Reviewed Article:

Function Follows Form: Assessing the Functionality of Shells and Greenstone Shell Effigies as Formative Period Mesoamerican Textile Fabrication Tools, Part 1: Tagelus plebeius Atlantic Stout Razor Clam Shells

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Author(s): Billie J. A. Follensbee [1]

[1] Missouri State University, 901 S. National Avenue, Springfield, MO 65806, USA.

Although the importance of textiles in Mesoamerica from the Classic period (AD 250-900) onward is well-recognised, until recently little research or exploration of earlier

Mesoamerican textile production has been conducted. This paucity of scholarship is attributable predominantly to the scant preservation of perishable ancient tools and textiles. New sources of information have been recognized, however, in the re-identification of a number of Pre-Classic/Formative period (1500 BC-AD 250) stone objects as high-status versions of tools used for fabricating textiles. Some of these ancient objects, such as spindle whorls and weaving awls, are readily identifiable as tools because closely comparable, preserved counterparts are found in later Mesoamerican cultures. Other potential tools may be less obvious, however, since early tools were often derived from natural objects that were adopted and repurposed for specific tasks because of their serendipitously appropriate form; stone versions of these tools may, therefore, be indistinguishable from stone effigies of the natural objects. One Pre-Classic/Formative period stone effigy that may in fact be a tool takes the form of an elongated bivalve shell; not only are these shell effigies pierced for suspension in the same manner as artifacts that have been identified as elite tools but the effigies – and perhaps the shells themselves – are also depicted in ancient stone sculpture illustrating high-status individuals who wear the stone artifacts and/or the shells in the same manner as tools are worn. Experimental archaeology has been used successfully to test reproductions of stone artifacts as textile-making tools, and this methodology may also therefore serve as a pragmatic method for testing actual natural objects – in this case, the shells – as textile-making tools.

> “The results of these experiments establish that, despite their somewhat delicate appearance, even modified and polished Tagelus plebeius shells remain strong and durable, withstanding sustained use as tools, and that these shells serve as practical and efficient tools…

Review of the Research

Scholarship of the past century has demonstrated that textiles have long played an important role in Mesoamerica, from the Classic period (AD 250-900) through contemporary cultures. Archaeological evidence preserved in the arid caves of northern Mexico confirm that textile production began much earlier, however, with extant examples of cordage, basketry, and netting by 6500 BC (MacNeish *et al.,* 1967, p.191, p.217), potsherd impressions of loom-woven fabrics by 1500 BC, and extant examples of cloth made with yucca, cotton, and cotton-blend fibers by 900 BC (Johnson, 1971, pp.297-321; MacNeish *et al.,* 1967, pp.191-193, 217-223; Vaillant, 1930, pp. 38, 188; Vaillant, 1939, p.170; Wilkerson, 2001, p.325). Nevertheless, only recently have studies begun to explore the importance of textiles prior to the Classic period, and this paucity of research is in great part due to scant preservation in the other regions of Mesoamerica.

On the Gulf Coast of Mesoamerica, where the Gulf Coast Olmec culture flourished during the early and middle eras of the Formative/Pre-Classic period (1500 BC-AD 250), the tropical environments and acidic soils have yielded little direct evidence of textiles. Just a few fragments of cordage and remnants of twill-patterned woven mats are extant, serendipitously preserved in an anaerobic spring (Ortíz Ceballos *et al.,* 1997, pp.56–65; Rodríguez Martínez *et al,.* 1994, pp.23–27), and only two textile-impressed potsherds have survived (Drucker, 1952, Plate 22e; Pohl *et al.,* 2019). Nevertheless, the rich pictorial evidence of fibers, nets, and woven cloth in Olmec and in Olmec-related ceramic and stone sculptures clearly attests to the production of elaborate fabric and clothing by these early cultures (See Figure 1a. La Venta Monument 13; Figure 1b. La Venta Monument 19; Figure 1c. La Venta Stela 5; Figure 2. Seated figure from southern Veracruz). Particularly abundant are depictions of garments composed of cordage, netting, and bands of finely twined or woven cloth that may be knotted, layered, wrapped, or interlaced to form elaborate headdresses, capes, necklaces and scarves, breast bands, crossed chest bands, armbands, wide belts, narrow belts, belts made of multiple bands, wrapped loincloths with flaps, pubic apron flaps, and leg bands (Follensbee, 2000; 2006; 2008; 2009; 2014; 2017a; 2019a; 2020; 2021; *in press*). Recent research has also established that the Gulf Coast Olmec region was a favorable and productive area for growing and procuring high-quality cotton, fur, and feather fibers in pre-Hispanic times (Stark, 2001, p.336; Stark *et al.,* 1998, pp.10–15, Footnotes 6–8).[1]

As with the ancient textiles, the vast majority of Gulf Coast Olmec objects made of wood, bone, and shell are preserved only in the rarest of circumstances, and ancient textile tools and equipment - which are typically made of these materials - have not survived. The re-analysis of a number of enigmatic small stone objects found in Olmec and early Maya graves and in “heirloom caches” of Formative period stone objects, however, has revealed that Formative period cultures used elite versions of tools and equipment made of “greenstone,” a coveted material in Pre-Columbian Mesoamerica that consisted of any green or bluish-green stone, with the most highly valued greenstone objects consisting of finely crafted jade (Follensbee, 2008, pp.87-88).

Many Formative period greenstone artifacts are readily identifiable as high-status adornments because they take the form of ear spools and flares, pendant ornaments, and beaded necklaces, bracelets, and anklets—adornments that are also clearly depicted in Olmec and Olmec-related sculpture and are found in nearly identical form in the burials, caches, and imagery of later Mesoamerican cultures. Other greenstone objects are much more enigmatic, however, and were initially identified by the excavators simply as “ornaments,” “objects of unknown use,” “miscellaneous objects,” and “implements for mysterious unknown purposes.” Scholars postulated that the more mysterious of these objects may have served as some sort of tools (Coe *et al.,* 1980, pp.240–242; Covarrubias, 1957, p.75; Drucker, 1952, pp.168–171; Drucker, 1955, pp.63–65; Drucker *et al.,* 1959, pp.191–194). Scholars have also long noted that ancient Mesoamerican artisans such as spinners, weavers, scribes, and painters commonly wore the functional tools of their trade as ornament and part of their regalia, as did the patron gods and goddesses of their arts, and that high-status versions of tools were made in prestige materials (Follensbee, 2008; McCafferty *et al*., 1994, pp.147–148; McCafferty et al., 2008; Kerr, 1994).

Re-analysis of the Formative period greenstone artifacts has revealed, in fact, that a number of these objects are closely comparable both in form and in functionality to tools that were used for spinning, netting, and weaving in later Mesoamerican cultures (Follensbee, 2008; 2015; 2017a; 2017b; 2018, 2019a, 2019b), while others have recently been identified as possible loom weights and/or twining tools[2] (Follensbee, 2020; 2021). These identifications of greenstone artifacts as functional tools have been substantially bolstered by recent studies of Pre-Columbian greenstone artifacts from other Mesoamerican cultures that have been identified as elite, but clearly utilitarian, versions of tools: Among other artifacts, several small greenstone celts from Middle Formative period (900-300 BC) caches at the Maya site of Ceibal have clearly identifiable use-wear confirming that they were used as woodworking tools (Aoyama *et al.,* 2017), and a jade gouge tool that fitted into a Classic period rosewood handle was found at the Maya site of Ek Way Nal (McKillop *et al.,* 2019).[3]

Other Formative period greenstone artifacts have remained enigmatic, however, because they do not have clear counterparts in later Mesoamerican societies. Although many of these objects are often dismissed as ornaments, some – particularly the effigies of natural objects – may yet turn out to have been utilitarian, for many early tools were derived from natural objects whose original form, or only slightly modified form, was well-suited for adoption and repurposing for specific tasks. Clear examples of such tools in ancient cultures would include river cobbles that were repurposed as hammerstones; antler tines repurposed as billet tools; broken animal bones that were repurposed as stilettos and awls; and large thorns used as weaving picks. Likewise, early greenstone artifacts that take the form of natural objects, while originally assumed to be simply ornamental effigies, may in fact represent utilitarian tools. Among these possible tools is a type of Formative period greenstone artifact that has long been identified as an effigy of an elongated bivalve shell, frequently referred to as a "clam shell"[4] (Andrews, 1986; Andrews, 1987; Covarrubias, 1946, p.172; Covarrubias, 1957, p.75; Drucker, 1955: Plates 49-50, Plate 36e and 40a-a'; Pohorilenko, 1981, pp.320-321; Stirling *et al.,* 1942, pp.640-641, 649).

The easy identification of these concave artifacts as effigies of clam shells rests in the widespread use of shell in the Pre-Columbian Americas, which is well-documented in the archaeological record as well as in ancient painting and sculpture. A wide variety of marine and lacustrine shells were imported, carved, and traded throughout ancient Mesoamerica by the Early Formative period, where shells were used in unmodified form as well as in intricately carved and polished form for a variety of purposes, from high-status, ritual ornament, to musical instruments, to utilitarian tools (e.g., Andrews, 1969; Bell, 2002; Domenici, 2017; Emery *et al.,* 2007; Feinman *et al..* 1995; Flannery, 2010; Grove, 1987; Hepp, 2019; Hohmann, 2002; Kidder *et al.,* 1946; Masson *et al,.* 2012; McKillop, 1984; Moholy-Nagy, 1985; Nuttall, 1975; Pillsbury *et al.,* 2017; Saturno *et al.,* 2005; Turner, 2020; Wheeler Pires-Ferreira, 1978).

At least 37 provenienced greenstone clam shell effigy pectorals or pendants have been recovered from Formative period Olmec, Olmec-related, and Maya sites and caches. The vast majority of these shell effigies consist of concave shells that are uniformly roundrect (rectangular with rounded corners), obround (rectangular with semicircular ends, also known as the stadium shape or pill shape), or oval in silhouette (See Figure 3a. Chacsinkin Jade 23; see Figure 3b. Chacsinkin Jade 26), while others have tapering versions of these silhouettes (See Figure 3c. Chacsinkin Jade 25; see Figure 4. Clam shell effigy from La Venta Mound A-2). The greenstone shell effigies tend to be beautifully carved, with an elegantly curved surface, a pronounced ridge on one side, and even a hinge-like feature at the top, all of which harken back to natural shell forms – but unlike the natural clams native to Mesoamerica, the jade effigies tend to be idealized, with fully intact examples having a perfectly regular silhouette. The concave interior face of the effigies, which according to the sculpted depictions would serve as the front, is also always highly polished, and when a hinge is depicted, this takes a streamlined or even highly stylized form that rarely shows hinge teeth. The greenstone shell effigies are also consistently drilled for suspension, either with a pair of two connected biconical holes drilled through the top and the back of the artifact or with two holes drilled through the shell just under the hinge; both of these types of holes allow the shell to be suspended horizontally by a cord that is hidden on the back of the artifact. When depicted in sculpture, the elongated shells and/or greenstone shell effigies are also worn as pectorals that are idealized as perfectly regular forms (See Figure 5a. La Venta Stela 2; see Figure 6. Incised celt from Guerrero).[5] While some of these depictions are sculpted with an actual concave surface (See Figure 5b. La Venta Throne 5), others may have a flat surface that is incised with a concentric interior line, suggesting both concavity and the reflection of a highly polished interior (See Figure 7. Pijijiapan Monument 1).

With all of these features taken into consideration, the closest natural model for the jade clam shell effigies is the *Tagelus* clam, also known as the Atlantic stout razor clam, most likely of the *plebeius* species (See Figure 8. Natural, unmodified *Tagelus plebeius* shells). Comparison of *Tagelus plebeius* shells to the greenstone clam shell effigies reveals that these are clearly the closest in natural silhouette, convexity, hinge position, and overall form. As the largest of the *Tagelus* shells native to the Olmec, Olmec-related, and Maya regions of Mesoamerica, ranging from five cm to nearly 12 cm in length, *Tagelus plebeius* are also the shell closest in size to the vast majority of the extant provenienced jade clam shell effigies (Sealifebase, 2022).[6]

One possible argument against the identification of *Tagelus plebeius* as the model for the jade clam shell effigies is this shell's dull white exterior and matte, chalky interior. Not only are the jade shell effigies highly polished, but most Mesoamerican shell ornaments also tend to be shiny, colourful, or even lustrous and iridescent, as with *Pteria* and *Pinctada* pearl oyster shells. Nevertheless, Mesoamericans also made both tools and ornaments of dull white shell (e.g., Moholy-Nagy, 1985; McKillop, 1984), and Mesoamerican shell-working artisans also often enhanced the appearance of ornaments by polishing shells that were naturally dull in appearance, such as the widely popular, highly valued red *Spondylus* shell.

As noted previously, marine shells of many types were widely used in ancient Mesoamerica for functional objects as well as for ornament. Different types of bivalves were used in both modified and unmodified forms as spoons and scrapers (Moholy-Nagy, 1985; McKillop, 1984), and archaeological excavations of cultures around the Gulf Coast have recovered clam shells and other shells that were cut into rectangular, roundrect, and obround shapes very much like the natural silhouettes of *Tagelus plebeius*, and that similarly range from 6 to 13.5 cm in length and 1.5 to 5.5 cm in width. Numerous studies of these carved shell objects and of closely similar objects made of wood, bone, and stone have identified these artifacts as netting gauges, which were widely used in the ancient Americas to create fishing and hunting nets with mesh of consistent sizes (Chase *et al.* 2008; Follensbee 2019b; Walker, 2000; see also McKillop, 1984). Another possibility that has been suggested for tools of this form and size is that they served as weaving shuttles (Grove, 1987, p.292). One further possibility only recently explored is that similar, oblong jade artifacts with well-spaced suspension holes may have served as loom weights and/or warp-twining tools (Follensbee, 2020; 2021). The possible use of *Tagelus plebeius* as tools, such as weaving, twining, and/or netting tools, thus merits further exploration and testing through replication studies.

Experimental Archaeology Project

Based on the above background research, this experimental archaeology project has been proposed to use replication studies to test several hypotheses:

1. This study postulates that the Formative period greenstone clam shells are effigies of *Tagelus plebeius* Atlantic stout razor clam shells. While the greenstone shell effigies mimic the natural forms of *Tagelus* shells, both the intact greenstone clam shell effigies and the images of clam shell pectorals in sculpture have regularized, idealized forms, with perfectly oval, obround, roundrect, and sometimes tapered silhouettes – and these perfected, logarithmic curves are a well-known hallmark of Olmec stylistic preferences. As ancient Mesoamericans were adept at working shell, could *Tagelus* shells have been relatively easily modified after their adoption as tools, to make them more regular in shape and, therefore, both more functional and aesthetically pleasing? If so, does this modification affect their strength, durability, and proposed functions?
2. Formative period stone sculpture illustrates figures wearing clam shell pectorals, and this study postulates that both greenstone clam shell effigies and actual *Tagelus* shells may have been worn for display. The greenstone shell effigies consistently have highly polished surfaces, however, and images of clam shell pectorals in stone sculpture are

often depicted with concentric interior incisions that suggest shiny, concave surfaces. Can the naturally dull, chalky *Tagelus* shells be polished to a shine as shown in the greenstone effigies and in the sculpture?

3. Fully intact, provenienced greenstone clam shell effigies have either a pair of biconical suspension holes drilled through the thick hinge area on the back of the artifact or two suspension holes drilled through the shell just underneath the hinge. Formative period stone sculpture depictions likewise illustrate the greenstone shell effigies – and likely the *Tagelus* shells -- being suspended horizontally as pectorals on high-status individuals, with the suspension line hidden behind the shell. Can *Tagelus* shells effectively be drilled with holes so that they may be suspended and displayed in the same manner?
4. This study postulates that *Tagelus* shells were adopted as textile-making tools because their natural shapes and size range closely match the shapes and sizes of later Mesoamerican textile-making tools. The specific shape may have served well for a number of different possible textile-making functions that merit testing:
    - Do *Tagelus* shells serve as effective, practical weaving battens?
    - Do *Tagelus* shells serve as effective, practical weaving shuttles?
    - Do *Tagelus* shells serve as effective, practical loom weights for weaving and/or twining?
    - Do *Tagelus* shells serve as effective, practical netting gauges?

Modifying *Tagelus plebeius* Shells

To begin these experiments and analysis, thirteen shells of the Atlantic stout razor clam (Class *Bivalvia*, Family *Solecurtidae,* Genus *Tagelus*, Species *plebeius)* were procured in typical sizes ranging from six to nine cm in length and from 2.5 to 3.2 cm in width, and typical oval, obround, and roundrect silhouettes that may or may not be tapered (See Figure 8). While some of these shells were very well-preserved, with smooth, unbroken edges, many of the shells were slightly chipped, which is apparently common for *Tagelus* shells that naturally wash up on tidal flats. The well-preserved shells have smooth edges desirable for textile tools, but the chipped shells were moderately sharp and uneven on the edges, and they would not have performed well as textile tools because they would catch on and perhaps even cut fibers and rip fabric.

The first experiment, therefore, tested whether or not chipped *Tagelus* shells could be easily modified to make them more suitable as a tool for working with fibers. The Olmec are known to have imported iron ores into the Gulf Coast area from the Early Formative through the Middle Formative period; these ores were cut and ground into mirrors, and the resulting iron ore debris was crushed into granular and powdered form to be used as a pigment and as a polishing agent (Carlson, 1993; Coe *et al.,* 1980; Drucker *et al.,* 1959; Follensbee *et al.,* 2017).[7] A piece of rough iron ore was, therefore, tested for use as a grinder on the *Tagelus* shells. The iron ore grinder worked very well, quickly and easily grinding away the chips and smoothing the edges of the shells (See Figure 9. Modifying a *Tagelus* shell). A consideration for the use of *Tagelus* shells as ornament would be conformity to Olmec aesthetic sensibilities, which tend to prefer smooth shapes with regular, logarithmic curves, and thus whether *Tagelus* could be made more conventionally attractive by grinding the shells into these more perfect geometric shapes. The rough iron ore grinder was also found to be very effective for reshaping *Tagelus* shell, easily grinding the shells into more perfectly oval, obround, or roundrect silhouettes, and even reshaping them into the more tapered shapes of some greenstone effigies, rendering the shells more desirable for display.

Next, to refine these reshaped silhouettes, granular iron ore was placed on top of a flat surface – in this case, a piece of wooden board – and moistened, and the shell was placed interior side-down on top of the iron ore. Moving the shell in back and forth and in circular motions served to further even out the perimeter of the shell as well as to bevel the edges to their original fineness (See Figure 10. Beveling a *Tagelus* shell). Likewise, experiments in polishing the matte white *Tagelus* shells were surprisingly effective, as the appearance of these shells changes markedly with little effort. Fifteen to 30 minutes of rubbing a *Tagelus* shell just with bare fingers transforms the chalky white interior to a smooth, satin finish. Further gentle polishing of the interior of the shell for 30 minutes to an hour with granular iron ore and saliva (which is less slippery than water) reveals a hard, glossy interior surface; additional polishing on the exterior smooths the shell and creates translucency (See Figure 11. Polishing a *Tagelus* shell; see Figure 12. Unpolished, satin-polished, and fully polished *Tagelus* shells). All together, these experiments in reshaping, beveling, and polishing *Tagelus* shells were very quick and effective, resulting in a more conventionally attractive shell for display, with a glossy interior that matches the highly polished surfaces of the jade effigies and correlates well with depictions of concave oval, obround, and roundrect pectorals in Olmec and Olmec-related sculpture.

Some interesting correlations to be noted here are that, like the curved, concentric lines incised on some greenstone clam shell pectorals (See Figure 3a) and on some clam shell pectorals depicted in Olmec and Olmec-related stone sculptures (See Figure 7), Maya artists also depicted shining surfaces with curving parallel lines (Stuart, 2010). This symbolism is illustrated in the Maya hieroglyphs T24 and T121, and Maya LEM hieroglyphs, which each consist of an oval, obround, or roundrect shape with one or a pair of off-center concentric lines inside the hieroglyph, and inside this interior shape is either a pair of curving parallel lines (See Figures 13a. Maya hieroglyph T24; Fig 13b. Maya hieroglyph LEM as a shiny celt) or smaller pair of concentric lines placed in an orientation opposite to the larger concentric lines (See Figure 13c. Maya hieroglyph T121; Fig 13d. Maya hieroglyph LEM). These hieroglyphs have been interpreted as denoting “shininess” (Stuart, 2010; Healy and Blainey, 2011), and scholars have suggested that the form of these hieroglyphs represents the profile view of a mirror (Schele and Miller, 1986), a shiny greenstone celt or polished stone (Macri and Looper, 2003; Stuart 2010; Healy and Blainey, 2011); or even shiny, reflective shell "tinklers" (Healy and Blainey, 2011). With their oval, obround, or roundrect shapes, concentric interior line(s), and/or interior parallel lines, these hieroglyphs are not only reminiscent of the incised greenstone clam shell effigies (See Figure 3a) and the incised clam shell pectorals in Olmec-related sculpture (See Figure 7), but the off-center concentric interior lines are extremely similar to the growth rings visible on the polished interior of a *Tagelus* shell (See Figure 14a. Polished *Tagelus* shell, growth rings), while the smaller concentric lines mimic the curved play of light across the interior of the concave shell. The interior, curving parallel lines of the hieroglyph, meanwhile, are also quite similar to the rounded perpendicular ribs visible on a polished *Tagelus* shell (See Figure 14b. Polished *Tagelus* shell, ribs).

Drilling *Tagelus plebeius* Shells for Suspension

The next experiment tested whether or not *Tagelus* shells could easily be drilled with holes for suspension, so that the shell may be worn as a pectoral ornament in the same manner as shown on Olmec and Olmec-related sculptures. Most greenstone clam shell effigies have two biconical holes on the back of the effigy that were drilled through the thicker top or hinge area of the shell (See Figures 3 and 4); these holes are not drilled through the front of the shell, so when a suspension cord is strung through the holes, the cord is not visible on the front. A subgroup of the greenstone effigies has two holes drilled through the shell just under the hinge; when the sculpted hinge is heavy enough, the horizontal length of cord strung through these holes would be hidden under the hinge (Gann, 1918, p.91 and Plate 16); the cord may also be threaded through the holes on the front so that the horizontal length of the cord is hidden on the back. In all of these cases, the holes are placed evenly on the shell, between 1/4 to 1/3 of the shell length from each end of the shell. This allows the shell to be suspended so that it hangs evenly in a horizontal manner.[8]

As *Tagelus* shells have relatively narrow, thin hinges, drilling two biconical holes as shown on the greenstone effigies is not effective physically or aesthetically. Biconical drilling creates four holes through the back of the shell, with at least two of the holes lower on the body of the shell and therefore visible on the front/interior of the shell; in addition, the tiny shell bridge between each set of these holes is particularly fragile and prone to breakage. The most effective way to suspend *Tagelus* shells as horizontal pectorals, therefore, is to drill two holes through the shell near the top hinge, as in the subgroup of greenstone shell effigies. As on the effigies, the most effective placement of the holes on a *Tagelus* shell for even, horizontal suspension is about one-quarter of the length from each end of the shell and just under the hinge. Since *Tagelus* shells have thinner areas of muscle scars in these two locations, this placement is convenient for relatively easy drilling; holes placed in these positions also have extra support on the inner edges by adjacent, thicker parts of the shell and at the top by the hinge. In this replication studies experiment, a flint dart projectile point, drill, or pointed flake was found to effectively and efficiently drill holes through the muscle scars of *Tagelus* shells, typically in less than five minutes for each hole (see Figure 15. Drilling suspension holes in a *Tagelus* shell). When a cord is threaded through the front holes of the shell, this hole configuration not only provides extra support exactly in the areas where the cord creates stress, but also allows for a balanced suspension of the shell, and the horizontal length of the suspension cord between the holes is hidden behind the shell (See Figure 14).

Testing *Tagelus plebeius* Shells as Tools

The fourth and final group of replication studies experiments tested whether *Tagelus* shells serve as practical and effective weaving, twining, or netting tools. To test *Tagelus* shells as weaving tools for bands of cloth, a belt loom was strung with commercially produced 8/4 un-mercerized natural cotton yarn and hand-spun 1 mm black-brown feline fur yarn, fibers available in the Formative period Gulf Coast region that closely match the 1.5-millimeter yarn used to create the tabby-weave textiles impressed on the two ceramic potsherds recovered in Gulf Coast Olmec excavations (Drucker, 1952, Plate 22e; Pohl *et al.,* 2019). Using a cotton weft, a 2 cm wide textile band was woven to approximate the narrow fabric bands illustrated in Olmec sculpture (See Figures 1a and 1b).

Testing *Tagelus plebeius* Shells as Battens

Both the naturally smooth *Tagelus* shells and the modified *Tagelus* shells worked well as small battens for weaving this band of cloth. The concave shape of the shell provided a secure grip for the weaver, while the thin bottom edge of the shell was effective for packing the weft and tightening the weave (See Figure 16. *Tagelus* shell batten, packing the weft). Turning the shell perpendicular to the warp efficiently opened the shed to allow easier passage of the weft (See Figure 17. *Tagelus* shell batten, opening the shed). Both modified and unmodified shells were also strong enough to withstand sustained use without chipping or breaking.

Testing *Tagelus plebeius* Shells as Loom Weight Weaving Tools

To test the *Tagelus* shells as loom weights and as weaving or twining tools, as for previous twining experiments (Follensbee, 2021), a simple warp-weighted loom was constructed using sidebars of two heavy, forked branches, each cut off at an angle on the bottom so that the loom would securely rest against a wall at an angle of approximately 60° (See Figure 18. Warp-weighted loom). A thinner branch that fit neatly into the forked tops was secured as the top loom bar, and these three pieces were tied together using 1.5 mm cotton yarn cordage. Another thin branch was tied horizontally across the middle of the loom on the front as a shed bar, which would also serve as a wrist-rest while weaving/twining.

Next, 22 warp yarns of 8/4 un-mercerized natural cotton were tied to the top bar of the loom, and 11 *Tagelus* shells were drilled with suspension holes. Each pair of warp yarns was then strung through the two holes in the back of a *Tagelus* shell, with the first warp yarn threaded through the proper right hole, the second yarn threaded through the proper left hole, and the 2 cords knotted on the interior/front side of the shell, so that all of the *Tagelus* shells were evenly lined up across the warp, and all of the shells were initially facing to the artisan's left. The separation of the holes in the *Tagelus* shells created a primary "natural shed," with the odd warp threads toward the back of the loom and the even warp threads toward the front of the loom (See Figure 19. *Tagelus* shells strung on loom). Although the mass of each *Tagelus* shell is relatively light, the shells provided ample weight to create stable tension for the warp, but not so much weight that they strained or threatened to break the cordage used. In addition, the cupped shape of the *Tagelus* shell weights efficiently served to hold the row of shells in position, reducing tangling in the warp even when the loom was picked up and moved from one place to another.

The *Tagelus* shell weights were then tested as weaving tools for creating a simple tabby weave. A weft thread was passed through the natural shed of the warp threads, and then the shells were turned one-half turn counter-clockwise so that all of the shells then faced to the artisan's right (See Figure 20. *Tagelus* shells turned to the artisan's right). A *Tagelus* shell batten was used to tighten the weft, and the weft was then passed through the secondary shed created by the shell weights. The shell weights were then turned clockwise to face the artisan's left, the weft was tightened, and the weft was passed again. This created an even tabby weave, demonstrating that *Tagelus* shells are effective as weaving tools to make smooth fabric panels like those illustrated on Olmec and Olmec-related monuments (See Figure 21. Different textiles created using *Tagelus* as loom weights and twining tools).

Testing *Tagelus plebeius* Shells as Loom Weight Twining Tools

Next, the *Tagelus* shell weights were tested as twining tools. Each shell weight was turned one-half turn clockwise, the previous weft tightened, and then the next weft was passed through the shed. Then the shells were again each turned a half turn clockwise, the previous weft tightened, and the weft passed again. After seven clockwise half-turns total, an even, open-weave gauze netting had been created (See Figure 21), demonstrating that *Tagelus* shells are effective as warp-twining tools to create fine gauze netting as illustrated in Olmec sculpture (See Figure 1a). Finally, a hand-spun 3 to 4 mm wide, black-brown feline fur yarn weft was introduced to the warp, and the weaver easily created seven rows of more packed-weft fabric (See Figure 21). Then 3 rows of double-weft twining were created (See Figure 21), which demonstrates that a multiple-weft fabric, such as the cape illustrated on an Olmec figure from southern Veracruz (See Figure 2), could easily be created on the weighted loom with the *Tagelus* shell battens and loom weights.

Testing *Tagelus plebeius* Shells as Shuttles

Attempts to use *Tagelus* shells as shuttles were much less successful than the other experiments in this study. Winding the weft yarn of cotton or fur onto the shell was a frustrating enterprise, as neither the more evenly proportioned shells nor the more tapering shells held the yarn well. Even when the weaver was able to load the weft successfully onto the shell, the yarn slipped off one end of the shell or the other when the shuttle was passed through the shed. Thus, contrary to suggestions that such smooth oval, obround, roundrect, or rectangular artifacts may have served as weaving shuttles, *Tagelus* do not perform at all well as shuttles, and this experiment further suggests that the smooth wood, bone, shell, or stone artifacts of this size and form also were not effective for this purpose.

Testing *Tagelus plebeius* Shells as Netting Gauges

Finally, to test *Tagelus* shells as netting gauges, a four-foot wide net was started using 2 mm sisal twine, and a *Tagelus* shell was employed as a netting gauge. For each diamond-shaped mesh, the twine was wrapped around the shell, and the shell was used to regulate the size of the mesh while the knots were tied (See Figure 22. *Tagelus* shell used as a netting gauge). The *Tagelus* shells worked surprisingly well as netting gauges; the concave shape of the shell was easy to hold in place, and size range of the shells was ideal for holding, gauging, and stabilizing several loops of mesh at a time, while the smooth oval, obround, and roundrect shapes and the tapered shapes all allow the sisal twine loops to slide easily off the end of the shell as the mesh is progressively knotted down the row of netting. As in the other experiments conducted, both modified and unmodified *Tagelus* shells also proved strong and durable as netting gauges, withstanding sustained use with the sisal twine without chipping or breaking. The mesh netting produced in this experiment also corresponds well with depictions of mesh nets on Formative period Gulf Coast Olmec sculpture (See Figure 1c).

Concluding Remarks

Strong, direct correlations clearly exist between the elongated oval, obround, and roundrect pectoral ornaments depicted in Olmec and Olmec-related stone relief sculpture and Formative period greenstone clam shell ornaments, which assume these same shapes. Study of the bivalve shells native to Mesoamerica further reveals that the shells of *Tagelus plebeius,* better known as the Atlantic stout razor clam, are the most likely natural models for the greenstone clam shell effigies, correlating closely not only with the silhouettes of the greenstone clam shell effigies, but also with the effigies' convexity, hinge placement, and size ranges. The results of these replication studies experiments in refining the shapes, smoothing and beveling the edges, polishing, and drilling *Tagelus* shells further suggests that these shells can easily be modified to conform to early Mesoamerican aesthetic preferences for idealized, logarithmic curves and glossy, highly reflective surfaces, even revealing a possible correlation between *Tagelus plebeius* shells and later Maya hieroglyphs denoting "shininess" – and suggesting that the *Tagelus* shells themselves likely also served as high-status adornments.

The results of these experiments also establish that, despite their somewhat delicate appearance, even modified and polished *Tagelus plebeius* shells remain strong and durable, withstanding sustained use as tools, and that these shells serve as practical and efficient tools for making the different types of textiles depicted in Formative period Olmec and Olmec-related sculpture. While the *Tagelus* shells did not work well as weaving shuttles, these shells served very effectively as small weaving battens for making bands of cloth, as loom weights for weaving wider cloth panels on a weighted loom, and as warp-twining tools for making both netted gauze and thick, packed-weft fabric. In addition, *Tagelus plebeius* shells serve particularly well as netting gauges for making evenly meshed nets, which are illustrated in Formative period sculpture as paraphernalia for fishing as well as for certain types of high-status clothing.

In demonstrating the possible functions of *Tagelus* shells as early textile-making tools, these replication studies experiments offer new hypotheses for the symbolism of *Tagelus* shells, of the Formative period greenstone clam shell effigies, and of the depictions of clam shell pectorals in Olmec and Olmec-related sculpture. If the clam shells functioned both as tools and as ornament, clam shell imagery would have shown pride in occupation and quite possibly would have displayed achievement and earned status as well. All together, these studies of *Tagelus plebeius* shells, their possible functions, and their possible symbolism serve to further expand our understanding of the greenstone effigies and of Olmec and Olmec-related sculptural depictions, as well as of the importance of textiles and textile-making in ancient Mesoamerica.

1 Among other mammal fibers, fur fibers commonly procured in this region include rabbit fur and feline fur.

2 For further discussion of recent discoveries on the use of different types of looms in ancient Mesoamerica, see Follensbee 2020.

3 Interestingly, the rosewood handle for this gouge takes a form identical to that of a handle recovered from the Gulf Coast Olmec site of La Venta (Drucker et al., 1959, pp.192-194, Figure 53e; see also Follensbee, 2008, pp.93-96, Figure 3d); because of its smaller, round aperture, however, the La Venta artifact would have served as the handle of a pick or awl rather than a gouge.

4 Matthew Stirling initially suggested that the La Venta Mound A-2 shell effigy was an effigy of a "clamshell" (Stirling, 1942, pp.640-641), but later suggested that this might be "the replica of a mussel shell" (Stirling, 1961, p.59, Figure 10), likely because mussels may have a similarly tapered shape. A few other jade shell effigies, such as Chacsinkin Jade 25 (Andrews, 1987) and jade clam shell pendant #3 from the Cenote of Sacrifice, Chichen Itza (Proskouriakoff ,1974, p.36 and Plate 38a), have tapered forms and thus could also have been modeled upon mussel shells; as corroborated by Snarskis (1998), several mussel shells native to this region, such as Mycetopoda Siliquosa, Mycetopoda Legumen and Arculata papyria, have tapered shapes similar to the jade effigies. Nevertheless, as illustrated in this study, the Tagelus plebeius Atlantic stout razor clam is more likely the model for the jade shell effigies, as not only may Tagelus shells sometimes be similarly tapered, but the mussel shells tend to be much more irregular in silhouette, and they do not tend to assume the three predominant shapes of the jade effigies as does Tagelus plebeius.

5 The obround hieroglyph on La Venta Monument 13 may also illustrate a Tagelus plebeius, or more likely a greenstone clam shell effigy; a tapering obround hieroglyph also appears on the Cascajal Block, an Early Formative period greenstone slab. These images will be discussed further in Part 2 of this experimental archaeology and research project, which will focus on the greenstone clam shell effigies.

6 This identification of the Tagelus stout razor clam shell as the model for the elongated Mesoamerican greenstone clam shell effigies is corroborated in a study by Snarskis (1998). In addition to the Tagelus plebeius species discussed in this essay, another Tagelus species that might be suggested as a model for the greenstone effigies is the Tagelus californianus clam, which grows to 13 cm, but is native to the more remote Gulf of California.

7 Powdered iron ores, also called jeweler's rouge, are still used today as a superior substance for polishing.

8 In rare cases, a greenstone clam shell effigy may have a hole drilled through one end of the shell, in the middle, apparently so the effigy can be suspended vertically, as a pendant. This occurs on the two small clam shells recovered from the Sandstone Cist at La Venta in 1943, and these have been interpreted as spoons and as ear pendants (Stirling. 1943; Drucker et al., 1952, p.161). Otherwise, however, this unusual single suspension hole appears only on heavily reworked heirloom greenstone clam shells.

Keywords textile
weaving
loom

Country Guatemala
Mexico

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Corresponding Author

Billie J. A. Follensbee
Missouri State University
901 S. National Avenue
Springfield, MO 65806
USA
E-mail Contact

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FIG 1A. LA VENTA MONUMENT 13, AN OLMEC RELIEF SCULPTURE THAT ILLUSTRATES A MALE FIGURE WEARING CLOTHING COMPOSED OF NETTING AND FABRIC BANDS, WITH POSSIBLE OBROUND CLAM SHELL HIEROGLYPH (TOP RIGHT). DRAWING BY BILLIE J. A. FOLLENSBEE

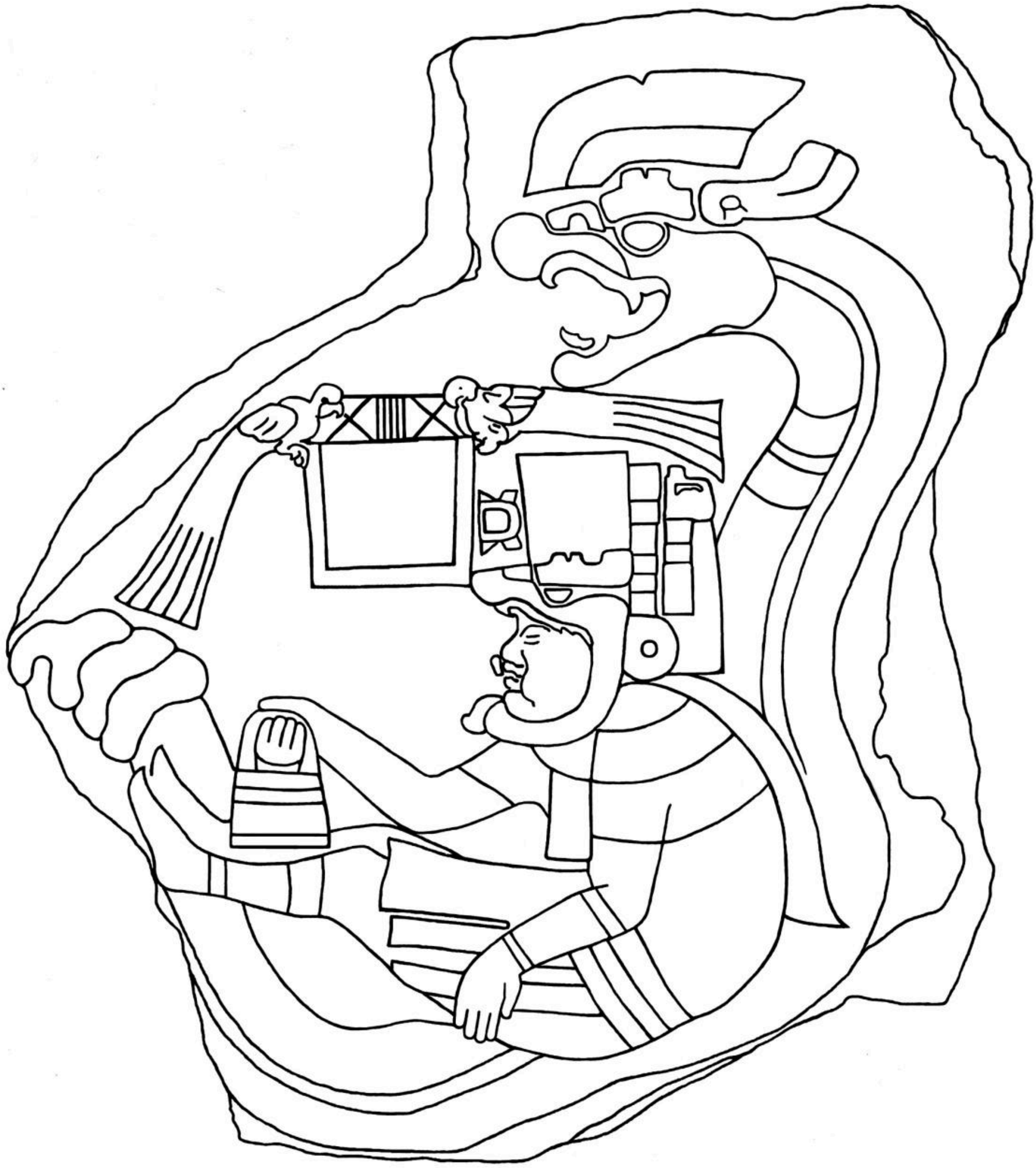

FIG 1B. LA VENTA MONUMENT 19, AN OLMEC RELIEF SCULPTURE THAT ILLUSTRATES AN ANDROGYNOUS FIGURE WEARING CLOTHING COMPOSED OF MANY FABRIC BANDS. DRAWING BY BILLIE J. A. FOLLENSBEE

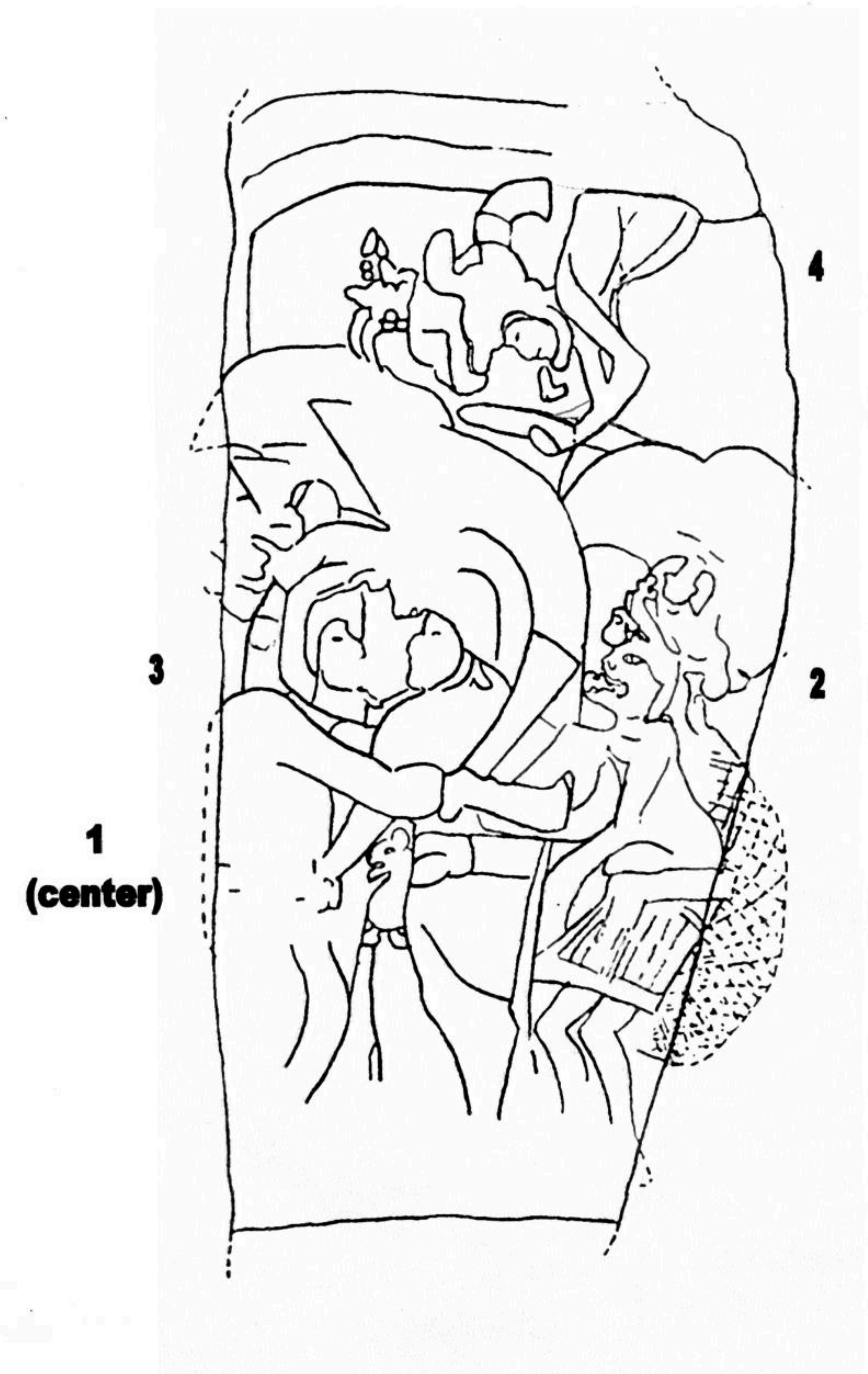

FIG 1C. LA VENTA STELA 5, AND OLMEC RELIEF SCULPTURE THAT ILLUSTRATES FIGURES WEARING CLOTHING AND HEADDRESSES OF CLOTH BANDS AND PANELS; THE FIGURE ON THE FAR RIGHT WEARS A MESH NETTED CAPE. DRAWING BY BILLIE J. A. FOLLENSBEE

FIG 2. A SEATED ANDROGYNOUS OLMEC FIGURE FROM SOUTHERN VERACRUZ IN THE MUSEO DE ANTROPOLOGÍA, XALAPA, VERACRUZ: BACK, SHOWING THE TWINED CAPE. PHOTO (WITH ADDED LINE DRAWING FOR CLARIFICATION) BY BILLIE J. A. FOLLENSBEE

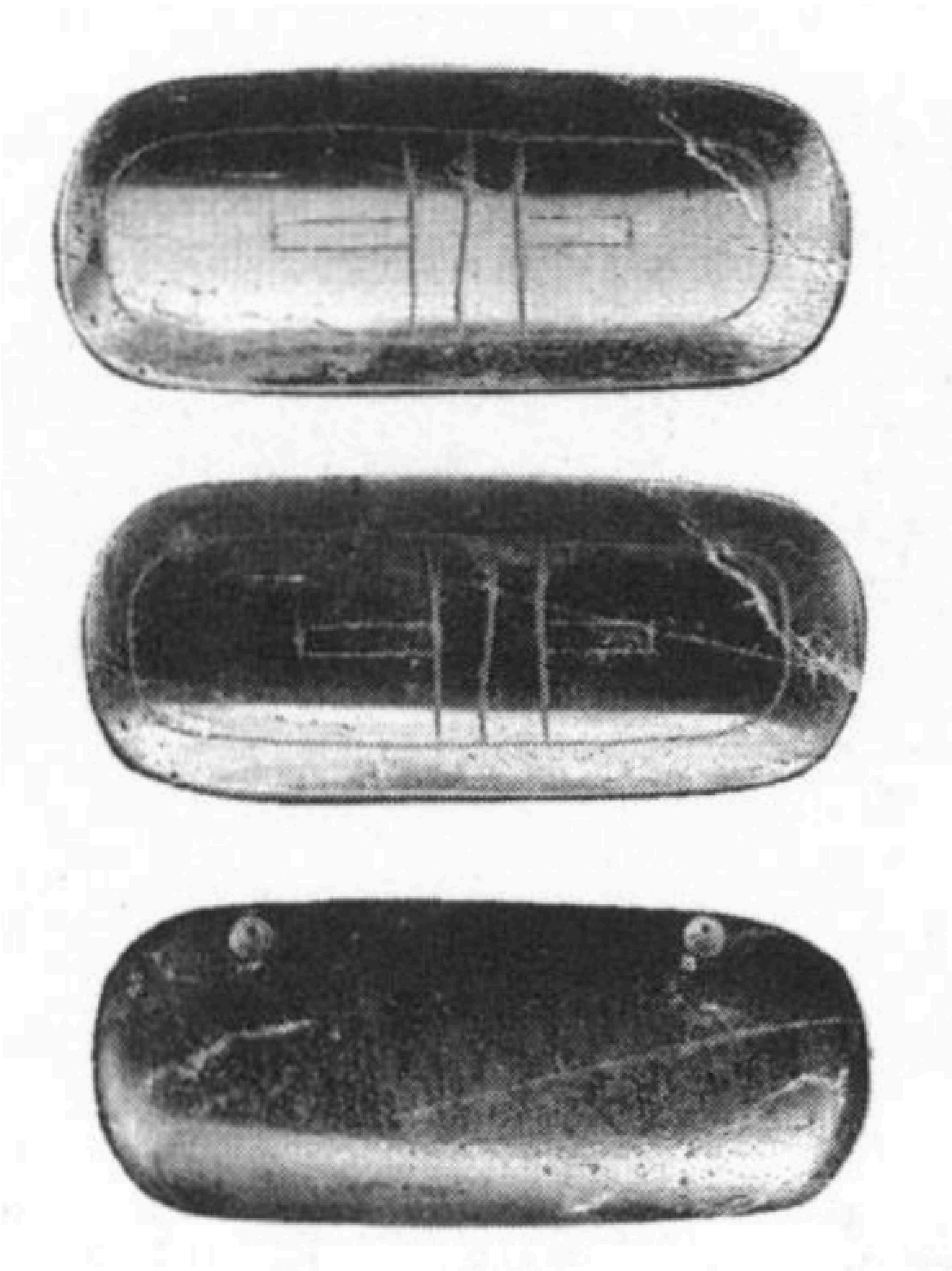

FIG 3A. CHACSINKIN JADE CLAMSHELL EFFIGIES: CHACSINKIN JADE 23, AN OBROUND JADE CLAMSHELL EFFIGY WITH INCISING ON CONCAVE SIDE. PHOTO BY E. WYLLYS ANDREWS V

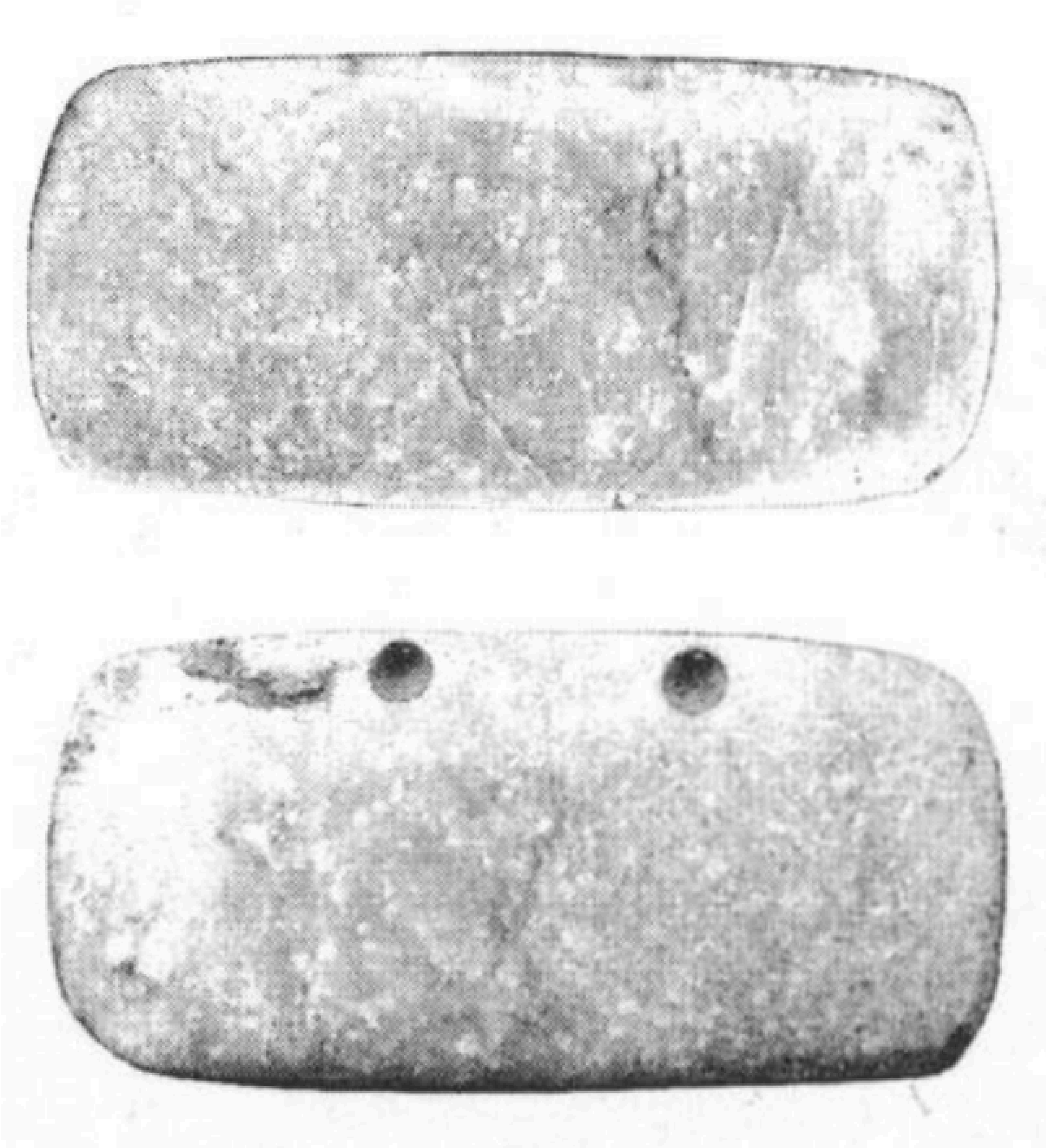

FIG 3B. CHACSINKIN JADE CLAMSHELL EFFIGIES: CHACSINKIN JADE 26, A ROUNDRECT JADE CLAMSHELL EFFIGY. PHOTO BY E. WYLLYS ANDREWS V

FIG 3C. CHACSINKIN JADE CLAMSHELL EFFIGIES: CHACSINKIN JADE 25, A TAPERED ROUNDRECT JADE CLAMSHELL EFFIGY, WITH THE SMALLER END MODIFIED INTO A ROUGHLY OVAL SHAPE. PHOTO BY E. WYLLYS ANDREWS V

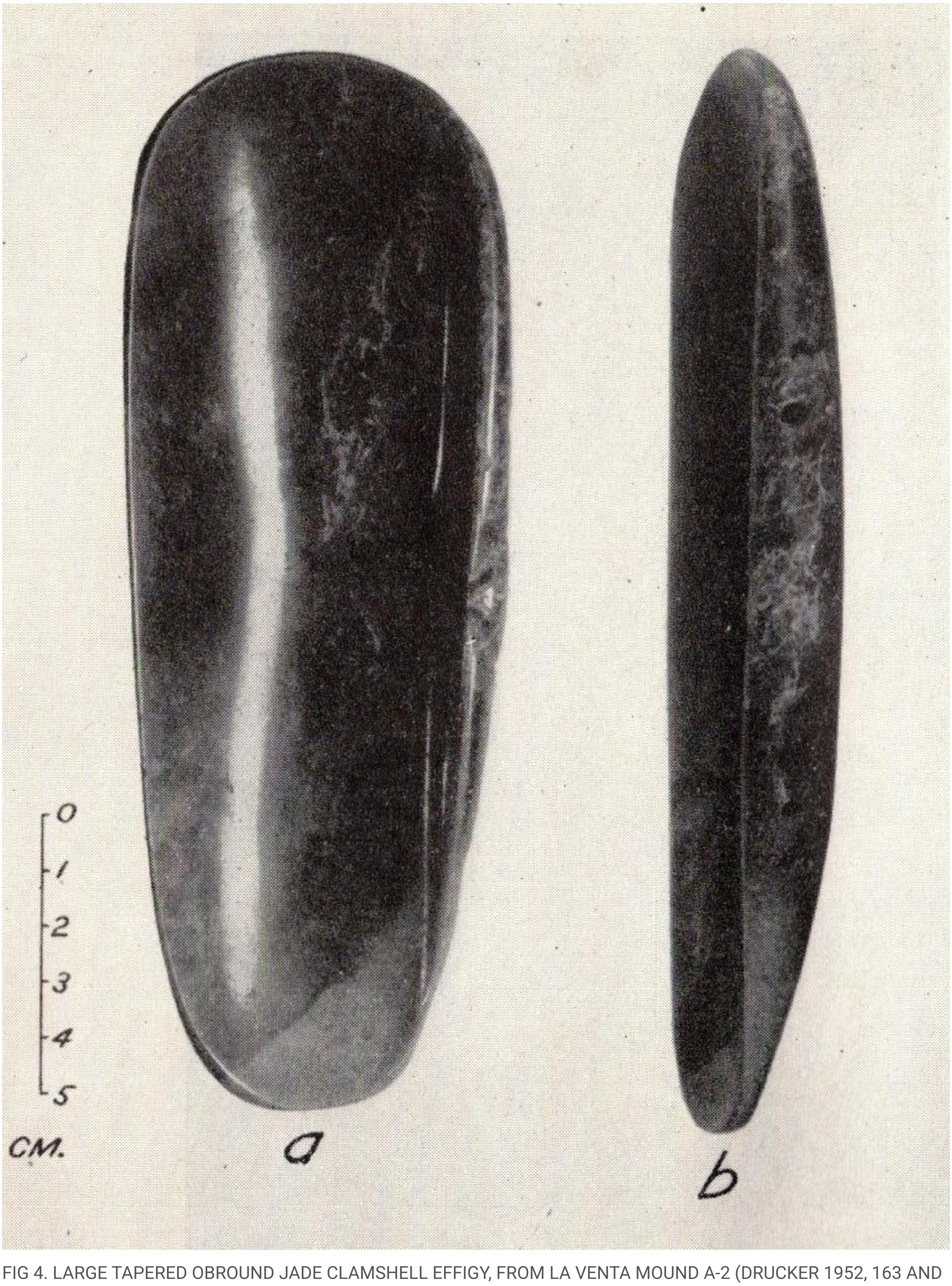

FIG 4. LARGE TAPERED OBROUND JADE CLAMSHELL EFFIGY, FROM LA VENTA MOUND A-2 (DRUCKER 1952, 163 AND PLATE 53). COURTESY OF THE SMITHSONIAN LIBRARIES: HTTPS://LIBRARY.SI.EDU/DIGITAL-LIBRARY/BOOK/BULLETIN1531952SMIT

FIG 5A. LA VENTA STELA 2, AN OLMEC RELIEF SCULPTURE; DETAIL SHOWING CENTRAL MALE FIGURE WEARING OBROUND PECTORAL. PHOTO (WITH ADDED LINE DRAWING FOR CLARIFICATION) BY BILLIE J. A. FOLLENSBE

FIG 5B. LA VENTA THRONE 5, AN OLMEC RELIEF SCULPTURE; PROPER LEFT SIDE, FEMALE FIGURE (L) AND MALE FIGURE (R), BOTH WEARING CONCAVE OBROUND PECTORALS. PHOTO BY BILLIE J. A. FOLLENSBEE

FIG 6. AN OLMEC-RELATED INCISED CELT FROM GUERRERO IN THE DALLAS MUSEUM OF ART; DETAIL SHOWING A FEMALE FIGURE WEARING COSTUME CONSISTING OF FABRIC BANDS AND ORNAMENTS, HOLDING A WEAVING AWL, AND WEARING A ROUNDRECT SHELL PECTORAL. DRAWING BY BILLIE J. A. FOLLENSBEE

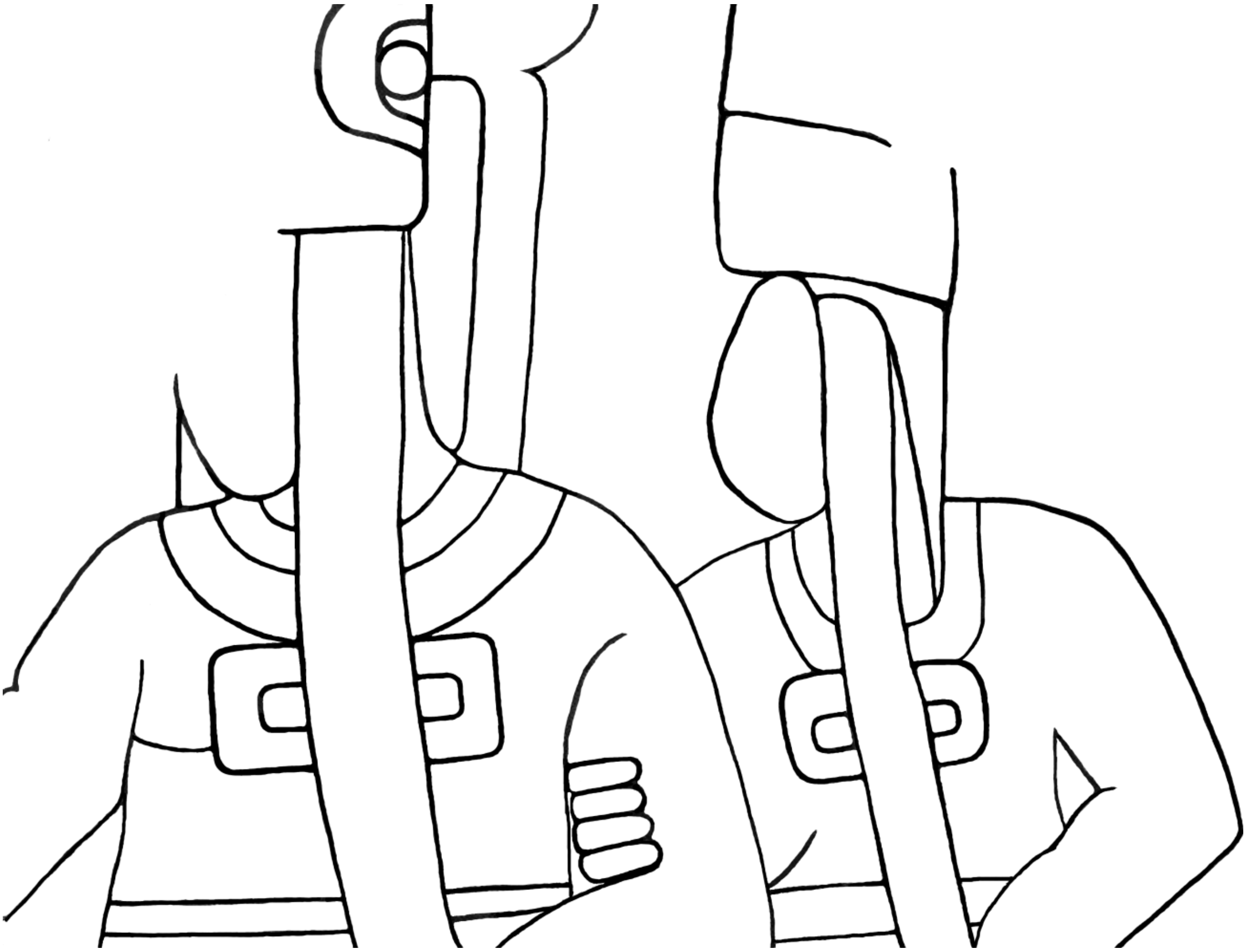

FIG 7. PIJIJIAPAN MONUMENT 1, AN OLMEC-RELATED RELIEF SCULPTURE; DETAIL SHOWING A MALE FIGURE (L) AND FEMALE FIGURE (R), BOTH WEARING ROUNDRECT SHELL PECTORALS WITH INCISED CONCENTRIC INTERIOR LINES (AFTER NAVARRETTE 1974, 4 AND FIGURE 2). DRAWING BY BILLIE J. A. FOLLENSBEE

FIG 8. NATURAL, UNMODIFIED TAGELUS PLEBEIUS SHELLS WITH OVAL, OBROUND, AND ROUNDRECT SILHOUETTES, SOME ALSO TAPERED. PHOTO BY BILLIE J. A. FOLLENSBEE

FIG 9. MODIFYING A TAGELUS PLEBEIUS SHELL, USING A ROUGH PIECE OF IRON ORE TO GRIND DOWN CHIPPED EDGES AND TO CREATE A MORE REGULAR SILHOUETTE. PHOTO BY BILLIE J. A. FOLLENSBEE

FIG 10. BEVELING THE EDGES OF A TAGELUS PLEBEIUS SHELL WITH GRANULAR IRON ORE AND WATER. PHOTO BY BILLIE J. A. FOLLENSBEE

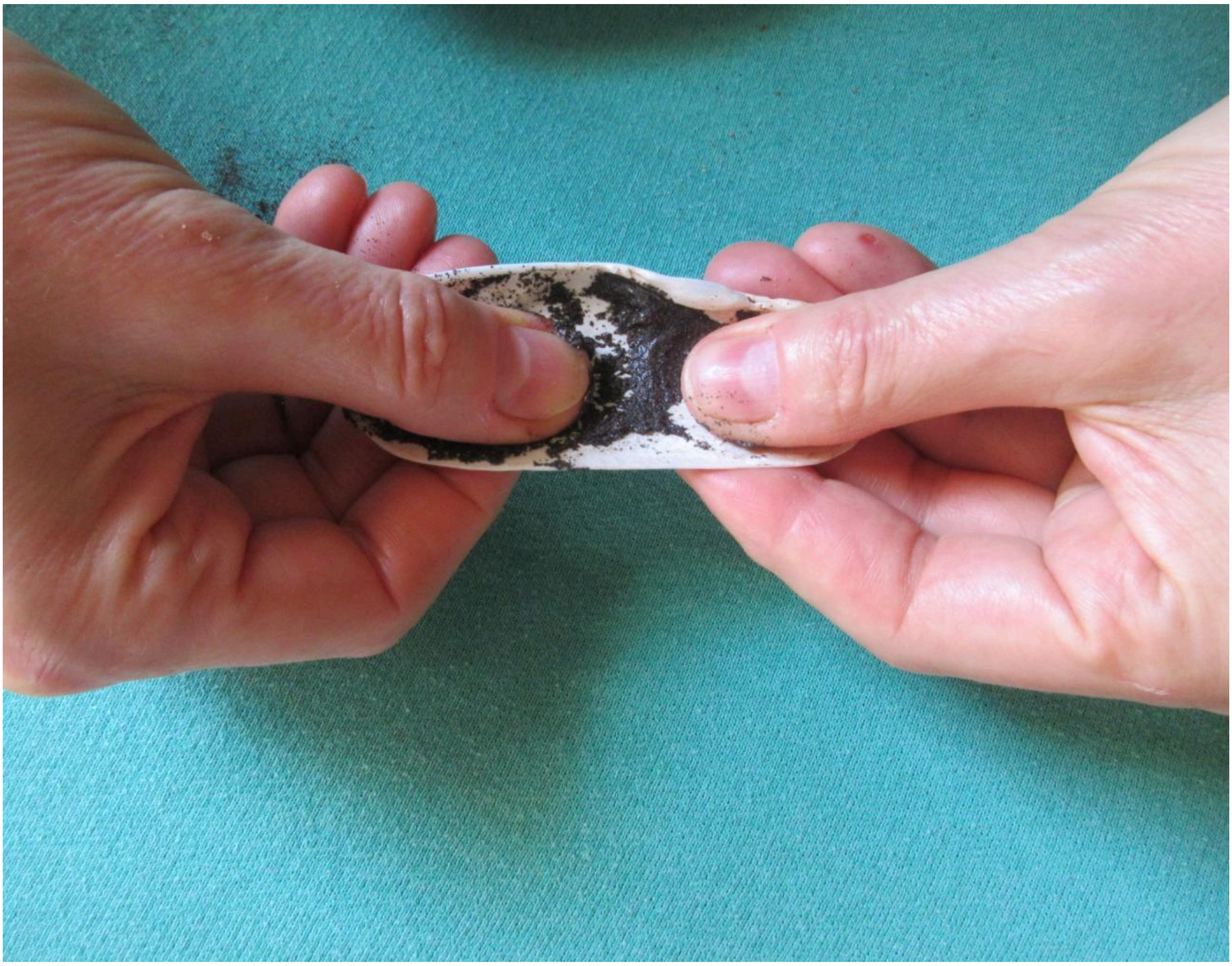

FIG 11. POLISHING A TAGELUS PLEBEIUS SHELL WITH GRANULAR IRON ORE AND SALIVA. PHOTO BY BILLIE J. A. FOLLENSBEE

FIG 12. TAGELUS PLEBEIUS SHELLS, RIGHT TO LEFT: UNPOLISHED SHELL, SHELL RUBBED TO A SATIN FINISH, AND SHELL POLISHED TO A GLOSSY TRANSLUCENCE. PHOTO BY BILLIE J. A. FOLLENSBEE

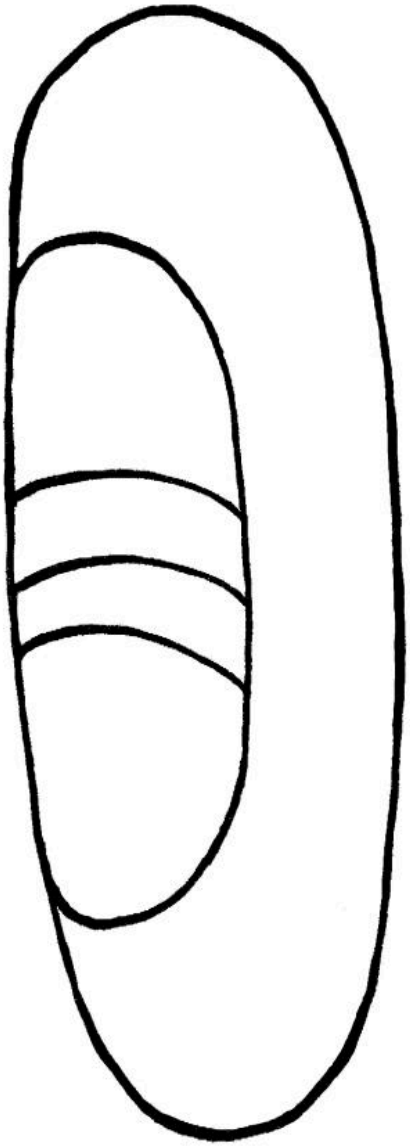

FIG 13A. IMAGES OF MAYA HIEROGLYPHS INTERPRETED AS “TO SHINE,” “SHINY/REFLECTIVE,” OR “SHINY THING” (STUART 2010): MAYA HIEROGLYPH T24 (AFTER MATSUMOTO 2013, FIG. 5). DRAWING BY BILLIE J. A. FOLLENSBEE

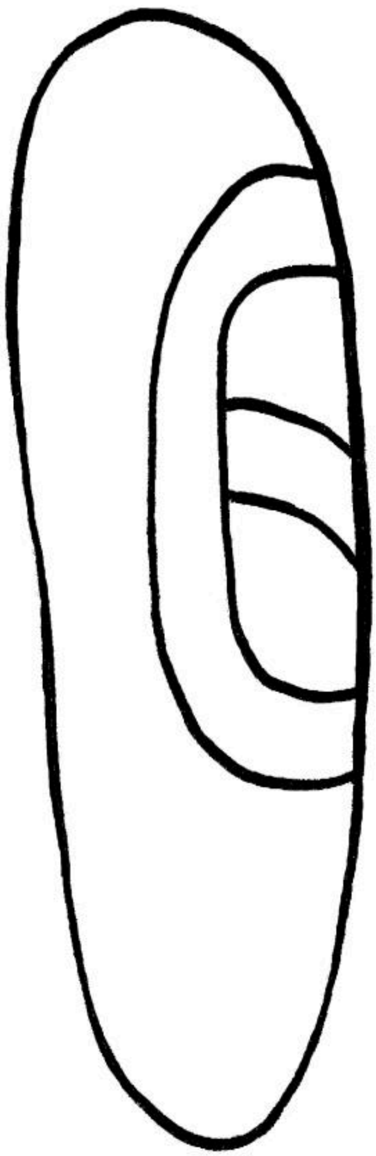

FIG 13B. IMAGES OF MAYA HIEROGLYPHS INTERPRETED AS "TO SHINE," "SHINY/REFLECTIVE," OR "SHINY THING" (STUART 2010): THE MAYA HIEROGLYPH LEM AS A SHINY CELT (AFTER STUART 2010, FIG. 12.5C). DRAWING BY BILLIE J. A. FOLLENSBEE

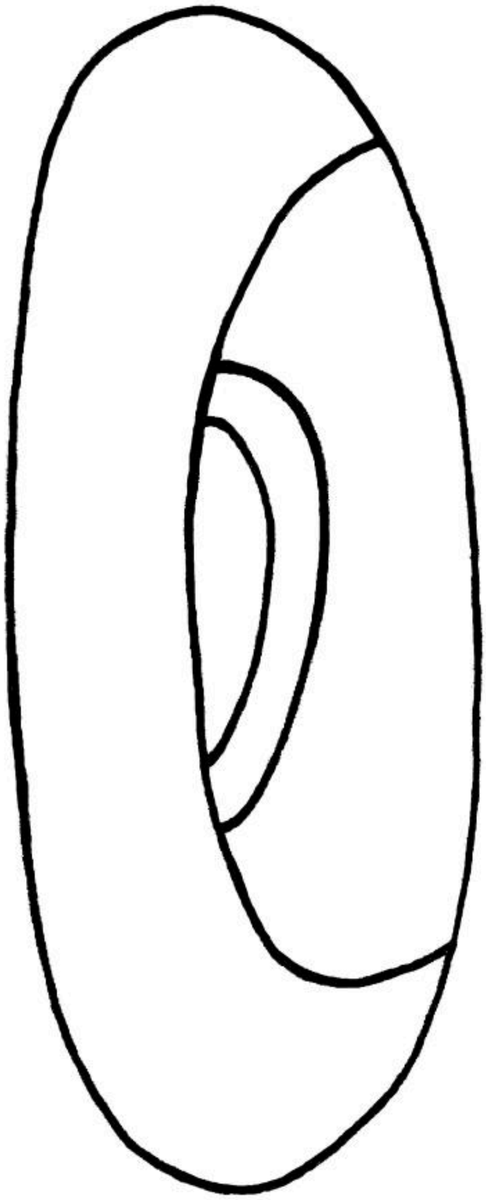

FIG 13C. IMAGES OF MAYA HIEROGLYPHS INTERPRETED AS “TO SHINE,” “SHINY/REFLECTIVE,” OR “SHINY THING” (STUART 2010): MAYA HIEROGLYPH T121 (AFTER MATSUMOTO 2013, FIG. 5). DRAWING BY BILLIE J. A. FOLLENSBEE

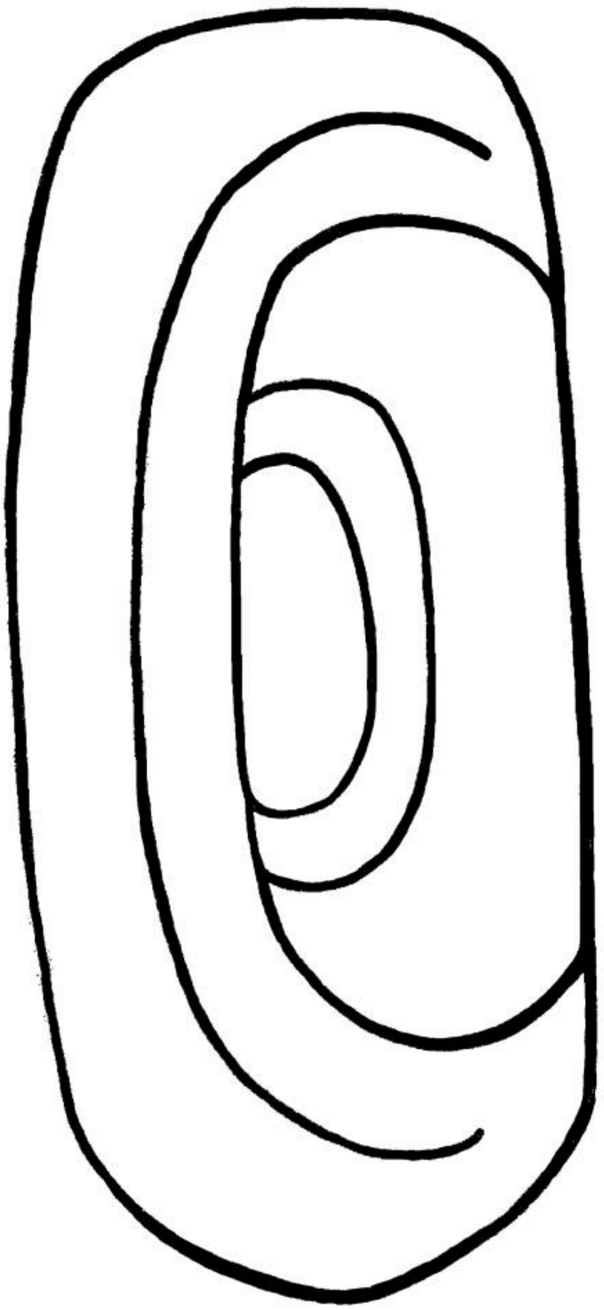

FIG 13D. IMAGES OF MAYA HIEROGLYPHS INTERPRETED AS “TO SHINE,” “SHINY/REFLECTIVE,” OR “SHINY THING” (STUART 2010): A STANDARD FORM OF THE MAYA HIEROGLYPH LEM (AFTER STUART 2010, FIG. 12.5A). DRAWING BY BILLIE J. A. FOLLENSBEE

FIG 14A. POLISHED, DRILLED, AND SUSPENDED OBROUND TAGELUS PLEBEIUS SHELL, SHOWING INTERIOR CONCENTRIC OBROUND GROWTH LINES AND ROUNDED REFLECTION. PHOTO BY BILLIE J. A. FOLLENSBEE

FIG 14B. POLISHED, DRILLED, AND SUSPENDED TAGELUS PLEBEIUS SHELL, SHOWING THE FANNING RIBS ACROSS THE SHELL. PHOTO BY BILLIE J. A. FOLLENSBEE

FIG 15. DRILLING SUSPENSION HOLES IN A TAGELUS PLEBEIUS SHELL WITH A FLINT PROJECTILE POINT. PHOTO BY BILLIE J. A. FOLLENSBEE

FIG 16. TAGELUS PLEBEIUS SHELL USED AS A BATTEN, PACKING THE WEFT. PHOTO BY BILLIE J. A. FOLLENSBEE

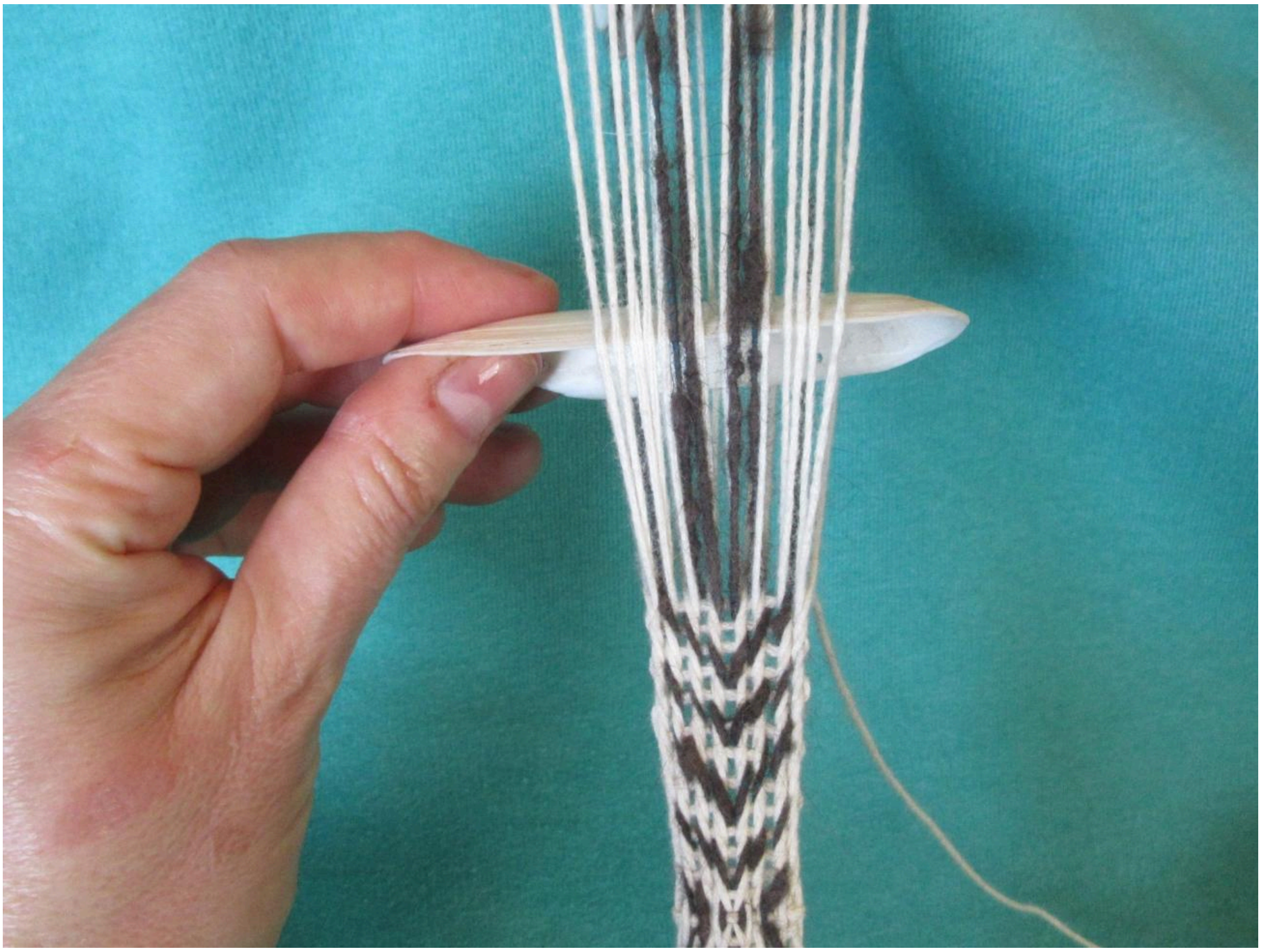

FIG 17. TAGELUS PLEBEIUS SHELL USED AS A BATTEN, OPENING THE SHED. PHOTO BY BILLIE J. A. FOLLENSBEE

FIG 18. TAGELUS PLEBEIUS SHELLS STRUNG AS WEIGHTS ON A WARP-WEIGHTED LOOM. PHOTO BY BILLIE J. A. FOLLENSBEE

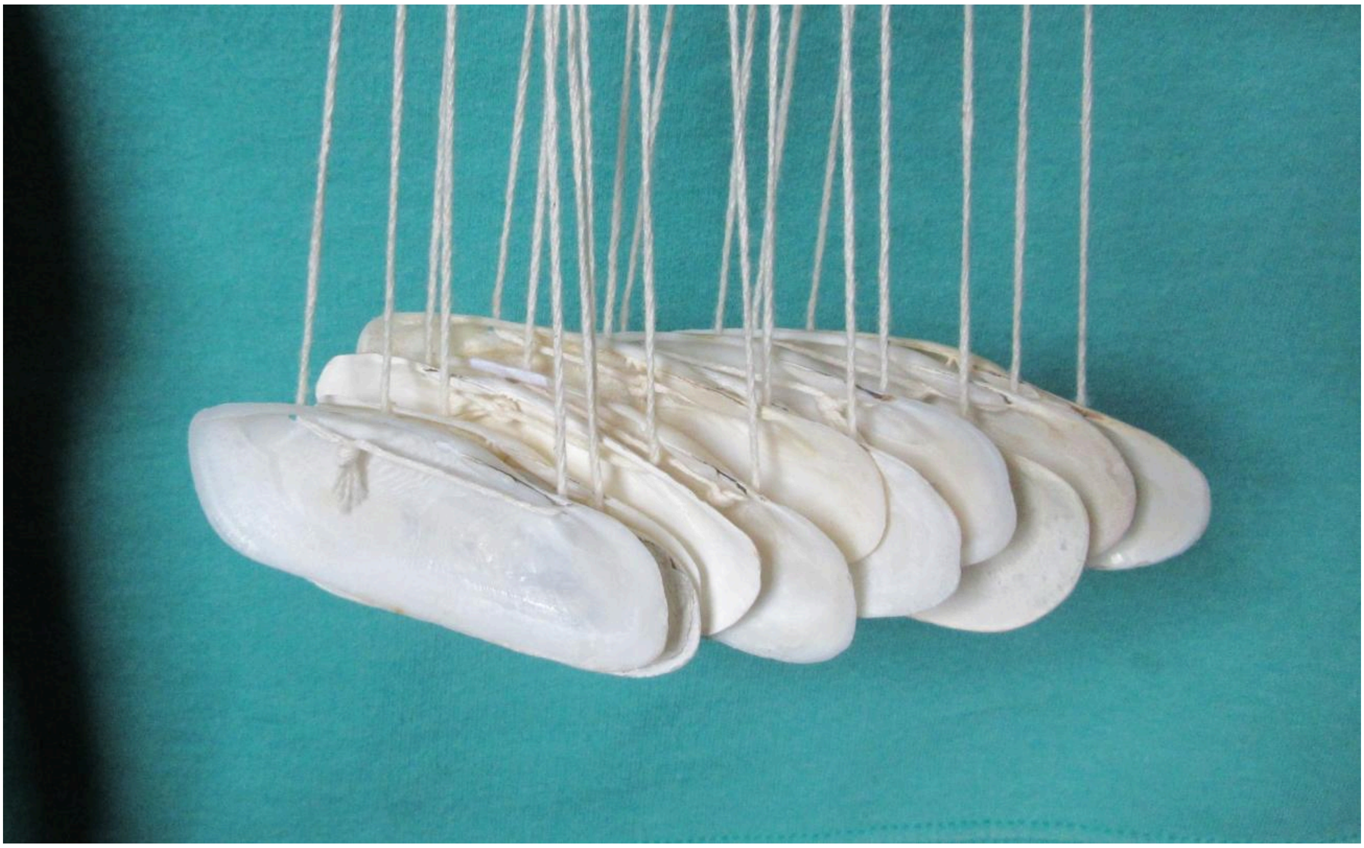

FIG 19. TAGELUS PLEBEIUS SHELLS ON WEIGHTED LOOM IN ORIGINAL STRUNG POSITION, TURNED TO THE ARTISAN'S LEFT. PHOTO BY BILLIE J. A. FOLLENSBEE

FIG 20. TAGELUS PLEBEIUS SHELLS ON WEIGHTED LOOM, EACH TURNED ONE-HALF TURN TO THE ARTISAN'S RIGHT. PHOTO BY BILLIE J. A. FOLLENSBEE