Evaluating rudimentary prehistoric stone artifacts from the American southwest and Mexico

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Abstract:

The goals and background of this study are presented. A sample of rudimentary artifacts, recovered through survey and excavation from contexts in the American Southwest and southern Mexico, were physically examined to verify or reject their assumed validity as tools and their use in agricultural activities. Macroscopic and microscopic examinations were undertaken on these often overlooked and misidentified artifacts to ascertain evidence of human manufacture and use-wear. The results of the study indicate the specimens represent three general form categories of tools that have uses related to excavation and earth moving. To augment this evidence, information was gathered regarding find contexts, historic records, and from relevant literature. The geographic find locations and contexts of the artifacts, as well as their temporal placement, and likely group affiliations, are then discussed. Evidence indicates that, although probably used for other purposes, these minimally-retouched, hand-held, digging and earth moving tools were used in the preparation and maintenance of agricultural fields and irrigation canals, and functioned to support the subsistence system from *ca.* 400-1450 CE. These implements evidently also held social and ceremonial values and functions. The rudimentary nature of these tools is often found not to be commensurate with the sophisticated complexity of the associated agricultural infrastructure. Initial, very tentative, hypotheses are presented for this incongruity.

Keywords: American Southwest; Mexico; prehistoric agricultural implements; lithic technology; subsistence system technology.

1. Introduction and background

The study of prehistoric tools is one of several ways archaeologists gain insights into the past behavior of prehistoric peoples. Such studies not only reveal what raw materials were used to manufacture these implements, how they were fashioned, and how they were modified through time, but also reveal the tasks for which these tools were used and their functions in the user's lifeway.

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This study has three goals.

- First, to critically assess the historically documented assumptions that these artifacts are human tools.
- Second, if found to be tools, to consider their distribution, temporal placement, and use/function.
- Third, to bring these artifacts to the attention of archaeologists so that they may be recognized during surveys and the analysis of excavated materials and dealt with accordingly.

1.1. Background

The artifacts under consideration were apparently first recognized, but not described or illustrated, by Hodge (1893: 324) in the Phoenix, Arizona area as "implements" that had been "cast upon the (canal) banks". Turney (1924: 1-11), in his study of the prehistoric Hohokam canals in the same area, provided additional details but still did not adequately describe or illustrate these artifacts. Later, Turney (1929: 11-13) noted: "The digging of the prehistoric canals in the Salt River Valley was done with stone hoes, always held in the hand; never was one mounted on a handle" "No pride was taken in fashioning the stone hoe; it was about the size and shape of a modern hoe blade, but with no perforation, notch or groove for a handle, simply a spall from a boulder, shaped thick at the back and thin in front." Thus, based on find contexts, Turney presumed that the stone "hoes" were used to excavate irrigation canals. Fourteen years later, Schroder (1943: 381) noted that broken hoes could still be found on canal banks in the Phoenix area. Haury (1945: 124, 134-137) was the first to illustrate and describe hoes that had been recovered by excavation from the archaeological site of Los Muertos in the Phoenix area. He mentions their association with canals, but comments that it was unclear if they were a cultivating or an excavation tool. In the early 1990s, similar tools were recognized during surveys of sites with agricultural features and canals in New Mexico (Neely 1993, 1995). More recently, finds were made in other widespread locations (Doolittle & Neely 2004; Neely 2014; 2017: 65-66; Neely & Lancaster 2019; Neely *et al*. 2015), which initiated this study.

2. Macroscopic and microscopic analyses

Of the 44-artifacts considered, 17 (38.6%) specimens recovered from survey were available for detailed macroscopic and microscopic physical examination. Measurements were taken of a variety of attributes, and observations were recorded relating to traces of manufacture and use-wear. Macroscopic examination was aided by a 20X hand lens, while microscopic inspection was undertaken using a binocular 40X MEIJI Techno EMZ-13TR binocular microscope with a detached Tungsten reflected light illuminator. The remaining 27 specimens, including those from Woodson's (1995: 216-224; 1999) Goat Hill site excavations, were not available for physical examination, but were photo documented, recorded with measurements, and included detailed observations of the raw material types and manufacturing characteristics.

To define our analytical protocol and the attributes employed in our study, we reviewed a number of experimental and archaeological studies focused on the analyses of archaeological specimens as well as the replication and experimental use of hoes (Fleming & Edmonds 1999; Milner *et al*. 2010; Sonnenfeld 1962; Waselkov 1977; Yerkes *et al*. 2003). In addition, a sample of documented tabular basalt hoe blades employed in historic quinoa agriculture in the Bolivian Altiplano also were examined (Tomka 2014). Experimental use of replica hoes suggests that the amount and degree of use-wear noted on tool blades depending on the type of stone used, soil conditions, and ground vegetation cover involved (Sonnenfeld 1962).

Macroscopic examinations revealed that both grinding and hard-hammer flaking or chipping techniques were used to fashion these tools, with some clearly exhibiting both procedures. In the literature, these tools have been classified as both flaked or chipped tools (*e.g.*, Gifford 1980: 60-61; Martin & Rinaldo 1950), but more generally as ground stone implements (*e.g.*, DiPeso *et al*. 1974: 205, 330, 359-361; Haury 1945: 124, 134-137; Martin *et al*. 1957; Wheat 1954: 130; 1955: 124).

Our analyses focused on three aspects of each specimen: the characteristics of the blank, the actual steps in the manufacture of the tool, and the use of the tool as determined from macro- and micro-wear traces. Examinations began with the identification of the raw material and measurements of the dimensions and weight of each artifact. Macroscopic and microscopic inspection of each face and the edges of each artifact followed to identify the modifications of the stone that were indicative of manufacture and tool-use. Areas away from the working edges of each tool were examined for traces of wear, including the presence of polish, striations, and rounding of topographically high areas. Polish was categorized as diffuse, linear, or localized. Diffuse polish is a light polish that is spread over broad surfaces of the artifact. Linear polish tends to be found on flake-scar ridges and other linear micro-features of the tool body protruding above the surrounding micro-topography. Localized polish occurs on topographic micro-features that rise above the surrounding tool surface, such as bumps, large coarse inclusions, and humps that are formed when repeated flake removals result in hinge- or step-fractures. Such areas are produced when the craftsman attempts to undercut previously failed flake removals. Next, high-resolution digital photographs were taken of each specimen's obverse and reverse face to facilitate the detailed description and illustration of use-wear through present traces of "micro-flaking," step-fracturing, edge smoothing, polishing, crushing, etc. The traces of use-wear were described and their locations marked on the digital photographs. Photo-micrographs to document the range of macroscopic and microscopic use-wear were taken of each face and edge of each tool.

The 44 artifacts in the study have been classified into three somewhat homogenous and relatively distinct shape categories: (1) disc, elliptical, ovate-shaped (n=16), (2) sub-rectangular-shaped (n=21), and (3) pick and mattock-shaped (n=7). In the following, we only describe and discuss in detail the implements listed on the tables presented.

2.1. Disc, elliptical, ovate-shaped tools (n = 16)

Sixteen implements (Table 1) have a plan view appearance that varies from discoidal to elliptical to ovate-shaped, a cross-section that ranges from thin tabular to thin plano-convex to thin bi-convex to a thin wedge-shape, working edges that vary from slightly to broadly convex, and are frequently "backed" for grasping. Only one implement (Specimen 18) exhibits shallow bifacial flaking along its entire perimeter. Nine specimens have a single working edge with the opposite side a natural rounded margin or a retouched blunted surface that could be held without concern for injuring one's hands while the tool was used (Figure 1a). One of these (Figure 1b) exhibits an asymmetrical working edge, and in two cases the longer lateral margin of the parent cobble was retouched to produce the working edge of the implement (Figure 2). The remaining six (38%) artifacts (Figure 1c) have two working edges situated on opposite ends of the implement. One working edge is usually narrow and somewhat pointed while the other is more broadly convex. The bulk of the flake removals on these six tools are short and terminate in step-fracture scars near the margins.

Table 1. Metric Characteristics of Disc, Elliptical, Ovate-shaped tools (n=16). Specimen numbers having one asterisk were subject to detailed metric analyses. Specimen numbers having two asterisks represent tools well documented in the field or gleaned from the literature.

Specimen Number or Identifier	**Max. Length (mm)**	**Max. Width (mm)**	**Max. Thickness (mm)**	**Weight (g)**	**Working Edges**	**Raw Material**
Specimen 4*	183	153	44	1191	2	basalt
Specimen 6*	210	183	26	879	2	ferruginous sandstone
Specimen 7*	224	177	29	1474	2	basalt
Specimen 9*	219	126	33	992	1	basalt
Specimen 14*	150	136	17	397	1	schist
Specimen 17*	246	136	38	1424	2	rhyolite
Specimen 18*	170	148	27	879	2	basalt
Specimen 19*	162	192	25	936	1	schist
FN-014**	141	116			1	schist
FN-124**	293	152			1	schist
FN-128 #1**	106	95			1	rhyolite
FN-128 #2**	220	155			1	rhyolite
FN-265 #1**	112	100			1	rhyolite
Apache Creek A**	290	249			1	schist
Apache Creek B**	281	252			1	schist
Purrón Complex, Site Tr-546 #1**	200	14			2	basalt
Mean of entire tool sample (n=16)	**200.4**	**157.0**	**28.9 (n=8)**	**1021.5 (n=8)**		
Mean of Basalt Tools (n=5)	**199.2**	**149.2**	**33.25 (n=4)**	**1134.0 (n=4)**		
Mean of Rhyolite Tools (n=4)	**171.0**	**143.5**	**38.0 (n=1)**	**1424.0 (n=1)**		
Mean of Schist and Sandstone Tools (n = 7)	**218.1**	**182.9**	**22.7 (n=3)**	**737.3 (n=3)**		

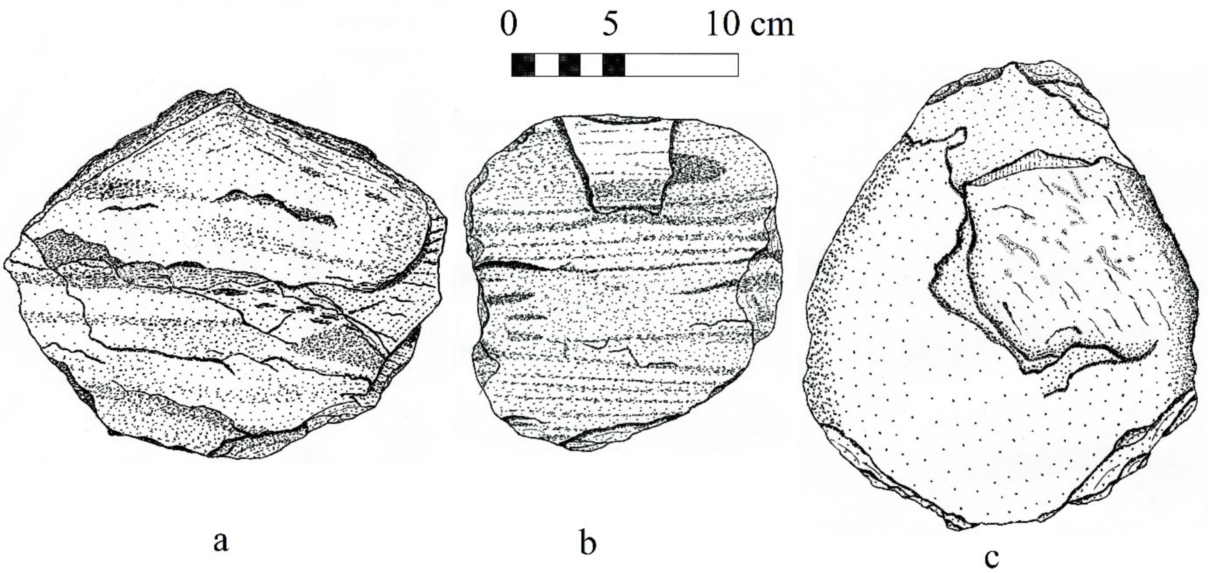

Figure 1. Disc and Ovate-shaped tools. (a) Specimen 19, a disc-shaped tool with natural intersecting flat surface backing, working edge pointed downward (see Figure 3). (b) Specimen 14. An ovate-shaped (originally sub-rectangular?) tool with an asymmetrical working edge. (c) Specimen 6, an ovate-shaped tool with working edges on both ends (seeFigure 7). (Drawings by Steve Tomka.)

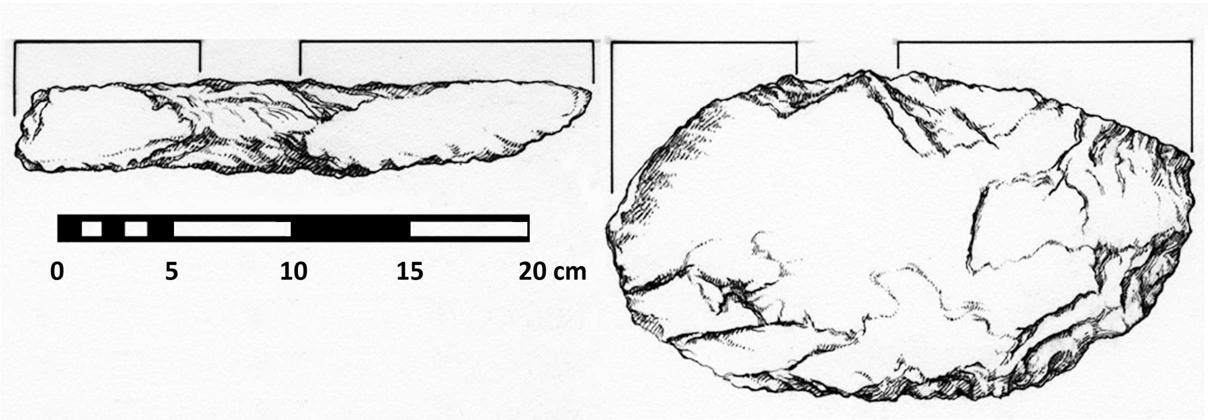

Figure 2. An Elliptical-shaped tool. Specimen 17, (a) flat surfaces (hand holds) interrupted by a retouched portion of the upper edge, and (b) face of the tool (working edge down). (Drawing by Narda Lebo.)

As a group, the 16 specimens have a mean length of 200.4 mm (range = 106-293 mm), a mean working edge width of 156.9 mm (range = 95-252 mm), and a mean thickness of 29.9 mm (range = 17-44 mm). The eight specimens subject to detailed laboratory analysis ranged from 397 g to 1474 g in weight, with a mean weight of 1021.5 g. Three of these eight specimens have a rather narrow range of weight, falling between 879 and 936 g.

Five of the 16 artifacts were fashioned from basalt nodules. The four available for measurement are relatively thick (mean = 33.3 mm; range = 27-44 mm) and heavy (mean weight = 1134 g; range = 879-1474 g). Four were made of rhyolite, a stone about as hard as basalt. The one rhyolite tool studied in detail was 38 mm thick and weighed 1424 g. Schist was fashioned into six tools. Although it is not as hard as basalt, it may have been chosen as it could be neatly split along cleavage planes. The two schist specimens examined are thinner (mean = 21 mm; range = 17-25 mm), and lighter (mean weight = 666.5 g; range = 397-936 g) than their basalt and rhyolite counterparts. The single laminated ferruginous sandstone specimen was probably not as durable as the other stones used. It was thicker (44 mm) than its counterparts, probably to compensate for its relative lack of durability, and weighed 879 g. The use of dense stone apparently reflects the need for a durable raw material that could withstand the physical force with which these tools were used and the materials encountered during use. Our examinations found damage to the leading edges of these tools resulted in flake-removals from the dorsal faces, likely caused by use in rocky soils, a condition also reported by Fleming & Edmonds (1999: 131-132) and Milner *et al*. (2010: 107-108). It is our assumption that the use of fine-grained raw materials, such as chert, would not have been desired due to their more brittle nature, and higher tendency to experience breakages and rapid edge-damage during use (Milner *et al*. 2010).

Many of the specimens were found in locations where the stone types used do not occur naturally. In fact, the initial recognition of these tools on the landscape was due to their different appearance from locally occurring rocks. Apparently, the rock types used in manufacture were chosen not for their local availability, but for their attributes of hardness and or relative ease of modification.

Figure 3. A disc-shaped tool (Specimen 19) of schist from the surface of site AZ CC:1:2 (ASM) (Doolittle & Neely 2004). Working edge facing downward (see Figure 1). (Photograph by James Neely.)

The retouch to shape the parent material and the subsequent use of the tool resulted in step-terminated flake removals and flake scars along the tool's working edges (Figure 2b). The rejuvenation of the step-fractured working edge introduced longitudinal asymmetry that may reflect habitual tool use-positions. As the tools were used, the edges of the step -and hinge- fracture scars came in contact with durable materials and secondary macro-flake removals resulted (Figure 4a). As the original scars stabilized through crushing, their sharp edges became smoothed and rounded (Figure 4b).

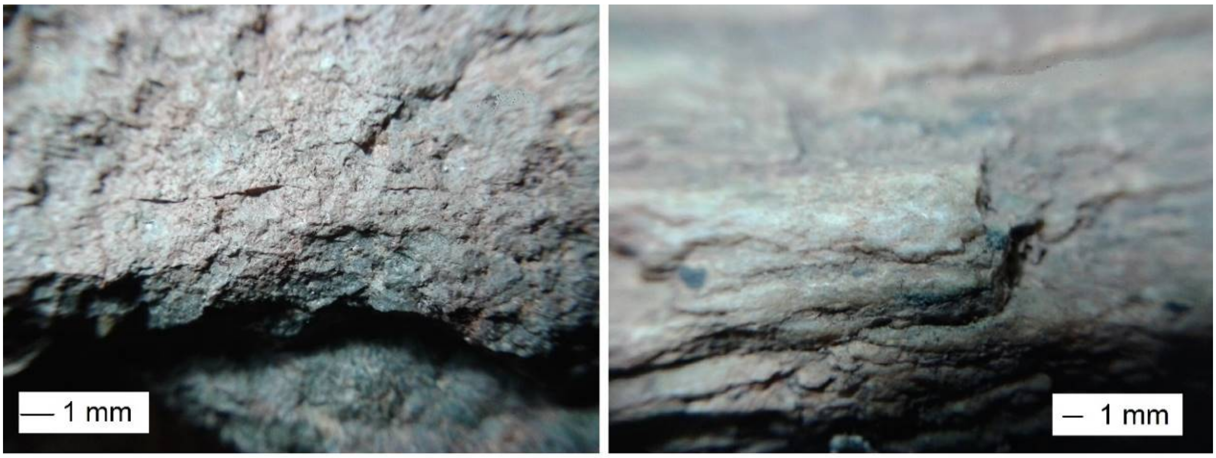

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Figure 4. (a) Specimen 7, a shallow secondary macro-flake step-fracture scar on the face; (b) Specimen 14, smoothed and rounded flake scar ridges. (Photographs by Steve Tomka.)

Six of the tools examined exhibit localized areas of polish on areas that rise above the surrounding micro-topography (Figure 5a). Specimen 7 has localized polish immediately behind the working edge, indicative of prolonged contact with the material being worked. Two of the six specimens retain large patches of diffuse polish on their faces (Figure 5b). On the obverse face of Specimen 19, an elongated patch of diffuse polish can be seen opposing the center of the working edge. It is located on a portion of the tool that would be in contact with the tool-user's hands, supporting the conclusion that the implement was hand-held during use.

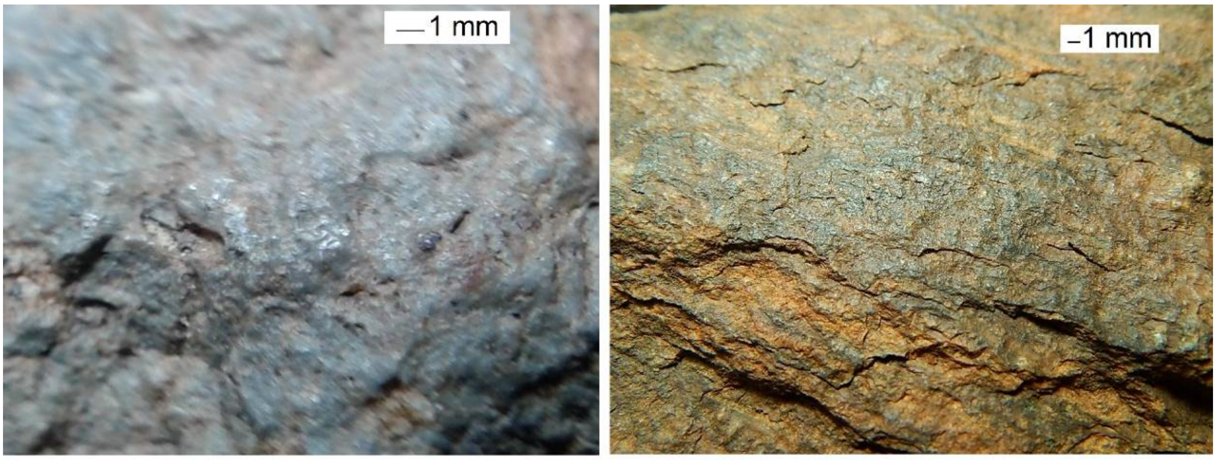

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Figure 5. (a) localized polish behind the working edge of Specimen 7; and (b) diffuse polish near the center of the face of Specimen 19. (Photographs by Steve Tomka.)

On specimen 6, linear polish is evident along a step-fracture scar (Figure 6a) and diffuse polish is present on the face of the tool near its hand-holds (Figures 6b and7a). Figure 7b provides an artist's rendition of the presumed manner of tool use. While present on the reverse face of the tool, polish is much more diffuse as compared to the obverse face. None of the tools being considered herein have the extensive high-gloss sheen or polish on their working edges as found on digging tools found elsewhere (*e.g.*, ovate and notched Mississippian hoes (Cobb 2000: 173; Waselkov 1977: 517)). This is likely due to different raw materials employed in tool manufacture, as well as regional differences in the soil and vegetation.

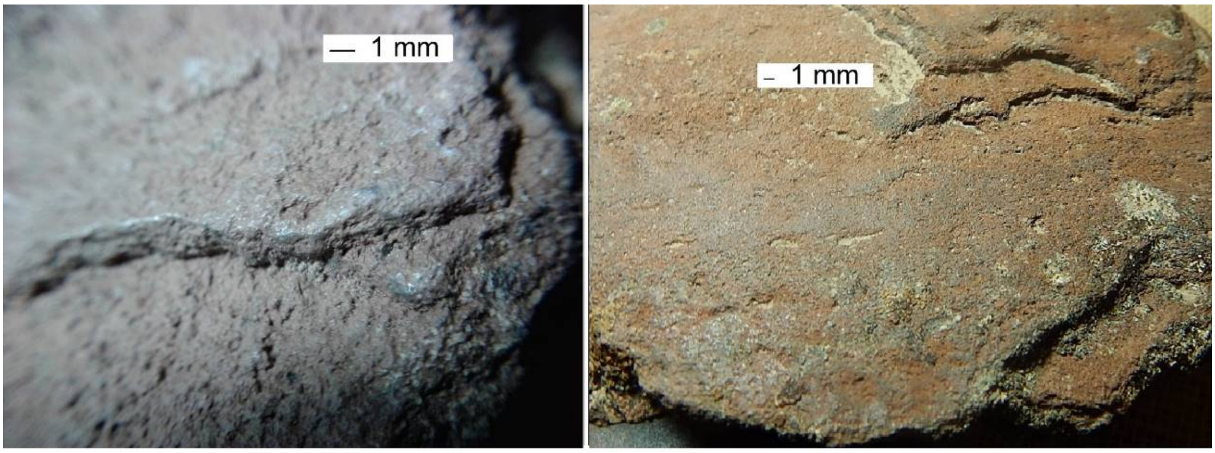

Figure 6. Specimen 6, (a) linear polish along a step-fracture scar, and (b) diffuse polish near the margin of the same tool. (Photographs by Steve Tomka.)

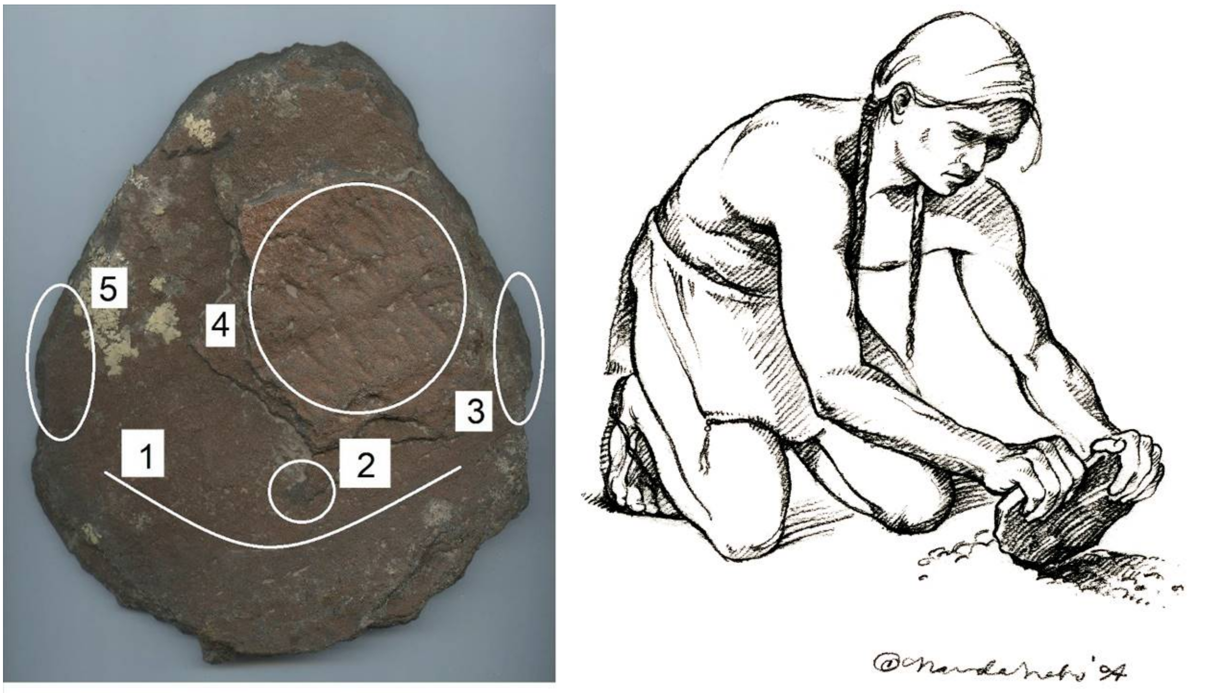

Figure 7. Specimen 6 (working edge on both ends), (a) Localized (2, 3, 5) and diffuse (1, 4) face polishing (see Figure 1). (b) Rendition of how disc, elliptical, ovate, and sub-rectangular-shaped tool forms were probably used. (Photograph by Steve Tomka; drawing by Narda Lebo).

2.2. Sub-rectangular-shaped tools (n = 21)

These tools (Table 2) have sub-rectangular plan view morphologies, are biconvex or plano-convex in cross-section, and are generally larger in size and heavier than the disc, elliptical, ovate-shaped tools. A nearly straight to convex working edge is at one end of most tools, with a natural or prepared flat or convex surface “backing” for grasping at the opposite end. However, a minority of the implements analyzed had two opposing working edges. All examples of these tools have been minimally shaped. The flake removals evident on these artifacts were intended to shape and thin or sharpen the distal work end(s), or "bit(s)"Figures 8a, b, c). Twelve of the 21 tools in this category were made of basalt, eight were schist, and one was rhyolite.

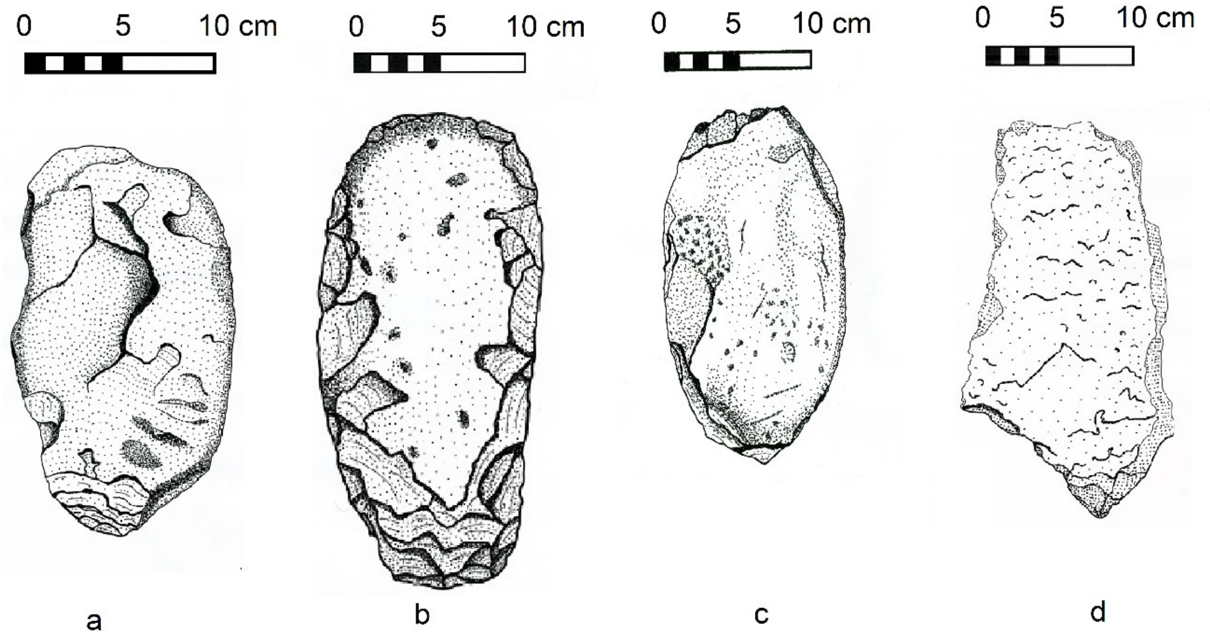

Figure 8. Examples of sub-rectangular-shaped digging tools. (a) Specimen 1, tool with one retouched working edge and retouched backing; (b) Specimen 10, tool with one working edge and two other edges extensively shaped by retouch; (c) Specimen 5, tool with two opposing retouched working edges; and (d) Specimen 8, tabular tool with a work-related step-fractured distal end. (Drawings by Steve Tomka.)

Eight implements have minimal retouch, a single retouched working edge, and an opposing edge having convex or flat backing (Figure 8a). However, an additional tool in this category, with one working edge and an opposing natural convex backing, has two other edges that have been extensively shaped through retouch (Figure 8b). Six implements (29%) have two opposing retouched working edges (Figure 8c). The remaining six artifacts have minimal working edge retouch, most of which consists of step-fractured flake scars and crushed edges resulting from use (Figure 8d).

The 21 specimens have a mean length of 240.5 mm (range = 146-415 mm), and a mean width of 120.3 mm (range = 81-172 mm). The mean thickness for the 15 implements with measurements available is 36.1 mm (range = 23-70 mm). This group averages 40.1 mm longer than the disc, elliptical, ovate-shaped specimens, and has shorter working edges.

Only eight specimens in this category were subject to our laboratory analysis. However, seven tools from the Goat Hill Site (Woodson 1995: 216-224) were included in the statistics as they were reported with photographs, details of manufacture, and complete metrics. The fourteen artifacts for which data are available have a mean weight of 2394.4 g, and range from 624 to 3960 grams. On average, the 14 weighed tools are 1372.9 g heavier than the disc, elliptical, ovate-shaped group, and eight of these tools are heavier than any single member of that group. Note that six of the Goat Hill specimens are heavier than the other weighed specimens in the sub-rectangular group, and that they cluster in a narrow weight range of about 2.1 pounds between 3000 g and 3960 g. In addition to being larger and heavier, the specimens in this group are narrower, longer, and thicker than the disc, elliptical, ovate-shaped implements. A question, which cannot yet be addressed, is: were these differences due to cultural preference, a difference in the task(s) to be performed, or to the nature of the locations in which the work was accomplished?

A distinctive variety of this tool type (Figure 9) has been termed a "split-stone hoe" (Neely 1995: 254). These tools were initially recognized as artifacts because of three factors: (1) the presence of a lithic material unusual for the find context, (2) the discovery of several, partial and complete, examples in a large relict field, their occurrence in a generally uniform sub-rectangular shape, with a distinguishing technique of manufacture; a twice split longitudinal blank. The first bifurcation produced a longitudinally split stone with a plano-convex cross-section. The second split was initiated from the "bit" toward the proximal end of the tool. This produced a pronounced "hinge-fracture" about half way toward the proximal end, resulting in a "blade" and "bit" thinner than the hand-held end of the tool. The flat face and convex back of the tool were usually left unmodified, although a few tools exhibit flake removals to further thin and shape the bit. The process produced a tool with a relatively thin blade and a thick upper portion which would better fit the hands and provide additional weight to facilitate driving the tool into the soil.

Figure 9. Specimen 2, a basalt sub-rectangular-shaped split-stone tool from the surface of a relict agricultural field. The working edge is pointed downward. (Photograph by James Neely.)

Four distinct classes of use-wear are present on sub-rectangular tools: (1) individual step-fracture flake removal scars, (2) rounding and polishing, (3) multiple sequential step-fracture flake removal scars, and (4) striations.

Individual step-fracture flake removal scars are present on all the working edges of these implements (Figure 10a). This use-wear formed as the working edges of tools made contact with hard surfaces initiating flake removals.

The second form of use-wear, rounded and polished flake scar ridges, is also present on all of these tools (Figure 10b). These traces form when weak areas are crushed and eventually rounded into structurally stable ridges that began to acquire polish over time.

Figure 10. (a) Specimen 3, an individual step-fracture removal scar on a working edge. (b) Specimen 12, rounding and light polish on a step-fracture scar ridge. (Photographs by Steve Tomka.)

Multiple sequential step-fractured flake removal scars originate from previous step-fracture scars along the working edges of tools (Figure 11a). These scars are formed during use as the lips of existing scars are driven against hard materials, thereby initiating new flake removals which also terminate in hinged or stepped morphologies. The frequency of step-fractured scars is higher on sub-rectangular tools than on disc, elliptical, ovate-shaped tools, indicating that the force with which these tools were used exceeded that employed in the use of the disc, elliptical, ovate forms.

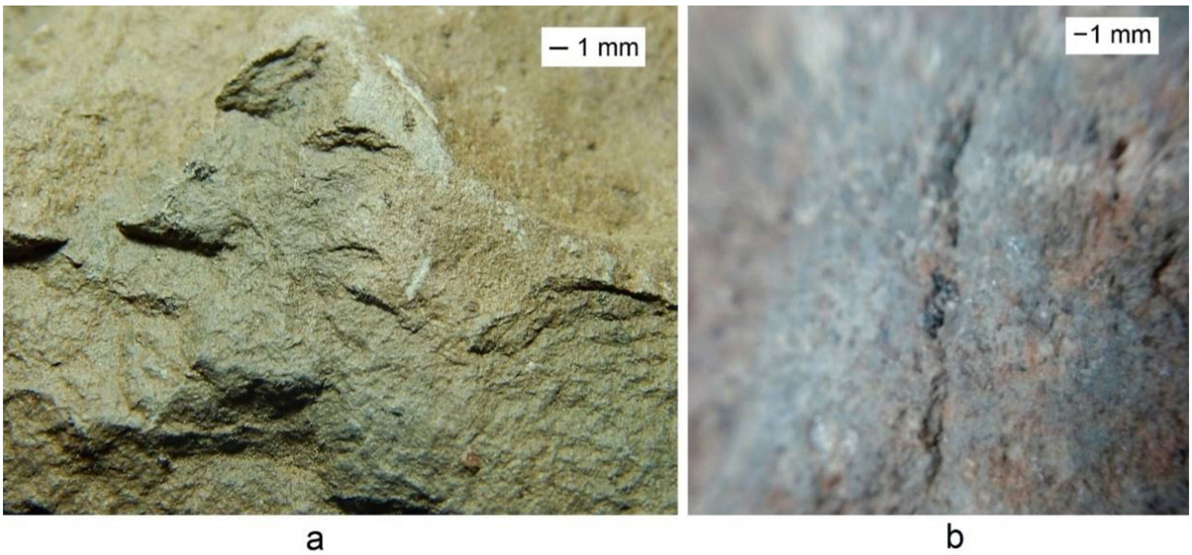

Figure 11. (a) Specimen 1, multiple sequential step-fracture scars on the tool body. (b) Specimen 5, a striation parallel to the longitudinal axis of the tool. (Photographs by Steve Tomka.)

Table 2. Metric Characteristics of Sub-Rectangular-shaped tools (n=21). Specimen numbers having one asterisk were subject to detailed metric analyses. Specimen numbers with two asterisks represent artifacts from Woodson's (1995, 1999) excavation. Specimen numbers with three asterisks represent tools documented in the field or gleaned from the literature.

Specimen number or identifier	Max. length (mm)	Max. width (mm)	Max. thickness (mm)	Weight (g)	Raw material
Specimen 1*	205	119	31	936	basalt
Specimen 2*	313	172	48	2353	basalt
Specimen 3*	146	93	36	624	basalt
Specimen 5*	224	132	33	1361	basalt
Specimen 8*	268	145	28	1134	basalt
Specimen 10*	276	136	46	2240	basalt
Specimen 11*	272	149	70	2977	basalt
Specimen 12*	188	111	33	737	basalt
Goat Hill B**	238	107	23	3000	schist
Goat Hill C**	207	104	24	3150	schist
Goat Hill E**	236	116	26	3700	schist
Goat Hill F**	265	117	26	3390	schist
Goat Hill G**	301	131	35	3960	schist
Goat Hill H**	225	131	36	3960	schist
Goat Hill J**	157	107	46	not stated	granitic (rhyolite?)
Specimen 22***	234	113	not stated	not stated	schist
FN-058***	366	128			basalt
Purrón Complex, Site Tr-506***	196	100			basalt
Purrón Complex, Site Tr-15***	165	90			basalt
Purrón Complex, Site Tr-67***	154	81			basalt
Purrón Complex, Site Tr-546 #2***	415	145			schist
Mean of tool sample (n = 21)	**240.5**	**120.3**	**36.1 (n=15)**	**2394.4 (n=14)**	
Mean of basalt tools (n = 12)	**231.1**	**121.3**	**40.6 (n=8)**	**1545.3 (n=8)**	
Mean of schist tools (n = 8)	**265.1**	**120.5**	**28.3 (n=6)**	**3526.7 (n=6)**	

Two of the sub-rectangular specimens (5 and 17) exhibit the fourth class of use-wear, striations parallel to the long axis of the tool (Figure 11b). In addition, both faces of

Specimen 5 exhibit flat and smoothed surfaces that retain diffuse polish interrupted by pitted areas; the products of pecking (Figure 12) carried out to roughen the surface. This would suggest the reuse of a grinding stone as a digging tool. Tools modified for multiple uses are found throughout the American Southwest (Adams 2014).

Figure 12. Specimen 5, close-up of the pecked surface. The distinct diagonal discoloration line marks portion of artifact buried (lower left), and that exposed on the ground surface (upper right). (Photograph by Steve Tomka.)

2.3. Pick and mattock-shaped tools (n = 7)

The elongated artifacts in this group have an irregular plano-convex to roughly cylindrical cross-section, and exhibit working edges at each end; one smaller and generally rounded to pointed, the other broader and shaped into an adze or mattock-shaped cutting edge (Figures 13 and 14). Unlike the "picks" illustrated by Haury (1945: 124, Plate 32e) and Wheat (1954: 137, fig. 43a-c), which have a smooth shaft, the samples in this study have uneven and rough shaft surfaces. Many similar tools were classified as "pestles" in the literature, but their descriptions and illustrations were often not detailed enough to determine if they were indeed used as pestles. Therefore, it is possible that a few of the tools labelled as a "Pick and Mattock" in Table 3 were pestles. It is also conceivable that some of those tools may have been used both as pestles and picks or mattocks.

Figure 13. Specimen FN-097, a pick and mattock tool made from schist. Note the pointed pick-like end to the left and the broader mattock-like end to the right. This implement has an irregular plano-convex cross-section. (Photograph by James Neely.)

All of the specimens are narrow elongated pieces of schist. Basalt or other stone types were not found, most likely because those stone types do not lend themselves to be easily modified into narrow elongated shapes. Given the consistency in their morphology, the weight, shape, and length of the parent material were desired attributes of the blanks. The tools have one end pecked into a rounded roughly conical point, while the opposite end was modified by percussion flaking into an adze or mattock-shaped bit. These characteristics would be especially well suited to be used as a digging bar in the excavation of relatively deep, small holes in rocky soils. All of these tools have pronounced multiple deep step-fracture scars, as well as extensive crushing and rounding, on their broader end (Figures 14a and b), which were also present in fewer numbers and less pronounced on the smaller, more pointed end.

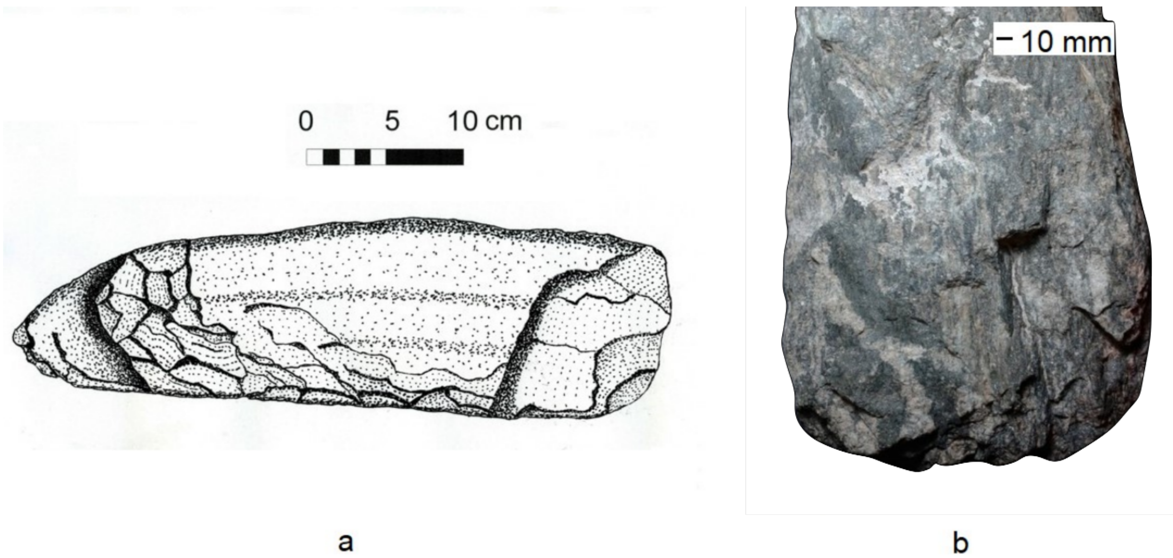

Figure 14. Specimen FN-007 #1, a pick and mattock tool made of schist. (a) Deep step-fracture scars on both ends of the obverse face of the tool. (b) Photo of broader distal working end, showing fracture scars on the reverse face. (Drawing and photograph by Steve Tomka.)

These traces suggest that impacts during use removed large portions of the implement's working ends making the tool less effective, and likely leading to its discard. In addition, striations parallel with the long axis of the tools were common, indicating the implements were employed by using near vertical thrusts into a resistant substance, such as a sandy soil and rock matrix, leading to the step-fracturing of the working edges.

These tools were probably used for multiple digging chores. Hodge (1893: 325) and Ackerly *et al*. (1987: 85-88) mention excavations in Hohokam canals that revealed a number of post-holes suggesting the former existence of a head-gate or weir. While digging sticks could have accomplished the goal of digging postholes, the stone pick and mattock would probably have served as a more effective and efficient digging implement, especially in rocky soils.

As a group, the six complete specimens have a mean length of 350.0 mm (range = 315-424 mm), and a mean width of 94.1 mm (range = 69-135 mm). The one specimen that was subject to detailed analysis had a maximum thickness of 75 mm, and weighed over five kilograms. These tools comprise the heaviest category of artifacts in this study. Our sample of artifacts correlates fairly well with the metrics of similar implements reported by DiPeso *et al*. (1974: 205, 359-360), Haury (1945: 124), and Wheat (1954: 130).

Table 3. Metric Characteristics of Pick and Mattock-shaped tools (n=7). The specimen number in bold print with one asterisk was subject to detailed metric analyses. Specimen numbers having two asterisks represent tools documented in the field or gleaned from the literature.

Specimen identifier	Max. length (mm)	Max. width (mm)	Max. thickness (mm)	Weight (g)	Raw material
FN-007 #1*	421	118	75	5103	schist
FN-007 #2**	290	82	82	2359	schist
FN-020**	424	135			schist
FN-097**	325	69			schist
FN-213**	315	74			schist
FN-265 #2**	315	77			schist
Goat Hill "A"** (broken, reused)	198 (broken)	99	22	2990 (broken)	schist
Mean of tool sample (n=7)	**348.3 (n=6)**	**93.4 (n=7)**	**59.7 (n=3)**	**3731 (n=2)**	

3. Find locations and contexts

Archaeological and historical artifact finds in the Phoenix area form the bases for the assumptions that these implements were used for canal excavations. However, recent field work, a literature search, and the canvassing of colleagues have expanded their find locations and augmented their find contexts. Furthermore, studies by Bell *et al*. (1967) and Doolittle (2000: 165-168) suggest that variations of these tools may well have had additional Prehistoric and Historic Period uses further east in North America.

Figure 15, and Tables 4 and 5, present the results of our research beyond our physical analysis, including a non-exhaustive literature search and the reporting of unpublished, but verified, fieldwork finds. The findings reveal a widespread geographic distribution. While sometimes superficial, the evidence provided (*i.e.*, shape, dimensions, material of manufacture, illustrations, and written description) for the reported implements was considered sufficient for us to list them as representing artifacts belonging to one of our three categories. However, notations as to the presence of backing and the battering and crushing of the working edges and other use-wear characteristics were lacking from the vast majority of the sources, and the tools were frequently misidentified as to use and function.

As may be observed on Table 4, the tools analysed have been mostly recovered from relict fields and in association with prehistoric canals. Conversely, the literature cites finds mostly from habitation sites (*e.g.*, Gifford 1980: 60; Smith 1952: 123, table 8; Woodson 1995: 218-223), less frequently from communal, ritual, and ceremonial contexts (*e.g.*, Smith 1952: 121, table 8; Woodson 1995: 221), and seldom from agricultural field or canal contexts. While these tools probably were also used for non-agriculturally related purposes, such as the excavation of house pits, disposal of the dead, and for digging water wells and reservoirs (Wheat 1952), the find context information strongly supports agriculturally related tool use.

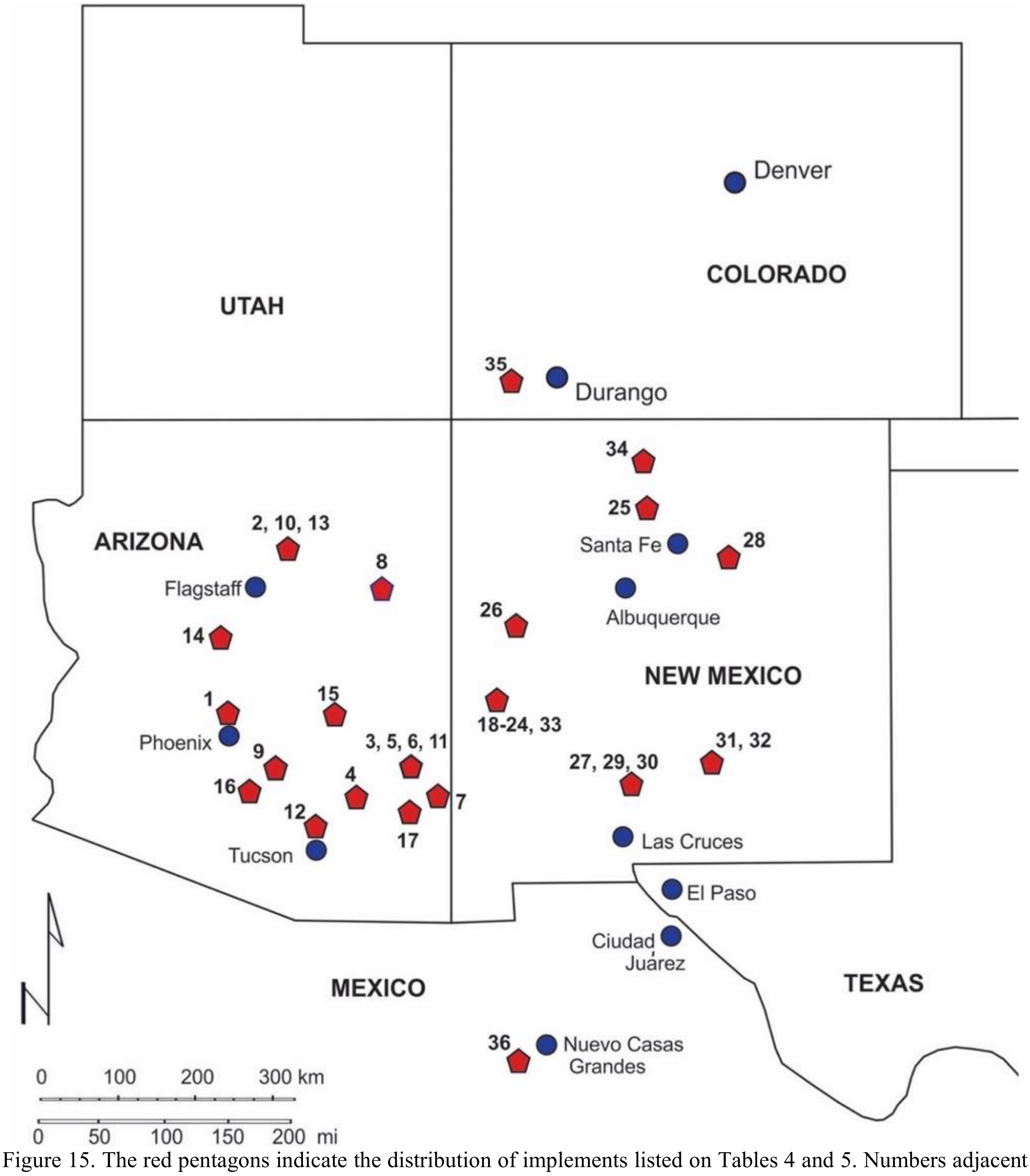

Figure 15. The red pentagons indicate the distribution of implements listed on Tables 4 and 5. Numbers adjacent to the pentagons correspond with those appearing in the left-most column of Table 5. The locations of finds from southern Mexico are not shown, but indicated with an asterisk (*) inTable 5. (Map by Steve Tomka.)

Table 4. Proveniences and Find Contexts of the Forty-Four Artifacts Analysed. Specimen numbers Specimen numbers having one asterisk were subject to detailed metric analyses. Specimen numbers with two asterisks represent artifacts from Woodson's (1995; 1999) excavation. Specimen numbers with three asterisks represent tools documented in the field or gleaned from the literature. SPN or ID: Specimen number or Identifier.

	SPN or ID	Provenience and Find Context
Disc, Elliptical, Ovoid-shaped tools (n = 16)	Specimen 4*	Los Alamos, New Mexico. Basin Land Exchange (BLE) - Site 11A. Surface find in prehistoric agricultural field (Neely 1993).
	Specimen 6*	Los Alamos, New Mexico. Basin Land Exchange (BLE) - just North of Site 20. Surface find in prehistoric agricultural field (Neely 1993).
	Specimen 7*	Los Alamos, New Mexico. Basin Land Exchange (BLE) - just North of Site 20. Surface find in prehistoric agricultural field (Neely1993).
	Specimen 9*	Los Alamos, New Mexico. Basin Land Exchange (BLE) - Site 17. Surface find in prehistoric agricultural field (Neely1993).
	Specimen 14*	Central Safford Basin, Arizona. Wes Jernigan Site (North) - AZ CC:1:38 (ASM). Surface find, 20 m west of canal AZ CC:1:167 (ASM) (Neely 2017).
	Specimen 17*	West-central New Mexico. Centerfire Creek Site. Surface find, 30 m north of a small prehistoric(?) canal (Neely, personal find).
	Specimen 18*	West-central New Mexico. One km SW of the Apache Creek site (LA-2949). Surface find in prehistoric agricultural field SW of Locus 1048. About 250 meters southeast of a small canal (Neely 1995).
	Specimen 19*	Central Safford Basin, Arizona. Safford Grid Fields - AZ CC:1:2 (ASM); Surface find in prehistoric agave field, half way between Field House # 1 and Pit House Locus # 1 (Doolittle & Neely 2004).
	FN-014***	Central Safford Basin, Arizona. Site AZ CC:5:36 (ASM). Surface find, 10 m east of canal AZ CC:1:143 (ASM) (Neely 2017).
	FN-124***	Central Safford Basin, Arizona. Coronado National Forest - Site AR03-05-04-332. Surface find, 30 m northeast of canal AR03-05-04-320 (Neely 2017).
	FN-128 #1***	Central Safford Basin, Arizona. Coronado National Forest - Site AR03-05-04-332. Surface find, 20 m northeast of canal AR03-05-04-320 (Neely 2017).
	FN-128 #2***	Central Safford Basin, Arizona. Coronado National Forest - Site AR03-05-04-332. Surface find, 30 m northeast of canal AR03-05-04-320 (Neely 2017).
	FN-265 #1***	Central Safford Basin, Arizona. Site AZ CC:5:38 (ASM). Surface find, 20 m east of canal AZ CC:5:28 (ASM) (Neely 2017).
	Apache Creek A***	West-central New Mexico. One km SE of Apache Creek Site (LA-2949). Surface find in prehistoric agricultural field SW of Locus 1048 (Neely 1995).
	Apache Creek B***	West-central New Mexico. About one km SE of the Apache Creek Site (LA-2949). Surface find in prehistoric agricultural field SW of Locus 1048 (Neely 1995: Figure 16.8).
	Purrón Complex. Post-Classic Site Tr-546 #1***	Tehuacán Valley, Puebla, Mexico. Purrón Dam Complex, Post-Classic site Tr-546. Surface find, 5 m east of Canal Tr-547 (Neely et al. 2015).

	SPN or ID	Provenience and Find Context
Sub-rectangular-shaped tools (n=21)	Specimen 1*	West-central New Mexico. One km to SE of the Apache Creek Site (LA-2949). Surface find in prehistoric agricultural field SW of Locus 1048 (Neely 1995).
	Specimen 2*	West-central New Mexico. One km to SE of the Apache Creek Site (LA-2949). Surface find near small prehistoric structure in prehistoric agricultural field 150 m to SW of Locus 1048 (Neely 1995: Figure 16.8).
	Specimen 3*	West-central New Mexico. One km to SE of the Apache Creek Site LA-2949). Surface find in prehistoric agricultural field, 53 meters south from small prehistoric structure and SW of Locus 1048 (Neely 1995).
	Specimen 5*	Los Alamos, New Mexico. Basin Land Exchange (BLE) - Site 17, SE Quadrant. Surface find in prehistoric agricultural field (Neely 1993).
	Specimen 8*	Los Alamos, New Mexico. Basin Land Exchange (BLE) - Site 20A. Lot 24 (FN-26). Surface find in prehistoric agricultural field (Neely 1993).
	Specimen 10*	Los Alamos, New Mexico. Basin Land Exchange (BLE) - Site 20A. Lot 24 (FN -2b). Surface find in prehistoric agricultural field (Neely 1993).
	Specimen 11*	Los Alamos, New Mexico. Basin Land Exchange (BLE) - WSW of Site 23 and ENE of Site 5. Surface find in prehistoric agricultural field (Neely 1993).
	Specimen 12*	West-central New Mexico. WS Ranch Site (LA-3099). West of the Great Kiva, about 5.3 meters southeast of permanent Datum N950 E1000. Surface find 20 m from refurbished prehistoric canal (Neely, personal find).
	Goat Hill B**	Central Safford Basin, Arizona. Goat Hill Site AZ CC:1:28 (ASM). Room 34, floor (Woodson 1995: 220).
	Goat Hill C**	Central Safford Basin, Arizona. Goat Hill Site AZ CC:1:28 (ASM). Room 34, fill (Woodson 1995: 220).
	Goat Hill E**	Central Safford Basin, Arizona. Goat Hill Site AZ CC:1:28 (ASM). Kiva, floor (Woodson 1995: 221).
	Goat Hill F**	Central Safford Basin, Arizona. Goat Hill Site AZ CC:1:28 (ASM) surface find between Rooms 14 and 18 (Woodson 1995: 222).
	Goat Hill G**	Central Safford Basin, Arizona. Goat Hill Site AZ CC:1:28 (ASM). Room 33, floor (Woodson 1995: 222-223).
	Goat Hill H**	Central Safford Basin, Arizona. Goat Hill Site AZ CC:1:28 (ASM). Room 14, surface (Woodson 1995: 223).
	Goat Hill J**	Central Safford Basin, Arizona. Goat Hill Site AZ CC:1:28 (ASM). Room 14, fill (Woodson 1995: 223).
	Specimen 22***	Central Safford Basin, Arizona. Found partly buried in down-slope spoil bank of Mud Springs Canal AZ CC:1:166 (ASM) at GPS Locus N32.84300 W109.81074 (Neely & Lancaster 2019).
	FN-058***	Central Safford Basin, Arizona. Site AZ CC:5:42 (ASM), FN-058. Surface find, 100 m west of canal AZ CC:5:51 (ASM) (Neely 2017).
	Purrón Complex, Post-Classic Site Tr-506***	Tehuacán Valley, Puebla, Mexico. Purrón Dam Complex, Post-Classic site Tr-506. Surface find, on large platform atop Site Tr-15 (Neely et al. 2015)
	Purrón Complex, Site Tr-15***	Tehuacán Valley, Puebla, Mexico. Purrón Dam Complex. Surface find atop site Tr-15, just east of Tr-506 (Neely et al. 2015).
	Purrón Complex, Post-Classic Site Tr-67 ***	Tehuacán Valley, Puebla, Mexico. Purrón Dam Complex, Site Tr-67, surface find, 6 m west of canal Tr-548 (Neely et al. 2015).
	Purrón Complex, Post-Classic Site Tr-546 #2***	Tehuacán Valley, Puebla, Mexico. Purrón Dam Complex, Post-Classic site Tr-546. Surface find, 5 m east of Canal Tr-547 (Neely et al. 2015).

	SPN or ID	Provenience and Find Context
Pick and mattock-shaped tools (n = 7)	FN-007 #1*	Central Safford Basin, Arizona. Site AZ CC:5:42 (ASM). Surface find, 60 m west of canal CC:5:51 (ASM) (Neely 2017).
	Goat Hill A**	Central Safford Basin, Arizona. Goat Hill Site AZ CC:1:28 (ASM). Room 33, floor (Woodson 1995: 218).
	FN-007 #2***	Central Safford Basin, Arizona. Site AZ CC:5:42 (ASM). Surface find, 50 m west of canal CC:5:51 (ASM) (Neely 2017).
	FN-020***	Central Safford Basin, Arizona. Site AZ CC:2:104 (ASM). Surface find, 5 m east of canal AZ CC:1:143 (ASM) (Neely 2017).
	FN-097***	Central Safford Basin, Arizona. Site AZ CC:5:38 (ASM). Surface find, 30 m east of canal AZ CC:5:28 West (ASM) (Neely 2017).
	FN-213***	Central Safford Basin, Arizona. Site AZ CC:5:47, FN-213. Surface find, a small prehistoric field in a drainage, 40 m west of canal AZ CC:5:51 (ASM) (Neely 2017).
	FN-265 #2***	Central Safford Basin, Arizona. Site AZ CC:5:38, FN-265. Surface find, 25 m east of canal AZ CC:5:28 (ASM) (Neely 2017).

To bridge the extensive geographical gap between the archaeological site of Casas Grandes in Chihuahua, Mexico and finds in the Tehuacán Valley of Puebla and the Nochixtlán Valley of Oaxaca, Mexico, we undertook a limited literature search and conducted an e-mail canvass of 46 U.S. and Mexican colleagues who have undertaken fieldwork in Mexico between, and including, the states of Chihuahua and Oaxaca.

The results of those efforts indicate that these tool forms have not been reported or seen. This is a conundrum, as tools recovered from the Tehuacán Valley and Nochixtlán (Tables 4 and 5) are definitely digging tools and are similar to those found in the Southwest! This apparent absence is likely due to the crude nature of our tool forms that has hindered their recognition in areas where the prehistoric production of finely made stone tools is the norm. We consider the absence of evidence as not necessarily evidence of the absence of these tool forms. A few citations and colleagues noted the presence of tools made of similar materials and similar in form to our tools, but that those artifacts were smaller in size, and, in the few cases where use-wear had been studied, apparently did not have the battered working edges of our tools. These smaller artifacts were identified by the authors and respondents as probable agave (*maguey*) processing tools. While our disc, elliptical, ovate, and sub-rectangular-shaped tool forms are generally similar to tools that were used in the processing of agave, three factors differentiate the tools; their size, weight, and the types of use-wear present.

4. Dating, distribution and likely group affiliations

Table 5 presents the temporal parameters of the site contexts for the implements studied, and are from the cited literature indicated. Most dates were derived from ceramic-crossdating based on ceramic and tree-ring associations at other sites since the 1920s. Dates in parentheses in Table 5 are from a recent compilation of tree-ring dates for the American Southwest (Kohler & Bocinsky 2015), and provide the most secure published dating.

Martin (1943: 222-223) and Wheat (1954: 116-118, 130) report the finding of schist or gneiss and basalt implements similar to all three of our categories at, respectively, the SU Site and Crooked Ridge Village. Those sites date to *ca.* 400-600 CE, and suggest that the tool forms may have originated from the Mogollon area. The early occurrence of these probable agricultural tools is not surprising considering the evidence for domesticated corn (*maize*) at several sites in the American Southwest by *ca.* 2100 BCE (Cordell & McBrinn 2012: 136), and other domesticated plants (*e.g.*, beans and squash) by around 800 BCE (Merrill *et al.* 2009).

Haury (1932: 98-99) notes the presence of tools similar to disc, elliptical, ovate-shaped tools at the Hohokam site of Roosevelt: 9 and 6 that dates to the later Colonial Period (*ca.* 825-1025 CE). Stone digging implements similar to all three of our morphological types were found during excavations at the Classic Period (*ca.* 1250-1450 CE) Hohokam sites of Casa Grande (Fewkes 1912: 131-132) and Los Muertos (Haury 1945: 124, 134-137). Within the central Safford Basin, in addition to tools found during survey, eight tools from the Goat Hill Site were recovered from well-dated (1275-1325 CE) excavated habitation and ceremonial structure floor contexts attributed to Kayenta migrants (Woodson 1995: 216-224; 1999). Our research indicates that these tools are found infrequently prior to *ca.* 1200 CE, but apparently occur in large numbers from *ca.* 1200-1450 CE (Table 5). In Mexico, similar tools were found during survey and excavation in the Tehuacán Valley of Puebla at Post-Classic Period sites (*ca.* 900-1520 CE) (MacNeish *et al*. 1967; Neely *et al.* 2015), and through excavation in Medio Period contexts (*ca.* 1300-1450 CE) at Casas Grandes (Paquimé) in Chihuahua (DiPeso *et al*. 1974: 360).

Table 5. The location, basic characteristics, and dating of examples of Prehistoric digging tool forms found in a brief literature search and from published and verified unpublished fieldwork finds. Numbers in the left column correspond with those next to the pentagons in the distribution map, Figure 15. The dates were derived from ceramic cross-dating and dendrochronology. Dates in parentheses indicate the most secure temporal placement of the sites by direct tree-ring associations (Kohler & Bocinsky 2015). **State or Country:** AZ: Arizona, NM: New Mexico, CO: Colorado, MX: Mexico. **Tool Forms**: D: Disc, Elliptical, Ovate-shaped; S: Sub-Rectangular-shaped; PM: Pick and Mattock-shaped. **Stone Types**: A: Flow Andesite; B: Basalt; R: Rhyolite; SCH: Schist or Gneiss; SH: Shale; SS: Sandstone; T: Dense Welded Tuff; L: Limestone; PW: Petrified Wood; Q: Quartzite.

	State or country	**Site name or number**	**Tool forms**	**Stone type**	**Dates CE**	**References**
1	**AZ**	Los Muertos	D, S, PM	R, A	1250-1450	Haury 1945
2		Sites NA537, 618, 680-682, 1179, 1814	D, PM	SS, B	1100-1225 (1129-1139)	Smith 1952
3		Red Bow Cliff Dwelling	D, S	Q	1325-1400	Gifford 1980
4		Babocomari Village	D, S	SCH, SS	1150-1450	DiPeso 1951
5		Site AZ W:10:37 (ASM)	D, S, PM	B, G, SCH	1000-1265	Olson 1959
6		Site AZ W:10:56 (ASM)	D, PM	B	1000-1265	Olson 1959
7		Site AZ CC:8:16 (ASM)	PM	SCH	?-500	Lascaux & Montgomery 2006
8		Homol'ovi	S	SS, PW	1275-1400 (1276)	Lang 1989
9		Snaketown	D, S	R, A	1025-1175	Haury 1976
10		Sites NA1653,1765, 3996	D, S	B, SS	600-1200 (688-1182)	Colton 1946
11		Crooked Ridge Village	S, PM	SCH, B	400-600	Wheat 1954
12		Site AZ BB:14:24 (ASM)	S	SCH	1100-1300	Zahniser 1966
13		Nalakihu (NA358)	D	SS	1175-1400 (1183)	King 1949
14		King's Ruin	S	B	1026-1200	Spicer & Caywood 1936
15		Sites AZ V:5:90 and AZ V:5:104 (ASM)	D, S	R, SS	950-1350	Elson & Clark 1995
16		Casa Grande Site	D, S	SCH	1250-1450	Fewkes 1912
17		Central Safford Basin sites, Bajada Canals & Goat Hill Site AZ CC:1:28 (ASM)	D, S, PM	B, SCH, R, SS	1200-1450 (1275-1325)	Neely 2017; Neely & Lancaster 2019; Woodson 1995, 1999

	State or country	Site name or number	Tool forms	Stone type	Dates CE	References
18	**NM**	Gila National Forest - U.S.F.S. Site 944 area	D, S	B, SCH		Neely 1995
19		The SU Site	D, S	B	500 (460)	Martin 1943
20		Apache Creek Pueblo (LA 2949) Area	D, S	B, SCH	1000-1300	Martin et al. 1957; Neely 1995
21		Higgins Flat Pueblo	D, S	B, SCH	1000-1300 (1260)	Martin et al. 1957
22		Sawmill Site	S	SCH	1000-1150	Bluhm 1957
23		Turkey Foot Ridge	D, S	B	850-1000 (783)	Martin & Rinaldo 1950
24		21 sites in Gallita Canyon	S	R, SS	900-1300	Shoberg 1998
25		USFS Bason Land Exchange, Los Alamos, NM	D, S	A, T	1000-1400	Neely 1993
26		Sandstone Hill Pueblo	D, S	SS	1115-1300	Barnett 1974
27		Cottonwood Site (LA175)	S	L	1275-1450	J. A. Neely - Personal Find
28		LA168643	D	SH	1275-1450	Kurota 2011
29		Jarilla Site (LA37470)	D, S	L, SH	1170-1280	Kurota et al. 2016
30		Huntington Pueblo (LA 14820)	D, S	SH, L	1000-1200	Kurota & Dello-Russo 2020
31		Creekside Site (LA146443)	S	L	650-825 (650-825)	D. Greenwald - Personal Find
32		Twin Kiva Site (LA 6832)	D, S	L	650-825	D. Greenwald - Personal Find
33		Techado Spring (LA 6010)	S	SS	1000-1300	Smith et al. 2009
34		Rio Del Oso and NE San Juan Pueblo Grant Area	D, S, PM	Q, B, SCH	1000-1600	Kurt Anschuetz - Personal Find.
35	**CO**	Mesa Verde Site 499 (NPS)	S	SCH	925-1125 (1123)	Lister 1964
36	**MX**	Casas Grandes (Paquimé), Chihuahua	D, S, PM	SCH, R	1150-145	Di Peso et al. 1974
*		Tehuacán Valley, Puebla - “Post-Classic Site”	S	SS	900-1520	MacNeish et al. 1967: 123, 132
*		Tehuacán Valley, Puebla Sites Tr-15, 67, 506 & 546	S	B, R	900-1520	J.A. Neely - Personal Find Neely et al. 2015.
*		Nochixtlan, Oaxaca	S	SCH	900-1520	J. A. Neely - Personal Find

Unlike southern Mexico, where the tools considered may be linked to known cultural or linguistic groups (*i.e*, Popoloca, Mexica, and Mixtec), the Southwestern agriculturalists using these tools apparently represented peoples of several archaeologically defined and named groups; the Mogollon, Western-Pueblo, Ancestral Pueblo, Sinagua, Hohokam and Salado.

5. Observations and discussion

5.1. Unimproved agricultural field identification

In several instances (*e.g.*, Neely 1993; 1995) the tools under consideration were instrumental in tentatively identifying unimproved prehistoric agricultural fields. The scattered presence of several tools in proximity provided the means to cautiously identify prehistoric fields lacking any tangible infrastructure (*i.e.*, linear contour borders, terracing, check dams, etc.), and to roughly indicate the size and shape of the fields as well. Awareness of these implements would greatly enhance one's ability to identify areas as loci of cultivation, pending additional studies.

5.2. Hafting

We are aware that some archaeological examples of large stone implements were likely hafted even though their shapes and sizes appear to make that improbable (Fowler 1946). It is exactly for this reason that we carefully examined the ends of each tool as well as the surfaces of both faces adjacent to each end. Our findings indicate that the pick and mattock tools described herein were unhafted, and our other two implement categories are backed tools lacking hafting notches and have characteristic use-wear, implying that they too were hand-held. Ethnographic descriptions support the contention that similar implements were hand-held and were utilized while kneeling or sitting (Figure 7b). Spier's (1928) treatise on the Havasupai, and Castetter and Bell's (1942: 136) Pima/Papago and Yuman (1951: 95, 240) work, document wooden tools that were hand-held and used for various digging, agricultural, and canal preparation tasks while in a kneeling or sitting position.

Some of our tool types have been found in association with contemporary hafted digging tools. Thus, while the vast majority of the disc, elliptical, ovate, and sub-rectangular-shaped tools examined in this study were probably hand-held, there is a possibility that some of those implements may have been hafted as "push hoes" (DiPeso *et al*. 1974: 359, fig. 448-7) or "shovels" (Fewkes 1912: 131, 134, fig. 39), with the backed areas perhaps used as "steps" where foot pressure could be applied. Our reticence in classifying the tools we have studied as push hoes or shovels is due to the presence of more than one opposing working edge, use-wear characteristics, as well as the thickness and weight of some specimens.

5.3. Use and function

The three forms of implements defined by this study evidently were used and functioned as tools integral in the subsistence and economic systems to provide vegetal foodstuffs for use and trade. Although one specimen (Specimen 19; Figures 1a, 3) was found in what has been interpreted as an agave field, the remainder of these tools were found in fields apparently dedicated to other crops. It is likely that they also were used and functioned in the settlement system to construct pit-houses as well as community and ceremonial structures, and as general-purpose tools for other digging activities. The disc, elliptical, ovate-shaped variants, have broad working edges that are suited for the movement of substantial amounts of soil with one stroke. The sub-rectangular tools are perhaps best designed for excavating the channels of irrigation canals and for the initial loosening of soils in agricultural fields. The pick and mattock tools appear to have been designed to conduct excavations in more compacted and rocky soils and for excavating postholes.

Due to its general similarity to some of the digging implements described, the "*tcamahia*" (Ellis 1967; Woodbury 1954: 165), warrants a brief mention here. *Tcamahias* are celt-like in form (*i.e*., refined, well-finished variations of our sub-rectangular tools), and occur most frequently in ceremonial contexts dating from *ca.* CE 400 into the historic present, and they have been found in locations partially overlapping the distribution of our tools (Figure 15) (Woodbury 1954: 166-170). However, following Smith (1952: 123), implements classified as *tcamahias* have not been included in our analyses as we consider them to be distinctly different; an artifact better made from "hornstone" found primarily in the Four Corners region (Ellis 1967: 36), and more standardized in a celt-like form. Furthermore, tools classified as "hoes", such as those reported by Cosgrove & Cosgrove (1932: 45, Plate 44) from the Swarts Ruin and other Mimbres area sites (personal communication with Darrell G. Creel on 2001), appear to combine the form and manufacturing characteristics of some of our tools and the *tcamahias.* They too have not been included in our analyses as they were described as not being: "worn on the edge or point." (Cosgrove & Cosgrove 1932: 45), and they appear to be more similar to *tcamahias* in form.

Tcamahias present a dilemma in relation to their use and function. A *tcamahia*, most likely dating to *ca.* 1250-1300 CE, was found hafted to a long cottonwood handle in Chaco Canyon (Hayes 1976: 74, Figures 1, 3) in a manner to suggest it was used as a "push hoe". However, *tcamahias* are generally considered as ritual or ceremonial artifacts due to their archaeological contexts, and as reported in ethnographic studies (*e.g*., Ellis 1967; Fewkes 1900). The presence of this artifact as an agricultural tool and in ritual or ceremonial contexts suggests that, as Morris (1919: 26) observed while noting that *tcamahias* appear on Zuni and Hopi altars, *tcamahias* may have originally been agricultural implements. It should be noted again that a semi-rectangular implement was found on the floor of the Goat Hill ceremonial kiva (Table 4). Thus, in some instances, digging tools may have been physically modified into the *tcamahia* and incorporated into rituals and ceremonies. Perhaps symbolically and functionally acting as metaphors for fertility to represent the importance of agriculturally related activities (*e.g.*, field preparation and canal excavation) in the petition for environmental events (*e.g.*, rainfall) and life necessities (*e.g.,* sufficient foodstuff) to sustain the agriculturalist's lifeway (see also: Baltus 2018).

5.4. Tool manufacture *vis-a-vis* agricultural infrastructure

The tools considered in this paper were made on raw material blanks that closely approximated their final finished form. As a result, many of the artifacts required little work to fashion them into usable tools, and they might be classified as "expedient" due to their minimally retouched forms. In contrast to the informal characteristics of these tools, in both the American Southwest and Mexico, the implements discussed herein are frequently found within the context of large-scale, long-term labour investments in agricultural infrastructure frequently requiring the levelling of fields, construction of terraces, and the construction of large-scale irrigation features and systems (*e.g*., Doolittle & Neely 2004; Neely 2014; Neely & Lancaster: 2019; Neely *et al.* 2015). Haury (1976: 300) also questioned why these tools were not more formalized and well finished commensurate with the sophisticated nature of their recovery context. Archaeologists researching the relationship between subsistence systems and tool design have advanced a variety of factors and variables (*i.e*., subsistence risk (Fitzhugh 2001); dependence on specialized food stuff (Oswalt 1976: 223); performance characteristics of alternative technologies (Bettinger *et al*. 2006)) that may be responsible for increased tool complexity among ethnographic groups involved in more sophisticated subsistence systems. Based on a number of these theoretical constructs, it would be expected that agricultural tools employed in relatively intensive pursuits, such as irrigated agriculture, would rely on more complex, multi-component tools, rather than the rudimentary forms we have described.

Perhaps further confusing the situation is their presence in well-dated floor contexts within habitation as well as communal and ceremonial (*i.e.*, kiva) structures (Smith 1952: 121; Woodson 1995: 216-224), implying that they were artifacts having a special value beyond their use as digging tools. Both of these occurrences bring to mind the question; why do these rudimentary artifacts continue to be made and used in the light of their associations with sophisticated agricultural infrastructure and presence in habitation as well as communal and ceremonial contexts? Could it have been simply because the crude tools were easily replaced when broken, or because their performance was satisfactory in tasks to which they were applied? Or, perhaps, their continued use involved a much subtler rationale! Can we view these implements as representing a "tradition" of tool manufacture? A "tradition" may be defined as anything passed down within a group or society from the past to the present (Shils 2006: 12-13). Their persistent use through time may be a classic case of: "If it was good enough for our grandfathers, it is good enough for me." These tools may have been found effective and continued to be made and used essentially unchanged for hundreds of years, while their personal and ceremonial value and function developed into a perceived symbolic importance in the maintenance of at least one cultural system (*i.e.*, the subsistence system).

6. Summary and conclusions

This investigation of a sample of minimally retouched, morphologically variable group of artifacts has accomplished three goals: 1) Detailed use-wear studies and find contexts have verified the historically documented assumption that these implements were digging tools used to dig irrigation canals and in other agricultural pursuits. 2) The implement's distribution, temporal placement, and functions have been initially determined, but likely need to be refined by further study. The apparent absence of these artifacts in the large geographic gap between the American Southwest and southern Mexico requires further investigation. 3) This article brings these tools to the attention of archaeologists and provides means for their identification.

Whether the three relatively distinct shape categories have validity other than as a means of classification remains uncertain. Contexts (Table 4) suggest that the pick and mattock-shaped tool was employed in canal excavations, while the other two tool shapes are nearly equally divided between field and canal find contexts. Occurrences listed in Table 5 largely report tools found in structural contexts, but it has been noted that those reports have seldom dealt with agriculturally related contexts.

Use-wear analysis has revealed that these were hand-held tools that were regularly employed in digging and earth moving tasks. The different types and degrees of use-wear seen on the three morphologically defined groups of tools indicates that the digging activities regularly encountered buried rocks. Contextual find evidence indicates the implements were frequently used in the movement of soils involved in preparing fields for planting and subsequent maintenance, as well as to create and maintain channels to direct water flow as proposed by Hodge, Turney, and others. However, it is logical that the implements were probably used for other digging chores as well. In addition, archaeological and ethnographic find contexts have disclosed that the tools also held a social and ritual or ceremonial value and function, most probably to petition for the continuance of reliable food production. The rudimentary nature of these tools remains incongruous in the light of their association with contemporaneous hafted digging tools and extensive labour intensive sophisticated agricultural infrastructure.

As we have noted, a number of excellent examples of experimental tool use and use-wear analysis exist that linked artifacts recovered from ancient fields to agricultural activities (*e.g.*, Fleming & Edmonds 1999; Milner *et al*. 2010; Sonnenfeld 1962; Waselkov 1977; Yerkes *et al*. 2003). However, the conclusions of those studies are of limited value in interpreting our artifact samples given the distinct lithic raw materials employed, and the nature of ground cover vegetation and soil conditions extant relevant to our examples (see Sonnenfeld 1962). We recognized that our study and conclusions would be greatly strengthened by the experimental manufacture and use of implements in the agricultural tasks discussed in our manuscript. Subsequent macroscopic and microscopic studies of these experimental specimens would build the methodological and observational linkages between tool manufacture, use, and agricultural pursuits as indicated in our current study. Consequently, experimental studies, additional fieldwork, and a more expansive review of survey and excavation literature will undoubtedly contribute to a better definition of tool use, refine implement distribution and the periods of tool use, as well as clarify functions and group affiliations. We encourage others to undertake such studies as independent verifications of our conclusions, and plan to do so ourselves if future circumstances allow.

In conclusion, this paper contributes to the study of the design and use of tools employed as part of developing prehistoric agricultural strategies and systems. It brings these tools to the attention of archaeologists so that they may be recognized during survey and excavation to add information in the study of prehistoric agriculture, its intensification, and the subtle, but highly important, interrelationships between the subsistence, settlement, social, and ceremonial systems.

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Data accessibility statement

The authors confirm that the data supporting the findings of this study are available within the article.

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Evaluando artefactos líticos prehistóricos rudimentarios del suroeste de Estados Unidos y México

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Resumen:

Aquí se presentan los objetivos y los antecedentes de este estudio. Una muestra de artefactos rudimentarios recuperados en prospecciones y excavaciones de contextos del suroeste de Estados Unidos han sido examinados físicamente para verificar o desechar su asumida validez como herramientas y su uso, en particular, para actividades agrícolas. Estas piezas, generalmente poco estudiadas e identificadas de forma errónea, han sido examinadas desde perspectivas macro y microscópicas para determinar las evidencias de fabricación humana y también su uso. Los resultados de este trabajo indican que los especímenes analizados presentan tres categorías formales como herramientas y que han sido utilizadas en actividades de excavación y movimiento de tierra. Para fortalecer estas evidencias, se ha recogido información acerca de los contextos de los hallazgos, diferentes registros históricos y también, de la bibliografía existente. La localización geográfica de los hallazgos, los contextos de los mismos, pero también su posicionamiento cronológico y la probable asignación hacia determinados grupos formales también ha sido tenido en cuenta en la discusión. Las evidencias mostradas indican que, aunque estas herramientas hayan sido utilizadas para diversos fines, estos artefactos mínimamente retocados, asidos con la mano y con capacidad para excavar y movilizar tierra fueron utilizados para la preparación y el mantenimiento de campos de cultivo agrarios y sus canales de irrigación, funcionando como apoyo para las actividades de subsistencia en la zona aproximadamente entre el 400 y el 1450 CE. Estos implementos obviamente también tuvieron funciones y valores sociales y ceremoniales. La rudimentaria naturaleza de estas herramientas no se corresponde con la complejidad de la infraestructura agrícola asociada. A pesar de ello, se presentan hipótesis iniciales y de tipo tentativo para solventar esta posible incongruencia.

Keywords: Suroeste de Estados Unidos; México; herramientas agrícolas prehistóricas; tecnología lítica; tecnología del sistema de subsistencia.