AN EXERCISE IN EXPERIMENTAL ARCHAEOLOGY ON CHINESE STONE SPADES

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ABSTRACT

Very limited study has been undertaken on ground stone tool technology and its manufacturing processes. The research described in this paper addresses attempts to recreate an ancient Chinese ground stone tool form through experimental archaeology. By mimicking the flake scarring and manufacture-wear patterns identified on the archaeological specimens through experimental knapping, grinding and polishing, a determination of how the originals were produced and the amount of time and effort invested in creating them has been made.

INTRODUCTION

As part of a larger project focusing on the Yilou region of central north China (Liu *et al.* 2004), a recent investigation in experimental archaeology was undertaken on Chinese stone spades. The exercise was designed to (1) explore possible ways of creating the tools that may have been used by the original creators of the archaeological specimens, (2) establish how the archaeological tools were utilised and (3) determine what the tools were used for (see Owen 2006). This paper describes the methodology behind the initial creation of the experimental tools and the results that were produced during their creation.

Since at least the late 1800s, researchers have been experimentally reproducing stone tools of types found in the archaeological record (Ingersoll and Macdonald 1977: xiii; Coles 1979: 162-163). Early work concentrated on the manufacturing techniques used to create replica implements. Later, due largely to the pioneering work of Semenov (1964), analyses were extended to include consideration of the past uses of tools by utilising replicas in a variety of ways to analyse fracture mechanics on different types of stone, and compare wear patterns between archaeological specimens and the replicas (e.g. Kamminga 1977: 205-212; Coles 1979: 165; Keeley 1980: 3; Odell and Odell-Vereecken 1980: 87-120; Knutsson 1988; Richards 1988: 4-9; Fullagar 1991: 1-24; Grace 1996: 209). However, limited experimental research has been undertaken on ground stone technology. It appears that most ground stone tools have been ascribed a function and given a name on the basis of their morphological characteristics without further research being applied.

The term spade, given to the tools under examination for this study, is a label that has been attributed to them at some stage in the past without the knowledge of what they actually are. Testing this presumed function was the having tools of the same type as the archaeological specimens, such tests could not be done. Therefore, the re-creation of the tool type was necessary.

The archaeological tools investigated for this research were recovered from the 25-hectare site of Huizui during initial excavations in 1959, survey of the site in 2001 and a further three seasons of more recent survey and excavation (Ford 2001: 12; Liu *et al.* 2004: 90). Huizui has been dated to between the Yangshao (c. 5000-3000 BC) and Zhou (1046-221 BC) periods in the region, and is believed to be a spade-manufacturing site (Ford 2001: 50; 66, Liu *et al.* 2004: 91; Chen 2005; Liu 2006a: 180-181; Liu *et al.* this volume). The majority (greater than 90%) of spades collected from Huizui were of oolitic dolomite (Chen 2005; Webb *et al.* this volume) and their finished form is usually highly polished.

The finished tools are elongate, narrow and relatively flat (Ford 2001: 24), with a slightly convex 'blade' at their distal end (Figure 1). Both finished and blank formsof the tool were examined during this study, though the proximal end is usually missing from the archaeological samples. However, the few tools identified with this end present indicate that it is flat and blunt.

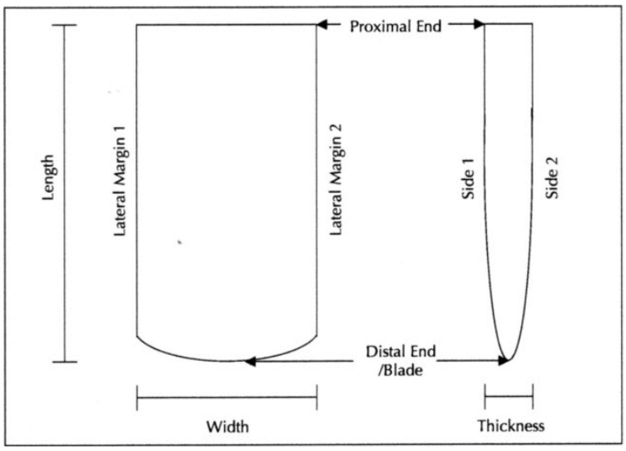

Figure 1. Terms and system used in the description and measurements of the tools.

The lateral margins of the tools are straight in their length and have a convex cross section, although some are slightly tapered towards either the distal or proximal end. Some examples that have been recorded as spades, possess a hole drilled through the body of the tool nearer the flat, blunt end (Ford 2001: 25; Liu 2006b), though none of those accessed for this study possessed this feature.

To address the issues to be investigated for the experimental manufacture of the tools, the archaeological samples were examined for manufacture-wear. Each relevant stage of manufacture identified was photographed so that they could be referenced and compared during the experimental re-creation.

To achieve the most accurate comparisons of manufacture-wear between the archaeological and experimental tools, similar raw materials from the region of Huizui were sought for the experimental manufacturing processes. Oolitic dolomite, river cobbles and sandstone from natural sources local to Huizui were collected and sent to Australia for this reason (Figure 2). Because Huizui is believed to be a spade manufacturing location, and these raw materials have all been collected from the site, they are thought to be those used for the manufacture of the tools. In particular, the dolomite available from nearby quarry locations in the Songshan Mountains is a layered (greater than 80 millimetres thick) outcrop, making it an ideal thickness to begin manufacture of the tools (see Webb *et al.* 2007: this volume). The raw materials sent from China were therefore utilised in the attempt to re-create the archaeological tool form in a manner that could have been used in the past.

Figure 2. Raw materials sent to Australia from China for this project.

Initial field research was undertaken on the archaeological specimens at the Henan Provincial Institute of Cultural Relics and Archaeology, and the Huizui Archaeology Station, Institute of Archaeology, Chinese Academy of Social Sciences. At these locations, the archaeological specimens represented all stages of the manufacturing process, which were closely examined and photographed. The photographic record was used as reference for the later production of the experimental tools. Each tool had its sides, lateral margins and ends photographed. Where applicable, additional photographs were taken of the specific stages of manufacture-wear.

STAGES OF MANUFACTURE

Through specific observation and practical experimentation in the re-creation process of this study, five stages of manufacture were identified. They consist of:

Stage 1: Initial quarrying of stone raw material;

Stage 2: Crudely shaping/knapping of quarried raw material so as to achieve a size and shape suitable for the next stage of processing (this stage creates the initial 'blank' of the tool);

Stage 3: Further shaping via finer knapping of edges and ridges, together with hammerdressing to achieve a form that is ready for the next stage;

Stage 4: Grinding the surface of the tools to further refine the desired shape and size of the tool;

Stage 5: Final polishing of the tool.

Within Stages 4 and 5, it is likely that several 'sub-stages' existed. Through the experiments, it was found beneficial to process the stone during these stages using materials of differing grades of coarseness. This is discussed in more detail below.

Overall, nine experimental tools were created during the project. However, only two were processed using solely Chinese materials.

METHODOLOGY AND RESULTS

For knapping the dolomite, experiments were conducted using different types of stone cobbles that were sent from China specifically for the task. One particular diabase cobble (John Webb, Department of Earth Sciences, La Trobe University, pers. comm. 2006) was chosen as the preferred tool due to its comfortable weight and size, and its more robust nature compared with the other stones available. This cobble was found to be sufficient for all stages of knapping and hammerdressing (Figure 3).

Figure 3. Diabase cobble used for knapping and hammerdressing the experimental tools.

Stage 2 of the manufacturing process (crude shaping/knapping), involved striking the proximal end, distal end and lateral margins with the hammerstone at an angle of approximately 45° to the surface of the raw material. This process shaped and, in effect, thinned the raw material to a size that was workable in the next stage. The blows were not made with great force as the raw material flaked quite easily. The distal end received more flaking during this stage to reduce the stones' mass closer to the desired blade form.

Stage 3 (fine knapping/hammerdressing) required softer striking of the stone so that only small flakes were struck from the blank, thus avoiding intrusive scarring that would have made the later stages more difficult. When striking prominent ridges or edges for removal during this stage, a similar striking angle to that of Stage 2 (i.e. 45°) was used. However, if such ridges only needed flattening or rounding without too much of the surface being removed, hammerdressing with direct blows (90°) proved most successful. When hammerdressing the body of the tool, glancing blows at a much greater angle proved to be more effective (Figure 4). The use of glancing blows rather than direct hits also seemed to reduce the risk of cracking or breaking the blank, as was experienced when practicing this stage before attempting to manufacture the experimental tools.

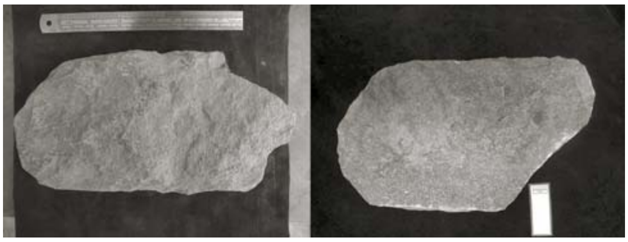

Figure 4. A comparison of an archaeological tool blank (left) and an experimental blank.

The debitage from manufacturing Stages 2 and 3 was collected to establish if differences were observable that could possibly be identified in the archaeological record (Figure 5). The Stage 2 process created large angular fragments of stone (greater than 80 millimetres in maximum dimension) and flakes ranging in size from large (greater than 40 millimetres) to small (less than 5 millimetres), whereas the Stage 3 mostly created flakes of small and medium size, and only one large flake.

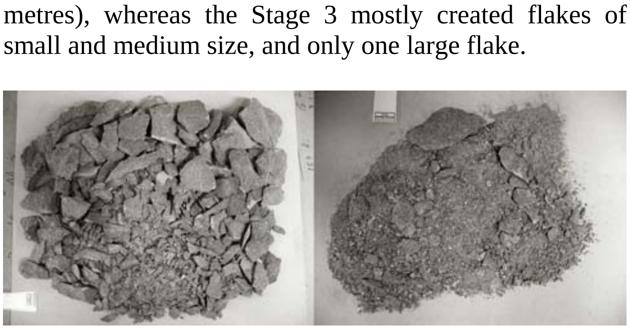

Figure 5. Examples of debitage created during the manufacturing Stages 2 (left) and 3 of a single experimental tool.

Only two experimental tools (Experimental Tools 1 and 2) were manufactured using the processes of Stages 2 and 3. Although an in-depth study of the debitage was not carried out, measurements of the largest and smallest pieces were considered (Table 1). All measurements of the debitage were taken in the same manner as the tools (Figure 1), however the proximal end was considered to be where the striking platform was present and the distal end was the flakes termination. Only lengths, widths and thicknesses of the selected debitage were recorded.

The largest fragments of stone produced during Stage 2 of the experimental tool production were 87.5 x 60.1 x 27.5 millimetres, and 238.5 x 150.7 x 45.5 millimetres respectively. The largest flakes produced during Stage 2 were 41.0 x 39.5 x 6.2 millimetres for Experimental Tool 1 and 35.9 x 35.8 x 11.9 millimetres for Experimental Tool 2.

During the hammerdressing of Stage 3, only one large flake was produced from Experimental Tool 2 and measured 43.1 x 21.1 x 3.3 millimetres. The largest flake produced from Experimental Tool 1 during the same stage was 9.6 x 12.9 x 2.5 millimetres.

For Experimental Tools 1 and 2, the smallest flakes produced during both Stages 2 and 3 of manufacture were less than one millimetre. Both Stages also created a fine dust from the stones used throughout the process. The hammerstone used during the process also received damage in the form of pitting and small flaking (Figure 3) causing detached parts of its mass to become mixed with the overall debitage.

As the Stage 2 process created a full range of debitage sizes, it would be impossible to distinguish Stage 3 debitage from Stage 2 debitage if it were mixed together. However, the lack of larger sized debitage in the Stage 3 process could make it identifiable if it was kept separate from the Stage 2 debitage.

Grinding and Polishing

Two types of stone possessing different grades of coarseness were sent from China for the experimental grinding/polishing of the tools. One is coarse-grained feldspathic white sandstone (John Webb pers. comm. 2006) collected from the quarry 1km south of Huizui and the other fine-grained purple sandstone obtained from the quarry east of Huizui. Both were effective in altering the surface of the limestone, however the fine-grained sandstone created a semi-polish rather than being effective as a grindstone. Therefore, the coarse-grained feldspathic sandstone was utilised as the grindstone of choice.

The grinding process involved resting the grindstone on the ground and rubbing the limestone across its surface (Figure 6). The flattest face of the grindstone was utilised for this purpose. It was found that adding water was more beneficial than grinding the stones dry, because the small 'troughs' evident on the surface of the grindstone would quickly fill with the fine particles/dust created during the grinding. The dust filled troughs located between the working ridges of the grindstone, creating a smoother and less effective grinding surface. It is also likely that the

Table 1. Largest and smallest debitage sizes produced during Stages 2 and 3 of the manufacturing process (all measurements are in millimetres).

Experimental tool #	Largest fragment	Largest flake	Smallest flake
Stage 2 - Crude Shaping			
1	87.5 x 60.1 x 27.5	41.0 x 39.5 x 6.2	< 1
2	238.5 x 150.7 x 45.5	35.9 x 35.8 x 11.9	< 1
Stage 3 - Hammerdressing			
1	-	9.6 x 12.9 x 2.5	< 1
2	-	43.1 x 21.1 x 6.3	< 1

Figure 6. Author attempting to polish an experimentally created spade blank using solely Chinese raw materials (Photograph by Li Liu).

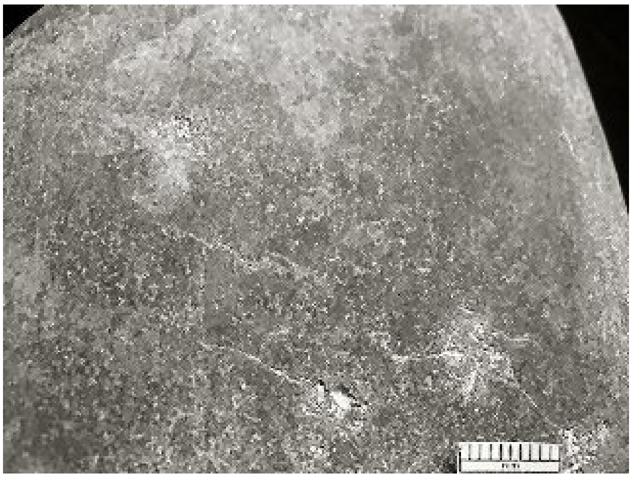

Figure 7. Semi-polish/matt finish achieved using Chinese materials.

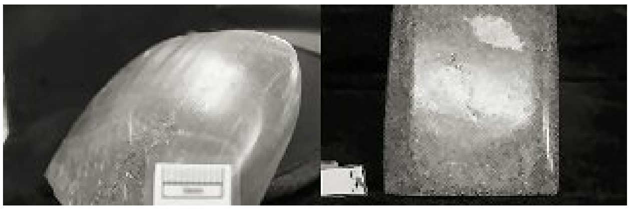

Figure 8. An example of polish on an archaeological tool (left) and an experimental tool created with the use of power tools.

dust particles came between the working and worked surfaces, thus further interfering with the effectiveness of the grindstone. Frequently adding a small amount of water to the surface and rubbing it over with one's hand quickly dispelled the dust and improved the grindstones effectiveness.

Unfortunately, due to the laborious and time consuming process of hand grinding the stone to the relevant size and shape, most of the tools were eventually ground using electric hand-held and bench grinders. Modern tools were utilised to create the finished experimental forms so that further experimental research could be carried out.

When polishing was attempted, only a semi-polish/matt finish could be created with the materials available from China. This was achieved by applying the fine-grained sandstone in the same manner as the grindstone (Figure 7).

As with the grinding process, the polishing of the experimental tools was completed using modern tools and material. By first rubbing the ground surfaces of the tools with gradually decreasing levels of coarse 'wet and dry' sand paper (from 100 to 400 to 800 to 2,000 grade), the tools were then polished on a bench grinder with a polishing wheel attached. A *Josco* white SS polishing compound was also added to this final process to create a lustrous finish similar to that found on most of the finished archaeological tools (Figure 8).

When grinding and polishing, it was found that by beginning with the coarsest material, and then changing to less coarse materials in turn, a better finish was achieved. Additionally, the less difference between one grade of coarseness to the next made the process easier and more successful. When a coarse grade is used, more material is taken off the stone, enabling quicker reduction of its mass than using a finer grade. As the grades become finer, less material is taken off and less visible alteration is done to the surface of the stone, eventually leading to a smooth finish. When attempting to use a fine grade immediately after a coarse grade, striations left by the coarse grade are not removed and remain visible. Therefore, each step from the most coarse grade through to polishing reduces the surface alteration inflicted by the previous grade more quickly than if a fine grade is immediately used after a coarse grade.

However, it was found that the sandstone used for the grinding process became less efficient the more it was used. Even when adding water and cleaning the surface, the working 'ridges' (quartz inclusions) tended to flatten and/or become rounded the more the limestone was rubbed across it. For a grindstone to keep its effectiveness over a long period of time, its surface would need to be constantly roughened with some sort of abrasive, broken to reveal a new coarse surface, or discarded for another stone. The grinding and polishing processes were found to be very labour intensive and time consuming, taking over eight hours without successfully producing the desired polish finish (Figure 6).

How the polish was achieved on the stones in antiquity was not determined during this study. After unsuccessful attempts to create the desired polish-finish with the Chinese materials available for this study, it was found likely that the makers of these tools utilised different materials in antiquity to grind and polish the stone, employed a mechanical method to achieve the finish, or were simply very patient and persistent in their task. However, there is no evidence of a mechanical devise that could perform this task in the archaeological record from the time period that they were being produced. Additionally, it could take up to two days to create a tool using the methods employed during this study, which seems like a very significant investment of time and effort given that the function of the polish may be merely aesthetic, or possibly symbolic.

Lu *et al.* (2005: 1-12) have raised the possibility that hard abrasives, such as corundum (ruby, sapphire) and/or diamond were used to create the polish that is found on the tools in antiquity. Although their research was on a different material and style of tool from southern China, the experiments undertaken were successful in re-creating similar polish on experimental tools to that found on the archaeological specimens examined during this study. Additionally, Lu *et al.* discuss an ancient technique where "fatty animal hide" is used to separate diamond from surrounding rock material. In this process, "the diamonds adhere to the grease while the rest of the rock washes away" (Lu *et al.*: 10). This method, along with the suggestion by a modern stonemason that oil or fat would have been added to achieve such a polish (Adam Mackinnon, Blake Brothers, Melbourne, pers. comm. 2006) could be a clue to the processes used to create it. Therefore it is possible that these or similar materials were used for polishing the spades.

CONCLUSION

Overall, this experiment in the attempted re-creation of an ancient Chinese stone tool form has had both success and failure. The experimental tools were successfully created to the final two stages of manufacture. A blank form of the tools was created in a time efficient manner using only raw materials local to the site of Huizui.

Only the grinding and polishing stages were not achieved utilising the available Chinese materials. Therefore, further research is needed in the possible processes of grinding and polishing of stone tools in China to determine how such finishes were achieved in antiquity.

The collection and initial recording of the debitage created during Stages 2 and 3 of the manufacturing process demonstrated the possibility of identifying manufacturing sites in the archaeological record. If sites show potential as spade manufacturing sites, careful excavation and collection of deposits, followed by examination of the debitage found therein, could prove beneficial in identifying manufacturing stone remains. However, further study in quantifying debotage using similar experimental processes as that used here is needed to determine the possible benefits of such research.

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