

THE ANCIENT MAYA SCRIPT OF HAND FORMS EMBEDDED IN
FIGURAL ART: A DECIPHERMENT OF NUMERALS SIGNED BY THE
RULERS OF ALTAR Q¹By RICH A. SANDOVAL 
Metropolitan State University of Denver

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ABSTRACT

Ancient Maya texts are informationally dominated by hieroglyphic inscriptions and visually dominated by figural art with distinctly formed hands. The hands suggest iconographically embedded hand signs, which would constitute a unique modality of semantic expression and a discourse complement to hieroglyphic writing. However, the hands have eluded decipherment. Here I take a novel approach. I use relevant phonological parameters (handshape, orientation, position) as features for defining a hand form as a graphic symbol. I also exploit inferences of scribal design and composition to constrain possible hand-sign values. Notably, I examine the hand-sign and hieroglyphic inscriptions of Altar Q, an 8th-century sculptural text that is ideal for its relative abundance of graphic hand signs, sizable hieroglyphic inscription and wealth of contextualising information. The resulting evidence (including isomorphisms between hand signs and hieroglyphs, intratextual references for hand-sign values, and direct links between hand-sign and hieroglyphic information) converges on a single solution: Each of Altar Q's hand signs is an esoterically formed numeral for one of four Long Count dates. I thus demonstrate and mathematically verify eleven unique numerical hand signs. Although partial, this initial decipherment of Ancient Maya graphic hand signs provides a strong base for future efforts.

Los textos Antiguos Mayas están dominados informativamente por inscripciones jeroglíficas y visualmente dominados por el arte figurativo con manos claramente formadas. Las manos sugieren signos de mano incrustados iconográficamente, que constituirían una modalidad única de expresión semántica y un complemento de discurso a la escritura jeroglífica. Sin embargo, las manos han eludido el desciframiento. Aquí adopto un enfoque novedoso. Utilizo parámetros fonológicos relevantes (forma de la mano, orientación, posición) como características para definir la forma de todo el signo de mano como símbolo gráfico. También exploto las inferencias del diseño y la composición de los escribas para limitar los posibles valores de los signos de mano. En

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particular, examino los signos manuales y las inscripciones jeroglíficas del Altar Q, un texto escultórico del siglo VIII que es ideal por su relativa abundancia de signos gráficos de mano, largas inscripciones jeroglíficas y gran cantidad de información contextualizadora. La evidencia resultante (incluidos isomorfismos entre signos de mano y jeroglíficos, referencias intratextuales para los valores de los signos de mano y vínculos directos entre los signos de mano y la información jeroglífica) converge en una única solución: Cada uno de los signos manuales del Altar Q es un número formado esotéricamente para una de las cuatro fechas de Cuenta Larga. De esta manera demuestro y verifico matemáticamente once signos numéricos únicos de mano. Aunque parcial, este desciframiento inicial de los signos gráficos de mano de los Antiguos Mayas proporciona una base sólida para esfuerzos futuros.

[Spanish]

1. INTRODUCTION

The Ancient Maya and, to a lesser extent, other Mesoamerican contemporaries (~500 BCE to 1,500 CE) left behind texts that demonstrate the unique integration of hieroglyphic writing and figural art that was central to scribal practice (e.g. Figure 1). Throughout the vast Maya corpus, the hands of depicted figures are visually salient, often distinctly formed with a high degree of variation and apparent patterning. Moreover, the distinctive hands are nearly omnipresent, found in all text types, from voluminous sculptures to image-heavy storyline vases. This display of hands in a figural-art text-based tradition is unparalleled. However, what the hands mean has largely remained a mystery. This is despite successful efforts to decipher Maya hieroglyphs and interpret the complex iconographic symbolism. For researchers, there is little doubt that many of the distinct hand forms are complex signifiers (Miller 1983; Ancona-Ha et al. 2000; Bishop & Cartmill 2020; Maitland Gardner 2022), if not with some relation to indigenous signed-language practices (Mallery 1972 [1893]; Benson 1973; Brennan 1998; Fox Tree 2009, 2016). Because figural hand forms might convey rich information that is complementary to an accompanying hieroglyphic inscription, the gap in understanding what the hands mean poses a potentially significant problem for achieving a complete and accurate readings of a given Maya text. In this paper, I work toward a solution by demonstrating the meanings of eleven hand forms and, in doing so, that a hieroglyph-only reading of some texts may be more partial than previously believed.

The few prior studies focusing on the distinctive Maya hand forms have yielded limited yet valuable insights. In one approach, formal properties displayed across many instances of hands in Maya figural art are analysed for relational patterns with meanings drawn from known contexts (Benson 1973; Miller 1983; Ancona-Ha et al. 2000; Palka 2002; Wright & Lemos 2018; Bishop & Cartmill 2020). The results generally highlight how the hand forms indicate social standing and distinction amongst portrayed individuals. The findings from this body of work have thus started to uncover one way that Ancient Maya scribes used the hands to express meaning.

A different set of approaches has explored how the scribes might have intended the hand forms to express more semantically concrete meanings. Researchers have recognised since the late 19th century that some of the figural hand forms resemble signs from modern indigenous signed languages within Mesoamerica and northward (Mallery 1972 [1893]; Brennan 1998; Fox Tree 2009, 2016). They suggest using current signs as a basis for interpreting the ancient hand forms. Based on his analysis of Plains Sign Language (Mallery 2011 [1881]); Mallery (1972 [1893]: 645–8) proposed meanings for a few ancient hand forms. Despite his

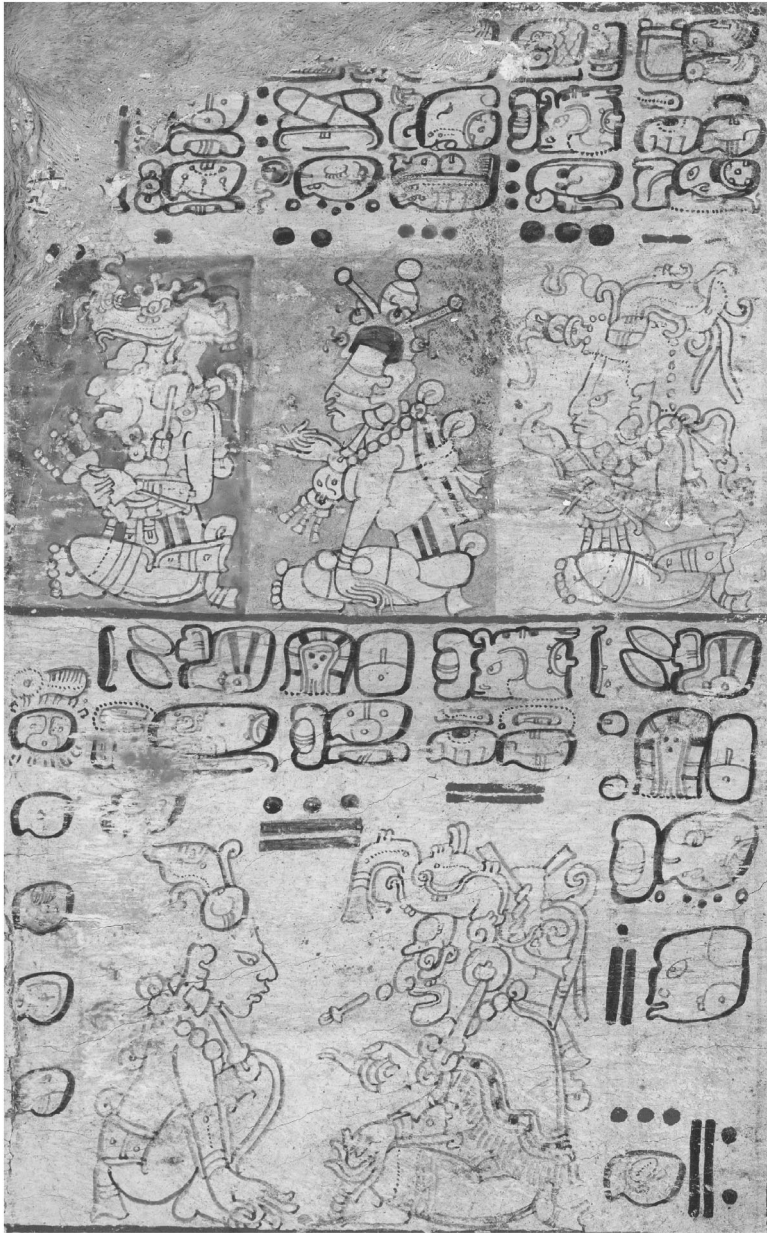


Figure 1. Unique hand formations in the Maya Dresden Codex. The Ancient Maya Dresden Codex, created around the twelfth century, concerns calendrical phenomena and divination. The upper sections of its 9th page, shown here, exemplify the scribal integration of hieroglyphic-block writing, bar-and-dot numerals and figures with distinctly formed hands. The meaning conveyed by the hands is unknown. However, the patterning and variation in formal features, such as handshape and palm orientation, suggest that the hands are complex graphic symbols. Image made available for use by the World Digital Library and retrieved from the Library of Congress Web Archives at <https://www.loc.gov/item/2021667917>

valuable insight that a network of indigenous signed-language practices was quite extensive and ancient, his proposals suffered from the lack of any substantial foundation in Ancient Maya writing or art. Fox Tree (2009, 2016) cautiously builds on this insight, with more effort toward a methodological program to establish connections between ancient figural art and modern signing practices. An overlapping approach examines connections between Maya hieroglyphs and figural hand forms. Many hieroglyphs feature distinct hand imagery, underscoring the significance of semantically enriched hand forms in Maya scribal traditions (Boot 2003). Nevertheless, attempts at using hieroglyphic hand imagery as an interpretative basis have remained at the level of one-off observations (e.g. Burdick 2010: 176–7; Hamann 2017: 52–3). Maitland Gardner (2019, 2022) takes a similar approach but largely relies on cross-culturally recognised gesture families as the basis of interpretation. Through its various comparative analyses, this body of research makes a compelling case that hand forms in Ancient Maya figural art express meanings that are more semantically anchored than conceptual gestures. Nevertheless, because the analyses rely almost exclusively on associative interpretations as supporting evidence, additional types of evidence are needed to cross verify the proposals put forth.

Despite the long-term enigmatic status of Ancient Maya hands in figural art, a radical hypothesis is implied by observation and motivated by the research: Some of the hands constitute expressions that are akin to writing. For the sake of clarity, I use ‘hand sign’ to describe this type of hand-based expression. Unlike manual gestures, hand signs adhere strictly to formal properties and convey linguistic or other semantically well-defined content, such as words or numbers. They are symbols, conventionalized to hold meaning out of context. A gesture’s meaning, however, is typically more conceptual and not independent of its context (see Kendon 2004: 325). When a gesture is depicted in figural art, its meaning must be understood with respect to the depicted figure and other aspects of the overall artistic context (see McNiven 2022). Prime examples are the *mudra* gestures of Buddhist statues (Todaro 1985) and the gestures of emotion systematically employed by 16th and 17th century European artists (Kendon 2004). In contrast, a depiction of a hand sign would constitute a graphic symbol, albeit one that may be obscured by being embedded in iconography. Nevertheless, as with more typical graphic symbols, a system of graphic hand signs would constitute a script. For Maya scribes, the hand-sign script would have accompanied the hieroglyphic script as complementary scripts within their complex writing system.

Here I reveal the existence of the Ancient Maya hand-sign script through a decipherment of hand signs with numerical value and calendrical function. To do this, I devised a novel approach. I identified a dataset that both controls for hand-sign variation and offers multiple possibilities for constraining a decipherment (see Zender 2017). This dataset consists of Altar Q (Figure 2), a single Classic Maya monumental text from late-8th century Copán (Figure 3). The text focuses on the Classic Copán dynasty, its founder, its 16th and final ruler, relevant rituals and the dynasty’s concurrence with the nearly 400 years of the 9th Bak’tun calendrical period (Stuart 2004a). It is one of the most storied artefacts of Ancient Mesoamerica, with scholarship dating to the mid-1800s (Herring 2014).

Altar Q serves as an ideal dataset for several reasons. First, as a single text, it eliminates noise resulting from variation. Second, with 16 figural depictions, Altar Q has a relatively long series of graphic hand signs, enhancing the probability that it will contain isomorphisms with hieroglyphic forms and patterns. Third, each figure is a depiction of one of Copán’s dynastic rulers, which eliminates the possibility of social status as a factor in hand-sign distribution (see Bishop & Cartmill 2020). Fourth, its hand forms vary in relevant phonological parameters (handshape, hand placement and hand orientation), while heads, torsos and legs are mostly static and thereby controlled for. Fifth, Altar Q’s context is well understood, thanks to its extensive hieroglyphic inscription, providing pertinent information for

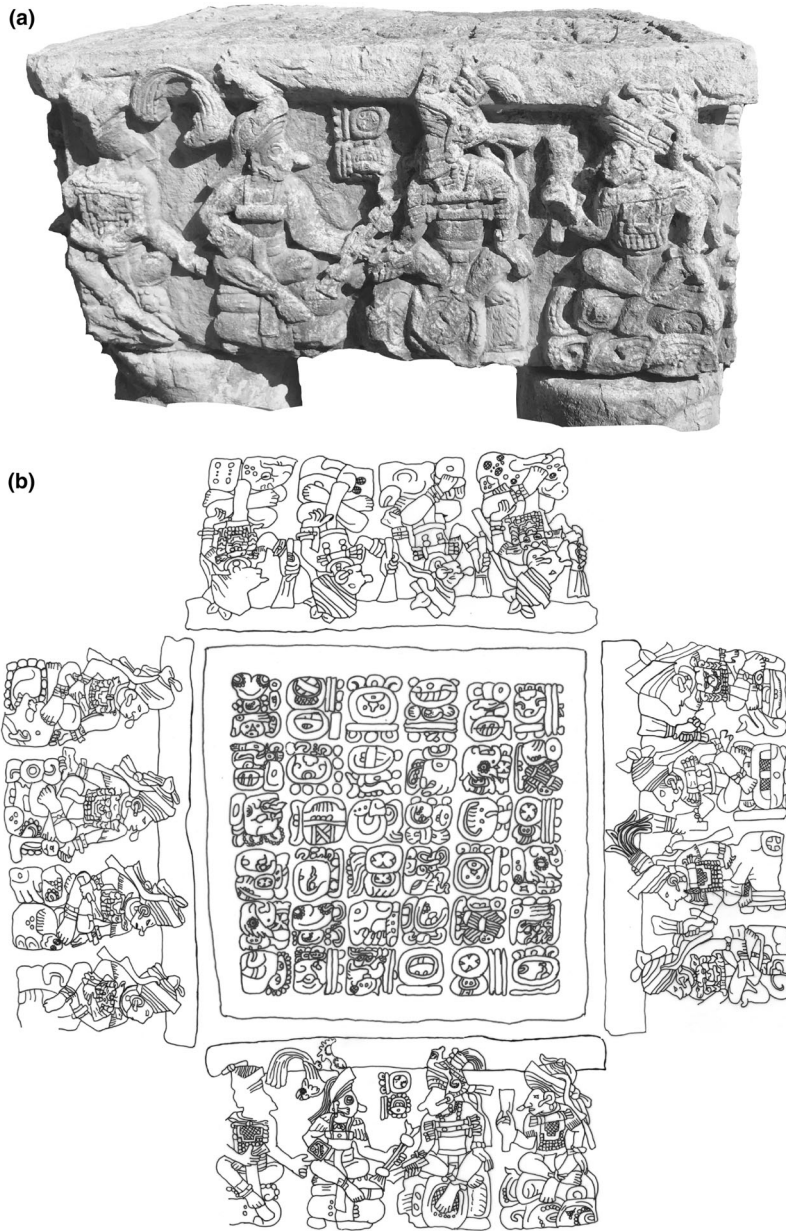


Figure 2. Altar Q. (a) The photograph of Altar Q showcases its prominent West Panel. Each panel is approximately 1 m on the horizontal and half a meter on the vertical. (b) Shown here as a flattened illustration, Altar Q includes 36 hieroglyphic blocks on its topside, one proper hieroglyphic date on its West Panel, depictions of 16 rulers sitting on self-identifying hieroglyphs, and many elements of iconographic symbolism and embedding. Note that because the West Panel is positioned on the bottom, the topside hieroglyphic inscription is upside down. (a) Photograph by author. (b) Drawing by author, following the interpretation of Linda Schele's illustration (see Schele & Freidel 1990: 310, fig. 8:3)

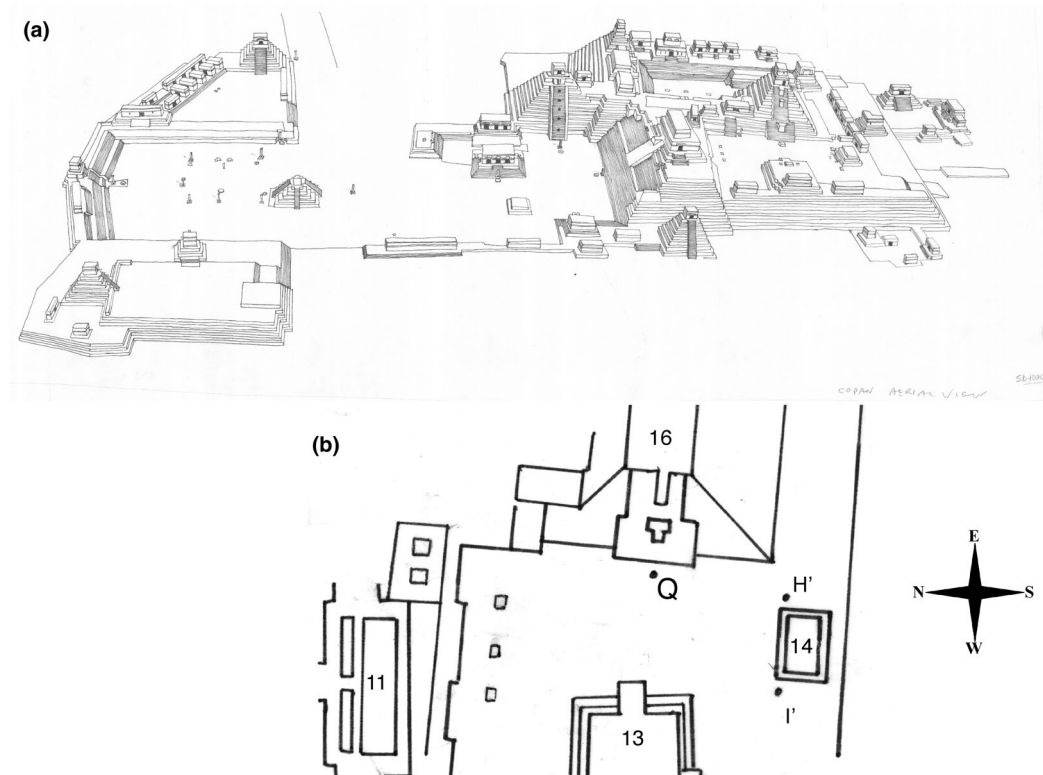


Figure 3. Classic Copán and its West Court. (a) Copán, a department of present-day western Honduras, is the location of the Classic Maya site of Copán. Shown in the drawing is Classic Copán's Principal Group, which is the central archaeological area. The West Court is defined as the prominent enclosed area at the right side. (b) The West Court has Altar Q (designated 'Q') situated just to the west of Structure 16, the founder's dominating pyramid tomb. The drawing includes the archaeological designations of other relevant West Court monuments. (a) Drawing by Linda Schele © David Schele courtesy of Ancient Americas at LACMA (ancientamericas.org); (b) Drawing by author

constraining decipherment proposals. And sixth, its hieroglyphic inscription reveals some abnormalities that can be resolved by positing certain information that seems to be missing. This information presents a source for decipherment candidates.

The outcome of my analysis is a robust decipherment of Altar Q's graphic hand signs. Each hand sign is a numeral. Together they constitute four calendrical dates, one on each of Altar Q's four side panels. Furthermore, the hand signs are esoterically formed in that there is not a transparent relationship between numerical value and form, as there is with finger counting. Subsystems comprised of formally complex numerals are attested for in signed languages, albeit rarely (see Zeshan et al. 2013). Moreso, the results are consistent with the Ancient Maya emphasis on numbers, calendars and an esoteric hieroglyphic script that is replete with opaque relationships between imagery and actual meaning, including relationships between handshape imagery and numerical meaning as shown in Figure 4. An ancient use of hand signs for calendrical notation is also ethnographically supported by a modern Maya use of specialised gestures for precise reckoning of cyclical time (Neuenswander 1981; Le Guen & Pool Balam 2012; see also Maitland Gardner 2019).

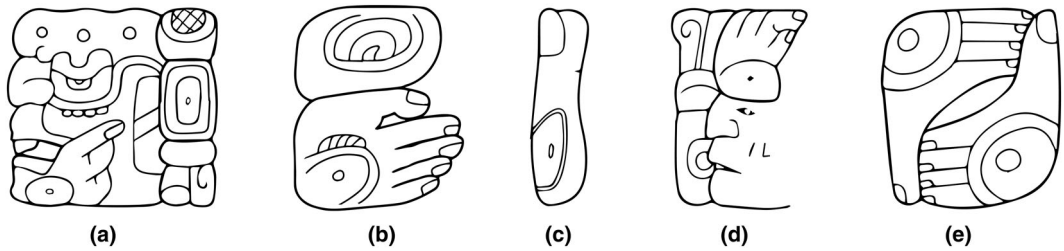


Figure 4. Hieroglyph numerals with hand imagery. (a) MIH, the head variant of numeral 0; (b) K'AL with flat-hand imagery is glossed as 'to bind' or 'to close', and K'AL with moon imagery is a variant of numeral 20 (Johnson 2013), which is synonymous with 0 in Maya cyclical conception (Montgomery 2002: 62–3); (c) JUN, a variant of numeral 1; (d) CHA', a variant of numeral 2; (e) LAJUN, a variant of numeral 10. Definitions (except where indicated) and drawings by Martha Macri & Matthew Looper, courtesy of the Maya Hieroglyphic Database (Looper & Macri 1991–2025). The drawing images have been digitally upscaled from the database originals

However, the results are unanticipated. In prior studies of ancient figural art, no proposal has been made for a numerical hand-sign system. Within the vast literature on Altar Q, there is no assertion that the depicted rulers convey readable information. Amongst known numerical notation systems, there are no other symbols that are represented by opaquely coded hand signs (Chrisomalis 2010). Altar Q's graphic hand signs are even unusual within the context of what is currently known about numeracy in signed languages, where the use of fingers and handshapes are typically based on readily accessible systems of quantitative reasoning (Bender & Beller 2012).

The decipherment is nevertheless supported by multiple independent lines of evidence, each of which was developed from a general decipherment constraint, as presented in Table 1. Each constraint is particular to the relationship between graphic hand signs and hieroglyphs, the multimodal nature of Ancient Maya texts, or the affordances presented by the scribal design and composition of Altar Q. For the most part, the sources of evidence are ontologically independent, which allows for cross-verification. Importantly, because multiple pieces of evidence are numerically derived, verification is supported mathematically. Table 1 categorises the evidence into three thematic groups. The group labels are shortened versions of subsection titles under which the analyses and evidence are elaborated throughout the main section of this paper. These subsections are organised to showcase the process by which I deciphered the numerical hand signs. I set up the main section by first providing an exposition of presumptions about the Ancient Maya graphic hand signs that underly my decipherment approach and methodology. I then describe the point of departure for my work with Altar Q, followed by a formal analysis of its graphic hand signs.

2. DECIPHERMENT PRELIMINARIES

The approach that I used with Altar Q to decipher its graphic hand signs was guided by a set of well-supported presumptions. The core presumption, as stated and supported in the introduction, is that at least some of the hand forms found in Ancient Maya figural art are graphic hand signs (as opposed to depictions of gestures or iconographic embellishments). Other presumptions suggest the need for a somewhat different approach than the state of the art within Maya epigraphy, especially concerning linguistic analysis and evidence (see

Table 1. Constraints and evidence for the decipherment of Altar Q's graphic hand signs

Short section title (section no.)	Constraint type	General summary of evidence
Isomorphisms (section 6.1)	Relationship between strings of inscribed symbols	Sequential patterns of Altar Q's graphic hand-sign forms are isomorphic to hieroglyphic numerical patterns typical of Long Count dates
Isomorphisms (section 6.2)	Formal relationship between script symbols	Two of Altar Q's recurrent hand-sign forms are isomorphic with handshape imagery in hieroglyphic variants of zero
Isomorphisms (section 6.3)	Textual format	Altar Q's design includes a format for Long Count dates with other specific qualities, configured for each of Altar Q's four side panels
Calendrical and Directional References (section 7)	Multimodal-text type complementarity	Expressions of Long Count dates are expected but missing from Altar Q's hieroglyphic inscription (and so a likely type of expression displayed by the hand signs)
Calendrical and Directional References (section 7.1)	Key attribute	The hieroglyphic content and design of Altar Q highlight dates with a certain 16-based numerical quality (and so dates in this class are candidate information encoded by the hand signs)
Calendrical and Directional References (section 7.2)	Multimodal-text information complementarity	Specific dates (e.g. certain ruler death dates) are expected but missing from Altar Q's hieroglyphic inscription (and so are candidate information encoded by the hand signs)
Calendrical and Directional References (sections 7.2 and 7.3)	Symbolic framework	Dates with discourse relevance to Altar Q expose calendrical structures within the 9th Bak'tun (and so dates and numerological relationships highlighted by these structures are candidate information encoded by the hand signs)
Calendrical and Directional References (sections 7.2 and 7.3)	Intertextual network	Altar Q's cosmologically oriented foursquare design and position within Copán's West Court provides a directional and relational index for nearby monuments and their discourse-relevant content (and so this content provides candidate information and/or support for what the hand signs particular to each of the four side panels encode)
Equations (section 8)	Multimodal-text information complementarity	Two obscured distance numbers in Altar Q's hieroglyphic inscription are not mathematically satisfied by pairs of dates within the inscription, thereby providing a direct indication of apparently missing dates (and so the missing dates are candidate information encoded by the hand signs)

Houston et al. 2001). These presumptions are thus better situated within a more general framework for archaeological decipherment. I therefore draw on Zender's 'five fundamental pillars' for decipherment (2017: 2–4). The pillars are each based on a type of evidential information that supports decipherment work and thereby has helped distinguish successful efforts from unsuccessful ones. For the sake of clarity, I pose each pillar as a focused question.

2.1. Pillar one

How do the graphic hand signs encode meaning? Typically, you can infer much about how the symbols of an undeciphered script encode meaning by taking a tally of the symbols. Logograph-heavy scripts, like the Chinese character script, have a much higher count than phonograph-heavy scripts, like the Roman alphabetic script. However, this method is based on scripts that reflect vocally produced languages. It cannot be applied to a script that more so reflects a signed language. Unlike the phonological units of vocal speech, hand signs are not linearly segmented and therefore cannot be counted in the same way. Rather hand signs consist of features, such as handshape and hand placement, that are produced simultaneously to encode a word or other semantic unit (Liddell 2003: 6–14). A comprehensive analysis of

hand forms in Ancient Maya figural art should start with a systematic examination of all potentially relevant features (see also Fox Tree 2016). Prior research has instead tended to focus just on handshape or a conflation of handshape and hand orientation, without accounting for other features.

A related concern is whether the hands depicted in Ancient Maya figural art represent contemporary communicative practices or if instead they are symbolic forms with their own unique graphic conventions. The distinction is critical. If symbolic, a graphic hand sign can be read unambiguously based on its observable features, as with a string of letters. If representational, a graphic hand sign is merely a snapshot of a more extensive manual action, which thereby obscures our perception of (and ability to analyse) the full form (see Ancona-Ha et al. 2000; Fox Tree 2016). There is no doubt that graphic hand signs originated early on as aspects of figural representation. However, the Ancient Maya scribal tradition spanned at least two millennia. Given the importance of figural art to this tradition, it is likely that scribes would have formalised hand-sign expressions, developing them into purely graphic symbols. This evolution would parallel the emergence of hieroglyphs from pictograms. Each graphic hand sign should thereby encode meaning as a semantically and formally coherent constellation of identifiable non-linear features.

2.2. *Pillar two*

Is the collection of hand-sign script samples extensive and diverse enough to enable the assessment and validation of decipherment proposals across numerous contexts? The corpus of Ancient Maya texts is vast, and within it, graphic hand signs are quite common. However, our limited understanding of their conventions and features results in a noisy corpus (see also Ancona-Ha et al. 2000; Bishop & Cartmill 2020). The variation in form is extensive. Compounding factors likely include textual genre, subtle changes in scribal traditions, and the stylistic choices of individual scribes. An additional factor is the fact that a given graphic hand sign also functions iconographically as the hand of a depicted figure, and so the hand may also be manipulating an object or gesturing. Initial efforts to decipher the hand signs should thereby work within a highly controlled analytical environment.

2.3. *Pillar three*

Is anything known about the hand-sign script's underlying language? Evidence suggests that the ancient hand signs have some relationship with modern indigenous American signed-language practices (see Fox Tree 2009). However, there is insufficient evidence to support a familial linguistic relationship, like the relationship between the language of Maya hieroglyphs and modern Mayan vocal languages (Safar 2019: 34–6). It is safer to assume a less-direct relationship, one constituted by a uniquely indigenous ideological tradition in which signed-language practices are not exclusive to deaf communities and not marginalised as inferior to vocal speech. This tradition is an areal phenomenon, documented throughout Mesoamerica (Fox Tree 2009; Safar 2019) as well as in North America (Davis 2016), especially throughout the Great Plains (Davis 2010; Mallery 2011 [1881]). There is also documentation of indigenous American rock art that reflects signing practices and thus the further extent of this tradition (see McKay-Cody 2019). The proliferation of Ancient Maya texts with hand-sign-rich figural art suggests they also held to this tradition. Thus, while this ideology seems to link the Ancient Maya hand signs with modern Mesoamerican signed languages, there is no compelling reason to presume a strong connection between the underlying languages. The ancient hand signs may instead have comprised a specialised

language or subsystem of meanings that, along with many of the Ancient Maya calendrical systems, political structures and architectural styles, largely fell out of use by colonial times.

Modern documentation of the indigenous signing tradition has further implications for the hand sign's underlying language. This comes from observations that complex interrelationships between vocal and signed languages have manifested in practices of simultaneous use (Davis 2011; Safar 2019). The record demonstrates how signing and vocal speech can be employed simultaneously to reinforce each other's meaning or express distinct yet complementary types of meaning (Farnell 2002). The distinct modalities can also be integrated into grammatically coherent expressions (Sandoval 2014). Ancient Maya scribes likewise constructed their texts with a high degree of integration between hieroglyphic writing and figural art with hand signs. This aspect of the indigenous signing tradition supports the presumption that the hieroglyphic and hand-sign scripts complement one another within a unified writing system. Given this relationship, it should be possible to glean the language (or subset of meanings) of Maya graphic hand signs from the hieroglyphs.

2.4. *Pillar four*

Is there a comprehensive understanding of the type of information that is conveyed through hand-sign inscriptions? The nature of Ancient Maya texts is relatively well understood due to the mostly readable hieroglyphs. Given the relationship between hieroglyphs and graphic hand signs (as supported within section 2.3), the hieroglyphic inscription of a specific text should guide expectations for the content of the accompanying graphic hand signs. However, because hand signs are relatively few but so visually prominent compared to the hieroglyphs within a given text, hand signs should be expected to convey information that is limited in scope and yet highly significant, such as names of high-status individuals, calendar dates or cosmologically based events.

2.5. *Pillar five*

Is there evidence for a decipherment of any of the Ancient Maya graphic hand signs? The strongest decipherment evidence comes from known information that serves to constrain possible proposals and thereby guard against speculation. The gold standard is a bscript or bilingual text, which comprises two inscriptions that convey the same information, albeit in different scripts, with one being the undeciphered target and the other being readable. Because Maya texts typically contain a much greater number of hieroglyphs than graphic hand signs, there are likely no true bscripts in the corpus.

However, if graphic hand signs have a complementary relationship with hieroglyphs, there are many other possible decipherment constraints. As discussed (section 2.4), the salient information of a given text is one source. However, a more specific constraint can be revealed by what a text might imply about its hand signs. Most significantly, this can be drawn from information that appears to be absent from a hieroglyphic inscription (when compared to similar texts). Such information (e.g. a specific name or date) would be a strong candidate for what is encoded by the accompanying hand-sign inscription. Another source of constraints are isomorphisms resulting from the long history of interrelationship between hieroglyphs and graphic hand signs. Thus, when handshape imagery from a hieroglyph matches a hand sign's handshape, the hieroglyph's meaning provides a candidate for what is encoded by the hand sign. Isomorphic properties can also arise because graphic hand signs and hieroglyphs convey identical types of information. This would result in sequential patterns of script forms that are common across both hieroglyphic inscriptions and lengthy hand-sign inscriptions. Because hand signs are not rooted in vocal language, candidate patterns would be derived from

sequences of semantically (not phonologically) grounded hieroglyphs, such as logograms, calendrical names and numerals.

While no single constraint for the decipherment of Maya hand signs would be as conclusive as a true biscript, the presumed constraints are ontologically independent of one another and would be quite compelling when considered collectively. A Maya text with a long hand-sign inscription would likely contain various constraints, allowing for cross-verification of evidence. Such a text should be at least as effective for decipherment as a biscript.

3. ALTAR Q PRIORS

Modern scholarship on Altar Q is quite extensive. It has been highlighted in, if not the focus of, countless articles and books. What follows is an overview of prior work, with special attention to the epigraphic reading of the monument's hieroglyphic inscription. This is not an exhaustive review but rather a snapshot of a large, varied and developing body of work taken at the onset of the present work.

3.1. *General text*

Altar Q is shaped like a thick table with the main hieroglyphic inscription on the topside and, depicted around the four side panels, figures enacting a fire ceremony. The foursquare design is orientated to the cardinal directions. Within the scholarly record, it was first designated as an 'altar' by a guide of explorer John Stephens in the mid-19th century (Stephens & Catherwood 1969 [1841]). The guide, who was indigenous to the site area, was certainly Ch'orti' (Maya) and thereby a direct descendant of the Classic Copán Maya. This ethnographic recognition of Altar Q's ancestral purpose was not just a matter of cultural memory. Its shape and directional orientation are also defining characteristics of altars used in highly sacred Ch'orti' rituals (Wisdom 1940; Girard 1995 [1966]; Hull 2011). With the cosmological implications of the orientation and fire symbolism, Altar Q can be grouped more broadly in the Maya world with altars used for foundational dawning rituals (e.g. Cojtí Ren 2021). The ritual nature of Altar Q's design is furthermore indicated by its placement in front of Copán's largest pyramid (Figure 3b), which is underscored by the symbolic connections and architectural coordination between the two (Taube 2004; Herring 2014). Notably, the pyramid functioned as the tomb and instrument of apotheosis for Classic Copán's dynasty founder, Yax K'uk' Mo', while Altar Q's text focuses primarily on him, his dynasty and associated rituals. The dynasty included 16 rulers in total, and it is their depictions that adorn Altar Q's side panels. Each ruler is holding a torch and otherwise embodying a Teotihuacan ritual for the succession of the founding fire (Taube 2004). Each ruler is also seated on a throne that is simultaneously an iconographically embedded identifying hieroglyph, and they are all arranged in line by order of dynastic succession. The ordering also reinforces the rulers' enumerated (alternate) identities, starting at centre left of the West Panel with the founder, Yax K'uk' Mo', as Ruler 1 (R1) and continuing to his right (clockwise from above) all the way around to R16 (Schele 1986; Stuart 1992). The West Panel features R1 in face-to-face communion with R16 (also known as Yax Pasaj Chan Yop'aat).

The main hieroglyphic inscription is composed of 36 blocks (Figure 5). It also features R1 and R16, highlighting a founder ritual, another ritual involving both rulers and the altar itself, and the nearly 400-year dynastic reign that is bookended by the two rulers and these two rituals (Stuart 2004a). Much work has gone into the reading of this hieroglyphic inscription, with the lion's share of credit going to David Stuart, who has taken the position that the inscription is atypically complex and was possibly constructed to allow several interpretations

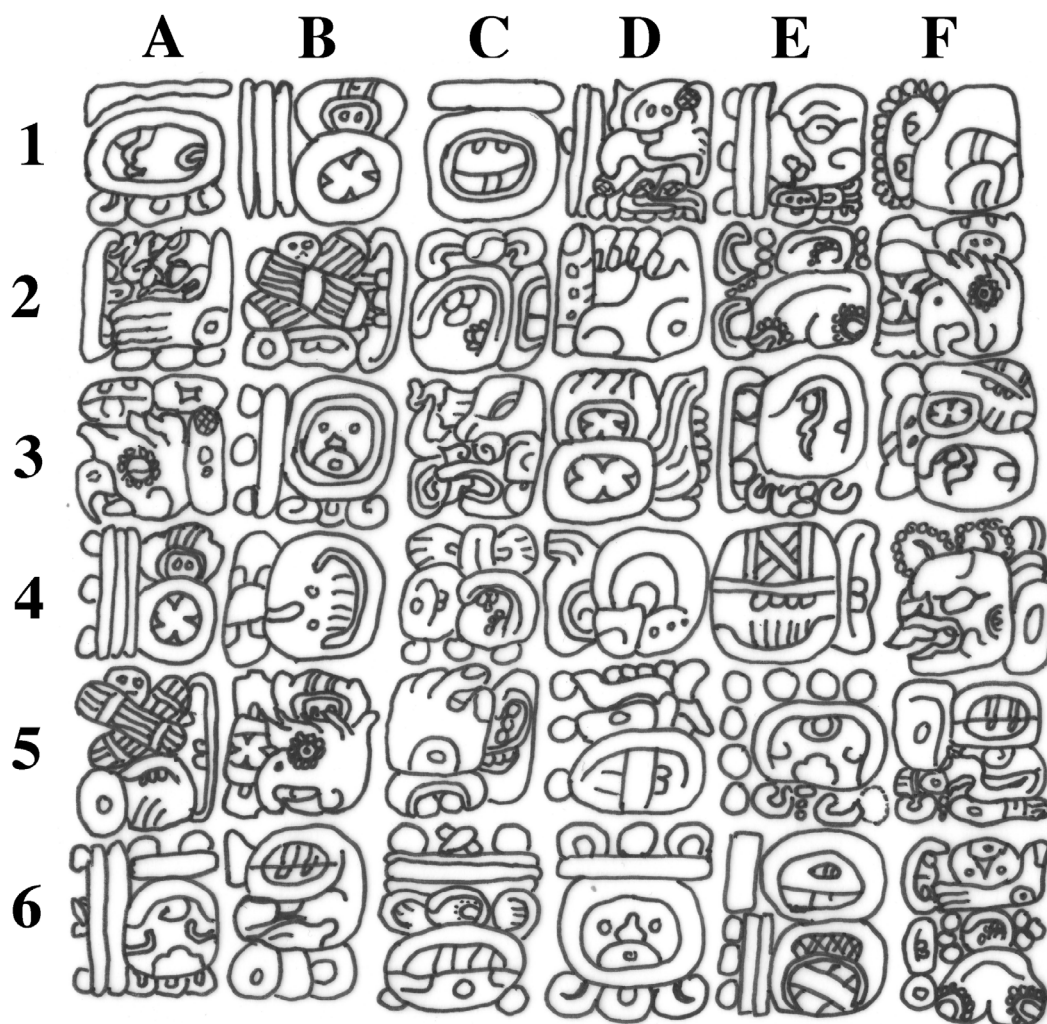


Figure 5. Altar Q's upper hieroglyphic inscription and block coordinates. Basic reading order is left to right, in double columns (i.e. A1, B1, A2, B2, ...). Drawing by author

(Stuart 2004a: 239). Nevertheless, a standard (linear) reading, as provided in Table 2, is mostly coherent, with two main passages that each highlight a ritual.

The first passage (blocks A1–D5) takes place in the second quarter of the 5th century CE and refers to a founder ritual, wherein R1 takes a series of actions that transform him from a basic lord to a dynastic founder with deity-like status, as reflected most notably by the block-B5 addition of K'inich 'Sun God' to his title (Stuart 2004a: 233). A sculpture depicting the founder as K'inich overlooked the altar from the main stairway of his nearby pyramid tomb. This transformation involved his procurement and use of a K'awiil effigy sceptre, K'awiil being a serpent-footed deity who enables communion between the earthly and celestial sphere of Maya cosmology (Schele & Grube 1992). He gets K'awiil from the Winte' Naah origin house (blocks A2–B2), which is associated with Teotihuacan authority and is thus important for this dynastic-founding ritual (Stuart 2004a: 238). The phrase C2, D2, C3 might have multiple readings. Because D2 can mean 'foot', the phrase might refer to the ritual action of

Table 2. Transcriptions and gloss translations for Altar Q's upper hieroglyphic inscription (Calendrical expressions in standard form with GMT correlation, see Stuart 2020b. Other information from Maya Hieroglyphic Database,Looper & Macri 1991–2025)

Blocks	Transcription	Gloss
A1, B1	5 Kab'an 15 Yaxk'in	September 3, 426 CE
A2	nah ch'am k'awiil	first taking of K'awiil
B2	wiinte' naah	Winte' Naah
A3	k'uk' mo' ajaw	lord K'u'k' Moo' (R1)
B3, A4	8 Ajaw 18 Yaxk'in	September 6, 426 CE
B4	tali	he comes/arrives (here)
A5	wiinte' naah	Winte' Naah
B5	k'inich yax k'uk' mo	K'inich Yax K'u'k' Moo' (R1)
A6	13 K'ins 7 Winal	153 days
B6	i uhti	and then it happens
C1, D1	5 B'en 11 Muwan	February 6, 427 CE
C2	hili	rests
D2, C3	ook k'awiil	Ook K'awiil
D3	ochk'in	West
C4	kalo'mte'	kaloomte'
D4	yitaa	in his company
C5	huuli	arrives
D5	hux wintik	Hux Wintik (Copan)
C6	17 K'atuns	~335 years
D6, E1	6 Ajaw 13 K'ayab	December 23, 775 CE
F1	t'abaayi?	appears 'ascends'?
E2	yahk'ol	above
F2	k'inich yax k'uk' mo'	K'inich Yax K'u'k' Moo' (R1)
E3	ukabjiy?	under his authority?
F3, E4, F4	yax pasaj chan yop'aat	Yax Pasaj Chan Yop'aat (R16)
E5	4 K'ins 3 Winal	64 days
F5	uhti y i uhti	it happened and then it happens
E6	5 K'an 12 Wo	February 25, 776 CE
F6	uch'amal te' kojbaal?	his taking of the wood? image?

R1 putting down the serpent foot of his K'awiil effigy sceptre (Schele & Grube 1992). Or blocks C2 and D2 may together give *hil okel* 'the leg resting', an idiomatic phrase indicating the end of R1's 153-day journey with his new K'awiil sceptre (Stuart 2004a). Near the end of the passage, R1 is referred to as Western Kalo'mte' (blocks D3–C4), an alternate title indicating his power and authority, specifically in relation to Teotihuacan (Martin 2020: 80). Blocks C5 and D5 together mark the end of R1's founding ritual with his arrival to Copán, thereby initiating his Copán dynasty (Stuart 2004a: 238). Given the association of this arrival (as indicated by block C5) with other powerful arrivals and founding moments in the Maya world, the event specifically refers to the establishment of a new political order and the kind of change that results from the introduction of ordained power (Martin 2020: 125).

The second passage is marked by block C6, which moves the text's temporal grounding 340 years forward to the final quarter of the 8th century CE, a time contemporaneous with the altar's construction. The second passage refers to a 64-day ritual that involves Altar Q itself. During this ritual R16 places an effigy above the founder's tomb (blocks E2–F2), which is located under the nearby pyramid (Stuart 2020a). Blocks F1–F2 may also refer to R1 being dead in the earthly sense but very much alive in the celestial realm, with agency and ability to give mandates well after his corporeal existence (see Fitzsimmons 2009: 117). This perspective would indicate that R1 is directing the actions of R16, as suggested by blocks F2–F4 (see Houston & Martin 2016: 449). After a specified 64 days (block E5), R16 takes the effigy away (blocks F5–F6).

3.2. *Calendrical expressions*

The two primary calendars used by the Ancient Maya were the ‘Calendar Round’ and the ‘Long Count’. The Calendar Round is a combination of two sub-calendars. The ‘Tzolk’in’ is a cycle of 260 days, each with a unique number-name combination given its synchronisation of an enumerated 13-day cycle and a cycle of 20 named days ($13 \times 20 = 260$). The ‘Haab’ is a cycle of 365 days, each with a unique number-name combination given its 18 named months of 20 days each and one month of 5 days ($18 \times 20 + 5 = 365$). The Calendar Round synchronizes the Tzolk’in and the Haab’ together into a grander cycle of 52 years, each day of which has a unique set of number-name combinations. Each sub-calendar component of a Calendar Round date is typically expressed as a bar-and-dot numeral and name hieroglyph. The Calendar Round provided a human-scaled temporal structure through which a calendrical quality of a ruler’s ascension, death, or other milestone could resonate with that of a past or future ruler (Whitmore 2012). The Long Count cycle operates on a much larger scale, effectively counting days in an absolute linear sense and giving every day a unique set of number-name combinations. The basic system involves five synchronized cycles, each named for its patron deity: ‘K’in’ (1 cycle = 1 day), ‘Winal’ (1 cycle = 20 K’in cycles = 20 days), ‘Tun’ (1 cycle = 18 Winal cycles = 360 days), ‘K’atun’ (1 cycle = 20 Tun cycles = 7,200 days) and ‘Bak’tun’ (1 cycle = 20 K’atun cycles = 144,000 days $\approx$ 400 years). A Long Count date is typically expressed starting with the largest subcycle, each subcycle represented by a bar-and-dot numeral and name hieroglyph. The Long Count’s cosmological nature is underscored by a ‘period ending’, which has zero counts on at least the two smallest subcycles and thereby marks a major cyclical incrementation (as an action of the respective patron deity). Period endings were thereby understood as opportune moments for rulers to commune with cosmological forces and help manage a proper cyclical renewal (Stuart 2020b: 645). Because a Calendar Round date has a specific corresponding Long Count date for any given day, a date inscribed solely in Calendar Round form implies the corresponding Long Count date (and vice versa).

A calendrical concept related to the Long Count is the ‘distance number’, which is not a date but rather a stated interval of days. Because a distance number usually defines the interval between a prior and subsequent date, a distance number and its endpoint dates are terms in an equation. Thus, given a single date and a distance number, another date is implied. Distance numbers are typically partial Long Count expressions given in reverse order (starting with the smallest subcycle). In some texts, intervals have internal structures that resonate with calendrical qualities particular to their discourse context (Aveni 2011). It is important here to note the distinction between ‘distance’ and ‘count’. The mathematical distance between dates *A* and *B* is a number (*n*) given by their difference ($B - A$). The count from dates *A* to *B* encompasses all the days within that set ($[A, B]$), and so its value is one more than that of the distance ($n + 1$).

All six calendrical dates in Altar Q’s hieroglyphic inscription (including the stand-alone date on the West Panel) are given as Calendar Round expressions. There are no Long Count expressions in the hieroglyphic inscription, giving it a typologically abnormal quality (Herring 2014: 217). However, the relevance of the Long Count to the inscription is demonstrated by Table 3’s transcription of the boundary dates for Altar Q’s 64-day ritual wherein the start date is notable for its implied Long Count date, which is a period ending. The momentous start of the 9th Bak’tun (9.0.0.0.0) is also heavily implied by Altar Q, given that the dynasty’s span, as indicated by the text, coincided with the beginning and end of this Bak’tun (Stuart 2004a).

Beyond the Long Count peculiarity, the hieroglyphic inscription presents the additional oddity that block C6 (17 K’atuns) is likely a distance number, even though it would be an

Table 3. Corresponding start and end dates for Altar Q's 64-day ritual

Blocks	Long count (<i>implied</i>)	Calendar round (<i>inscribed</i>)	
	Bak'tun.K'atun.Tun.Winal.K'in	Tzolk'in	Haab'
D6, E1	9.17.5.0.0	6 Ajaw	13 K'ayab
E6	9.17.5.3.4	5 K'an	12 Wo

abnormally imprecise indication of the interval between prior and subsequent dates (see Stuart 2018). The 64-day ritual, explicitly anchored to its 64-day interval by a distance number (block E5), has yet other consequential implications. First, the period ending that initiates this ritual (9.17.5.0.0, GMT December 23rd 775 CE) was a few days after the winter solstice, which is a cosmologically important time, especially for Classic Copán (see Freidel et al. 1995: 85–7). Second, 64 ($= 4 \times 4 \times 4$) may relate to the cosmological foursquare symmetry of the monument (Stuart 2004a: 239). Third, because the distance interval is 64, the count is 65 days, which is a quarter of a full Tzolk'in count ($65 \times 4 = 260$). A Tzolk'in quarter or 'Burner Period' is 'one of the seminal Maya divisions of time', involving fire ceremony and agricultural concerns (Aveni 2011: 199). Fourth, at the absolute centre of the 64-day period is the end of the special 5-day 'Wayeb' month of the Haab' calendar. This month 'was the single most important ritual period of the year among the Maya prior to the Spanish Conquest' (Christenson 2016: 16). Special observances were made during this month of death and disorder to ensure a rebirth of the world at the onset of the Haab' new year, which directly follows. Finally, the 64 days encompass two important new year events that, particular to 776 CE, were ritually ideal: the Haab' New Year (at the seating of Pop, see Stuart 2004b) (GMT January 24th 776 CE) and, 15 days later (GMT February 8th 776 CE), the initiating rites for the new agricultural year, which were designated to occur annually on February 8th by their Ch'orti' Maya descendants (Girard 1995 [1966]: 19). These two moments were ritually ideal because there was a rare conjunction of a new moon with that Haab' New Year and a rare conjunction of a full moon with that February 8th (for a table of ancient moon phases, see Espenak 2014). Importantly, the period of the solar year defined by the days around February 8th had deeper associations with cosmological creation or dawning by the Classic Maya (Freidel et al. 1995: 69, 95, 97). Indeed, Altar Q indicates that the rise of K'inich Yax K'uk' Mo' as Copán's dynastic founder occurs at this special time, given by blocks C1–D1 as the date 5 B'en 11 Muwan (GMT February 6th 427 CE).

4. OBSERVATIONAL MATERIALS

My primary observational text was Altar Q itself, housed in the Copán Sculpture Museum. I also used a variety of representational materials. Notably, I created a three-dimensional scale model that was big enough to clearly see all textual elements, yet small enough to hold and rotate. I also made frequent use of high-resolution photographs. Nevertheless, access to the actual monument was crucial because many of the monument's hand forms are slightly ruined but leave trace indications of their original form.

To observe specific dates and calendrical behaviours, I created a spreadsheet of the 9th Bak'tun's 144,000 days. Each day is a row, populated with its corresponding Long Count and Calendar Round components. Each of the five Long Count subcomponents and four Calendar Round subcomponents are separated and defined as columns. To build the spreadsheet, I created a formula for each cell of the first row based on that subcomponent's functional dependency on other calendrical subcycles (see Appendix A in Supporting

Information). The formulas thereby enable the generation of a list of dates by row. With this capability, I created a list of the Long Count and Calendar Round components for each of the 144,000 days of 9th Bak'tun. There is evidence that the Ancient Maya made use of similar long tables of day-by-day counts to do their calculations (Saturno et al. 2012). With the spreadsheet, I was able to create sophisticated search functions to find and mark dates with specific Calendar Round and Long Count qualities and then examine their relationships and distributions. As a supplementary tool for quicker basic calculations but with a much broader calendrical scope, I used 'Bars & Dots Online, A Maya Calendric Computer' (Barnhart & Neel n.d.).

5. FORMAL ANALYSIS OF ALTAR Q'S HAND SIGNS

To analyse the forms of Altar Q's graphic hand signs, I focused on the features of handshape, hand placement and hand orientation, assuming manual-exclusive articulation (see Liddell 2003: 6–14). Formal attributes of hand signs within other Maya texts might suggest other features, including hand movement and facial form (see Fox Tree 2016). However, as we see in Figure 6, the rulers depicted on Altar Q have nearly identical facial expressions and there are no illusions of movement.

An additional complexity is that the hand-and-arm configuration of each ruler includes a torch-grasping hand and a free hand. With two exceptions (R1 and R14), the right hand is grasping, and the left is free. Because R1 was depicted accurately with no right hand and because of how he is engaging to his left with R16, R1's left grasping hand is a special case. Handedness therefore lacks significant variation. However, the pragmatic distinction between a free and grasping suggests that free hands may be more constitutive of hand-sign forms. However, this is not a given. One-handed and two-handed hand signs are both possible in any living signed language. Thus, for each ruler, I needed to be able to account for any of three possibilities: A single hand sign constituted by one hand; Two distinct hand signs, one constituted by each hand; Or a single hand sign constituted by both hands, likely with one hand being dominant. In analysing handshape, placement and orientation, I therefore treated rulers' free hands separately from their grasping hands and compared them, when applicable. Additionally, for each feature, I worked to define salient parameters with respect to how Altar Q's hand forms display similarity and difference. Where this is not clear, notably for the feature of hand orientation, I erred on the side of etic detail, given contrastive distinctions expected in the manual articulation of hand signs in a signed language. Additionally, the legibility of some handshapes is questionable due to ruin. Interestingly, much of the ruin appears to be the result of a contemporary ritual destruction of Altar Q. It is notable that most of this intentional destruction seems to have been targeted on the figural hand forms.

The analytical framework and descriptive classifications for hand placement and hand orientation are outlined in Figure 7a. Handshape terminology and classification is provided in Figure 7b. The complete formal analysis is provided in Appendix B in Supporting Information.

A comparative examination of the hand forms provides some important insights for how they might constitute hand signs. Overall, grasping-hand forms reveal graphic potential, despite their depicted torch-grasping function. However, as expected, free hands have more of the formal distinction and distribution expected of hand signs and script symbols, respectively. This is especially the case with handshape, in that only the free hands have some of the more visually distinctive shapes (e.g. FlatB, ModA, LaxG) and, overall, free hands involve a larger variety of handshapes, which are additionally more evenly distributed. It is evident with hand placement and orientation too. While free-hand placements and orientations are evenly distributed as expected of script symbols, grasping hands have a very

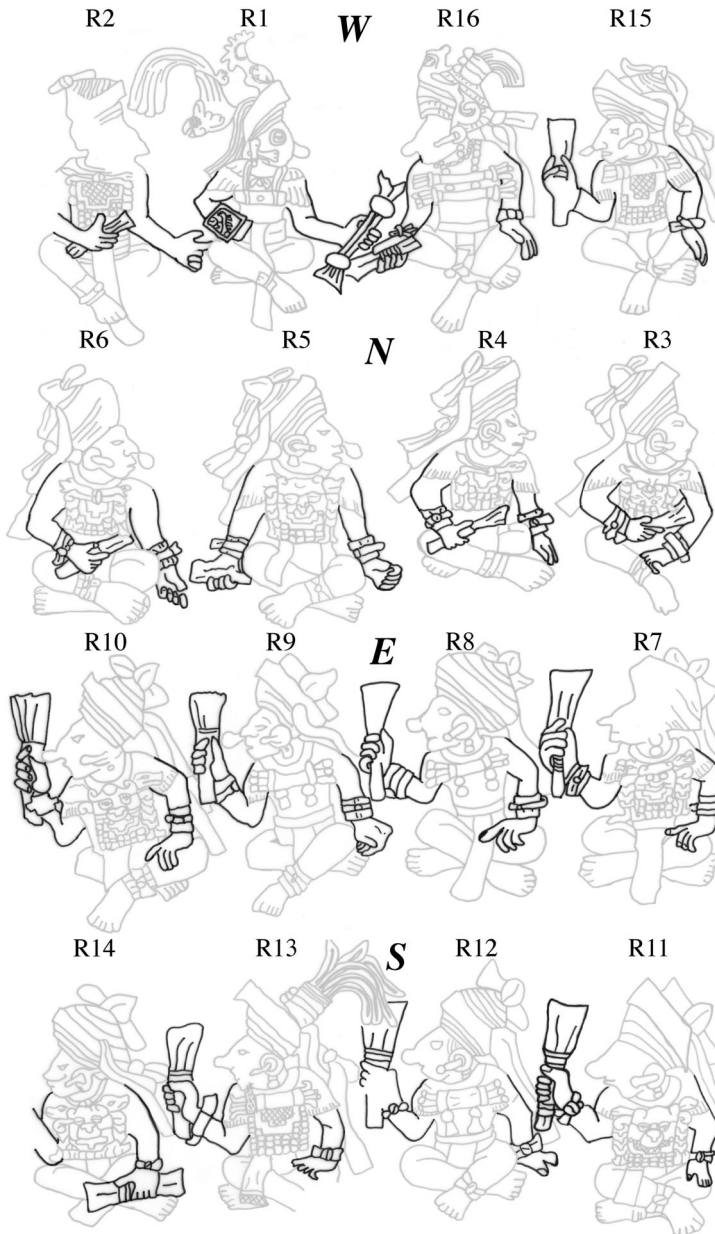


Figure 6. Altar Q's rulers in isolation with hand forms highlighted. Above each ruler is his enumerated dynastic-succession title. Above each panel-based group of four is the panel-facing direction. Drawing by author

large cluster of seven hands that are placed up with orientations that face forward and point outward. More importantly, when handshape, placement and orientation are considered together, we find a few relatively large sets of identical forms amongst both free and grasping hands. The distribution of these recurrent forms reinforces how free hands pattern more so like script symbols. Amongst free hands there are only two instances of a recurrent form in a

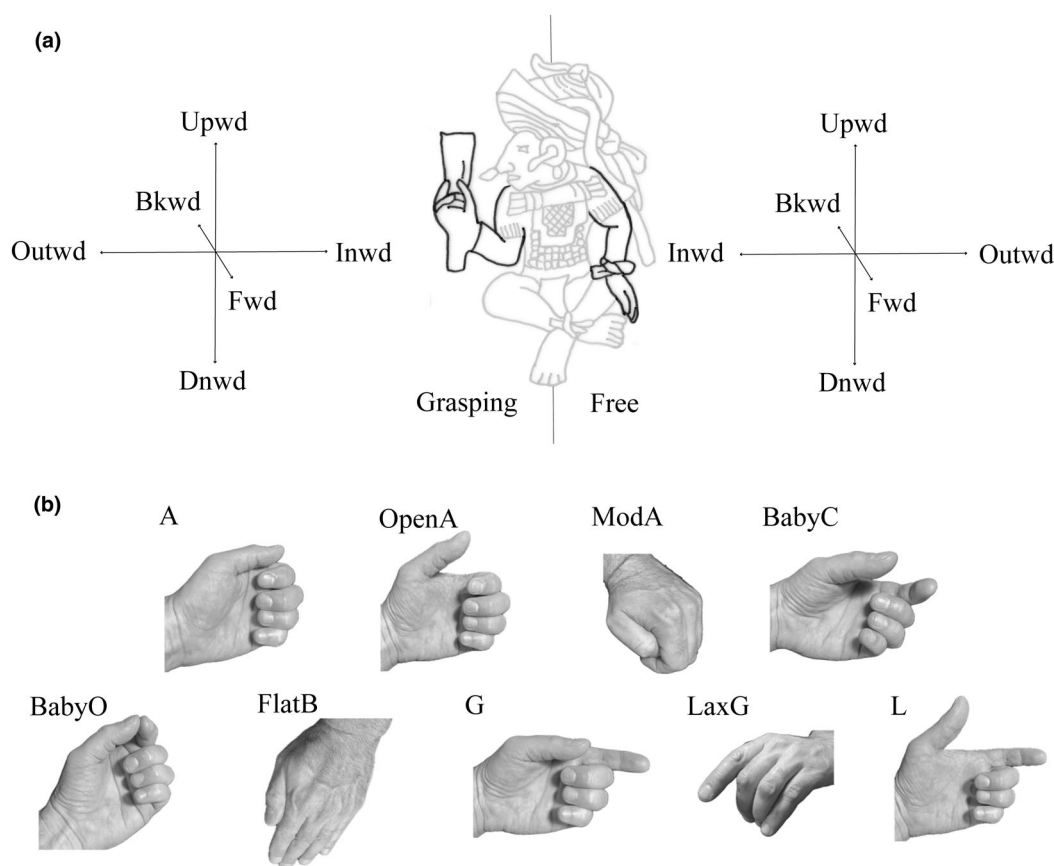


Figure 7. Framework and terms for formal analysis of Altar Q's rulers' hands. Analytical terms and their abbreviations given here are used in the table of Appendix B in Supporting Information, which provides a complete formal definition of features for each set of hands. (a) R15 is used for example. A ruler's hand is defined by its status as grasping a torch or free. The heel of a ruler's hand defines the salient locus of hand placement. Possible placements are up at shoulder level, down and to a body's outside, on the knee and in the lap area. R15's grasping hand is placed up and his free hand is placed on the knee. A hand orientation is defined by two dimensions: the direction the palm is facing and the direction the hand is pointing, from heel to knuckles. Orientation directions are defined with respect to the median, horizontal and frontal body planes. The dotted line running through R15 indicates his median plane. His chest defines the frontal plane. Basic orientations are indicated in their abbreviated forms by the graphical projections to either side of R15. Angled orientations are indicated with a slash between the bisected planar orientations. R15's grasping hand is oriented with palm facing Fwd and palm pointing Outwd. The free hand is oriented with palm facing Inwd/Dnwd and pointing Outwd/Dnwd. (b) Salient Altar Q handshapes are designated in accordance with standardised ASL names. R15's grasping hand has BabyC shape and his free hand has a FlatB shape. (a) Drawing by author. (b) Photographs and hand modelling by author

cluster, and each of these clusters has only two members (i.e. R15 and R16 of recurrent set {R4, R11, R15, R16} and R7 and R8 of recurrent set {R7, R8, R10}). In contrast, amongst grasping hands, all members of each set of recurrent forms occur in a cluster (i.e. sets {R7, R8, R9, R10} and {R11, R12, R13}).

It is additionally notable that only R3 and R5 exhibit two-handed symmetry of placement. None of the rulers have symmetric (grasping and free) handshapes or symmetric hand orientations. Although, R3 and R5 are the only two with nearly symmetric handshapes and orientations. Feature symmetry thus seems to be a graphic property that distinguishes the hand signs of R3 and R5 from the others. One implication of these forms being only nearly symmetric is that some of my analytical parameters may be overly granular. This is further supported by my analysis of R11's free hand as having an orientation that is wholly unique while only differing by a subtlety of bisection from the free-hand orientations of R4, R15 and R16. In both handshape and placement, however, R11's form is identical to these others. Thus, I consider these four free hands to constitute a set of recurrent forms. There is not enough of such evidence to further reconsider any other analysis. Another implication of R3 and R5 displaying feature symmetry is that, for at least some rulers, both sides of a hand-and-arm configuration may contribute to a hand-sign form. Although, the analysis makes it clear that a given free hand is the dominant hand, if not the sole component, of a hand-sign form (see also 'dominance condition' in Davis 2010: 138).

6. EVIDENCE FROM ISOMORPHIC RELATIONSHIPS BETWEEN MAYA HIEROGLYPHS AND ALTAR Q'S HAND SIGNS

With the results of the formal analysis, I focused on the free hands. R1, accurately depicted without a free hand, presented a potential complication. I therefore temporarily considered R1's hand form as an unknown factor and continued to assume 16 hand signs in total. I proceeded to expose evidence for hand-sign meaning by comparing the free-hand forms with hieroglyphic script patterns and individual hieroglyphic forms.

6.1. *Distributional analysis of hand-sign inscription*

By examining free hands sequentially, I found patterning exhibited by the two sets of recurrent forms: the FlatB set {R4, R11, R15, R16} and the LaxG set {R7, R8, R10}. Together, the two recurrent forms account for roughly half of the free hands, while the eight other free hands differ from one another by at least one of the three features. Each recurrent form also has one instance of sequential duplication. The FlatB form is duplicated by R15 and R16, while the LaxG form is duplicated by R7 and R8. Thus, highly recurrent and duplicate forms characterise this hand-sign inscription. In comparison to hieroglyphic patterns, we only see this type of recurrence and duplication in the 0 s of Long Count calendrical expressions. This is due to the importance of period endings, which manifest as Long Count dates with 0 s at the lower end. Thus, I presumed that FlatB and LaxG hand signs encode 0 s.

6.2. *Relationships with known hieroglyphic handshapes*

One potential problem with the distributional analysis is that it resulted in two distinct forms that each pattern like the 0 components of Long Count dates. However, Maya hieroglyphic writing characteristically has a high frequency of synonymic formal variants, and so we might expect this of Maya graphic hand signs. Moreover, each of the 0 hand-sign forms visually reflects a hieroglyphic variant for numeral 0:

- The FlatB handshape matches the hand imagery of a hieroglyph variant for K'AL 'to close' (which is synonymous with numeral 0) as seen in Figure 4b (see also Burdick 2010: 176–7).
- The LaxG handshape is identical to the hand imagery used in a regular glyph variant of 0 (see Coe & Stone 2005: 38) and nearly identical to the hand jaw plate of a head variant of 0, as shown in Figure 4a.

6.3. The side-panel Long Count format

Building on the preceding isomorphic evidence, I found that the graphic hand signs constitute four 9th Bak'tun Long Count dates, one on each side panel. Panel-facing direction and other design features index additional qualities about these dates. The general format for each panel is given by Figure 8.

The first bit of support for this Long Count format comes from the East Panel and West Panel each having the proposed doublet 0 hand signs on their right end, matching the end of a typical Long Count period ending. The implication is that each panel's hand signs encode the K'atun, Tun, Winal and K'in values of a Long Count date, read from left to right. The justification is as follows:

- Normal reading of hieroglyphic elements goes from top to bottom and left to right.
- Long Count period endings have 0 s for the lower values.
- Period endings are common Long Count expressions.
- The doublet positioning of 0 hand signs on the right end is repeated on two of four panels (with another panel having a single 0 hand sign on the right end).
- The symmetric design of Altar Q's panels suggests that each set of hand signs would encode the same type of expression.
- The hand signs with value 0 are in a panel-based complementary distribution, with the East Panel's LaxG hand signs being exclusive to that panel and the FlatB hand signs occurring on the other panels. This variational pattern highlights the panels as mutually exclusive contexts for the 0 hand-sign expressions.
- Although the hand signs are not accompanied by explicit indicators of Long Count periods (e.g. K'atun) as was the norm for Classic Maya hieroglyphic Long Count dates, there is precedent for Long Count dates without period indicators (see Stuart 2020b).

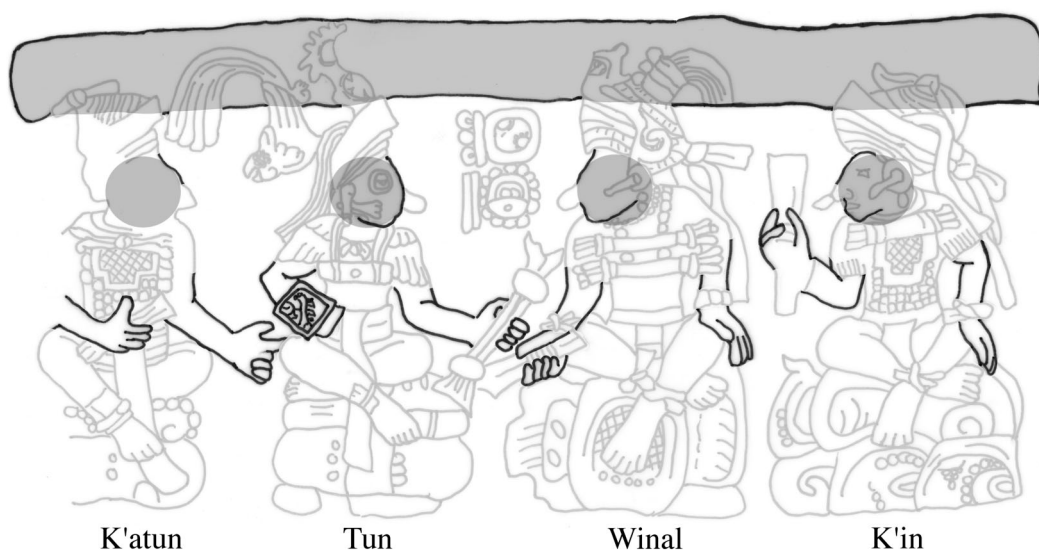


Figure 8. Altar Q's panel format for Long Count dates. The format is shown here for the West Panel. Each indicated Long Count subcycle is expressed above it by a ruler-based hand sign. As highlighted, the Bak'tun value in the format is an embedded bar-and-dot numeral 9, configured by rim and ruler heads. Drawing by Author

Second, the upper rim and four ruler heads of each panel constitute a perfectly well-formed hieroglyphic bar-and-dot numeral nine (Figure 8). A numeral 9, floating above four graphic hand signs, is a hieroglyphic embedding in the iconography of each side panel. Such ‘embedded texts’ are quite common throughout Maya and other Mesoamerican textual traditions (Berlo 1983). Altar Q is rich with hieroglyphic embedding, as clearly demonstrated by the title-identifying hieroglyphic thrones on which each rulers sits. Less obvious is the headdress of R1, which is composed of hieroglyphic elements that spell out his name (Stuart & Schele 1986). If each panel-set of hand signs constitute the four lower values of a Long Count date, the implication is that a panel’s iconographically embedded 9 is its otherwise missing Bak’tun value, giving the full Long Count format shown in Figure 8. Therefore, each side-panel would encode a hand-sign-and-hieroglyph hybrid Long Count date in the 9th Bak’tun, which is fitting given the high discourse relevance of the 9th Bak’tun to Altar Q. Moreover, as a matter of numerological design, the four embedded 9 s are further substantiated by how they mathematically resonate with the 36 hieroglyphic blocks of the upper inscription (i.e. $9 \times 4 = 36$).

A notable feature of the embedded numeral 9 s is that they are atypically formed hieroglyphic numerals, with the four dots below the bar instead of above it. Upside-down numerals are quite rare in the Classic Maya corpus. However, evidence suggests that Altar Q’s iconographically embedded 9 s index information related to the realm of the dead or, more generally, the Maya cosmological underworld:

- Altar Q’s embedded numeral 9 s are featured along with Copán’s deceased dynastic rulers on panels iconographically situated below the monument’s surface, whereas the surface inscription specifically highlights the earthly actions of two of those rulers.
- Upside-down hieroglyphic 9 s, in particular, are most commonly found in expressions of lunation lengths of 29 ($20 + 9$) for the lunar calendrical series. In this numeral variant for 29, the 9 is situated upside down under a moon-sign variant for 20. The moon itself is associated with the underworld.
- Number 9 alone had numerological significance in relation to the underworld, given a ‘Lords of Night’ 9-day calendrical cycle.
- Upside-down symbolism was used elsewhere in Classic Copán inscriptions in reference to death and ancestral shrines (Andrews & Fash 1992: 71–4).
- Ch’orti’ (descendants of Classic Copán Maya) also conceptualise the underworld as upside down (Hull 2011: 161).

Finally, because each side panel constitutes a squared background, each makes an ideal textual space for a discrete expression. Each space is also ideal in this way for its unique directional orientation, a distinction that is fundamental to Altar Q’s ritual design. On its own, the directionality indicates that the cosmological orientation of each panel has significance. Altar Q’s panels also are also directed at important architectural zones, given how it was situated on the floor of Copán’s squared West Court (Figure 3). This architectural directionality indicates intertextual relationships between Altar Q and surrounding monuments. Such an intertextual and directionally sensitive network is apparent by the known relationship between Altar Q and the founder’s pyramid a few feet to the east (the direction of the Sun’s dawning). Precedent at Copán for an extensive cosmologically oriented intertextual network comes from the discourse constructed by the multiple stelae of the Grand Court (see Newsome 2001). It follows that each panel’s Long Count date should have both a cosmological and architectural relationship in accordance with its panel-facing direction.

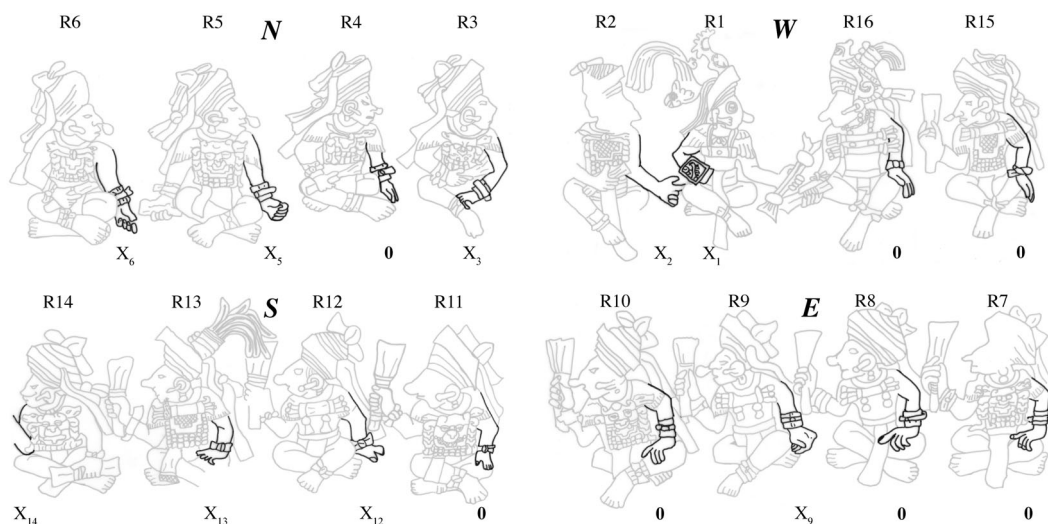


Figure 9. Numerical hand sign values, focusing on free hands and isomorphic evidence. Each ruler's free hand is highlighted, below which is the value of his hand sign from the isomorphic evidence. There are seven with 0 values, while the others do not have specific values deducible from isomorphic evidence. The non-0 values are designated as 'X' with a subscript according to ruler enumeration. However, each of the X values is known to be unique within the set of all X values (i.e. none of the non-0 hand signs are formally recurrent with one another, given handshape, hand placement and hand orientation). Drawing by author

6.4. Results

The analysis demonstrates strong isomorphic evidence that Altar Q's free hands, as the loci of graphic hand signs, have numerical value and they sequentially constitute four Long Count dates within the 9th Bak'tun. Specifically, seven of the hand signs have a value of 0 and the other nine are unknown (by the preceding analysis) but lack recurrence, as represented in Figure 9. Additionally, each date has some discourse-relevant connection with the underworld as well as the cosmological and architectural significance of its panel-facing direction.

7. EVIDENCE FROM CALENDRIAL AND DIRECTIONAL REFERENCES

Distinct support for the idea that Altar Q's hand signs encode Long Count dates comes from Altar Q's hieroglyphic inscription, in that it is abnormal for lacking explicit Long Count dates. The presence of Long Count dates in the hand-sign inscription resolves the abnormality. To constrain the field of candidates further from the results of the preceding section, as summarised in Figure 9, I examined the Calendar Round dates expressed in the hieroglyphic inscription with respect to their (implied) Long Count dates. Only three dates fall within the 9th Bak'tun, and only one of them has an implied Long Count date that matches a panel's isomorphically constrained 0 values. This Calendar Round date is 6 Ajaw 13 K'ayab (blocks D6–E1), which initiates the 64-day ritual period. Its implied Long Count date is 9.17.5.0.0, which matches the West Panel constraint (Figure 9). Stronger support for a match of the date to this panel would come from some type of link to a text that is to the west of Altar Q within the West Court. However, 9.17.5.0.0 has no clear association with the west but rather with the north, given that to the north we find Temple 11, the inscriptions of which

include this exact date and other related content (see Schele & Miller 1986: 123–6). This evidence suggests that Altar Q's hieroglyphic inscription and hand-sign inscription are not informationally redundant. Therefore, I looked to Altar Q's hieroglyphic inscription for implicit information about relevant Long Count dates within the 9th Bak'tun. Drawing on the evidence gathered to this point about Altar Q's scribal design and composition, I presumed the following additional constraints:

- The dates have some type of numerological resonance with some other aspect of the Altar Q text (as with the relationship between the count of topside hieroglyphic blocks and the iconographically embedded 9 s).
- The dates have an association with death or other aspects of the Maya cosmological underworld.
- Each date has cosmological relevance for its panel-facing direction.
- Each date has a potential cross reference to another monumental text that is within the local vicinity and pointed to by the date's panel-facing direction.

7.1. *Calendar Round sum as the key calendrical reference*

With this analytical framework for Altar Q, I made the crucial observation that it highlights a special date attribute: The Calendar Round sum of 16 (CRsum16), found by summing the two numerical coefficients of a Calendar Round expression. Although (to my knowledge) there is no precedent in the Maya corpus for the use of Calendar Round sums, ethnographic evidence supports a Maya creative practice of incorporating locally and situationally significant factors into the standard cosmological framework of a ritual (see Wisdom 1940: 374). Given the numerological weight of 16 for Altar Q via its enshrinement of Copán's 16 dynastic rulers, CRsum16 is an ideal calendrical quality for Altar Q's ritual-based discourse (see also MacLeod 2021: 176). It is prominently displayed by a pair of Calendar Round expressions situated in proximity, one (6 Kab'an 10 Mol $\rightarrow 6 + 10 = 16$) between R1 and R16 and the other (5 B'en 11 Muwan $\rightarrow 5 + 11 = 16$) directly above in the topside hieroglyphic inscription, as shown in Figure 10.

The upper Calendar Round expression marks R1's 'arrival' to Copán and ascension to dynastic founder, while the lower marks R16's ascension to dynastic rulership. The prominence of the ascension dates is highlighted by their spatially contiguous pairing and matching CRsum16s. They are also chronologically paired and centred amongst Altar Q's six Calendar Round expressions and, more importantly, are the only of the dates with CRsum16, as displayed in Table 4. Thus, CRsum16 resonates strongly with the numerological theme of Altar Q, it is visually highlighted at Altar Q's focal point, and it is contextualised exclusively with respect to the text's two primary rulers. I therefore presumed that these qualities were by-design indicators of CRsum16 as a calendrical code and thereby a key constraint for deciphering the four side-panel Long Count dates.

7.2. *The east panel and west panel*

On inspecting a list of important dates for all 16 Copán rulers, which is compiled in Table 5, I found a near absence of dates with a CRsum16. I also found a non-patterned distribution of Calendar Round sums with the notable exception of the dates for R1 and R16. Along with their ascension dates, they each have one other date with a CRsum16. That of R1 is his death date, 9.0.2.0.0 (Calendar Round 13 Ajaw 3 Keh $\rightarrow 13 + 3 = 16$), a date which might also be understood as his celestial apotheosis (Taube 2004). That of R16 is his death date, 9.19.10.0.0 (Calendar Round 8 Ajaw 8 Xul $\rightarrow 8 + 8 = 16$).

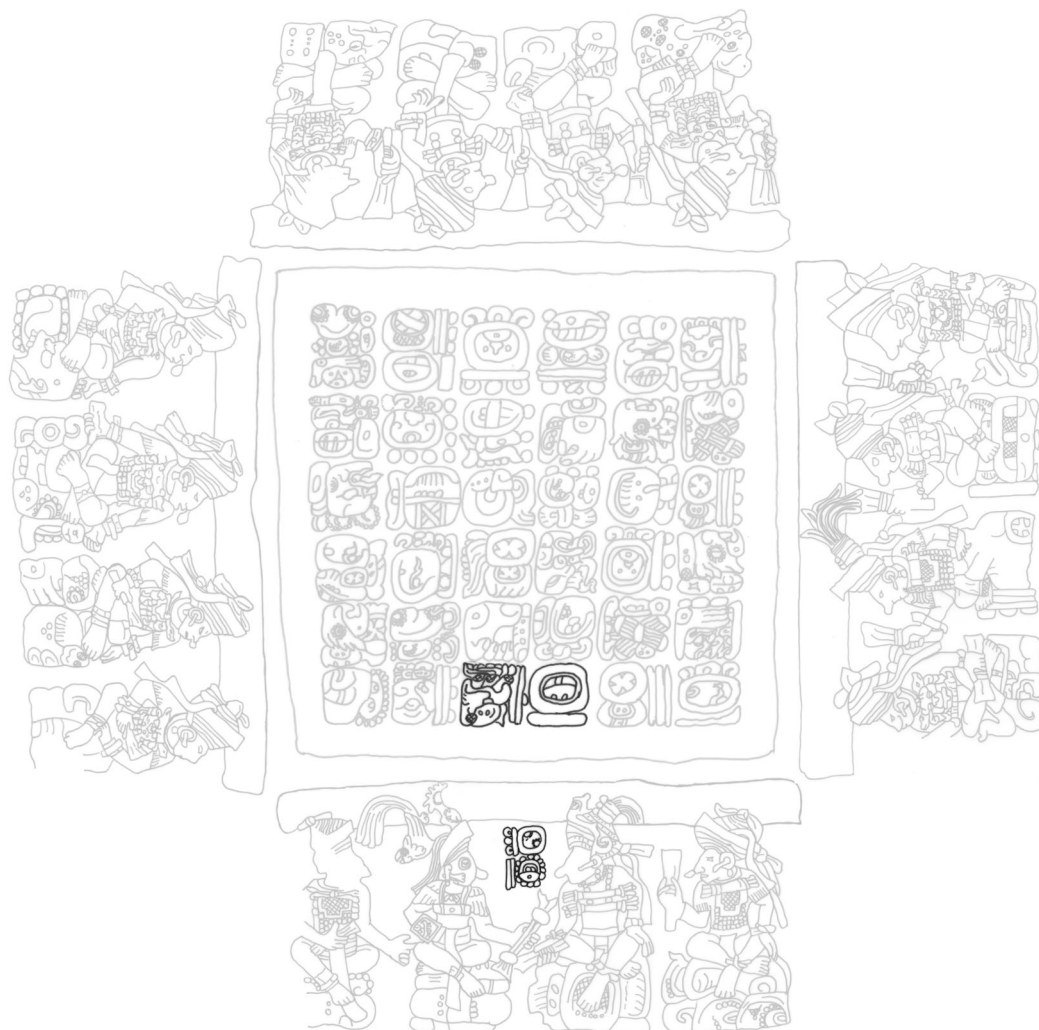


Figure 10. Altar Q's exclusive display of its two Calendar Round dates with a sum of 16. The monument is designed so that its only two instances of dates with a CRsum16 are in proximity, with R1's dynastic ascension date, 5 B'en 11 Muwan ($5 + 11 = 16$), hovering over R16's ascension date, 6 Kab'an 10 Mol ($6 + 10 = 16$). The former is highlighted in the upper hieroglyphic inscription, while the latter is highlighted directly below on the West Panel. Drawing by author

Table 4. Chronological ordering of Altar Q's hieroglyphic dates, with Calendar Round sums

Altar Q location	Long count (<i>implied</i>)	Calendar round (<i>inscribed</i>)	Calendar round sum (* = CRsum16)
A1, B1	8.19.10.10.17	5 Kab'an 15 Yaxk'in	$5 + 15 = 20$
B3, A4	8.19.10.11.0	8 Ajaw 18 Yaxk'in	$8 + 18 = 26$
C1, D1	8.19.11.0.13	5 B'en 11 Muwan	$5 + 11 = 16^*$
West panel	9.16.12.5.17	6 Kab'an 10 Mol	$6 + 10 = 16^*$
D6, E1	9.17.5.0.0	6 Ajaw 13 K'ayab	$6 + 13 = 19$
E6	9.17.5.3.4	5 K'an 12 Wo	$5 + 12 = 17$

Table 5. Important dates of Copán's dynastic rulers and Calendar Round sums (list compiled from Altar Q; Fash & Agurcia Fasquelle 2007: 38–41; and Martin & Grube 2008)

Ruler	Likely significance	Long count	Calendar round	Calendar round sum (* = CRsum16)
R1	Ascension (general)	8.19.10.0.0	9 Ajaw 3 Muwan	9 + 3 = 12
R1	Ascension (founder)	8.19.11.0.13	5 B'en 11 Muwan	5 + 11 = 16*
R1	Death (also R2 ascension)	9.0.2.0.0	13 Ajaw 3 Keh	13 + 3 = 16*
R4	Ascension	9.2.10.0.0	3 Ajaw 8 Kum'k'u	3 + 8 = 11
R4	Death	9.3.0.0.0	2 Ajaw 18 Muwan	2 + 18 = 20
R7	Ascension a	9.4.9.17.0	5 Ajaw 8 Yaxk'in	5 + 8 = 13
R7	Ascension b	9.4.10.0.0	12 Ajaw 8 Mol	12 + 8 = 20
R8	Ascension	9.4.18.6.12	8 Eb 0 Mak	8 + 0 = 8
R9	Ascension	9.5.17.13.7	2 Manik' 0 Muwan	2 + 0 = 2
R10	Ascension	9.5.19.3.0	8 Ajaw 3 Sotz'	8 + 3 = 11
R10	Death	9.7.4.17.4	10 K'an 2 Keh	10 + 2 = 12
R11	Ascension	9.7.5.0.8	8 Lamat 6 Mak	8 + 6 = 14
R11	Death	9.9.14.6.9	11 Muluk 2 Yaxk'in	11 + 2 = 13
R12	Birth	9.8.11.6.19	9 Kawak 7 Mak	9 + 7 = 16*
R12	Ascension	9.9.14.17.5	6 Chikchan 18 K'ayab	6 + 18 = 24
R12	Death a	9.13.3.5.7	12 Manik' 0 Yaxk'in	12 + 0 = 12
R12	Death b	9.13.3.5.9	1 Muluk 2 Yaxk'in	1 + 2 = 3
R13	Ascension	9.13.3.6.8	7 Lamat 1 Mol	7 + 1 = 8
R13	Death	9.15.6.14.6	6 Kimi 4 Sec	6 + 4 = 10
R14	Ascension	9.15.6.16.5	6 Chikchan 3 Yaxk'in	6 + 3 = 9
R14	Death	9.15.17.12.16	10 Kib' 4 Wayeb	10 + 4 = 14
R15	Ascension	9.15.17.13.10	11 Ok 13 Pop	11 + 13 = 24
R16	Ascension	9.16.12.5.17	6 Kab'an 10 Mol	6 + 10 = 16*
R16	Death	9.19.10.0.0	8 Ajaw 8 Xul	8 + 8 = 16*
Ukit Took'	Ascension	9.19.11.14.5	3 Chikchan 3 Wo	3 + 3 = 6

For a text with historical content that focuses on the span of two specific rulers, a statement of their death dates is an expected complement to their ascension dates. However, the death dates of R1 and R16 are, in this respect, missing from Altar Q's hieroglyphic inscription. Additionally, the death dates satisfy the constraint concerning some relation to the underworld. Thus, because these dates are expected and because they uniquely share the rare CRsum16 quality with the ascension dates, I presumed that the two death dates were two of the hand-sign-encoded Long Count dates.

For support, I surveyed the 9th Bak'tun for additional relationships between the two death dates and CRsum16. This was a straightforward task because both Long Count dates are also period endings. There are 400 possible period endings in the 9th Bak'tun, with only 24 having CRsum16 (Table 6). As the first and last of the 24, the two rulers' death dates demonstrate additional resonance with Altar Q's message of Copán's 16-ruler dynastic embodiment of the 9th Bak'tun. Additional support for the relevance of this 24-date structure is that the special 16th date is 9.13.0.0.0, which is the only K'atun period ending of the 24. The date is otherwise one of the most cosmologically important dates for the Classic Maya (Miller & Taube 1997: 52). In fact, this date is inscribed on Altar H', which is directly south of Altar Q in the West Court (Figure 3b).

I next tested R1's death date against the 0-value isomorphic constraints (Figure 9). His death date of 9.0.2.0.0 adheres to the East Panel 0 values. Also, R9's hand sign, which is assigned the 2 (Tun) value in this date, has a free-hand handshape that is consistent with hand imagery on a head variant for numeral 2 (Figure 4d; see also Boot 2003: 2). Additionally, the

Table 6. All 9th Bak'tun Long Count period endings with CRsum16

Order	Long count (period endings)	Calendar round (with CRsum16)	Notes
1	9.0.2.0.0	13 Ajaw 3 Keh	First date; Death date of R1; Inscribed on Xukpi stone of Str. 16, just feet to the East
2	9.0.13.0.0	8 Ajaw 8 Ch'en	
3	9.1.4.0.0	3 Ajaw 13 Xul	16th date and only K'atun period ending; Highly important Maya date; inscribed on nearby Altar H'
4	9.3.7.0.0	13 Ajaw 3 K'ank'in	
5	9.3.18.0.0	8 Ajaw 8 Sak	
6	9.4.9.0.0	3 Ajaw 13 Mol	
7	9.5.19.0.0	13 Ajaw 3 Pop	
8	9.6.12.0.0	13 Ajaw 3 Pax	
9	9.7.3.0.0	8 Ajaw 8 Mak	
10	9.7.14.0.0	3 Ajaw 13 Yax	
11	9.9.4.0.0	13 Ajaw 3 Sip	
12	9.9.17.0.0	13 Ajaw 3 Kum'ku	
13	9.10.8.0.0	8 Ajaw 8 Muwan	
14	9.10.19.0.0	3 Ajaw 13 Keh	
15	9.12.9.0.0	13 Ajaw 3 Sek	
16	9.13.0.0.0	8 Ajaw 8 Woh	
17	9.13.13.0.0	8 Ajaw 8 K'ayab	
18	9.14.4.0.0	3 Ajaw 13 K'ank'in	
19	9.15.14.0.0	13 Ajaw 3 Yaxk'in	
20	9.16.5.0.0	8 Ajaw 8 Sotz'	
21	9.16.16.0.0	3 Ajaw 13 Pop	
22	9.17.9.0.0	3 Ajaw 13 Pax	
23	9.18.19.0.0	13 Ajaw 3 Ch'en	
24	9.19.10.0.0	8 Ajaw 8 Xul	Last date; Death date of R16

East Panel faces R1's pyramid tomb (Str. 16), giving the date's inscription a constraint-appropriate directional quality. Notably, 9.0.2.0.0 was inscribed on the Xukpi stone, found within the pyramid's earlier Margarita tomb (Stuart 2004a). As for R16's death date of 9.19.10.0.0, it adheres to the West Panel isomorphic constraints (Figure 9). This panel also faces a relevant monument, as just to the west of Altar Q is Structure 13 (Figure 3b), a shrine to Copán ancestors who have descended to the underworld (Fash & Agurcia Fasquelle 2007). In marking the end of the dynasty, R16's death is exemplary of that finality. This seems also to be much of the message of Stela 11, which highlights R16 and his 9.19.10.0.0 death date (see Newsome 2001: 52). Additionally, the two panels and their dates' east-to-west (i.e. earlier-to-later) temporal order aligns with Maya ritual directionality, which follows the Sun's east-to-west daily path (see Girard 1995 [1966]).

7.3. The south panel and north panel

I found similar lines of evidence for the Long Count dates of the North Panel and South Panel. By examining Altar Q's 64-day ritual period for each day's calendrical qualities, I established that it encompasses a rich and unique calendrical structure for Altar Q, as summed up by Table 7.

Starting on the first day, the period can be divided into four 16-day counts. The 64-day completion, as inscribed, is marked as the day after (which alternatively marks the complete 65-day Tzolk'in Burner Period). The period has three CRsum16 dates, but the two shown in Table 7 align with the 16-day counts. Specifically, the first and third 16-day count end on a CRsum16. The second 16-day count ends in the final moments of the all-important Wayeb month. As I previously documented, this time was momentous for being at the onset of Haab'

Table 7. Calendrical Structure of Altar Q’s 64-day Period

Long count	Calendar round	Period day #	Notes
9.17.5.0.0	6 Ajaw 13 K’ayab	1	Period ending inscribed as Calendar Round (blocks D6 –E1); also inscribed on nearby Temple (Str. 11), directly north
9.17.5.0.15	8 Men 8 Kumk’u	16	CRsum16; 16 × 16 × 16 day count and 819 × 5 (= 585 × 7) distance interval from 9.16.13.12.0, a CRsum16 associated with
9.17.5.1.11	11 Chuwen 4 Wayeb	32 (= 16 × 2)	Altar F’, which has provenance just south of West Court last Wayeb day (transition to Haab’ New Year with new-moon conjunction)
9.17.5.2.7	1 Manik’ 15 Pop	48 (= 16 × 3)	CRsum16; Feb. 8, ritual start of agricultural year and conjunction with full moon
9.17.5.3.3	4 Ak’bal 11 Wo	64 (= 16 × 4)	Inscribed as Calendar Round (block E6)
9.17.5.3.4	5 K’an 12 Wo	65	

New Year in conjunction with a new moon, while the end of the third 16-day count is additionally special for being the important cosmological-creation and agriculture-based ritual day in conjunction with a full moon. To be sure that the calendrical relationships in this 64-day period were unique, I examined the 9th Bak’tun for other 64-day periods that start on a period ending. I found it to be rare for such periods to have two 16-day counts that end on CRsum16 days. The only other such period to have its first 16-day count end on a CRsum16 came 75 years earlier, on 9.13.9.0.0.

After further examination, I found the CRsum16 day that falls on the end of the first 16-day count, 9.17.5.0.15 (8 Men 8 Kumk’u → 8 + 8 = 16), to be a strong candidate for a side-panel date because it has a 16-based relationship with another special CRsum16 day. The date is 9.16.13.12.0 (8 Ajaw 8 K’ank’in → 8 + 8 = 16), and it is the day before a date implied by Altar F’ (Schele 1993). The count from 9.16.13.12.0 to 9.17.5.0.15 is 16 × 16 × 16 (= 4,096). Besides this important 16-based relationship, the distance interval between these dates (4,096 – 1 = 4,095) is significant because it has 819 as a factor (819 × 5 = 4,095), which means that it resonates with the ‘819-Day Count’ calendrical cycle. In other words, both dates (9.16.13.12.0 and 9.17.5.0.15) land on the same day within the 819-Day Count (day 73). Iterations of this calendrical cycle were important for how they were commensurate with astronomical cycles, a focal relationship being 4,095 days as it has 819 as a factor as well as the 585-day approximation for the Venus synodic cycle (819 × 5 = 585 × 7 = 4,095) (Linden & Bricker 2023: 696). To be sure, Venus and its cycle were central to the cosmologically oriented development of Classic Copán and, more specifically, the actions of its founder, R1 (Freidel et al. 1995: 309, 437–8). The 819-Day Count cycle is additionally relevant to R1 for its primary association with K’awiil effigies (Linden & Bricker 2023: 694).

The date 9.16.13.12.0 is more specifically relevant to the discourse of Altar Q because Altar F’ involves the bonding of R16 to his patron deity Chahk in effigy form (Schele 1993). Relatedly, Altar Q’s 64-day ritual period involves R16 managing R1’s effigy. Additionally, the nearby Temple 11 to the north has an inscription highlighting 9.17.5.0.0 (the start of Altar Q’s 64-day period) in relation to communion with cosmological forces and the Venus cycle (Schele & Miller 1986: 123–6). Temple 11 is especially significant here for including a symbolic construction of a portal to the underworld (Freidel et al. 1995: 222, 352–3). It is also notable that Temple 11 has a passage with both an 819-Day Count component and a reference to the Altar Q passage concerning R1’s resting of the foot of his K’awiil effigy (Schele & Grube 1992). Maya rulers required the assistance of powerful deities, often in effigy form, to

properly conduct rituals that enabled communion with cosmological forces (Baron 2016). Long Count dates associated with such activities are also good constraint-based candidates for the North Panel and South Panel because, within the relevant ethnographic record, these directional orientations are also associated with such communion (Wisdom 1940: 393; Girard 1995 [1966]: 31).

With further evidence, I was able to confirm and situate these two CRsum16 dates as side-panel dates. First, the date associated with Altar F', 9.16.13.12.0, adheres to the South Panel 0-value isomorphic constraints, and the date within the 64-day ritual, 9.17.5.0.15, adheres to the North Panel 0-value constraints (Figure 9). Second, the temporal flow from south to north (i.e. earlier-to-later) is ethnographically documented for relevant ritual activity (Girard 1995 [1966]: 84). South to north is also the direction in which the Classic Maya 'axis of the cosmos' was directed (Freidel et al. 1995: 73). Third, the South Panel faces the area of provenance for Altar F' (see Andrews & Fash 1992). The North Panel faces Temple 11 (Figure 3B).

7.4. Results

The accumulation of evidence gives the mapping of numerical value to graphic hand sign, construed for the free hands alone, which is shown in Figure 11. The evidence is drawn from disparate and independent constraint-based sources: references to numerically derived calendrical observations; Altar Q's textual discourse; relevant ethnographic documentation; the hieroglyph and hand-sign isomorphisms; and Altar Q's directionally indexed textual network with nearby monuments. Thus, Figure 11 displays a strongly supported decipherment of Altar Q's hand signs, albeit exclusive to free-hand forms.

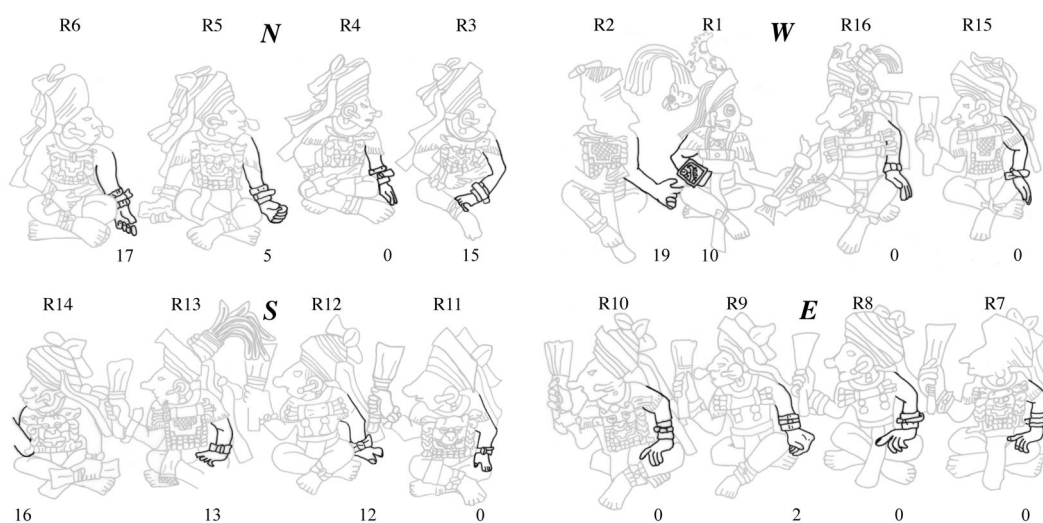


Figure 11. Decipherment mapping of Long Count values to free hands for Altar Q's graphic hand signs. Each ruler's free hand is highlighted, below which is the numerical value deciphered for his hand sign. Each panel's hand signs constitute the lower values of a 9th Bak'tun date. Each date is cross-verified by independent constraint-based evidence. Drawing by author

8. FURTHER EVIDENCE FROM DISTANCE NUMBER EQUATIONS

With compelling evidence for the four side-panel Long Count dates, I further scrutinised Altar Q's hieroglyphic inscription and found two distance numbers that additionally support the East Panel and South Panel dates. The distance numbers are both found within a single three-block chunk, shown in Figure 12. The blocks are intentionally polyvalent, together having multiple correct interpretations (see Tedlock 1992: 131).

The first relevant reading involves keeping block C6 as the 17 K'atun component of a distance number and adding D5 as the Tun component. Doing so assumes that the Tun indicator is absent from D5, which is not uncommon for the smaller-value components of a

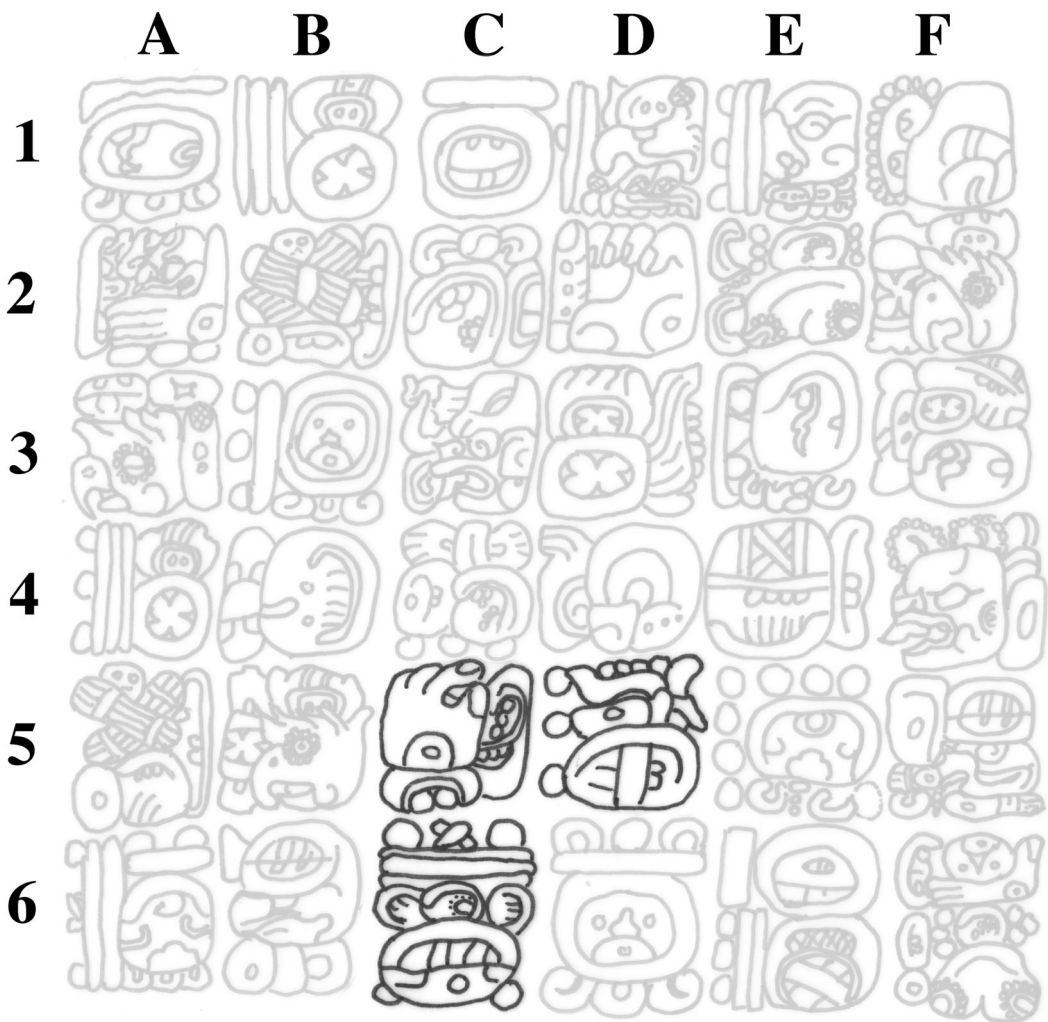


Figure 12. Altar Q distance numbers, directly linking graphic hand signs with the hieroglyphic inscription. Blocks C5, D5 and C6 define a phrase from Altar Q's upper hieroglyphic inscription. The phrase has multiple correct readings, including two distance numbers, as outlined in Table 8. Each distance number is the exact difference between a date from a panel and one from the hieroglyphic inscription. Drawing by author

Table 8. Altar Q distance number equations with hieroglyphic and hand-sign dates

Prior long count date +	Distance number =	Subsequent long count date
9.0.2.0.0 (East Panel hand signs)	0.17.3.0.0 (blocks D5, C6)	9.17.5.0.0 (inscribed as Calendar Round 6 Ajaw 13 K'ayab; blocks D6, E1)
8.19.10.11.0 (inscribed as Calendar Round 8 Ajaw 18 Yaxk'in; blocks B3, A4)	0.17.3.1.0 (blocks C5, D5, C6)	9.16.13.12.0 (South Panel hand signs)

distance number phrase (Montgomery 2002: 116). By giving the numeral 3 of block D5 its numerical (and not phonemic) value, the resulting distance number is 17.3.0.0. Given the possible prior and subsequent dates in the hieroglyphic inscription alone, the distance number gives an equation with missing terms. However, as shown in Table 8, this is the exact interval between the East Panel date, 9.0.2.0.0 and 9.17.5.0.0 (implied by blocks D6–E1), which is the start of Altar Q's 64-day ritual period.

The other distance number is read by keeping the numerical values for blocks D5 and C6, while adding block C5 as the Winal component. Doing so involves not only assuming that the Long Count period indicator for C5 is absent but also assuming that C5 is a non-standard numerical variant, which is also a phenomenon found in other distance numbers (Montgomery 2002: 115). The numerical value for C5 is 1, an alternation of the logogram HUL, which is C5's standard reading, again translated as 'arrival' and indicates the arrival of R1's new dynastic order to Copán. This numerical alternation is derived as follows:

- HUL is also used in other Maya inscriptions to indicate a count of days from the arrival of a new crescent moon (Bricker & Bricker 2020). The arrival would thus start the count.
- In the cyclical manner of Maya calendrical counts, HUL is also strongly associated with 1 because this number is the arrival of something from nothing or, in other words, a beginning (see Miller & Taube 1997: 125).
- Although not apparent from block C5, HUL hand imagery often features an extended forefinger, as does a hieroglyphic variant for JUN, the numeral 1 (Figure 4c).
- There are other polyvalent logograms that similarly have both non-numerical and numerical meanings related by their cyclical connotations (see Montgomery 2002: 62–3).

By assigning C5 a value of 1, the resulting distance number is 17.3.1.0. As shown in Table 8, this is the exact interval between 8.19.10.11.0 (the implied Long Count of Altar Q's second hieroglyphically inscribed date, given by blocks B3–A4) and 9.16.13.12.0, the South Panel hand-sign date.

9. DECIPHERMENT VERIFICATION

My mapping of proposed Long Count values to free-hand forms (Figure 11) is the outcome of a decipherment process that I have thus far described without being very explicit about verification. Here I highlight the aspects of the verification that make the decipherment robust. From a mathematical perspective, my evidential observations are unlikely illusions of coincidence. They are, rather, recognitions of intentional patterns. Consider the following abstracts of select evidence for Altar Q's intended scribal design and composition:

- It includes four iconographically embedded hieroglyphic numeral 9 s, which are situated on the side panels so that they also frame the 36 hieroglyphic blocks of the upper inscription. The numeral 9 s are not only perfectly formed but when summed together they give 36. Given the relevance of the 9th Bak'tun and the four-direction cosmological orientation to its textual discourse, the numbers 9 and 4 are numerologically salient. (See sections 3 and 6.3 for further details.)
- Its entire hieroglyphic-block inscription includes six dates, all of which are in Calendar Round form. The absence of explicitly inscribed Long Count dates is abnormal for this type of textual discourse. The expectation for dates in Long Count form is underscored by the highly discourse-relevant 9th Bak'tun and the implied period ending anchoring of one of its two described rituals. (See sections 3.2 and 7 for further details.)
- It features two Calendar Round dates inscribed as hieroglyphic blocks in co-linear alignment, whereby one is on the prominent West Panel while the other is directly above it, in the upper inscription. With respect to all six inscribed Calendar Round dates, the two dates are chronologically centred and are the only ones with a CRsum16. The two dates mark the ascensions to rulership for the first and last of Copán's dynastic rulers, R1 and R16. The importance of enumeration for its ruler succession puts the number 16 in numerological focus. (See sections 3.1 and 7.1 for further details.)
- Its discourse underscores the 9th Bak'tun as the encompassing time span of Classic Copán's 16-ruler dynasty. The West Panel visually highlights R1 and R16 as the beginning and end of that dynasty. Of all ascension and death dates for Copán's 16 dynastic rulers, R1 and R16 are the only with both milestones having CRsum16. Their death dates (9.0.2.0.0 and 9.19.10.0.0, respectively) mark the first and last of 24 days within the 9th Bak'tun that are period endings with a CRsum16. Additionally, the 16th of those 24 days is the very important 9.13.0.0.0 date. (See sections 3 and 7.2 for further details.)
- Its upper hieroglyphic inscription includes a ritual that starts on an implied period ending and has the 65-day count of a Burner Period. An inscribed distance number of 64 days highlights the interval, which has special factors of 16 and 4. The period is structured as four implied 16-day counts. The third count lands on a CRsum16 date that otherwise has special cosmological value, which is heightened by the conjunction with a full moon. The second count lands at the end of a Wayeb month that sets the stage for the conjunction of a new moon with the Haab' New Year. The first count lands on a CRsum16 date (9.17.5.0.15) with a special connection to another CRsum16 date (9.16.13.12.0), which is associated with Altar F', a local discourse-relevant monumental text. The count from one date to the other is 16^3 (or 4,096) days, while the distance interval between them defines a special relationship between the 819-Day Count and the Venus cycle. (See sections 3 and 7.3 for further details.)
- Its upper hieroglyphic inscription includes a polyvalent phrase with two distance numbers. Each distance number is a numerical interval that precisely implies an inscribed prior date and a subsequent date as its endpoints. However, of the six dates inscribed in normal hieroglyphic form, there are no pairs that define the endpoints for either distance number. The three dates prior to and three dates subsequent to the two distance numbers thus imply 12 candidate dates that are not included in the hieroglyphic inscription but would satisfy both distance number equations. None of the 12 dates are locally attested or otherwise relevant except for two: R1's death date (9.0.2.0.0) and the date associated with Altar F' (9.16.13.12.0). (See section 8 for further details.)

While any given piece of evidence making up one of the preceding bulleted statements might be suspect as likely coincidence, taken together they provide a high confidence of evidential support for the decipherment. This is largely because each bullet presents a bundle

of co-supporting evidence, none of which presupposes Altar Q's side-panel hand signs nor its extra-hieroglyphic encoding of well-defined semantic information.

Furthermore, while each bundle is substantial on its own, the premise of each is consistent with respect to the decipherment. That is, while the first three bulleted statements collectively point to four 9th Bak'tun Long Count dates with a corresponding CRsum16, the last three bulleted statements point to four specific dates with those qualities. Notably, because the distance numbers and their equations provide mathematical evidence for two of the dates in a manner that is completely independent from the calendar-based mathematical observations that produce the same dates, their convergence is highly reliable. This aspect of verification is bolstered by the fact that the distance between any one of these four dates is on the order of thousands of days, as a lower limit. With so many numerical data points, the probability is astronomically low for a coincidence of numerology in the graphic design, numerology in calendrical relationships, and equations made explicit through distance numbers.

From a formal perspective, the mapping of the four Long Count dates to free-hand forms (Figure 11) supports the overall decipherment verification. First, the nine (non-0) variable locations have form-meaning consistency. Given his lack of a free hand, R1's hand-sign form is still (at this point) unclear but certainly unique from the others. The remaining eight free-hand forms are distinct from one another, each with a unique combination of handshape, orientation and placement (Appendix B in Supporting Information). Because the nine non-0 numerical values are also distinct from one another, there are no contradictions in pairing of form and meaning.

10. A SECONDARY ANALYSIS AND ALTAR Q'S UNIQUELY COMPLEX HAND SIGN

Because the decipherment has been solely based on free-hand forms, it is not yet complete. This is due to the original (intended-by-design) absence of a free hand by R1. To better understand what type of hand-sign form on the West Panel could involve R1 and encode the value 10 (for 9.19.10.0.0), I used the prior results to conduct a secondary analysis. I first expanded my analytical scope to include both hands of each ruler, which brings the focus to R5 and R3, who again are the only rulers with near symmetry in free- and grasping-hand forms (i.e. handshape, placement and orientation). We now know that they are also the only rulers with known hand-sign forms to have hand signs in the multiple-of-5 set (i.e. {5, 10, 15}). The implication is that featural symmetry signals hand signs with values in this set. This also reflects bar-and-dot base-5 notational patterning (i.e. bars without dots for {5, 10, 15}). A hieroglyphic variant for 10 with two-handed imagery provides further evidence that the hand sign for 10 might be symmetrically formed (Figure 4e). My presumption therefore was that the hand sign for 10 on the West Panel was formed by two hands in formal symmetry and somehow associated with R1. The only formation on the West Panel that satisfies this constraint is the conjoining placement of R1's grasping hand with the grasping hand of R16. The following details support this unique (two-person) hand sign:

- Their conjoined grasping hands also show symmetry in handshape and near symmetry in hand orientation.
- It constitutes the only instance on Altar Q where separate rulers' hands are placed in near contact.

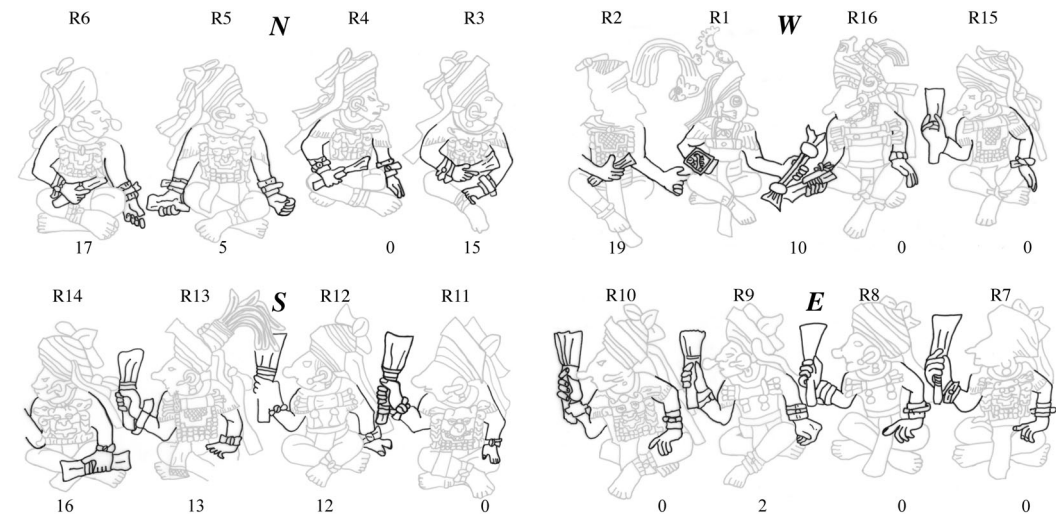


Figure 13. Complete decipherment mapping of Altar Q's graphic hand signs and numerical values. Numerical values are given below the hand form that constitutes the locus of its hand sign. Hand signs with 0 value are signalled primarily by unique handshapes, specifically handshapes that have some extension of all fingers. The hand signs for boundary numbers {5, 10, 15} are signalled primarily by how and where two hands are symmetrically placed. These hand signs show a high degree of symmetry with other features too. The rest of the hand signs (i.e. with non-boundary numerical values) are signalled by two-handed asymmetric placement and distinguished from one another by the unique handshape, placement and orientation features of the dominant hand (i.e. the free hand). Drawing by author

- Given that the Death God is 10's patron deity, this joint formation by founder R1 and final ruler R16 reinforces the West Panel's message of dynastic end (see also Newsome 2001: 52, 90, 185). This type of textual coherence is also demonstrated by R14, who has the sole raised free hand and the only hand encoding the special value 16.

In sum, hand-placement symmetry not only allows us to see the hand sign for 10 but to understand that such two-handed symmetry (or lack thereof) is an ordering feature that distinguishes hand signs of the boundary set {5, 10, 15} from all others. This more-complete decipherment of Altar Q's hand signs is provided as Figure 13.

11. DISCUSSION

Although my decipherment of Altar Q's graphic hand signs (Figure 13) is supported by multiple lines of independent evidence (Table 1) and thereby robust, the findings motivate many next-step inquiries. One area of needed attention involves the meaning potential of graphic hand signs, especially in relation to hieroglyphs. If the hand-sign script is primarily numerical, this limited domain is underscored by the typically very low hand-sign-to-hieroglyph ratio in Ancient Maya texts. Yet we should not downplay the importance of the numerical domain for the Ancient Maya. Unlike most of the world's texts, ancient or otherwise, where dates and other numerical expressions help contextualise non-numerical

language, within Ancient Maya texts the converse is often the case. However, any given hand sign can certainly also carry gestural or other meaning. We see this with Altar Q in that its South Panel and East Panel are marked by rulers with one hand raised while all but one of the North Panel and South Panel rulers have lowered hands, which is surely a matter of directional symbolism. Additionally, the conjoining of R1 and R16's grasping hands in the hand sign for 10 is also likely a motif associated with dynastic transition, reflecting a very similar depiction of R1 and R2 in Copán's Motmot floor marker, created centuries before Altar Q (Burdick 2010: 153). This sense of transition is also embodied by the general nature of 10 as the centre point in a 20-count cycle, the salience of which is underscored by the Death God transition at 10 in Maya head-variant numerals. Similarly, Altar Q's hand sign for 19, held by R2, has an L handshape that also seemingly functions as a pointing hand. The forefinger is directed at R1, a likely testament to the end of his dynasty given that the number 19 marks the end of a 20-count cycle. This evidence suggests the possibility that at least some graphic hand signs are polyvalent and that the script may encompass non-numerical meanings.

Regardless of any possible meaning limitations of the hand signs, their textual integration with hieroglyphs implies a uniquely complex writing system. The Altar Q text highlights this reality, with a lack of redundancy between the rich information encoded by each inscription type. Its hieroglyphs and hand signs are nevertheless meant to be read together, as highlighted by the distance numbers that connect hand-sign panel dates to hieroglyphic dates (Table 8). The finding supports recent efforts to understand the complex multimodality of Ancient Maya texts, which work to subvert Western categories of textual analysis (see Burdick 2010; Stone & Zender 2011; Hamann 2018). From an interpretive perspective, the textual relationship between graphic hand signs and hieroglyphs underscores how essential the hand signs are for a full reading of (at least some) Ancient Maya texts. Indeed, the present focus on Altar Q's decipherment has left much about its text and intertextual discourse that needs further attention. Generally, there is much left to understand about how hand signs and hieroglyphs constituted distinctive yet complementary scribal resources.

Additionally, many unknowns remain about the form of hand signs. With the decipherment we have a strong formal understanding of 11 hand signs (i.e. with values 0, 0, 2, 5, 10, 12, 13, 15, 16, 17 and 19). However, this leaves no accounting for half of the numerical hand signs of the full 20 count, as well as any other variants and non-numerical hand signs that might exist. An essential developmental step will be to better define the features that distinguish one graphic hand sign from another. A primary concern is allographic variation. We know that certain differences in thumb and forefinger are important factors for distinguishing handshape, although the scope of those differences is not yet clear. The Altar Q data provides much less insight into the role of the lesser fingers, which seem to be important for distinguishing the handshapes in other Maya texts (e.g. Figure 1). For hand placement, we know that places are defined by salient body spaces to either side of a median plane and that symmetry is important for distinguishing hand signs of the boundary set {5, 10, 15} from hand signs with other values. However, it is not yet clear how else placement might be used to distinguish hand-sign forms. As for hand orientation, my analysis (and bit of re-analysis) suggests that it might be the most difficult feature to define. A related factor that I did not need to consider is how to analyse hand orientation when a body is depicted from a side view. If orientation distinctions are made in relation to the planes of a depicted signer's body,

then the same orientation will appear differently for a body depicted from a front view than a side view.

Another complexity of form involves deviations from the (supposed) ideal for a graphic hand sign, as configured by the two free hands of a single depicted signer. Potential deviations include handshapes constituted by grasping (or other object manipulating) hands, hand signs primarily constituted by one hand, and hand signs constituted by two individuals. All these possibilities can be highlighted in relation to Altar Q's hand sign for 10. First, the formal analysis shows that Altar Q's grasping hands demonstrate an array of handshapes that are not entirely specific to their grasping task (cf. Maitland Gardner 2022). That is, all rulers are grasping identical items but doing so with a few distinct handshapes, some of which demonstrate patterning (e.g. the BabyO handshape is exclusive to the East Panel grasping hands). The formation of the hand sign for 10 involves the conjunction of R1 and R16's grasping hands, which have matching OpenA handshapes. It is likely, however, that OpenA is not an ideal handshape for the 10 hand sign, as suggested by the symmetric open flat hands in the hieroglyphic variant for 10 (Figure 4e). If the OpenA handshape is a deviation from the ideal for 10, then the Altar Q 10 hand sign is likely signalled by the more ideal nature of its other properties (i.e. the overall symmetry of features and the specifics of placement and orientation). Similarly, R16's depiction strays from the ideal by contributing to two hand signs. With his right hand, he is contributing to the hand sign for 10, while his left hand is the primary component of a hand sign for 0. Additionally, the hand sign for 10 demonstrates a deviation in that a single hand sign is formed as a collaboration of features from two depicted individuals. Thus, as with hieroglyphs, it seems that graphic hand signs are both esoterically formed and constituted by a rich constellation of features, giving the ancient scribes much artistic flexibility in how they might have deviated from ideal norms.

12. CONCLUSION

The nature of the distinctly formed hands in Ancient Maya figural art has, for over a century, remained an enigma for researchers. Comparisons with indigenous American signed language practices and Maya hieroglyphs with hand imagery strongly suggested that the hands in figural art were meaningfully complex, if not actual hand signs. However, as a basis for interpreting meanings conveyed by specific graphic hand forms, such comparative data lacks evidential breadth and support. In my novel approach, I avoided relying on such interpretations. Instead, I treated the hands as forms that could be defined as graphic symbols and deciphered with a well-grounded and appropriate methodology. My first step was to identify Altar Q as an ideal dataset for hand-sign decipherment. Throughout the paper, I described my work to decipher Altar Q's graphic hand signs, which included various independent lines of converging evidence, ensuring cross-verified and robust findings. The results are summarised in Figure 13. A technical summary of the analysis and evidence is presented as Table 9. With this initial decipherment of Ancient Maya graphic hand signs, we have a solid basis on which to hypothesize, test and refine our understanding of them by examining additional texts, including other (non-Maya) Ancient Mesoamerican texts. As we progress, we will be able to apply these understandings, moving our readings of Ancient Maya texts beyond the limitations of hieroglyph exclusivity, which I have started to do here with Altar Q.

Table 9. Evidence summary for the decipherment of Altar Q's graphic hand signs

Altar Q domain	Technical summary of evidence (<i>special subscript notation: e.g., x_4 is the value of R4's hand sign</i>)
General text	Altar Q's text is a ritual and dynastic discourse, notably involving calendrical and astronomical cycles (sections 3 and 7)
General design	Despite its size, Altar Q's foursquare shape and directional orientation is typical of Maya altars and ethnographically recognised as such (section 3.1)
All panels, directional	Each of Altar Q's panels is oriented to one of the four cardinal cosmological directions (sections 3.1, 6.3, and 7)
All panels, intertextual	- Altar Q is part of the West Court intertextual network (sections 1, 3.1 and 7) - Altar Q is central to the West Court's defining monuments, highlighting the contextual relevance of the four cardinal directions (sections 3.1, 6.3, and 7)
All panels, calendrical	- Long Count dates are expected of Altar Q but missing from its hieroglyphic inscription, implying alternatively expressed Long Count dates (sections 3.2 and 7) - CRsum16 (i.e. sum of Calendar Round coefficients = 16) is highlighted as Altar Q's calendrical key, given the multimodal foregrounding and spatial arrangement of R1 and R16's ascension dates (5 B'en 11 Muwan and 6 Kab'an 10 Mol) (section 7.1)
All panels, format	Each panel is designed to display a Long Count date in the 9th Bak'tun with relevance to the underworld, as given by an iconographically embedded upside-down numeral 9 hovering over four hand signs (encoding, from left to right, K'atun, Tun, Winal and K'in values) (section 6.3)
All panels, formal analysis	x_4, x_{11}, x_{15}, x_{16} are recurrent forms (sections 5 and 6.1) x_7, x_8, x_{10} are recurrent forms (sections 5 and 6.1) x_1, x_2, x_3, x_5, x_6, x_9, x_{12}, x_{13}, x_{14} are all formally distinct from one another (by handshape, hand orientation and/or hand placement) (section 5 and 9) x_3 and x_5 are unique for each having two-hand symmetry (sections 5 and 10)
East panel (9.0.2.0.0)	- Isomorphic evidence for $0_{10}.x_9.0_8.0_7$, given handshape and inscription-sequence relationships between hand signs and hieroglyphs (sections 6.1 and 6.2) - Isomorphic evidence for 2₉, given handshape of hieroglyph variant for 2 (section 7.2) 9.0.2.0.0's corresponding Calendar Round (13 Ajaw 3 Keh) has CRsum16 (section 7.2) 9.0.2.0.0 is R1's death date, which is notably missing from Altar Q's hieroglyphic inscription (section 7.2) - East Panel faces R1's pyramid tomb (Str. 16) where 9.0.2.0.0 was inscribed on Xukpi stone (sections 1, 3.1, and 7.2) 9.0.2.0.0 is mathematically implied for Altar Q by distance number 0.17.3.0.0 (blocks D5, C6) and 9.17.5.0.0 (inscribed as Calendar Round 6 Ajaw 13 K'ayab; blocks D6, E1) (section 8)
West panel (9.19.10.0.0)	- Isomorphic evidence for $x_2.x_1.0_{16}.0_{15}$, given handshape and inscription-sequence relationships between hand signs and hieroglyphs (sections 6.1 and 6.2) - Isomorphic evidence for 10₁, given handshape of hieroglyph variant for 10 (section 10) - Evidence for special form of 10₁, grounded by two-handed symmetry as feature signal of boundary set {5,10,15} (sections 5 and 10) 9.19.10.0.0's corresponding Calendar Round (8 Ajaw 8 Xul) has CRsum16 (section 7.2) 9.19.10.0.0 is R16's death date, which is notably missing from Altar Q's hieroglyphic inscription (section 7.2) - West Panel faces Structure 13, the West Court ancestral shrine (sections 1 and 7.2)

(continued)

Table 9: (continued)

Altar Q domain	Technical summary of evidence (<i>special subscript notation: e.g., x_4 is the value of R_4's hand sign</i>)
Coupling of east and west panels	9.0.2.0.0 and 9.19.10.0.0 are the first and last Long Count period endings with CRsum16 in the 9th Bak'tun (section 7.2) 9.0.2.0.0 and 9.19.10.0.0 as R1 and R16's death dates are matched with their ascension dates in having CRsum16, being unique in this way amongst such dates for the other Copán dynastic rulers (section 7.2) - The monuments associated with the dates (R1's pyramid tomb and Structure 13) both involve transitions between cosmological realms (i.e. celestial, earthly, underworld) (section 7.2) 9.0.2.0.0 and 9.19.10.0.0 are temporally ordered from east to west in accordance with the primary directionality of Maya dawning and renewal rituals, following the Sun's daily path as it works to illuminate the cosmological realms (section 7.2)
South panel (9.16.13.12.0)	- Isomorphic evidence for $x_{14}, x_{13}, x_{12}, 0_{11}$, given handshape and inscription-sequence relationships between hand signs and hieroglyphs (sections 6.1 and 6.2) 9.16.13.12.0's corresponding Calendar Round (8 Ajaw 8 K'ank'in) has CRsum16 (section 7.3) 9.16.13.12.0 is associated with Altar F', which has provenance just south of West Court (section 7.3) 9.16.13.12.0 is mathematically implied for Altar Q by distance number 0.17.3.1.0 (blocks C5, D5, C6) and 8.19.10.11.0 (given as 8 Ajaw 18 Yaxk'in; blocks B3, A4) (section 8)
North panel (9.17.5.0.15)	- Isomorphic evidence for $x_6, x_5, 0_4, x_3$, given handshape and inscription-sequence relationships between hand signs and hieroglyphs (sections 6.1 and 6.2) 9.17.5.0.15's corresponding Calendar Round (8 Men 8 Kum'u) has CRsum16 (section 7.3) 9.17.5.0.15 is situated within Altar Q's 64-day period with start date of 9.17.5.0.0, which is inscribed to the north of Altar Q on Temple 11, in the West Court (section 7.3)
Coupling of south and north panels	9.16.13.12.0 and 9.17.5.0.15 have a $16 \times 16 \times 16 (= 4,096)$ day count, giving them a unique 16-based relationship (section 7.3) 9.16.13.12.0 and 9.17.5.0.15 also have an interval of $(819 \times 5 = 585 \times 7 =) 4,095$ days, the 819-Day Count commensuration with the Venus cycle (section 7.3) - The monuments associated with the dates (Altar F' and Temple 11) both involve ritual communion with cosmological forces (section 7.3) 9.16.13.12.0 and 9.17.5.0.15 are temporally ordered from south to north in accordance with directionality for Maya rituals involving communion with cosmological forces (section 7.3)

CONFLICT OF INTEREST STATEMENT

I have no conflicts of interest to disclose.

Correspondence

Rich A. Sandoval

Department of Sociology and Anthropology

Metropolitan State University of Denver

Denver, CO, USA

Email: rsando24@msudenver.edu

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SUPPORTING INFORMATION

APPENDIX A

Functional dependencies of the basic Maya Calendars for the 9th Bak'tun

Calendar	Cycle	1 st Day (i = 1)	Functional Dependency
Long Count	Bak'tun	9	$Bak'tun_{i+1} = Bak'tun_i = 9.$
Long Count	K'atun	0	If $K'atun_i = 19$ and $Tun_i = 19$ and $Winal_i = 17$ and $K'in_i = 19$, then $K'atun_{i+1} = 0$; Else if $K'atun_i \neq 19$ and $Tun_i = 19$ and $Winal_i = 17$ and $K'in_i = 19$, then $K'atun_{i+1} = K'atun_i + 1$. Else $K'atun_{i+1} = K'atun_i$.
Long Count	Tun	0	If $Tun_i = 19$ and $Winal_i = 17$ and $K'in_i = 19$, then $Tun_{i+1} = 0$; Else if $Tun_i \neq 19$ and $Winal_i = 17$ and $K'in_i = 19$, then $Tun_{i+1} = Tun_i + 1$. Else $Tun_{i+1} = Tun_i$.
Long Count	Winal	0	If $Winal_i = 17$ and $K'in_i = 19$, then $Winal_{i+1} = 0$; Else if $Winal_i \neq 17$ and $K'in_i = 19$, then $Winal_{i+1} = Winal_i + 1$. Else $Winal_{i+1} = Winal_i$.
Long Count	K'in	0	If $K'in_i = 19$, then $K'in_{i+1} = 0$. Else $K'in_{i+1} = K'in_i + 1$.
Tzolk'in	Day Number	8	For the repeating sequence (1, 2, 3, ..., 13), if $DayNumber_i = n$, then $DayNumber_{i+1} = n+1$.
Tzolk'in	Day Name	Ajaw	For the repeating sequence (Ajaw, Imix, Ik', Ak'bal, K'an, Chikchan, Kimi, Manik', Lamat, Muluk, Ok, Chuwen, Eb', B'en, Ix, Men, Kib', Kab'an, Etz'nab', Kawak), if $DayName_i = n$, then $DayName_{i+1} = n + 1$.
Haab'	Month Day	13	If $MonthName_i \neq Wayeb$ and $MonthDay_i = 19$, then $MonthDay_{i+1} = 0$; Else if $MonthName_i = Wayeb$ and $MonthDay_i = 4$, then $MonthDay_{i+1} = 0$. Else $MonthDay_{i+1} = MonthDay_i + 1$.
Haab'	Month Name	Keh	For the repeating sequence (Pop, Wo, Sip, Sotz', Sek, Xul, Yaxk'in, Mol, Ch'en, Yax, Sak, Keh, Mak, K'ank'in, Muwan, Pax, K'ayab, Kumk'u, Wayeb), if $MonthDay_i = 4$ and $MonthName_i = Wayeb$, then $MonthName_{i+1} = Pop$; Else if $MonthDay_i = 19$ and $MonthName_i = n$, $MonthName_{i+1} = n + 1$. Else $MonthName_{i+1} = MonthName_i$.

APPENDIX B

Complete analysis of handshape, hand placement, and hand orientation for Altar Q's rulers' hand forms

- Hand placement ("pl") is defined by where the heel of a ruler's hand is. Possible placements are up at shoulder level ("Up"), down and to a body's outside ("Outside"), on the knee ("Knee"), and in the lap area ("Inside").
- Hand orientation ("or") is defined by two dimensions: the direction the palm is facing ("or.fc") and the direction the hand is pointing, from heel to knuckles (".pt"). Orientation directions are defined with respect to the median, horizontal, and frontal body planes. Thus, directions are forward from the frontal plane ("Fwd"), backward from the frontal plane ("Bkwd"), away or outward from the median plane ("Outwd"), into or inward toward the median plane ("Inwd"), upward from the horizontal plane ("Upwd"), and downward from the horizontal plane ("Dnwd"). Angled orientations are indicated with a slash ("/") between the bisected planar orientations.
- Handshapes ("shp") are designated in accordance with standardized ASL names.
- See [Figure 7](#) for further guidance on terminology, abbreviation, and analytical definition

Ruler	Free Hand	Grasping Hand	Notes
R1	shp: n/a pl: Knee or.fc: n/a .pt: n/a	shp: OpenA pl: Outside or.fc: Fwd .pt: Outwd/Dnwd	-No free hand (Missing as part of sculpture's original design.) -Grasping hand: unique form
R2	shp: L pl: Outside or.fc: Fwd .pt: Outwd	shp: OpenA pl: Inside or.fc: Bkwd .pt: Inwd	-Free hand: unique form (Partially ruined, but with clear indication of form.) -Grasping hand: unique form
R3	shp: BabyO(?) pl: Inside or.fc: Bkwd/Dnwd .pt: Inwd	shp: G pl: Inside or.fc: Bkwd .pt: Inwd	-Free hand: unique form (Partially ruined, but traces indicate a special case: a right hand on a left arm. Notably, the curled-in finger furthest from the frontal plane is relatively long, as expected of a forefinger. To its side is a thumb knuckle and partial proximal phalanx, suggesting a thumb that originally extended toward forefinger tip.) -Grasping hand: unique form -Free and grasping forms are nearly symmetric (Subtle differences in orientation and handshape.)
R4	shp: FlatB pl: Outside or.fc: Inwd/Dnwd .pt: Outwd/Dnwd	shp: OpenA pl: Knee or.fc: Bkwd .pt: Inwd/Dnwd	-Free hand: recurrent form in set {R4,R11,R15,R16} -Grasping hand: unique form
R5	shp: ModA pl: Outside or.fc: Fwd .pt: Outwd	shp: OpenA pl: Outside or.fc: Fwd .pt: Dnwd	-Free hand: unique form -Grasping hand: unique form (Thumb ruined but traces suggest it extended out.) -Free and grasping forms are nearly symmetric (Subtle differences in orientation and handshape.)

Appendix B table continued

Ruler	Free Hand	Grasping Hand	Notes
R6	shp: BabyC(?) pl: Outside or.fc: Fwd .pt: Dnwd	shp: L pl: Inside or.fc: Bkwd .pt: Inwd	-Free hand: unique form (Partially ruined, but thumb's remaining proximal phalanx is in the palm area, roughly in line with the forefinger. What is left of the forefinger extends further than the proximal joints of the other fingers.) -Grasping hand: unique form
R7	shp: LaxG pl: Knee or.fc: Dnwd .pt: Inwd	shp: BabyO(?) pl: Up or.fc: Fwd .pt: Outwd	-Free hand: recurrent form in set {R7,R8,R10} -Grasping hand: recurrent form in set {R7,R8,R9,R10} (Partially ruined, but with good indication of form.)
R8	shp: LaxG pl: Knee or.fc: Dnwd .pt: Inwd	shp: BabyO pl: Up or.fc: Fwd .pt: Outwd	-Free hand: recurrent form in set {R7,R8,R10} -Grasping hand: recurrent form in set {R7,R8,R9,R10} (Partially ruined, but with clear indication of form.)
R9	shp: ModA pl: Outside or.fc: Dnwd .pt: Outwd	shp: BabyO pl: Up or.fc: Fwd .pt: Outwd	-Free hand: unique form -Grasping hand: recurrent form in set {R7,R8,R9,R10}
R10	shp: LaxG pl: Knee or.fc: Dnwd .pt: Inwd	shp: BabyO pl: Up or.fc: Fwd .pt: Outwd	-Free hand: recurrent form in set {R7,R8,R10} -Grasping hand: recurrent form in set {R7,R8,R9,R10}
R11	shp: FlatB pl: Knee or.fc: Dnwd/Bkwd .pt: Dnwd/Fwd	shp: A pl: Up or.fc: Fwd .pt: Outwd	-Free hand: recurrent form in set {R4,R11,R15,R16} (Subtle difference in orientation from other members; Partially ruined, but with clear indication of form.) -Grasping hand: recurrent form in set {R11,R12,R13}
R12	shp: (?) pl: Outside or.fc: Dnwd/Bkwd(?) .pt: Outwd	shp: A pl: Up or.fc: Fwd .pt: Outwd	-Free hand: unique form (Significantly ruined, missing fingers. The area near the knuckles suggests some bending of fingers. The thumb is slightly extended, as with OpenA and BabyC shapes. The position of the thumbnail suggests a palm-facing orientation that is angled backward.) -Grasping hand: recurrent form in set {R11,R12,R13} (Partially ruined, but with some indication of form.)
R13	shp: G(?) pl: Knee or.fc: Dnwd/Bkwd .pt: Inwd	shp: A pl: Up or.fc: Fwd .pt: Outwd	-Free hand: unique form (Partially ruined, but with relatively clear indication of form. Because thumb is out of view, we know it was not extended. Pinky is unique, with relative lax extension.) -Grasping hand: recurrent form in set {R11,R12,R13}
R14	shp: (?) pl: Up or.fc: (?) .pt: (?)	shp: OpenA pl: Knee or.fc: Bkwd .pt: Dnwd	-Free hand: unique form (Although completely ruined, it is the only free hand with Up placement, making it unique.) -Grasping hand: unique form
R15	shp: FlatB pl: Knee or.fc: Inwd/Dnwd .pt: Outwd/Dnwd	shp: BabyC pl: Up or.fc: Fwd .pt: Outwd	-Free hand: recurrent form in set {R4,R11,R15,R16} -Grasping hand: unique form (Partially ruined, but with clear indication of form.)
R16	shp: FlatB pl: Knee or.fc: Inwd/Dnwd .pt: Outwd/Dnwd	shp: OpenA pl: Outside or.fc: Fwd .pt: Dnwd/Inwd	-Free hand: recurrent form in set {R4,R11,R15,R16} -Grasping hand: unique form