district, Bình Dương Province	2230±40 BP (Nguyễn 2008) 2338–2151 cal. BP (Note: this date represents the later phase of occupation with evidence of metal artefact production. The site also includes an earlier neolithic phase of occupation.)	Centre for Archaeological Studies of the Southern Institute of Social Sciences, Ho Chi Minh City	Nguyễn 2008; Fontaine 1975, 1971
Đa Kai	Đa Kai village, Đức Linh district, Bình Thuận Province	3376–3215 cal. BP, 3455–3299 cal. BP (Nishimura, Nguyễn and Nguyễn 2009)	N/A	Nishimura, Nguyễn and Nguyễn 2009
Đình Ông	Gò Dầu district, Tây Ninh Province	Neolithic ceramic forms and decoration (no radiocarbon dates)	Centre for Archaeological Studies of the Southern Institute of Social Sciences, Ho Chi Minh City	N/A
Gỗ Cao Su (insufficient information for comparison)	Đức Hòa district, Long An Province	3370±80 BP, 2650±70 BP (Bùi, Vương and Nishimura 1997) 3833–3445 cal. BP, 2928–2499 cal. BP	N/A	N/A
Lộc Giang	Lộc An hamlet, Lộc Giang village, Đức Hòa district, Long An Province	3950±75 BP (Nishimura and Nguyễn 2002) 4783–4152 cal. BP	Long An Provincial Museum, Tân An	Quang and Ngô 1994
Rạch Núi	Đông Thạnh village, Cần Giuộc district, Long An Province	2400±100 BP (H. Fontaine in Bùi, Vương and Nishimura 1997) 2743–2180 cal. BP	On site at 2012 excavation	Nishimura and Nguyễn 2002

	Location	Date (uncalibrated dates calibrated with OxCal 4.1.7 IntCal09 to 95.4% probability) (Reimer et al. 2009; Bronk Ramsey 2010)	Location of studied material culture	References
Rạch Lá	Quới Thạnh hamlet, Phước An village, Nhơn Trạch district, Đồng Nai Province	3790±60 BP, 3900±60 BP, 3960±85 BP, 4080±90 BP (Unknown author, The excavation of Rạch Lá 2002) 4408–3987 cal. BP, 4515–4152 cal. BP, 4801–4152 cal. BP, 4843–4305 cal. BP	Đồng Nai Provincial Museum, Biên Hòa	Unknown author, The excavation of Rạch Lá 2002
Rạch Rừng (insufficient information for comparison)	Tân Lập village, Mộc Hoá district, Long An Province	2780±40 BP, 2800±45 BP (Bùi, Vương and Nishimura 1997) 2968–2778 cal. BP, 3059–2782 cal. BP	N/A	N/A
Suối Linh	Trị An village, Vĩnh Cửu district, Đồng Nai Province	c. 3500–2500 BP (no radiocarbon dates) (Trịnh 2005)	Đồng Nai Provincial Museum, Biên Hòa	Trịnh 2005; Trịnh et al. 2003

Source: Compiled by C. Sarjeant.

Mainland Southeast Asia

The method of correspondence analysis, described above, was also applied in the comparison between An Sơn and notable sites elsewhere in mainland Southeast Asia. These sites were selected for the presence of neolithic occupation and material culture and available literature resources (and additional information from researchers). In this statistical analysis the presence and absence data for the CA focused on the range of ceramic decorations and non-ceramic cultural material, rather than on vessel forms, since the variability in forms was too great to consider over such a broad geographical region. The slight variations in ceramic forms were only considered in the CA of the southern Vietnam region.

The CA comparion of An Sơn and other sites in mainland Southeast Asia primarily focused on reported information, and personal observations of some collections. The comparison included what might be identified as neolithic cultural material from the sites of Samrong Sen, Laang Spean, Krek, Khok Phanom Di, Nong Nor, Tha Kae, Khok Charoen, Ban Lum Khao, Ban Non Wat, Non Nok Tha, Ban Chiang, Bàu Tró, Mán Bạc, and Xóm Rền (Table 3.3). Some of these sites are better understood than others due to greater attention to dating, stratigraphic sequence, specific studies of material culture, and cultural relationships. To relate the chronology of the analysed sites to the sequence at An Sơn, the material culture at An Sơn was divided into a burial phase and early, middle and late phases of occupation. The presence and absence of the analysed variables at each site are listed in Appendix C.

Table 3.3. Sites in mainland Southeast Asia with neolithic sequences included in the comparative study with An Sơn.

	Location	Date	References
Ban Chiang	Northeast Thailand	c. 2000 BC (Gorman and Charoenwongsa 1976)	McGovern, Vernon and White 1985; Bayard 1977; Gorman and Charoenwongsa 1976; see also Bubpha 2003
Ban Lum Khao	Northeast Thailand	Neolithic occupation: c. 1450–1000 BC (T.F.G. Higham in Higham and Thosarat 2004d: 5)	Chang 2004; Higham and Thosarat 2004a, 2004b
Ban Non Wat	Northeast Thailand	Neolithic occupation: c. 1750–1500 cal. BC Neolithic phase 1 burials: c. 1450–1350 cal. BC Neolithic phase 2 burials: c. 1350–1150 cal. BC (Higham and Higham 2009a, 2009b)	Higham and Kijngam 2011; Higham and Wiriyaromp 2011c, 2011d; Higham 2009a, 2009b, 2009c; Wiriyaromp 2007
Bàu Tró	Central Vietnam	c. 4000–3500 BP (Phạm 1997)	Phạm 1997; Patte 1924
Khok Charoen	Central Thailand	980±450 BC, 1180±300/1080±300 BC (uncalibrated, thermoluminescence) (Watson 1979)	Higham 2011c; Ho 1984; Watson 1979
Khok Phanom Di	Coastal central Thailand	2000 and 1500 BC (Higham and Bannanurag 1990)	Higham and Thosarat 2004c; Vincent 2004; Higham and Bannanurag 1990
Krek	Cambodia	Neolithic material culture (Dega 1999)	Dega 2002; Albrecht et al. 2000
Laang Spean	Cambodia	Possible neolithic deposits: c. 2050 BC (Mourer and Mourer 1970)	Mourer and Mourer 1970
Mán Bạc	Northern Vietnam	2000–1500 cal. BC (Oxenham et al. 2008)	Oxenham, Matsumura and Nguyễn 2011; Nguyễn 2006
Non Nok Tha	Northeast Thailand	c. 2000 BC (Gorman and Charoenwongsa 1976)	Bayard and Solheim 2009; Rispoli 1997; Bayard 1977; Gorman and Charoenwongsa 1976
Nong Nor	Coastal central Thailand	2500–2100 cal. BC (Higham and Hogg 1998)	Higham and Thosarat 1998b, 1998e; O'Reilly 1998b
Samrong Sen	Cambodia	3230±120 BP (Carbonnel and Delebrias 1968)	Heng 2007; Vanna 2002; Mourer 1977
Tha Kae	Central Thailand	Neolithic occupation: end of the third millennium BC–beginning of the second millennium BC, based on ceramic typologies (Ciarla n.d.; Rispoli 1997, 1992)	Ciarla n.d., 1992; Rispoli 1997, 1992
Xóm Rền	Northern Vietnam	Phùng Nguyên phase/early Bronze Age (Nguyễn 2006)	Hán 2009; Nguyễn 2006

Source: Compiled by C. Sarjeant.

Summary

This methodology chapter has outlined the analytical steps undertaken in the remainder of this monograph. Background excavation and material culture details for An Sơn are presented in the following Chapter 4. Chapter 3 has outlined the methods used for analysing ceramic morphology and decoration with respect to stratigraphic and other contextual information. The results of this ceramic analysis of An Sơn are presented in Chapter 5. The analytical results concerning fabric, temper and clay chemistry, using microscopic and SEM-EDX analysis are presented in Chapter 6.

The basic analyses of the An Sơn ceramics are expanded with a study of standardisation, specifically analysing dimensional attributes of the morphology of certain ceramic vessels and/or rim forms. Alongside PCA, hierarchical cluster analysis and CVA, the coefficient of variation (CV) is utilised to interpret the level of homogeneity in the production of morphologically similar ceramic vessels at An Sơn. The results are presented in Chapter 7.

The results from these analyses revealed comprehensive data from which to begin comparisons with neolithic sites in both southern Vietnam (Chapter 8) and the wider Southeast Asian region (Chapter 9), in terms of ceramics and other material culture. A correspondence analysis is undertaken in order to compare An Sơn with other sites and particular material culture variables, in order to contextualise An Sơn in terms of the broader neolithic developments in Southeast Asia, and in southern Vietnam specifically.

The results of these analyses are combined in order to address the research questions listed in Chapter 1 with respect to theoretical approaches in material culture studies, the organisation of craft production, cultural transmission, the identity and role of potters in the community, and the contribution of potters and ceramic material culture to the neolithic identity of An Sơn. This is presented in the discussion and conclusions of Chapters 10 and 11.

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