Rongorongo Script: Carving Techniques and Scribal Corrections

by

Paul HORLEY*

ABSTRACT

Studies of three original rongorongo *tablets (*Tahua, Aruku Kurenga *and* Mamari*) revealed clear traces of two-stage carving (pre-incising with an obsidian flake and contour enhancement with a shark tooth). Most probably, the texts were written in short fragments with shark-tooth engraving applied before passing to the next fragment. Additional multiple engraving sessions might been performed for finished inscription, aiming to enhance glyph contours. Despite laborious and time-consuming writing technology, the scribes display extremely high professional level, making only a few errors and corrections in the studied inscriptions totaling to about 4,000 glyphs. These errors usually consist in pre-term writing of a passage, re-insertion of omitted symbols (even on the edge of the tablet) and palimpsest corrections. Pronounced shape variation of signs entering inline repetitive fragments seems indicative of direct on-tablet composition of the text without any draft inscriptions. Corrections and parallel passages suggest allography of glyphs 133 and 067, which by analogy may imply allography of signs 055b and 068 in Barthel's notation.*

KEYWORDS: Easter Island, *rongorongo*, script, paleography, allograph

RÉSUMÉ

L'étude menée sur trois tablettes rongorongo originales (Tahua, Aruku Kurenga et Mamari) montre clairement que les signes ont été tracés au cours de deux étapes successives : pré-incision avec un éclat d'obsidienne puis gravure des contours avec une dent de requin. Il est probable que de courts fragments de textes étaient écrits et gravés à l'aide d'une dent de requin avant de tracer le fragment de texte suivant. Des reprises de gravure ont pu être exécutées afin d'améliorer les contours des glyphes. Malgré une technique de tracé minutieuse et complexe, peu d'erreurs ont été faites par les scribes dans le texte étudié totalisant environ 4 000 glyphes. Ces erreurs consistent essentiellement dans l'écriture initiale d'un passage, dans la réinsertion de symboles omis (même sur le bord d'une tablette) et dans les corrections par ablation partielle d'inscriptions (palimpseste). La variation prononcée dans la forme de certains signes présents dans des fragments répétitifs semble indiquer une composition du texte directement sur la tablette sans pré-incision préalable. Les corrections et les fragments de textes similaires suggèrent une allographie des signes 133 et 067, qui par analogie peut impliquer l'allographie des glyphes 055 et 068 dans le système de notation de Barthel.

MOTS-CLÉS : île de Pâques, *rongorongo*, écriture, paléographie, allographe

* Yuri Fedkovych Chernivtsi National University, Chernivtsi, Ukraine, e-mail paulmn@operamail.com

Rongorongo script of Easter Island, first mentioned by Brother Eugène Eyraud in 1864 (Orliac and Orliac, 2008: 62), survived on about two dozens of inscribed artifacts collected in a short period during the late 19th century. The first tablet, *Echancreé*, was presented to the Bishop Tepano Jaussen by Father Gaspar Zumbohm in 1869 (*ibid*, 259); three tablets deposited by J.L. Young to the Bishop Museum at Honolulu are the latest collected around 1888 (Fischer, 1997: 459). The radiocarbon dating of the wood of Small St. Petersburg tablet yielded the possible dates in the ranges AD 1680-1740 and 1800-1871 (Orliac, 2005: 118). The first interval advocates for a considerable antiquity of the script expanding to pre-contact (1722) time, while the second range practically overlaps with a period when the majority of *rongorongo* tablets were collected. The existence of inscriptions on a European oar (tablet *Tahua*) and four *kohau rongorongo* made of conifer wood (Orliac and Orliac, 2008: 257) that could be probably sourced from the crosses set at Poike by Gonzalez in 1770 (Orliac, 2007: 9), suggests that Easter Island script was still active in post-contact time including late 18th century.

Rongorongo studies revealed that several artifacts have the same text (Kudryavtsev, 1949: 180; Barthel, 1958: 56-70) and share many parallel passages (Barthel, 1958: 156-157; Pozdniakov, 1996: 295; Sproat, 2003; Horley, 2007: 26). The inscriptions contains repetitive sequences delimited with a fixed glyph groups (Harrison, 1873: 379, 380-382; Butinov and Knorozov, 1956: 82; Barthel, 1958: 304; Fedorova, 1982: 38, 66; Fischer, 1995: 306; Guy 2006: 59, 60; Horley, 2007: 27-29; Melka, 2008: 162). Analysis of parallel passages helped to define reading order for the ligatures (Métraux, 1940: 401; Guy, 1982: 447; Pozdniakov, 1996: 297). Results of statistical analysis of *rongorongo* texts suggest that the script most probably had a predominant syllabic nature (Pozdniakov, 1996: 300; Horley, 2005: 114; Pozdniakov and Pozdniakov, 2007: 12).

One of the important problems that should be solved to enable decipherment of *rongorongo* consists in a proper identification of basic glyph elements and their allographic forms. In addition to parallel sequences, much information for allographic studies can be extracted from the calligraphy of the script, which is closely related to carving techniques and properties of writing media itself.

Carving of *Rongorongo* inscriptions

According to Brother Eugène Eyraud:

«one finds in all the houses [on Rapa Nui] wooden tablets and staffs covered with sort of hieroglyphic characters. These are figures of animals unknown to the island, which natives trace by means of sharp stones.» (Fischer, 1997: 12)

Later ethnographic studies revealed that the signs were carved with obsidian flakes and shark teeth (Englert, 1948: 317). To increase the precision and lower the strain, both types of tools should be hafted (Fischer, 1997: 388). This detail is confirmed with a crossed-out passage in the notes of Tepano Jaussen (Orliac and Orliac, 2008: 247). Before carving in wood, the pupils practiced writing with a bone stylus over banana stems and leaves (Englert, 1948: 316), which proved to be an excellent writing media (Barthel, 1959: 164). Moreover, the veins of banana plant (separated in average by 10 mm and 15 mm space for stems and leaves, respectively) offered an efficient natural lining that might determined glyph size for inscriptions in wood (*ibid*). It was suggested that banana leaves were also possibly used to keep a «draft text» intended for carving on wooden tablet (Fischer, 1997: 647).

Predominant glyph orientation perpendicular to the fibers of leaf or wood (Orliac and Orliac, 2008: 253) most probably was an important factor defining the shape of the signs; they are practically devoid of horizontal segments that are capable to damage the integrity of a leaf or cause slips of writing implement on wood. Even rectangle-looking signs usually have inclined or v-shaped top and bottom parts to avoid cutting lines along the fibers. The similar restrictions can be seen in other scripts (unrelated to *rongorongo*) designed for incising on palm leaves – Kannada, Telugu and Oriya from India – which widely use curved lines to avoid tearing the leaves apart (Masica, 1993: 143, 144). Runic script, developed for carving in wood, also lacks horizontal segments that will be hard to distinguish from wood fibers or cracks (Greetham, 1994: 65). To the contrary, scripts designed for non-incising writing implements (*e.g.*, Chinese or Maya hieroglyphs intended for brush and ink writing on a paper), are usually free from this restriction on horizontal lines.

Prior to carving, the surface of a tablet was usually carefully polished (Fischer, 1997: 388); then, a set of shallow grooves (flutes) few tenths of a millimeter deep (Orliac and Orliac, 2008: 245) was formed on its surface to aid alignment of the signs and protect them from wearing (Harrison, 1873: 372). The glyphs were pre-

incised with an obsidian flake (Orliac and Orliac, 2008: 246) and deepened with a shark tooth (Dederen and Fischer, 1993: 182). The properties of writing media also influenced the choice of a proper instrument – old and worn shark tooth proved to be more useful than a new one, because it does not tear wood fibers during carving of acute angles (*ibid.*: 184).

The lines of *rongorongo* texts are arranged in reverse boustrophedon fashion (Métraux, 1940: 394), requiring rotation of a tablet upon reaching the end of each line. In many cases, observation of fitted and overlapped signs in the neighboring lines helps to deduce their reading order even without resorting to analysis of parallel textual fragments.

Methodology and general comments

This paper focuses on three *rongorongo* tablets *Tahua*, *Aruku Kurenga* and *Mamari* from the Collection of the Congregation of the Sacred Hearts of Jesus and Mary (SS.CC.), Rome. All three artifacts were displayed at the Exhibition of 60 objects from Easter Island (Paris, Galerie Louise Leiris, June 3 - July 31, 2008). The showcases for the tablets were made of a special glass with anti-reflective coating, allowing clear view of each inscription from the both sides. To detect faint pre-incised glyphs and scribal corrections, the visual study was aided with a magnifying glass and an additional light source when needed. The texts of the original inscriptions were compared with the tracings published by Barthel (1958) and Fischer (1997); further analysis was performed with computer-enhanced photographs of the artifacts.

Even a brief observation of original tablets reveals amazing artistic skills of the scribes, *tangata rongorongo*. All the signs, despite of their small size and multitude of fine details, are carefully carved « with a freedom, a keen appreciation of proportion, and a vigor » (Métraux, 1940: 393) – and practically without errors. The number of corrections in the studied texts (totaling up to about 4,000 glyphs in Barthel's notation) is astonishingly few. The *presence* of corrections suggests that apart from aesthetic issues, the scribes obeyed writing rules, and were concerned about producing the most accurate text. To simplify the analysis, all scribal errors and corrections were grouped by their type: minor corrections (influencing only a part of the sign), pre-term writing evidenced by faint pre-incised contours, re-insertion of omitted glyphs and palimpsest corrections.

The tracings of *rongorongo* glyphs shown in the figures were made after the photos from the SS.CC. Archives and illustrations published by Orliac and Orliac (2008), Chauvet (1935), Heyerdahl (1975), Butinov and Knorozov (1956). Barthel's notation is used for referencing tablets, lines and individual glyphs; glyph codes are zero-padded (also in figures, if the space permits) to three-digit numbers according to the CEIPP extended Barthel system.

Minor scribal corrections

Minor corrections of mistaken glyph elements can be detected by unusual contours featuring pronounced angle on what should be a smooth curve, or survived pre-incised lines (Figure 1). Graceful anthropomorphic signs with long necks or curved backs were quite difficult for carving; sometimes, several pre-incisions might have been required to achieve a proper shape (Figure 1, Aa5). If long neck was pre-incised too close to the body, it precluded engraving of a head without intersection of the contours. In such cases, the scribe «skewed» the head at unnatural angle (Figure 1, Aa1, sign 655) or abandoned pre-incised contour, re-writing both neck and head properly (Figure 1, Bv6, sign 474). In rare cases pre-incision of a standardized duplicated form shows a single-glyph analog, such as faint traces of a «star» 008 in place of a «double star» 080 (Figure 1, Ab1), and outlines of a single sign 200 in place of 208 in line Aa3 (Figure 1). The scribe of tablet *Tahua* confused leg types for anthropomorphic glyphs, correcting himself before deepening the contours with a shark tooth (Figure 1, Aa3 and $Ab7_1$) or appending a proper leg to a finalized glyph (Figure 1, Aa6 and Ab2).

Marked list delimiters 001.009:005, characteristic for the tablet *Tahua*, renders sign 009 with a smooth and rounded bottom part (Figure 1, Aa7 and $Ab7_1$), resembling that in the ligature 045.009.037 (Figure 7, $Bv8_2$). In some cases, the tri-line sign 005 is carved slightly to the right from axis of glyph 009 (Figure 1, Aa7), possibly implying that it should be read after. In line Ab4 (Figure 1), the fragment 010.599d-005 includes a pre-incised contour of sign 001 unlinked from glyph 599. The lower part of the latter was probably too small for clear incision of a vertical line, so that a full-size sign 005 was carved next. Two «feathered» version of sign 050 (Figure 1, $Ab7_2$ and Ab8) feature a faint «feather garland» glyph 003 at their left side.

Minor scribal corrections in *Aruku Kurenga* text include clearly marked toe division in the

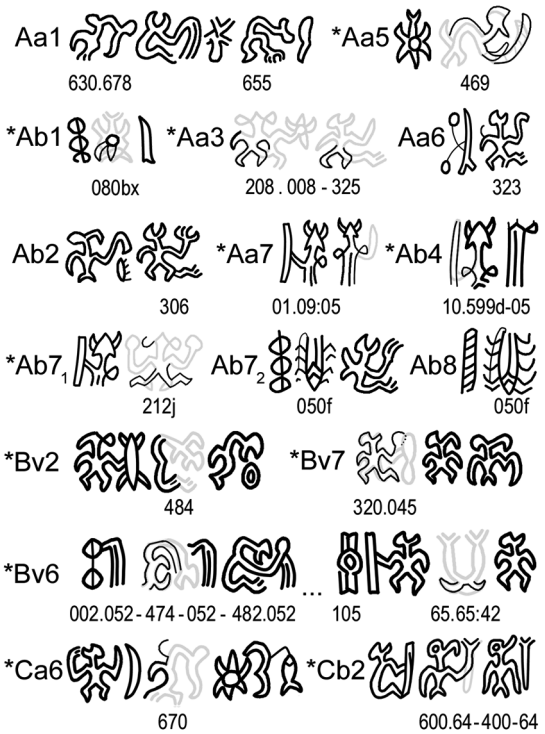

FIGURE 1. – Minor scribal corrections

The lines with an asterisk (*) include deep contours (thick black / grey curves) and hairline pre-incision (thin curves).

middle of the foot for sign 484 (Figure 1, Bv2), suggesting that the present foot might have been added to balance composition of the glyph. A pre-incision in line Bv7 (Figure 1) reveals scribe's intention to carve sign 322 with a rounded fist, which was changed in favor of full-size glyph 045. A pre-incised contour in line Bv6 shows slightly different basal shape for the ligature 065.065:042.

In the first delimiter group of lunar calendar of tablet *Mamari* (Figure 1, Ca6) there is a rounded pre-incision at the neck of sign 670. It is only the second occurrence of this glyph on the tablet (the first one is in line Ca1), so the carver might have been not accustomed yet to write this sign in its standardized form, trying to spell it by components instead. The same situation takes place in tablet *Tahua*, where before the first occurrence of glyph 670 in line Aa1 one can see a strikingly similar ligature 630.678 (Figure 1, Aa1) with a rounded-head glyph 630 matching pre-incision in Ca6. This evidence may suggest that a long-beaked sign 670 has a composite nature, corresponding to fusion of glyphs 630.678. The remaining minor correction in tablet *Mamari* is a ligature 600.64, initially outlined as a single sign 604 (Figure 1, Cb2).

Evidence for pre-term writing

In some rare cases a textual fragment becomes written too early (*i.e.*, has a pre-term appearance), which is corrected by repeating the same passage in a proper context like illustrated here in the example illustrated here. In place of crossed-out words, *rongorongo* inscription will feature hairline obsidian pre-incision below the final deeply carved signs. The existence of such re-written glyphs on tablet *Mamari* (see Figure 2, Ca7 and Cb6$_4$) were described by Barthel (1963: 373, footnote 3) without any illustration or discussion about their relation to the neighboring signs. Fischer confirms that the other tablets contain the « entire sequences of etched hairline glyphs [that] have been written over with different, deeply incised glyphs » (1997: 388, 389), also without illustrating any examples.

Pre-term writing occurs on each artifact studied. Tablet *Tahua* has two such instances: a «fisherman» 306.711 erroneously incised in place of sign 305f.020 and a ligature pre-incised as 450.240.002, but re-carved adding a hand 006 to a «sitting man» sign (Figure 2, Ab1 and Ab8, respectively).

Aruku Kurenga has three corrections in neighboring lines Br4 and Br5 (Figure 2): anthropomorphic glyph 263s pre-incised below signs 700-001, causing curved contours of overlaying «stick» 001, and a misplaced glyph 065 held by a «bird». The most interesting example features signs 133-773 pre-incised in reverse order (Figure 2, Br5$_2$). Surprisingly, the second glyph (corresponding to sign 133 with a closed upper part) was initially traced as a «palm tree» 067 with X-shaped top. The implied allography (or interchangeability) of signs 133 and 067 makes this sequence «rhythmic»: 607-**063-730-067-**773-**063-730-067**.

At the *verso* side, the scribe omitted glyphs 430-739 and proceeded with pre-incision of a lengthy sequence 022-050-022-002-022.010 (Figure 2, Bv2). When the error was realized, the missing signs were inserted and writing resumed from the contour of glyph 022, resulting in a wide space after sign 739. The underlying faint contour of glyph 002 explains the rounded « tail » in Barthel's version of the sign 739 (most probably based on Figure 156 from Chauvet, 1935). Fischer's tracings show sign 739 in its final form with pointed ends of the « tail ». Mistakenly incising sign 381 as 385 (Figure 2, Bv7), the scribe proceed with a delimiter 003.065.200 of a list-like structure in lines Bv5-Bv7, writing it in «mirrored» form 300.065.003.

FIGURE 2. – Pre-term writing examples shown in pairs illustrating pre-incised (marked with an asterisk) and final version of the inscription

In the text of tablet *Mamari*, pre-term writing occurs inside lunar calendar delimiter (Figure 2, Ca7), where the bird with a long beak 670y was pre-incised immediately after sign 378y, skipping a crescent 041 existing in all such delimiters. The head of both pre-incised and final version of glyph 670y looks to the left, contrary to the usual head-right orientation. Possibly, it was intended to convey a special meaning, such as a change from waxing to waning moon (Guy, 1990: 141). The pre-incision left no space to insert the missing crescent even in superscript form (see Figure 3, Ca7, Ca8), causing the scribe to abandon this contour and to write a full-size crescent 041 on top of it. The residual hairline grooves, filled with powder to increase contrast in early pictures (Chauvet, 1935: Figure163), create an impression of a deliberate hatching:

> «the lines through this moon are only apparent on high quality photographs of the tablet. We propose them to indicate that the moon is diminished from full luminosity.» (Berthin and Berthin, 2006: 96)

The new superb photo of tablet *Mamari* (Orliac and Orliac, 2008: 256, Figure 194) clearly show the underlying bird glyph. The hatched moon signs do exist (*e.g.* Figure 2, Br9, Bv10). However, hatching is applied after marking glyph contour, so it does not expand beyond sign outlines (at least not as much as seen in Chauvet's photo).

Another pre-term writing occurs in a structured sequence in lines Cb6-Cb7 (Figure 2) where the sitting sign 381 was incised in place of glyph 030b, defining the wavy shape of the leftmost «feathered stem» and the bottom part of the sign. It is curious that sign 030b is located in the same position within the repetitive pattern as three unidentified glyphs with «feathered circles» (Figure 2, $Cb6_3$), suggesting that these signs may be related. The delimiter group 004-066-**760**-004-066 includes glyph 066 before the «lizard» 760 in three cases; in the fourth one, there is a faint pre-incised contour (Figure 2, $Cb6_4$), which might possibly intended to represent sign 066 or 092.

Omissions and palimpsest corrections

The easiest way to correct omission of a short segment (one-two glyphs) is to fit them between the existing signs, resulting in small subscript / superscript forms distinguished by letters *t* and *h*

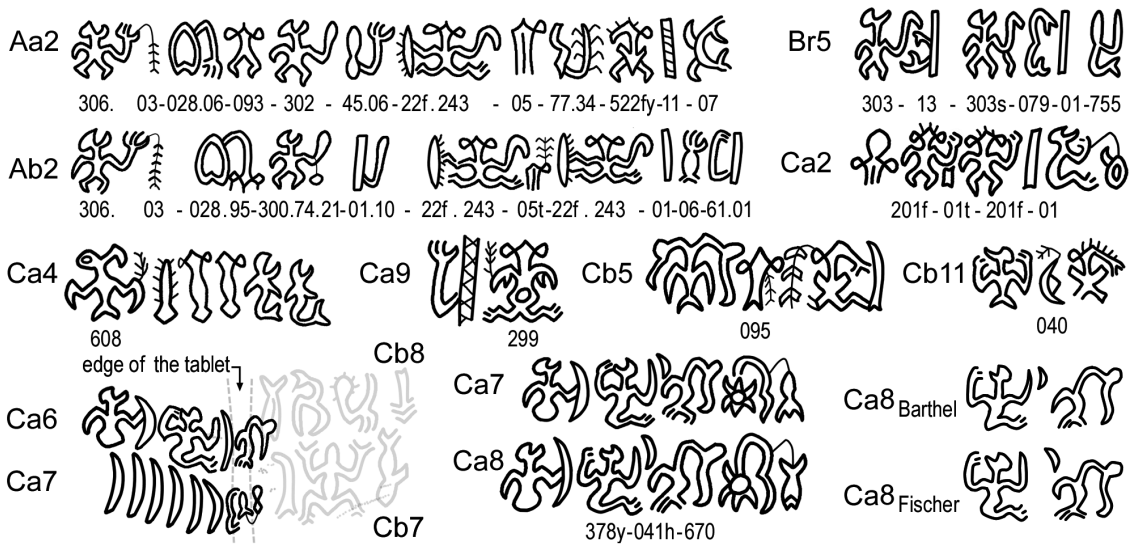

FIGURE 3. – Inserted glyphs and sign adornments in the tablets *Tahua*, *Aruku Kurenga* and *Mamari*

in Barthel's notation. Not all small-size glyphs constitute corrected omissions; the majority of them were written in this way for efficient use of space or, possibly, for inscription embellishment purposes. However, a tentative judgment about re-insertion of omitted glyphs can be made for parallel or repetitive fragments, if one of them uses small-sized signs where the other shows full-size forms.

On tablet *Tahua*, two passages feature the same text with minor variations (Figure 3, Aa2 and Ab2), such as sequence 028.006-093 condensed to a ligature 028.095 (Kudryavtsev, 1949: 191). The similar simplification takes place with a fragment 022f. 243-005-077.034, abbreviated as 022f.243-005t in line Ab2. Additionally, there is a miniature sign 034 above the subscript glyph 005t; its hairline incision is undetectable in Chauvet's photo (1935: Figure 169) and does not appear in Barthel's tracings. A modern illustration (Orliac and Orliac, 2008: 248, Figure 185) allows to see this hairline incision, which may represent an example of re-inserted sign. Four hairline glyphs 003 are similarly fitted in tight spaces in tablet *Mamari* (Figure 3, Ca4, Ca9, Cb5, Cb11; Orliac and Orliac, 2008: Figs. 193, 194); they are absent in Barthel's tracings, but are documented by Fischer (1997: 413-416).

In-line repetitions can also reveal possible re-inserted glyphs. A two-headed glyph 013 in *Aruku Kurenga* text (Figure 3, Br5) was possibly intended to represent ligature 079.001 written a couple of signs further. If so, then two heads 079 were probably omitted and further squeezed between signs 303 and 001. In duplicated group 201f-001 (Figure 3, Ca2) a «stick» 001 is set under the elbow of first anthropomorph, but appears in full size after the second one, despite there was a space to fit it in the same manner. It this case, one becomes inclined to think that the first sign 001 may have been re-inserted.

The most famous example of inserted glyphs appears in the second delimiter group of lunar calendar (Figure 3, Ca6). It was first documented by Fischer (1997: 418) as a:

> «composite glyph, perhaps v631By.78, [...] incised on the tablet edge that begins RR 2a7 [Ca7 in Barthel's notation], in other words, within the "calendar's" text. Since it is on the edge of the artifact, this glyph appears neither in any photographs of the tablets nor in Barthel's transcription.»

Study of original tablet confirms the existence of these edge glyphs (Figure 3, Ca6/7). They have more elaborate shape than that depicted by Fischer (1997: 418), perfectly fitting the missing part of a delimiter group (*e.g.* Figure 3, Ca8). First sign is a long-beaked bird 670 with a hand-like claw and a head expanding over the side Cb, where it overlaps gaping-mouth head of a fish (Figure 3, Cb8). Both head and a beak *are visible* in the new photo of *Mamari* (Orliac and Orliac, 2008: 255, Figure 193). The second edge glyph corresponds to star-prefixed group 008.078.711 and also starts on b-side, significantly away from the first sign in line Cb7. Being carved over an «uncomfortable» surface, the «star» is reduced to a lozenge-like form (a central circle and a ray?), which is also visible in the aforementioned photo. The fish glyph 711 is carved completely over the edge. It belongs to the first part of the calendar where all fish glyphs in delimiter groups are pointed upwards, most probably implying that the moon phase is waxing (Guy, 1990: 141).

Surprisingly, the edge fish looks down, which may mean that its omission was detected after the carver passed to the waning moon part of the calendar (*i.e.*, upon completing line Ca7, or even both sides of the artifact). The curved glyph 078 is misplaced after the fish, extending to side Ca and becoming partially visible in the modern photo (Orliac and Orliac, 2008: Figure 194). To facilitate detection of the edge glyphs discussed, Figure 3 includes dashed curves representing tablet outline for a particular case of photos published by Orliac and Orliac (2008: Figs. 193 and 194); a magnifying glass is helpful to see these glyphs clearly.

Two delimiter groups of lunar calendar include superscript crescents 041h (Figure 3, Ca7 and Ca8), the small size of which was suggested to represent small apparent diameter of the Moon in the apogee of its orbit (Guy, 1990**:** 139). Possibly, one or two intercalary nights *Hotu* and *Hiro* were inserted into lunar calendar when the apogee criterion was met (*ibid*, 140). Indeed, Barthel's tracings suggest that these crescents were carved small despite there was plenty of space to write a full-size sign (Figure 3, Ca8 Barthel). In Fischer's tracings, both crescents 041 are more closely related to the next sign 670. This discrepancy stems from the best intentions of both authors to produce the most readable tracings, which required unification of spaces between the signs for the sake of presentation clarity. However, as it can be seen from the photos of the artifact, these superscript crescents show no preferred association with either of signs 378y and 670; instead, they are fitted between aforementioned glyphs. Therefore, following the previously discussed examples, one becomes inclined to think that these crescents were possibly omitted and then «squeezed» into available space. The pre-incised sign 670y in the same line Ca7 (Figure 2) supports this hypothesis, proving that the carver already omitted crescent 041 once, but in that case he has no place to insert it in superscript form and thus has to carve a full-size glyph. Moreover, the structure of delimiter group may «facilitate» such omission because the hand of glyph 378y resembles a crescent itself. Thus, it could be natural for a scribe to skip sign 041, as he just carved the very same shape as a part of sign 378y. A further discussion on superscript crescents follows in the next section.

If omission mistake was detected already after deepening glyph contours with a shark tooth, the scribe was forced to use palimpsest as an «ultimate» re-insertion technique – to polish off a part of the inscription and re-write correct glyphs over it. Such corrections are detectable by characteristic localized «bumps» (Laurens, 2008) aligned with individual lines. These polished areas are easy to reveal in slanting light, but they can be practically invisible under frontal illumination. For three *rongorongo* tablets studied, the palimpsest corrections can be clearly seen in the photos published in *Trésors de l'île de Pâques/Treasures of Easter Island* (Orliac and Orliac, 2008 : Figure 186 [Aa], Figure 193 [Cb] and Figure 197 [Aa, Ca]).

The number of palimpsests per artifact seems to depend on the professional level of the scribe. More masterly executed *Aruku Kurenga* and *Tahua* feature only one and two corrections of this type, respectively (Figure 4). The situation with tablet *Mamari* is more complicated, as its wooden support was already damaged in several places on (what became) side Cb before the incision (Orliac and Orliac, 2008: 257), including a deep cavity close to the corner (Figure 4, Cb3). The signs inside this cavity were studied using an additional light source and traced after a photograph subjected to computer image enhancement. These glyphs are best seen in the photo from SS.CC. Archives (*ibid*, Figure 192), which used white powder to enhance image contrast. The original surface defects may also include smoothed areas in lines Cb4, Cb6, and Cb7. To the contrary, the polished sections Ca3, Ca5, Ca7, Cb2, and Cb12 were certainly made deliberately for text correction needs.

The polished area in line Aa3 (Figure 4) is especially interesting as it enters the neighboring line – which can only post-date the correction. The obtained line order perfectly coincides with that determined by Barthel. Usually, all palimpsest corrections are short; the scribe may polished away a part of a single sign, *e.g.* removing erroneously written head 050 of glyph 254a, which had to belong to a second anthropomorph (Figure 4, Aa5). The same probably occurred to the bird sign in line Ca5 to make it a «star-head bird». One crescent in lunar calendar also underwent modification (Figure 4, Ca7). Line Ca3 contains the longest (for artifacts studied) palimpsest correction with a polished area expanding over six Barthel's glyphs (Figure 4).

Pits and holes in the tablets

The tablets feature pits (not penetrating through the whole plank) or holes used to pass a cord for hanging. The interaction between pits / holes and glyphs (Figure 4) allows to infer about their temporal relation. If the hole postdates the

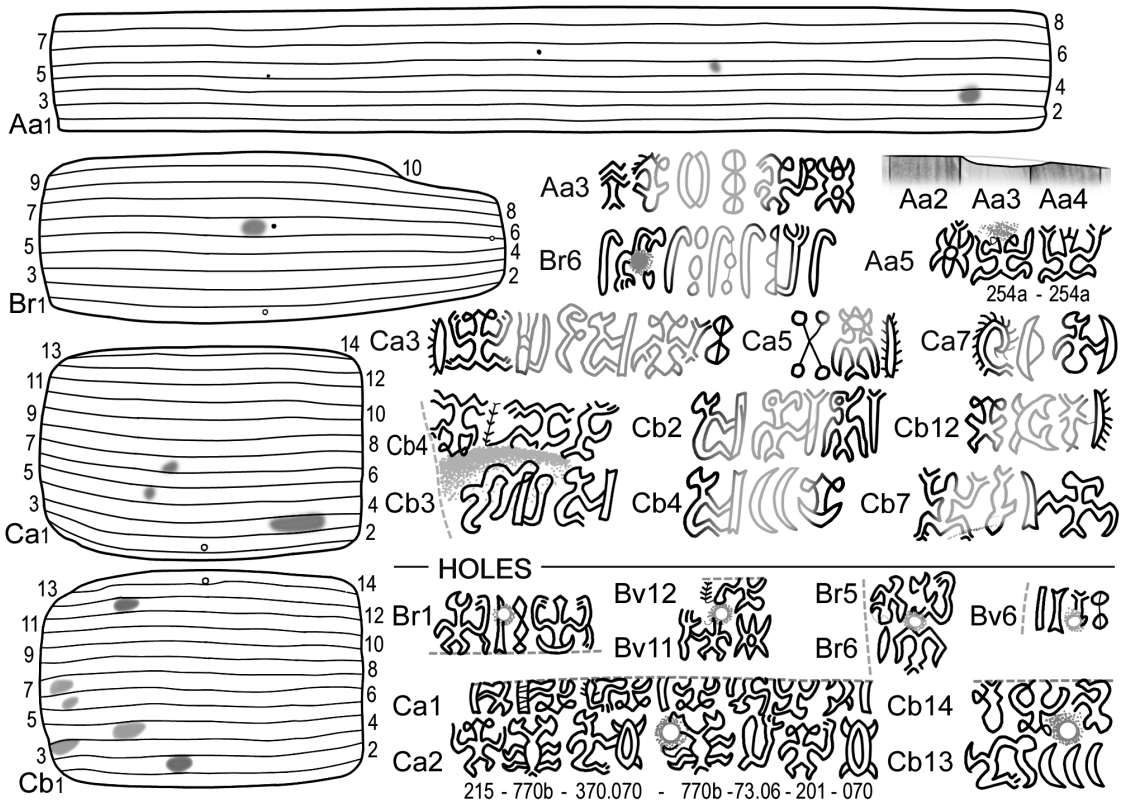

FIGURE 4. – Holes and polished-off areas on the tablets; schematic profile of a polishing in line Aa3. Glyphs located in such areas are shown in light grey tone

inscription, it will cut through the glyphs, showing halves of a sign at its sides or erasing a vital part of the glyph (Figure 4, Br1 and Bv11). On the base of such analysis, one can conclude that the middle hole in the long side of *Aruku Kurenga* post-dates its inscription (Orliac and Orliac, 2008: 255). If the hole was there before the carving of the text, the glyphs are usually arranged around it without intersection. After prolonged use of a hanging cord, the surface around the hole became worn and may obliterate peripheral sign details (Figure 4, Br5/Br6). Therefore, the hole in the narrow part of *Aruku Kurenga* seems to pre-date the text of Br, where it barely touches the signs. To the contrary, it erases significant part of a glyph on Bv side, which may mean that the hole is younger (Figure 4, Bv6), supporting the hypothesis about partial re-writing of the tablet (*ibid.*: 254).

On side Ca of tablet *Mamari*, the left head of sign 770b (Figure 4, Ca2) is partially obliterated by wear area around the hole. However, the presence of a large space between this sign and preceding ligature 370.070 strongly suggest that the scribe intended to avoid the existing hole, slightly miscalculating the width of sign 770b (which also implies that its bottom part was incised first). The very same situation can be seen earlier in line Ca2, where glyph 770b is placed too close to glyph 215. On the other side of the tablet, the signs are inscribed around the hole (Figure 4, Cb13/14). Therefore, one can conclude that the hole in tablet *Mamari* most probably pre-dates its inscription.

Hypothesizing that the scribe could define the shape and the size of this perforation, it will be interesting to verify if it could be related with suggested use of the tablet as an astronomic canon for insertion of intercalary nights basing on observation of the apparent diameter of the Moon (Guy, 1990: 140). As we know, the average visible diameter of our Natural satellite is 31'05''. When the Moon is in perigee (closest orbital point), its diameter reaches the maximal value 33'29''; for apogee (far orbital point) Moon it decreases to 29'23'' (Grego, 2005: 44). These changes (comprising about 12%) are easily detectable in side-by-side comparison (Figure 5). However, they are hardly noticeable in life due to gradual variation of aforesaid diameter during anomalistic month of 27.555 days, the time between consecutive perigee points (Karttunen *et al.*, 2007: 136). Anomalistic month does not match synodic month of 29.531 days

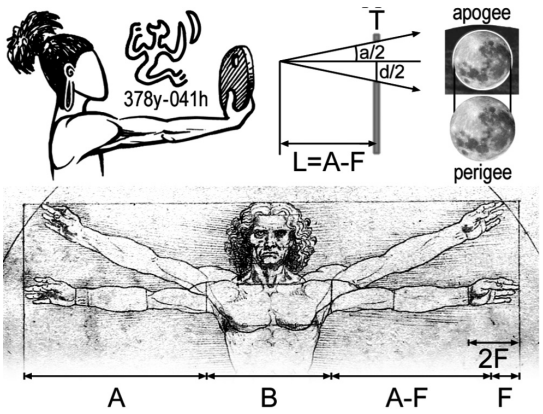

FIGURE 5. – Hypothesized use of tablet *Mamari* to detect apogee Moon
Below: arm length estimated from Vitruvius body proportion model, illustrated by drawing of Leonardo da Vinci.

describing lunar phases (*ibid.*: 135), which means that the same phase may coincide with a perigee and later with apogee position (Grego, 2005: 43). Therefore, to detect variation of apparent Moon diameter it should be measured.

Ancient Rapanui had good astronomical knowledge and oriented their ceremonial structures for important sunrise and sunset directions (Liller, 1993: 11-27). For observation of a moving celestial body, they might have used some portable devices, such as «a length of string tied to a shell or piece of wood with a hole drilled through or notches cut along the edge» (Guy, 1990: 140). If tablet *Mamari* contains a canon relying on observation of apogee Moon (which is useless if the measurements can't be performed), it is tempting to speculate that the inscription may contain instructions for producing a required device – or that the tablet with its hole represents such device itself.

The perforation in tablet *Mamari* is comparatively large and cylindrical in shape, with slightly worn edges (Orliac and Orliac, 2008: 257). With artifact thickness of about 2.5 cm (*ibid*, 256), the wearing induced by a cord will first affect the surface of the tablet, keeping hole interior relatively intact. In this way, a measuring device with a hole is more wear-resistant in comparison with the marks / notches engraved on wood surface.

One can hypothesize that the hole should frame the «smallest» apogee Moon, «cropping» it for larger visual diameter. Glyphs 378y-041h in the delimiter group, tentatively interpreted as «apparent diameter of the moon should be measured to decide whether a supplementary night is required for the current month» (Guy, 1990: 143) were suggested to depict a person making such measurements with a rod or an outstretched arm implying «the notion of "measurement" or "comparison with a standard"» (*ibid.*). A man holding a tablet in his outstretched arm also agrees well with this pictographic interpretation of sign 378y (Figure 5).

The diameter of the hole d, *estimated* from the photos of the artifact, is about 4.1 mm. Viewed from the distance L (Figure 5) it will encompass an angle a such that $\tan(a/2) = d/(2L)$. For small angles $\tan(a<<1 \text{ radian}) \approx a$, allowing to simplify the formula as $a \approx d/L$. For $a = 29'23'' = 0.008547$ radian and $d = 4.1$ mm, the viewing distance L will be about 48 cm. To estimate correlation of L with an outstretched arm length, we will use human body proportions model suggested by Marcus Vitruvius in 1st century BC. He wrote:

> «the human body is so designed by nature that [...] a tenth part of the whole height [is the same as] the open hand from the wrist to the tip of the middle finger [...] the breadth of the breast is also one fourth [...] the distance from the soles of the feet to the top of the head and [...] outstretched arms [...] [are] the same.» (Morgan, 1914: 72, 73)

Introducing a variable H for body height (equal to arm span), B for breast width, and A for arm length, one can obtain $H = B+2A$ (Figure 5). Using proportions suggested by Vitruvius, arm length becomes $A = 3H/8$. The latter value needs refining as the fingers (F, approximately half-palm long) are not outstretched but hold the tablet. Thus, $L = A–F = (3/8–1/20)H = 13H/40$. For the average stature of Easter Islander $H = 1.73$ m (Shapiro, 1940: 28), the viewing distance $L \approx 56$ cm. The latter value is slightly greater the estimation $L = 48$ cm calculated in assumption that the hole in the tablet should be seen at the same angle as apogee Moon. Using the same formulas, one can show that viewing distance $L = 48$ cm will correspond to a hypothetic stature 1.48 m; hole diameter d required to get an angle 29'23'' from distance $L = 56$ cm should be 4.8 mm (about 117% of estimated perforation diameter).

Therefore, analysis of hole size, angles describing apparent Moon diameter, and body proportions of people who might used the tablet yields intriguing similarities, which may possibly imply an additional function of tablet *Mamari* related to lunar observations. The further research should use the exact measurements of tablet perforation diameter and detailed anthropometric data aiming to improve the correlations obtained. It will be fascinating to confirm a possible use of this tablet to detect apogee Moon, which would be an additional supporting evidence for astronomical canon hypothesis.

Any extra proof that ancient Rapanui were aware of varying apparent Moon diameter and moreover, used it for fine-tuning their lunar calendar would be an important contribution to archeoastronomy of Easter Island. Alternatively, the small size of two crescents in lines Ca7 and Ca8 can be also plausibly explained from paleographic point of view, suggesting that both signs were omitted and re-inserted into available space. Additional research is required to clarify the meaning of these small crescents.

Discussion on carving techniques

All discussed scribal errors and corrections in *rongorongo* tablets are completely *expected* and *natural* for a proper writing system, further confirming that Easter Island script represents an « écriture "de bon aloi" » (Pozdniakov, 1996: 297).

A particular attention should be paid to preterm writing, which seems to preclude the complete pre-incision of the text by generating an unintelligible mixture of contours for each pre-incision error. Under these circumstances, it looks reasonable to assume that the inscription was carved in short fragments – first incised with an obsidian flake and then engraved with a shark tooth *before* passing to the next fragment. After the text was completed, the tablet might have been subjected to additional engraving sessions required to achieve smooth contours of the glyphs. The homogeneity of carving style within each *rongorongo* artifact – with rare exceptions of tablet *Échancrée* (Fischer, 1997: 422) and *Aruku Kurenga* (Orliac and Orliac, 2008: 254) – suggests that the majority of tablets were completed by the same scribe (Fischer, 1997: 385).

The existence of almost exact copies of the same text on several tablets (Kudryavtsev, 1949: 180; Barthel, 1958: 56-70) highlights the importance of old inscription reproduction (Fischer, 1997: 384). However, the differences between the texts, such as varying number and composition of glyphs in tablets H/P/Q (Olderogge, 1947: 237), omission of list items in Gr / K (Butinov and Knorozov, 1956: 84) and substitution of bird heads (Gr) to gaping mouth heads in text K (Barthel, 1958: 156, 238) seem indicative of indirect copying. The inscriptions might have been written from memory, which poses a related question if the texts were composed *directly* on the tablet or the scribes used «drafts» on banana leaves to be «transferred, without modification, to wood» (Fischer, 1997: 647). Hints to this question can be found in numerous inline repetitions of (not always identical) glyphic sequences (Métraux, 1940: 402), revealing a surprising improvement of calligraphy and composition practically after each repetition.

Three fragments in tablet *Tahua* (Figure 6, Aa3) start with the sign 316, depicting a human with both arms raised. In the first occurrence, the scribe incised glyph's body too close to the preceding sign, fitting its left arm into tight space. This miscalculation does not appear in second repetition of the group and is less pronounced in the third one. Delimiter groups of lunar calendar on the tablet *Mamari* also feature gradual conventionalization with each repetition (Figure 6, $Ca6_1$-$Ca8_1$). The first group includes second glyph 315y standing, while further on it is sitting; in the third group, its left hand is carved separately as if it was added to the glyph after deepening its outline with a shark tooth. In the fifth group, the first sign has a bird head in place of the usual gaping mouth head; this substitution can be also seen in the other texts (Barthel, 1958: 238).

Improvement of sign composition is more evident for rare or complicated glyphs. The text of *Aruku Kurenga* contains triplicate fragment beginning with (003).001-470-091t (Figure 6, Br4). The first group features sign 558 resembling glyph 493 with gaping mouth head similar to that of sign 470, appended with a lozenge head of glyph 091. Most probably, the perplexing appearance of resulting sign 558 caused the scribe to repeat glyph 091 in a full size. The next two groups show these signs in proper arrangement; they also illustrate «floating» glyph connections with ligatures 091.450 and 001.470 formed only in the first and the second group, respectively. Elaborate «lizards» 762 and 761 (Figure 6, Cb11) probably represents two calligraphic variants of the same sign; similarly, the following glyphs 557 and 556 show the second sign in more conventionalized form as well. This calligraphy improvement phenomenon is not limited to artifacts from the Collections of SS.CC.; in-line repetitions in *Atua Mata Riri* tablet (Figure 6, Rb8) and Great St. Petersburg tablet (Figure 6, Pr9) clearly show pronouncedly better composition of glyphs 762 and 491a on their second occurrence.

It seems improbable that the scribe was merely practicing his writing skills with these repetitive groups – a careful engraving of the contours suggests that the inscription is final. At the same time, if one of the repeated groups were erroneous, it would be most probably re-written using palimpsest correction technique. Thus, the

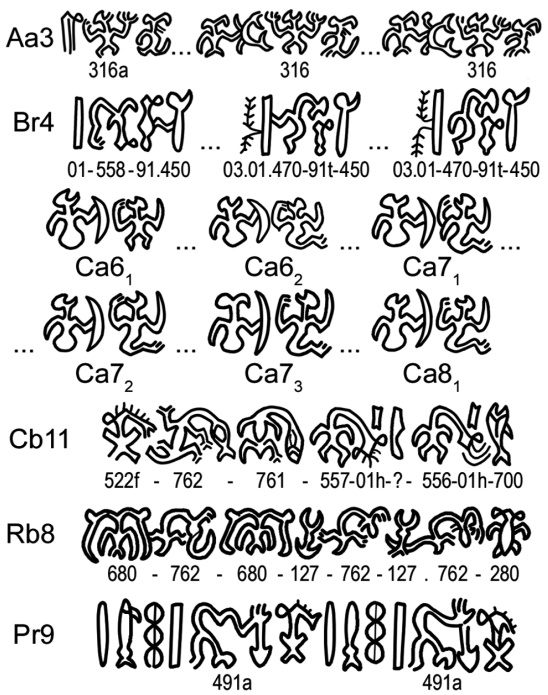

FIGURE 6. – Glyph variations in repetitive sequences

repetitions discussed should have been acceptably accurate from the scribe's point of view, and all of them intended to appear in the inscription. In this case, it is tempting to interpret the observed calligraphy improvements as an evidence for direct on-tablet composition of text, naturally resulting from increasing familiarity of the scribe with particular signs and ligatures. If *tangata rongorongo* had a «draft» inscription on banana leaf or another tablet in front of him, he most probably would carve all glyphs in these repetitive fragments properly starting from their first occurrence.

Allographic observations

Discussed scribal corrections offer several allographic insights. The most interesting of these is replacement of pre-incised sign 067 with glyph 133, which differ by their open and closed upper part (Figure 2, Br5$_2$). Due to slight ambiguity of Barthel's notation, code 133 also describes unrelated glyph with a lozenge head (*e.g.*, Figure 2, Bv7); at the same time, glyph code 169 represents a ligature based on sign 133 (Figure 7, Bv2). It is important that all occurrences of sign 133 (excluding dissimilar lozenge-head glyphs) and 169 are limited to *Aruku Kurenga*, as if they are part of a carving style characteristic for the scribe responsible for this tablet. The interchangeability of signs 133 and 067 is additionally confirmed with parallel passage appearing in lines Bv2 and Cb13/14 (Figure 7), containing equivalent groups 010.133-060-169.678 and 010.067-067-145. These parallel sequences also imply that a curved «arm» of sign 169 – Pozdniakovs' element 901 (2007: 22), usually *merged* as a body part of glyphs 207, 247, 277, 387, 408, 618, 749, *etc*. – should correspond to an *isolated* «fishhook» sign 145.

Further analysis of these parallel fragments seems indicative that signs 484-470-021t from line Bv2 are shuffled in text Cb14, so that 484 = 725 (both featuring leg 060 at their left side; a long arm of sign 725 may correspond to the upper limb of glyph 484) and 470 = 664. The latter allography (see also signs 453 = 670, Figure 7, Ab7 and Bv8$_1$) agrees with observation about interchangeability of gaping-mouth head on a long neck and bird head with a long beak (Horley, 2007: 30). The small glyph 021t subscribed below the mouth of sign 470 in line Bv2 may be related to digraph 017 in Cb14; the similar group 470-017t can be found in lines Br6 (Figure 4) and Bv11.

In analogy to suggested allography 133 = 067 it is possible to propose that glyphs 055b and 068 (also different only by closed and open shape of their upper part) could be interchangeable as well. As one can see from the parallel fragments Ra5/Bv3 and Sa5$_1$/Bv8$_2$ (Figure 7), both glyph 055b and 068 occur in characteristic combination with sign 022f. Preceding abstract glyph 166 may be a contracted version of ligature 044.607 (Figure 7, Ra5), when the body of bird 607 is omitted, but its curved wing is preserved. The use of contraction is evident for the sequence 200f.025-324 (Figure 7, Ab7), re-written as 200.171 in text of *Aruku Kurenga* (Figure 7, Bv8$_1$), retaining only a foot and a hand of glyph 324 in abstract sign 171. This interpretation of contracted ligatures could be helpful to identify the components in Barthel's glyphs 162-176 (see Figure 7, Bv8$_1$ for sign 165).

Glyphs 300.079, seemingly related to 068-022f series (Figure 7, Bv3) can be compactly written as another associated sign 190a (Figure 7, Sa5$_1$) following the rules of vertical ligature formation with rotation of a composing element (Guy, 1982: 447; Pozdniakov, 1996: 297). Moreover, the allography 055b = 068 would also explain (and eliminate) the puzzling change of delimiter glyph in a sequence from Large Washington tablet (Figure 7, Sa5$_2$).

FIGURE 7. – Parallel sequence suggesting allography of signs 133 and 067; in similar fashion, signs 055b and 068 also could be related. Glyph conflation ligatures are illustrated with Ra5 / Bv3 and Ab7 / $Bv8_1$

Conclusions

Exceptional quality of carving exhibited by *rongorongo* artifacts proves high professional level of the ancient scribes. The miniature signs are incised with an outstanding precision and attention to details. Errors and corrections, being surprisingly few, are completely expectable and natural to a true writing system. They include corrections of misspelled elements, preterm writing detectable *via* pre-incised hairline contours, omissions and re-insertion of a single or several signs accomplished by fitting glyphs into available space (including edges of the tablet), or by polishing off the incorrect part to write a proper inscription. The length of the corrected fragments for three tablets studied is small (less than ten glyphs), strongly suggesting that the scribe was writing the text in short fragments, first pre-incising glyphs with an obsidian flake and engraving the contours with a shark tooth before proceeding further. To achieve contour smoothness, additional engraving sessions could be performed for a completed inscription.

Study of in-line repetition fragments revealed surprising conventionalization of glyph forms already upon their second occurrence, suggesting that *tangata rongorongo* became familiarized with specific ligatures. This observation allows to hypothesize about direct on-tablet composition of the text without any intermediate «draft» inscriptions.

Analysis of parallel fragments shared between the tablets suggested allography of sign 133 (limited to *Aruku Kurenga*, which may be indicative for an individual scribal style) and «palm tree» glyph 067. Both signs have similar shape except for closed and open upper part. By analogy, the allography of glyphs 055b and 068 was also proposed. Assumption of their interchangeability removed ambiguity for variation of delimiter sign in a structured sequence and revealed an example of a conflated ligature. A further study of such ligatures may help to identify composing elements for Barthel's glyphs 162-176.

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