The implication of this finding is that construction projects were carried out in sub-regions of the field system whose boundaries were not coincident with *ahupua'a* boundaries until relatively late in traditional Hawaiian times and quite possibly into the post-contact era. To the extent that *ali'i* authority was projected into the field system within *ahupua'a* land units, this result suggests that *ali'i* authority played a late, largely post-contact, role in construction of the field system.

A consideration of the tempo of change indicated by the Bayesian calibration contraindicates the impression of regularity and inevitability left by the chronology of the origin narrative. Instead, the expansion of agriculture into the region made possible by the late introduction of sweet potato was a fairly long, drawn out affair that is imprecisely dated with current evidence. This is a period during which expert agriculturalists experimented with a new crop plant in areas that had previously seen little, if any, use. Presumably, it was at this time that the limits of rain-fed cultivation of sweet potato were discovered—the arid boundary of the lowland fields and the nutrient deficient boundary in the wet uplands (Vitousek et al. 2004). Some experimentation with agricultural walls in the late seventeenth century indicate efforts, presumably successful, to control soil moisture against the combined effects of strong winds and variability in precipitation. This long period of expansion and initial experimentation was punctuated, probably early in the historic period, by a period of intensive wall construction and field subdivision that ended less than a century later when the field system was abandoned. The irregular tempo of change revealed by the Bayesian calibration, with a late burst of investment in the field system infrastructure followed soon after by its abandonment, suggests the importance of contingency in the history of agricultural development and raises the possibility that the response to contingent events, which disrupted several hundred years of apparently successful agricultural and social development, was not in the end sustainable.

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The double-body glyphs and palaeographic chronology in the *rongorongo* script

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Abstract

In the *rongorongo* script we encounter many anthropomorphic glyphs with an enlarged body and a hole in the belly. Based primarily on structural evidence present in parallel passages, it is argued that hollow-belly glyphs are in fact a compact form of two normal-belly single anthropomorphic glyphs. The scriptural evolution from two single-body glyphs into one double-body glyph was gradual and its various stages can be seen in different *rongorongo* inscriptions. The presence of these double-body (hollow-belly) glyphs may well be an indicator of the late chronological association of a text. Bearing this in mind, different *rongorongo* inscriptions can be classified into older and younger forms. Other palaeographic differences can also be employed for similar classifications. The forms of glyphs 099 and 522 also bear evidence for gradual change from more pictorial forms into other, more simplified forms. A reading of the related literature shows more scribal differences in other *rongorongo* glyphs as well. By combining various scribal differences together with the analysis of hollow-belly and 099/522 glyphs, most of the existing *rongorongo* inscriptions can be classified into a chronological list of texts based on their apparent palaeographic chronology. Comparing this list to the artifacts of known manufacture date reveals that palaeographic differences were probably developing quite quickly in *rongorongo* script evolution and that at least half of all known *rongorongo* artifacts were probably manufactured in the first half of the nineteenth century.

Introduction

Our knowledge of Rapa Nui's *rongorongo* script is still, after decades of research, somewhat scant. However, some progress in the understanding of this script has been made in recent years; new parallel passages have been discovered (Guy 2006: 65), statistical analysis has revealed similar structures between *rongorongo* texts and Rapanui poetry (Harris 2010; Horley 2005; Melka 2009a; Pozdniakov & Pozdniakov 2007), new structural observations have shed light on the likeliness of phoneticism in the *rongorongo* text, and inscriptions have recently been subdivided into meaningful fragments (Guy 2003; Horley 2007; Melka 2008). For an authoritative overview of our present knowledge on *rongorongo* inscriptions, the reader is directed to Guy's recent publication on the subject (2006).

In the inventory of the few hundred *rongorongo* glyphs of which the corpus is composed (Barthel 1958) are a few glyphs often referred to as "the hollow-belly glyphs", which is a fairly accurate description of their visual appearance. In the numerical system of glyph classification established by Barthel (1958: 40-41) all glyphs in the *rongorongo* corpus are divided into seven families. Glyphs numbered 001-099 are common geometric designs; glyphs 100-199 are more rare geometrical designs; glyphs 200-299 are anthropo- or zoomorphic glyphs with visible "ears" or "eyes"; glyphs 300-399 are anthropo- or zoomorphic glyphs with gaping mouths shown in profile; glyphs 400-499 are gaping mouth glyphs with various unusual body shapes; glyphs 500-599 are anthropo- or zoomorphic glyphs with unusual head forms; glyphs 600-699 are zoomorphic figures of birds; and the family of glyphs numbered 700-799 are other zoomorphic designs. Second and third digits may also be meaningful in describing a particular body or limb form.

According to the aforementioned classification, hollow-belly glyphs, which are the subject of this work, are usually given the third digit 8 or 9 (Figure 1). I argue that these hollow-belly glyphs represent compound forms of two basic glyphs in their respective zoomorphic family. Support for this claim is presented with a structural analysis of various parallel passages in the *rongorongo* texts.

The theory which I present for the meaning of these hollow-belly glyphs is that the evolution towards these glyphs was gradual and developed as a means of more economic space usage. This notion suggests that we might be able to categorize different *rongorongo* documents on a time scale based on their palaeographic style. With this thought in mind, another palaeographic difference is revealed: the shape of the bottom of glyphs 099 and 522. A gradual evolution is proposed from one form to another for these glyphs as well.

My work continues with the combination of the results of both of these analyses (hollow-belly and 099/522) combined with three previous similar attempts found in the literature (Barthel 1958: 159; Fischer 1997a: 389; Guy 1985: 387). The combination of these concepts led to a tentative assignment of the relative chronological relationship amongst 15 of the 25 documented *rongorongo* texts.

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The Hollow-Belly Glyphs

The possibility of hollow-belly glyphs being a duplication of single-body glyphs was first proposed by Horley in 2005 (Horley 2005: 109). The same author has, in a more recent publication (Horley 2010: 54), dubbed glyph 208 as a "double-body man", which is perhaps a more accurate description than the classical description of "the hollow-belly man." Hollow-belly glyphs are encountered in every family of four-limbed glyphs in Barthel's inventory (1958: 40-41). We find them in the 200, 300, 500 and 600 series of glyphs. The 400 series is composed of glyphs with a head shape (gaping-mouth) that is characteristic of glyphs belonging to the 300 series on various unusual bodies. Since the hollow-belly is coded by glyph 308 (Figure 1), we do not encounter the hollow-belly in the 400 series simply by the definition upon which this glyph series was based. Interestingly enough, all 308 glyphs have two heads. Contrary to other zoomorphic series, we never encounter any hollow-belly glyphs of the 300 series with one head.

Each of the 25 authentic *rongorongo* artifacts are referred to with a single capital letter; from A to Y (Barthel 1958: 14-33). Additionally, each tablet has a less formal descriptive name by convention. For example, tablet C is also known as the Mamari tablet, tablet H as the Large Santiago tablet, tablet E as the Keiti tablet, and so on. The two sides of each tablet are referred to as *recto* and *verso* (when the direction of reading is known), in short, *r* and *v*, or as *a* and *b* when the direction of reading is not certain. In addition, every line of each side of each artifact is numbered. This nomenclature gives a practical method of unambiguous reference to any particular portion of a *rongorongo* text. Thus, shorthand Ca1 refers to the first line of side *a* of the Mamari tablet, shorthand Qr4/5 refers to a piece of text from the *recto* side of the Small St. Petersburg tablet that begins on line 4 and finishes on line 5.

Rongorongo tablets C, E, H, N, P and R share a parallel sequence of text first mentioned by Pozdniakov (1996: 301) and shown in Figure 2. A parallel sequence is a piece of *rongorongo* text from different tablets, or from different fragments of the same tablet, which have the same or a similar sequence of glyphs. The existence of parallel fragments gives us a unique opportunity to understand the internal mechanisms of *rongorongo*. This can be compared to a situation in an English text where we have, in the same context, written *Archaeology* in one passage and *archæology* in another; in the decipherment of such an English text, one might therefore deduce that *A* and *a* are equivalents, and that the same goes for *ae* and *æ*. The same basic principle applies to *rongorongo*.

In a fragment of the parallel sequence presented in Figure 2, we have, in two instances (tablets E and R), glyph 561: a linked pair of birds with "chevron" heads. This glyph is replaced in the remaining tablets (C, H, N, P) by the hollow-belly anthropomorphic glyph 208 or its similar

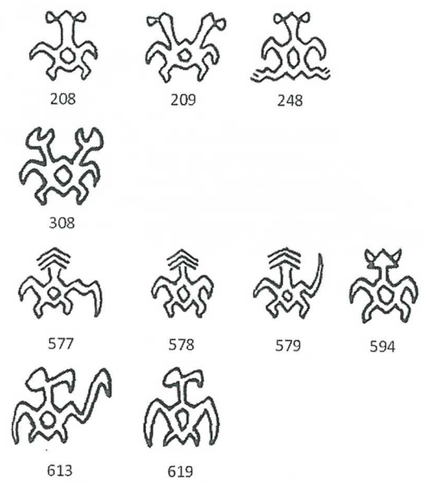


Figure 1. Various hollow-belly glyphs.

derivatives. The heads of glyph 561 are "masked off" with the chevron glyph 069. The same "masking off" is seen in the hollow-belly glyph from tablet P, of the discussed fragment, whereas hollow-belly glyphs of lines Ca1 and Hr1 are "holding" the chevron glyph 069.

The feature of "masking off" is a property known from other parallel sequences (see Guy 2006: 57 for a discussion and some of the terminology used here). We speak of "masking off" when, in one fragment of text, an anthropomorphic glyph is holding another glyph, but in the parallel fragment from another tablet, the glyph that was previously held is now in place of the head of the anthropomorphic glyph, thus it is "masking it off." In Figure 2 this is best seen when comparing the fragment from Hr1 to the one from Pr1.

Based on the parallel sequence presented above, one may deduce that hollow-belly glyphs are allographs of double anthropo- or zoomorphic glyphs, therefore, in this particular case the chevron-headed hollow-belly glyph 577 would be equivalent to the pair of chevron-headed birds of glyph 561. Figure 3A shows another parallel sequence shared by two lines on the *verso* of tablet B. This sequence, first mentioned by Butinov and Knorozov (1957: 11), is also present on the "Grand Tradition" tablets (H, P and Q). The so-called Grand Tradition is the longest known parallel sequence in *rongorongo*, with nearly all the material present on tablets H, P and Q constituting the same text (Barthel 1958: 155-156). Additionally, parts of this parallel sequence are also present on tablet A (Guy 1985: 367).

In the fragment presented in Figure 3A, one may observe how the "one-head hollow-belly" glyph 208 is being replaced by a "two-head hollow-belly" equivalent, classified as glyph 209 or 308. The two-headed hollow-belly glyphs seem to be

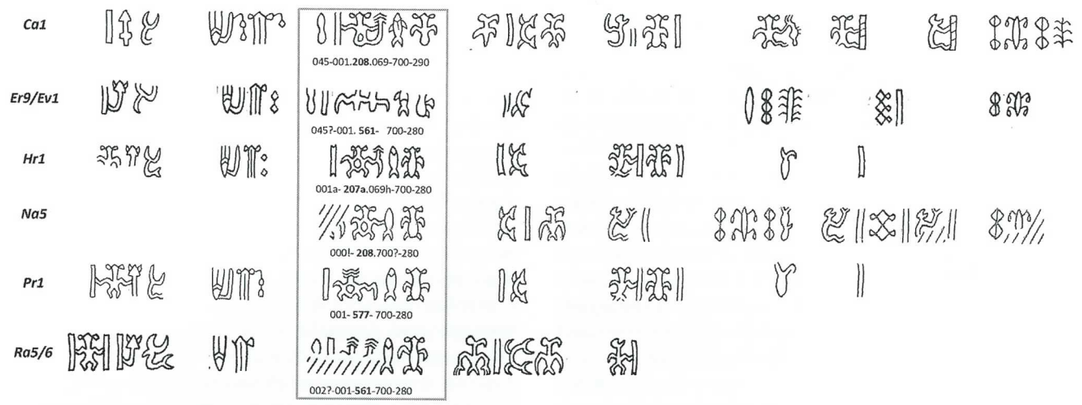


Figure 2. Parallel sequences with hollow-belly glyphs.

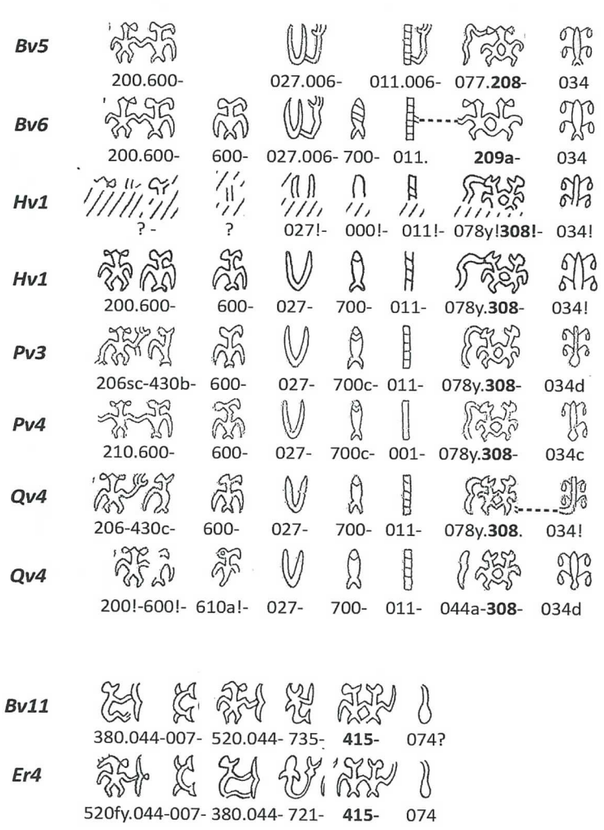


Figure 3. A. Parallel sequences between the Grand Tradition (tablets H, P and Q) and the Aruku Kurenga tablet (tablet B). It is interesting to notice that in all four texts this passage is repeated twice in a very short distance between both occurrences. Allography between one-headed glyph 208 and two-headed glyphs 209/308 is shown. B. Parallel sequences between text B and the Keiti tablet (tablet E). It shows the putative origin of the hole of the hollow-belly glyphs.

composed of two single anthropomorphic figures, which hold not only their hands but also their legs. These two forms; double-headed and single-headed, appear to be allographic in this parallel passage. This suggests that hollow-belly glyphs may have evolved from single-body glyphs through the two-headed form.

There is yet another parallel passage, one shared between tablets B and E, which may form a hollow-belly impression (Figure 3B). In line Er4 (tablet E) is glyph 415—two birds holding hands. The equivalent glyph in line Bv11 has the two birds joined not only at the arms but also partially at the legs—forming a hollow-belly impression. This suggests that the hole in the hollow-belly glyphs may have originated as a space between the arms and legs of two joined bodies.

Although relatively rare, there are a few examples of palindromic fragments in *rongorongo* texts. One such fragment, present in the Grand Tradition, is depicted in Figure 4. In this passage, we have seven consecutive glyphs which form a palindrome—glyphs A, B, C & D in Figure 4. If we look further on the flanks of this passage, one may observe the same group of glyphs on both sides which surround this passage in a palindromic fashion (groups E and F in Figure 4). This picture is slightly obscured by the intercalation of three additional non-palindromic glyphs (x and y in Figure 4). Also, group E contains an excellent example of "masking," which clearly shows that compound glyphs should be read from the bottom up (Guy 2006: 57).

If the whole of the presented sequence was really intended to be palindromic, including groups E and F, and its internal structure is not merely coincidental, then we have yet another example in which the hollow-belly glyph is carved as a replacement for two single-man glyphs (glyph

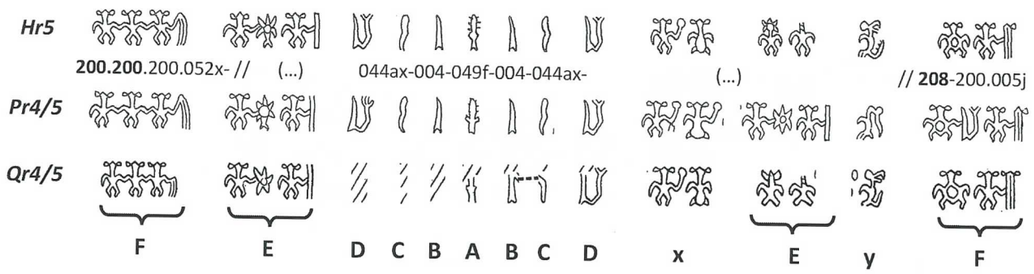


Figure 4. The Grand Tradition palindrome. Part D is composed of two glyphs: 004.064a; Part E of four: 200.081-200.001.

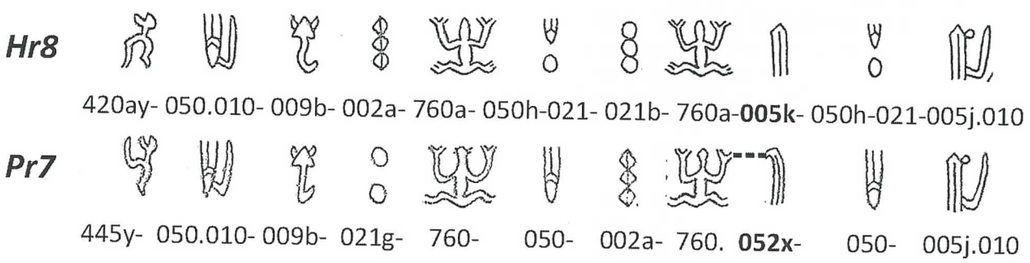


Figure 5. Parallel sequences with allography between glyphs 005 and 052.

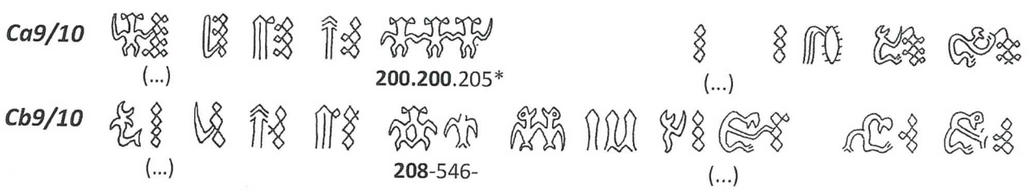


Figure 6. Putative parallel sequences from the Mamari tablet.

200). Note that in the first occurrence (with three single-man glyphs), group F contains glyph 052, whereas in the second occurrence (with the hollow-belly glyph), it contains glyph 005. Those two glyphs look similar and are allographic. This can be seen in a fragment of the Grand Tradition presented in Figure 5.

On one side of the Mamari tablet (tablet C), a well-known fragment is present in line Cb10; here, we have a unique string of glyphs that resembles a raw pictorial script (Melka 2009b: 127). Recently, it was proposed that this "kinetic" fragment has a parallel sequence on the other side of the same tablet in lines Ca9/10 (Horley 2010: 55-56). The rendering of those two sequences is presented in Figure 6. In the fragment from side *b*, the hollow-belly glyph 208 is accompanied by a partially erased anthropomorphic glyph designated as 546, whereas in the respective fragment from side *a*, we have three single-body anthropomorphic figures (Figure 6). This is yet another instance in which one hollow-belly glyph replaces two single-body glyphs.

Rongorongo has many parallel sequences, from very literal quotations such as the Grand Tradition (fragments in Figures 3, 4 and 5) to sequences with more variations, such as the sequence in Er9/Hr1/Pr1/Ca1/Ra5/Na5 (Figure 2). There are also those that do not immediately catch the eye, but become evident under closer scrutiny. An example of one such sequence is Cb10/Pr3/Hr4 (Guy 2006: 64-5; Horley 2010: 54). Finally, there are those that have so many variations between them that their whole alignment becomes questionable. This last case may apply to the passage presented in Figure 6. Since we don't know how far scribal variations were permitted in *rongorongo* writing, we cannot exclude the hypothesis that the many similarities present between lines Ca9/10 and Cb9/10 are due, in fact, to these sequences being parallel. However, they may also simply result from the remote mentioning of the same topic or word, or even by coincidental combinations of similar glyphs. Since we are dealing with a largely undeciphered script, we can only make educated guesses.

Figure 7. Scribal corrections. Bold line represents pre-incisions, grey line the final version. The hole in the belly comes from the space between arm and leg (from Horley 2009: 252).

If the aforementioned sequences are genuinely parallel, this is yet another case supporting the hollow-belly thesis which is the focus of the present work. Interestingly, one can view this situation as being more supportive of the double-body glyph idea for Ca9/10 and Cb9/10 being parallel rather than *vice versa*.

As observed in Figure 3, hollow-belly glyphs very likely evolved through an intermediate form which had two heads and a hole in the body created from the space between the adjoining arms and legs of two glyphs. This scenario is supported by the observation of a certain scribal error made in line Aa3 of the Tahua tablet (Horley 2009: 252). It has been observed that glyph 208 was carved upon a previous hairline pre-incision of glyph 200, and the belly of glyph 208 was formed exactly from the space between the arm and body of glyph 200 (Figure 7).

All the structural evidence presented above, mostly from parallel sequences, points to the conclusion that hollow-belly glyphs represent compound forms of two basic glyphs in their respective zoomorphic family. Glyph 208 would thus be a doubling of glyph 200, with glyph 308 being a doubling of glyph 300, etc.

The need for double-body glyphs is obvious and quite logical if we consider the peculiarities surrounding Rapa Nui's writing culture. Wood, the material on which *rongorongo* was inscribed, was very scarce on Rapa Nui. This led to the inscribing of the carving boards until the very last square centimeter "in order to save as much room on the precious writing material as possible in order to accommodate more text" (Fischer 1997a: 382). It also resulted in many ingenious ways of reducing the space taken by a given text. Single glyphs were linked and stacked one above another, while at the same time being simultaneously rotated. Heads were erased by masks made from the next

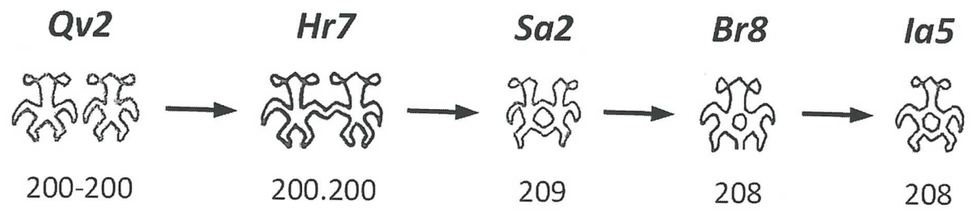


Figure 8. Proposed evolution from two single anthropomorphs to a hollow-belly glyph.

glyphs, which were also held or held aloft for convenience, and legs were erased if necessary (Guy 1982, 2006: 56-9). Thus, double-body glyphs fit perfectly into the known properties of *rongorongo* glyph combinations. There are also other examples of double glyphs: the "star" glyph 008 has its double form 080 and the "*rei miro*" glyph 007 has its double form, glyph 140 (Macri 1996: 186).

Thanks to the relationships presented in Figures 3 and 7, we can reconstruct how hollow-belly glyphs might have originated through gradual evolution from two single-man glyphs. This proposition is presented in Figure 8.

Hollow-Belly Chronology

The evolution toward hollow-belly glyphs is not the only palaeographic variation that we can observe in *rongorongo* texts. Other variations point toward the possibility of establishing some kind of chronological relationship between various *rongorongo* artifacts. The presence of hollow-belly glyphs in a text may indicate that we are dealing with a later, more developed form of script. The lack of hollow-belly glyphs may point toward older, less developed texts. However, this sort of chronological deduction must be done with caution; many *rongorongo* texts are too short to perform this kind of analysis, and the lack of hollow-belly glyphs might simply be an "edge effect"—there might be no need for them in certain short texts. On the other hand, we cannot produce a false positive result; therefore, if a short text has a hollow-belly glyph, we can safely conclude that it belongs to this "new" spelling form.

For the analysis of "old" and "new" spelling preferences, we should use only the texts that are long enough for statistical analysis, mainly texts A, B, C, E, G, H, I, P, Q, R and S. From these, texts that extensively use hollow-belly glyphs are: A, B, C, E (perhaps only Er), H, I, P and Q. From shorter tablets, we can also observe hollow-belly glyphs in texts D, M and N. The texts in which hollow-belly glyphs do not occur or in which we encounter only double-head hollow-bellies are G, R, S and perhaps Ev. The text of Gr is repeated, in a manner that could perhaps be rightly called the "Small Tradition", on tablet K. Neither of these tablets use hollow-belly glyphs on any occasion.

Other Palaeographic Variations

We can construct similar lists for other palaeographic variations, one of the more prominent variations being the two forms of glyphs 099 and 522. One of the forms of these highly similar glyphs has a bottom part in the shape of a rod with two legs attached, while the other form has its bottom part simplified into an x-shape (Figure 9a).

The only tablet that uses both bottom shapes is tablet A. Barthel (1958: 159) noticed that tablet A is also the only one that is using two different forms of glyph 070, whereas all other texts contain only one form of glyph 070—this led him to postulate that the text of tablet A was carved by more than one scribe. All other tablets use only one form of 099/522. The use of this feature is even more conservative than the right-left orientation of glyph 522. Each tablet preferably uses one of the two orientations, but some texts like B, E and K have a seemingly random distribution of right and left facing forms. The shortest *rongorongo* inscription, text J, has the 522 glyph which, interestingly, looks like an intermediate between the two forms. Combining this with other occurrences of 522, we can propose the putative evolutionary pathway that may have taken place in the transition of one form to another (Figure 9b).

It is tempting to assume that the x-shaped bottom, which is simpler and probably easier to carve, was developed later as a natural evolution from its more complex original form.

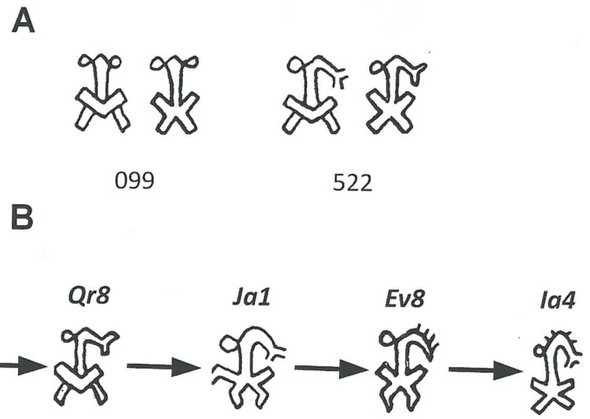


Figure 9. *a.* Two forms of glyphs 099 and 522; *b.* Proposed evolution from one form of 522 to another.

If one were to analyze all the artifacts according to the usage of one of these two forms, one would come to the following chronological division: older = D, F, M, N, Q, R and S; younger = B, C, E, G, H, I, K and P.

The first attempt to chronologically classify different *rongorongo* texts based on palaeographic evidence was done by Guy in 1985. He compared a fragment of the Grand Tradition, and his analysis revealed that "fewer signs are used on tablet A to record this text than on any of the other three tablets" (Guy 1985: 387). Combined with the notion that "the increasing scarcity of suitable wood is likely to cause alterations to the rules of the writing system, resulting in a more economical use of the recording medium" (*ibid.*), this leads us directly to the conclusion that tablet A is younger than H, P and Q; a notion that is supported by the fact that text A is engraved on European oar of ash wood (*ibid.*).

Fischer noted one such relationship between the Small Santiago tablet (tablet G) and the London tablet (tablet K). In his 1997a publication, Fischer notes that while tablet G has long-beaked 600 glyphs, tablet K has short-beaked (gaping-mouth) 400 glyphs. Since the gaping-mouth is a somewhat simplified version of the long-beak, it led Fischer to claim that "this would doubtless mean that the London Tablet is younger than the Small Santiago" (Fischer 1997a: 389).

Barthel (1958: 159) made yet another attempt at palaeographic classification. In the search for some kind of evolution of sign standardization based on the forms of two glyphs: 070 – a shield that can occur with or without internal detail, and 053 – vertical waves that can point either right or left, Barthel observed that, while most tablets use both the right and left form of glyph 053, on the contrary, every tablet, except for A, uses only one form of glyph 070.

We can either assume that 070 without the internal detail is a later simplified form of 070, or that 070 with internal detail is a later, less ambiguous form of 070. The first assumption produces a list of texts that counters the other aforementioned analyses. Therefore, it is assumed in this article that the form of 070 with the internal detail is a later, more evolved form. The results of this analysis, as well as the other previous attempts at palaeographic classification, are presented in Table 1.

Discussion

Table 1 presents five distinct palaeographic attempts at differentiation between various *rongorongo* texts. In each case, items are divided into two groups—older and newer. The internal relationship between items in the same group is not determined. However, we can summarize the artifacts that appear more than once in Table 1 into a single list with all relationships combined. In almost every case, the different palaeographic variations are in agreement with each other. Tablets G and K are an exception, since they do not possess hollow-belly glyphs; they are therefore viewed as older (than tablets D, M, N, Q) in that analysis, but simultaneously they have the x-shaped glyph 099/522, and are therefore assigned to the newer group (newer than tablets D, M, N and Q) in

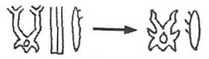
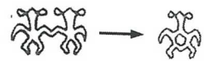
base of difference		older than →	← newer than	reference
form of 070		B, N, Q, R	E, I, P, T	Barthel 1958:159
general economics of glyph usage		H, P, Q	A	Guy 1985:387
glyph 600 vs. 400		G	K	Fischer 1997:389
occurence of hollow-belly glyphs		G, K, R, S	A, B, C, D, E, H, I, M, N, P, Q	this work
form of 099 and 522		D, F, M, N, Q, R, S	B, C, E, G,H, I, K, P	this work

Table 1. Palaeographic evidence for different styles in rongorongo artifacts.

the 099/522 analysis. Because the hollow-belly analysis is susceptible to false negative results, namely that the absence of hollow-belly glyphs might be an edge effect, it is assumed here that texts G and K are younger than D, M, N and Q, as it is pointed out in the analysis of glyphs 099/522.

The combination of the information gathered in Table 1 gives the following scheme of relative chronological relationships of different artifacts:

R, S → D, M, N, Q → B, G → K → C, E, I, H, P → A

In this scheme, involving 15 of the 25 known *rongorongo* artifacts, the oldest are the specimens held in the Smithsonian Institution collection—texts R and S. The youngest is the Tahua tablet, held in the Archives of the Congregation of the Sacred Hearts of Jesus and Mary (SSCC) and inscribed on a European oar.

The Santiago Staff (Item I), together with texts G and T, was postulated to be among the oldest *rongorongo* artifacts (Fischer 1997a: 457). This observation was made after classifying them as having "procreation triads with phallic suffix" (Fischer 1995). Items A, D, P, Q and R were classified as having "procreation triads without phallic suffix", thereby being later simplified forms. Métraux (1940: 404) also pointed out that sticks and batons were the original mediums for carving by the *rongorongo* scholars. The tablets seem to be a later addition. Even the name of the "script," *te kohau rongorongo*, means "the stick of the *rongorongo* men" (Métraux 1940: 389).

However, Métraux's notion cannot be treated as a decisive factor in ascribing relative age to different artifacts, since we have no ethnographic data which would suggest that when *rongorongo* scribes started using tablets, they stopped using batons (staffs). It is more likely that after the introduction of tablets as a writing medium, staffs were then used simultaneously with tablets. Thus, some staffs could be carved after some of the tablets, and the sole attribute of being carved on a staff cannot justify the classification of a text as being of more ancient origin.

As for Fischer's hypothesis, no other researchers in the *rongorongo* field agree that any "procreation triads without phallic suffix" exist in the first place (Guy 1998a, 1998b; Melka 2009a; Pozdniakov 1996; Robinson 2002: 241, Sproat 2003). Consequently, the whole idea of texts I, G and T possessing a more primeval form of those triads seems to be unfounded. The only clue that we are left with is the very fine style of carving on the Santiago Staff (Fischer 1997a: 455-7). This, however, may not be an argument for chronological pre-dating, as fine and careful craftsmanship is more likely to be a result of the great importance of an item, rather than its old manufacturing. In the case of the Santiago Staff, the fine craftsmanship may have been due to the fact that this artifact presumably belonged to an *ariki* (Barthel 1958: 25-6), a Rapanui chief or king, and was probably a *ta'u*, a list of warlike exploits (Guy 1998c).

Barthel himself believed that the Santiago Staff contains astronomical information (Barthel 1990), although he later endorsed Fischer's hypothesis (Fischer 1997b: 222). The only remaining clues for the relative chronological position of the Santiago Staff are the palaeographic differences listed in Table 1. However, these clues point towards a younger rather than an older production date.

There is no consensus among scholars about the age of the present *rongorongo* artifacts, and whether they pre-date or post-date the first contact between islanders and European sailors in the eighteenth century (Melka 2009b: 118-9 and references therein). The only hard evidence we might have could be from direct dating of the wood of each artifact. However, up until now, radiocarbon dating has been performed on only one tablet, tablet Q (Orliac 2005). One may justifiably call it a scientific disgrace that up to this very day, none of the other 24 *rongorongo* artifacts have been dated. The results obtained for tablet Q were intervals from 1680 to 1740 or, alternatively from 1800 to 1930 based on calibrated radiocarbon dating at 2 SD (Orliac 2005: 118). Since tablet Q was collected in the second half of the nineteenth century, the second presented interval is arguably more probable.

Almost all other *rongorongo* artifacts were collected around the same time period. Although a few were brought to the attention of researchers later on, the likely date for their collection is during the second half of the nineteenth century as well (Fischer 1997a: 404-507). It is not known whether the texts were manufactured shortly before their collection in the first half of nineteenth century, or much earlier and then kept as important documents up until the time of the devastating events of the 1860s. Only radiocarbon dating could shed more light on this issue.

It is known that a few texts were inscribed on European or American oars. These are tablets A (Métraux 1940: 393), V (Fischer 1997a: 463) and T (Métraux 1938: 4). Therefore, their texts were undoubtedly carved during the second half of the eighteenth century or the first half of the nineteenth century, when the *rongorongo* tradition was still alive and the people of Rapa Nui were already in contact with Western ships. Additionally, the diameter of tablet C suggests that it was cut from a tree (Pacific Rosewood, *Thespesia populnea*) of a height of 15m (Orliac 2005: 117). Since trees that high may have been long extinct on Rapa Nui by the time of first European contact, it points to the possibility of the ancient origin of this artifact (*ibid.*). However, the wood of *Thespesia populnea* is not very durable, and would require great efforts to preserve for hundreds of years (*ibid.*: 118). Again, this particular case calls for radiocarbon dating.

In another interesting study, Orliac (2007) identified the Large St. Petersburg tablet (tablet P) as made of wood belonging to the genus *Podocarpus*. Three other *rongorongo* artifacts were previously described as belonging to *Podocarpus* as well (Lavachery 1934). They are tablets D, N and S. Since *Podocarpus sp.* has never grown on Rapa Nui, Orliac (2007:9) has advanced a hypothesis that all those

artifacts (D, N, P and S) were carved from the same single source of wood—perhaps the crosses raised by the Spanish in 1770 on the Poike peninsula. Following this logic, it is possible that all four artifacts were carved more or less at the same time. While this is a very important observation, the comparability of the different botanical identifications that were done in different laboratories and at completely different times (more than 70 years apart) may be questionable.

Nevertheless, and quite fortunately, in the aforementioned study, two out of four tablets containing parts of the Grand Tradition text have their manufacture date broadly established (tablets A and Q). We may therefore compare these results with the results of the palaeographic analysis presented in Table 1 and the subsequent scheme derived from it. Dating of the tablets gives more or less the same time—the first half of the nineteenth century. Analysis carried out by Guy (1985: 387) favors text A as a newer form than Q. If this is correct, it would point to either a very rapid development of the *rongorongo* script or to the presence of more than one school/style of writing. Perhaps both of those options are correct. It is also possible that differences in the style of carving could be the result of varying skills of different scribes (Fischer 1997a: 648, note 25).

Texts A and Q, both coming from the first half of the nineteenth century, are close to the extremes of the proposed scheme above. This suggests that at least half of the artifacts—A, B, C, E, G, H, I, K, P, Q, T and V (ten from the scheme plus T and V, which are inscribed on oars)—originate from this period. Some of the remaining tablets may come from this time as well.

Based on all the studies mentioned in the above text, the best candidates for the oldest *rongorongo* items are tablets R and S. It is the author's opinion that these two artifacts should be the first candidates for radiocarbon dating, as this would shed new light on the question as to whether the *rongorongo* script originated before or after the Rapanui peoples' first contacts with Europeans, as this is a pivotal point in *rongorongo* research.

Conclusion

Rongorongo glyphs 208, 308, and other related glyphs resembling a man or a zoomorphic figure with a hollow-belly may very likely be fused duplications of two simpler glyphs; the hole in the body of these glyphs may be reminiscent of an early form of such a combination of two single glyphs in which both anthropomorphs were joined by their arms and legs, resulting in the space between these joined legs and arms forming a hole in the belly.

Glyphs 099 and 522 share a common lower part, which occurs in two forms; the second forming a simplified version of the first. The occurrence of hollow-belly glyphs, simplified forms of 099/522 glyphs, as well as other palaeographic differences, suggests the possibility of a relative chronological orientation of various *rongorongo* texts based on their palaeographic properties. A scheme presenting such relative chronological relationships and involving 15 out of the 25 *rongorongo* artifacts has been proposed. Radiocarbon dating of *rongorongo* tablets would be desirable for future palaeographic studies, especially for texts R and S (known as the Small and Large Washington tablets), which seem to be the oldest, based on the preceding analysis.

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Geochemical characterization of volcanic glass from Pu'u Wa'awa'a, Hawai'i Island

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Abstract

New fieldwork and laboratory research are reported here to help better define a major source of volcanic glass in the Hawaiian Islands: Pu'u Wa'awa'a volcanic cone. This research centers on two questions: (1) What is the size of raw material available at the source and how does this parent material compare with debitage in archaeological collections? And, (2) Can chemical variably in Pu'u Wa'awa'a volcanic glass allow us to sub-classify artifacts? As one would expect, average size and weights are predictably smaller when comparing raw material to primary reduction, and smaller again when comparing primary reduction to core reduction. XRF chemical characterisation shows that while all volcanic glass derived from Pu'u Wa'awa'a is chemically similar, it is possible to sub-classify artifacts by copper (Cu) content. The vast majority of artifacts made from Pu'u Wa'awa'a volcanic glass are from Cu-poor eruptions. There are, however, rare examples of Cu-rich artifacts. The frequency of Cu-rich artifacts increases with distance from source. One explanation for this enigmatic pattern is that it is the by-product of a process similar to serial founder effect. Cu-rich flaking cores could have increased in relative proportion as the total amount of Pu'u Wa'awa'a glass in assemblages became smaller at sites further distant from the source. Alternatively, this pattern may simply reflect the general pattern of increased fragmentation of Pu'u Wa'awa'a cores as they are passed further down the line. Interestingly, in the South Point region we do not find any examples of Cu-rich material, again suggesting a pattern of access and exchange similar to the closest sites to the source.

Introduction

The assignment of archaeological artifacts to a geological source relies on our knowledge of that source's geological history, local geomorphology, and within-source geochemical variation (e.g., Mills et al. 2008). New fieldwork and laboratory research are reported here to help better define a major source of volcanic glass in the Hawaiian Islands: Pu'u Wa'awa'a[1] volcanic cone. Located on the northern flanks of

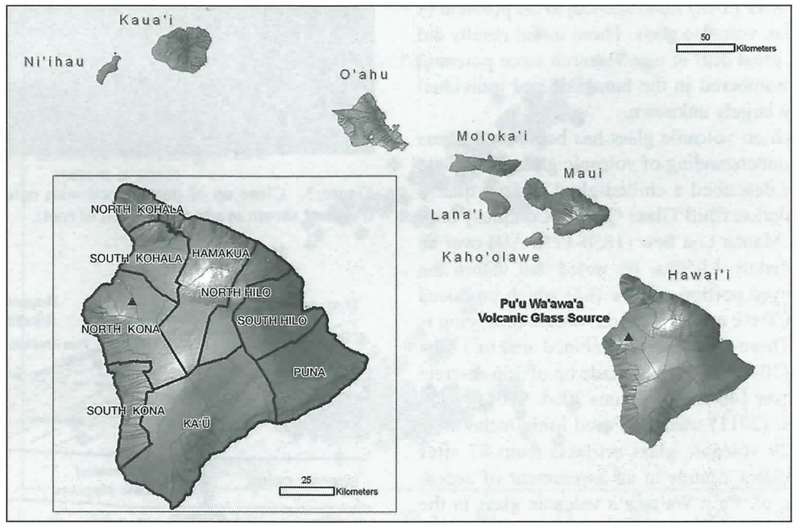

Figure 1. Location of a major volcanic glass source: Pu'u Wa'awa'a, Hawai'i Island.

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