THE NON SILA LITHIC ANALYSIS

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An excavation carried out at the site of Non Sila in northeast Thailand indicated that it was a quarry and workshop for the production of unground axe/adze preforms. As far as can be determined the site was in use during Metal Age times, the first millennium BC, and this indicates the persistence of volcanic stone as a cheap alternative raw material to bronze and iron for tool making. The reduction sequence for the preforms appears to be straightforward, involving the hard hammer shaping of easily procured andesitic tuff nuclei.

The site of Non Sila (literally "stone mound") is an axe quarry located about 250 m east of Na Khae village, Udon Thani province, northeast Thailand. It is situated on the crest of a greywacke hill about 60 metres high, part of the Phu Kon Range which rises to a maximum altitude of 827 metres above sea level. The Phu Kon Range is comprised of rhyolite, andesite, tuff, and a volcanic stone agglomerate. The lithic material at the Non Sila quarry was identified as andesitic tuff. The Non Sila hill was used as a military base camp from 1976 to 1978, and numerous defensive bunkers were dug into the archaeological deposit.

The recovery of ground stone axe/adzes in Thailand has been periodically reported since the early 1930s (Evans 1931; Seidenfaden 1941; van Heekeren 1947; Heider 1958). Most of these tools have come from surface collections, and consequently typological studies have often been undertaken without the benefit of stratified samples or secure chronological contexts. During the past twenty years the methods of studying ground stone tools have improved, and the number of specimens collected in Thailand has markedly increased (Sorensen and Hatting 1967; van Heekeren and Knuth 1967; Gorman 1970; Bayard 1970 and 1980; Gorman and Charoenwongsa 1976; Higham and Kijngam 1984).

Studies of ground stone axe/adzes are still rare in Southeast Asia, and remain typological in emphasis. Elsewhere in the world functional analyses, petrological studies for the purpose of identifying trade and exchange networks, and the reconstruction of reduction sequences have provided many new data about these artefacts and the circumstances of their manufacture and use.

IPPA Bulletin 12, 1992:32-43

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Only a few studies of prehistoric stone flaking have been reported from Thailand (Bayard 1980:86; White and Gorman 1979), and these deal mainly with "Hoabinhian" assemblages of volcanic rocks and coarse-grained silicious material, rather than with axe/adze production. A Pleistocene and Holocene assemblage of flakes and cores made from chert and silicified shale has recently been excavated by Anderson (1987:184-198) in southern Thailand. Bayard (1980:84) has reported that a variety of rock types was exploited for making Hoabinhian tools at the Mekhong Riverbank site at Chiang Khan village, 47 km west of Non Sila.

AIMS AND METHODOLOGY OF THE STUDY

The aims of this study are threefold: to explain the quarrying method used at the Non Sila quarry; to identify the reduction sequence of stone axe/adze production; and to derive behavioural information that may be evident from the reduction sequence.

My methods centred on the technological analysis of the debitage at the Non Sila quarry, which includes cores, blanks, preforms and flakes, both from excavations and surface collections. A computer analysis using the Statistical Package for Social Sciences (SPSS) programme has been applied in this study in order to test a hypothesized reduction sequence determined intuitively, and to see whether there was any change in the reduction sequence through time.

The present study on the Non Sila quarry is a new venture for lithic studies in Thailand because no quarry site has previously been studied from a technological viewpoint. The only report on stone axe/adze manufacturing sites in Thailand, by Prishanchit and his colleagues (1985), refers to a number of manufacturing sites in Nan and Uttaradit provinces, and in Obluang district of Chiangmai province, northern Thailand. It includes illustrations of stone tools and debitage, but there is no technological analysis of axe/adze manufacturing. Prishanchit and his colleagues have postulated that their sites indicate a continuation of some elements of the "Hoabinhian technocomplex" in Thailand. However, if the tools being manufactured at these sites are ground stone axes or adzes, which is probably the case, there need be no link with the Hoabinhian at all.

THE NON SILA QUARRY COMPLEX

Altogether, three excavation squares, fourteen test pits and nine scraped sections were excavated at Non Sila, and all visible sections were recorded. The stratigraphic levels were organised into five layers, based on cultural and natural features. Only layer 3 contained *in situ* archaeological materials. The highest layers, 1a and 1b, accumulated through the construction of the military base on the hill. Spoil originating from the construction of the bunkers was piled on top of layer 2. This layer was the original land surface prior to the army's construction activities in 1976-78. As a result, stone artefacts from the main artefactual layer 3 were redeposited on the surface of the hill by the soldiers.

The southeast part of the site was shown to be the main area of artefact discard, both by surface collection and subsequent excavation, and it is presumed that this area

corresponds to the area of most intense axe/adze manufacturing. No artefactual material or other evidence of human activity was seen below layer 3. The fine reddish-yellow silty clay with white and yellow mottles that comprises layer 4 is a decomposed bedrock horizon. The platy andesitic tuff of Layer 5 is believed to be the major source of raw material used by the tool knappers, though the rocks of layer 5 visible in the section are heavily weathered and no direct evidence of quarrying in this layer was observed in the areas excavated.

There is no direct evidence from surface inspection or from excavation at the site to indicate the precise source of the tuff used for axe/adze-making. Evidence of deep quarrying activities, such as shafts or substantial pits, was not detected during the exploration of the hill. It is probable that exposed block material of layer 5 (Figure 1) was collected from the sides and possibly the top of the hill. Procurement of the stone may have involved some digging, and if this is the case then the angular shape of the blocks would have made it easy to lever them out of the parent rock, as described by McBryde (1984) for Mt. William in southeast Australia. Today, veins of andesitic tuff occur just below the surface of the hill, and are easily accessible.

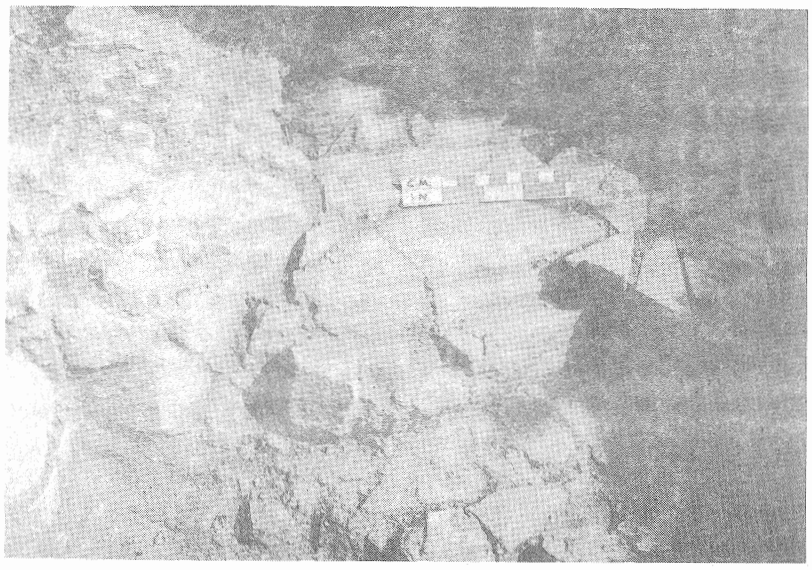

FIGURE 1: WEATHERED ANDESITIC TUFF EXPOSED AFTER REMOVAL OF QUARRY DEBRIS DURING EXCAVATION AT NON SILA

One charcoal sample was collected from the 50-60 cm level within the quarry debitage of layer 3, in the northwest corner of square A. This sample was found underneath stone flakes in the quarry debris layer, and its stratigraphic context suggests that the sample was approximately contemporary with the formation of the layer. The date for the sample is

2400±190 BP (ANU-4040), equivalent to an approximate corrected age range of 855±40 BC (Klein et. al. 1982). Iron was available in Thailand for at least part of the time that the quarry was in use. The manufacture of stone tools when iron tools were available suggests that the new material was perhaps still too difficult to acquire or too expensive for the inhabitants of this inland hilly region of Thailand. Stone axe/adzes were found in graves at Non Nok Tha also dating to the first millennium BC. Here, where metal was more freely available, such artefacts may have been heirlooms or have served ritual function (see Burton 1984a and 1984b for highland New Guinea parallels).

A large quantity of debitage, i.e. cores, blanks, preforms and flakes, was found scattered across the surface of the site, over an area of 30 x 40 m, and also found *in situ* in the sections exposed in the bunker walls. The blanks found in the Non Sila quarry ere naturally cleaved rocks of different shapes and sizes. The knappers presumably selected their blanks with desired shapes and sizes for flaking. To manufacture axe/adzes of a standard shape and size it is appropriate to select tool blanks that themselves tend towards a standard form. In relation to the Non Sila quarry it is probably also the case that the nature of the available raw material, its mechanical properties and its tabular blocky shape, predicated the reduction sequence at least to some extent, and perhaps also had an influence on the formal shapes and sizes of the finished tools (see Leach 1981; Jones 1984).

It is notable that no finished ground axe/adzes were recovered. Most of the preforms in the surface collection were clearly production failures, being either too thick or thin, or transversely broken pieces. A number of artefacts similar in appearance to the so-called "short axe" reported for Hoabinhian assemblages (Bellwood 1978:69) were found in the flaking debitage at Non Sila, but given their context they were unquestionably transversely broken axe/adze preforms; that is, they were production failures (see Olausson 1983). This kind of breakage pattern is very common for partly completed preforms in axe quarries in Australia, such as Mt. William (I.M. McBryde, pers. comm.; 1984).

THE QUESTION OF HABITATION AT NON SILA

When Non Sila was first surveyed in 1983 the main aim of the work was to determine whether the site was an open habitation site of the Hoabinhian "technocomplex" (Gorman 1970; Bayard 1980). The excavations that followed in 1984 were similarly conducted in the expectation that the results would shed some light on this question.

Apart from the axe/adze-making debitage, stone artefacts that might indicate other activities were not found in the surface collections at or around the quarry, or in the excavated material; nor was there any other habitation debris, such as faunal remains or potsherds. Confining the narrow Na Khae Valley are the two ranges of Phu Kon and Phu Luang. Many parts of the hilly terrain around Na Khae village are still primary forests. While the flat area of the valley is used for wet rice agriculture, the rest of the hilly land is used for swidden cultivation of upland rice and other crops. Even today, intensive agriculture is quite difficult in the area because of its topography.

In prehistoric times the area must have been agriculturally peripheral, and intensive wet rice agriculture would probably have begun in the valley at a fairly late date. Because of this, a dense population would not be expected in the area in early times. The lack of archaeological evidence for habitation strongly suggests that Non Sila quarry served only as a source of raw material and was possibly visited for very short periods to make axe/adze blanks. The finished axe/adze preforms must have been taken away to one or more nearby sites for grinding and, if used locally, for hafting. None of these sites, whether settlements or specialised grinding locales at creeks, were located during my archaeological reconnaissance of the region. Significantly, not a single finished and polished axe/adze, whole or broken, was discovered during the collection of surface material or the subsequent excavations at Non Sila.

Thus the Non Sila quarry is unlike the prehistoric copper mining complex at Phu Lon, 50 km north of Non Sila quarry, where evidence for both mining and domestic activities were encountered (Pigott 1984). The artefacts from Phu Lon found in clearing the fill of a shaft mine included red-slipped ceramic pedestal vessels that may have served as food or water containers or lamps, or which may have been associated with rituals. The radiocarbon dates from this site indicate that it was occupied during the first half of the first millennium BC. The site is at least partly contemporary with axe/adze-making at the Non Sila quarry.

The range of artefacts found at the Phu Lon site indicates habitation by the people who worked at the quarry. This combination of quarrying activity and habitation is in contrast to the specialised quarrying activity without habitation evident at the Non Sila site. Copper mining at Phu Lon appears to comprise intensive sustained procurement and processing activities, whereas axe/adze-making at Non Sila was evidently a sporadic or intermittent activity of short duration that did not require living at the quarry or possibly even craft specialisation.

THE NON SILA RAW MATERIAL

It was readily apparent from *ad hoc* experiments on the stone at the site that the andesitic tuff has a relatively low fracture toughness and is therefore easy to flake. It is also unable to sustain very heavy-duty use. The Non Sila preforms were prepared for the production of partially or completely polished tools, though there is no strong evidence to indicate whether the finished tools were designed to serve as axe or adze heads, or as both (see Blackwood 1950). While it is possible to distinguish an axe from an adze by the shape and position of the cutting edge and evidence of use-wear (Semenov 1964:123-125), there is no sample of utilised axe/adzes from the Non Sila quarry available for this kind of study.

The Non Sila sedimentary andesitic tuff has natural cleavages which occur both horizontally and vertically. The rock is normally greenish-blue when it is freshly broken, but all artefacts from the Non Sila collection display surface weathering that is buff to light yellowish-brown in colour. Sometimes it is difficult to distinguish between the original cortex of the artefacts and patination that has occurred on a surface after flaking, and in such instances other features of the artefacts were used to confirm identifications.

The primary classification of the blanks from the quarry is based on cross-section. The blanks can be grouped into five shape categories: triangular and sub-triangular; square; rectangular; trapezoidal and irregular. Blank size is also an important attribute in axe/adze manufacturing (Leach 1981:181; Jones 1984:250). Some relationships between the cross-sectional shapes and the sizes of the blanks and preforms from Non Sila can be observed. The original geometric form of a blank is a result of weathering and natural fracturing processes. The knappers had to choose the best blanks from a wide range of potential materials for axe/adze manufacturing to proceed successfully.

For this study, an attempt was made to compare the cross sections of natural blanks (or blanks with some flakes removed) with the cross-sections of the more advanced preforms. One hundred and seventy-two preforms were identified in the surface collection at Non Sila. Some are made on cores, others from large flakes.

In general, the small preforms (30-200 grammes), made from either cores or large flakes, have lenticular cross-sections, with a few being sub-triangular. The large preforms (201-699 grammes), however, have more varied types of cross-section: square, rectangular, sub-triangular, oval, lenticular and semi-lenticular (Figures 2-5). The small lenticular cross-sectioned specimens could have been flaked from blanks with any shape of original cross-section, but since they have been flaked so extensively it is no longer possible to identify the original blank shapes and sizes. However, the large preforms, especially those displaying some cortex, generally preserve the original blank cross-sections more clearly. The lenticular sectioned small preforms seem to be the most finished, and appear, in terms of desired preform shapes, to have been the aim of the knapping process.

Even though finished axe/adzes and whetstones or grindstones have not been encountered at Non Sila, they have been found at prehistoric habitation sites within the general region. A number of ground stone axe/adzes (sixty-seven) were collected during my general survey of western Udon Thani and Loei provinces, particularly from a cluster of sites located about one hundred kilometres south of Non Sila. It was not possible to analyse petrologically the majority of these artefacts, many of which are of stone that is basically similar in appearance to the andesitic rhyolite at Non Sila. Therefore, at this stage, the possibility that some of these artefacts are from the Non Sila quarry or from a quarry in the same andesite formation cannot be excluded.

THE AXE/ADZE MANUFACTURING REDUCTION SEQUENCE

The stone materials recovered from surface collection and excavation at Non Sila include blanks, flakes, cores, preforms and debitage. The collection offers valuable information as almost all manufacturing stages, from unworked blanks, through blanks with a few flake scars, to finished preforms, can be seen in the collection. As a result, a reduction sequence of axe/adze manufacturing at Non Sila can be reconstructed.

Unmodified and partially modified blanks of various sizes and cross-sections are found at the site. Partially modified blanks are those with a few flake scars, still almost totally with cortex. Knappers obviously selected blanks of different sizes from the quarry. Small

FIGURE 2: NON SILA: PREFORMS WITH LENTICULAR CROSS-SECTIONS

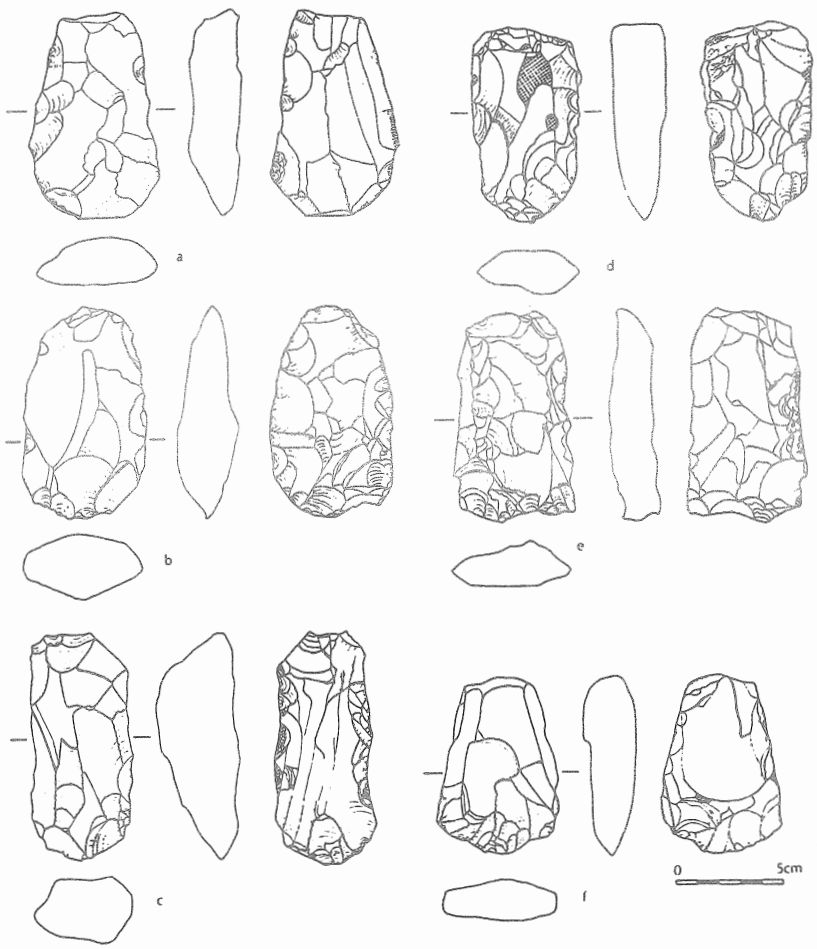

FIGURE 3: NON SILA: PREFORMS WITH OVAL (a,b,c) AND RECTANGULOID (e,f) CROSS-SECTIONS

blanks (200-300 grammes) were used probably because the shapes and sizes were most desirable, requiring only minimum flaking. Preforms which derive from small blanks usually have cortex on some parts of their surface. More work was needed to reduce large blanks into preforms, so preforms derived from large blanks do not usually have any cortex remaining. Some preforms were also made from large flakes; obviously these flakes were struck off large initial blanks.