# Chapter 16

# More than Fun and Games? An Experimental Study of Worked Bone Astragali from Two Middle Bronze Age Hungarian Sites

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Dense, compact astragali are ideal raw materials that likely served a variety of functions in the past. Astragali have most often been interpreted as gaming and ritual artifacts at archaeological sites (Gilmour 1997). Building upon previous worked bone studies, a comparison of archaeological wear on astragali and experimentally-produced wear was undertaken to investigate several functional interpretations of these artifacts. Multiple lines of evidence derived from use-wear and experimental studies indicate that astragali were likely used as ceramic burnishers at the Middle Bronze Age sites of Zagyvapálfalva-Homokbanya and Kisterenye-Hársas in Hungary. However, astragali were still potentially multipurpose objects.

*Keywords*
Bronze Age Hungary; usewear analysis; astragali; experimental archaeology; ceramic burnishing.

## Introduction

Ungulate astragali were frequently chosen as raw materials to serve a variety of functions in the past due to their dense, compact structure and aesthetically-pleasing symmetrical shape (Dandoy 2006; Brien 1982). These hind limb bones have most often been interpreted as gaming pieces and religious artifacts, such as divination pieces, at archaeological sites from diverse time periods beginning in the Chalcolithic at sites in the Near East (Gilmour 1997; Dandoy 2006), Mediterranean Europe (Reese 2000) and contact period sites in North America (Lewis 1990). More recent interpretations have suggested that medio-laterally polished astragali functioned as hide softeners (Bejenaru *et al.* 2010) or ceramic burnishers (Choyke and Bartosiewicz 2009; Meier 2009; S. Olsen pers. comm. 9 August, 2009). This paper documents use wear and experimental studies conducted to test these recent hypotheses. These findings offer new insight into the function of astragali artifacts at the Middle Bronze Age sites of Zagyvapálfalva-Homokbanya and Kisterenye-Hársas in Hungary.

Modified astragali have been recovered from a wide range of time periods and geographic areas and, not surprisingly, have been interpreted in a variety of ways. The modified astragali are frequently flattened on the medial and lateral sides and are often associated with gaming, cultic or ritual activities. This interpretation has been applied to astragalus bones with smoothed sides from the Middle Bronze Age site of Megiddo, Israel and from Alishar Huyuk, Turkey (Gilmour 1997). The traditional interpretation of astragali as game pieces was influenced by classical period sculptures depicting

individuals playing knuckle bone games (Newton 1874) and ethnographic studies of astragali games (Lovett *et al.*1901). Flattened astragali have also been called counting objects or tokens of exchange based on contextual information. These include medio-laterally ground astragali found in Iron Age domestic storerooms at Tel Beersheba, Israel (Sasson 2007). Modified astragali have also been interpreted as amulets, such as the drilled astragali found in Late Bronze Age to medieval levels at Gordion in Turkey (Dandoy 2006). The significance of these pieces is attested by the manufacture of amulet copies of the modified bones. For example, flattened and drilled caprine astragali were recovered at the same site as glass and ivory jewelry imitations of flattened astragali in the Classical Greek occupation levels at Heracleia (Brien 1982). Flattened astragali were also found associated with marble replicas in the Central Asian Bronze Age site of Bactria-Margiana (Hiebert 1994).

Modified astragali have been recovered from several sites in Hungary with extensive, ongoing worked bone research programs (Choyke and Schibler 2007). Like in other regions, culturally modified astragali recovered from several Bronze Age sites in Hungary have previously been interpreted as counting, gaming or time-keeping pieces (Bartosiewicz 1999). Medio-laterally abraded and polished astragali recovered from the Bronze Age sites of Jászdózsa-Kápolnahalom and Nagyrév (Choyke and Bartosiewicz 2009) were interpreted similarly. Twenty-six flattened astragali were also recovered from the sites of Zagyvapálfalva-Homokbanya (Fig. 16.1) and Kisterenye-Hársas. These were studied as part of a Master's thesis on the worked bone assemblages from the two sites (Meier 2009). The worked astragali were selected for the experimental study reported here, because despite widespread interpretations, no experimental wear studies have yet been conducted to test the hypotheses of their functions.

Furthermore, the astragali artifacts studied are of special interest, because they derive from sites that are among the first in Hungary to keep faunal material for study (Bartosiewicz and Gal 2010). The assemblages lack detailed contextual information due to the early date of these excavations and this limits the functional interpretations of the flattened astragali. Moreover, only worked bones were saved during the excavations. Even so, the collection of these bone artifacts marks an important methodological development in the history of Hungarian zooarchaeology and an experimental wear study was conducted to gain more information about the potential of these landmark artefacts.

A total of 26 worked astragali were recovered from Zagyvapálfalva-Homokbanya (Fig 16.1) and Kisterenye-Hársas, 13 from each site. The astragali from the two sites

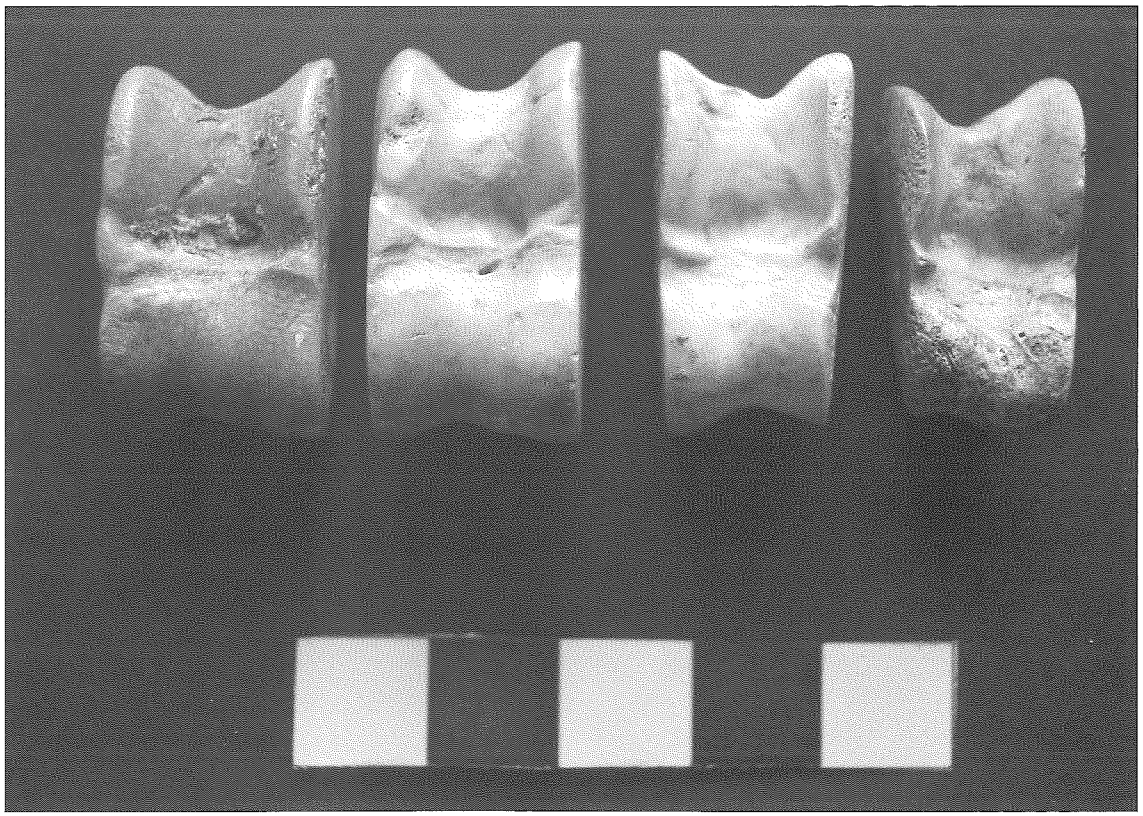

*Figure 16.1 Examples of flattened astragali from Zagyvapálfalva-Homokbanya.*

originated nearly entirely from sheep and goat, but often could not be identified to taxon because of the high degree of modification on the bones. The Zagyvapálfalva-Homokbanya sample is identified as goat (N=1), sheep (N=3), sheep/goat (N=8) and medium-sized ungulate (N=1), while the astragali from Kisterenye-Hársas were identified as sheep/goat (N=12) and sheep (N=1).

A preliminary usewear study of the astragali artifacts from Zagyvapálfalva-Homokbanya and Kisterenye-Hársas suggests that they were handheld and abraded flat on a coarse granular surface such as ceramic or treated hide (S. Olsen pers. comm. 9 August, 2009; Meier 2009). Hide and ceramic processing industries are evidenced by the presence of hide scrapers made of antler (Bartosiewicz 2009) and burnished ceramic vessels (Guba 2009) on these sites, thus the astragali wear could have developed during their use as tools for either activity. Additionally, unmodified astragali have flat medial and lateral surfaces with convex outer margins that are similar in shape to the beveled edges of many long bone tools typically utilized in these industries in the Bronze Age (Choyke 2000; Christidou and Legrand 2005). Building upon the preliminary analysis of the artifact wear and evidence of site-level industries, an experimental study was developed with the following four objectives:

1. To investigate potential functions of the astragali as scrapers or burnishers by comparing the wear on archaeological specimens to wear produced on experimentally worked astragali.
2. To determine if astragali are efficient tools for ceramic and hide processing.
3. To use experimentation to isolate three factors that affect the appearance of wear on astragali: the type of material worked, the moisture level of the material and duration of use.
4. To determine the most likely combination of factors that produced the artifact wear through comparison of the archaeological specimens and experimentally-produced wear.

## Methods

The possible functions of the flattened astragali from Zagyvapálfalva-Homokbanya and Kisterenye-Hársas were investigated by using modern astragali on four different working surfaces. Four domestic goat astragali were used to work each of the following materials for 120 minutes each: moist clay, leather hard clay, soaked deer hide, and dried deer hide. Both the medial and lateral sides of each astragalus were experimentally worked. The reconstruction of the worked materials and the manner in which the astragali were used in the past was based on archaeological evidence and previous experimental bone tool studies (Griffiths 2006; Christidou and Legrand 2005). The methods employed to recreate the past activities in which the artifact wear potentially developed are described to demonstrate the comparability of the resulting wear.

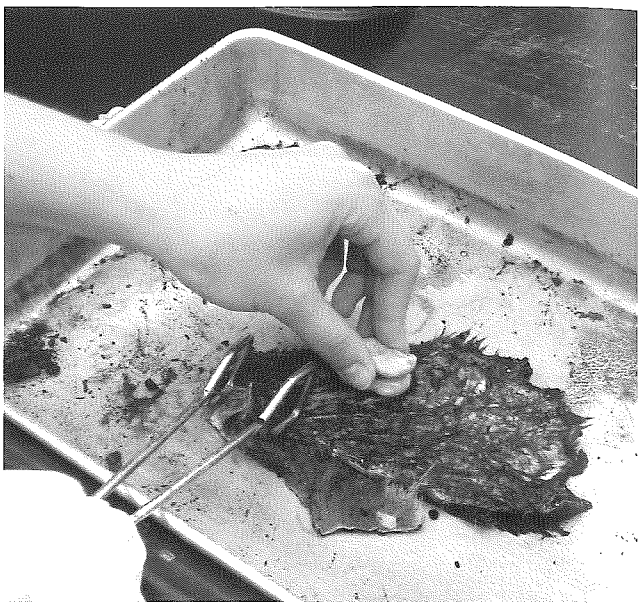

*Figure 16.2 Astragalus used to work wet hide.*

For the most part, the clay and hide materials were prepared in a manner that best replicated the archaeological materials found at the two sites. The hardness and particle size of ceramic vessels from the two sites were recreated by adding minerals and temper grog to OM Ban Clay. The ceramic chemical formula specifications were derived from analysis of the fabric composition of pots from a nearby (~200 m) cemetery dated within 50 years of the two sites (Orsolya 2009). Coil-built clay cylinders mimicking the shape and diameter of the pots were manufactured and either dried until leather hard or kept moist. Next, deer hind limbs were obtained from the Massachusetts Wildlife Department. Hide was removed from the legs and prepared by soaking in an ash solution (Griffiths 2006) or by defleshing and drying. The wet and dry sections of the two materials were then worked with astragali.

Goat astragali were held as indicated by the circular handling polish on the astragali artifacts (Fig. 16.2) and applied to the material with moderate pressure. The abraded lateral and medial aspects of all experimentally worked bones were examined every 10 minutes at 10×, 20×, 30× and 40× magnification and every 30 minutes at 65× magnification on a Nikon SMZ800 stereomicroscope. Characteristics of the resultant wear were noted in detail.

## Results

### *Preliminary analysis of archaeological wear*

The function of the astragali artifacts from the two sites was assessed by comparing the intensity, extent and type of wear present to that on experimentally worked astragali. Both optical

and backscatter imaging (Fig. 16.3) were used to observe the wear on the flattened surfaces of the astragali artifacts. Heavy wear and polish was noted macroscopically on the medial and lateral sides of the artifacts. A pattern of diagonally striated wear, with some micropitting and cracking was observed on the magnified surfaces (Table 16.1). There was no evidence that the sides were flattened by cutting. Two circular areas of handling polish were present on most of the artifacts, which suggests that two fingers gripped the bones by the dorsal and ventral sides as in Figure 16.2. It appears that the abrasive use of astragali on a gritty material resulted in striated wear and considerable volume deformation of the surfaces. This preliminary hypothesis of the artifact function was further investigated using experimental archaeology.

*Table 16.1 Description of wear variation by material worked (120 minutes).*

| Type of Material Worked Artifact Wear | | Astragali | Dry hide | Wet clay | Leather-hard clay | Wet hide |
|---|---|---|---|---|---|---|
| | | *Least Grit* → | | | *Most Grit* | |
| Intensity of Wear | | Heavy | Rare | Light | Heavy | Heavy |
| Extent of Wear | | Entire Medial & Lateral Surface | Outer Margins Only | Entire Medial & Lateral Surface | Entire Medial & Lateral Surface | Outer Margins Only |
| Pitting | *% of Total Wear* | Moderate–High (40–60%) | None | Low (< 5 %) | Moderate (30–40%) | High (> 80%) |
| | *Size* | Micropits | N/A | Micropits | Micropits | Micropits and Craters |
| Striations | *% of Total Wear* | >90% | Few | ~50% | >90% | <50% |
| | *Average Length (% of astragalus)* | 25% | 5–10% | 50% | 10–25% | 5–10% |
| | *Outline* | Shallow; sharp margins | Shallow | Shallow, sharp margins | Shallow; sharp margins | Deep; broad |
| | *Orientation* | Diagonal | Random | Random; curving | Diagonal | Proximal-Distal |
| Osteons | | Few exposed and rounded by polish | Not exposed | Not Exposed | Moderate amount exposed and polished | Many exposed; sharp outline |
| Polish | | Heavy | Light | Moderate | Heavy | Heavy |

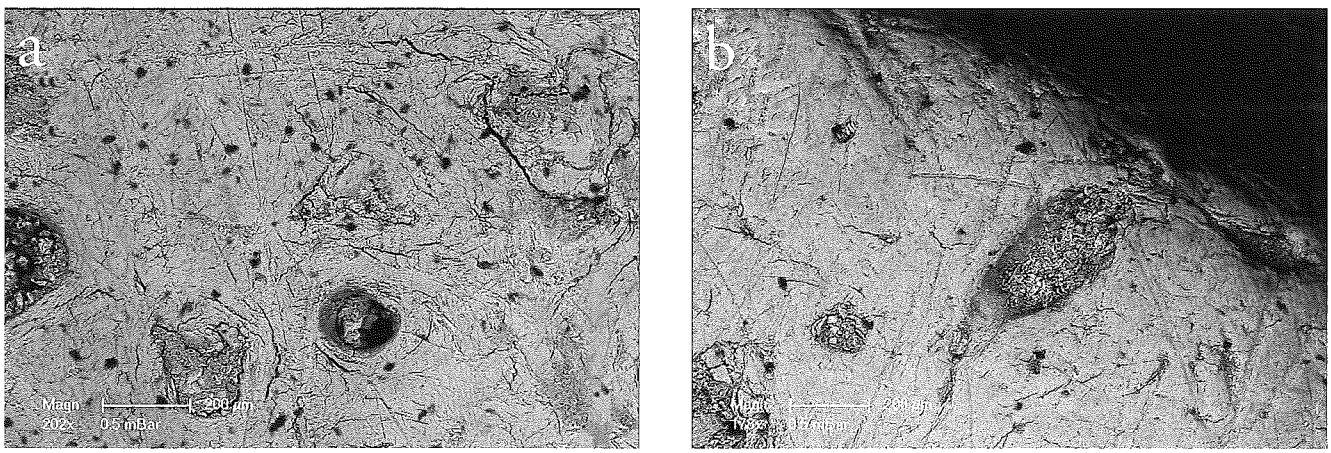


*Figure 16.3 BSI images of worked astragali. a) 92.55.7 (Zagyvapálfalva), b) 92.62.28/1 (Kisterenye).*

### *Analysis of experimentally-produced wear*

The experiment isolated three variables that potentially influenced wear development on the astragali artifacts: type of material worked (ceramic or hide), moisture of material (wet or dry) and duration of use. Working astragali with different combinations of these variables produced distinct wear patterns (Table 16.1). The intensity and extent of the artifact wear were most similar to wear produced by experimentally working leather-hard clay and wet hide. Additionally, polish of the working surface, presence and orientation of striations, and micropitting were observed on the experimental astragali and compared to the astragali artifacts. The characteristics observed on astragali used to work leather-hard clay were most similar to the artifact wear (Table 16.1). Moreover, the ease of using astragali to work the materials was indicative of their potential functions.

### *Intensity of wear*

Astragali experimentally used to work ash-treated wet hide or leather-hard clay exhibited an evenly distributed reduction of the active tool surface. This flattening and heavy wear was similar to that on the astragali artifacts. Diminution of the surface occurred quickly due to the plasticity and softness of the bone in relation to the hardness of the worked material, the abrasive particles on the surface and the pressure applied to the astragalus during use (Lemoine 1994). The hardness of the worked clay was related to the moisture level (Fig. 16.4). Leather-hard clay flattened the astragali surface to a greater extent than wet clay. In contrast, astragali used to work wet hide had more reduced surfaces than those employed in dry hide working (Table 16.2). In summary, these results indicate that the degree of surface reduction was affected both by the amount of grit and the moisture level of the material.

### *Extent of wear*

The location of wear on the astragali differed according to the type of material worked. The extent of the wear on astragali used to work the cylinders of leather-hard clay was most similar to the extent of wear on the astragali artifacts (Fig. 16.5). Wear was localized on the margins of the astragali used to work wet hide, but evenly covered the entire medial/lateral side of astragali worked on leather-hard clay material. This difference was related to the manner in which astragali were angled to gain leverage against the slick, tough hide material (Fig. 16.6). In contrast, using the entire surface of the bone was more beneficial for working the interior and exterior of the shaped clay.

*Table 16.2 Surface reduction of astragali by material worked (30 min).*

| Material | Clay | | Hide | |
|---|---|---|---|---|
| Moisture Level | Wet | Leather-Hard | Dry | Wet |
| Reduced Width (average mm) | 0.05 | 0.6 | 0.04 | 0.17 |


*Figure 16.4 Variation in wear due to moisture level. Astragali used to work clay material for 30 minutes. Surface viewed at 20×.*

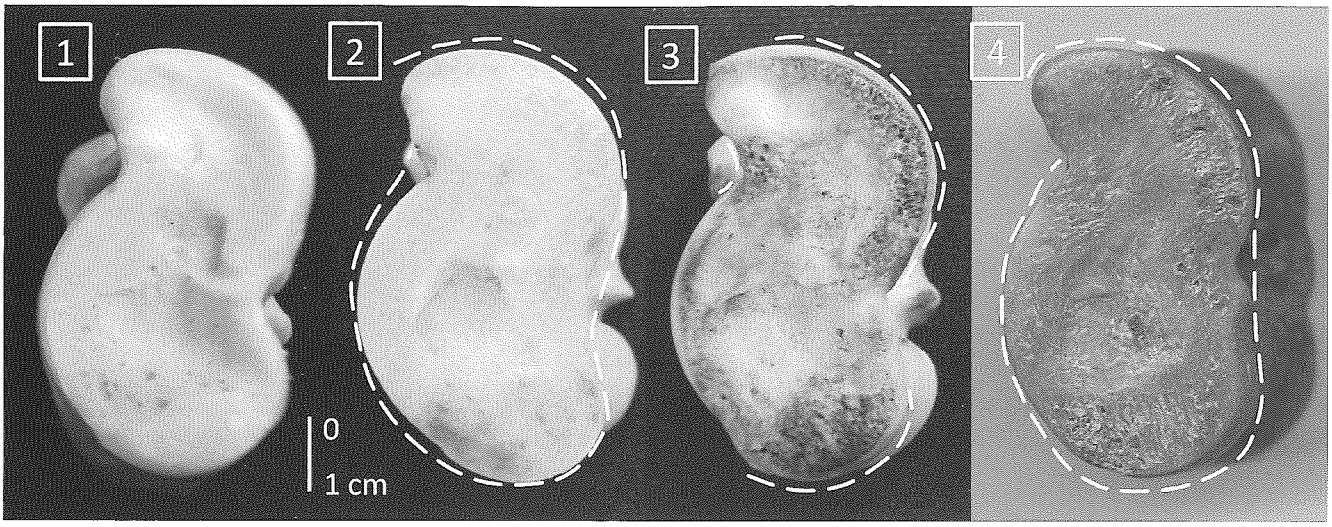


*Figure 16.5 Variation in extent of wear. Lateral aspect (1) control astragalus compared to the same aspect that was experimentally worn by (2) working wet hide and (3) burnishing leather-hard clay and an (4) astragalus artifact. Volume deformation of surface indicated by dashed line. Active tool surface is task-specific.*

## Discussion

### *Ease of use*

Astragali were not effective hide softeners or scrapers when held as indicated by the handling polish. These small bones easily slipped from the hand when moistened by the wet hide and the rounded medial and lateral margins were not sharp enough to remove flesh. In contrast, astragali successfully and efficiently burnished leather-hard clay cylinders. Removal of excess material and smoothing of rough areas was accomplished in a modest amount of time (3 minutes per sq. in/6.45 $cm^2$) and little energy was expended on the work as moderate pressure sufficed for adequate burnishing. Faster burnishing was possible as the working surfaces of astragali were flattened. This effectively resharpened the margins of the abrading medial or lateral side and smoothed the working surface. The results showed that both the medial and lateral sides of astragali effectively functioned as ceramic burnishers.

### *Summary of wear results*

Astragali used to burnish leather-hard clay for 120 minutes exhibited an even reduction of the active tool surface and wear that was similar to the flat surfaces on the artifacts. Volume deformation from hide-working was considerable, but not evenly distributed and thus was dissimilar to the wear on the astragali artifacts. Likewise, wear on astragali used to soften dry hide and smooth wet clay was not similar to the artifact wear. Although the astragali used to work wet clay had a similar pattern of striated wear as the artifacts, the level of volume deformation was not comparable. Similarly, the surface volume was not reduced on the astragali used to soften dry hide and striations were scarce.

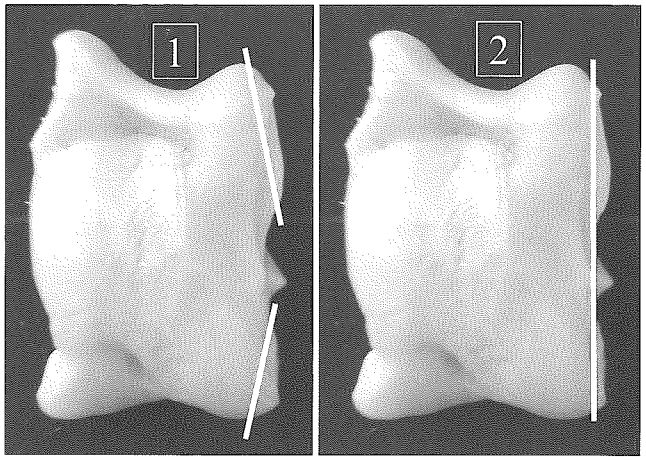


*Figure 16.6 Extent of wear by function. Areas of lateral surface flattened by (1) working wet hide and (2) burnishing leather-hard clay indicated by white line on control astragali.*

Not only were the astragali used as burnishers efficient and easy to use, but they became more productive as their duration of use increased. The margins of the astragali became sharper with use as working the leather-hard ceramic removed the outmost features of the bone. In contrast, astragali easily slipped from the hand while working wet hide, and were not effective defleshers.

## Conclusion

The experimental study indicates that wear on the flat astragali artifacts is most consistent with wear produced when astragali were used as ceramic burnishers. A comparison of artifact and experimentally-produced wear reduces the problem of

equifinality, yet astragali were still potentially multipurpose objects. It is also possible that the astragali were smoothed on ceramic surfaces, but not as a part of burnishing. For example, astragali could have been worn on a ceramic surface solely to modify the bones, because astragali with flattened sides have a more random outcome when rolled as dice than unaltered astragali (Lorenson 1947; *in* Lewis 1988). However, the ease of using astragali as ceramic burnishers and the manner that they resharpen with use supports this functional interpretation. Furthermore, the minimum amount of time required to develop the burnishing wear and surface reduction characteristic of the artifacts was 120 minutes (Fig. 16.7), a considerable period to spend modifying astragali for another purpose. Other evidence for ceramic burnishing at the sites indicates that this process created striations on the surface of vessels (Guba pers. comm). Kiln-firing of the experimentally burnished surfaces and comparison to the ceramic artifact surfaces could further indicate how astragali burnishers modify the surface of ceramic containers. In conclusion, the efficacy and characteristic wear of astragali functioning as ceramic burnishers should be considered in future worked astragali studies.

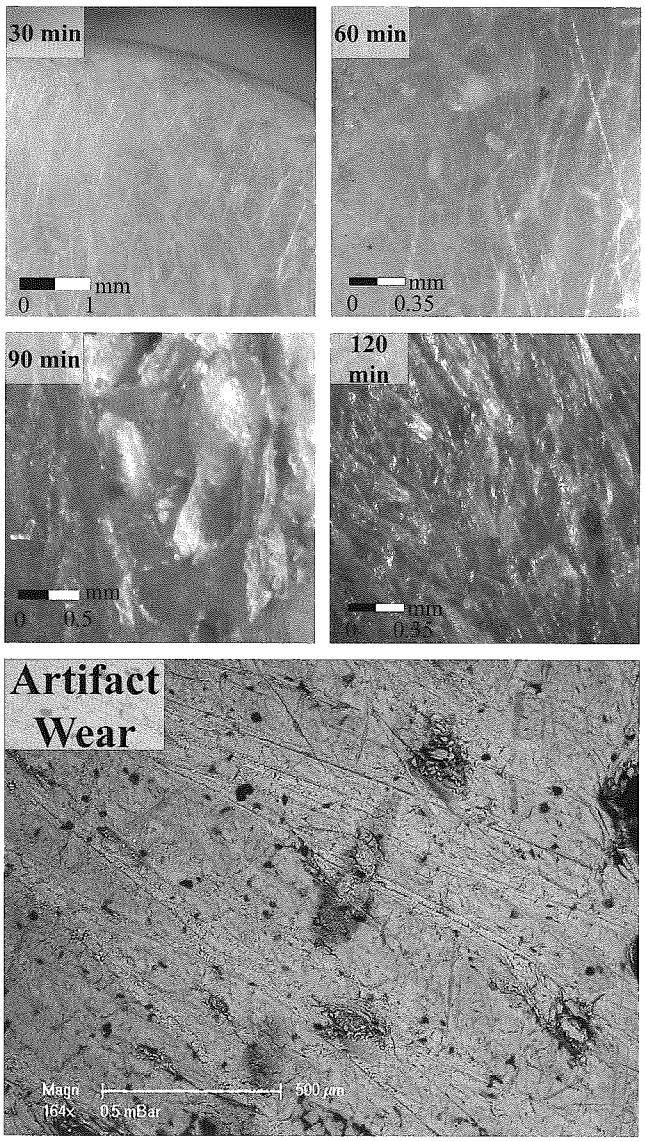


*Figure 16.7 Variation in wear on astragali over duration of use as leather-hard ceramic burnishers in comparison to artefact wear (lateral aspect).*

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