An ancient Maya ritual cache at Pook's Hill, Belize

Technological and functional analyses of the obsidian blades

Stemp, W. James; Braswell, Geoffrey E.; Helmke, Christophe; Awe, Jaime J.

Published in:
Journal of Archaeological Science: Reports

Publication date:
2018

Document version
Publisher's PDF, also known as Version of record

Citation for published version (APA):
Stemp, W. J., Braswell, G. E., Helmke, C., & Awe, J. J. (2018). An ancient Maya ritual cache at Pook's Hill, Belize: Technological and functional analyses of the obsidian blades. *Journal of Archaeological Science: Reports*, *18*, 889-901.

Journal of Archaeological Science: Reports 18 (2018) 889–901

Contents lists available at ScienceDirect

Journal of Archaeological Science: Reports

journal homepage: www.elsevier.com/locate/jasrep

An ancient Maya ritual cache at Pook's Hill, Belize: Technological and functional analyses of the obsidian blades

W. James Stemp[a,*], Geoffrey E. Braswell[b], Christophe G.B. Helmke[c], Jaime J. Awe[d]

[a] Department of Sociology, Anthropology and Criminology, Keene State College, Keene, NH 03435-3400, USA
[b] Department of Anthropology, University of California-San Diego, La Jolla, CA 92093-0532, USA
[c] Institute of Cross-cultural and Regional Studies, University of Copenhagen, Karen Blixens Plads 8, DK-2300 Copenhagen S, Denmark
[d] Department of Anthropology, Northern Arizona University, Flagstaff, AZ 86011-5200, USA

ARTICLE INFO

Keywords:
Obsidian
Blood-letting
Caches
Maya
Pook's Hill
Use-wear analysis

ABSTRACT

When recovered from ritual contexts at ancient Maya sites, obsidian blades are frequently viewed as blood-letters used for auto-sacrifice. Most evidence supporting this interpretation is circumstantial and derives from iconographic and ethnohistoric sources. Such a deductive approach does not provide a means to determine whether individual blades were used to let blood. In contrast, microscopic use-wear analysis of lithic artifacts can be used to examine blades for evidence of their use, and—provided comparative experimental data are available—to determine if they were blood-letters. The technological and use-wear analyses of 48 obsidian blades recovered from a Late Classic (c. 550–650 CE) dedicatory cache at the site of Pook's Hill, Belize, serve as a test case to explore the relationship between obsidian blades and ancient Maya auto-sacrificial blood-letting. The results of the analyses indicate that some blades from the cache may have been used to let blood; however, not all obsidian blades appear to have been used in the same way. The obsidian blood-letters recovered from the cache were used in cutting, piercing, and piercing-twisting motions. Although some blades were used to let blood, the edge and surface wear on most of the used obsidian blades are consistent with other functions, including cutting meat/skin/fresh hide, cutting or sawing wood and dry hide, cutting or sawing other soft and hard materials, and scraping hard materials. Clearly, not all blades from this ritual deposit were blood-letters, which raises questions about the manner in which such a ritual deposit was formed and the nature of ritual activity associated with caching behavior at Classic period Maya sites.

1. Introduction

Obsidian was an important resource for the ancient Maya in many socio-economic, political, and ideological respects. This naturally occurring volcanic glass was mined from the highlands of Guatemala and Central Mexico and transported over hundreds of kilometers by land and sea to its final destinations. Sourcing data indicate that the obsidian sources primarily exploited by the Maya varied in different regions and over time (e.g., Braswell, 2003; Golitko et al., 2012; Nelson, 1985; Rice, 1984). Once acquired, obsidian was chipped or ground into a variety of tools, decorative objects, and ceremonial items. In particular, prismatic blades were forced from polyhedral cores through indirect percussion or pressure (Clark, 1988) to produce very sharp implements, well suited for piercing and cutting. Obsidian blades and blade fragments have been recovered by the thousands from domestic, non-domestic, and ceremonial contexts at ancient Maya sites and were used by commoners and elites alike for subsistence, crafting, warfare, and ritual activities of many types (e.g., Aoyama, 1999, 2009, 2014; Lewenstein, 1987; Stemp, 2016a; Stemp and Awe, 2014; Stemp et al., 2013). In this paper, we focus on the procurement and ritual use of obsidian blades. Our sample of 46 blade fragments and two complete blades comes from Cache 4A-2 at Pook's Hill, Belize (Fig. 1). Results of microscopic use-wear analysis indicate that *some* of the blades from this cache possess use-wear traces consistent with blood-letting based on comparisons with experimental tools. Nonetheless, the majority of blades possess use-wear consistent with other domestic activities. This suggests a number of possibilities for the procurement of the blades, the activities undertaken with them, and the formation of the cache. Our results underscore that not all blades recovered from caches were necessarily used directly in ritual actions involving the formation of these types of deposits. Some blade segments may have been brought to the cache for inclusion as ritual objects from other locations where they were initially used.

* Corresponding author.
E-mail addresses: jstemp@keene.edu (W.J. Stemp), gbraswel@ucsd.edu (G.E. Braswell), cgbh@hum.ku.dk (C.G.B. Helmke), Jaime.awe@nau.edu (J.J. Awe).

http://dx.doi.org/10.1016/j.jasrep.2017.07.011
Received 30 January 2017; Received in revised form 31 March 2017; Accepted 12 July 2017
Available online 21 July 2017
2352-409X/

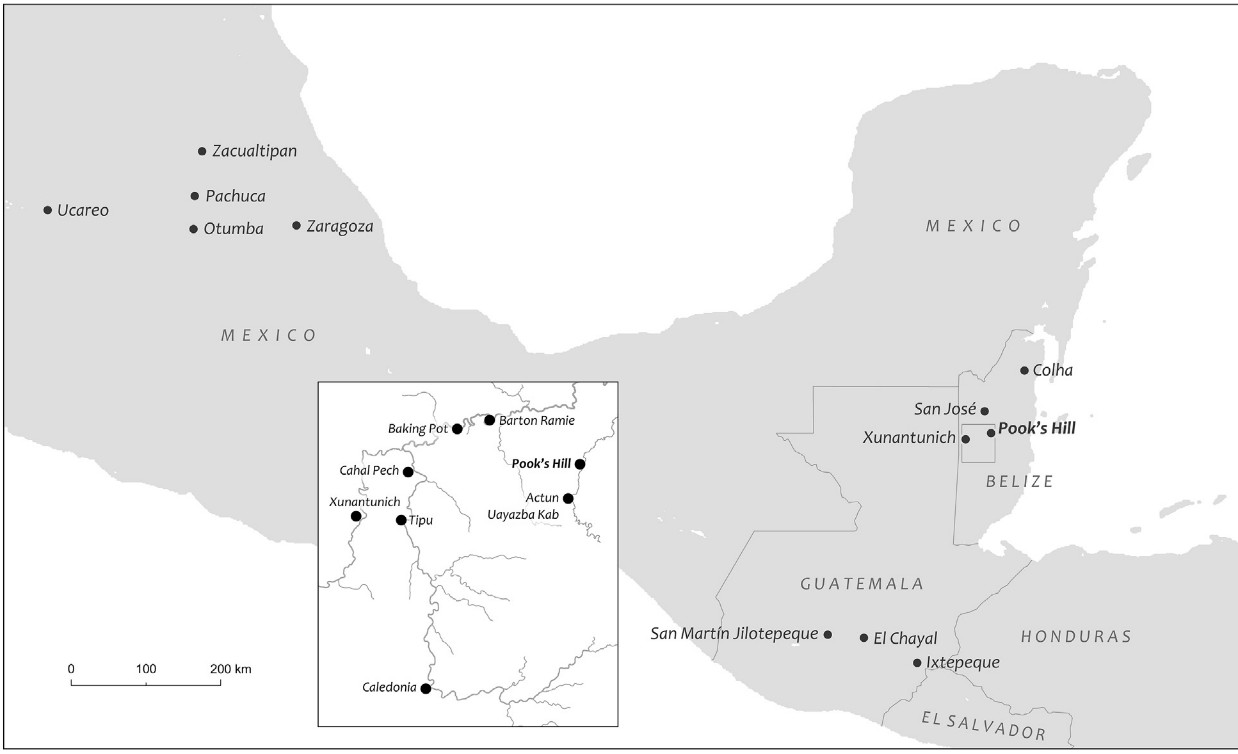

Fig. 1. Map of Mesoamerica showing the location of Pook's Hill and other localities mentioned in the text. The inset map shows the location of sites in western Belize (map by Christophe Helmke).

2. Blood sacrifice among the ancient Maya

Decades of research on iconography and epigraphy have helped to refine our understanding of the intangible world of the Classic Maya, their beliefs and world-view (Helmke, 2012; Houston and Taube, 2000; Houston et al., 2006; Stone and Zender, 2011; Schele and Miller, 1986). We now know that for the ancient Maya blood was the substance that contained 'godliness', the life-force that could be offered to the gods as sustenance (Houston and Stuart, 1996:292; Helmke, 2012:63–67). As a means of ingratiation and placating the divine, as well as marking important ritual events, the Maya offered blood by various means of sacrifice (Stone and Zender, 2011:75). The practice was even thought to have divine precedent; deities were believed to have offered blood in the distant mythic past (see Thompson, 1961) (Fig. 2a). Blood-soaked paper strips were placed in offering bowls and set alight. Within the smoke, Vision Serpents appeared. From the maws of these serpentine entities, divinities and deified ancestors emerged with whom the officiant would commune (Schele and Miller, 1986:177–179; Stuart, 1988) (Fig. 2b). Detailed depictions of these rituals clearly show that the Maya employed a variety of implements in blood-letting rituals, including obsidian blades (Fig. 2c), sharpened bone awls or needles, stingray spines, shark teeth, and agave thorns embedded in ropes. These were used to cut or pierce the ears, lips, nostrils, tongue, arms, legs, or the penis (Joralemon, 1974; see Tozzer, 1941 for Spanish Colonial accounts). Both males and females were participants in blood-letting rituals (Schele and Miller, 1986:175–207), but males are most frequently depicted in artwork. Men drawing blood from their penises are depicted in several media, including modeled ceramic figurines, painted murals and cylindrical vases, and carved lintels (e.g., Chase, 1991; Gann, 1918; Joralemon, 1974; Schele and Miller, 1986; Stone, 1995; Stuart, 1984, 1988, 1996). Although it is clear that blood-letting was an integral part of ancient Maya ritual practice, this aspect of Maya culture garnered great attention in the 1970s and especially the 1980s. At that time, scholars looked for hieroglyphic expressions associated with depictions of blood-letting scenes (Joralemon, 1974; Stuart, 1984; Schele and Miller, 1986). Such interpretations are now generally discounted and there is no substantive epigraphic evidence for ancient Maya blood-letting. Although this aspect of ritual practice now figures much less prominently in academic literature, many researchers still assume that obsidian blades found in ritual contexts were used to let blood (Stone and Zender, 2011:73, Fig. 1).

3. Obsidian blades as blood-letters

The assumption that obsidian blades were used as blood-letters is derived from iconographic, ethnohistoric, and contextual information—including the placement of blood-letters in the pelvic areas of skeletal remains found within tombs. Nonetheless, the Maya used blades for many purposes, and it is not easy to identify a particular obsidian blade as a blood-letting implement. Results of previous use-wear analyses demonstrate that obsidian blades were used by the ancient Maya for a wide variety of functions including food processing, other domestic activities, craft-production, warfare, and, at times, ritual practices (e.g., Aoyama, 1999, 2001, 2007, 2009; Lewenstein, 1987; Peterson, 2006; Stemp, 2016a; Stemp and Awe, 2014; Stemp et al., 2013). Both use-wear studies (Reents-Budet and MacLeod, 1997; Aoyama, 1999, 2001, 2009, 2014; Stemp, 2016b, 2016c; Stemp and Awe, 2014) and residue analysis have contributed to the study of ancient Maya blood-letting (Meissner and Rice 2015; Newman, 1993; Potter, 1994; Sievert, 1992; see Stemp, 2016c).

3.1. Microscopic use-wear analysis and obsidian blades

In the past, archaeologists relied on contextual and form-function interpretations to identify obsidian blades as blood-letters (e.g., Brady, 1989:324; MacLeod and Puleston, 1978:7; see Brady and Peterson, 2008:81; Sievert, 1992:34). Often the lack of edge damage on obsidian blades, their general form, and their recovery from what are deemed to be ritual contexts were used as the criteria for classification as a blood-letter or perforator (Coe, 1959:30; Kidder, 1947:15; Willey et al.,

Fig. 2. Ancient Maya depictions of blood-letting and blood-letters: a) A mythic scene involving a trio of deities, squatting over offering bowls, about to impale their male members to let blood (photograph by Justin Kerr). b) Detail of a blood-letting scene wherein a female officiant conjures a Vision Serpent that belches forth an ancestral figure. Note the bowl braced by the officiant containing blood-spattered paper, a stingray spine and a curved obsidian blade (photograph by Christophe Helmke). c) A Classic Maya obsidian blood-letter projecting from a personified haft, made of perishable material, bound in cloth and topped by a spray of feathers (drawing by Linda Schele).

1965:444–445). Some archaeologists have undertaken experiments to replicate blood-letting by using animal tissue as a proxy medium for cutting, piercing, and drilling human tissue with variable results (Online Supplement 1). For example, Clark (1988:245) reports that: "Almost no damage was noted on the blades used to pierce, cut, or drill meat […] I had anticipated that a drilling motion would cause microflakes to spall off the fine feather edges of the blades, but none did." Sievert (1992:71), on the other hand, describes such use-wear as "slight rounding and fine edge damage along the entire edge with blunting along projecting edge portions. Polish developed along the proximal portion of the cutting edge […] it incurred rather subtle changes to the edge, including brightening, a bit more topographical coalescence, and edge damage." She also states that "bloodletting will show no contact with bone" based on her experiments using chert tools (Sievert, 1992:76, Table 8.7). The level of magnification (10 ×) employed by Clark was insufficient to detect very small-scale surface modification and edge damage. The results reported by Sievert are due to the duration of the experiment, which essentially demonstrated the use-wear expected from cutting meat, skin, or fresh hide during an activity more closely related to butchery than blood-letting (see Aoyama, 1999, 2009; Lewenstein, 1987; Stemp, 2001; Hurcombe, 1992). The combined results of Stemp's (Stemp, 2016b, 2016c; Stemp and Awe, 2014; Stemp et al., 2015) blood-letting experiments on chicken, cow, and pig tissue produced use-wear of different types based on varying tool motions (cutting, piercing, and piercing with rotation) that can be detected at different levels of magnification. These data are summarized in Online Supplement 2. The determination of other tool functions discussed here are based on Stemp's (2016a: Online Supplement 1) experimental data derived from flakes and blades used for various subsistence and crafting activities.

4. Maya caching practices

In the Maya lowlands, caches are generally defined as one or more objects that are found apart from burials and whose contexts suggest that they were purposely deposited as an offering (see also Coe, 1959:77). In contrast, deposits resembling caches that contain refuse or human remains are designated as "problematic deposits" since they straddle the otherwise neat division between caches and burials (see Becker, 1993). Based on their context, caches are also described as "being associated with dedicatory or termination rituals" (Awe, 1992:369). Dedicatory caches were intentionally deposited during the erection of monuments (i.e., stelae or altars), or placed in the construction core of a particular architectural feature or structure. Termination caches are offerings that were intentionally deposited to mark the cessation of use of an architectural feature, construction phase, or building. They are often discovered on floors or are intrusive into architecture. Artifacts in termination caches are generally discovered in a fragmented condition or perforated with "kill holes", while most found in dedicatory caches are complete, although ritually "killed" objects are found in both types of caches. The Maya "killed" objects in order to release the life-force contained within them, allowing these lifeless objects to be deposited in a ritually significant context. The breaking of artifacts prior to their deposition in ritual contexts such as burials, caches, and caves is now a well-known practice and appears to have been a pan-Mesoamerican feature of religious practice (e.g. Thompson, 1959:125; Garber, 1986; Reents-Budet, 1994:198; Helmke, 2012:67).

4.1. Caching practices in the Belize River Valley

Archaeological investigations in the Belize River Valley indicate that both dedicatory and termination caching occurred from the end of the Early Preclassic (e.g. at Cahal Pech [Awe, 1992] and Blackman Eddy [Brown, 2003]) to the Late Postclassic and early Historic periods (e.g. at Tipu [Graham, 2011:242–243]). Dedicatory and termination caches can contain one or more objects. At Cahal Pech, for example, the earliest Cunil Phase cache (ca. 1200–900 BCE) contained 27 obsidian flakes, 77 chert flakes, a fragmented ceramic vessel, three pieces of jadeite, and objects made from marine, freshwater and terrestrial animal remains (Awe, 1992:339). In contrast, an early Historic period cache in a cave along the Roaring Creek Valley contained a single European sword (Awe and Helmke, 2015). The most common Middle to Late Preclassic caches, however, contain perforated marine shell discs and hand-modeled figurine fragments. Beginning in the Late Preclassic and continuing into the early facet of the Late Classic period, ceramic vessels were the predominant cache object in the Belize Valley (for Barton Ramie see [Willey et al., 1965:89–90, 125]; for Caledonia [Awe, 1985]; and for Cahal Pech [Awe, 1992]). By the start of the Late Classic period, chert and obsidian eccentrics replaced ceramics as the predominant cache objects, particularly in dedicatory offerings. This is true at Barton Ramie, San José, Xunantunich, Cahal Pech, and Baking Pot (Awe, 1992; Conlon, 1995:38; Iannone and Conlon, 1993; Willey et al., 1965:445–452; Sullivan, 2017; Thompson, 1939, 1940). For instance, as part of recent excavations at Xunantunich, a dedicatory cache containing nine obsidian eccentrics and marine shells (both *bivalvia* and *gastropoda*) was discovered in proximity to the stela erected at the foot of Str. A9 (Helmke and Awe, 2016:4) (Fig. 3). This pairing of objects of obsidian with marine shell is of note because it duplicates characteristics of Cache 4A-2 at Pook's Hill, which we examine here, as an offering that conforms to the Late Classic ritual practices of the Belize Valley caching tradition.

Fig. 3. A cache of obsidian eccentrics and seashells discovered at the base of Structure A9 at Xunantunich, Belize (photograph by Kelsey Sullivan).

A unique obsidian eccentric from a ritual context was recovered from the cave site of Actun Uayazba Kab, located 4.9 km south of Pook's Hill in the Upper Roaring Creek Valley. This small eccentric is chipped from a blade segment made of green Pachuca obsidian from Central Mexico. This artifact possibly represents the glyph for ***k'ik'***, 'blood', which may symbolically link it to blood-sacrifice in a subterranean space (Stemp et al., 2012:118).

Prior to our analysis, at least one known cache with direct evidence for blood-letting has been identified. Potter (1994) reports human blood residue on a chert blade found in a Late Preclassic cache at Colha, Belize. The cache also included four shell ornaments, two shell beads, ten shark teeth, twelve jadeite beads, and some decayed organic material. Beneath a ceramic vessel in the cache, a chert macrocore and a rejected chert blade were found. The artifacts placed in the cache are believed to reflect auto-sacrifice.

5. Pook's Hill, Belize

The archaeological site of Pook's Hill is located in rolling karstic hills overlooking the fertile Roaring Creek Valley of west-central Belize. The many house mounds documented in the area attest that the valley was densely populated in the Classic period (Helmke et al., 2004). Pook's Hill is an average-sized household group, known as a *plazuela* ('little plaza' in Spanish), consisting of nine masonry platforms that were topped in antiquity by perishable superstructures of wattle, daub and palm thatch (Fig. 4). In all, the group occupies a surface area of 1106 m^2, of which about a third is the plaza. The platforms range in height from 0.8 to 2.9 m above the plaza. The principal structures, to the north, west and south of the *plazuela* (i.e., Strs. 1A, 2A and 3A) all appear to have served primarily domestic and residential functions. We interpret Str. 1A as the residence of the head of the lineage or extended family that resided at the site (Helmke, 2006a:69–81, 2006c:80–82). Structure 1B served as a sweatbath (Helmke, 2006a:53–68, 2006c:78–80; Helmke and Awe, 2010) and Str. 1C was a residential platform where minor craft activities were conducted. This interpretation is based on lithic evidence and the presence of fragmentary slate mirror backings, hematite/pyrite *tesseræ*, and bark beaters (Helmke, 2006a:51–53; Stemp et al., 2010:222, 224, 230). To the east, the larger Str. 4A is distinct for its architecture, resembling a diminutive temple or shrine. The pattern of eastern shrines is typical of the area and is commonly found throughout the eastern central lowlands (e.g., Chase and Chase, 1994; Becker, 1999; Awe et al., in press). Whereas inhumations are found at key locations throughout the *plazuela*, these shrines were preferred loci for the interment of exalted members of the lineage. The ritual function of such structures is corroborated by the high number of burials and caches. We concentrate on Cache 4A-2 from this structure.

Pook's Hill has been intensively investigated by archaeological excavations between 1999 and 2002 and again in 2005, with intervening lab seasons. A total of 46 work weeks of survey and excavations have been conducted at the site, exposing the terminal phase architecture, trenching its most prominent structures and the plaza platform, and consolidating the architecture for tourism (Fig. 5).

5.1. Cache 4A-2

Excavations of Str. 4A were conducted over several seasons. In 1999, our efforts focused on conducting salvage excavations of Str. 4A, which was bisected by a looters' trench. The looters exposed a crypt built with capstones and masonry walls. The ceramic sherds and human remains stacked at the mouth of the trench imply that it contained multiple individuals and dates to the initial century of the Late Classic period (the pottery was predominantly of the Tiger Run ceramic complex; see Gifford, 1976:191–225) (Bassendale, 2000:Fig. 3; Helmke, 2000:309–310). Having cleared out the trench and documented the

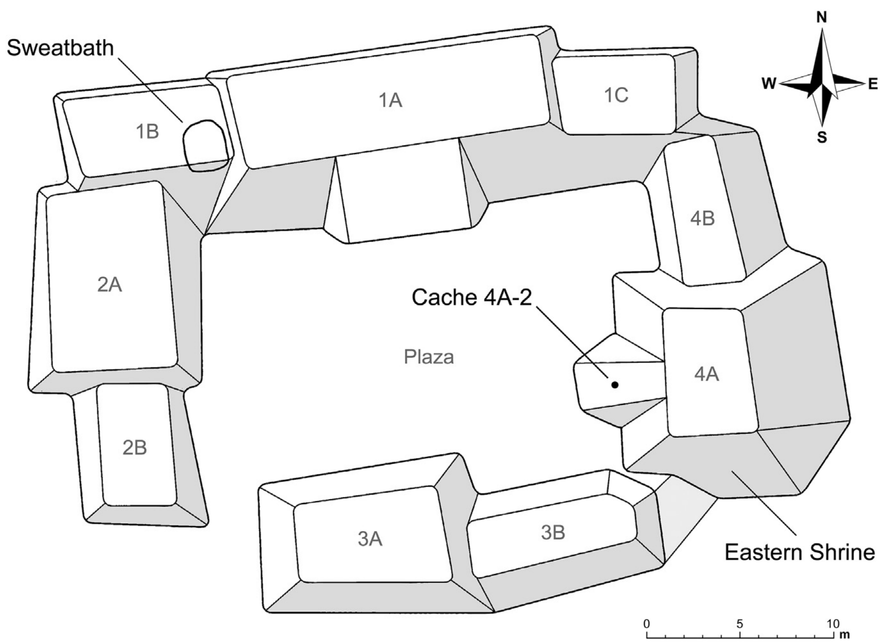

Fig. 4. Plan of the archaeological site of Pook's Hill, showing the structures mentioned in the text as well as the location of Cache 4A-2 (plan by Christophe Helmke).

exposed architecture in section drawings, we backfilled the structure. Between 2000 and 2002, we cleared, documented and consolidated the penultimate and terminal phases of architecture. We also recorded and recovered peri-abandonment artefactual deposits along the base of Str. 4A (Helmke, 2003, 2006b). To document the architectural stratigraphy of this building, we conducted excavations along its primary axis and exposed the terminal stair, excavating it in its entirety and penetrating through a sequence of three superimposed plaza floors until we reached bedrock (on average 0.49 m below the last floor). In so doing, we encountered eight burials and two caches. Most burials contained few funerary items and were primary interments of single individuals, all in extended position and oriented with the head to the south, as is typical of the area (e.g., Welsh, 1988). The one exception is Burial 4A-3, found within the outset stair of the final construction phase. It contained the remains of at least seven individuals (designated Indv. A–G) interred with a series of objects including several Terminal Classic ceramic vessels, such as a pyriform vase, a tripod vase, a fragmentary censer, a molded-carved vase, two exhausted obsidian cores, fragmentary obsidian prismatic blades, a granite sphere, an *olivella* shell pendant, a square jadeite inlay and a pyrite *tessera* (see Helmke, 2003:122, 2006b:179–180).

In addition to burials, there were two caches. Both can be described as dedicatory in that they served to ritually initiate a construction phase being inclusive into the architectural core of plaza floors at the foot of the eastern shrine. The earlier of the two is Cache 4A-1 (Stratigraphic Unit 49), which consisted of three red and orange ware dishes with medial ridges, a modal trait dating to the initial facet of the Late Classic (c. 550–650 CE) (see Gifford, 1976:193–195, 182; Helmke et al., 2001: Fig. 17, 368–371; Helmke, 2006b:180). Based on orientation and context these appear to have been placed lip-to-lip as is typical for such votive offerings.

The second cache, designated Cache 4A-2 (SU 244), was found inclusively in the core of Floor 3, in perfect alignment with the primary axis of the eastern shrine. It consists largely of an accumulation of charcoal and carbonized organic residue, measuring 26.5 cm E–W by 25.2 cm N–S, and is as much as 3 cm thick (Helmke, 2006b:180–181) (Fig. 6). The carbonized residue is probably from pine or incense such as *copal* (made from the resin of *Protium copal*), whereas the charcoal is entirely of pine wood (*Pinus* sp.) (Morehart, 2007: Table 1; see Morehart, 2001). Although the particular species has not been identified it is possible that the wood was Caribbean Pine (*Pinus caribaea*) or another endemic species. Mixed in among the carbon were three ceramic sherds showing signs of exposure to fire (Fig. 7). One, a rim sherd, is identified as Garbutt Creek Red (Gifford, 1976:230–233) and, although typically identified as a Late Classic type, based on the angle of the rim it dates to the early facet of the Late Classic period (i.e., 550–650) (see LeCount, 1996:146–150). As such, the diagnostic sherd may help to date the deposit, assuming that it was a deliberate inclusion, or alternatively serves as a *post quem* date if the inclusion is incidental. Forty-eight obsidian prismatic blades and blade fragments were deposited across the surface of the heap of charcoal and burned residue. Based on their placement, the blades were added as one of the final ritual acts that formed the deposit. Since none have been affected by heat (see Nakazawa, 2002), as might have been the case if deposited directly atop burning embers (see Chase and Chase, 2011:10–11, Fig. 5), we surmise that the cinders cooled prior to the deposition of the

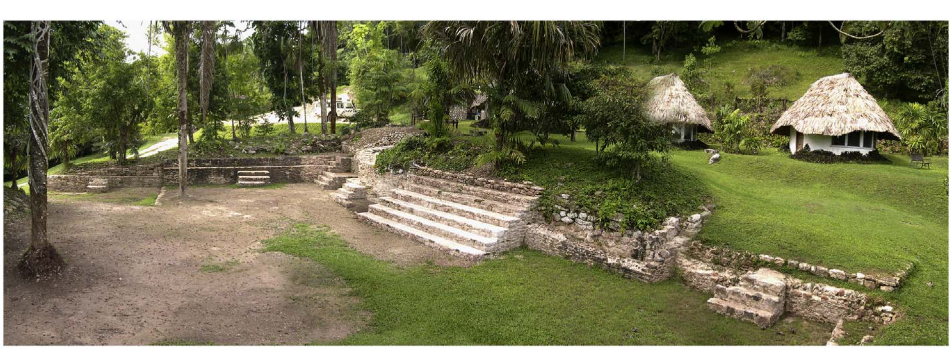

Fig. 5. A panoramic view of the Pook's Hill *plazuela* as consolidated at the end of the 2005 season, as seen from the summit of Str. 4A. The structures to the left are those defining the western end of the *plazuela*, and those to the right, the northern side (composite photograph by Christophe Helmke).

Fig. 6. Cache 4A-2 as exposed under raking light (photograph by Christophe Helmke).

obsidian blades. Another item included in the cache is a shell ornament in the form of a star with six pointed rays. Two of the rays were broken off prior to deposition (and these were not recovered from the cache matrix) suggesting that this object was ritually "killed" prior to deposition. Similarly, all but two of the blades were snapped into at least three segments or more and many are missing their proximal or distal ends (Fig. 8).

6. Typological, attribute, metric, and source analyses of Cache 4A-2 obsidian

In 2005, we analyzed a total of 496 obsidian artifacts from Pook's Hill, recovered from all contexts throughout the site. Our studies included typological, attribute, and visual sourcing analyses. The latter was conducted because, at the time, portable XRF was uncommon. In addition, we recorded basic metric attributes for each piece. The 48 obsidian artifacts from Cache 4A-2, therefore, can be compared to the Pook's Hill collection as a whole. Online Supplement 3 provides the data for the artifacts in the cache.

6.1. Typological and non-metric attribute analyses

6.1.1. The Pook's Hill collection (N = 496)

All obsidian artifacts were given provisional source assignments based on visual characteristics. Visual sourcing is—and should be—a controversial technique, but when conducted by trained analysts using a good reference collection, and in partnership with an informed sampling strategy for chemical assay, it can be quite accurate (e.g., Braswell and Glascock, 2011:121–123; Braswell et al., 2000).

The goal of the initial analysis (Braswell, 2007) was to source as accurately as possible the entire Pook's Hill collection, as well as to identify visual outliers suitable for neutron activation analysis. Fully 469 (95%) of the obsidian artifacts were tentatively assigned to the El Chayal source, 17 (3%) to Ixtepeque, five (1%) to the "Mexican black" sources (Ucareo, Zaragoza, or possibly Otumba and Zacualtipan), two to Pachuca, two to San Martin Jilotepeque, and one was labeled as "Unknown." The presence of Pachuca and Mexican black obsidian with pecked-and-ground platforms demonstrates occupation well into the Terminal Classic, but the collection is dominated by obsidian from the El Chayal source. This, and the large number of whole prismatic blades and fragments (N = 374), as well as exhausted polyhedral cores and core fragments, strongly imply that the collection mostly dates to the Late Preclassic through Late Classic periods. Every obsidian artifact from Cache 4A-2 was assigned to the El Chayal source based on visual criteria, consistent with the Late Classic date proposed for the context.

No obsidian artifact in the entire collection from Pook's Hill shows

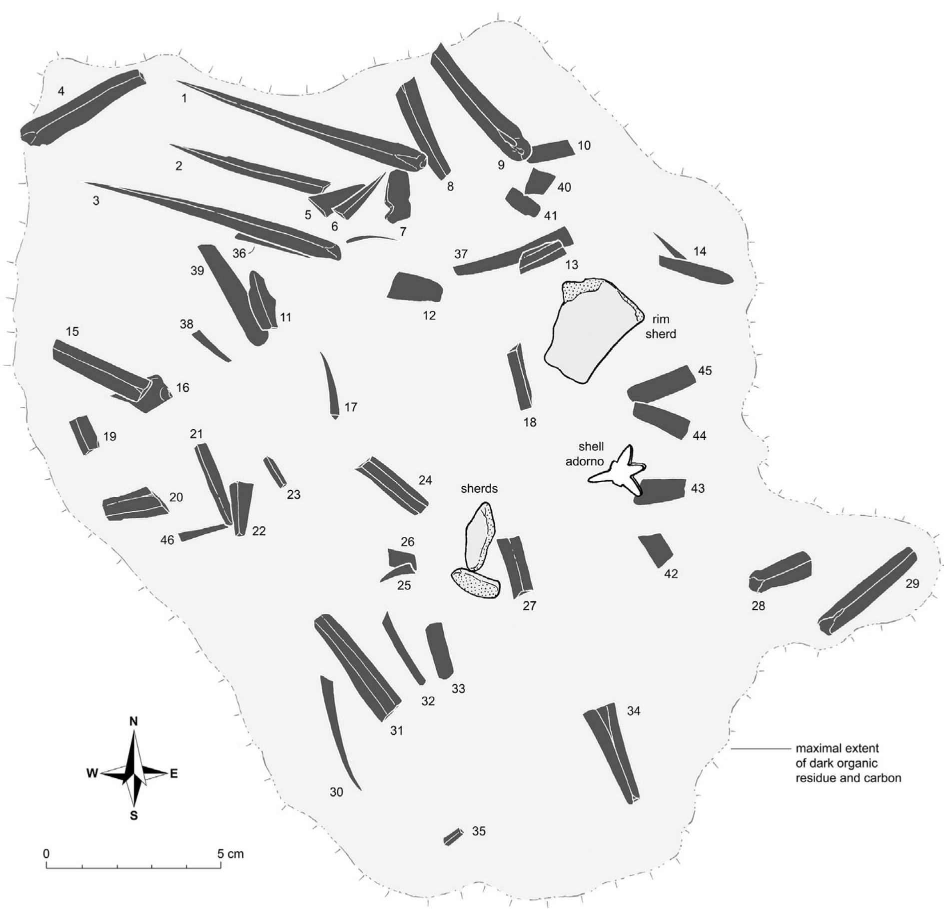

Fig. 7. Plan of Cache 4A-2, with obsidian blades numbered. Note the shell *adorno* and the ceramic inclusions (plan by Christophe Helmke).

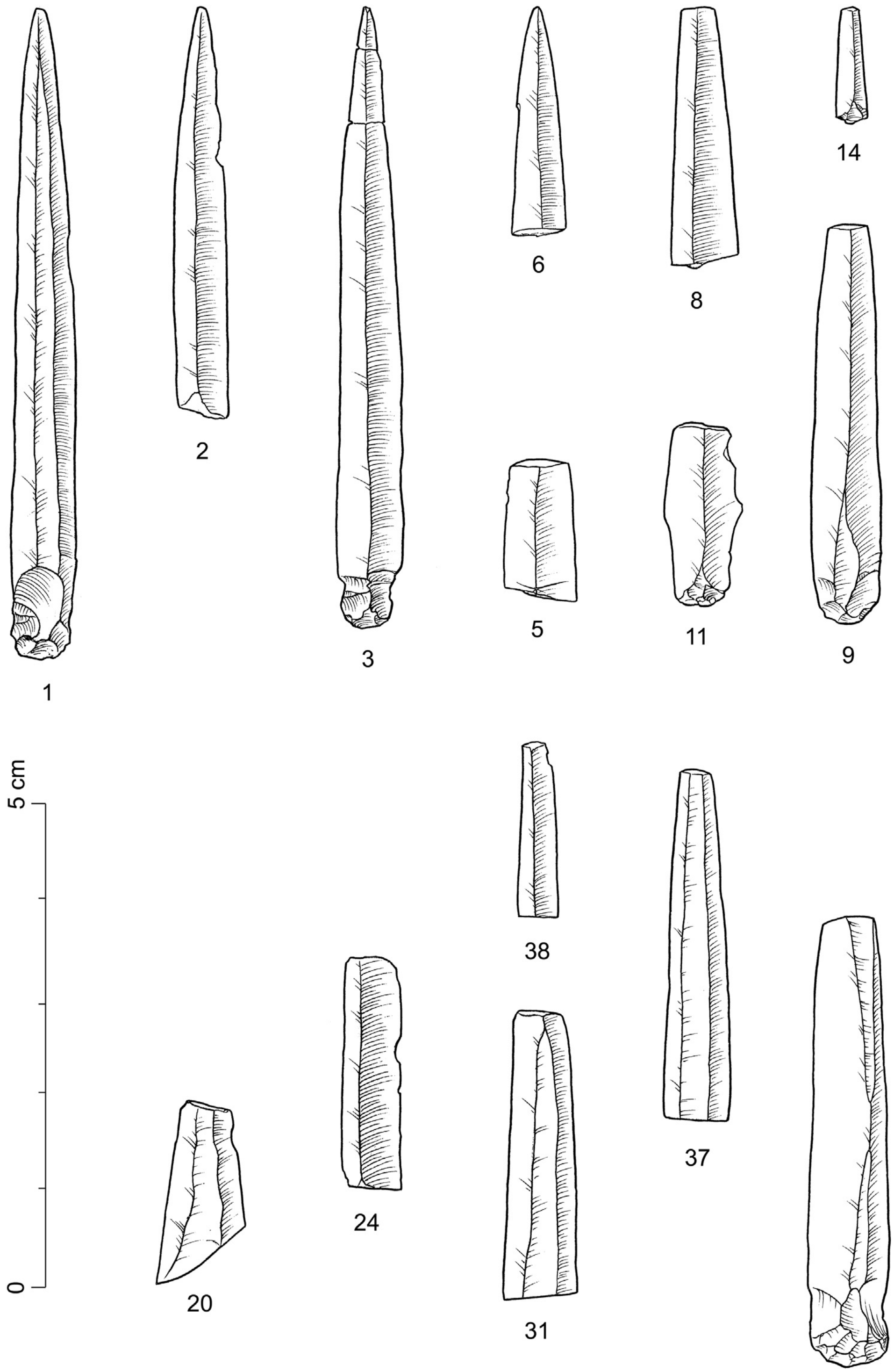

Fig. 8. Drawing of a selection of obsidian blades and blade fragments from Cache 4A-2. Numerical designations correspond to those attributed to them in the plan (Fig. 7) (drawings by Christophe Helmke).

evidence of retouch. Moreover, no thinning flakes (a debitage class) are found in the collection. We therefore have no indication of the production or consumption of obsidian unifaces, bifaces, or other retouched artifacts at Pook's Hill. Flakes and chunks are relatively common, but these were produced by free-hand or bipolar percussion, mostly as a way to recycle exhausted polyhedral cores.

All of the blades and fragments in the collection are classified as final series blades. That is, they are not from the first or second ring of pressure blades removed from a large polyhedral core. Consistent with this, not one of the prismatic blades and fragments recovered from the site has any cortex on its dorsal surface. Only seven artifacts (1.4%) of the entire collection have any trace of cortex. Six of these are flakes and one artifact is a chunk; three of these come from the distal extremes of polyhedral cores, the very last part of a core to retain some cortex. All these data suggest that polyhedral cores reached Pook's Hill in an already reduced state.

6.1.2. *Obsidian from Cache 4A-2 (N = 48)*

All the obsidian artifacts in the cache are prismatic blades (Fig. 8). Two of these are complete. Seventeen are proximal, 20 are medial, and

9 are distal fragments. Assuming that the fragments are representative of whole blades that have been snapped, a typical blade was broken into just three and sometimes into four segments. Nonetheless, neither Braswell nor Stemp have identified any refits. We therefore conclude that the blades were snapped before the cache was created.

There are more proximal than distal fragments in the cache. This is typical for most contexts that reflect consumption rather than production. Distal sections often feather to a point and are easily broken. Moreover, because of the bullet shape of most cores, they are often curved. For these reasons, the distal extremes of prismatic blades were not favored for use in composite tools, and most often were broken off and discarded. An important exception is the obsidian perforator used for blood-letting. These have feathered terminations that end in a point, ideally without much curvature. Nonetheless, not all blades with this characteristic were blood-letters. Form limits, but does not determine, function.

6.1.2.1. Complete blades. It is uncommon to encounter many whole blades for the same reasons that most distal fragments were discarded. Whole blades could be perforators, or were deliberately made to correct an error on the surface of the core, or were made in error. In the case of the two examples from Cache 4A-2, their slender points suggest they could be perforators. Moreover, they are the second and third longest whole blades (out of nine total) in the entire collection from Pook's Hill; most of the other six complete examples are half the length of the blades from the cache. Nonetheless, these two complete prismatic blades lack retouched notches just beneath the bulb of percussion. Such notches were commonly used to haft perforators at many Maya sites. For this reason, use-wear analysis may clarify an ambiguous functional classification made based on morphology.

6.1.2.2. Proximal fragments. During the Late Preclassic, Early Classic, and Late Classic periods, core platforms were either left unmodified or, more frequently in the Maya region, scratched. Complete cores often have a scratched ring around the outer edge of the platform. Scratching was achieved either with a sharp graver or by abrading the edge of the core on a rough surface. The latter also served to remove platform overhang. Another common platform modification technique is pecking and grinding. Unlike scratching and abrasion, which were performed throughout the production process, pecking and grinding took place all at once before reducing the core or as a step in core rejuvenation. Light platform abrasion can be confused with pecking and grinding, but the latter is much heavier and produces a white, rough surface. Pecking and grinding began as a technique in Central Mexico during the Epiclassic period, spread to the Maya area in the Terminal Classic, and became dominant during the Postclassic period (Braswell and Glascock, 2011:126, Fig. 10.7). Fourteen of the 19 platforms (74%) on the whole and proximal fragments show signs of light scratching. Two more are plain platforms; finally, three have platforms that are too small to evaluate. Overall, the technology is consistent with production before the Terminal Classic period.

6.1.2.3. Medial and distal fragments. Segments from the middle of prismatic blades are the most common obsidian artifact found at all Classic Maya sites. Because of their regular shape and thickness, they were prized for composite and simple tools. Because they lack platforms, bulbs of percussion, and (distal) terminations, they are not particularly useful to the analyst.

Eight of the nine distal fragments end in tapered, sharp points. These are consistent with a tentative functional identification as perforators. Like the whole blades, they lack the notches that are often found on hafted perforators.

6.2. Metric analysis

The length (from proximal-most point to distal-most, following curves of force), width (maximum distance perpendicular to length and parallel to the ventral surface), thickness (maximum distance perpendicular to the ventral surface), total cutting edge, and mass of each artifact were measured. The cutting edge to mass ratio was calculated from these data for all blades. Online Supplement 3 presents these data for the 46 fragments and two complete blades in Cache 4A-2.

6.2.1. Comparing blades from Cache 4A-2 to others from Pook's Hill

The sample size (N = 2) of whole blades from the cache is woefully small, and that for the rest of the collection (N = 7) is not much better. Nonetheless, it is noteworthy that two of the three longest blades in the entire collection come from Cache 4A-2. The chances of this happening as a random occurrence are just 1 in 12, or about 8%. It is also possible to compare the interrelationship of four independent variables: length, width, thickness, and mass (cutting edge is not considered as an independent variable because it is closely related to length). This comparison reveals at a greater than 99% confidence level that the two samples are not drawn from the same distribution. Overall, the complete blades from the cache are much longer (mean = 77.1 mm versus 46.8 mm) yet have about the same mass (mean = 1.0 g versus 1.4 g). This is because the whole blades from the cache are somewhat less wide (mean = 8.1 mm versus 11.7 mm) and thinner (mean = 2.3 mm versus 3.0 mm). In sum, the two complete blades from the cache (as well as a single outlier from the rest of the collection) appear to be thin, long, and delicate, while six of the remaining complete blades are comparatively stubby, wide, and thick. This difference in form suggests a different reason for their production. Perhaps the long, thin blades were intended either to be perforators or to be snapped into segments, while the shorter and thicker blades were errors of production or correction blades.

Unlike the whole blades in the cache, the fragments are generally about the same length as those in the collection as a whole. For example, the median length of the 20 cached medial fragments (19.5 mm, standard deviation = 6.5 mm) is not distinguishable from that of all (N = 128) medial blade fragments recovered from Pook's Hill (mean = 19.9 mm, standard deviation = 7.4 mm). This is also true for proximal and distal fragments. This suggests that the snapped blade fragments were not chosen for the cache because of their length.

Nonetheless, proximal, medial, and distal fragments from the cache are all significantly less wide, less thick, and less massive than those from the collection as a whole. Together, the probability that the cache sample shares the same distribution for these variables as the collection as a whole is less than 1%. In other words, the whole blades in the cache are longer and more delicate than their counterparts in the general collection, and the blade fragments in the cache (although just as long as their counterparts in the entire sample) are also more delicate.

These metric differences suggest design; the blades in the cache seem to have been chosen for their morphology. If form follows function, we can conclude that the blades in the cache were used for a different purpose than those recovered from other contexts. Moreover, their function can be accomplished by lighter rather than heavier blades. One of these functions might be bloodletting.

6.3. Conclusions of typological and attribute analyses

The two complete and 46 fragments of prismatic blades found within Cache 4A-2 come from El Chayal, a source consistent with the Late Preclassic through Late Classic periods in the Belize River Valley and much of the Maya lowlands. Moreover, the blades were made according to the technology of that period. Specifically, they do not date to the Terminal Classic or Postclassic periods. The two complete blades and at least eight of the nine distal fragments have pointed, sharp terminations consistent with blood-letters. The blades and fragments from the cache are considerably finer than their counterparts from the rest of the site, also consistent with a more delicate use than those from the rest of the site. Among the possibilities is ritual bloodletting.

Nonetheless, these artifacts all lack the characteristic notching below the bulb that is found on many suspected perforators from the Maya area. Detailed use-wear analysis is therefore needed to support a functional assessment based on morphological difference. The complete lack of any evidence of retouch on obsidian artifacts from Pook's Hill—implying that obsidian unifaces and bifaces were neither made nor used at the site—may explain the lack of notching.

7. Microscopic use-wear analysis

7.1. Cleaning

Cleaning of the obsidian blades from the Pook's Hill cache followed the same protocols used for the experimental blades (see Stemp, 2016b, 2016c). Prior to microscopic examination, each artifact was washed in a warm, liquid detergent solution and then rinsed in warm water. After rinsing, the artifacts were placed in a warm solution of 15% hydrochloric acid (HCl) for a period of 15 min. They were removed from the solution, rinsed in cold water, and then placed in another room-temperature solution of 20% sodium hydroxide (NaOH) for 15 min. The blades were removed and rinsed again in cold water and left to air dry.

7.2. Equipment

A Unitron MS-2BD metallurgical microscope was used to locate and identify use-wear features at both low- and high-power (40 ×, 100 ×, 200 ×, 400 ×) magnification with bright- and dark-field illumination. Photomicrographs of the tools were taken using a Steindorff DCM 130 (1.3 MPX) digital microscope camera mounted onto the microscope. The analysis included observation and documentation of edge-damage (microflaking), striations, surface abrasion, and surface polish on the obsidian artifacts. Used areas on the tools were recorded using an independent use-zone (IUZ) method in keeping with Aoyama's (1999, 2009) approach.

8. Results of use-wear analysis of obsidian blades from Cache 4A-2

The use-wear data indicate that 38 (79.2%) of the 48 obsidian blades and segments recovered from Cache 4A-2 possess evidence of having been used. Most blades and segments (30 of 38 or 78.9%) only had one IUZ; either on the blade tip or one edge. Overall, the results of the use-wear analysis reveal that 11 (28.9%) of the 38 used blades, which represent roughly a quarter of the IUZs, exhibit wear that is consistent with that observed in the replicative blood-letting experiments (see Stemp, 2016b, 2016c; Stemp et al., 2015; Online Supplement 2) involving a short-term cutting or piercing motion on animal tissue (Fig. 9). Of these, cutting is only represented by a single IUZ on one medial blade segment edge (2.2%) (Figs. 8-31, 10a), three blade tips possess IUZs consistent with piercing (6.5%) (Figs. 8-2, -37, 10b), and six blade tips and one distal segment possess IUZs consistent with piecing and twisting (15.2%) (Figs. 8-1, -3, -6, -14, 10c–f). The other used blades and blade segments were employed for different tasks, including cutting meat, skin, or fresh hide (N = 12 IUZs) (Figs. 8-9, -11, -14, -39, 11b), cutting/sawing wood (N = 4 IUZs) (Figs. 8-5, 11c), cutting/sawing dry hide (N = 2 IUZs) (Figs. 8-20, 11d), and working soft (N = 3 IUZs) or hard contact materials (N = 2 IUZs) (Fig. 11a) whose specific types cannot be identified based on existing wear patterns. The use-wear associated with the IUZs identified as cutting meat, skin or fresh hide was deemed too well-developed to have resulted from auto-sacrificial blood-letting due to the quantity of edge microflaking, the number of short striations, and minimal amounts of weak and fairly smooth polish near the edges of the blades. Minimal surface pitting was sometimes observed near the edges as well. It is more likely that this better developed wear resulted from more prolonged use that was the result of butchery or feasting (Aoyama, 2001; Hurcombe, 1992; Stemp and Awe, 2014; see Chase, 1991; MacLeod and Puleston, 1978; Owen, 2005; Pohl, 1983; Tozzer, 1941) – although, it is important to note that contact with bone was not observed on these blade fragments. The remaining IUZs (N = 10 or 21.7%) on the obsidian blade segments were difficult to interpret due to post-depositional damage on the edges and surfaces of these artifacts (Fig. 8-24, -39). The best that can be said is that they possess some evidence of having been used, but specific motions and/or contact materials cannot be confidently assigned to them. In a few instances, there is microwear that suggests blood-letters may be included among the used blades classified as indeterminate in terms of function; as such, there may have been more obsidian blood-letters in the cache than can be reliably identified. It is important to note that the blade segments with no use-wear traces may have originally been parts of blades that had been used. When the blades were snapped into pieces post-use, the segment with no use-related wear may have been included in the cache, but the used portion was not.

9. Discussion

Based on the results of the technological and use-wear analyses, there is evidence that less than a third of the blades recovered from the cache in Structure 4A were used in a fashion that is consistent with experimental blood-letters (Stemp, 2016b, 2016c; Stemp et al., 2015). It is also clear that not all blades were used as blood-letters and that

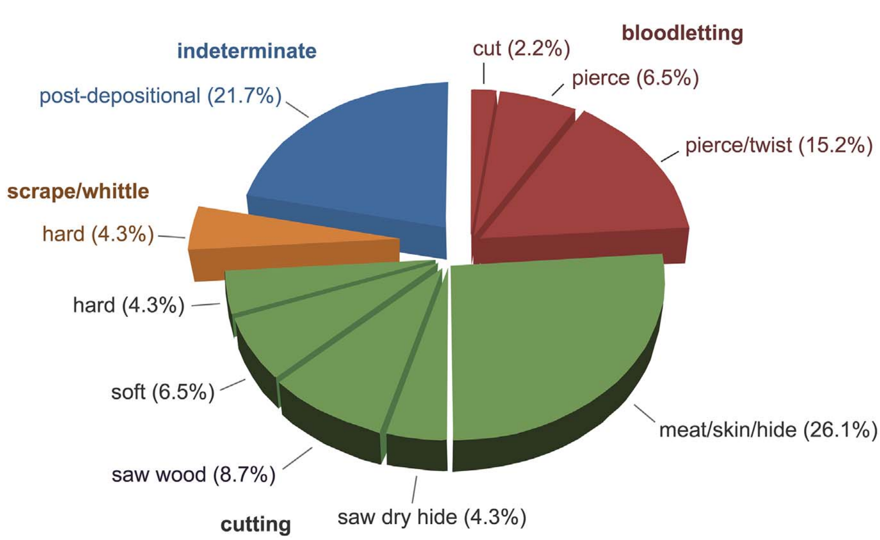

Fig. 9. Percentages of use-wear types on obsidian blades from Cache 4A-2 divided by independent use-zones (IUZs) (chart by W. James Stemp and Christophe Helmke).

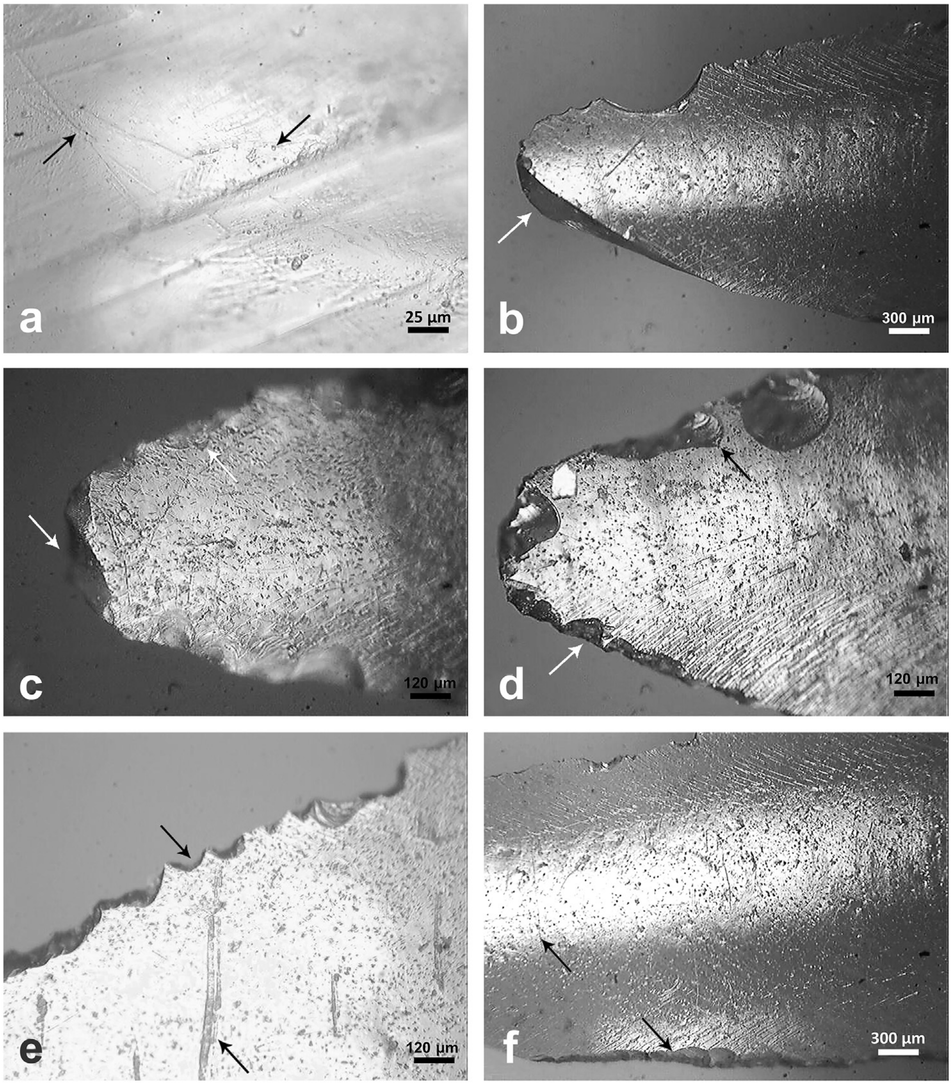

Fig. 10. Photomicrographs of microwear consistent with blood-letting on obsidian blades recovered from Cache 4A-2: a) Blade 31 - cutting (400 ×) based on the micropitting of the stress fissures and the striations [both indicated by arrows] resulting from the microflakes detached from the stress fissure margins; b) Blade 2 - piercing with some post-depositional edge damage [top] (40 ×) based on the burination/snap fracture extending from the tip [indicated by arrow] and lack of microflaking on the lateral margins near the tip; c) Blade 3 - piercing and twisting (100 ×) based on the bending fractures on the tip and the microflaking extending from the tip along both lateral margins [both indicated by arrows]; d) Blade 6 - piercing and twisting (100 ×) based on the cone-like fracture with mild hinge termination of the tip and the microflaking extending from the tip along both lateral margins [indicated by arrows]; e) Blade 30 - piercing and twisting (100 ×) based on the microflaking of the lateral margin further up from the tip and the multiple striations perpendicular to the edge resulting from the detachment of microflakes from the edge [both indicated by arrows]; f) Blade 1 - piercing and twisting (40 ×) based on the snap fracture of the tip (not shown) and the microflaking of both lateral margins further up from the tip and the fine striations perpendicular to the edges resulting from the detachment of microflakes from the edges [both indicated by arrows] (photomicrographs by W. James Stemp).

some blades were used for other tasks involving cutting and scraping of meat, skin or fresh hide, dry hide, and wood, in addition to other unidentifiable functions. Thus, metric and morphological studies are not sufficient on their own to determine function; a blade may look like a blood-letter but could be used for other purposes. Nonetheless, the fact that the blades and fragments in the cache are significantly finer than their counterparts recovered elsewhere at the site does suggest that they were deliberately chosen for use in ritual caching because of their morphology.

Although we can confirm that blood-letting was one of the ritual activities involved in the formation of Cache 4A-2 at Pook's Hill during the Late Classic period, we cannot say if it was performed at or near the cache itself, as part of the very formation of the deposit, or somewhere else as part of another ritual, before the blades were deposited there. That the blades do not form part of a unified set is also suggested by the fact that they cannot be refitted. These data tell us that, in the absence of use-wear or residue analysis, it cannot be known if rituals involving blood-letting occurred in association with caches containing obsidian blades at other Maya sites. Nonetheless, this study highlights the possibility that blood-letting was indeed an integral part of some ancient Maya caching rituals, especially those connected with the deposition of lithic artifacts.

It is possible that some obsidian blades previously used for activities not directly associated with the cache were subsequently included as offerings or *sacra* (see Brown, 2000, 2005). Support for this is derived from some blades that were snapped after use because wear features along their edges (i.e., microflake scars, striations) appear to have extended beyond the end breaks. The ritual deposition of such obsidian blades in the cache could support a number of other interpretations (Parry, 2014:300). Were most blades used for other ritual activities, involving other materials such as wood, meat, skin, fresh hide, or dry hide, at or near the cache? Were some blades first used for other, perhaps more mundane, domestic activities away from the cache only to be subsequently brought to it for inclusion as offerings of another sort (e.g., Lucero, 2010; Walker and Lucero, 2000)? Maybe the fragments included in the cache are thin and delicate because they were not of optimal size for use in daily activities. Although use-wear analysis can determine which blades were used for blood-letting, it cannot provide us with clues concerning whether the blood-letting was definitively auto-sacrificial, nor when, where, or on which occasion such activities occurred. What can be said is that: (1) blades and segments possessing use-wear consistent with cutting and piercing soft tissue for very short periods of time (i.e., blood-letting) were among the obsidian artifacts included in the cache; (2) whole blades and the distal pointed ends of blades possess the most use-wear evidence for blood-letting; and (3) it is not only the distal ends of the thinnest blades that possess use-wear consistent with blood-letting. One final observation based on technological and microscopic analyses concerns the bending fractures on the ends of some of the blade fragments (Figs. 8-39, 11e–f). Although obsidian blades from many Maya sites were snapped into segments to

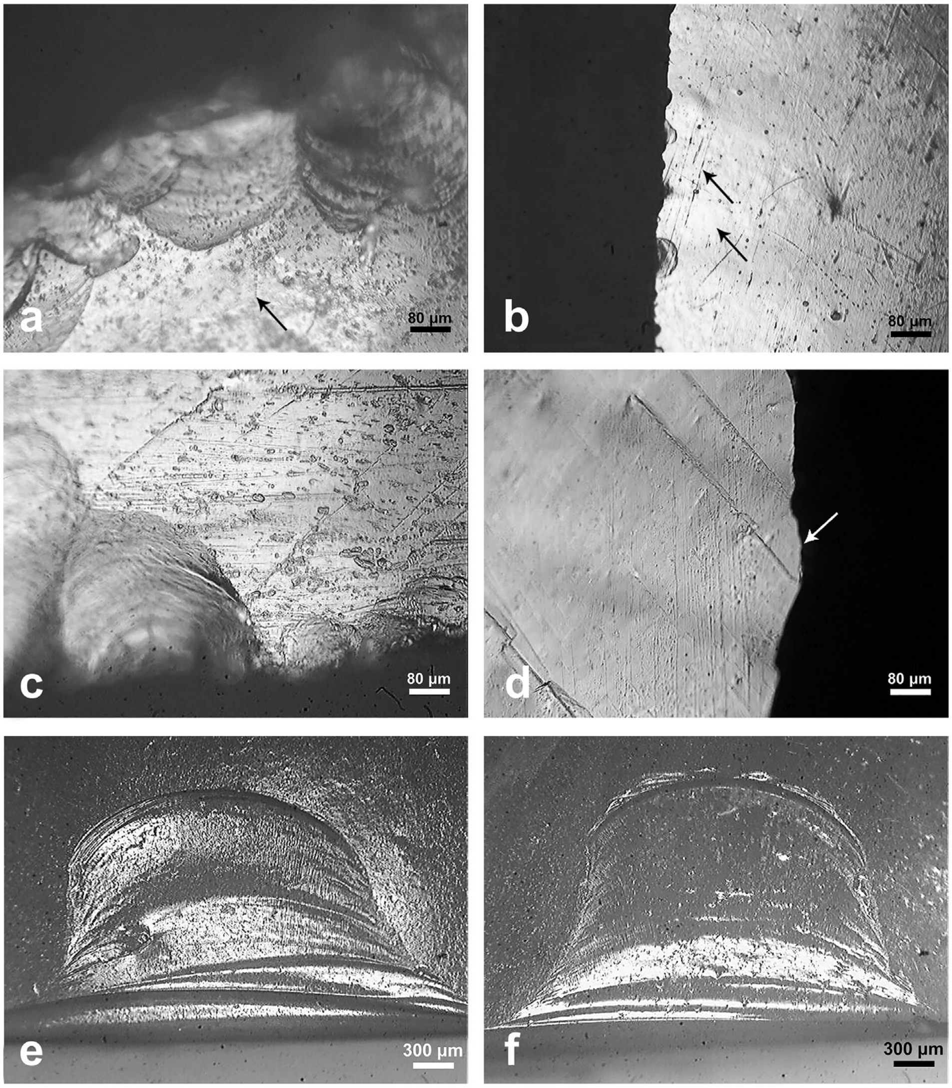

Fig. 11. Photomicrographs of microwear consistent with multiple functions on obsidian blades recovered from Cache 4A-2 - a) Blade 34 - scraping/whittling hard material [wood?] (200 ×) based on the multiple tiers of continuous, overlapping feather-, hinge- and step-terminating microflake scars, the micropitting/abrasion in the microflake scars and around the microflake scar margins, and the striations perpendicular/diagonal to the edge [indicated by arrow]; b) Blade 9 - cutting meat/skin/fresh hide (200 ×) based on the discontinuous, small snap microfracturing on the thin edge margin and small feather- and hinge-terminating microflake scars, the fine short striations diagonal to the edge [indicated by arrow], and the weakly developed polish [indicated by arrow]; c) Blade 5 - cutting/sawing wood (200 ×) based on the two tiers of continuous, overlapping feather- and mild hinge-termination microflake scars along the edge, the numerous long striations parallel to the tool edge on the surface and within some of the microflake scars, and the micropitting of the surface [Note: This is earlier in the wear process before the development of heavier edge abrasion]; d) Blade 20 - cutting/sawing dry hide (200 ×) based on the slight to moderate rounding of the edge [indicated by arrow], the numerous long, thin, shallow striations parallel to the edge; e) Blade 39 - bending fracture (40 ×); f) Blade 27 - bending fracture (40 ×) (photomicrographs by W. James Stemp).

produce smaller, regular pieces for technological reasons, some archaeologists (Reents-Budet and MacLeod, 1997:64; see Brady and Peterson, 2008:89) have suggested that blade segments recovered from cave contexts were deliberately snapped to ritually "kill" the objects (see above).

10. Conclusion

Auto-sacrificial blood-letting represented one way in which the ancient Maya could petition the supernatural entities for assistance in an unpredictable and sometimes chaotic world. It also provided a means by which Maya leaders could perform rituals to generate authority or demonstrate power over people, places, and resources in order to legitimize their identities as ritual specialists who ensured the survival and success of the masses (McAnany, 2008; Wells, 2006; see Geertz, 1977). In a world where everything was essentially created and controlled by supernatural forces, access to and dialogue with the supernatural—available to some, but not all—through ritual practices became an essential component of the structural organization of class-based society (McAnany, 2008; Wolf, 1990).

What technological and use-wear analyses offer archaeologists studying artifacts recovered from ritual contexts is the ability to identify obsidian blades actually used for blood-letting. In so doing, this permits a more accurate reconstruction of past Maya activities in association with caches and other ritual locations. To better understand the frequency of blood-letting using obsidian blades, more technological and use-wear analyses of these artifacts from ritual contexts is necessary (see Stemp and Awe, 2014). With enough information, it may be possible to understand blood-letting throughout a region and over time. This could allow us to evaluate change in ritual practice in response to major climatic events like droughts (Zender, 2004) or important cultural factors such as the calendar (Chase, 1991).

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.jasrep.2017.07.011.

Acknowledgments

Our thanks are due to the Belizean Institute of Archaeology, its Director and its members for their support and granting permission to conduct work at Pook's Hill between 1999 and 2005. Our gratitude is also due to Ray and Vicki Snaddon for allowing excavations on their property, providing ideal lodgings, as well as supplying unwavering logistical support. The contributions, perseverance, patience and hard work of all those who have participated in the many field seasons are warmly thanked. Funding for the excavations was provided by the Belize Valley Archaeological Reconnaissance Project, Pook's Hill Lodge, grants to Helmke from the Institute of Archaeology, University College London, and the Research Project Fund of the Graduate School of the University of London. The use-wear analysis by Stemp was supported through a Faculty Development grant and Faculty Enhancement funds provided by Keene State College.

References

Aoyama, K., 1999. Ancient Maya State, Urbanism, Exchange and Craft Specialization. Chipped Stone Evidence from the Copan Valley and the La Entrada Region, Honduras. University of Pittsburgh Memoirs in Latin American Archaeology, No.12. University of Pittsburgh, Pittsburgh.
Aoyama, K., 2001. Ritos de plebeyos mayas en la Cueva Gordon no. 3 de Copán (Honduras) durante el periodo Clásico: análisis de las microhuellas de uso sobre la litica menor de obsidiana. Mayab. 14. pp. 5–16.
Aoyama, K., 2007. Elite Artists and Craft Producers in Classic Maya Society: Lithic Evidence from Aguateca, Guatemala. Lat. Am. Antiq. 18, 3–26.
Aoyama, K., 2009. Elite Craft Producers, Artists, and Warriors at Aguateca: Lithic Analysis. Monographs of the Aguateca Archaeological Project First Phase, Volume 2. University of Utah Press, Salt Lake City.
Aoyama, K., 2014. Symbolic and ritual dimensions of exchange, production, use, and deposition of ancient Maya obsidian artifacts. In: Levine, M.N., Carballo, D.M. (Eds.), Obsidian Reflections: Symbolic Dimensions of Obsidian in Mesoamerica. University Press of Colorado, Boulder, pp. 127–158.
Awe, J.J., 1985. Archaeological Investigations at Caledonia, Belize. (M.A. thesis) Department of Anthropology, Trent University, Peterborough.
Awe, J.J., 1992. Dawn in the Land Between the Rivers: Formative Occupation at Cahal Pech, Belize and Its Implication for Preclassic Developments in the Maya Lowlands. (Ph.D. dissertation) Institute of Archaeology, University of London, London.
Awe, J.J., Helmke, C., 2015. The sword and the olive jar: material evidence of seventeenth-century Maya Spanish interaction in Central Belize. Ethnohistory 62, 333–360.
Awe J.J., Hoggarth J.A. and Aimers J.J., Of apples and oranges: the case of E-groups and eastern triadic architectural assemblages in the Belize River Valley, In: Freidel D.A., Chase A.F., Dowd A. and Murdock J.F., (Eds.), Early Maya E-Groups, Solar Calendars, and the Role of Astronomy in the Rise of Lowland Maya Urbanism, University Press of Florida; Gainesville, (in press).
Bassendale, M.L., 2000. Preliminary comments on the human skeletal remains from Structure 4A, Pook's Hill 1, Cayo, Belize. In: Griffith, C.S., Ishihara, R., Awe, J.J. (Eds.), The Western Belize Regional Cave Project: A Report of the 1999 Field Season. Department of Anthropology, Occasional Paper No. 3. University of New Hampshire, Durham, pp. 331–344.
Becker, M.J., 1993. Earth offering among the Classic Period Lowland Maya: burials and caches as ritual deposits. In: Ponce de León, M.J.I., Perramon, F.L. (Eds.), Perspectivas antropológicas en el mundo maya. Sociedad Española de Estudios Mayas, Madrid, pp. 45–73.
Becker, M.J., 1999. Excavations in Residential Areas of Tikal: Groups with Shrines. Tikal Report 21, University Museum Monograph 104. University of Pennsylvania, Philadelphia.
Brady, J.E., 1989. An Investigation of Maya Ritual Cave use with Special Reference to Naj Tunich, Peten, Guatemala. (Ph.D. dissertation) Department of Anthropology, University of California, Los Angeles.
Brady, J.E., Peterson, P.A., 2008. Re-envisioning ancient Maya ritual assemblages. In: Fogelin, L. (Ed.), Religion, Archaeology, and the Material World. Center for Archaeological Investigations, Occasional Paper No. 36. Southern Illinois University, Carbondale, pp. 78–96.
Braswell, G.E., 2003. Obsidian exchange spheres. In: Smith, M.E., Berdan, F.F. (Eds.), The Postclassic Mesoamerican World. University of Utah Press, Salt Lake City, pp. 131–158.
Braswell, G.E., 2007. The obsidian artifacts of Pook's Hill, Belize (1999–2005). In: Helmke, C.G.B., Awe, J.J. (Eds.), The Belize Valley Archaeological Reconnaissance Project: A Report of the 2006 Field Season. Belize Institute of Archaeology, National Institute of Culture and History, Belmopan, pp. 101–118.
Braswell, G.E., Glascock, M.D., 2011. Procurement and production of obsidian artifacts at Calakmul. In: Hruby, Z.X., Braswell, G.E., Chinchilla Mazariegos, O. (Eds.), The Technology of Maya Civilization: Political Economy and Beyond in Lithic Studies. Routledge, New York, pp. 119–129.
Braswell, G.E., Clark, J.E., Aoyama, K., McKillop, H.I., Glascock, M.D., 2000. Determining the geological provenance of obsidian artifacts from the Maya region: a test of the efficacy of visual sourcing. Lat. Am. Antiq. 11, 269–282.
Brown, L.A., 2000. From discard to divination: demarcating the sacred through the collection and curation of discarded objects. Lat. Am. Antiq. 11, 319–333.
Brown, L.A., 2005. Planting the bones: hunting ceremonialism at contemporary and nineteenth-century shrines in the Guatemalan highlands. Lat. Am. Antiq. 16, 131–146.
Brown, M.K., 2003. Emerging Complexity in the Maya Lowlands: A View From Blackman Eddy, Belize. (Ph.D. dissertation) Southern Methodist University. University Microfilms International, Ann Arbor, Michigan.
Chase, D., 1991. Lifeline to the gods: ritual bloodletting at Santa Rita Corozal. In: Robertson, M.G., Fields, V.M. (Eds.), Sixth Palenque Round Table, 1986. University of Oklahoma Press, Norman, pp. 89–96.
Chase, A.F., Chase, D.Z., 1994. Maya veneration of the dead at Caracol, Belize. In: Robertson, M.G., Fields, V.M. (Eds.), Seventh Palenque Round Table 1989. Pre-Columbian Art Research Institute, San Francisco, pp. 55–62.
Chase, A.F., Chase, D.Z., 2011. Status and power: Caracol, Teotihuacan, and the Early Classic Maya world. Res. Rep. Belizean Archaeol. 8, 3–18.
Clark, J.E., 1988. The Lithic Artifacts of La Libertad, Chiapas, Mexico: An Economic Perspective. Papers of the New World Archaeological Foundation, No.52. Brigham Young University, Provo.
Coe, W.R., 1959. Piedras Negras Archaeology: Artifacts, Caches, and Burials. Museum Monographs, No. 4. University of Pennsylvania Museum of Archaeology and Anthropology. University of Pennsylvania Press, Philadelphia.
Conlon, J.M., 1995. Incorporation, integration and irrigation at the ancient Maya site of Baking Pot, Belize. Pap. Inst. Archaeol. 6, 31–46.
Gann, T.W.F., 1918. The Maya Indians of Southern Yucatan and Northern British Honduras. U.S. Bureau of American Ethnology, Bulletin 64, Washington, D.C.
Garber, J.F., 1986. The artifacts. In: Robertson, R.A., Freidel, D.A. (Eds.), Archaeology at Cerros, Belize, Central America. Vol. I. Southern Methodist University Press, Dallas, pp. 117–126.
Geertz, C., 1977. Centers, kings, and charisma: Reflections on the symbolics of power. In: Ben-David, J., Clark, T. (Eds.), Culture and its Creators. University of Chicago Press, Chicago, pp. 150–171.
Gifford, J.C., 1976. Prehistoric Pottery Analysis and the Ceramics of Barton Ramie in the Belize Valley. Memoirs of the Peabody Museum of Archaeology and Ethnology 18. Harvard University, Cambridge.
Golitko, M., Meierhoff, J., Feinman, G.M., Williams, P.R., 2012. Complexities of collapse: the evidence of Maya obsidian as revealed by social network graphical analysis. Antiquity 86, 507–523.
Graham, E., 2011. Maya Christians and their Churches in Sixteenth-Century Belize. University Press of Florida, Gainesville.
Helmke, C.G.B., 2000. Pook's Hill 1, Operations 1 through 3: salvage excavations of Structure 4A, Roaring Creek Valley, Cayo District, Belize. In: Griffith, C.S., Ishihara, R., Awe, J.J. (Eds.), The Western Belize Regional Cave Project: A Report of the 1999 Field Season. Department of Anthropology, Occasional Paper No. 3. University of New Hampshire, Durham, pp. 287–330.
Helmke, C.G.B., 2003. The 2002 season investigations at Pook's Hill, Belize. Pap. Inst. Archaeol. 14, 119–128.
Helmke, C.G.B., 2006a. A report of the 2005 season of archaeological investigations at Pook's Hill, Cayo District, Belize. In: Awe, J.J. (Ed.), The Belize Valley Archaeological Reconnaissance Project: A Report of the 2005 Field Season. Institute of Archaeology, National Institute of Culture and History, Belmopan, pp. 39–92.
Helmke, C.G.B., 2006b. A summary of the 1999-2002 seasons of archaeological investigations at Pook's Hill, Cayo District, Belize. Res. Rep. Belizean Archaeol. 3, 173–191.
Helmke, C.G.B., 2006c. Recent investigations into ancient Maya domestic and ritual activities at Pook's Hill, Belize. Pap. Inst. Archaeol. 17, 77–85.
Helmke, C., 2012. Mayojen pantheon/Mayas panteon/The Maya pantheon. In: Didrichsen, M., Kettunen, H. (Eds.), Maya III: Life, Death, Time. Didrichsen Museum of Art and Culture, Helsinki, pp. 62–103.
Helmke, C., Awe, J., 2010. Hot archaeology: an ancient Maya sweatbath at Pook's Hill. Curr. World Archaeol. 40, 38–43.
Helmke, C., Awe, J.J., 2016. Death becomes her: an analysis of Panel 3, Xunantunich, Belize. PARI J. 16 (4), 1–14.
Helmke, C.G.B., Piehl, J.C., Bassendale, M.L., 2001. Pook's Hill 1, Operation 4A: investigations of the plaza platform and eastern shrine Structure 4A, Roaring Creek Valley, Cayo District, Belize. In: Ishihara, R., Griffith, C.S., Awe, J.J. (Eds.), The Western Belize Regional Cave Project: A Report of the 2000 Field Season. Department of Anthropology, Occasional Paper No. 4. University of New Hampshire, Durham, pp. 325–390.
Helmke, C., Bevan, A., Awe, J., 2004. Roaring Creek: life along an ancient Maya valley. Curr. World Archaeol. 4, 10–16.
Houston, S., Stuart, D., 1996. Of gods, glyphs and kings: divinity and rulership among the Classic Maya. Antiq. 70, 289–312.
Houston, S.D., Taube, K., 2000. An archaeology of the senses: perception and cultural expression in ancient Mesoamerica. Camb. Archaeol. J. 10 (2), 261–294.
Houston, S., Stuart, D., Taube, K., 2006. The Memory of Bones: Body, Being, and Experience among the Classic Maya. University of Texas Press, Austin.
Hurcombe, L.M., 1992. Use Wear Analysis and Obsidian: Theory, Experiments and Results. Sheffield Archaeological Monographs 4. Sheffield: JR Collis Publications, University of Sheffield, Sheffield.
Iannone, G., Conlon, J.M., 1993. Elites, eccentrics, and empowerment in the Maya area: implications for the interpretation of a peripheral settlement cluster near Cahal Pech, Cayo District, Belize. Pap. Inst. Archaeol. 4, 77–89.
Joralemon, D., 1974. Ritual blood-sacrifice among the ancient Maya: part 1. In: Robertson, M.G. (Ed.), Primera Mesa Redonda de Palenque, Part II. Robert Louis Stevenson School, Pebble Beach, pp. 59–75.
Kidder, A.V., 1947. The Artifacts of Uaxactun, Guatemala. Carnegie Institution of Washington Publication 576. Carnegie Institution of Washington, Washington, D.C.
LeCount, L.J., 1996. Pottery and Power: Feasting, Gifting, and Displaying Wealth among the Late and Terminal Classic Lowland Maya. (Ph.D. dissertation) Department of Anthropology, University of California, Los Angeles.
Lewenstein, S.M., 1987. Stone Tool Use at Cerros: The Ethnoarchaeological and Use-wear Evidence. University of Texas Press, Austin.
Lucero, L.J., 2010. Materialized cosmology among ancient Maya commoners. J. Soc. Archaeol. 10, 138–167.
MacLeod, B., Puleston, D.E., 1978. Pathways into darkness: the search for the road to Xibalba. In: Robertson, M.G., Jeffers, D.C. (Eds.), Tercera Mesa Redonda de Palenque. 4. Herald Peters, Monterey, pp. 71–77.
Meissner, N.J., Rice, P.M., 2015. Postclassic Petén Maya bow-and-arrow use as revealed by immunological analysis. J. Archaeol. Sci. 64, 67–76.
McAnany, P.A., 2008. Shaping social difference: political and ritual economy of Classic Maya royal courts. In: Wells, E.C., McAnany, P.A. (Eds.), Dimensions of Ritual Economy: Research in Economic Anthropology. Vol. 27. JAI Press, Emerald Group Publishing, Bingley, pp. 219–247.
Morehart, C.T., 2001. 2001 preliminary analysis of the paleoethnobotanical samples from

Pook's Hill 1, Cayo District, Belize. In: Ishihara, R., Griffith, C.S., Awe, J.J. (Eds.), The Belize Valley Archaeological Reconnaissance Project: A Progress Report of the 2000 Field Season. Department of Anthropology, Occasional Paper No. 4. University of New Hampshire, Durham, pp. 401–413.

Morehart, C.T., 2007. Continued paleoethnobotanical research at Pook's Hill, Belize. In: Helmke, C.G.B., Awe, J.J. (Eds.), The Belize Valley Archaeological Reconnaissance Project: A Report of the 2006 Field Season. Belize Institute of Archaeology, National Institute of Culture and History, Belmopan, pp. 119–133.

Nakazawa, Y., 2002. An experimental examination for detecting thermal traits on obsidian artifacts. In: Loyd, J.M., Origer, T.M., Frederickson, D.D. (Eds.), The Effects of Fire and Heat on Obsidian (Papers presented in Symposium 2, The Effects of Fire/ Heat on Obsidian, 33rd Annnual Meeting of the Society for American Archaeology, April 23-25, 1999, Sacramento, California), pp. 203–219. http://members.peak.org/~obsidian/pdf/loyd_etal_2002.pdf.

Nelson, F., 1985. Summary of the results of analysis of obsidian artifacts from the Maya lowlands. Scan. Electron Microsc. 11, 631–649.

Newman, M., 1993. Organic residues on obsidian blades. In: Sheets, P.D., Simmons, S.E. (Eds.), Preliminary Report of the Cerén Research Project, 1993 Season. University of Colorado, Boulder, pp. 182–184.

Owen, V.A., 2005. A question of sacrifice: Classic Maya cave mortuary practices at Barton Creek Cave, Belize. In: Prufer, K.M., Brady, J.E. (Eds.), Stone Houses and Earth Lords: Maya Religion in the Cave Context. University of Colorado Press, Boulder, pp. 323–340.

Parry, W.J., 2014. Reflections on reflections. In: Levine, M.N., Carballo, D.M. (Eds.), Obsidian Reflections: Symbolic Dimensions of Obsidian in Mesoamerica. University Press of Colorado, Boulder, pp. 279–318.

Peterson, P.A., 2006. Ancient Maya Cave Use in the Sibun Valley, Belize. (Ph.D. dissertation) Department of Archaeology, Boston University, Boston.

Pohl, M.D., 1983. Maya ritual faunas: vertebrate remains from burials, caches, caves, and cenotes in the Maya Lowlands. In: Leventhal, R.M., Kolata, A.L. (Eds.), Civilization in the Ancient Americas: Essays in Honor of Gordon R. Willey. University of New Mexico Press, Albuquerque, pp. 55–103.

Potter, D.R., 1994. Strat 55, operation 2012, and comments on lowland Maya blood rituals. In: Hester, T.R., Shafer, H.J., Eaton, J.D. (Eds.), Continuing Archaeology at Colha Belize. Studies in Archaeology 16. Texas Archaeological Research Laboratory, University of Texas, Austin, pp. 31–37.

Reents-Budet, D., 1994. Painting the Maya Universe: Royal Ceramics of the Classic Period. Duke University Press and Duke University Museum of Art, Durham and London.

Reents-Budet, D., MacLeod, B., 1997. The Archaeology of Petroglyph Cave, Cayo District, Belize. (Unpublished Report) Royal Ontario Museum, Toronto.

Rice, P.M., 1984. Obsidian procurement in the Central Peten Lakes Region, Guatemala. J. Field Archaeol. 11, 181–194.

Schele, L., Miller, M.E., 1986. The Blood of Kings: Dynasty and Ritual in Maya Art. Kimbell Art Museum, George Braziller, Inc, Fort Worth.

Sievert, A.K., 1992. Maya Ceremonial Specialization: Lithic Tools from the Sacred Cenote at Chichen Itza, Yucatan. Monographs in World Archaeology, No. 12. Prehistory Press, Madison.

Stemp, W.J., 2001. Chipped Stone Tool Use in the Maya Coastal Economies of Marco Gonzalez and San Pedro, Ambergris Caye, Belize. BAR International Series 935, Oxford.

Stemp, W.J., 2016a. Coastal Maya obsidian tool use and socio-economy in the Late Postclassic-Early Spanish Colonial Period at San Pedro, Ambergris Caye, Belize. J. Field Archaeol. 41, 162–176.

Stemp, W.J., 2016b. Explorations in ancient Maya blood-letting: experimentation and microscopic use-wear analysis of obsidian blades. J. Archaeol. Sci. Rep. 7, 368–378.

Stemp, W.J., 2016c. Twist and shout: experiments in ancient Maya blood-letting by piercing with obsidian blades and splinters. J. Archaeol. Sci. Rep. 9, 134–142.

Stemp, W.J., Awe, J.J., 2014. Ritual use of obsidian from Maya caves in Belize: a functional and symbolic analysis. In: Levine, M.N., Carballo, D.M. (Eds.), Obsidian Reflections: Symbolic Dimensions of Obsidian in Mesoamerica. University Press of Colorado, Boulder, pp. 223–254.

Stemp, W.J., Helmke, C.G.B., Awe, J.J., 2010. Evidence for Maya household subsistence and domestic activities: use-wear analysis of the chipped chert assemblage from Pook's Hill, Belize. J. Field Archaeol. 35, 217–234.

Stemp, W.J., Helmke, C.G.B., Awe, J.J., Carter, T., Grant, S., 2012. A green obsidian eccentric from Actun Uayazba Kab, Belize. In: Brady, J.E. (Ed.), Heart of Earth: Studies in Maya Ritual Cave Use, Bulletin 23. Association for Mexican Cave Studies, Austin, pp. 111–124.

Stemp, W.J., Wrobel, G.D., Awe, J.J., Payeur, K., 2013. Stir it up, little darlin': the chipped stone assemblage from mixed deposits from Caves Branch Rockshelter, Belize. Can. J. Archaeol. 123–167.

Stemp, W.J., Andruskiewicz, M.D., Gleason, M.A., Rashid, Y.H., 2015. Experiments in ancient Maya blood-letting: quantification of surface wear on obsidian blades. Archaeol. Anthropol. Sci. 7, 423–439.

Stone, A., 1995. Images from the Underworld: Naj Tunich and the Tradition of Maya Cave Painting. University of Texas Press, Austin.

Stone, A., Zender, M., 2011. Reading Maya Art: A Hieroglyphic Guide to Ancient Maya Painting and Sculpture. Thames and Hudson, London.

Stuart, D., 1984. Royal Auto-sacrifice among the Maya: a study of image and meaning. RES: Anthropol. Aesthet. 7/8, 6–20.

Stuart, D., 1988. Blood symbolism in Maya iconography. In: Benson, E., Griffin, G. (Eds.), Maya Iconography. Princeton University Press, Princeton, pp. 173–221.

Stuart, D., 1996. Kings of stone: a consideration of stelae in ancient Maya ritual and representation. RES: Anthropol. Aesthet. 29/30, 148–171.

Sullivan, K., 2017. Caching It in: Regional Patterns in Ancient Maya Ritual Caches of Eccentric Lithics. (M.A. thesis) Northern Arizona University, Flagstaff.

Thompson, J.E.S., 1939. Excavations at San Jose, British Honduras. Carnegie Institution of Washington Publication 506. Carnegie Institution of Washington, Washington, D.C.

Thompson, J.E.S., 1940. Late Ceramic Horizons at Benque Viejo, British Honduras. Carnegie Institution of Washington, Contributions to American Anthropology and History 35. Carnegie Institution of Washington, Washington, D.C.

Thompson, J.E.S., 1959. The role of caves in Maya culture. Mitt. Mus. Völkerkunde Hambg. 25, 122–129.

Thompson, J.E.S., 1961. A blood-drawing ceremony painted on a Maya vase. Estudios Cult. Maya 1, 13–20.

Tozzer, A.M., 1941. Landa's Relacion de Las Cosas de Yucatan. Papers of the Peabody Museum of American Archaeology and Ethnology. Vol. 18 Harvard University, Cambridge.

Walker, W.H., Lucero, L.J., 2000. The depositional history of ritual and power. In: Dobres, M.-A., Robb, J. (Eds.), Agency in Archaeology. Routledge Press, London, pp. 130–147.

Wells, E.C., 2006. Recent trends in theorizing Prehispanic Mesoamerican economies. J. Archaeol. Res. 14, 265–312.

Welsh, B.M., 1988. An Analysis of Classic Lowland Maya Burials. BAR International Series Vol. 409 (Oxford).

Willey, G.R., Bullard Jr., W.R., Glass, J.B., Gifford, J.C., 1965. Prehistoric Maya Settlements in the Belize Valley. Papers of the Peabody Museum of Archaeology and Ethnology. Vol. 54 Harvard University, Cambridge.

Wolf, E.R., 1990. Distinguished lecture: facing power – old insights, new questions. Am. Anthropol. 92, 586–596.

Zender, M., 2004. Study of Classic Maya Priesthood. (Ph.D. dissertation) Department of Archaeology, University of Calgary, University Microfilms International, Ann Arbor, Michigan.