REDUCTION AND ADZE FORM: GROUND STONE ADZES FROM BAN NON WAT, NORTHEAST THAILAND

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ABSTRACT

This paper examines the relationship between reduction and adze form using an assemblage of ground stone adzes from Ban Non Wat, northeast Thailand. Methods for detecting reduction on ground stone adzes are proposed and tested against the assemblage. The results indicate that changes in adze form may occur as reduction proceeds, which casts doubt on the usefulness of traditional adze typologies.

INTRODUCTION

The effect of reduction on stone artefact morphology has long been acknowledged (Holmes 1890, 1891, 1892, 1893, as cited in Hiscock and Attenbrow 2005:45), but for the most part has been not been considered in the construction and use of Southeast Asian ground stone adze typologies (Duff 1970; Heine-Geldern 1932). The traditional typological approach attempts to provide rigid groupings of adze types which can then be associated with specific cultural developments. Such associations have largely been dismissed, yet the typological framework continues to be used as a classification tool with little emphasis on interpretation. As will be argued in this paper, understanding the relationship between artefact form and reduction can offer an alternative interpretive framework in which to study the prehistory of Southeast Asia.

Very few sites in Thailand have more than 30 complete ground stone adzes. The adze assemblage from Ban Non Wat represents one of the largest samples of stone adzes (n=125) from an individual site in Thailand, providing a unique opportunity to examine the effects of reduction on adzes within a single assemblage.

A 'ground stone adze' is defined as any adze for which part of the manufacturing process involved abrasion or grinding. 'Ground' indicates the type of manufacturing technology. 'Polish' may be the result of manufacturing techniques, but it can also have other origins (Adams 2002: 31-32). Whilst the majority of the Ban Non Wat adzes are polished, and therefore similar to adzes from other parts of Southeast Asia, it is unclear whether this polish was attained during manufacture, or from later use. Thus for clarity 'ground stone' has been used throughout this paper to identify the technology by which the adzes have been manufactured.

The nature and flaws of previous Southeast Asian adze typologies will be briefly outlined, followed by a summary of the 'reduction thesis,' which will be used as an analytical method to test how reduction can best be detected on ground stone adzes. Finally, the relationship between reduction and adze form will be examined and the implications for understanding the Ban Non Wat assemblage discussed.

ADZE TYPOLOGIES IN SOUTHEAST ASIA

Heine-Geldern (1932) identified three main types of adzes which he associated with different cultural groups who migrated through the Southeast Asian region. He claimed these adze types could be used as chronological markers for these migrations. Heine-Geldern's typology placed substantial emphasis on shouldered adzes, as compared to non-shouldered adzes. However, doubts about the scheme were raised as early as the late 1960s (Sørensen 1967: 86; van Heekeren 1972: 200-202), and archaeological evidence recovered subsequently did not support this staged migration model (Bellwood 1978: 171, 175).

A more comprehensive typology was devised by Duff (1970) and has remained useful for its wide geographic coverage, comprehensive descriptions and numerous illustrations, but is less useful for interpretation. Duff proposed that adze types in Southeast Asia were derived from archaic adze types which clustered in three focus areas, Eastern China (Focus 1), Northern Laos (Focus 2) and the tip of Peninsular Malaysia (Focus 3). These foci were regarded as general locations from which specific adze types diffused to other parts of Southeast Asia, and in some cases into Polynesia (Duff 1970). Duff used butt modification (shouldered or stepped) as a major functional criterion for separating adze types, as the butt modification provided a "lashing grip" (Duff 1970: 11). Of significance for intra-site analysis is that shouldered and non-shouldered adzes often occur together, implying that whilst particular shouldered varieties might have significance on a regional scale, the shouldered/non-shouldered dichotomy might not be relevant for more narrowly focused studies. For instance, studies from

Cambodia reveal that shouldered and non-shouldered adzes occur in the same area (Lévy 1943; Malleret 1960).

The adze focus model proposed by Duff (1970) was strongly criticised by Green (1971), on the basis that it lacked a solid chronological basis and therefore was of limited use to archaeological investigations. Bellwood also suggested that some types were idiosyncratic and more likely to have arisen from local developments than diffusion (Bellwood 1978: 173). In addition, Pisnupong (1988: 124) asserted that the Duff typology was of little use for intra-site assemblage analysis because it ignored the effects of reduction and life history of the adzes in the construction of adze types.

Previous approaches to ground stone adzes in Southeast Asia regarded adzes as discrete, essentialist entities, whereby adze types did not overlap and were associated with specific cultural developments. Shouldered adzes were identified as separate types from non-shouldered adzes and these types were associated with specific migrations or diffusion events. By contrast this paper will compare shouldered and non-shouldered adze forms, whereby 'form' is used to describe an adze with a recognisable shape and morphological features, but avoids any specific cultural or functional associations. Adzes with a shouldered form are defined as adzes which have an invasive removal of stone material from their lateral margins. This removal demarcates the poll from the shaft so that the margin is discontinuous separated by a shoulder and a tang. Adzes of a non-shouldered form, by contrast have continuous, uninterrupted margins. This paper examines the traditional dichotomy of shouldered and non-shouldered types, using the methodological framework of the reduction thesis.

Approaches to Reduction

The traditional typological approach to stone tools has been labelled as a 'segmented' model of implement variation (Hiscock and Attenbrow 2002, 2005). However, the 'continuum' model recognises that morphological variation is a continuous process which is strongly affected by reduction processes, and thus overlap in implement forms may occur (Hiscock and Attenbrow 2002, 2005). The process of reduction has been conceived as a 'staged reduction sequence' in which stone tool forms are associated with particular stages of reduction (Hoffman 1985), or alternatively as a 'reduction continuum' which lacks defined stages (Shott 1996; Sullivan and Rozen 1985). A number of studies have developed methods for measuring reduction on flaked stone tools (Blades 2003; Clarkson 2002; Clarkson and Lamb 2005; Dibble 1984, 1987; Grimes and Grimes 1985; Kuhn 1990, for example). Together these methods and theoretical perspectives have been described as the 'reduction thesis' (Shott 2005). The reduction thesis appears to have great utility in the interpretation of Southeast Asian stone tool assemblages (Marwick, this volume).

A number of methods have been devised for measuring reduction on flaked stone artefacts, however, measuring reduction on ground stone percussive implements, such as axes and adzes, is far from straightforward, as grinding technology tends to obliterate previous modification and resharpening events. Lekberg's (2000) study of shaft-hole axes from central Sweden is significant because he used length to measure reduction. Using length in this way is problematic because there is no absolute means of knowing original length at time of manufacture. However, in some cases, there are clear indications that the implement was previously larger. For instance, Lekberg observed that a small polished vertical groove in the butt end, or a heart shaped butt end, was evidence that a shaft-hole axe had been reworked from a larger axe fragment (Lekberg 2000: 156). Length as a measure of reduction is not absolute, but is useful for aggregate data analysis.

Ban Non Wat

Ban Non Wat is a mound site, approximately 400 metres in diameter (Fig. 1), elevated several metres above the surrounding rice fields and encircled by two concentric earthworks (Boyd, Higham, and McGrath 1999; Boyd and McGrath 2001; Boyd, McGrath, and Higham 1999; McGrath and Boyd 2001). The site is located in Nakhon Ratchasima province on the Khorat Plateau of northeast Thailand (15°16' N, 102°17' E) and contains primarily a Neolithic and Bronze Age cemetery, with associated occupation contexts. The excavation is over 500 square metres in area and has an average depth of 5 metres. The Ban Non Wat excavation is one of the largest prehistoric excavations conducted in mainland Southeast Asia.

The adze assemblage is derived from the Neolithic and early Bronze Age layers and includes 125 near-complete ground stone adze heads. The adzes analysed in this paper are made from metamorphic facies rocks, including meta-andesitic tuff and meta-basalt. The source area/s for the adze raw material is still under investigation. Although high terrace gravels comprising of metamorphic facies cobbles have been reported within 30 kilometres of Ban Non Wat (Parry 1996), their size, accessibility and suitability for adze production has yet to be ascertained. Another source area for metamorphic facies rocks is located in the Petchabun ranges, around 150 kilometres from Ban Non Wat.

METHODOLOGY

Reduction was examined using adze dimensions, cross-sections and shoulder forms. The adze dimensions measured are shown in Fig. 2. For shouldered adzes, the shoulder shape or form was recorded. Different shoulder forms observed in assemblages from Thailand include: flaked, gradual sloping, slight, curved, defined sloping and square (Table 1 and Fig. 3). Shoulder forms in Fig. 3 have been roughly grouped into less invasive and more invasive categories. Whereby less invasive shoulder forms involve less stone removal and may have required less skill than the more invasive and refined shoulder types. It has been suggested that square shoulders were produced by attrition sawing and therefore would have required additional knowledge and skills for their manufacture (Duff 1970). For non-shouldered adzes shaft

Table 1: Definitions of Shoulder Forms.

Shoulder Form	Shoulder Descriptions	
Flaked Shoulder	A flaked shoulder is a shoulder which has only been added to the adze by the removal of flakes. A flaked shoulder may be added during the manufacturing stage or at a later time during the life history of the adze, such as, when a polished adze is broken during use and a shoulder is added to a broken fragment to refit the piece to the haft.	
	Manufactured Flaked Shoulder	A shoulder which has been added during the process of adze manufacture by removing flakes from the adze blank and was initiated before the surface of the adze was ground.
	Flaked Modification Shoulder	A shoulder which has been added by the removal of flakes after the adze was ground and is a later modification to the ground stone adze. There is a clear junction between the edge of the negative flake scar and the ground surface which indicates the flake was removed after the surface was ground. Duff's typology included a similar shoulder type which he labelled a Pseudo-shoulder Grip (Duff 1970: 8).
Gradual Sloping Shoulder	Gradual sloping shoulders form only a very shallow tang on the adze, with only a small distinction between shaft and tang.	
Slight Shoulders	Slight shoulders were formed by the removal of a small amount of stone from the lateral margins, have a distinct junction between shaft and shoulder, and have a curved and roughly perpendicular junction between the shoulder and the tang (Figure 2).	
Curved Shoulder	Curved shoulders are more invasive than slight shoulders. Curved shoulders involve a greater amount of stone removal (than slight shoulders) and have a curved and roughly perpendicular junction between the shoulder and the tang.	
Defined Sloping Shoulder	A defined sloping shoulder is a shoulder that slopes at an obtuse angle to the tang. Unlike a gradual sloping shoulder, the junction between the shoulder and tang can be easily discerned.	
Square Shoulder	In a square shoulder the junction between the tang and shoulder is perpendicular, and highly defined. It is likely that in some regions square type shoulders were created by a sawing technique (Duff 1970: 14).	

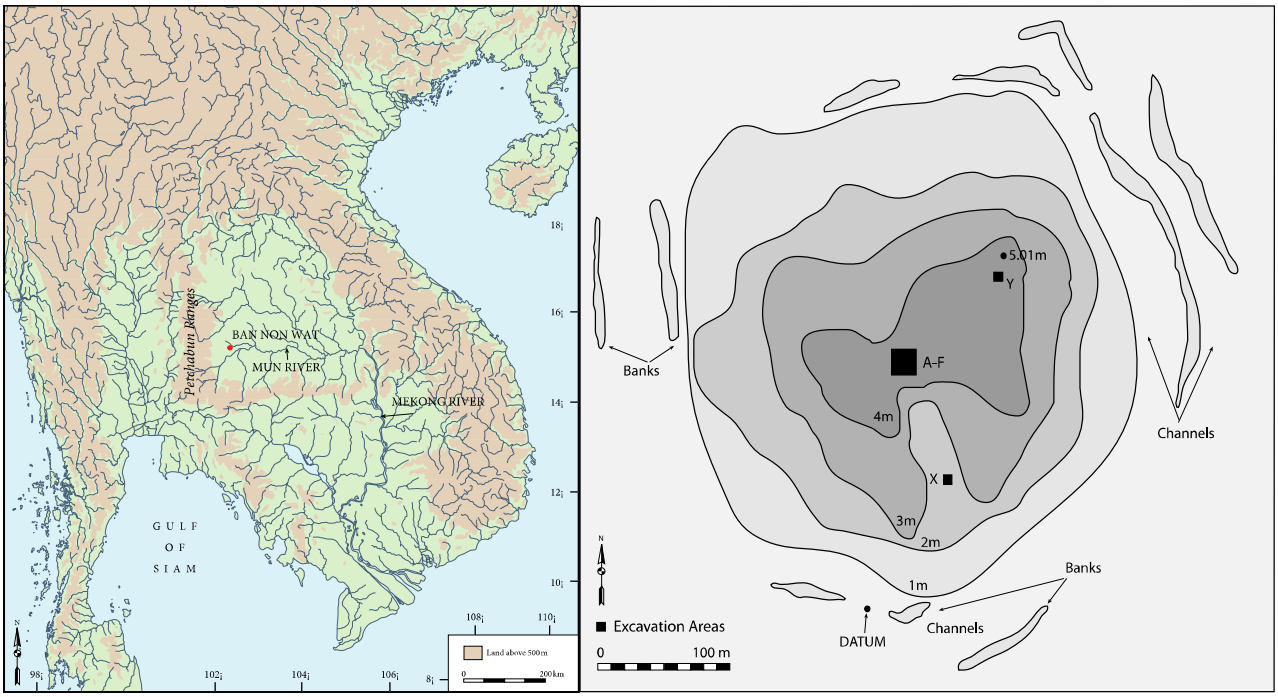

Figure 1: Location of Ban Non Wat (left) and detail of excavation areas within the mound (right)

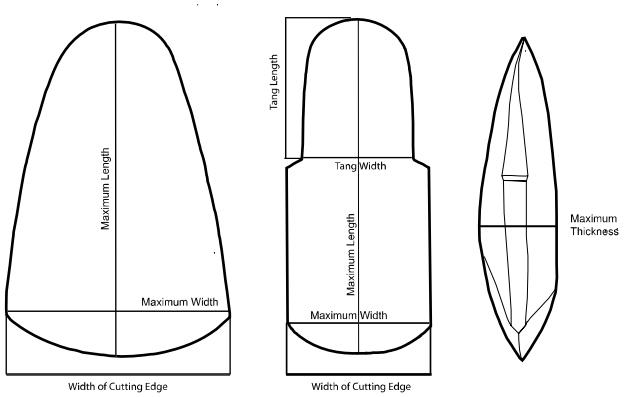

Figure 2: Measurements

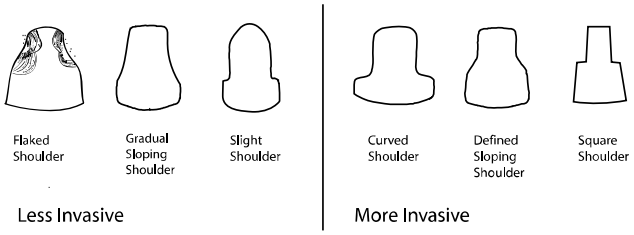

Figure 3: Adze shoulder forms

cross-section was recorded at the midpoint of the length (Fig. 4). Both tang and shaft cross-sections were recorded on shouldered adzes, as for most adzes cross-section shape varied between the tang and the shaft. Cross-section shapes observed included lenticular, ovoid, plano-convex, sub- rectangular and rectangular (Fig. 4).

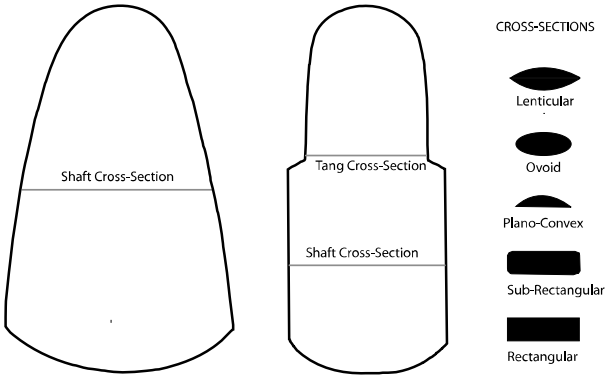

Figure 4: Locations of adze cross-sections. On shouldered adzes both tang cross-section and shaft cross-section were recorded.

The analysis was undertaken on 125 'complete' adzes. These adzes are not necessarily in their original or pristine condition, as in many cases there was some damage particularly along the blade. Adzes were defined as complete if they had a blade and poll.

RESULTS

Initial comparisons of adze dimensions show that the shouldered and non-shouldered adzes are fairly similar. There is little variation of thickness between the shouldered adzes (15.5±2.3 mm, range 11.6 mm to 23.0 mm, n=37) and the non-shouldered adzes (15.0±2.1 mm, range 9.8 to 19.0 mm, n=88). Likewise, there is no significant difference between these thicknesses (t=1.181, df=123, p=0.2398). Bickler and Turner (2002:29) define adzes as 'thin' when the thickness at the midpoint (of the length) is less than twice the width. By this classification, 99.2% of the shouldered and non-shouldered adzes are thin. Experimental work suggests that the functional capability of an adze is related to its thickness (Turner 2005: 93). The uniform thickness of shouldered and non-shouldered adzes at Ban Non Wat suggests that they had similar functions and had probably been applied to similar woodworking tasks.

The adzes from Ban Non Wat are generally small. The mean length of the complete adzes is 53±14 mm (range 26 to 135 mm) and mean weight is 48±24 grams (range 6.37 to 138.82 gm). When length, width and thickness are compared, shouldered and non-shouldered adzes do not cluster separately, rather their distributions overlap (Fig. 5). Thus again there appears to be no substantial differ

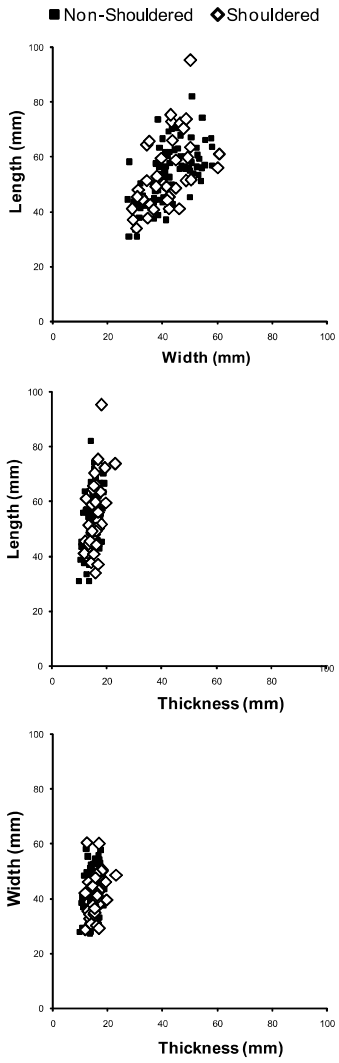

Figure 5: Comparison of metric dimensions between non-shouldered (n=88) and shouldered adzes (n=37)

ence between the shouldered and the non-shouldered adzes.

Analysis suggests that a reduction continuum involving a transition from shouldered to non-shouldered adzes exists in the Ban Non Wat adze assemblage. As the adze is reduced through re-sharpening, the shaft section reduces in size relative to the shoulder and tang section of the adze. At some point during reduction the shaft section is completely ground away and only a small remnant lip of the shoulder remains and takes on the form of a transitional stage adze (Fig. 6). If the adze continues to be used and resharpened, this remnant lip is completely removed and the 'shouldered' adze becomes a non-shouldered adze. The maximum tang length of an adze can be used to specify a length threshold for the detection of shouldered adzes in assemblages. That is, non-shouldered adzes shorter than the maximum tang length may have once been shouldered, but the shoulder has been exhausted by the continuous resharpening of the blade, or by breakage. For convenience this threshold will be referred to as the 'shoulder exhaustion threshold.' At Ban Non Wat the maximum tang length was 59.7, thus the shoulder exhaustion threshold was around 60 mm (Fig. 7).

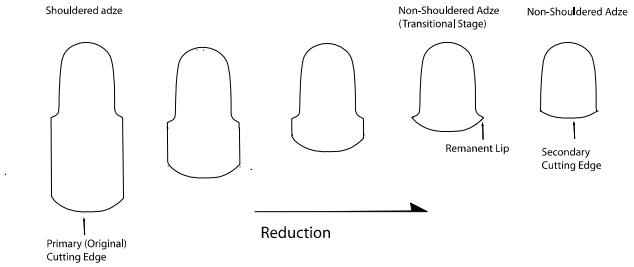

Figure 6: A possible reduction continuum for shouldered adzes to non-shouldered adzes

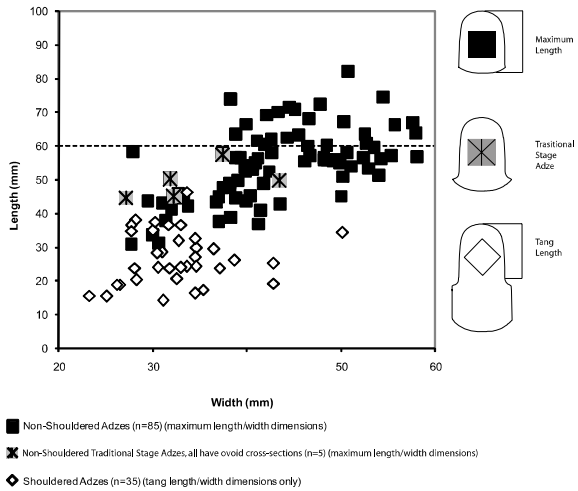

Figure 7: The 'shoulder exhaustion threshold' (dotted line) indicates the length threshold beyond which shouldered adzes may transform into non-shouldered adzes.

The majority of shouldered adzes at Ban Non Wat had an ovoid tang cross-section (97%). Thus it would be expected that adzes that had become non-shouldered through resharpening would have ovoid cross-sections. Fig. 8 shows that almost all the non-shouldered adzes with ovoid cross-sections have lengths less than 60mm and thus are below the shoulder exhaustion threshold. The data suggests that the ovoid-sectioned non-shouldered adzes are the remanent tang/polls of previously shouldered adzes.

A 'static shoulder threshold' also exists, that is, adzes with tang lengths of less than 30 mm will not be transformed into non-shouldered adzes, because 30 mm is the minimum length of a non-shouldered adze at Ban Non Wat (Fig. 8). Thus, the shouldered to non-shouldered reduction continuum does not apply to adzes with a tang length less than 30 mm.

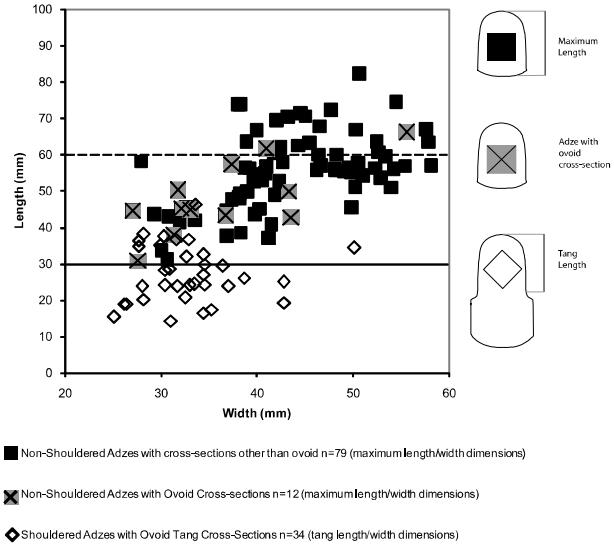

Figure 8: Ovoid cross-sections on some non-shouldered adzes, supports the shouldered to non-shouldered transition (Model 1). The 'static shoulder threshold'(solid line) indicates that shouldered adzes with a tang length of less than 30 mm will always be observed as shouldered adzes, because 30 mm is the minimum length of a non-shouldered adze in the assemblage.

Analysis of the shoulder forms reveals that slight shoulders were the most common and that the less invasive shoulder forms were preferred (Table 2). Less stone is sacrificed in the manufacture of such shoulder types and thus the tang width is of similar width to the shaft. As noted previously, if shoulders are removed from an adze through continual resharpening, then the tang becomes the new (or secondary) cutting edge. Thus if the tang width is maximised by adopting less invasive shouldering forms, then the width of the secondary cutting edge is also

Table 2: Ban Non Wat Shoulder Forms

Shoulder Form	Count	Percentage
Flaked Modification	7	19
Gradual Sloping	10	27
Slight	20	54

Table 3: Slight Shouldered Adzes (n=20) blade lengths and tang widths compared

	Minimum (mm)	Maximum (mm)	Mean (mm)	Standard Deviation (mm)
Original Blade Length	28.5	48.5	38.1	5.8
Tang Width/possible secondary blade length	23.3	39.1	30.4	3.6
Difference between original blade length and tang width/possible secondary blade length	2.0	14.8	7.7	4.0

maximised when the adze is reduced below the shoulder exhaustion threshold. Table 3 summarises the differences between the cutting edge widths and the tang widths (possible secondary cutting edge) for slight shouldered adzes. The mean tang/secondary cutting edge width was 30.4 mm compared to an original mean cutting edge width of 38.1 mm. Thus, on average, the secondary cutting edge for slight shouldered adzes was only 8 mm less than the original cutting edge width. The adoption of less invasive shoulder forms suggests that stone economisation was a factor in the manufacture of shouldered adzes at Ban Non Wat.

DISCUSSION

Reduction can be detected on assemblages that contain shouldered and non-shouldered adzes by comparing their morphology and size dimensions. However, whilst length measurements are useful in detecting reduction they cannot be used as an absolute measure of reduction. It does not follow that small adzes are highly reduced adzes because some adzes may have been manufactured as small adzes from the outset.

To test this proposition, quarries or manufacturing sites would be needed for comparison. Unfortunately, no evidence for manufacturing has been recovered from Ban Non Wat and no quarries or manufacturing sites have been published from the southern portion the Khorat plateau, so comparative material for the immediate region is somewhat constrained. Non Sila Quarry, located around 275 km north of Ban Non Wat, however, provides some comparative information. Discarded adze performs at this site measure between 85 and 170 mm in length and average around 100 mm, as interpreted from the available illustrations (Leyavanija 1992: 38-41; Rutnin 1988: 175-178). The adzes at Ban Non Wat are on average half the size of those from Non Sila. In the absence of information on manufacturing sites closer to Ban Non Wat it is difficult to dismiss the possibility that the adzes at the site were small when manufactured. Evidence of a shouldered to non-shouldered reduction continuum, however, suggests that even if Ban Non Wat adzes were manufactured as small tools they were still substantially reduced.

Data from the adze shoulder forms imply that less invasive shoulders were preferred so that secondary blade lengths could be maximised. This data combined with a substantially reduced assemblage suggests that the ground stone adze reduction strategy aimed to economise the utility of the stone raw material. This implies that access to stone resources at Ban Non Wat were scarce. The procurement system for stone raw material at Ban Non Wat is still under investigation and thus the explanations which could account for the scarcity of stone material can only be hypothesised here. Scarcity of raw material may have been caused by the procurement of materials through an infrequent long distance exchange network from metamorphic outcrops in the Petchabun ranges. Alternatively, closer gravel sources may have been exploited, but may have contained only small quantities of suitable materials for the production of adzes, which would also result in a scarcity of raw material.

CONCLUSIONS

This paper has sought to explore alternate explanations for adze form, which do not rely on the ascription of particular adze typologies. The analysis of shouldered and non-shouldered adze forms using the framework of the reduction thesis has revealed strategies of raw material economisation in the design of ground stone adzes. It appears that the prehistoric occupants of Ban Non Wat were cognisant of reductive processes and capitalised the stone resource by utilising less invasive shouldering techniques. Such patterns of human behaviour would not have been revealed if traditional typological frameworks had been applied, even if their application had been for descriptive purposes only. It is possible that adze types may still be relevant in relation to particular functional tasks, as experimental research in New Zealand has demonstrated (Turner 2000, 2002), but further research is required to show this is the case for adzes in Southeast Asia. It appears that the Ban Non Wat adzes were used for similar woodworking tasks on the basis of their thickness and thus functional differentiation of the adzes appears less relevant for this particular site. Further research into the apparent scarcity of raw material supply to Ban Non Wat is required. However, the results thus far have provided new insights into the design and use of ground stone adzes, insights which would not have been gained had traditional typological frameworks been utilised. The results suggest that the adoption of a reduction thesis methodology has the potential to provide new and exciting directions for the analysis of ground stone adzes in Southeast Asia.

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