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The *Journal of Arizona Archaeology* is a peer-reviewed journal that focuses on the presentation of emerging ideas, new methods, and current research in Arizona archaeology. It endeavors to be a forum for the scholarly, yet simple communication of research and management related to Arizona's archaeological record. The *Journal* is published twice a year by the Arizona Archaeological Council (AAC) in both electronic and paper formats. At least one issue per year is devoted to the theme of the AAC annual fall conference. The remaining issues of the *Journal* are intended for open submissions. Invited guest editors assist with the compilation of each issue.

Subscription

Members of the AAC receive an annual subscription to the electronic format as part of their annual membership fee of \$35, and may order an annual paper format for an additional \$10 per year. Non-members may purchase a single issue of the *Journal* for \$5 per electronic copy and \$15 per paper format, which includes postage and handling.

To apply for AAC membership please visit the website: <http://arizonaarchaeologicalcouncil.org>.
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Instructions for Authors

The format of all submitted papers should correspond to the SAA style guide, which can be accessed at this web address: <http://www.saa.org/AbouttheSociety/Publications/StyleGuide/tabid/984/Default.aspx>. Manuscripts must be submitted as a MS Word document, as all review and editing will be conducted electronically. Authors should be familiar with the "track changes" and "comments" functions of MS Word. Authors are encouraged to contact the editor with questions regarding the content or formatting of their manuscripts prior to submitting their papers. The editor will review each paper prior to peer review to determine if the manuscript meets content and formatting guidelines. If the paper meets these guidelines, the editor will send the manuscript out for peer review. The editor makes the final decision to accept a manuscript on the basis of the reviews of the peer referees. If a manuscript is accepted for publication, authors must submit images in at least 300 dpi. All permissions for photographs and figures are the responsibility of the author and must be obtained prior to publication.

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PREFACE

J. Simon Bruder, Guest Editor

From its inception in 2010 the intention of the Arizona Archaeological Council (AAC) has been to publish the *Journal of Arizona Archaeology* twice a year, with one issue devoted to the theme of the AAC's annual fall conference and the second issue open to all topics. It was not until 2015, however, that two issues of the *Journal* began to be published each year, and through 2017 both issues were devoted to publishing a backlog of conference proceedings.

This issue finally inaugurates the *Journal's* original goal of devoting one issue per year to submissions on any topic. Not surprisingly the five papers included here cover a wide range of topics and range from the detailed consideration of a specific artifact type (Curcija) to new perspectives on the sociopolitical organization of an entire archaeological cultural tradition (Howard and Woodson). The papers address the archaeology of northeastern Arizona (Curcija), north central Arizona (Sorrell, Weintraub, and Downum), the Upper Verde River Valley (Guebard, Bass, and Porter), the Middle Gila River Valley (Guebard, Bass, and Porter; Howard and Woodson), and the Salt River Valley (Howard and Woodson; Steinbach).

The *Journal's* mission is to serve as a platform for the presentation of emerging ideas, new methods, and current research in Arizona archaeology. Each of the papers included here exemplify one or more of these goals. All are the result of independent research conducted to satisfy the authors' individual interests. None of the research reported required a permit.

Zachary Curcija presents an exhaustive description of bow drill technology and details how best to distinguish hand-spun drills from archery bows and toys. The paper by Matthew Guebard, Angelyn Bass, and Douglas Porter compares colored washes used as wall decoration at the Montezuma Castle cliff dwelling and the Casa Grande great house and addresses their possible visual symbolism and intended audiences. Jerry Howard and Kyle Woodson offer new perspectives on Hohokam sociopolitical organization as that relates to our increased understanding of prehistoric irrigation systems. A dating method that uses increasing sherd thickness through time to date San Francisco Mountain Gray Wares with potential precision of less than a century and the ability to place sites on a continuous temporal scale is the topic explored by Daniel Sorrell, Neil Weintraub, and Christian Downum. Lastly, Erik Steinbach amassed and synthesized the results of over three dozen cultural resource management efforts conducted over the last 40 years to trace the development of the Hohokam village known as La Plaza and to offer an explanation as to how that development responded to the geographic benefits and constraints of the Salt River, the Mesa Terrace, and Tempe Butte.

I thank each of the authors who contributed to this issue. Thanks also to Chris Caseldine, Daniel Garcia, Dennis Gilpin, Andrea Gregory, Kathleen Henderson, Andrew Lack, Jill Neitzel, A.E. (Gene) Rogge, Arthur Vokes, and Henry Wallace along with two anonymous peer reviewers. Several members of the *Journal's* editorial panel assisted with copy editing. Finally, many thanks to the *Journal's* editor Glen Rice for inviting me to be a guest editor and who was invaluable in guiding me through the process, and to managing editor Erik Steinbach for pulling it all together.

CALL FOR PAPERS FALL 2018 CONFERENCE, ARIZONA ARCHAEOLOGICAL COUNCIL

Conference Date: October 19, 2018

Abstracts Due: October 1, 2018 (see instructions below)

Venue: Arizona History Museum, Tucson

Conference Organizer: David R. Hart

Conference Theme: Recent Research in Commodities Exchange in Arizona Archaeology.

Abstract: The AAC Fall Conference of 2018 will address recent archaeological research in production and exchange of commodities among populations of Arizona and neighboring regions. Presenters are invited to consider the full range of commodities, including crafts, raw materials, agricultural products, and meat, and to address the context of production (e.g. households, villages, and quarries), the context of exchange (markets, trading partners, and inter-household reciprocity) and the role of exchange in maintenance of networks, social identity and adaptive systems.

Afternoon Panel Discussion: The future of the past and its effect on the present: The present state of archaeology as affected by the current political climate.

Abstract: Recent political efforts to change natural and cultural resources laws at the Federal and state level, including in Arizona, have the potential to drastically affect the practice of archaeology. As part of the 2018 Fall Conference the AAC panelists will discuss current challenges and solutions to keep archaeology viable in the foreseeable future.

Instructions: Presentations are limited to 20 minutes per paper. Submit an abstract of not more than 300 words to David R. Hart (dhart@gsrccorp.com) by October 1, 2018.

CALL FOR PAPERS SOUTHERN SOUTHWEST ARCHAEOLOGICAL CONFERENCE (SSWAC)

Conference Date: January 11-12, 2019

Abstracts Due: August 15, 2018 (visit www.sswac.org for instructions and information)

Venue: Pueblo Grande Museum, Phoenix

Conference Contact Person: Christopher R. Caseldine (ccaseldi@asu.edu)

The Southern Southwest Archaeological Conference (SSWAC) is coming to Pueblo Grande Museum January 11-12, 2019. Abstracts are due August 15th, 2018 (www.sswac.org).

SSWAC is a new conference aimed at highlighting current archaeological research in the Southern Southwest United States and Northwest Mexico. The aim is to hold this conference every other year, each time in a different location around the region. This will allow participants to explore the history of various localities through site visits and other activities while also showcasing new and innovative research from throughout the region. Alongside sharing research, goals for the conference include building community and facilitating collaboration among those interested in the archaeology of the region.

BOW DRILL TECHNOLOGY IN PREHISTORIC ARIZONA

Zachary S. Curcija

ABSTRACT

Hand-spun drills overwhelmingly dominate the archaeological record of prehistoric Southwestern drilling technology. In this paper, I present examples of probable bow drill technology from prehistoric settlements in northeastern Arizona, focusing on a previously undescribed bow from Scaffold House, Tsegi Canyon. I also offer a provisional guide to distinguishing utilitarian bow drills from archery bows and their toy and ceremonial representations.

Current archaeological evidence from the prehistoric Southwest suggests that the hand-spun drill was the primary, and in many areas the only, method for creating both fire-by-friction and for perforating materials. Hand-spun fire drills are a relatively common perishable artifact found at prehistoric sites where the conditions are favorable for the preservation of organic material. They have been found throughout the Southwest, including at cliff-dwellings along the upper Gila, the Verde Valley, Ventana Cave, and numerous sites in the Four Corners region (Cosgrove 1947:Fig140a,l; Haury 1950:414-15; Kidder and Guernsey 1919:Plate 50; Peter Pilles, personal communication, 2015).

Miniature bows, which superficially resemble bow drill components, have been found in prehistoric sites across the region, including the lower Tonto cliff-dwelling, Canyon Creek Ruin, Ceremonial Cave in the Winchester Mountains, cliff-dwellings along the Upper Gila River, Bear Creek Cave, and Kiet Siel (Anderson 1969:76; Bohrer 1957:88; Fulton 1941:20; Haury 1934:106; Hough 1914:97-102; Parks 2017:50). Most of these objects, however, do not exhibit the morphological characteristics expected of functional bow drills.

In this paper, I synthesize current data on prehistoric Southwestern bow drill technology focusing on definite and probable bow drills from northeastern Arizona. The growing count of bow drills identified in curated

collections indicates that they are likely not anomalies or misidentified historic-era artifacts. The evidence suggests that bow drill technology existed earlier, and was potentially more widespread, in the prehistoric Southwest than is currently acknowledged.

In 1934, Paul Martin, of the Field Museum of Natural History, presented the first account of bow drill technology from the prehistoric Southwest (Figure 1). The artifacts were recovered from a cliff-dwelling in Grand Gulch, Utah by Charles McLoyd and Charles Cary Graham in 1890 (Martin 1934:96). The assemblage includes all components of a bow drill: a bow fitted with a 2-ply s-spun Z-twist *Yucca* sp. fiber cord, a bearing block, two hearth boards, a drill with a flaked-stone drill bit, and two fire-drills.

The assemblage was not directly dated; however, Martin suggests that it dates from the Pueblo-III period, an estimation also supported by Dr. Alfred V. Kidder (Martin 1934:97). The set is probably temporally consistent with other items from Grand Gulch, which date between AD 1050 - 1250 (Laurie Webster, personal communication, 2015).

The Grand Gulch bow drill set is the most conclusive evidence of bow drill technology in the prehistoric Southwest and serves as the template used to recognize incomplete bow drill sets discussed in this paper. The presence of a hearth board and multiple drills, with both fire-making and perforation-drilling capabilities, indicate that bow drill technology was used to create both fire-by-friction and to make perforations.

The second example of prehistoric Southwestern bow drill technology is a single bow fitted with a frayed 2-ply s-spun Z-twist *Yucca* sp. cord from White Canyon, southeastern Utah. This probable bow drill bow was collected by McLoyd and Graham in 1892-93 and is curated at the American Museum of Natural History (Charles T. LaRue, personal communication 2017). The third speci-

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Figure 1. The bow drill set from Grand Gulch, Utah, including the bow with a 2-ply *Yucca* sp. fiber cord, a spindle with a flaked chalcedony drill bit, and a bearing block (Courtesy of The Field Museum, Cat. No. 21490, 21546, Photographer Laurie D. Webster)

men, from Scaffold House in Tsegi Canyon, northeastern Arizona, is in the collections of the University of Arizona and is described here for the first time (Figure 2). Also from northeastern Arizona, is a broken, stone-tipped spindle attached to a bow-like stick from Ruin 7 (Olla House) in Sayodneechee Canyon. Each of the specimens from northeastern Arizona are described in greater detail below.

BOW DRILL TECHNOLOGY

The bow drill set provides a mechanical advantage for rotating a spindle compared to rotating a spindle between the hands, as in the hand drill method. The appa-

ratus is used to produce friction through the synergy of two perpendicular forces: rapid revolutions of the drill and downward pressure. The bow cord wraps around the spindle so that the spindle rotates as the bow moves along a horizontal plane. The bow provides greater velocity and range of motion than the hand-rotated spindle.

At the proximal end of the drill, a bearing block provides downward pressure, increasing the amount of friction applied to the passive element being drilled and stabilizing the spindle as it rotates. The distal end of the spindle can be the blunt end of a softwood fire drill or a hafted flaked-stone drill bit, depending on the intended use of the tool. If a wooden spindle is drilled



Figure 2. The bow drill bow from Scaffold House, Tsegi Canyon, northeastern Arizona (1273 C.E. - 1285 C.E.) with a 2-ply *Apocynum cannabinum* fiber cord (Catalog number 1795 from the collection of Arizona State Museum)

into a hearth board of the appropriate wood, the friction will create heat and fine wood dust. If a small notch is carved into the edge of the hearth board so that it intersects the burned cavity created by spindle, the fine wood dust created by the friction will consolidate within the notch. Exposure to the intense heat created during drilling can ignite the consolidated wood dust into an ember that can be coaxed into flame in a tinder bundle. If the distal end of the spindle is tipped with a flaked-stone drill bit, the same mechanics of the bow drill can perforate drilled material.

THE TSEGI CANYON BOW DRILL

The Tsegi Canyon bow drill is the first identified representative of bow drill technology from prehistoric Arizona. The artifact was recovered from Scaffold House (AZ D:65:5), an alcove settlement within the Bubbling Springs branch of Tsegi Canyon, during the University of Arizona Archaeological Expedition of 1916 led by Byron Cummings (Andrew T. Higgins, personal communication 2017). Tree ring dates from Scaffold House indicate that the community was established in AD 1273 and that construction continued until AD 1285 (Dean 1969:157).

The bow is made from a debarked branch that is most likely Gambel oak (*Quercus gambelli*). The bow measures 59 cm long and between 0.7 – 2 cm in diameter, with the thicker end serving as the handle and proximal end of the bow. The ends of the bow are identified by the presence of a permanent knot at the distal end and an adjustable knot at the proximal end, discussed in

greater detail below. The branch is unmodified except for a split in the proximal end, the removal of bark and branches, and an encircling groove carved into the distal end to receive the string. The cross-section reflects the natural circular shape of the branch apart from where the split in the proximal end creates a D-shaped cross-section in that area.

Plant fiber cordage remains fully intact, wrapped around the bow's length and bound on either end with knots. The cord is 2-ply z-spun S-twist dogbane (*Apocynum cannabinum*) cordage. The cordage varies between approximately 2.2 and 3 mm in diameter, the thinner region denoting the areas of use compressed by rotating a drill (Figure 3).

The bow's working length is determined by the presence of the overhand knot along the length of the cord and the variance between how the cord is wrapped around the bow on either side of the knot. Working length refers to the portion of the cord that engages and rotates the drill-spindle. The cordage within the working area is compressed, stretched, and exhibits tribochemical wear polishing indicative of operating a spindle (Adams 2014:34-36). In contrast, the section between the knot and the proximal end exhibits the loft and fullness of freshly spun cordage (Figure 3).

The cord is attached to the distal end of the bow with a loop created by wrapping the running end of the cord within the bow's encircling groove, then tying an overhand knot around the passive end of the cord that continues down the length of the bow. The running end was subsequently tied with an overhand knot, result-



Figure 3. Detail of the proximal end of the Scaffold House the bow. Note the stretch, compression, and polish from tribochemical wear on the working section of the bow cord. The medial knot divides the working and non-working sections of cord (Catalog number 1795 from the collection of Arizona State Museum)

ing in a sliding loop that constricts within the encircling groove of the bow when taut. (Figure 4).

From the distal attachment, the cord is wrapped around the length of the bow at a rate of approximately one wrap per 3 cm. An overhand knot along the cord delineates a working length of approximately 45 cm from the distal end. Beyond the knot, the cord wraps around the bow at a greater frequency toward the proximal attachment, possibly designating a handle. The cord is attached to the proximal end by tying the running end of the cord in a half hitch under the last wrapping along the bow. The half hitch is secured with a stopper knot that appears to be a double half-hitch with an overhand knot on the end of the cord. It is likely that the proximal attachment represents a temporary bind to secure the wound cord to the bow and not the operational attachment.

If the cordage was unwound from the Scaffold House bow and made ready for use, the brace height of the working cord would be approximately 9 cm. Brace height refers to the distance between the belly of the strung bow and the bow cord. With a working length of 45 cm, the bow could have rotated a spindle the diameter of the Grand Gulch spindle, 2.5 cm in diameter, approximately five revolutions forward and five revolutions back.

The Scaffold House bow drill is morphologically unique when compared to other miniature bows from the Tsegi Canyon region. Anderson's review of Tsegi Phase technology identified three miniature bows (An-

derson 1969:76; Christian E. Downum, personal communication 2017). The most complete example, from Kiet Siel, is 48.3 cm long and contains a loosely Z-spun single-ply shredded *Yucca* sp. leaf cord composed of two short leaf fragments bound in a knot (Anderson 1969:76) (Figure 5).

The fragility of a minimally processed *Yucca* sp. leaf cord and the presence of a large knot in the cord contest the artifact's viability as a functional bow drill. A replication experiment with a Grand Gulch-style spindle and hearth board demonstrated that a bow with a shredded *Yucca* sp. leaf cord is inadequately durable to create an ember before the cord breaks. Furthermore, the cord on the Kiet Siel bow does not have enough slack to accommodate a spindle.

A PROBABLE BOW DRILL FROM NORTHEASTERN ARIZONA

Additional evidence for bow drill technology was found in Ruin 7 (Olla House), a cliff-dwelling in Sayod-neechee Canyon (Kidder and Guernsey 1919:47, 127). The artifact was recovered by Alfred V. Kidder and Samuel Guernsey during their 1914 field season for the Peabody Museum of Archaeology and Ethnology, Harvard University.

The following description is based on photographs from the Peabody Museum and Kidder and Guernsey's brief description (Kidder and Guernsey 1919:127). They did not assign a relative date, but the architecture of



Figure 4. The distal end of the Scaffold House bow. Note the stretch, compression, and polish on the working section of cord compared to the section of cord on the left side of the knot (Catalog number 1795 from the collection of Arizona State Museum)



Figure 5. A miniature bow-like object from Kiet Siel, Northeastern Arizona. The bow measures 48.3 cm long. The shredded *Yucca* sp. leaf string is too taut and fragile to accommodate and rotate a drill-spindle (Courtesy of the American Southwest Virtual Museum, Bilby Research Center, Northern Arizona University)

Ruin 7 and the ceramic assemblages found therein are used here to infer a date range of AD 1050 - 1240 (Christian E. Downum, personal communication 2017).

A broken spindle, approximately 4 mm in diameter, is bound to a fragmentary stick that resembles a bow. Because they are broken, identification as components of a bow drill set is tentative (see Figure 6). It is possible

that this artifact is a toy or ceremonial representation of a bow and arrow.

A small flaked-stone drill bit is hafted into the distal end of the spindle. The bit measures approximately 3 mm thick at the haft and around 1 mm thick at the working end of the tip. It is comparable in size to jewelry microdrills recovered from ornament production

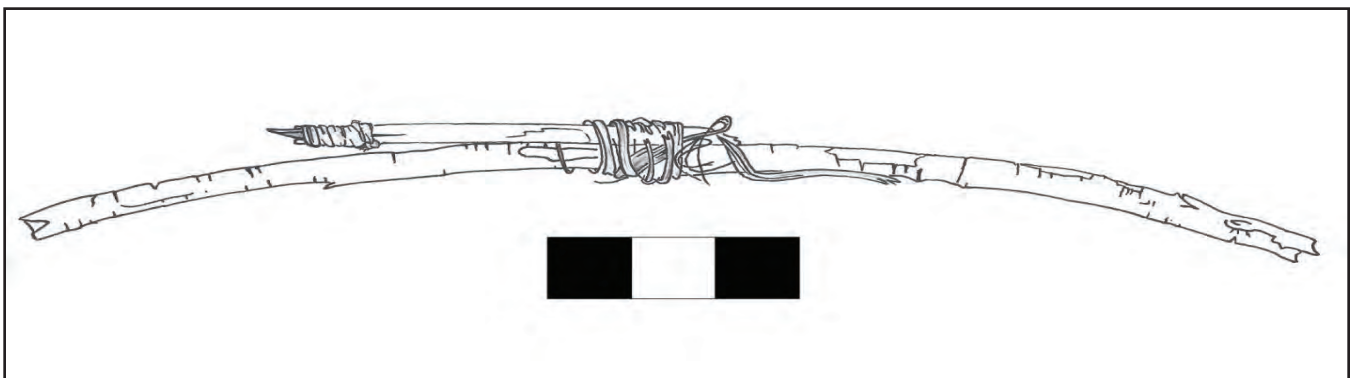


Figure 6. An illustration of the possible fragmentary bow drill set from Ruin 7 (Olla House), Sayodneechee Canyon, northeastern Arizona (1050 - 1240 C.E.). This object consists of a possible spindle tipped with a flaked-stone drill bit bound to a bow-like stick with a split *Yucca* sp. leaf wrapping. The drill bit is compression hafted into a split in the end of the spindle and reinforced with split *Yucca* sp. leaf binding. This object is curated at the Peabody Museum of American Ethnology and Archaeology, Harvard University (based on photographs by J. Desany Ganong, Peabody Museum of Archaeology and Ethnology, New Haven, CT where the artifact is curated)

sites in central and southern Arizona (Haury 1985:119-20; Copus 1993:437). This specimen is the only hafted microdrill documented in a literature review conducted for this article.

The plausible microdrill appears hafted by pressure: the drill bit is inserted into a split in the wooden shaft and the split is reinforced with a split *Yucca* sp. leaf wrapping. No adhesive is visible from the images and while it is possible that the adhesive degraded over time, replication experiments demonstrate that a compression-hafted microdrill can withstand the stresses of drilling stone and shell ornaments (Curcija 2018:37).

IDENTIFYING BOW DRILLS IN THE ARCHAEOLOGICAL RECORD

There are, undoubtedly, undiscovered and unidentified examples of prehistoric Southwestern bow drills within prehistoric sites and in curated collections. The bow drills described here provide attributes for distinguishing bow drills from ceremonial, toy, and children's archery bows. These attributes are derived from a limited sample, and should be considered as general guidelines rather than conclusive representations of prehistoric Southwestern bow drills.

The bow must be rigid enough to adequately rotate a drill-spindle and withstand the resultant tension and compression. Similarly, the cord must be sufficiently robust to endure the friction and tensile stress of the rotating spindle. These structural requirements immediately relegate most of the miniature bows in the archaeological record to another function. Many miniature bows, such as the small bow from the lower ruin of Tonto National Monument, are simply too long and narrow for use as a bow drill (Bohrer 1957:88).

There are child-size archery bows that are similar in length to the bows described here. Small archery bows from Dyck Ranch in the Verde Valley in a collection recently acquired by the Verde Valley Archaeology Center provide contrasting attributes to the small bow drills. Different functions of bow drill bows and archery bows require marked morphological differences. Bow drills do not store energy, and therefore do not exhibit the profile of equally tapered bow limbs diagnostic of prehistoric Southwestern archery bows (Dixon 1956:46; Guernsey 1931:101; Parks 2017:35, 53, 90). The profiles of identified bow drill bows reflect the natural taper of the limb with minimal signs of modification beyond shaping the ends, removing branches, and carving encircling grooves. The White Canyon specimen was worked to have a flat belly with a D-shaped cross section in the middle, but the rest of the bow was unmodified (Charles T. LaRue, personal communication 2017).

The method of cord attachment also differs between archery bows and bow drills. The bow drill bow has a single encircling groove at one end or a pair of grooves at both ends to accommodate the bow cord.

To receive the bowstring, prehistoric Southwestern archery bows exhibit either shallow notches along the edges of the bow limb or they lack notches altogether (Dixon 1956:43; Parks 2017:53). Prehistoric bowyers generally avoided violating the outermost growth ring of the tree limb that forms the "back" of the bow, the section of the bow that faces the target when in use (Dixon 1956:46-47; Parks 2017:94). Maintaining the integrity of a bow-limb's outermost growth ring, however, is not imperative for a lightweight child's bow or a non-utilitarian ceremonial or toy bow, and some in the archaeological record may exhibit encircling grooves. Fifty-eight of the 61 ceremonial bows from the Winchester Mountains lack notches of any form (Fulton 1941:20).

Many prehistoric Southwestern archery bows exhibit painted decoration (Parks 2017:52-53) and small ceremonial bows, such as those found along the upper Gila River, in the Flagstaff region, and within Ceremonial Cave in the Winchester Mountains, are typically embellished with elaborately painted designs (Fulton 1941:20; Hough 1914:97-102; McGregor 1943:206). The identified bow drill bows lack painted decoration.

Finally, bow drill bow cords exhibit the attributes of contact with a rotating spindle: signs of stretching, compression, and tribochemical wear; wear such as bends or fraying along the cord created by rotating a drill; and/or surplus bow cord length. In contrast, archery bowstrings, and their ceremonial and toy portrayals, are taut when the bow is braced.

Bow cord use-wear provides the most convincing line of evidence to support the identification of a bow-like artifact as a bow drill when all other criteria are met. For example, the miniature bow from Canyon Creek Ruin meets most of the presented conditions for identifying bow drill. The bow measures 39.5 cm long with a 2-ply s-spun Z-plyed *Yucca* sp. or *Agave* sp. fiber cordage 2 mm in diameter. Although it was shaped on the belly and sides to taper from the median towards the tips like an archery bow, the object displays sufficient rigidity to function as a small bow drill. The bow was likely not a serviceable bow drill, however, given the absence of expected use-wear on, and the fragility of, the bow cord (Haury 1934:105, Figure 22a, 106) (Figure 7).

CONCLUSION

A synthesis of recognized bow drills recovered from Pueblo II – Pueblo III era settlements suggest that bow drill technology was available by at least AD 1050 in the northern Southwest. Considering the sphere of social interaction that existed within the greater Southwest, it seems reasonable to assume that the technology existed in regions where it is not yet identified in the archaeological record. A closer examination of curated and newly recovered artifacts resembling bows is warranted to reveal the extent and distribution of bow drill technology in the prehistoric Southwest.



Figure 7. Detail of the Canyon Creek Ruin bow end with preserved 2-ply *Yucca* sp. or *Agave* sp. fiber cordage. The cord lacks use-wear indicative of operating a spindle, therefore, the object is likely not a bow drill bow (Catalog Number 16784 from the collection of Arizona State Museum)

Possible widespread use of bow drill technology is particularly interesting within the context of the prehistoric Southwestern ornament industry, where artisans used a drilling apparatus to a far greater extent than would be required for domestic fire-making. A few craft production sites have yielded flaked-stone microdrills, including Shelltown and the Hind Site in southern Arizona and Tla Kii Ruin in east-central Arizona; however, it is unknown what drilling apparatus manipulated the microdrills (Copus 1993:447; Haury 1985:120).

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COLORED WASHES AND CULTURAL MEANING AT THE MONTEZUMA CASTLE CLIFF DWELLING AND CASA GRANDE GREAT HOUSE

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ABSTRACT

Colored earthen washes are the primary form of wall decoration at the Montezuma Castle cliff dwelling (AZ O:5:14 [ASM]) and the Casa Grande great house (AZ AA:02:14 [ASM]). This paper explores the possible meaning of colored washes at both sites using an interdisciplinary approach incorporating architectural analysis, archaeology, and Native American oral histories. Yellow washes at Montezuma Castle, and red micaceous earth and gypsum washes at Casa Grande are compared with other objects in the archaeological record, particularly ceramics, to investigate visual symbolism. Additionally, the intended audiences for these washes are considered by investigating concepts of physical and visual access. Taken together, this approach provides an interesting perspective on the aesthetic preferences of past people and the possible cultural meaning associated with colored washes at both sites.

In this paper, we briefly discuss the recent identification and characterization of earthen plasters and colored washes at two sites in Arizona -- the Montezuma Castle cliff dwelling (AZ O:5:14 [ASM]) and the Casa Grande great house (AZ AA:02:14 [ASM]) (Figure 1). The use of various colored earthen washes constitutes one of the principal forms of plaster embellishment at each site, and provides information about the past. As Cameron (1999:12) noted, "cultural ideals and values are encoded in vernacular buildings."¹ To that end, this paper attempts to decode visual symbolism associated with yellow earthen washes at Montezuma Castle and washes of red micaceous earth and gypsum at Casa Grande using an interdisciplinary approach that includes architectural analysis, archaeology, and Native American traditional knowledge.

We hypothesize that these yellow and red micaceous earth and gypsum washes are indicators of ideological concepts relating to water and fertility symbolism. First, we investigate the aesthetics of each wash (Munson 2011). Each wash is conceptually related to other

objects in the archaeological record and is assumed to represent an aesthetic preference with deep-rooted cultural meanings. We rely heavily on past archaeological studies investigating the visual symbolism of ceramics and other objects to compare possible meanings associated with the color yellow, as well as visual effects created by micaceous and burnished materials. We draw on information from Native American oral histories to strengthen these interpretations. Second, we discuss the intended audiences and access to each wash (Munson 2011). That is, who had visual or physical access to the rooms with earthen washes? To do this, we briefly discuss the physical location of each earthen wash and the ways in which visual or physical access may have been restricted or controlled. Taken together, this information provides an interesting and unique perspective on the possible symbolism and function of earthen washes at each site.

WALL PLASTER DATA AND ANALYTICAL TECHNIQUES

Previous archaeological studies of wall plasters have focused on the iconography of painted and incised murals, but relatively little attention has been given to the cultural significance of plaster washes. For example, studies of Pueblo III period (AD 1150–1325) wall paintings in the Four Corners area and Rio Grande Valley focus on the placement of monochrome and bichrome color fields and geometric patterns as well as the related experience of the viewer (Brody 1991; Chapman 1938; Cole 2006; Meyers 2012; Munson 2011; Newsome and Hays-Gilpin 2012; Schaafsma 2007; Smith 1952). Intricately painted murals dating to the Pueblo IV period (AD 1325–1680) have been studied in greater detail (Brody 1991; Crotty 2007; Hays-Gilpin 2010; Hays-Gilpin and LeBlanc 2007; Meyers 2012; Newsome 2010; Schaafs-

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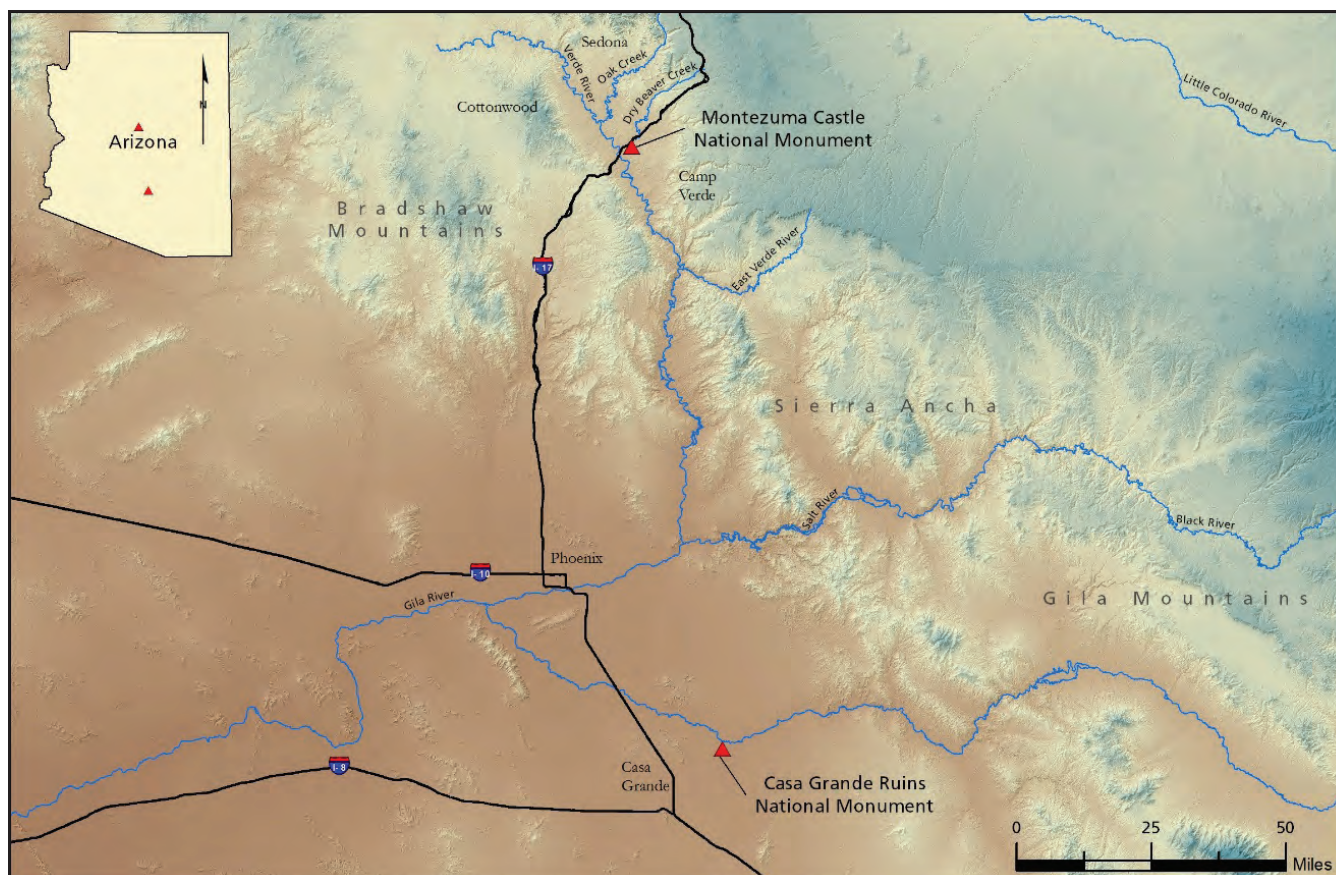


Figure 1. Map showing the location of Casa Grande Ruins National Monument and Montezuma Castle National Monument

ma 2007, 2010:22; Webster 2007). These murals depict complex scenes including human, allegorical and mythological figures, spiritual beings, ceremonial and ritual activities and paraphernalia, animals, plants, landscape imagery, and geometric or abstract designs. Archaeological interpretations of these murals have identified iconographic schemas relying heavily on ethnographic comparisons. Researchers studying these murals have also employed a cross-media approach that compares design elements and color symbolism on a variety of artifacts and rock art (Hays 1992; Hays-Gilpin 2006, 2010; Hays-Gilpin and Hill 1999; Hays-Gilpin and LeBlanc 2007; Smith 1952; Taube 2010).

Techniques for characterizing earthen materials generally require large samples.² At Montezuma Castle and Casa Grande, sample sizes were small to preserve architectural material in situ. The mineralogical content of samples was determined through X-ray diffraction (XRD) analysis conducted by the Institute of Meteoritics in the Department of Earth and Planetary Science at the University of New Mexico. XRD data were collected from air-dried, glycolated, and heat-treated samples using standard procedures (Poppe et al. 2001). Semi-quantitative phase analysis was done using the Reference Intensity Ratio (RIR) method included with the PANalytical HighScore Plus software (Version 4.7). To aid in the identification of clay, portions of selected samples

were mounted and analyzed on a JEOL JSM5800LV scanning electron microscope (SEM). The chemistry of individual clay particles was determined using an Oxford Instruments Energy Dispersive X-ray spectrometer (EDS). Semi-quantitative EDS analysis was accomplished using the Oxford software with elemental peak profiles measured on in-house mineral standards and built-in correction routines for data reduction. Backscattered electron imaging and EDS analyses were conducted exclusively on polished petrographic thin sections, coated with approximately 20 nm of gold-palladium alloy for conductivity.

By combining optical microscopy, XRD, SEM and EDS to identify clays and aggregates, secondary minerals, and soluble salts, investigators were able to produce detailed characterizations using very small samples (Bass et al. 2017). These analytical techniques resulted in a complex dataset that was then interpreted within an archaeologically meaningful framework. This included investigation of plaster embellishments, soil processing and application techniques, repair episodes, occupational sequences, and physical characteristics affecting plaster performance and deterioration (Bass et al. 2014, 2015; Bass et al. 2017; Nordby 2014, 2015).

Montezuma Castle and Casa Grande do not have painted murals with elaborate or stylized compositions. Yet, colored washes may represent the shared beliefs

and aesthetic preferences of past people. For this reason, we consider the possible meaning of colored washes within their respective geographic and chronological contexts. It is important to note that there are no published archaeological studies on decorative wall plasters in the Verde Valley and Gila River Valley. The following discussion describes and interprets earthen plasters and colored washes at each site.

MONTEZUMA CASTLE CLIFF DWELLING

The Montezuma Castle cliff dwelling consists of five architectural stories and 20 rooms in an alcove high above Beaver Creek in the Verde Valley of central Arizona (Figure 2). The iconic site is located within the Southern Sinagua archaeological culture area, defined by pueblo-style architecture, inhumation burials, and distinctive plain ware ceramics (Colton 1946). Based on the radiocarbon age of wooden beams at the site, as well as the cross-dating of decorated ceramics, the Montezuma Castle cliff dwelling was likely built during the Honanki phase (AD 1150–1300) (Breternitz 1960; Colton 1946; Hodgins et al. 2018; Wells and Anderson 1988). Architectural repairs and artifacts found at the

site indicate that the cliff dwelling grew over time and that occupation continued until the late-fourteenth century (Guebard 2015, 2016; Nordby 2015).

The Castle's Yellow Washes

Sixteen rooms with ancient wall plaster were analyzed at Montezuma Castle (Bass et al. 2017). Most interior walls in the Castle have three layers of plaster, although some have as many as six. Additionally, walls also contain repair patches and infills, many located on the lower portion of the wall surface. Cross sections of plastered surfaces prepared for microscopic analysis indicate that wall stratigraphy contains thick dust and soot layers between plaster applications, suggesting that substantial time passed between each plastering episode (Figure 3).

Of the 16 rooms included in the study, 7 have traces of red, yellow, or white earthen washes (Bass et al. 2014). These washes consist of clays selected for color, manipulated to remove larger particles and increase the binder proportion, and mixed with enough water so that they spread like paint. These washes were used to highlight architectural features such as dados³, doorways, and other openings. While the use of all colored washes likely held important meaning, we focus here on yellow washes.



Figure 2. Montezuma Castle cliff dwelling, 2017



Figure 3. Thin section of finish plaster in Room 3-4, south wall, showing up to six plaster and wash layers separated by dust and soot

Yellow earthen washes were identified in three rooms, on a total of seven wall elevations. The yellow washes contain approximately 12.5 percent albite, a mineral that appears light yellow or light green in color (Mineral Atlas 2017). Interestingly, albite did not appear in any of the other plasters or washes analyzed for this study, suggesting that it may contribute to the yellow color of the plaster wash. At Montezuma Castle, the yellow washes comprise the outermost layer of interior walls. While these layers were not chronometrically dated, they are late within the occupational sequence of the dwelling. Recent research suggests the site was abandoned sometime after AD 1375 (Guebard 2015, 2016). It is therefore reasonable to assume that yellow plaster washes at Montezuma Castle were applied to walls during the mid- to late-fourteenth century.

As Figure 4 illustrates, the condition of yellow washes is poor and heavily impacted by animal activity and the presence of soluble salts. As a result, yellow

plaster washes now appear as small, discrete patches surrounded by larger areas of surface erosion and plaster delamination. Although much of the yellow wash is now obscured or destroyed, we located all surviving yellow fabric at the dado level. Based on this finding, dado plasters in three rooms at the Montezuma Castle cliff dwelling likely featured bright yellow washes. In the next section, we discuss the possible meanings associated with yellow ceramics and washes.

The Color Yellow: Aesthetics and Associations

In the Pueblo world, the color yellow denotes a direction (northwest) and is also associated with birds, fire, rainbows, butterflies, pollen, flowers and the summer growing season (Hays-Gilpin et al. 2010; Hays-Gilpin and Hill 1999; Hill 1992; Lewis 2002). Using this set of shared visual concepts, Hill and Hays-Gilpin identified and described a shared system of verbal imagery called the Flower World (Hays-Gilpin and Hill 1999; Hill 1992). Associated with the Uto-Aztec language, Flower World imagery is prevalent in songs and represented in material culture. The Flower World concept is thought to originate in Mesoamerica and includes a variety of complex ideas with similar imagery and themes including moisture and fertility (Hays-Gilpin et al. 2010).

Jeddito Yellow Ware ceramics are one example of Flower World imagery expressed in visual media. Jeddito Yellow Ware consists of distinctive yellow, coal-fired ceramics manufactured only on the Hopi Mesas. According to Hays-Gilpin, “Regardless of painted design, each Jeddito Yellow Ware vessel can evoke Flower World in color.... Selecting certain clays, the use of coal as fuel, and firing pottery in the open to oxidize it at high temperatures ensure that the quintessential flowery color—yellow—pervades each vessel” (2010:123).

Early varieties of Jeddito Yellow Ware were first made around AD 1300, and quickly circulated throughout the American Southwest. In the northern Southwest, these ceramics and the ideas they represent may have facilitated the spread of the Katsina religion (Adams 1991; Adams and LaMotta 2006; Newsome 2010). Katsinas are part of the Flower World and share similar concepts associated with water and fertility.

At the Homol’ovi villages, approximately 100 miles from Montezuma Castle, Adams and LaMotta (2006) concluded that large quantities of Jeddito Yellow Ware ceramics, as well as artifacts depicting Katsina images, signaled the adoption of Katsina ceremonies in the mid-fourteenth century. While the spread of these ideas

might be accepted or incorporated differently at each village, this is a reasonable way to understand how Katsina ideology was adopted. Although there have been no Katsina images found at Montezuma Castle, yellow ware ceramics are pervasive. These ceramics denote a strong economic and social connection with the Hopi Mesas and also may signal the adoption of the Flower World ideology.

Awatovi Black-on-yellow and Jeddito Black-on-yellow, two distinct types of Jeddito Yellow Ware, account for approximately 69 percent of all decorated Tuzigoot phase (AD 1300–1400) ceramics collected at the nearby Castle A site (Guebard 2015:94). Similarities in yellow ware ceramics and the colored washes at Montezuma Castle are striking. The color of the yellow earthen washes is 2.5 Y 7/4 “pale brown” (Munsell 2015). This color is very similar to paste and surface colors noted on early Jeddito Yellow Ware vessels found near the site. So, while yellow washes and ceramics probably do not indicate the adoption of specific Katsina ceremonies at Montezuma Castle, together they may indicate the acceptance of Flower World concepts. Regardless, yellow ceramics indicate aesthetic preferences associated with social and economic changes occurring on the Hopi Mesas. Hopi oral histories provide additional information about this connection.

Oral histories indicate a strong connection between the cliff dwelling and the Hopi village of Songoopavi, located on Second Mesa. Members of the Bearstrap Clan at Songoopavi trace their ancestral lineage to the people that built and lived in the Montezuma Castle (Guebard 2016; Kralj KenCairn and Randall 2007). Ac-

cording to oral histories, clan members abandoned Montezuma Castle following a violent attack. Ancestral Hopi people continued north on a migration path that eventually ended in the village of Songoopavi. Neutron Activation Analysis conducted on yellow ware ceramics from the Verde Valley indicate that these vessels were made primarily on Second Mesa (Adams 2013:119). This suggests, perhaps, that Second Mesa villages were responsible for the manufacture and distribution of yellow ware ceramics in and around Montezuma Castle.

Trade routes associated with the exchange of ceramics are corridors for the transmission of ideas and concepts. The Flower World ideology, represented by yellow artifacts, was prevalent in the northern Southwest during the fourteenth century. The social and economic connections between the Hopi Mesas and Montezuma Castle may have facilitated the spread of this ideology and contributed to the use of yellow earthen washes. In this way, there is a connection between ceramics and architecture that signals a shared iconographic, social and economic connection between Montezuma Castle and Second Mesa.

Access to Yellow Washes

For the purposes of this paper, we use the concepts of physical and visual access, both of which have been used to analyze artwork (Munson 2011). Although many archaeologists may dispute the classification of colored washes as “art,” per se, the concepts discussed below are relevant for understanding how ancestral Native Americans may have accessed, experienced and viewed colored washes. Physical access is defined as the way in

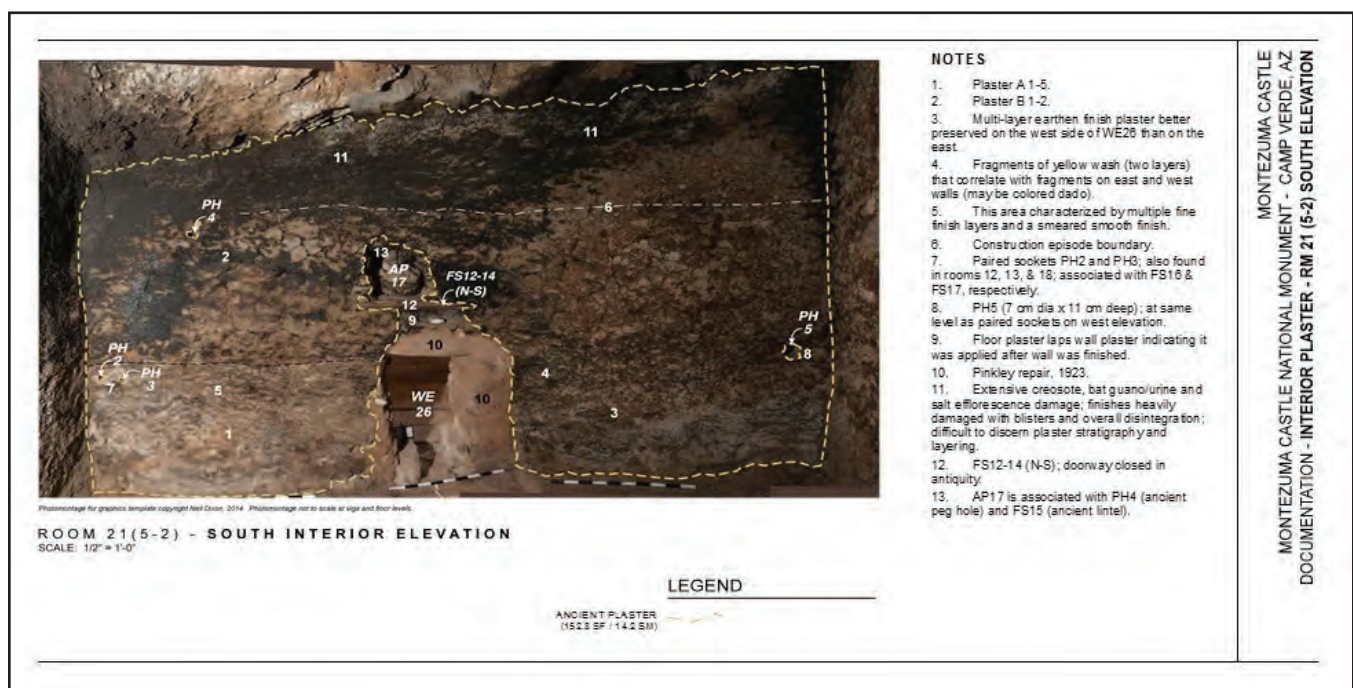


Figure 4. Plaster survey and condition assessment graphics for Room 5-2, south wall. There are remnants of a yellow dado throughout the south, east and west elevations (From Bass et al. 2015)

which a room's size and shape facilitates certain intended visual experiences (Munson 2011). As an example, Room 5-2 is located on the top story of the Montezuma Castle cliff dwelling. The room is connected to an open area with an expansive view of the southern horizon and surrounding valley. The room contains yellow earthen washes, small geometric plaster glyphs and several enigmatic features that may have served as peg holes, viewing ports, ventilator holes, niches and a cistern.

Room 5-2 is the largest within the cliff dwelling, but is not substantially larger than rooms in nearby dwellings (Wells and Anderson 1988:227). While most rooms inside Montezuma Castle are narrow and rectangular, Room 5-2 is broad and open, making it an ideal gathering space. At approximately 21 m² in size, this room could have contained approximately 20 people (Wells and Anderson 1988:226). The size and shape, as well as the presence of earthen washes and other specialized features may indicate that the room was used for group activities such as ceremonies. Furthermore, yellow earthen washes may have created an atmosphere necessary for certain activities and performances associated with Flower World ideology.

It is also important to consider where washes could be seen within the dwelling. This idea has been called "visual access" and refers to "the qualities and characteristics of a work of art that are visible at different distances or from different locations" (Munson 2011:79). The place where a wash is visible may indicate the intended audience. Yellow washes in Room 5-2 were not visible from other rooms in the cliff dwelling, nor were they visible from anywhere outside the dwelling. This means that to experience the washes, participants would need to physically enter the room. Access to yellow washes and associated activities could therefore be controlled by restricting access to the room.

Summary

Yellow washes at the Montezuma Castle cliff dwelling are unique and represent a dynamic period during the mid- to late-fourteenth century. These washes are part of a shared aesthetic representing strong associations with water and fertility. Most notably, these washes facilitated a shared, but restricted experience that connected the Montezuma Castle cliff dwelling with the Hopi Mesas, particularly Second Mesa and the village of Songoopavi. In this way, the development of certain ideologies on the Hopi Mesas, particularly the Flower World concept and related ceremonies, affected people at Montezuma Castle.

CASA GRANDE GREAT HOUSE

The Casa Grande great house is a large puddled earth structure with the remains of four architectural stories and 11 rooms (Figure 5). The site is located near the Gila River and prehistorically, was part of an exten-

sive irrigation canal system. The great house sits within a large compound and is surrounded by evidence of other walled compounds, an elliptical ballcourt, a platform mound and other earthen structures. The great house was built during the Civano phase (AD 1300–1450) and is associated with the Classic Period of the Hohokam archaeological culture area, defined by the presence of walled compounds, public architecture, population aggregation, increasing use of inhumation burials, and the appearance of polished red and polychrome ceramics (Abbott et al. 2003:8). Ceramics found at Casa Grande suggest the site was occupied until the mid-fifteenth century (Steen 1965; Wilcox and Shenk 1977). Later architectural repairs are evident throughout the building and may represent a short period of abandonment followed by reuse. The earthen washes discussed here are associated with the early occupation of the building, approximately AD 1350.

The Great House's Micaceous and Gypsum Washes

All rooms at Casa Grande have interior plasters that include one or more leveling coats and a dense finish coat. The finish coat has a grayish cast that previous archaeologists identified as sooting (Fewkes 1907:296; Nordby 2015:84; Wilcox and Shenk 1977:157). The wall surfaces also include a single, thin (100–130µm), red earthen wash. Our analysis indicates a lack of soot and dust between plaster and wash layers in all rooms, suggesting that the finishing sequence was completed without significant time intervals between coats, and fire was used inside the building infrequently or not at all (Figure 6). Regardless of the room, all walls contain the same, single layer of red wash suggesting that all interior walls within the building were coated in a single and coordinated effort. Red washes are composed of illite and palygorskite clays and contain a distinctive calcium phosphate component that appears to be the result of the admixture of ash or bone to the wash. Finishing plasters and red washes contain micaceous clays in larger proportion than is typical of other earthen materials used at the great house, suggesting that the materials were deliberately sourced or amended.

In Hohokam culture, the color red was seemingly important and used in decorated and plain ware ceramics. Similarly, red mineral pigments and argillite jewelry were common adornments and burial offerings (Bostwick et al. 2010:91). While the color red most certainly held important meaning for the inhabitants of Casa Grande, this paper only discusses the micaceous clay and gypsum washes found inside the great house. Future researchers will find it useful to address the symbolism associated with the color red. A thin (15–32µm) gypsum wash was applied over the red, micaceous wash in every room. The use of micaceous clays and gypsum seems intended to impart a reflective quality to the wall surfaces (Figure 7). We are not the first to



Figure 5. The Casa Grande great house, 2016

note this stunning visual effect. Seventeenth century Spanish travelers and nineteenth century American explorers and scientists all commented on the appearance of these washes (Mindeleff 1896:310; Van Valkenburgh 1962:7).⁴

Micaceous Materials: Aesthetics and Associations

Micaceous clays and gypsum washes are found in every room at the Casa Grande great house. The visual effect is similar to mica-tempered ceramics and other reflective archaeological materials found in the Hohokam culture area. This suggests an aesthetic preference for reflective objects, but also indicates deep cultural meanings and associations. It is therefore useful to briefly consider the possible visual symbolism associated with these objects.

The use of micaceous schist temper in Hohokam ceramics has been extensively studied (Heidke 1989, 2012; Miksa 1998, 2001; Ownby et al. 2004; Walsh-Anduze 1993). Micaceous schist is available in the Middle Gila River Valley and is more heavily used as temper during the Hohokam pre-Classic Periods (Abbott et al. 2007). The possible ideological meaning associated with pre-Classic schist-tempered ceramics, along with other reflective objects, is hypothesized to represent an ideological movement in the Hohokam area (Wallace 2014; Whittlesey 1997). Although researchers disagree about the specific details of this movement,

one component is the symbolic representation of water (Heidke 2012:314; Wallace 2014:478). Micaceous tempers impart a reflective quality and may have symbolized water shimmering in sunlight. Researchers have also suggested an ideological connection between water and mountains (Whittlesey 2009). The creation of pottery with micaceous schist temper extracted from mountains in the Gila River Valley may therefore represent an attempt to physically incorporate this ideology into ceramic vessels (Whittlesey 2009). The following discussion presents one possible explanation for the appearance of reflective plaster washes and the visual symbolism they promoted.

The Hohokam Classic Period is recognized by archaeologists as a time of social and cultural transition. Public architecture as well as concurrent changes in material culture and mortuary practices are often considered markers of increasing social stratification, the appearance of religious elites, the adoption of new religious or ideological concepts, or a combination of these changes (e.g., Abbott 2000; Abbott et al. 2003; Bostwick and Downum 1994; Bostwick et al. 2010; Doyel 1981; Elson 1998; Gladwin et al. 1937; Haury 1945, 1976; Howard 1992; Wasley 2009; Wilcox and Shenk 1977). The volume of archaeological literature discussing this transition is overwhelming. Not surprisingly, archaeological interpretations of this transition are varied and sometimes contentious. With this in mind,

one possible explanation for the appearance of the Casa Grande great house is the rise of individuals with specialized religious or ceremonial responsibilities (Abbott 2000; Mitchell and Brunson-Hadley 2001). Bostwick argues that platform mounds were symbolic mountains and specialized structures for elites with ceremonial responsibilities associated with rain (Bostwick 1992; Bostwick et al. 2010). The Casa Grande great house appears to have served a similar function.

O'Odham oral histories recount the Casa Grande great house as the home of a lineage of priests associated with the Morning-Blue Sivanyi (Loendorf and Lewis 2017). According to these oral histories, priests were responsible for ceremonies associated with the control of rain and wind (Teague 1993:441). The great house is identified as the home of these priests, indicating that important ceremonies were conducted within the building. Oral

histories along with the presence of reflective plaster washes and a lack of sooting on walls may indicate that the great house was used for ceremonial purposes related to the control of weather. In the next section, we briefly discuss access to reflective washes at Casa Grande.

Access to Reflective Washes

The great house consists of adjoining rectangular rooms of uniform sizes. These rooms are not appreciably larger than other rooms within the surrounding compound, although their configuration may be significant (Wilcox and Shenk 1977:168-169). Some researchers have suggested that the floor plan of the great house represents the religious cosmology of its builders (Cushing 1892; David Jacobs, personal communication 2017). In this way, movement through the building may have constituted a ritual action. While this may be true, there has been very little research on this topic. Perhaps future work will help to connect reflective plasters with other ideological concepts encoded in the site's architecture.

Reflective earthen washes cover all interior walls in the building, suggesting that the same visual experience was intended for each room. Unlike Montezuma Castle, builders and designers appear to have been particularly concerned with the uniform appearance of interior walls. Each wall was meticulously finished to be smooth and plumb and covered in the same reflective wash. This finding matches with previous architectural studies concluding that the entire building was intended for a single, integrated function and was managed by a centralized authority (Nordby 2015; Wilcox and Shenk 1977). Perhaps the Sivanyi identified in O'Odham histories were responsible for managing the site. Regardless,

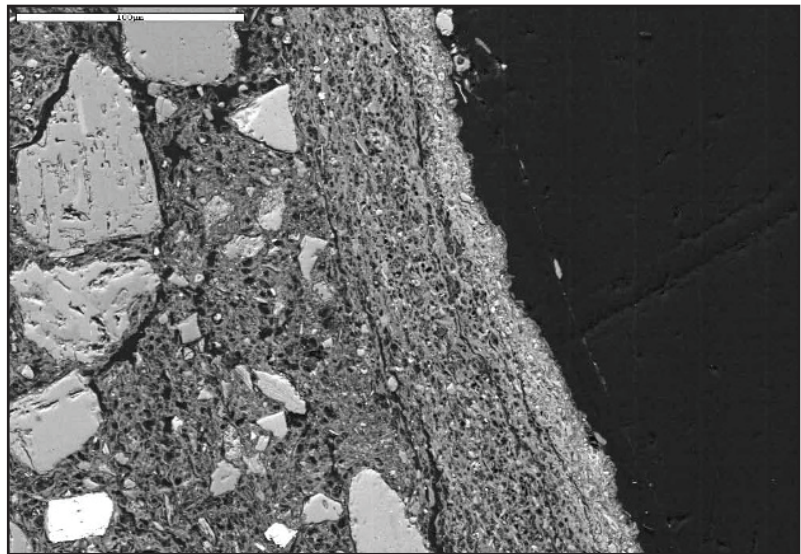


Figure 6. SEM photomicrograph (330x) of a Casa Grande sample showing a thin gypsum layer (far right), single clay wash (middle) and plaster substrate (far left)

the initial intended function of the building appears to be ceremonial.

Visual access to interior rooms at the great house was restricted. Reflective plasters are not visible from anywhere outside the building. Additionally, a compound wall approximately 2 m tall limited physical and visual access to the great house (Fewkes 1907:96). It is important to note that compound architecture was common during the Classic Period, meaning that the use of compound walls was a regional trend. Nevertheless, the walls at Casa Grande were intended to restrict access to buildings within the compound. As was the case at Montezuma Castle, this suggests that only those with access to the compound and the great house could see and experience the washes.

Summary

Interior walls at the Casa Grande great house were adorned with plaster washes similar in appearance to mica-tempered ceramics and other archaeological objects representing water symbolism. O'Odham oral histories suggest that Casa Grande was managed by priests with important ceremonial responsibilities associated with the control of weather. Visual and physical access to rooms containing earthen washes was likely restricted. The lack of sooting on walls indicates that fires were prohibited and suggests that the building functioned as a ceremonial structure. Matching plaster stratigraphy throughout the great house also indicates corporate control over the appearance and maintenance of the building. This interpretation matches well with oral histories recounting control of the building by a small group of religious elites.



Figure 7. Photograph of plaster and wash finishes from the northwest corner of Stack A, Casa Grande great house. Note the red wash and underlying gray plaster

FINAL DISCUSSION

This paper illustrates how the in-depth study of subtle architectural features can provide evidence capable of addressing archaeological questions about prehistoric room use and aesthetics. By characterizing earthen washes and incorporating concepts of access we have attempted to decode aesthetic preferences and identify possible meanings associated with the use of yellow and reflective red washes. Native American traditional knowledge also provided important information that guided our conclusion. While the interpretations in this paper are tentative, they present an interesting and unique perspective on architectural features at both sites.

We can only speculate about the meaning of earthen washes, but there are strong connections to symbolic representations of water and fertility at both sites. Additionally, rooms and sites containing washes had specialized features and floorplans suggesting they were used to enhance group activities such as ceremonial performances. Finally, visual and physical access to rooms with colored washes appear to have been restricted, suggesting that only those permitted inside each room had access to the activities and experiences occurring therein.

Admittedly, the focus of this paper is quite narrow. Montezuma Castle and Casa Grande are idiosyncratic buildings representing periods of use and adaptive reuse. As such, additional study of the architecture at both sites is necessary to refine the interpretations presented here. We hope, however, that this study will provide a positive example of interdisciplinary research that includes architectural analysis, plaster characterization, archaeology, and Native American traditional knowledge.

Notes.

1 The Merriam-Webster Dictionary (2017) defines vernacular as “of, relating to, or being the common building style of a period or place.” The Montezuma Castle cliff dwelling and Casa Grande great house are not typical design styles, however, the materials and methods used to construct both buildings were common throughout each region. Coupled with architectural and archaeological data as well as Native American traditional knowledge, each

building has the ability to convey important information about the designers, builders and occupants.

2 See ASTM C 1324-05 (Standard Test Method for Examination and Analysis of Hardened Masonry Mortar), ASTM D7928 – 16 (Standard Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation [Hydrometer] Analysis), ASTM D6913 – 04 (Standard Test Methods for Particle-Size Distribution [Gradation] of Soils Using Sieve Analysis).

3. The dado level refers to the lower portion of a wall surface. At Montezuma Castle, the dado level is demarcated by colored washes.

4. Captain Juan Mateo Manje, a member of the 1697 Kino expedition to Casa Grande, made a similar connection between plaster washes and ceramics not-

ing that the walls at Casa Grande “shone like Puebla earthenware” (Van Valkenburgh 1962:7).

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THE DEVELOPMENT OF PREHISTORIC IRRIGATION STUDIES IN ARIZONA UNDER THE NATIONAL HISTORIC PRESERVATION ACT

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ABSTRACT

The passage of the National Historic Preservation Act (NHPA) and the establishment of the Section 106 process played a central role in advancing Hohokam archaeology and the study of prehistoric irrigation in Arizona. Opening research opportunities, the NHPA allowed for the development of both long term research programs and new techniques and methodological approaches. This led to advances in our understanding of the layout and operation of irrigation systems, the geoarchaeology of irrigation features, the development of techniques for paleohydraulic reconstructions, and the dating of irrigation features. This greater understanding of prehistoric irrigation systems, combined with improved chronological control, resulted in new perspectives on Hohokam sociopolitical organization and agricultural success through time. This paper examines the development of Hohokam irrigation studies in the primary agricultural areas, the Salt and Gila river valleys.

What is it that propels the advancement of our knowledge of the past? Does it happen suddenly through great discoveries? Is it brilliant ideas that flash upon the minds of scholars in the middle of the night? Is it persistence and long-term commitment to resolving specific issues? Or, is it funding as suggested by those words so forcefully delivered in the movie *The Right Stuff* "No bucks, no Buck Rogers?"

As with many things, scientific advancement is not a unicausal phenomenon. All of the above elements contribute to the programs that allow us to advance the frontiers of knowledge. Clearly, new ideas and the ability to look at old issues in new ways is a major driving force. But funding and the research opportunities it can present may be the lifeblood of science.

When we look at the history of archaeology over the last century great strides were made at times when funding presented such opportunities. The senior author (meaning age only) recalls sitting around an archae-

ological campfire and listening to the tales and wisdom of one of his mentors, Franklin Fenega, one of the grand old men of California archaeology. Frank began a distinguished career in archaeology during the Great Depression, which intuitively seems like a very poor time to fund archaeological projects. But in fact, the Works Progress Administration (WPA) funded an unprecedented wave of archaeological research across the country (including work by Julian Hayden [1938] at Pueblo Grande and Al Schroeder [1940] on the Salt River Valley Stratigraphic Survey). It was a way to put people to work. Residing in Georgia and just a beginning college student, Frank was one of the few that knew anything about archaeological techniques and he was, therefore, recruited to run a large WPA archaeological project. He painted a rather amusing picture of a young man who panicked when he saw his first archaeological crew, which consisted of approximately 100 African-American women all brandishing the tool they were told by management to bring, a common garden hoe (Figure 1). Yet, through the WPA funding and those intrepid and excellent field workers, Frank's project and archaeology overall advanced at a rapid rate.

The establishment of the G.I. Bill provided another dramatic expansion in our ability to do archaeology. The bill, and the postwar economic scene, allowed returning soldiers, and the common man, to go to college for the first time. Veterans from both World War II and Korea were trained in archaeology and they began to establish archaeological programs in universities throughout the United States. They prepared to train the next generation of field workers, the baby boomers. But as the ranks of archaeological technicians grew, how were they to secure research funding and opportunities?

The answer came with the passage of the National Historic Preservation Act (NHPA). The act established the National Register of Historic Places to help preserve

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cultural resources. Importantly, it established the Section 106 process, which required federal agencies to consider the impacts of undertakings on historic properties, leading to a major increase in archaeological work on federal projects. Just as importantly, most states followed suit, establishing similar requirements on state lands. Cultural Resource Management (CRM) was born and by the early 1970s archaeology was riding the wave of the environmental movement sweeping the country. If natural resources were important, cultural resources were important, as well. From the perspective of the field archaeologist, however, it provided funding, opportunity and jobs. Advancements in archaeological survey, excavation, and analysis methods over the last 50 years have produced a surge of new information on ancient canal irrigation systems in Arizona. These discoveries occurred largely during projects conducted in compliance with the NHPA, enacted in 1966 and celebrating its 52nd anniversary this year.

IRRIGATION STUDIES IN ARIZONA BEFORE THE DAWN OF CRM

Prior to the advent of CRM, archaeological studies, including irrigation studies in Arizona, were initially based in privately funded investigations. The major research focus of the work on prehistoric irrigation was mapping the location of prehistoric canals on the landscape. Pioneering efforts by James Goodwin (1887) and Herbert Patrick (1903) began this process in the lower Salt River Valley, which culminated in the excellent work of Omar Turney and Frank Midvale. This provided a context for studying Hohokam archaeology in the Salt River Valley. It was the first documentation of the immense scale of the irrigation systems and a first clue to the engineering and complexity of social organization required to accomplish such a feat (Figure 2). The publication of Turney's two pamphlets, *Land of the Stone Hoe* (Turney 1922, 1924) and the first book on the Hohokam, *Prehistoric Irrigation in Arizona* (Turney 1929), also provided the first public appreciation for the prehistory of our area. With the exception of the work by the Hemenway Southwest Archaeological Expedition (Haury 1945), however, an almost total lack of actual excavation projects limited our knowledge and understanding of these canal systems.



Figure1. Photograph of African-American women working at Irene Mound, Savannah, Georgia, during a Works Progress Administration (WPA) archaeological project in November 1937; here some of the women are pausing to fill their tobacco pipes (source: website essay titled "The Women of the Irene Mound," photo is titled "Pipe Break," <http://www.sip.armstrong.edu/Irene/Irene11.html>)

In the Gila River Valley, researchers Adolph Bandelier (1892) and Jesse Walter Fewkes (1913:113–115) noted their observations about canals along the middle Gila, but produced no maps. Charles Southworth mapped a few prehistoric canals during his Gila River Survey in 1914–15. The first important map of middle Gila canals, however, was drawn by A. Larson (1926) and published by Byron Cummings in 1926 (Cummings 1926). Larson's map focused on the Coolidge and Florence areas. Thereafter, Frank Midvale (1935, 1946, 1963, 1965, 1972) made significant contributions to the mapping of canals and settlements during survey efforts between 1918 and 1972. His 1963 map of the Casa Grande Ruins area is still used by many archaeologists today as a standard archaeological reference (Figure 3). The first excavations at Snaketown provided some of the earliest and best documentation of Hohokam canals (Haury 1937).

In academia, research on prehistoric irrigation done through universities and museums moved at a very slow pace. Richard Woodbury, working with the University of Arizona Arid Lands program from 1959 to 1963, conducted important excavations at Park of Four Waters south of Pueblo Grande in Phoenix, establishing some of the first scientific archaeological approaches to canal studies (Woodbury 1960). This was quickly followed by Emil Haury's (1976) pioneering 1964–1965 work on irrigation features at Snaketown. Bruce Masse noted that "By the mid-1960s, a total of seven or eight prehistoric canals have been tested..." (Masse 1976:38).

features. This direction changed when two unexpectedly large canal features were encountered (Ackerly et al. 1987). These canals are still among the largest irrigation canals found within Canal System 2. Lacking the multidisciplinary team on the Las Colinas project, one of us (Howard) was asked to lead the investigation of the irrigation features at La Ciudad and he joined forces with the Las Colinas personnel. A series of very interesting features were uncovered, including the two massive main canals (one tracked for approximately one mile), and a distribution canal that was tracked to its diversion point from the main canal (Figure 6), where a well-preserved water control feature was found. The detailed reconstruction of this feature provided some of the earliest documentation and insight on canal system management, distribution techniques, and system organization. Finally, a series of three chronologically distinct reservoirs used for domestic water storage were found and excavated. The report included an insightful chapter written by Neal Ackerly with important information using historic irrigation analogs and posing new research questions (see Ackerly et al. 1987).

Also as part of the La Ciudad project (and as an extension of her dissertation research), Linda Nicho-

las used aerial photointerpretation to compile a new map of the irrigation systems in the Lower Salt Valley (Ackerly, Rice and Nicholas 1987:13-16; Nicholas 1981; Nicholas and Feinman 1988; Nicholas and Neitzel 1984) showing considerably greater detail than previous maps (e.g., Turney 1929). This was an exemplary effort combining new approaches, insightful research goals, and detailed analysis. Howard subsequently used Nicholas' maps as one of the data sources for his map of the irrigation canals (Howard and Huckleberry 1991).

One legacy of the La Ciudad Project was the development of a long-term research project by Howard. Working as Director of Research for Soil Systems, Inc., an effort was begun to target specific archaeological contracts that would provide samples from Canal System 2 and allow us to establish an overall database for this canal system. The objectives were several fold. We wished to continue research on the basic elements of the canal system and learn how the system worked. There were still basic questions concerning the operation of the system. For example, how was water distribution accomplished and controlled? Further, the intent was to model water flow through the individual main canals from their heads to their termini.



Figure 5. Photograph of Jennifer Strand and Michael Bartlett preparing to photograph clay-settling basin in Trench 9-3, SW face at Las Colinas (AZ T:12:10 [ASM]), AZ, January 1984, Helga Teiwes, photographer (ASM Las Colinas PR-2-381) (c/o Arizona State Museum, University of Arizona)

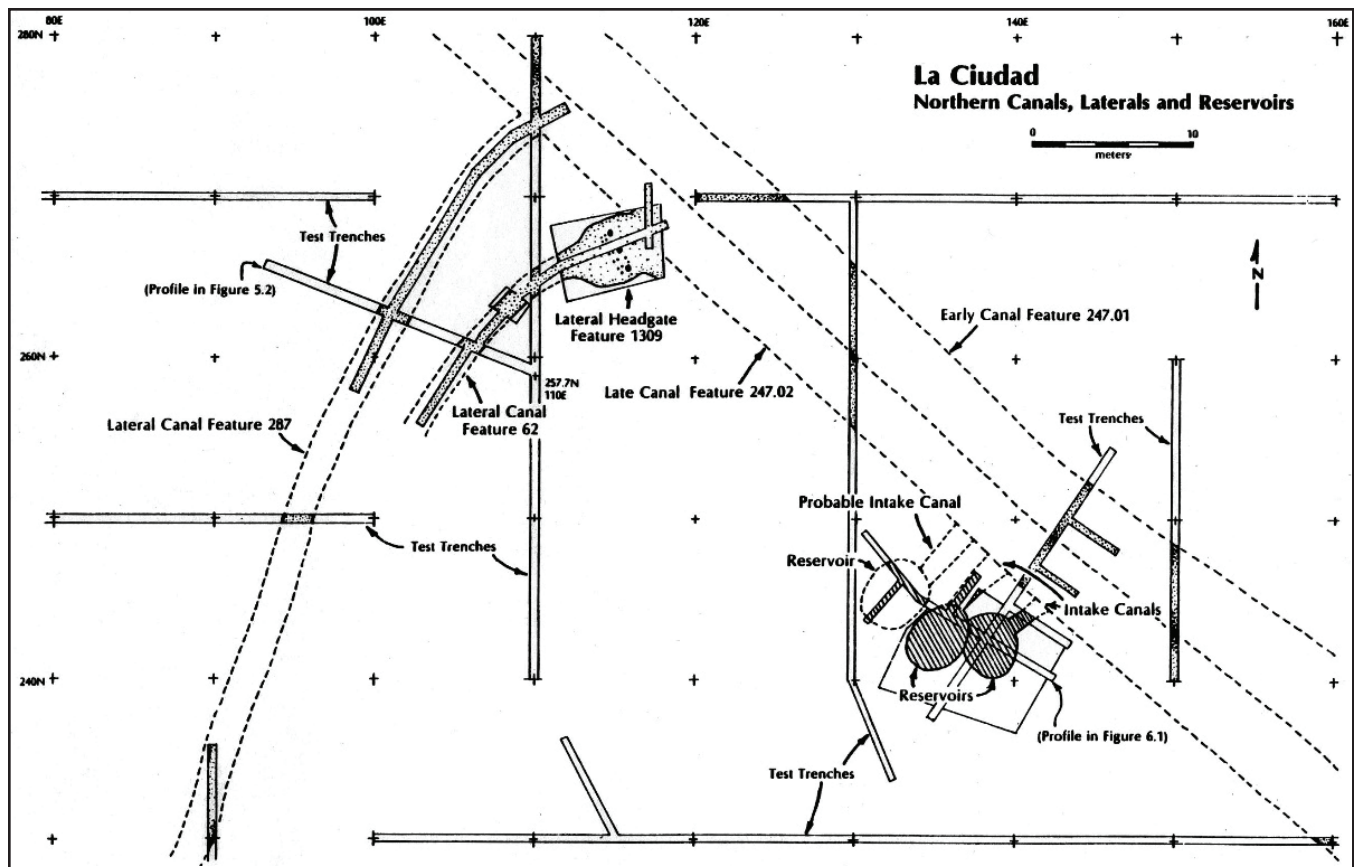


Figure 6. Plan map of Northern canals, lateral, and reservoirs at La Ciudad (from Ackerly et al. 1987:80)

This research program resulted in several important outcomes. First, the program produced a revised and updated map of the prehistoric canals and villages in the Salt River Valley (Howard 1990, 1992; Figure 7). The program continued the Las Colinas approach using a trained geomorphologist, Gary Huckleberry, and initiated studies of grain-size distributions in canal sediments (Howard and Huckleberry 1991). It was the first project to have a comprehensive program of using open channel equations to calculate channel velocity and discharge of individual canal features. This provided a measure of the relative size and capacity of irrigation features. It resulted in the modeling of changing cross-sectional area from canal heads to their termini providing a measure of the cubic meters of material that had to be removed for canal construction. This provided new insights into the labor required for canal construction. Finally, additional progress was made on dating canals using ceramics, radiocarbon dating and the development of archaeomagnetic dating of canal clays (Eighmy and Howard 1991).

Many other projects followed and they cannot all be enumerated here. One would be remiss, however, if mention was not made of the "Price Road Freeway Project" directed by Kathy Henderson with Northland Research, Inc. (Ackerly and Henderson 1989). In addition to the many things learned, Henderson excavated

one of the most complex areas of intersecting canals ever seen and produced what is undoubtedly one of the largest holes ever dug in Hohokam archaeology. Her more recent work on the Phoenix Sky Harbor Airport North Runway project with Desert Archaeology, Inc. (Henderson 2004) and the PHX Sky Train project (Henderson 2015) also made great strides, including the pioneering use of optically stimulated luminescence (OSL) dating to obtain absolute dates of canal sediments and the unprecedented discovery of evidence of an irrigated field system in the Phoenix Basin. Another groundbreaking irrigation study of the Scottsdale Canal System was completed during an ADOT project along State Route 87 (Hackbarth et al. 1995).

On the Gila River, NHPA-mandated projects were not as numerous as those seen in the rapidly expanding urban area to the north. Several very large projects were conducted, however, including Arizona State University's Santan Region Project for the East Maricopa Floodway (Rice et al. 1979), which located a series of main canals at Gila Butte, some of which extended to the Snaketown area. The massive Central Arizona Project Salt-Gila Aqueduct Project, funded by the U.S. Bureau of Reclamation, also identified and analyzed canals and reservoirs along Queen Creek and the Gila River area in the 1980s (Crown 1984; Dart 1983; Teague and Crown 1983, 1984). During the 1990s, ADOT-spon-

sored work at the Grewe Site resulted in much new data from the Grewe-Casa Grande Canal System (Phillips and Craig 2001), and work for the BHP Florence Copper Mine uncovered evidence of the Poston Canal System (Foster et al. 1996).

The pace of research and generation of new knowledge on the Gila River changed dramatically with the introduction of Bureau of Reclamation projects that required compliance with the NHPA and Section 106. By 1993 the Gila River Indian Community's new Cultural Resource Management Program (GRIC-CRMP) was investigating prehistoric irrigation across the vast Gila River landscape in conjunction with the Pima-Maricopa Irrigation Project (Woodson 2003). After more than a decade of research, this effort has provided detailed information on 13 distinct canal systems heading on the Gila River (Woodson 2010a, 2013; Figure 8). The relatively undeveloped landscape of the Gila River Basin allowed greater access than was available in the Salt River Basin and even the ability to track prehistoric irrigation features on the surface of the land. Large excavated samples have been obtained from individual irrigation systems, including more than 50 canal cuts on the Santan System and the investigation of 40 canals at four different sites in the Riverbend Canal System. These detailed data provide the further benefit of allowing a critical assessment of the size of the irrigated field areas (or command area). Estimates indicate that 12,000 to 19,000 hectares may have been irrigated along the middle Gila River.

Detailed chronological information also has been obtained from Gila River canals suggesting a different pattern of growth than has yet been documented for the Salt River. Woodson (2010a, 2010b, 2016) suggests that a number of the canal systems on the Gila River, including the Grewe-Casa Grande System, began as two smaller systems but were later consolidated into one larger system. Woodson suggests that this process of system consolidation was well underway by the Sedentary Period. Further, bifurcations of canals (true branch canals) have been confirmed on the Gila River, whereas such branches on the Salt River appear to be rare.

In the Tucson Basin, canal research started later. This was due to the fact that, earlier in time, most people did not believe that (or had not positively identified) prehistoric canals stemming from the Santa Cruz River. One of us (Howard) remembers receiving a call from a colleague inquiring as to whether or not we thought that Paul Fish was seeing things when he proclaimed that he had found a canal. Could it be true? Or was Paul just spending too much time in the heat? But great advances, again driven by the NHPA and Section 106, were to follow with work by Jonathan Mabry and Desert Archaeology, Inc. establishing the existence of canals of much greater antiquity than had ever been considered. They identified a long tradition of irrigation agriculture starting over 3,000 years ago prior to

the advent of the Hohokam, and defined the Early Agricultural Period (Mabry 1998, 2008; Figure 9). This is a major advance in our understanding of the early beginnings of agriculture, sedentism, and irrigation technology. Surprisingly, these early irrigation features appear to have been quite advanced in their layout and engineering (Vint and Nials 2015).

NHPA-driven archaeological research also has expanded our knowledge of canal irrigation in areas outside the massive canal systems along the lower Salt and middle Gila rivers (see Woodson and Huckleberry 2002 for overview). These include irrigation features documented in the northern Phoenix Basin along the New River, Agua Fria River, and Cave Creek; the lower Gila River near Gila Bend; Queen Creek; the Verde River; Tonto Basin; and the upper Gila River in the Saford Valley. Most of these canals and irrigated field areas were considerably smaller than those in the core Phoenix Basin and some canals are situated on alluvial fans and utilized runoff water from ephemeral streams (e.g., Huckleberry 2013; Neely 2001; Neely and Murphy 2008; Schaafsma and Briggs 2007). Nevertheless, it seems that indigenous people were farming by means of canal irrigation in most areas in the Sonoran Desert along perennial or semi-perennial streams with sizable floodplains (Woodson and Huckleberry 2002; see Nials et al. 2011).

In addition to the explosion of new data on canals, important discoveries have been made of prehistoric irrigated agricultural fields as a result of NHPA projects. The GRIC-CRMP team has documented archaeological and soil evidence of prehistoric irrigated fields along the Snaketown, Santan, and Blackwater canal systems (Miles et al. 2010; Woodson 2010a, 2016; Woodson et al. 2015). Desert Archaeology, Inc. has found extensive evidence of Early Agricultural period fields at the Las Capas site (Vint and Nials 2015) and elsewhere in the Tucson Basin, as well as Hohokam fields near Sky Harbor Airport (Henderson 2015). Schaafsma and Briggs (2007) studied a Hohokam floodwater irrigation agricultural system with soil buildup in the northern Phoenix Basin. In this area, Hohokam farmers are inferred to have deliberately diverted silt-laden floodwaters out of ephemeral washes using canals to create arable land (known as "silt fields") where none had existed before.

Lastly, NHPA-driven work led to increased attention to the consequences of prolonged irrigation in the Hohokam region. Means (1901), during the earliest soil survey of the Salt River Valley, was the first to note the correlation of "heavy" clay-enriched soils (termed "Salt River adobe") with ancient canals and hypothesized they might be prehistoric irrigation-affected soils. Dart (1986) studied the association between soil phases mapped by the Natural Resources Conservation Service (NRCS) as narrow bands, or "ribbons," and prehistoric Hohokam canal alignments along Queen Creek and a portion of the lower Salt River. His premise is that sediments trans-

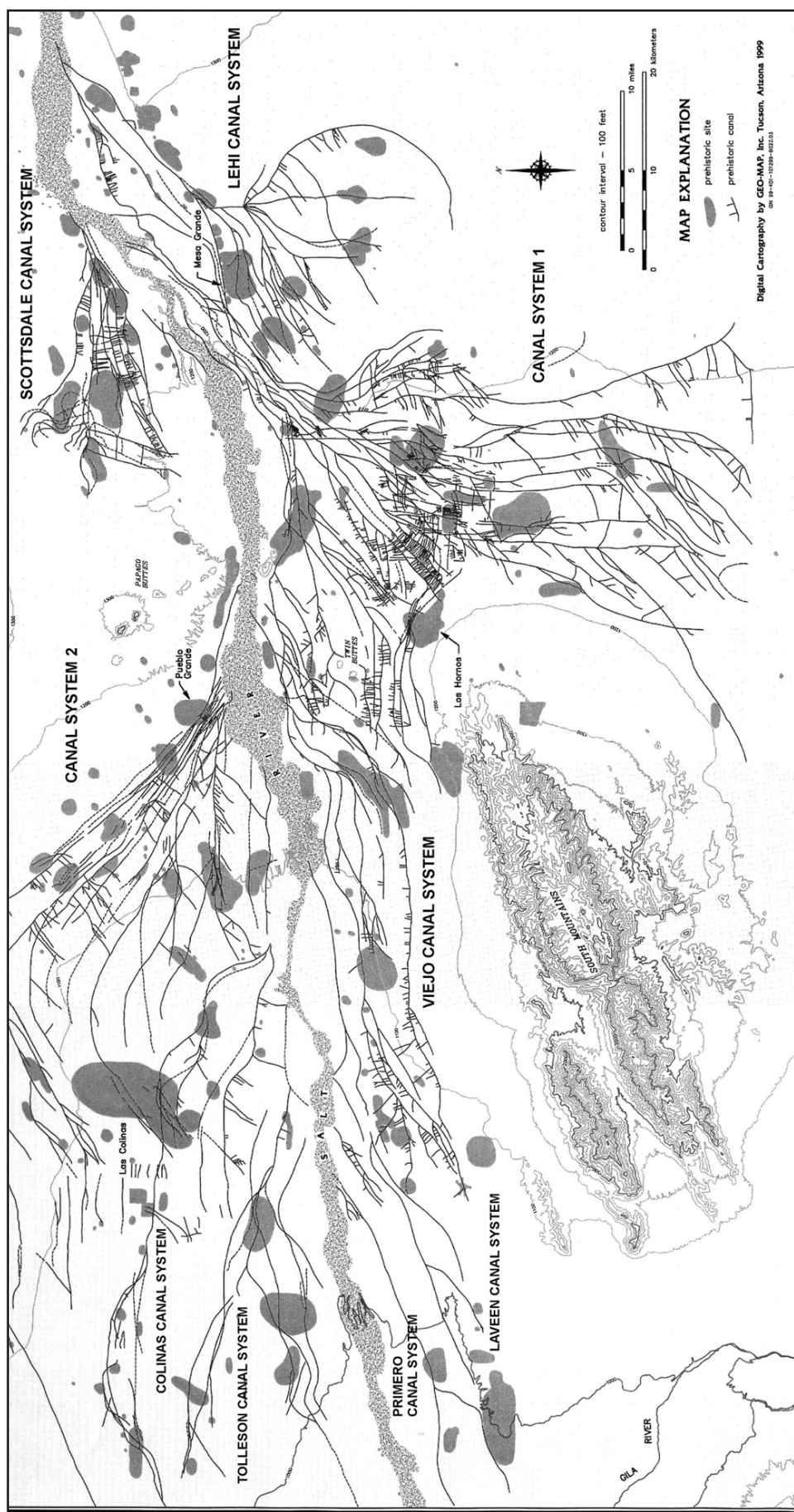


Figure 7. Map of prehistoric Hohokam canals in the lower Salt Valley, Arizona (Howard 1992, c/o Jerry Howard)



Figure 8. Map of Hohokam canal systems along the middle Gila River, Arizona (Original map from *Archaeology Southwest Magazine*, Fall 2009)

ported by canals and deposited along them over long periods of time resulted in the formation of soil phase “ribbons” that are often distinct from surrounding soils. Dart (1986:74) found that only “about 14 percent of the total canal length in the study area coincides precisely with soil ribbons as a direct result of canal sediment deposition.” Huckleberry (1992) emphasized the more general and expansive impacts to soil due to irrigation, including the deposition of sediments in field areas as well as along the canals. He noted that the deposition of fine-textured alluvium (fine sands, silts, and clays) physically modifies soils into cohesive, fine-textured surface horizons that tend to be resistant to many post-depositional processes, and the thickness of irrigation sediment is related to cumulative irrigation history. A recent study of the Snaketown Canal System demonstrates an irrigated soil was formed within the irrigated fields over a millennium of irrigation (Woodson et al. 2015). The extent of this irrigated soil corresponds closely with a soil mapped independently by the USDA-NRCS. Remarkably, this irrigated soil continues to retain favorable textures and chemical properties for agriculture although it has not been farmed for about 560 years.

CONCLUSION

The gains in research and expansion of our knowledge of prehistoric irrigation in Arizona that resulted from the passage of the NHPA cannot be overstated. The Act itself focused on preservation, saving those places of our past or the knowledge that they contain. By successfully doing that, the NHPA provided many opportunities and the funding to conduct archaeological research. Our studies of prehistoric irrigation have progressed from simple gathering of basic information to an explosion of new projects, new methodologies, and new techniques. It has provided us not only with new details on the structure and chronological expansion of irrigation systems, but also with answers to higher-level questions concerning sociopolitical organization. Understanding changes in Hohokam irrigation through time provides a unique measure of demographic change, the labor required to construct and maintain these systems, and changing agricultural risk. Importantly, we believe that this research effort is still in its formative stages. We expect that, through the continued research opportunities offered by the NHPA combined with new questions, our understanding of Hohokam irrigation will continue to grow for many years.



Figure 9. Photograph of Early Agricultural period canal (San Pedro phase) at Las Capas in Tucson, Arizona, Jonathon Mabry pictured (by William Doelle, c/o Desert Archaeology, Inc., Tucson, Arizona)

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DATING COHONINA ARCHAEOLOGICAL SITES THROUGH A CONSIDERATION OF SAN FRANCISCO MOUNTAIN GRAY WARE THICKNESS: SOME CASE STUDIES

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ABSTRACT

Manufactured from about AD 750/800 to perhaps as late as AD 1200, San Francisco Mountain Gray Ware (SFMGW) is the pottery ware associated with prehistoric groups in north-central Arizona referred to by archaeologists as Cohonina (Colton 1958; Colton and Hargrave 1937; Hargrave 1932, 1937). In his Master's thesis, Sorrell (2005) demonstrated that the thickness of sherds derived from SFMGW vessels tends to increase through time. Because the correlation between sherd thickness and site age in his test sample was very strong, he suggested that researchers might credibly date archaeological sites that contain SFMGW based solely on the thickness of sherds of this rarely painted pottery. In 2006, archaeologists from the Kaibab National Forest Heritage Resources program tested Sorrell's (2005) hypothesis (Weintraub 2006; see also Weintraub 2008). After reviewing Sorrell's thesis findings and the results of a few similar studies, this article presents the results of that study.

In this article, we describe and evaluate a method for dating sites based on the thickness of a rarely painted ceramic ware, San Francisco Mountain Gray Ware (SFMGW), which is associated with Cohonina groups who inhabited north-central Arizona from about AD 750/800 to perhaps as late as AD 1200 (Colton 1958; Colton and Hargrave 1937; Hargrave 1932, 1937). Traditionally, chronology building with respect to the Cohonina has been heavily dependent on the presence of well-dated ceramic imports such as Tusayan White Ware and Tsegi Orange Ware. Our proposed method for dating Cohonina sites uses locally produced SFMGW, which, unlike the aforementioned imported wares, is typically abundant on sites identified as Cohonina. The method offers a potential precision of less than a century and, unlike ceramic cross-dating, places sites on a continuous temporal scale.

In his Master's thesis, Sorrell observed that more than 90 percent of 2,832 previously documented Coho-

nina sites on the Kaibab National Forest had been dated with a resolution of no better than 200 years, and more than 1,000 of these had been assigned to low precision time spans of at least 400 years (Sorrell 2005:59). The fundamental reasons for this were simple: (1) Cohonina pottery was rarely decorated and archaeologists studying Cohonina pottery had not adequately defined and tracked the evolution of SFMGW design styles (cf. Schubert 2008); (2) the creators of the Northern Arizona ceramic typology (Colton 1958; Colton and Hargrave 1937) assigned undecorated SFMGW types very broad production dates, and recognized no changes in attribute states across long periods of time; and (3) Cohonina sites commonly contained little or no well-dated ceramic types of other wares (e.g., Tusayan White Ware, Tsegi Orange Ware).

CORRELATION BETWEEN MEAN SFMGW THICKNESS AND ESTIMATED SITE CONSTRUCTION DATE

As part of his thesis research Sorrell (2005) tested an observation made by his committee chair, Chris Downum, that the walls of SFMGW vessels appear to increase in thickness through time. He measured the thickness of 2,545 SFMGW sherds from a sample of 21 excavated and tree-ring dated archaeological sites to determine if the attribute varied through time. Four measurements of thickness were recorded for each sherd, "generally on four corners (preferably on more or less evenly spaced, diametrically paired points). For trianguloid sherds, [he] measured the three corners and the midpoint of the longest lateral edge. For some long, narrow sherds, [he] measured the two ends and the two midpoints along long laterals" (Sorrell 2005:83-84). All 21 excavated sites were associated with tree-ring cutting dates, which al-

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lowed for plausible inferences regarding construction dates. (Sample selection criteria, as well as references for the various sites considered, are offered in Sorrell 2005:65-69; also, see especially Downum 1988.)

Visual inspections of the sherd thickness data distributions, as well as considerations of median values, skewness, and kurtosis, indicate no extreme departures from normality. A Pearson product-moment correlation measure ($r = 0.897$; $p < .0001$) indicates a very strong, positive relationship between estimated construction dates and mean sherd thickness (Table 1; Figure 1). These data, which a Doornik and Hansen (2008) omnibus test suggests are bivariate normal ($E_p = 0.62$, $p = .961$), resulted in the following quadratic equation, potentially useful for dating archaeological sites containing SFMGW sherds:

$$y = (138.81)(x^2) + (1600.09)(x) - 3528.90 \text{ (Sorrell 2005:101).}$$

In the equation, y represents estimated site construction date and x represents mean SFMGW sherd thickness. For the sample of 21 sites, the quadratic regression model for predicting site construction date produces an average absolute residual (that is, predicted date minus inferred construction date) of just 34 years. The standard deviation for the distribution of residuals is 42 (Sorrell 2005:103). While the results seemed quite promising, Sorrell (2005:122, citing Goetze and Mills [1993]) lists several factors – often difficult to detect in a site's ceramic assemblage – that might introduce error into the model's predicted dates. These include, but are surely not limited to, the activities performed at a specific site, artifact reuse and reclamation practices, occupational duration, and, perhaps most detrimentally, the potential for multiple temporal components.

FOUR INDEPENDENT APPLICATIONS OF THE MODEL

Four independent applications of the model are presented here.

McCormick (2007)

The model has been independently tested on four subsequent projects. In her Master's thesis, McCormick (2007) measured 100 sherds excavated from Kaibab National Forest site AR-03-01-04-1007 (also known as MU 125) by the University of Cincinnati's Upper Basin Archaeological Research Project (Sullivan et al. 1996; Sullivan and Sorrell

1997). In her application she took just one measurement from the thickest part of each analyzed sherd (McCormick 2007:23), which differed from Sorrell's method of four measurements per sherd. Applying Sorrell's regression equation gave a site construction date of AD 1074. MU 125 produced tree-ring cutting dates of AD 1070 and AD1080 (McCormick 2007), bracketing the date based on Sorrell's regression equation. McCormick (2007) also tested the model on a number of surface assemblages. In these tests, predicted dates were compared with inferred occupation ranges based on ceramic groups (Downum and Sullivan 1990), resulting in mixed, but generally positive results. McCormick's measurement methods, however, differed somewhat from Sorrell's (2005), so the results of her analyses, however encouraging, should be viewed with a measure of caution.

Sorrell and Downum (2011)

Sorrell and Downum (2011) applied Sorrell's (2005) model to an assemblage of ceramics recovered during excavation of site B:16:105 (GRCA) – a small Cohonina habitation site within Grand Canyon National Park (Downum 2011). The mean thickness of 1,314 SFMGW sherds recovered from this site was 4.97 mm, which, using Sorrell's quadratic regression equation, yields a date of AD 1045. Mean ceramic dating (see below) of the recovered ceramic assemblage suggested a date around AD 1103 (or AD 1092, if only decorated sherds are considered [Sorrell and Downum 2011:44]). Sorrell and Downum (2011:44) suggest that the earlier date of AD 1045 is a plausible date of initial occupation at site

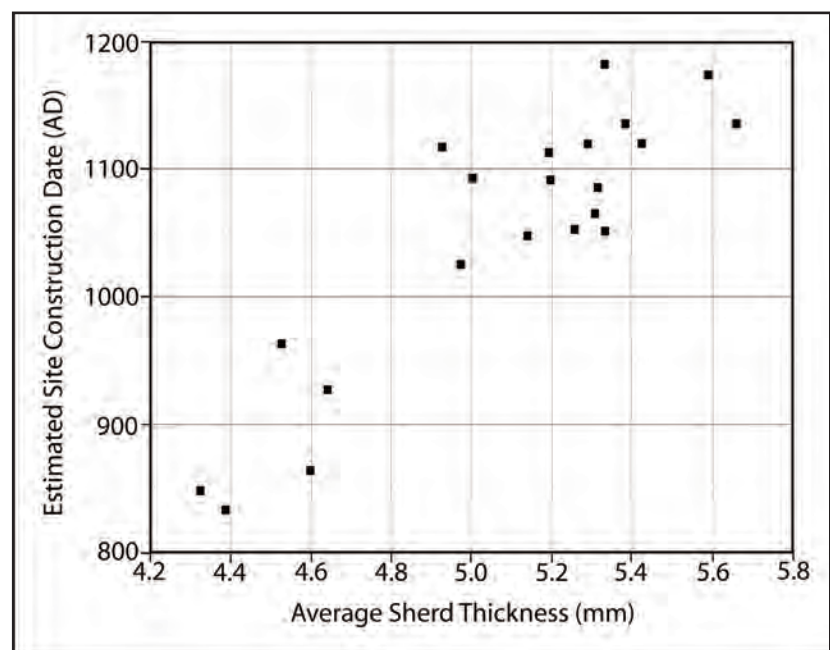


Figure 1. The relationship between sherds thickness and estimated construction dates based on tree-ring cutting dates (from Sorrell 2005:Figure 7-1)

Table 1. Inferred Construction Dates and Mean SFMGW Sherd Thicknesses for Sites Used in Sorrell's (2005) Analysis

Site Designation	Estimated Construction Date	Number of sherds Measured	Mean Sherd Thickness (mm)	Standard Error (mm)	Median Sherd Thickness (mm)	Skewness / Kurtosis*
NA 1925	834	98	4.39	.07	4.29	0.83 / 1.19
UNM 442-93	849	48	4.32	.06	4.38	-0.51 / -0.14
NA 2800	865	120	4.59	.05	4.51	0.45 / 0.64
NA 2798	928	292	4.64	.03	4.57	0.31 / 0.10
NA 1531	964	34	4.53	.11	4.45	0.18 / 0.34
NA 20619	1027	229	4.97	.04	4.95	-0.09 / 0.42
NA 862	1049	120	5.14	.07	5.14	0.18 / 0.70
NA 3577	1053	125	5.33	.07	5.21	0.74 / 0.19
NA 5149	1054	221	5.26	.05	5.14	0.52 / 0.12
NA 1238	1066	110	5.31	.07	5.24	-0.01 / -0.38
NA 2133	1086	101	5.32	.09	5.33	0.02 / -0.67
NA 192	1093	121	5.20	.07	5.21	0.51 / 0.59
NA 1244	1094	53	5.00	.09	4.95	0.98 / 2.52
NA 2001	1114	94	5.18	.06	5.08	0.65 / 0.06
NA 2002	1118	122	4.93	.06	4.76	0.74 / -0.23
NA 5137	1120	186	5.30	.05	5.27	0.54 / 0.98
NA 11237	1120	167	5.42	.06	5.40	0.50 / 0.91
NA 1814	1136	109	5.66	.07	5.59	0.97 / 2.47
NA 405	1137	63	5.38	.06	5.33	0.47 / 1.31
NA 1764	1175	86	5.59	.07	5.52	0.41 / 0.05
NA 358	1183	46	5.33	.09	5.27	0.56 / -0.11

*I.e., Pearson kurtosis minus 3.

B:16:105, noting, importantly: "The scheme in Sorrell (2005) is calibrated with the initial construction dates of individual features, so the resulting date should be thought of as a possible date of initial occupation (as opposed to the mean ceramic date, which estimates occupational mid-point)" (Sorrell and Downum 2011:44).

Cureton (2014)

In his study of Cohonina social organization, Cureton (2014) applies Sorrell's equation to surface assemblages from a suite of Cohonina archaeology sites, and compares the results to ranges of occupation suggested by ceramic cross-dating, which he describes as "a method of archaeological chronology that uses the presence and absence of individual tree-ring dated ceramics to assign temporal designations to sites or features within sites" (Cureton 2014:98). He continues, "Typically, this is accomplished by arranging the production dates for ceramic types in a graph known as a 'chronogram.' The presence and absence of those types in a ceramic assemblage is applied to the chronogram and the analyst looks for overlap in production dates to arrive at a date range for the assemblage. This method ... generally overestimates the length of temporal assignments" (Cureton 2014:98).

Table 2 presents a comparison of Cureton's ceramic cross-dates and those resulting from the application of the SFMGW mean thickness model (Cureton 2014:Table B.2). All data presented in Table 2 are derived from surface manifestations. A Doornik-Hansen omnibus test for bivariate normality (Doornik and Hansen 2008) suggests no serious cause for concern with respect to normality ($E_p = 8.47$, $p = .076$), so the data might be suitable to examination through Pearson correlation. The test suggests a strong correlation between the variables ($r = 0.66$, $p = .003$). A non-parametric Spearman correlation test yields similar results ($\rho = 0.68$, $p = .002$).

Kaibab National Forest Passport in Time Project

In 2006, professional archaeologists and a group of volunteers took part in the Kaibab National Forest's annual Passport in Time project just west of Grand Canyon National Park (Weintraub 2006; see also Weintraub 2008). During the project, participants recorded measurements of SFMGW thickness from surface assemblages at 15 archaeological sites. They also collected data on other ceramic types amenable for chronometric analysis through mean ceramic dating. Mean ceramic dating is a technique of dating that considers the median date of individual well-dated ceramic types and

Table 2. Cureton's (2014) Project, Comparison of Predicted Dates based on Ceramic Cross-Dates and SFMGW Mean Sherd Thickness (Adopted from Cureton 2014:Table B.2, with augmented information derived from elsewhere in Cureton 2014. Note: Three cases have been omitted from this table. Site -0889 was exempted from consideration because the information provided in Cureton's table was derived from Sorrell 2005. Sites -2782 and -2788 were omitted because the SFMGW thickness data were too few to provide reliable results; see Cureton 2014:320 and Tables B.12 and B.16.)

Site No. (prefixed AR-03-07-01)	Site Type	Ceramic Cross-Dating Mid-point (AD)	SFMGW Thickness Dating		
			n	Mean Sherd Thickness (mm)	Predicted Date (AD)
-0238	Artifact scatter	1000	33	4.63	946
-1468	Habitation	1133	47	5.30	1109
-2433	Habitation	940	33	4.67	961
-2774	Habitation	1133	33	5.34	1114
-2775	Artifact scatter	1108	33	5.47	1130
-2776	Habitation	1088	33	5.66	1145
-2778	Habitation	1000	33	5.24	1100
-2779	Habitation	938	33	5.12	1078
-2780	Habitation	988	33	5.27	1105
-2783	Artifact scatter	938	33	4.96	1041
-2784	Artifact scatter	913	33	4.77	991
-2786	Habitation	1088	33	4.86	1017
-2792	Artifact scatter	1000	42	5.56	1139
-2793	Artifact scatter	1088	50	5.50	1133
-2795	Artifact scatter	1000	33	4.93	1035
-2796	Artifact scatter	1163	32	5.84	1150
-2800	Habitation	1113	33	5.62	1142
-2803	Rock shelter/rock art	913	33	4.84	1010

the relative frequencies of those types to derive date of site occupation. Pioneered by Stanley South (1977) in a study of historic ceramics, the technique also has been shown to be a feasible chronometric method for prehistoric sites, especially when modified to weight the influence of ceramic types that exhibit short spans of use (see Christenson 1992, 1994, 1995; Garcia 2004; Downum and Vance 2017:98). The mean ceramic date estimates the mid-point of site occupation. Median dates *and* weight factors for ceramic types used in the analyses are presented in Table 3. Date ranges for the ceramic types and weight factors were provided by Chris Downum, based on reviews of tree-ring dates and associated ceramic assemblages from the Flagstaff area and surrounding region (Ahlstrom and Downum 2014; Brennan 2003; Downum 1988; Downum and Vance 2017; Sullivan et al. 1995.)

The sample sizes of sherds (Table 4), collected from the surfaces of habitation sites are likely too small to yield a reliable Pearson correlation test between the two sets of predicted dates. Moreover, a Doornik-

Hansen omnibus test for bivariate normality (Doornik and Hansen 2008) suggests deviation from bivariate normality ($E_p = 10.75$; $p = .030$), which might further hinder the reliability of test results. Alternatively, a Spearman correlation test was used to compare the variables. Spearman correlation suggests that the dates predicted by SFMGW thickness, on the one hand, and the mean ceramic dating method, on the other, are strongly positively correlated ($\rho = 0.73$; $p = .005$) (Figure 2). Statistical tests for this analysis were conducted with PAST freeware (Hammer and others 2001).

Positive test results notwithstanding, the presence of two outliers, represented by sites 1426 (north locus) and 1809, are troubling (site numbers are preceded by AR-03-07-01-). Except for the cases that post-date AD 1060, the derived scatterplot (Figure 2) does not show a strong association between variables. Clearly, the SFMGW thickness and mean ceramic dating methods are not in agreement with respect to these two cases. Omitting these two cases results in a Spearman's ρ of 0.89 – a very strong association ($p = .0002$).

A detailed look at the two outlier cases reveals some possible explanations for their lack of fit with the SFMGW regression model. The SFMGW thickness data from both sites appear to be reasonably normally distributed. The ceramic assemblage at site 1426 (north locus) suggests that the site may have been occupied intermittently over as many as four centuries. Surface inventories included the relatively early ceramic type Kana-a Black-on-white (AD 800-1025), but also some significantly later types – especially Flagstaff Black-on-white (AD 1150-1225) and Citadel/Tusayan Polychrome (AD 1150-1250). Alternatively, it is also possible, though highly unlikely given known patterns of Cohonina settlement, that the site witnessed a single occupation of considerable duration. Either situation could severely affect the reliability of the SFMGW thickness dating method. Multiple components are not suggested, however, by the site 1809 ceramic assemblage, where a solid Pueblo II (AD 1050-1150) use is suggested. There may well be an earlier component inherent at the site, but it is not reflected in surface pottery types.

Table 3. Estimated Ceramic Type Production Date Ranges, Median Construction Dates, and Weight Factors Used in the Analysis

Ceramic Type*	Date Range (AD)	Median Date (AD)	Weight Factor
Lino Gray	550-825	687.5	0.75
Kana-a Gray	800-1025	912.5	1.25
Medicine/Coconino Gray	1025-1065	1045	3.10
Tusayan Corrugated	1050-1175	1112.5	2.25
Moenkopi Corrugated	1130-1250	1190	2.3
Kana-a Black-on-white	800-1025	912.5	1.25
Black Mesa/Holbrook A Black-on-white	1025-1150	1087.5	2.25
Sosi/Holbrook B Black-on-white	1050-1200	1125	2.00
Dogoszhi/Padre Black-on-white	1050-1200	1125	2.00
Flagstaff/Walnut Black-on-white	1150-1225	1187.5	2.75
Deadmans Black-on-red	825-1065	945	1.10
Medicine Black-on-red	1050-1125	1087.5	2.75
Tusayan Black-on-red	1065-1200	1132.5	2.15
Cameron Polychrome	1100-1125	1112.5	3.25
Citadel/Tusayan Polychrome	1125-1275	1200	2.00
Sunset Red	1070-1250	1160	1.70

*The Passport in Time team of professionals and volunteers identified numerous sherds in their analysis as Angell Brown and Winona Brown – two types of pottery that are notoriously difficult to distinguish from each other because of subjective judgements regarding temper size, which is the distinguishing characteristic between the types (Downum 1988; Garcia 2004; Kamp and Whittaker 1999). For this reason, we have opted to exclude the types Angell Brown and Winona Brown from our current mean ceramic dating calculations.

DISCUSSION

Strictly speaking, this study pertains only to developing a chronological method based on an easily-measured pottery attribute, sherd thickness. The underlying reason for an increase in the thickness of the ancient pottery vessel walls that produced the sherds is, for the purpose of chronology building, largely irrelevant. The study has, nonetheless, revealed a previously undetected trend in the evolution of Formative Southwest pottery, namely an apparent and relatively steady increase in the thickness of SFMGW pottery vessel walls through time. Interestingly, Crossley (2001), in a study of the thickness of Alameda Brown Ware pottery (a mostly undecorated ware made just east of the production zone for SFMGW) detected a closely similar trend toward increasing Alameda Brown Ware vessel wall thickness through time. In the case of Alameda Brown Ware, average sherd thickness increased from about 4.69 to 7.82 mm in the period from AD 688 to 1363. Thus, a parallel evolutionary trend in the thickness of pottery vessels was taking place in two adjacent areas of the same region at roughly the same time, albeit with Alameda Brown Ware being overall slightly thicker than SFMGW and persisting slightly longer. Elsewhere in the

New World, Vidal and Pérez (2016) have recently demonstrated thickening of pottery vessel walls between the Formative (3000 BC to AD 1000) and Late (AD 550 to 1300) periods in the *Antofagasta de la Sierra* of northern Argentina. During this transition, vessel walls increased in thickness from about 6 or 7 mm to 9 or 10 mm (Vidal and Pérez 2016:1293-1295).

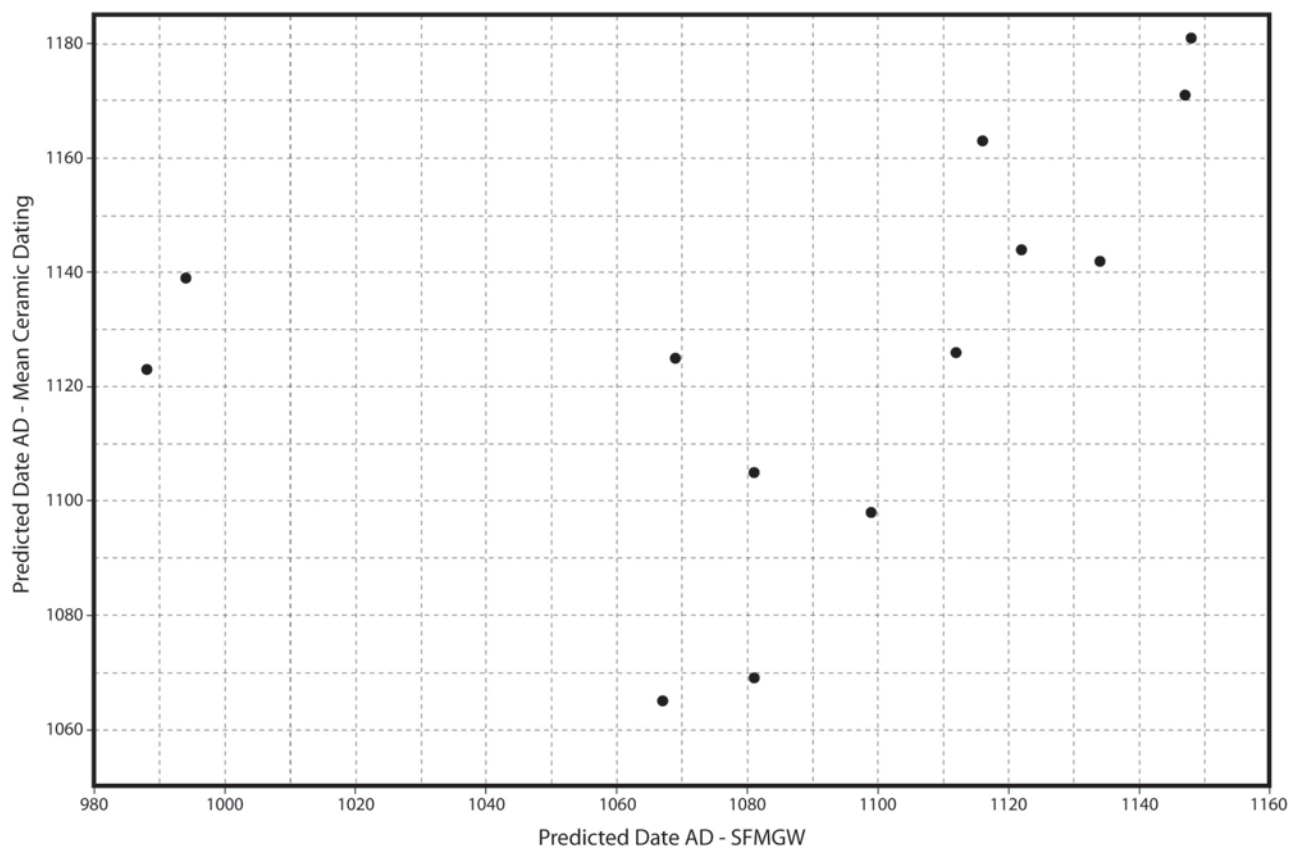
As noted by Rice (1987:227-228) and Vidal and Pérez (2016:1293), the thickness of pottery vessels in specific situations depends on a complex interplay between design choices; available manufacturing materials and technologies; intended functions of the pots; and social contexts of pottery manufacture, distribution, and exchange. Potters make their pots according to some combination of stylistic and technofunctional considerations, some of which operate at the level of conscious choice and some of which are learned or adopted at a subconscious level (Ard 2013; Croucher and Wynne-Jones 2006:115-116; Lechtman 1977; Sackett 1982). Regarding pottery thickness, Rice (1987:227) observes that “there must be continual compromise in design...between the advantages and disadvantages of thick walls in dry-

ing and during use.” Vidal and Perez (2016:1296), employing a chaîne opératoire approach to understanding changes in pottery thickness, acknowledge that there exists “an intimate relationship between technological factors and the potters’ decisions when creating a vessel, regardless of potential changes in symbolic value.”

Generally, thickness of pottery vessel walls can be attributed to two major factors: (1) vessel size and (2) intended use of the vessel (Rice 1987:227). Pottery vessels with thick walls are better able to support themselves during the manufacturing process: “In general, larger vessels require thicker walls for structural support” (Rice 1987:227). Thicker vessel walls also may make a pot more stable, more resistant to moisture, and more durable when subjected to the stresses of food processing and cooking, which involve activities such as “pounding, stirring, or mixing” (Rice 1987:227). Pots with thick walls thus are better suited to storage and processing activities (Vidal and Pérez 2016:1293). On the other hand, thick vessel walls mean heavier and less portable pots and a slower transfer of heat from vessel interiors to exteriors, and vice versa. Thicker pottery keeps recently-heated food warmer for a longer period of time, but it also means that more fuel must be used in cooking fires because thick vessel walls conduct heat more slowly from a hearth to the inside of a pot. Larger

Table 4. Passport in Time Project, Comparison of Predicted Dates based on SFMGW Thickness and Mean Ceramic Dating

Site No. (prefixed AR-03-07-04)	SFMGW Thickness Dating			Mean Ceramic Dating		Difference (years)
	n	Mean Sherd Thickness (mm)	Predicted Date (AD)	n	Predicted Date (AD)	
-0004	50	5.14	1081	65	1105	-24
-0005	50	5.70	1147	73	1171	-24
-0006	50	5.51	1134	82	1142	-8
-0511	50	5.35	1116	47	1163	-47
-1365	50	5.75	1148	61	1181	-33
-1384	50	5.14	1081	39	1069	+12
-1415	19	5.08	1069	11	1125	-56
-1422	50	5.32	1112	119	1126	-14
-1426 (north locus)	50	4.76	988	48	1123	-135
-1426 (south locus)	50	5.24	1099	34	1098	+1
-1809	50	4.78	994	12	1139	-145
-1811	50	5.40	1122	27	1144	-22
-1813	50	5.07	1067	8	1065	+2

**Figure 2. The relationship between dates predicted by the SFMGW thickness model and mean ceramic dating, Passport in Time project**

and thicker pots also require more fuel to successfully complete the firing process during manufacture. For these reasons, pots with thinner walls may be more economical to manufacture and are better suited for cooking (Braun 1983; Skibo et al. 1989:131; Vidal and Pérez 2016:1293).

Several possible explanations for increasing thickness of SFMGW can be explored through future research. Among these are (1) decreasing mobility of Cohonina populations through time and therefore relaxed pressure on the need to maintain thin vessel walls that would minimize weight and thus optimize portability of ceramic containers (Rice 1987:226; Skibo et al. 1989:126); (2) increasing use of SFMGW pots for storage or food processing activities (thick-walled vessels preferred for moisture resistance, stability, strength, and durability) rather than cooking (thin walled vessels preferred for rapid heat transfer); and (3) increasing overall size of SFMGW pots through time (thick-walled vessels preferred due to their ability to support their own weight and form during the manufacturing process). Currently each of these possibilities seem viable explanations, and all could be investigated through detailed time-series analyses of Cohonina settlement patterns, examination of SFMGW residues and use-wear traces, and collection of data on SFMGW vessel sizes and vessel wall thickness.

In his Master's thesis, Sorrell wondered if his chronometric technique would be a viable and practicable option for archaeologists working in the "real world" (Sorrell 2005:105). That is, would the model work on the types of assemblages that archaeologists are likely to encounter with regularity, such as surface assemblages requiring documentation during survey efforts and ceramic assemblages recovered from sites that do not yield tree-ring cutting dates? The findings of the subsequent applications reported in this article are promising. We recommend, however, that continual refinements to the model be made as new data are recovered, with a particular focus on data collected from tree-ring dated contexts.

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HOW A RIVER, A TERRACE, AND A BUTTE INFLUENCED THE SPATIAL DEVELOPMENT OF A HOHOKAM VILLAGE

Erik Steinbach

ABSTRACT

AZ U:9:165 (ASM) (also known as La Plaza and hereafter referred to as Site 165) is an extensive, multi-component site that includes a large Hohokam village situated at the base of Tempe Butte and continues east along the edge of an upper terrace of the Salt River within the urbanized portion of the City of Tempe and the Arizona State University (ASU) Tempe campus. The founding and early growth of the City of Tempe in the late 19th century covered major portions of the site before its boundaries and structure could be adequately documented by archaeological surveys. A number of subsequent excavation projects have documented cultural deposits but due to the limited size and fragmentation of those cultural resource projects it has been difficult to put together a large-scale study of the entire settlement. I review data from over three dozen cultural resource management projects undertaken in the last 40 years, to trace the development of the Hohokam village through time and tie the spatial layout to the geographic benefits and restraints of three major geographic features: the Salt River, the Mesa Terrace, and Tempe Butte.

AZ U:9:165 (ASM) is a large multi-component site that includes a large Hohokam village situated at the base of Tempe Butte and continuing east along the edge of an upper terrace of the Salt River within the urbanized portion of City of Tempe and the Arizona State University (ASU) Tempe campus. Also known as La Plaza or La Plaza de Tempe, it is referred from here on as Site 165. Tempe Butte has separate site numbers, recently consolidated under AZ U:9:114 (ASM). For the purposes of this discussion AZ U:9:114 (ASM) will be considered part of Site 165. Archaeological investigations at Site 165 have occurred in limited areas of the site within the City of Tempe and on the ASU campus since the 1980s. Due to the fragmented nature of these projects, it has been difficult to gain an insight into the overall village

structure of Site 165. By combining the data of over three dozen cultural resource projects conducted in the last 40 years, a map that traces the spatial extent of Site 165 over time is presented. The spatial patterning of the prehistoric Hohokam village is then placed within the context of three geographic features that influenced its growth: the Salt River, the Mesa Terrace, and Tempe Butte.

The cultural resource management projects shown in Figure 1 are the data used to analyze the organization of Site 165. Projects documenting cultural resources occur both within and outside the boundaries of the site as currently recorded. At one time this boundary enclosed an area in which archaeological projects had identified cultural deposits, but subsequent work has shown that cultural resources have a wider distribution to the south than once thought. The shading of the project areas show the relative density of prehistoric features, with darker shading indicating cultural features characteristic of hamlets and villages and light shading indicating features characteristic of agricultural fields, including farmsteads, field houses, canals, and irrigated fields. No shading represents projects that found no or only isolated prehistoric features. Some larger projects have more than one type of shading; for instance the Valley Metro Light Rail project recorded numerous features between the Tempe Transportation Center and Rural Road, but few between Rural Road and Apache Boulevard.

TERMINOLOGY AND SITE STRUCTURE

The boundary of Site 165 as recorded by Frank Midvale in the early twentieth century encompasses extensive field areas and overstates the size of the hamlet/village, which was limited to a linear strip along the base of Tempe Butte and extending to the east along

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the edge of the Mesa Terrace. Tempe Butte is a site in itself (AZ U:9:114 [ASM]) that includes Hohokam petroglyph panels (Loendorf and Loendorf 1995), small habitation areas with burials, and terraced gardens (Kwiatkowski 1999). The boundary as depicted in Figure 1 is from Jerry Howard's irrigation map of the Phoenix Basin (Howard and Hucklberry 1991) with some modification by Schilz and others (2011). The site area incorporates a variety of site types.

Hohokam site types include villages, hamlets, agricultural fields, and areas used for specialized economic, social, and ideological purposes. Non-residential site types can include canals (Howard and Woodson, this issue), terraces, check dams, rock-piles (Fish et al. 1992; Fish and Fish 2007), trails (Darling and Lewis 2007), rock art (Loendorf and Loendorf 1995; Bostwick and Krocek 2002; Wright 2014), and quarries (Bostwick and Burton 1993).

In a commonly used classificatory scheme (Gregory 1991:148-149; Mitchell 1989:280) Hohokam residential settlements are further subdivided into villages, hamlets, farmsteads, and field houses. *Villages* and *hamlets* were permanent settlements occupied year round and frequently for long duration; villages differed from

hamlets in having larger populations (in excess of 100 people) and public architecture such as ball courts or platform mounds. *Farmsteads* and *field house* sites were seasonally occupied settlements generally occupied by single social groups tending agricultural fields. Compared to villages and hamlets, farmsteads and field house sites had lower accumulations of refuse and smaller structures (ca. 10 m² for farmsteads, 5 to 8 m² for field house sites versus 16 to 22 m² for hamlets and villages). Houses at farmsteads tended to be more substantial, with internal support posts and plastered hearths not found in the smaller field houses (Cable and Mitchell 1988; Crown 1983:11-15; Mitchell 1989:280; Henderson 1989). Watkins (2011) concludes that some field houses were occupied by migrants living in the desert settlements beyond the irrigated zones who were temporarily living on the canals as sharecroppers working for local landowners (Watkins 2011).

The area of Site 165 on the Mesa Terrace was divided by a prehistoric canal into two zones (Figure 1, Table 1), a residential area to the north and agricultural fields to the south. There is also a second area of agricultural fields on a remnant of the lower Lehi Terrace to the north of the Mesa Terrace. Jacobs (Jacobs et al. 2001)

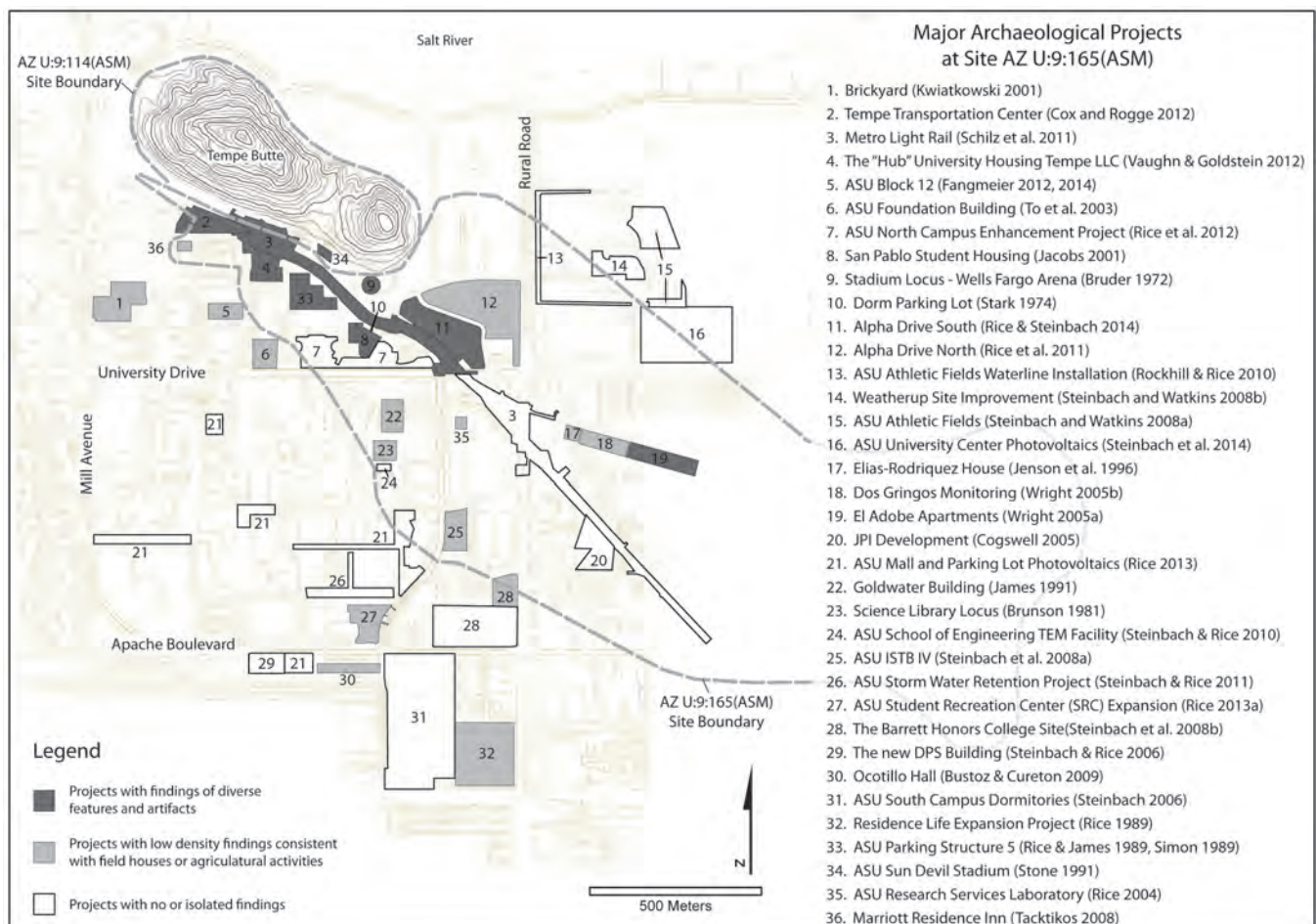


Figure 1. Major cultural resource management projects conducted within or near Site 165

Table 1. Average Floor Area (m²) in Residential and Agricultural Field Zones of Site 165 (Intact Floors Only).

Period	North Side of Canal		South Side of Canal*	
	Average Floor Area	Cases	Average Floor Area	Cases
Pioneer	9.5	2		
Colonial	8.1	4	5.2	3
Colonial-Sedentary	19.3	5	7.0	1
Sedentary	15.7	5	9.4	2
Sedentary-Classic	16.7	8		
Classic	24.1	8	16.1	1
All Periods	17.3	32	8.2	7

* Includes one Sedentary Period structure on the Lehi Terrace

was the first to comment on this organizing principle of the site. For the most part, residential areas, cemeteries, and public architecture are on the upslope (north) side of canal and fields houses and farmsteads are on the downslope (south) side of the canal.

This spatial pattern is seen in the different sizes of house floors (Table 1) in the time from the Colonial-Sedentary transition through the Classic Period. Larger size structures characteristic of hamlets and villages occur on the north side of the canal and smaller field houses and farmsteads on the south side. The data hint at the possibility that initially, in the Pioneer and Colonial periods, the occupation on the north side of the canal also consisted of farmsteads and field houses. Although more than 100 structures have been excavated at Site 165, many of the features were so badly disturbed by subsequent prehistoric and modern activities that accurate measurements of floor area could be obtained from only 32 of the dated features (Table 1). Sample sizes are small for the early periods. On the north side of the canal two measurable Pioneer Period houses and three of the four Colonial Period structures were less than 10 m² in area, in the size range of field houses. A single Colonial Period structure was larger (13.7 m²), in the range for farmsteads or small structures in a hamlet or village. Larger size structures in the Colonial/Sedentary transition (roughly AD 850) mark the development of a hamlet (which had no ball court). In the Classic Period (AD 1200 to 1400) this developed into a village with the addition of a platform mound. The hamlet/village was situated at the base of Hayden Butte and was probably confined to the north (upslope) side of the canal to avoid taking up space in irrigated fields on the south side. With time the settlement expanded eastward from the butte, remaining confined to a narrow strip along the north bank of the canal.

An extensive area on the Mesa Terrace to the south of the irrigation canal was devoted to agricultural fields and a scattering of field houses and farmsteads, ad-

ditional canals, laterals, roasting pits, pits, artifact scatters, and lenses of burned field stubble. During the Colonial and Sedentary periods the structures averaged from 5 – 10 m², the range for field houses and farmsteads. A single Classic Period structure south of the canal is much larger, in the size range typical of hamlets and villages, but other characteristics such as modest artifact density and absence of neighboring structures mark it as a farmstead. Agricultural features also have been recorded on a remnant of the lower (Lehi) terrace at the northeast base of Tempe Butte (see Project 12, Figure 1).

SITE ORGANIZATION OVER TIME

The occupation and use of Site 165 began during the Pioneer Period and persisted through the Civano phase of the Classic Period. The peak of the occupation appears to have occurred during the Sedentary and early Classic periods based on counts of house features, or in the Classic Period based on counts of mortuary features (Table 2). The disparity in these two feature categories suggests that the late nineteenth and twentieth century development of Tempe destroyed a disproportionate number of Classic Period houses.

Site 165 had at least one platform mound in the Classic Period, but no pre-Classic ballcourt has been located. It has been difficult to identify courtyard groups used by extended households because of the poor preservation of structures, and most data recovery projects have been limited to small or narrow parcels too limited for the identification of spatial groups. Cox and Rogge (2012:16-6 to 16-7), however, suggest that in their project area courtyard clusters of houses may have occurred as early as the Pioneer Period and throughout the Colonial and Sedentary periods. Most of the Classic Period houses dated to the Soho phase, and the patterning was more equivocal. Only one house dated to the Civano phase, and there was no evidence it was associated with a compound.

Pioneer and Pioneer-Colonial Periods

The Pioneer and Pioneer-Colonial periods are evidenced by eight structures, two mortuary features, and several thermal features from four project areas (Cox and Rogge 2012; Schilz et al. 2011; To et al. 2003; Rice and Steinbach 2014). Maize was being grown at the base of the butte during the Pioneer Period. Structures were found only on the north side of the prehistoric canal and were heavily disturbed but the few with measurable floor areas are in the size range of field houses and farmsteads, and occupation may have been limited to the growing season. The effects of

sampling error cannot be discounted however, and future excavations could find larger houses characteristic of hamlets occupied year-round. This occupation may have used a canal drawing water from the Salt River (Canal Tempe) from as far as 7 km upstream and irrigating fields on the south side of Tempe Butte (Cox and Rogge 2012:16-9).

Excavations conducted for the Tempe Transportation Center (Cox and Rogge 2012) at the base of Tempe Butte recorded four pit houses dated to the Pioneer Period and two houses that could be dated to the Pioneer or Colonial periods. Two cremations were assigned to the Pioneer Period (Number 2 on Figure 2). A roasting pit also was radiocarbon dated to the Pioneer Period. Immediately to the east of the Tempe Transportation Center project, data recovery efforts for the Valley Metro Light Rail at what the authors referred to as the Sun Devil Stadium Locus (Schilz et al. 2011) recorded two Pioneer Period structures, although no Pioneer burials were identified.

Work done prior to the construction of the ASU Foundation Building (Number 6 on Figure 2) recorded a roasting pit, a hearth, and an artifact scatter. A radiocarbon date obtained from the roasting pit had a 2-sigma calibrated range of AD 390 to 550 or the Vahki phase of the Pioneer Period (To et al. 2003:44-45). Another early radiocarbon date was obtained from a pit feature containing Zea Mays cupules, which came

Table 2. Houses and Mortuary Features by Location and Time Period.

Period	North Side of Canal		South Side of Canal, Lehi Terrace	
	Houses	Burials	Houses	Burials
Pioneer	6	2	0	0
Pioneer-Colonial	2	0	0	0
Colonial	11	7	3	0
Colonial-Sedentary	12	0	2	0
Sedentary	10	6	3	0
Sedentary-Classic	26	34	0	0
Classic	26	165	1	10
Not Dated	13	142	0	1
TOTAL	106	356	9	11

* Includes one Sedentary Period structure on the Lehi Terrace

from a pit beneath a pit house remnant (Number 11 on Figure 2), in the Alpha Drive South (Rice and Steinbach 2014) project and provided a 2-sigma calibrated range of AD 420 to 560 indicating that the area was used during the Pioneer Period, although the relationship of the pit to the floor remnant was unclear. These

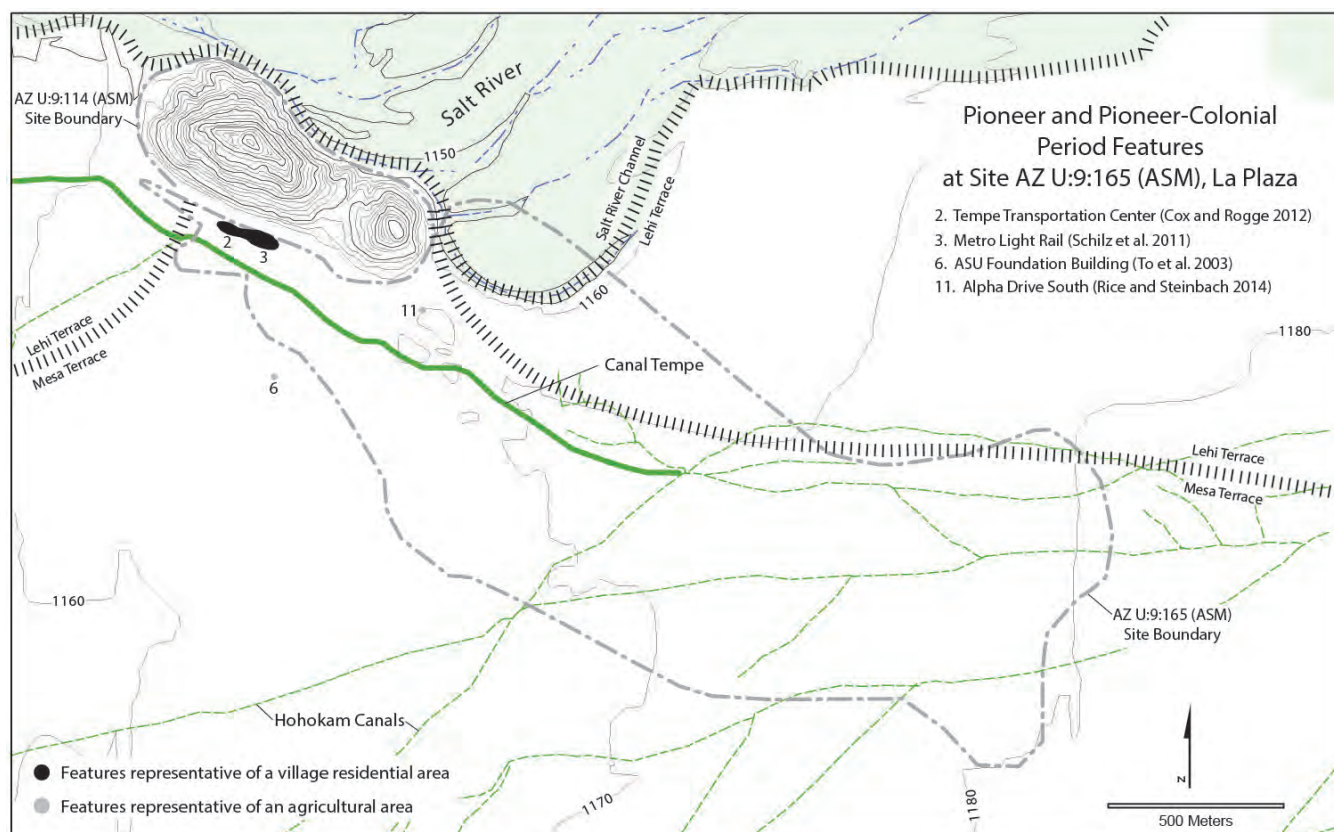


Figure 2. Pioneer and Pioneer-Colonial Period features recorded within, or in the vicinity of, Site 165

two Pioneer Period loci appear to be isolated from the main area of occupation at the base of Tempe Butte and probably represent agricultural use areas.

Colonial and Colonial-Sedentary Periods

Features dating to the Colonial and Colonial-Sedentary transition were recorded during nine projects (Figure 3), four on the north side of the prehistoric canal, four on the south, and one on the lower Lehi Terrace. The sample includes 23 structures and 7 mortuary features on the north side, 5 field houses on the south, and trash pits, middens, use areas, a second irrigation canal on the Mesa Terrace, and an irrigation ditch on the lower Lehi Terrace. By the Colonial-Sedentary transition the occupation on the north side of the canal was clearly a hamlet with larger size houses, and farmsteads and field houses on the south side of the canal.

Occupation at Site 165 continued into the Colonial Period within the Tempe Transportation Center project area where nine Colonial Period houses and an additional seven houses that could be dated to either the Colonial or Sedentary periods were recorded. One inhumation and one cremation were assigned to this period as well (Number 2 on Figure 3). At the Sun Devil Stadium locus (Number 3 on Figure 3) 10 features (including 2 structures) dated to the Colonial Period and 35 possibly dated to the Colonial Period, including an-

other 5 structures. Further to the southeast, near Wells Fargo Arena, another 10 features were assigned to the Colonial Period by Schilz and others (2011). Within the Valley Metro Light Rail right-of-way five mortuary features were also assigned to the Colonial Period. At what is now the Wells Fargo Arena (Number 9 on Figure 3) features dated to the Santa Cruz phase of the Colonial Period were identified by ASU students during the construction of the arena (Bruder 1972). Further east at the El Adobe Apartments project (Number 19 on Figure 3), archaeologists recorded a residential area that was founded in the Colonial Period at a distance from Tempe Butte and on the edge of Mesa Terrace. This occupation would become more substantial during the Sedentary Period (Wright 2005a) and would include a cluster of residential features and canal alignments.

Loci with features more indicative of agricultural activities and field houses were recorded at some distance south of Tempe Butte on the Mesa Terrace and on the lower Lehi Terrace east of the butte. Archaeological monitoring at ASU Block 12 (Fangmeier 2012, 2014; Number 5 on Figure 3), identified 2 thermal pits, a pit of undetermined function, a cultural surface and a trash pit—all assigned to the Colonial Period. The trash pit continued to be used into the Sedentary Period although no other Sedentary Period features were recorded within that project area. To the east of the

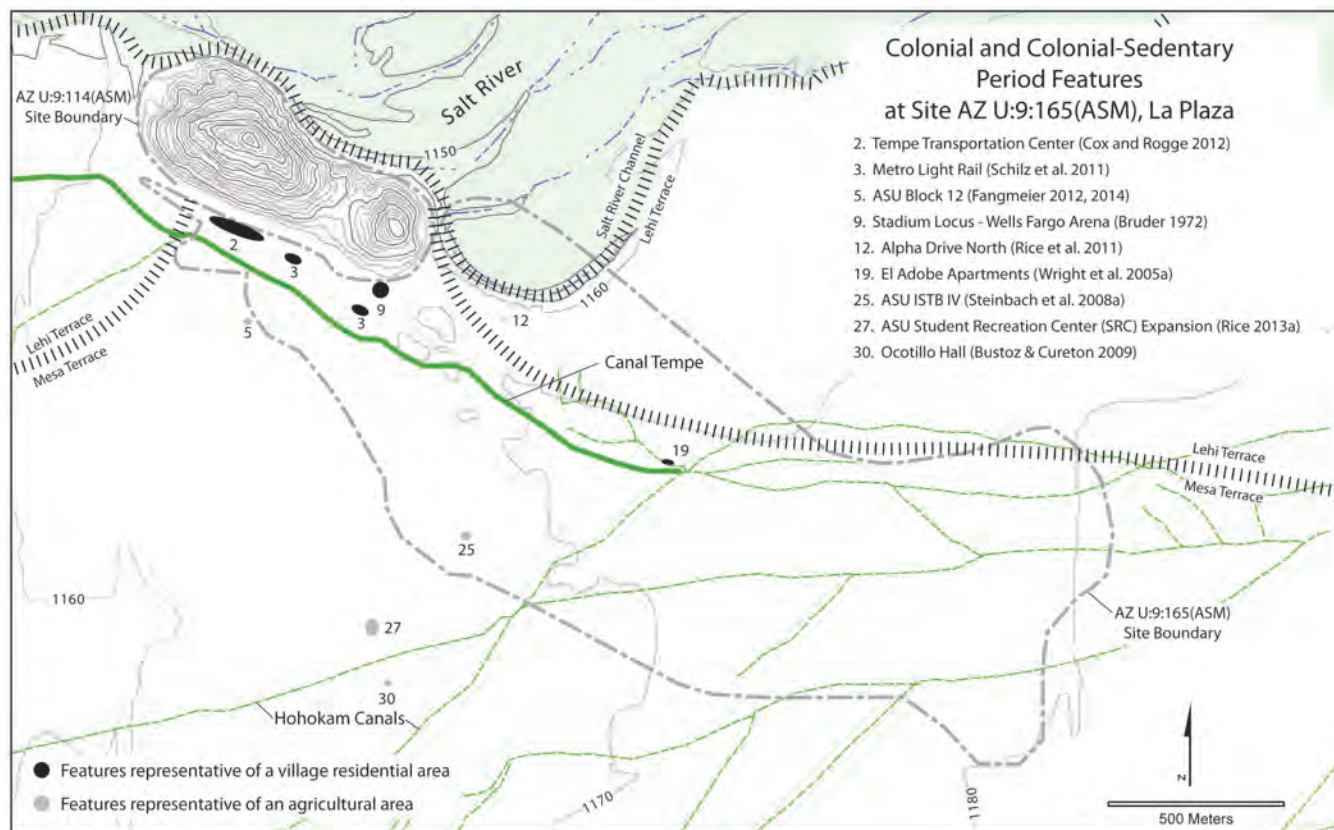


Figure 3. Colonial and Colonial-Sedentary Period features recorded within, or in the vicinity of, Site 165

smaller of the two knolls of Tempe Butte and down on the Lehi Terrace (Number 12 on Figure 3) a small irrigation ditch dating to the late Gila Butte phase was identified (Rice et al. 2011). Much further south (Number 25 on Figure 3), during data recovery for ASU's Interdisciplinary Science and Technology Building IV construction (Steinbach, Watkins, and Bustoz 2008), a cultural surface, three extramural hearths, and a trash pit containing Colonial Period ceramics were recorded. During data recovery for the ASU Student Recreation Center Expansion (Number 27 on Figure 3) three Gila Butte phase field houses and two field houses that could be dated to the Colonial-Sedentary Period were recorded (Rice 2013a). On the south side of Apache Boulevard at ASU's Ocotillo Hall (Number 30 on Figure 3) a small agricultural activity area was recorded (Bustoz and Cureton 2009) consisting of a thermal pit and a puddling pit containing Colonial Period ceramics. The thermal pit produced a radiocarbon 2-sigma calibrated range of AD 770 to 980.

During the Colonial Period, the core of the hamlet expanded southeast along the base of Tempe Butte and along at least some portion of the edge of the upper terrace further east. An irrigation ditch was documented on the Lehi Terrace indicating the lower terrace was used for irrigation farming during this period (Number 12 on Figure 3). A cluster of field houses at the ASU Student Recreation Center and other loci con-

taining pits and cultural surfaces show that parts of the Mesa Terrace south of Canal Tempe was used for agricultural purposes.

Sedentary and Sedentary-Classic Periods

Fourteen projects documented the Sedentary and Sedentary-Classic transition periods, nine on the north side of the canal, four on the south, and one on the Lehi Terrace (Figure 4). On the Mesa Terrace to the north of the prehistoric canal the sample includes 36 structures and 40 mortuary features along with a variety of thermal features, pits, and trash features. The agricultural fields to the south of the canal on the Mesa Terrace and on the remnant of the Lehi Terrace included three field houses and associated use surfaces, trash pits, and latrines.

During the Sedentary Period the core of the hamlet appears to have remained at the southern edge of Tempe Butte with the densest occupation shifting east toward the base of the smaller knoll of the butte. Occupation at the Tempe Transportation Center (Cox and Rogge 2012) project area continued into the Sedentary Period, although the number of structures assigned specifically to this period dropped to one house and an additional two houses that could be dated to either the Sedentary or Classic periods. One inhumation and one cremation were assigned to this period (Number 2 on Figure 4) and an additional five inhumations could be dated to either

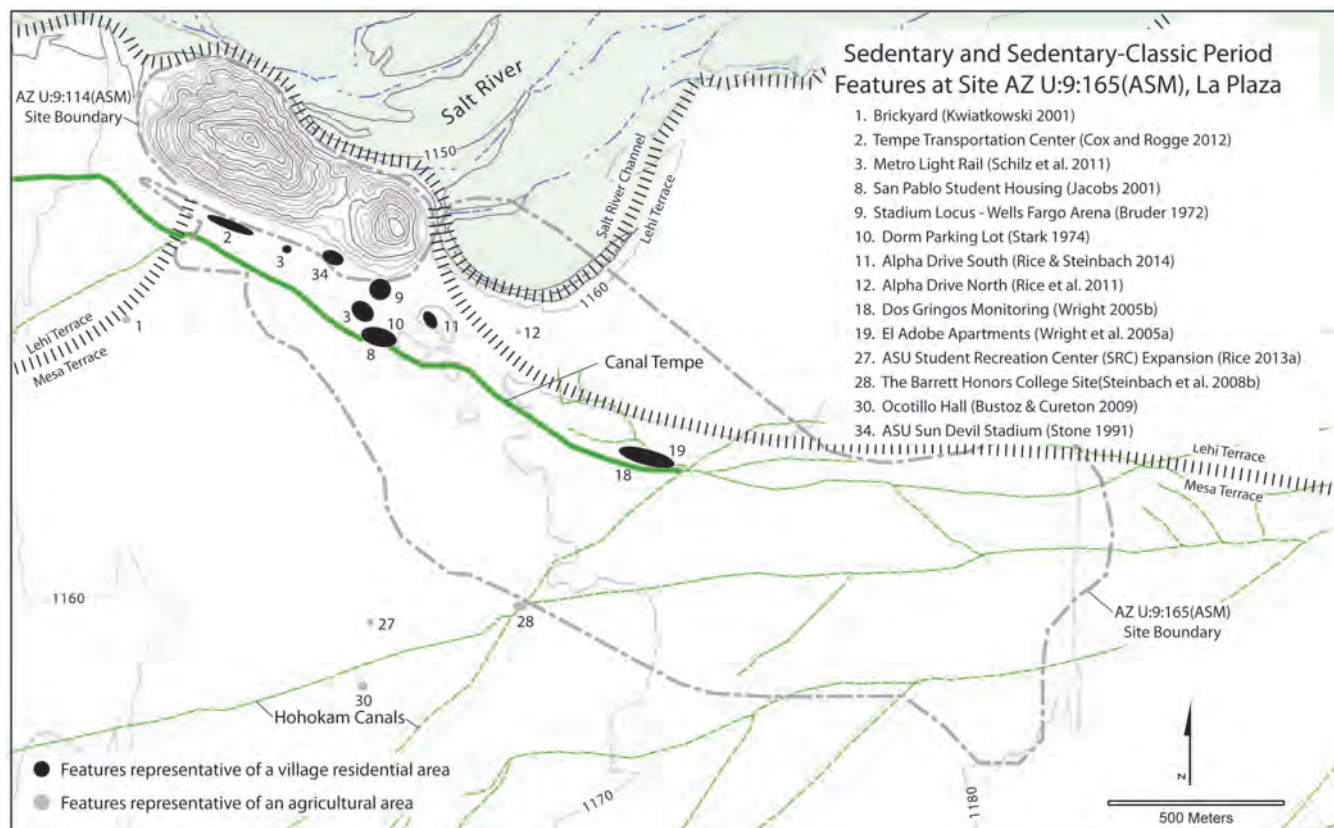


Figure 4. Sedentary and Sedentary-Classic Period features recorded within, or in the vicinity of, Site 165

the Sedentary Period or the Classic Period. At the Sun Devil Stadium locus (the western Number 3 on Figure 4; Schilz et al. 2011) five features were dated to the Sedentary Period including one structure. An additional 47 features (including 7 structures) that could possibly date to the Sedentary Period were recorded at the Sun Devil Stadium locus. At the Valley Metro Light Rail's Wells Fargo Arena locus (the eastern Number 3 on Figure 4), 15 features were assigned to the Sedentary Period by Schilz and others (2011) with the number of structures occupied during this period increasing to 14. Within the Valley Metro Light Rail right-of-way just 3 mortuary features were assigned specifically to the Sedentary Period, but another 26 were assigned to a range covering the Sedentary through Classic periods. These appear to be concentrated at the western, Sun Devil Stadium, locus.

During work done prior to the construction of the San Pablo Student Housing project (Jacobs, ed. 2001) recorded 13 prehistoric features including canal segments, a canine burial, a roasting pit, and a midden dating to the Sedentary and early Classic periods were recorded just south and east of the Wells Fargo Arena locus (Number 8 on Figure 4). In the same area during 1973 construction work in a dormitory parking lot, two human burials, a pit oven, and a midden were documented (Number 10 on Figure 4). These features also dated to the Sedentary and early Classic periods (Kwiatkowski 1999:25; Stark 1974). On the north side of Veteran's Way, at what is now the Wells Fargo Arena (Number 9 on Figure 4), a pit house dated to the Sedentary Period was recorded (Bruder 1972). Further northwest, near the southern entrance to Sun Devil Stadium (Number 34 on Figure 4), nine pit houses, no mortuary features, four cultural surfaces, two isolated pits, and a rock pile were dated to the Sedentary Period (Stone 1991).

Within the Alpha Drive project area and just east of 6th Street (Number 11 on Figure 4) 8 inhumations, 1 cremation, 1 canine burial, and 14 trash pits were assigned to the Sedentary Period (Rice and Steinbach 2014). There is an apparent gap in occupation between the features documented by the Valley Metro Light Rail project to the west and the Alpha Drive features dated to the Sedentary Period; however historical land leveling possibly removed archaeological features not deeply buried in this area. Another locus of dense occupation during this period is located approximately 900 meters to the southeast along the terrace edge (Numbers 18 and 19 on Figure 4). A Sedentary Period residential structure and three cremation burials were documented within the El Adobe Apartments project (Wright 2005a) and a midden or leveled trash mound noted during monitoring for the Dos Gringos project was dated to the middle Sacaton phase (Wright 2005b).

The Alpha Drive Locus (Number 11 on Figure 4) was likely the eastern boundary of dense occupation for the core of the prehistoric village because the number of archaeological features drops sharply further east. A field

house and trash pit dated to the middle Sacaton phase of the Sedentary Period were recorded on the Lehi Terrace (Number 12 on Figure 4; Rice et al. 2011). Beyond the western site boundary of Site 165 (Number 1 on Figure 4), an irrigation lateral and a roasting pit dated to the Sacaton phase were recorded during work at the Brickyard (Kwiatkowski 2001). To the south of the village core, agricultural evidence of continued agricultural activities into the Sedentary Period was documented at ASU's Student Recreation Center (Number 27 on Figure 4; Rice 2013a), with two field houses dated to this period, as well as at the Barrett Honors College (Number 28 on Figure 4; Steinbach, Watkins, and Rice 2008) with one field house and a pit assigned to the Sedentary Period. Three pit features documented at the Ocotillo Hall project (Number 30 on Figure 4) were dated to the middle Sacaton phase based on decorated ceramic types (Bustoz and Cureton 2009).

Classic Period

By the Classic Period the earlier hamlet had developed into a village with the addition of at least one platform mound. The spatial extent of the core village did not change during the transition to the Classic Period but there was an internal re-arrangement of residential areas and mortuary areas. The location of one platform mound constructed during the Classic Period can be identified in early twentieth century air photos within the Valley Metro Light Rail right-of-way near the present day Wells Fargo Arena (Schilz et al. 2011:613). The locations of two other possible platform mounds have been reported by Turney (1929) and Midvale (1966) although no recent archaeological projects have found evidence for either of them. One of those possible platform mounds was in the path of Valley Metro Light Rail right-of-way; however archaeological monitoring during construction (Schilz et al. 2011) did not detect the mound or any evidence of substantial prehistoric occupation in the vicinity (shown on Figure 5 as the middle square box).

Sixteen projects document Classic Period features at Site 165, eight in the residential area north of the canal, seven south of the canal, and one on the Lehi Terrace. Twenty six structures and 165 mortuary features were documented in the village area, and 1 farmstead and 10 mortuary features in the agricultural fields south of the canal.

Occupation within the Tempe Transportation Center project area (Number 2 on Figure 5) continued into the Classic Period and the number of structures assigned specifically to this period increased to nine including one dated to the Civano phase of the Classic Period. The number of burials also rose substantially with 53 of the 66 dated burials assigned to the Classic Period (Cox and Rogge 2012). The Metro Light Rail (Schilz et al. 2011) project (Number 3 on Figure 5), also showed an increase in residential structures and burials during the Classic

Period. Near Wells Fargo Arena there were 16 structures, of which 9 were specifically dated to the late Classic Period. Within the Metro Light Rail project area 20 inhumation burials and 22 secondary cremation burials dated to the Classic Period (Schilz et al. 2011:987). Schilz and others (2011:613) place a platform mound between Wells Fargo Arena and ASU's Parking Structure 5 based on historic aerial photographs and a newspaper article that reported the discovery of adobe walls during construction of a street north of the Palo Verde Residence Hall. The Valley Metro Light Rail (Schilz et al. 2011) project also found 15 features with probable dates in the Classic Period and 16 possible features dated to the Classic Period, including one structure, within this locus. No structures in this area were dated to the late Classic Period.

Work conducted at ASU's Parking Structure 5 (Number 33 on Figure 5) documented early Classic (AD 1300) period middens, along with five Civano phase graves (Simon 1989). In the 1990s work done in the parking lot in front of Sun Devil Stadium (Number 34 on Figure 5) recorded 58 secondary cremations and 3 inhumations dated to the Soho phase of the Classic Period (Stone 1991). Features dated to the Soho phase also were documented at the San Pablo Student Housing project (Jacobs, ed. 2001) including 2 inhumation burials, and in work done by Stark (1974) in the parking lot north of

San Pablo (Numbers 8 and 10 on Figure 5). The Alpha Drive (Rice and Steinbach 2014) project area (Number 11 on Figure 5) identified 4 cremations and 37 inhumation burials probably belonging to household cemeteries that dated to the Classic Period. Only one of these burials was specifically dated to the Civano phase. A large trash pit, as well as several smaller trash pits, were assigned to the Soho phase of the Classic Period. In addition to the Civano phase inhumation, only one other feature in the Alpha Drive project area dated to the later Classic Period. This feature was a pit filled with angular rock that had a 2-sigma calibrated radiocarbon date range of AD 1400 to 1440.

Farther south, away from the village core, four discoveries of human burials on or near the ASU campus dated to the Classic Period (Brunson 1981; Rice 2004; Steinbach, Watkins, and Rice 2008; Vaughn and Goldstein 2012). At the Science Library Locus (Number 23 on Figure 5) three canal segments, one cremation, three inhumations, and a trash pit were documented; the burials and trash pit dated to the Classic Period (Brunson 1981). A Classic Period inhumation, a roasting pit and a midden were identified at the ASU Research Services Laboratory (Number 35 on Figure 5; Rice 2004). At the Barrett Honors College two cremations and one inhumation were associated with a Classic Period farmstead, but only two of the burials could be definitely assigned to the Classic

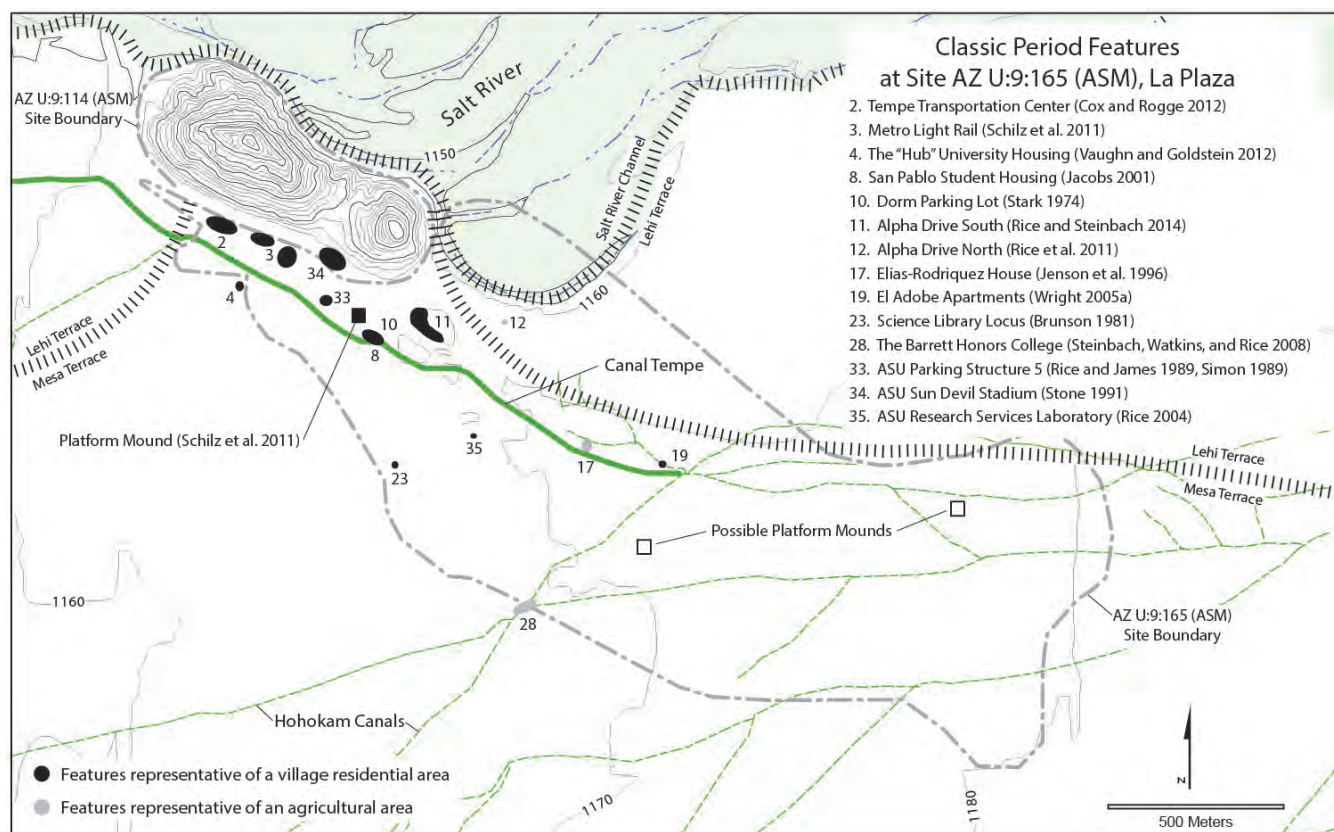


Figure 5. Classic Period features recorded within, or in the vicinity of, Site 165

Period. Just outside the Site 165 site boundary, monitoring for University Housing Tempe LLC (Number 4 on Figure 5; Vaughn and Goldstein 2012) recorded three prehistoric inhumations and a trash pit that dated to the Classic Period. It is not clear if these loci were part of the village proper or if they represented farmsteads similar to the one documented at Barrett Honors College (Number 28 on Figure 5; Steinbach, Watkins, and Rice 2008), which also was occupied during the Classic Period.

A Classic Period structure, an irrigation canal, and trash-filled pits were recorded at the Barrett Honors College project (Number 28 on Figure 5). The irrigation canal was dated to the Civano phase based on Gila polychrome ceramics recovered from its basal layer (Steinbach, Watkins, and Rice 2008). At the El Adobe Apartments (Wright 2005a; Number 19 on Figure 5) evidence of occupation during the Classic Period was identified; however, it was not as intense as during the Sedentary Period. Canal segments, charcoal lenses, and a pit containing ceramics dating to the Classic Period were documented at the Elias-Rodriguez House (Number 17 on Figure 5; Jenson et al. 1996). On the Lehi terrace within the Alpha Drive North project area (Rice et al. 2011), a single extramural hearth was dated to the Classic Period based on associated ceramics. This hearth was located immediately above a late Gila Butte phase irrigation channel. The hearth showed that the lower terrace was used during the Classic Period and that approximately 50 cm of alluvium had been deposited sometime between the late Gila Butte phase and the Classic Period on the Lehi Terrace.

GEOGRAPHIC FEATURES AFFECTING THE PLACEMENT AND GROWTH OF SITE 165

The spatial layout of Site 165, as seen in Figures 2 through 5, was influenced by three geographical features: the Salt River, the Mesa Terrace, and Tempe Butte. These three landforms contributed to the economic, social, and ideological considerations determining the cultural use of the landscape in and around Site 165. The earliest occupation occurred on the southern base of Tempe Butte and expanded eastward along the edge of the Mesa Terrace. Agricultural loci were located on the upper Mesa Terrace as well as the lower Lehi Terrace. Although there is evidence of minor irrigation ditches on the Lehi Terrace floodplain, most of the canal system serving Site 165 was on the higher terrace, which was less prone to flooding.

The Salt River

Two properties of the Salt River were of particular significance for the people living and working at Site 165. The mean annual discharge of the Salt is the highest of any river in the Hohokam region, and three times greater than the Gila River with the next highest

discharge (Graybill et al. 2006:82-83). The Salt was an abundant source of water for agriculture and domestic purposes. But the high discharge also led to frequent flooding and scouring of the floodplain and lower Lehi Terrace eroding agricultural fields and destroying canals and houses in that location. It was thus advantageous for the local populations to locate residential loci and agricultural fields on the higher Mesa Terrace once irrigation canals had been constructed to deliver water to the upper terrace.

The Salt River drains approximately 35,000 km²) of central Arizona carrying alluvium from the Superstition, Goldfield and Mazatzal mountains creating four major terraces in the Phoenix Basin (Wellendorf et al. 1986); only the Lehi and Mesa terraces are present in the vicinity of Site 165. The lower Salt River today flows through a much narrower channel than it did during prehistoric and historical times. Modern development of both banks of the river in Tempe has restricted the river channel and upstream dams have almost completely eliminated major flood events that in the past caused overbanking of the river and channel scouring (Honker 2000). As late as 1965, a large flood caused major damage in the Phoenix area and inundated an area east of Rural Road and north of University Drive. The current area of the ASU Athletic Fields was at that time a channel of the Salt River.

The effects of early twentieth century flooding are seen in a 1934 aerial photograph (Figure 6), where a channel of the Salt River flowed south through the area of the current Karsten Golf Course and then southwest toward the intersection of Rural Road and 6th Street (currently the entrance to the ASU Athletic Fields) before turning northwest toward the gap between Tempe Butte and Papago Park. The channel scouring removed terrace deposits containing Hohokam and pre-1934 historic sites. Work at the Weatherup Center Project in 2008 demonstrated that this channel of the Salt River was subsequently used as a landfill for rock dynamited out of Tempe Butte during construction of the football stadium (Steinbach and Watkins 2008a and 2008b).

Episodes of prehistoric down cutting and aggradation are recorded in two remnants of the Lehi Terrace dating to the Hohokam era, one located near the eastern base of Tempe Butte (Figure 3) and the second occurring at the base of the Mesa Terrace, both in the vicinity of what is now Alpha Drive. The archaeological work for the 2011 Alpha Drive North project (Rice et al. 2011) recorded a cluster of prehistoric features along a southeast to northwest remnant of the Lehi Terrace sandwiched between two former channels of the Salt filled with sterile flood deposits. The features dated from the early Gila Butte phase to the Classic Period of the Hohokam sequence, and were completely isolated from the main locus of Site 165 (Rice et al. 2011) by a channel of the Salt River cut sometime between the end of the Hohokam era and the beginning of the modern

period. This channel pre-dates those seen in the 1934 aerial photograph in the location shown in Figure 6. It was subsequently filled in by overbank flooding, possibly during the early historic period.

A second remnant of the Lehi Terrace set into the base of the Mesa Terrace was identified in 2013 by excavations on the south side of Alpha Drive. There was an abrupt interface between soils containing cultural features dating from the Vahki phase of the Hohokam tradition and sterile flood deposits (Rice and Steinbach 2014). The general alignment of this transition zone also was from southeast to northwest. Clear visual evidence of a channel cut by the Salt River during the protohistoric or historic era could not be traced in this location due to the similarity of the recent flood deposits to the older Hohokam era terrace deposits.

There was also a Hohokam era episode of over-bank flooding that deposited approximately half a meter of soil on the Lehi Terrace sometime between the late Gila Butte phase and the middle Sacaton phase. Within the 2011 Alpha Drive North project area a small irrigation ditch was located 49 cm directly below an extramural

hearth (Rice et al. 2011:31). The ditch was dated to the late Gila Butte phase based on decorated red-on-buff ceramics and a radiocarbon date (1-sigma calibrated AD 770-870). The extramural hearth dated to the Classic Period (AD 1150-1450) based on an associated red ware bowl. Within the same project area three other prehistoric features were recorded dating to the early Sacaton and middle Sacaton phases, all of which originated and terminated in soils stratigraphically similar to the hearth and above the ditch. This brackets the period of terrace aggradation to after the late Gila Butte phase and prior to the middle Sacaton phase.

The Mesa Terrace

The Mesa Terrace was important to the Hohokam populations at Site 165 because it provided a broad area for irrigated fields lying beyond the destructive threat of all but the largest floods, but it paradoxically constrained the placement of the hamlet and village to a narrow linear zone along the terrace edge and base of Tempe Butte. The landform of the Mesa Terrace is associated with a much earlier course of the Salt River, and

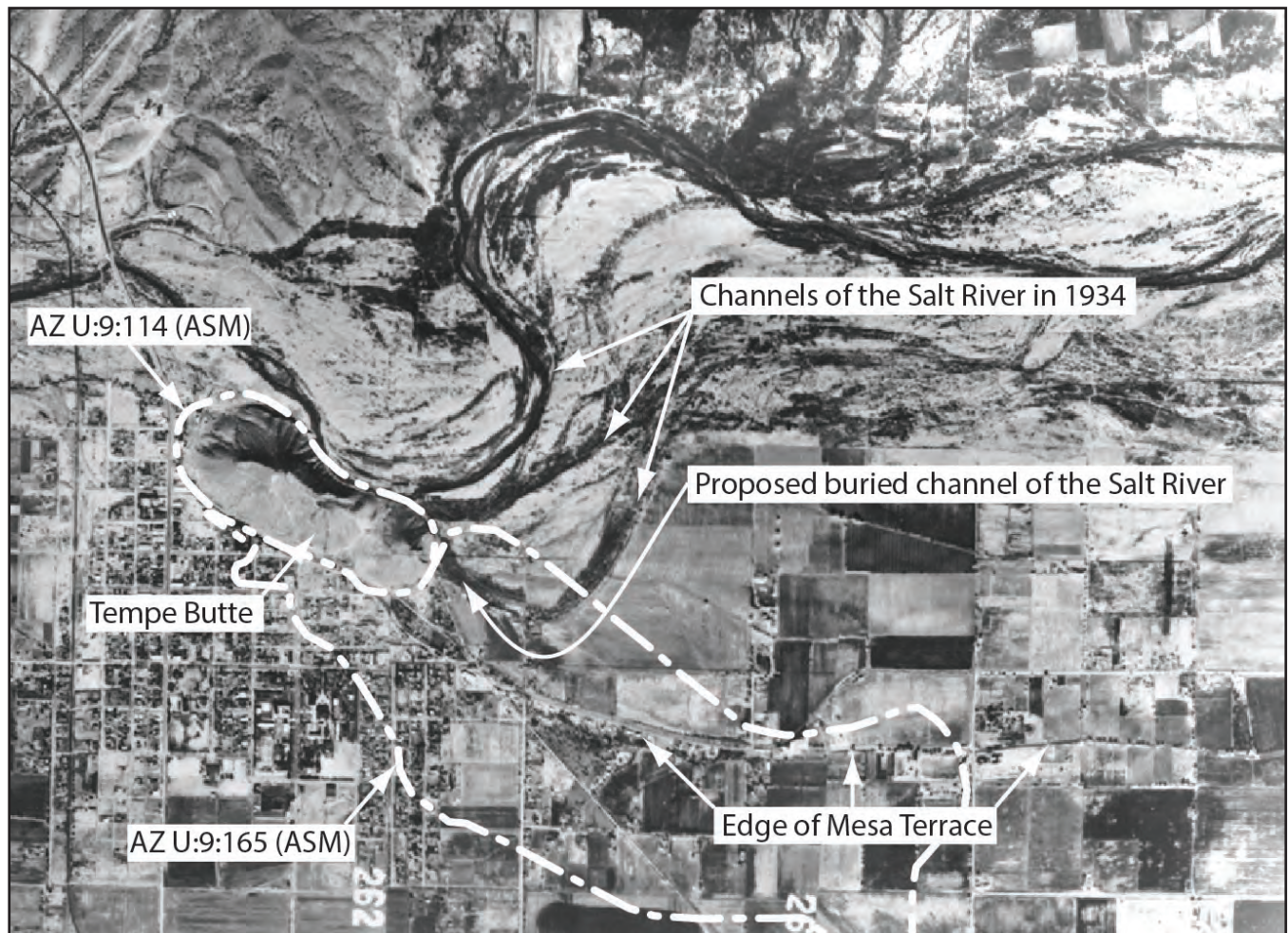


Figure 6. Location of the project area on a 1934 aerial photograph of Tempe showing the channels of the Salt River (based on Honker 2000)

as a consequence slopes away rather than towards the current channel. To make maximum use of the terrace, therefore, one irrigation canal following the northern edge of the terrace westward providing water to irrigation laterals and branch canals flowing to the south (Figures 2 through 5). To avoid occupying land that could more profitably be used for irrigated fields, the permanent residences in the hamlet and village were constructed in a narrow zone between the north bank of the canal and the edge of the Mesa Terrace or the base of Tempe Butte.

Prior to the advent of dams upstream from Tempe on the Salt and the Verde rivers and the channelization of the Salt River in the Phoenix Basin, the Salt River meandered across a fairly wide area upstream of the narrow channel between the Papago Park Pediment and Tempe Butte. Lateral erosion caused by this meandering created an extensive floodplain. In the vicinity of Tempe Butte there are two alluvial terraces that are remnants of earlier floodplains of the Salt River. As the mountains to the east slowly rose, the river cut down through the alluvium of these earlier flood plains creating the higher Mesa Terrace and the lower Lehi Terrace (Wellendorf et al. 1986). The Lehi Terrace is the youngest terrace and the current geological floodplain of the Salt River. Fossil evidence discovered within the terrace suggests it dates to the late Pleistocene (Wellendorf et al. 1986). The terrace is only 1.5 m above the river bed at the north-eastern corner of Tempe Butte. At this point, the Lehi Terrace narrows, disappearing and reappearing on the west side of Tempe Butte. Three kilometers upstream the terrace is as wide as 1,500 m providing opportunities to channel water onto the terrace for irrigation farming. As mentioned above however, the low rise of the Lehi Terrace above the Salt River leaves it prone to overbank inundation during major flood events such as those documented during historic times (Honker 2000).

The Mesa Terrace is approximately 500,000 years old (Larson et al. 2010) and is the most prominent landform to the south and east of Tempe Butte. It rises 3 to 4.5 m above the bed of the Salt River and is the terrace on which the cities of Tempe and Mesa were founded. The Mesa Terrace is a broad, gently sloping, fertile land that affords an optimal environment for irrigation farming. Based on discharge rates, Phillips (2005:238) estimated that prehistoric Canal Tempe could have provided enough water to irrigate 5,000 ha of land west of Rural Road.

From the southeastern corner of Tempe Butte, the edge of the Mesa Terrace curves southeast toward the modern intersection of Veteran's Way and University Drive and then continues east along 8th Street. Most of the archaeological finds characterized by high artifact density and features consistent with permanent settlements were recorded along the base of Tempe Butte or on the northern margin of the Mesa Terrace overlooking the lower Lehi Terrace. The terrace edge was also im-

portant during the development of the original Tempe and Mesa townsites. The Hayden Canal and the railroad that served the Hayden Flour Mill and Tempe Creamery also followed the edge of the terrace.

Tempe Butte

Tempe Butte is a prominent landmark in the Lower Salt River valley. It is a traditional cultural place for the four southern tribes and is mentioned in O'Odham song cycles and place names. The prevalence of Hohokam petroglyph panels and a few mortuary features suggest it was of ritual significance in antiquity as well. Terraces and small structures on the slopes indicate the butte also was used for farming, perhaps of agave and other plants not requiring irrigation. Thus, people may have been drawn to the base of the butte for practical as well as ideological reasons. Jacobs (ed., 2001) sees the Butte as a pilgrimage destination in Hohokam times, much as it is for O'Odham populations today. The people residing at the base of the butte may have served as caretakers of the ritual space on the butte and possibly hosted pilgrims visiting the site.

The base of Tempe Butte was not the best setting for a permanent settlement. The amount of space available for a hamlet and/or village was constrained by the economic need of placing the canal as close to the base of the Butte and the terrace edge as possible. The agricultural fields to the south of the butte could have been managed from other nearby Hohokam settlements. Nonetheless, despite the disadvantages of the location, a hamlet was established at the base of the Butte at least by the late Colonial Period and possibly earlier. By the Classic Period the settlement had developed into a village that included monumental architecture (at least one platform mound).

Tempe Butte is an outcrop of erosion-resistant andesite of volcanic origin overlying sedimentary and rhyolite deposits that were tilted upwards by block faulting during the mid-Tertiary Period (Wellendorf et al. 1986). The highest point on Tempe Butte is 426 m above sea level (asl) and the base is at approximately 350 m asl.

Tempe Butte was, and is, a culturally important area to native peoples and several archaeological site numbers have been assigned to various aspects of this landform (Kwiatkowski and Wright 2004). Petroglyphs are located on boulders, especially on the southern face of the butte (Loendorf and Loendorf 1995) indicating that it was a sacred place of cultural significance to the Hohokam (Jacobs and Rice 2001). Small habitation areas with burials have been recorded on the north and south sides of the butte, as well as the saddle between the two knolls of the butte (Wright 2005b:37-43). Terraced gardens have been reported in the saddle and on the northwestern portion of the butte (Kwiatkowski 1999).

Tempe Butte was a strategic landform for the irrigation systems in that, along with the Papago Park Pediment, its bedrock base forced waters flowing in the Salt

River channels closer to the surface, allowing head gates located just downstream to draw away irrigation water. The main head gates for Canal System 2 are located on the north side of the Salt River at the Pueblo Grande site and head gates for Canal 7 are on the south side of the Salt River just downstream from Tempe Butte.

Mountains were also important to the belief systems of native peoples and were often connected with life-giving water (Whittlesey 2007). Traditional O'odham song-poems refer to prominent mountains as points along a mythic journey to the west, and resonate with the O'odham to this day as a reminder of their traditional cultural heritage (Cox and Rogge 2012:xxxiii; Darling 2006:Figure 2; Darling and Lewis 2007). One of these, the Ant Song, refers to Tempe Butte as Dead Field Mountain (oidbad duag), a name referring to the Hohokam agricultural fields at the base of the butte (Bahr et al. 1997:82). The poem says

Wa:m 'o kaidam ñe'et cuhugam 'oidka'i, wa:m 'o kaidam ñe'et 'oidbad: duag an keek

These lines have been translated by Bahr et al. (1997:42) as:

*Manic sounding sing. Darkness following,
Manic sounding sing. Dead-field mountain there stands*

Another translation according to Wanberg (2012) could be:

*Sing this song especially throughout the night,
especially sing it loudly where dead-field mountain stands.*

Tempe Butte was listed on the National Register of Historic Places on April 8, 2011 under Criteria C and D due to its direct cultural affiliation with the Hohokam and as a traditional cultural place important to the Four Southern Tribes. Specifically, the petroglyphs on the butte are directly associated with the Colonial, Sedentary and Classic periods of Hohokam history (Tempe Butte National Register Nomination).

CONCLUSION

Site 165 (AZ U:9:165 [ASM]) as currently recorded is a composite of settlement types, including a permanently occupied hamlet that subsequently became a village, a number of seasonally occupied farmsteads and field houses, and agricultural fields with canals, thermal features, and other kinds of activity areas. In addition, Tempe Butte (AZ U:9:114 [ASM]) immediately adjacent to Site 165 has field houses, agricultural terraces for dry farming, and petroglyph panels. Based on the distribution of settlement types, Site 165 is divided into two general zones, a narrow strip on the north on which a permanent settlement was established, and a broader zone to the south used as irrigated agricultural fields. To

this can be added a third zone of Tempe Butte with dry farm agricultural terraces and ritual space.

The Hohokam occupation of Site 165 began during the Pioneer Period along the southern base of Tempe Butte, although because of the disturbance generated by later occupations it is not possible to determine if the occupation was in the form of seasonally occupied farmsteads and field houses or as a hamlet occupied year-round. By the late Colonial Period a hamlet had been established at the base of Tempe Butte, while to the south a series of farmsteads, field house sites, and agricultural features indicate that the irrigation of the Mesa Terrace was underway. Over time the hamlet at the base of the Butte expanded towards the east, following the edge of the Mesa Terrace overlooking the Salt River. In the Classic Period the hamlet had become a village with the addition of monumental architecture (at least one platform mound).

The spatial layout of Site 165 was determined by three prominent features of the landscape; the Salt River, the Mesa Terrace, and Tempe Butte. The river provided a year-round and abundant source of water, but flood events could destroy fields, canals and residential structures on the lower Lehi Terrace. By living on the upper Mesa Terrace, homes, canals, and fields were protected from all but the most extreme flood events, and a much larger area could be brought under cultivation. Fields continued to be maintained on the lower terrace as well, maximizing the agricultural use of both terraces.

But the slope of the Mesa Terrace to the south constrained where people could live. To maximize the irrigation of the Mesa Terrace, it was advantageous to run an irrigation canal along the edge of the terrace to serve fields lying to the south. To avoid the field areas, most permanent residential structures were built on the north side of the canal, where they were constrained to a narrow strip of land between the canal and either the base of the butte or the edge of the terrace.

The farmers owning the fields in the area of Site 165 could easily have lived in other nearby Hohokam villages and managed their fields using farmsteads occupied during the growing season (which some of them probably did). There was no economic necessity for establishing a community at the base of Tempe Butte, particularly because the landform and irrigation canal constrained the size of the settlement. But Tempe Butte was a landform of ritual importance both to the residents of Site 165 and to other Hohokam communities, and it provided the residents with a vantage point from which they could look south over their fields and canals.

The abundance of water in the Salt River, the large expanse of the Mesa Terrace, and the protection it provided from flood waters promoted its use for irrigated agricultural fields. But the slope of the terrace dictated the placement of a canal along its edge, limiting the area that could be used as a village to a narrow strip between the canal and the base of the butte. The ideological im-

portance of Tempe Butte, however, and its prominence as a landmark outweighed these factors, and by the latter part of the Colonial Period a Hohokam hamlet had been established at the base of the butte, growing by the Classic Period into a village with at least one platform mound.

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