ANNVARIO

DELLA

SCUOLA ARCHEOLOGICA DI ATENE

E DELLE

MISSIONI ITALIANE IN ORIENTE

VOLUME 95

SCUOLA ARCHEOLOGICA ITALIANA DI ATENE

2017

Annuario della Scuola Archeologica di Atene e delle Missioni Italiane in Oriente 95, 2017

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Scuola Archeologica Italiana di Atene
Parthenonos 14
11742 Atene
Grecia

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Scuola Archeologica Italiana di Atene
ISSN 0067-0081 (cartaceo)
ISSN 2585-2418 (on-line)

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SOMMARIO

Scavi e ricerche

THE LINEAR B *PA-I-TO* EPIGRAPHIC PROJECT*

Alessandro Greco, Georgia Flouda

Riassunto. «The Linear B *pa-i-to* Epigraphic Project» è un progetto pilota di epigrafia e filologia mirato alla pubblicazione di una nuova edizione critica delle 94 tavolette in Lineare B da Cnosso, conservate al Museo di Heraklion, sulle quali è menzionato il nome dell'antica città di Phaestos —*pa-i-to*. In particolar modo, cerchiamo di sviluppare nuovi approcci allo studio, alla pubblicazione e all'edizione di questo piccolo corpus di tavolette applicando nuove tecnologie non invasive, non distruttive e tecnologie digitali e fotografiche. Questa metodologia consiste nel combinare due separate procedure di acquisizione digitale; la scansione delle tavolette attraverso un laser scanner 3D portatile e la fotografia delle stesse attraverso la tecnologia RTI (Reflectance Transformation Imaging). Partendo da queste premesse, in questo contributo si descrivono gli approcci metodologici adottati e i primi risultati raggiunti dal progetto.

Περίληψη. The Linear B *pa-i-to* Epigraphic Project» είναι ένα πιλοτικό πρόγραμμα επιγραφικής και φιλολογίας με στόχο τη δημοσίευση μιας νέας κριτικής έκδοσης των 94 πινακίδων Γραμμικής Β από την Κνωσό, που φυλάσσονται στο Μουσείο Ηρακλείου και στις οποίες γίνεται μνεία του ονόματος της αρχαίας πόλης της Φαιστού —*pa-i-to*. Συγκεκριμένα, προσπαθούμε να αναπτύξουμε νέες προσεγγίσεις στη μελέτη, τη δημοσίευση και την έκδοση αυτού του μικρού corpus πινακίδων εφαρμόζοντας καινούριες μη επεμβατικές, μη καταστροφικές τεχνολογίες καθώς και ψηφιακές και φωτογραφικές τεχνολογίες. Η μεθοδολογία αυτή αποτελεί το συνδυασμό δύο ξεχωριστών διαδικασιών ψηφιακής πρόσληψης: την ηλεκτρονική σάρωση των πινακίδων με ένα φορητό *laser scanner 3D* και τη φωτογράφησή τους διαμέσου της τεχνολογίας RTI (*Reflectance Transformation Imaging*). Ξεκινώντας από αυτό, στο παρόν άρθρο περιγράφονται οι μεθοδολογικές προσεγγίσεις που υιοθετήθηκαν και τα πρώτα αποτελέσματα του προγράμματος.

Abstract. «The Linear B *pa-i-to* Epigraphic Project» is an epigraphic and philological pilot project aimed at publishing a new critical edition of 94 Linear B tablets from Knossos, kept in the Heraklion Museum where there is mention of the name of the ancient town of Phaestos —*pa-i-to*. Especially, we aim at developing new approaches in the study, the publication and the edition of this small corpus of tablets by applying new non-invasive, non-destructive and non-contact digital and photographic technologies. This methodology consists in combining two separate procedures of digital acquisition: scanning the tablets through a portable 3D Laser scanner and taking pictures of the tablets through the RTI technology (Reflectance Transformation Imaging). Starting from these premises, the paper describes the methodological approaches adopted and the first results achieved of the project.

Introduction

In Linear B, Phaistos, as is well known, is attested in the form *pa-i-to*. *Pa-i-to* appears 71 times in the Knossos archives and is the second most frequent place-name in the entire clay tablet corpus from this site. The high number of occurrences of *Pa-i-to* from the first appearance of Linear B at Knossos, in the final Late Minoan II[2], through to the destruction of the palace between LMIIIA2 and LMIIIB1, and the economic information that can be deduced from the tablet entries, allow us to infer that Phaistos played a major role in the economy of the state established under the Knossian

* We would like to thank E. Papi for his kind permission to present the project during the Ergon of the Italian Phaestian missions held in Athens, 27th October 2017, as well as for his invitation to present here, for the first time, this project. Chapters 1, 2, 2.3, 3, 5.1 and 6 by Alessandro Greco and Georgia Flouda; Chapters 2.1, 2.2, 4, 5.2, 5.3, 5.4, 5.5 by Alessandro Greco.

[1] The toponym *pa-i-to* occours 57 times, and the ethnic adjective *pa-i-ti-jo*/*pa-i-ti-ja*, 10 times. Finally, in four documents, the reference is incomplete. Ak(3) 828, Ap 639, Da 1156+, Da 1161+, Da 1163+, Da 1164+, Da 1170+, Da 1172+, Da 1173+, Da 1341+, Da 1352+, Da 1378+, Da 1495+, Da 8201+, Db 1159, Db 1160+, Db 1344+, Db 1464+, Db 1507, Dd 1157, Dd 1171, Dd 1342, Dd 1429+, Dd 5174+, De 1084, Dg 1158, Dm 1180+, Dm 1184+, Dn 1094+, Dp 1061, Dq(3) 7126, Dq(3) 7137, Dq(3) 7852, Dv 1085+, Dv 1509+, Dv 1607+, Dv 5075, Dv 9568, Dv 9591, Dv 9603+, Dv 9604+, D 747, E 36, E 777, F(2) 841+, Ga(2) 416, Ga(5) 1536+, Gg 701, Lc(1) 546, Le 641+, Le 5629+, L(6) 469, Od 502, Od(1) 681, Od 765+, Og(1) 180, Pp 498, Sd 4413, So(1) 4448+, V(3) 655+, X 522, X 697, X <1474>, U 1539+, Wb 2001, Xf 5104, X 7546, X 7629, X 7554, X 9196, X 8502.

[2] In tablet Og(1) 180, from the archive of the Room of the Chariot Tablets.

administration[3]. It is not easy, however, to understand what its political role was and the relations it had with the administrative capital, despite the notion that control of the Mesara seems to have remained a priority for the *wanaktes* of Knossos. From a political point of view, the fact that a chariot contingent was stationed at *pa-i-to* sheds further light on the role of the site for the strategic control of this fundamental part of the kingdom[4].

"The Linear B *pa-i-to* Epigraphic Project" is an epigraphic and philological project aimed principally at studying Mycenaean Phaistos through Linear B documents and publishing a new critical edition of all tablets mentioning the name of this ancient city. It is an offshoot of the *Phaistos Survey Project*[5], whose intended first publication[6] will present all written and documentary sources pertaining to the site of Phaistos from the Mycenaean to the Venetian period. Thus it can be considered a natural consequence of the methodological approach to the history of the site that constitutes the *leitmotiv* of the Phaistos *Survey* Project.

Since its first conception[7], the project has benefited from the endorsement of the SAIA, the University of Padua[8] and the University of Milan[9]. It has become possible to work in direct collaboration with the Archaeological Museum of Heraklion, thanks to the kind interest of its director, S. Mandalaki, to whom our warm acknowledgements are addressed[10].

1. The digital technologies used and the Project's philosophy

"The Linear B pa-i-to Epigraphic Project" is focused on a thematically coherent set of clay tablets, mentioning the town of Phaistos or relevant toponymic adjectives. It aims to integrate the epigraphic, palaeographic and philological data from the tablets within the archaeological context provided by the excavations and field surveys conducted in the territory of Phaistos, in order of providing a new history of the region during the Late Minoan IIIA-B periods[11]. With the objective to provide a comprehensive picture of the Mycenaean sources dealing with Phaistos, our initial concern was to create a new medium for the study of the tablets. The *Corpus of Mycenaean Inscriptions from Knossos* is still the most valid tool for studying this material[12]. However, thirty years after its publication, the progress of innovative digital photographic technology has imposed the need for its revision. Consequently, we have chosen to employ two digital processing techniques, namely, 3D reproduction and Reflectance Transformation Imaging (RTI). These technologies are being currently employed in the documentation of the Linear B tablets from Mycenaean Pylos by Dimitris Nakassis[13], but have not been published yet. On the other hand, the RTI technique has been applied to the small corpus of Knossian tablets kept at the Evans Collection

[3] Bennet 1985; 1987a; 1987b; 1990; 1992; Cremona *et alii* 1978; Driessen 1992; 1996; 2001; Godart-Tzedakis 1992; 1997; Greco 2018; forthcoming; McArthur 1981; 1985a; 1985b; 1993; Melena 1975; 1976; 1983; Olivier 2001; Palmer 1971; 1972; 1973; 1978; 1979.

[4] Driessen 1996 (in particular 486, 492) with *status quaestionis* and bibliography. See also Lejeune 1968 (in particular 23-24); Duhoux 1976 (in particular 99); Ruijgh 1976; 1979; Crouwel 1981 (in particular 128); Uchitel 1988; Bernabé *et alii* 1991; Hiller 1992; Bernabe *et alii* 1993 (in particular 141, 158); 2001 (in particular 168-169 and footnote 9); Bernabé-Luján 2008; 2012; Greco 2018; forthcoming.

[5] The *Phaistos Survey Project* is an archaeological project undertaken in cooperation with the Ephoreia of Heraklion and directed by Prof. E. Greco (the previous Director of the Italian Archaeological School of Athens), by Prof. F. Longo (University of Salerno) with the collaboration of Dr A. Greco (University of Rome, Sapienza). As concerns its methodology and objectives, see Bredaki *et alii* 2009; Longo *et alii* 2010; Longo 2014; 2015; Longo-Bredaki 2014; Longo-Greco 2014; Greco-Betto 2015; Greco 2018; Greco-Palio forthcoming; Greco *et alii* forthcoming a and b.

[6] Longo-Greco forthcoming.

[7] The project is a self standing project, directed by Dr A. Greco (University of Rome, Sapienza) and Dr G. Flouda (Archaeological Museum of Heraklion). It has benefited from the scientific and financial support of: the Project «Writing Techniques vs Technologies for Writing» directed by L. Verderame (University of Rome, Sapienza), with the collaboration of A. Greco (University of Rome, Sapienza), A. Sacconi (University of Rome, Sapienza), and G. Flouda (Archaeological Museum of Heraklion); the project «Nomi, soprannomi e pseudonimi. Forme e funzioni dall'antichità all'età moderna», directed by L. Bettarini (University of Rome, Sapienza), with the collaboration of A. Greco, M. Di Marco and E. Tagliaferro (University of Rome, Sapienza); the non-profit organization (ONLUS) "Gli amici di Minosse e Radamente" directed by Dr L. Andrioli and Dr A. Greco.

[8] G. Salemi and E. Faresin in the framework of the Project «Writing Techniques vs Technologies for Writing» (A. Greco – University of Rome, Sapienza).

[9] Dr E. Notti directs the project «Dalla Tavoletta al Tablet. Indagini di *imaging* per applicazioni all'epigrafia e ai beni culturali» with the collaboration of Prof. M. Negri, Prof. G. Rocca (IULM UNiversity), Dr A. Greco, Sapienza, University of Rome and Dr G. Flouda, Archaeological Museum of Heraklion. This project actively supports the *Pa-i-to* project.

[10] We express our gratitude to the following staff members of the Heraklion Archaeological Museum: G. Marakis (chief conservator), as well as M. Stratigi and E. Sinadinaki (antiquities guards), a team of professionals who have done and are still doing a great deal for this project.

[11] See also La Rosa 1985; 1997; Cucuzza 2003; Privitera 2010; Greco 2018 and *Id*. forthcoming.

[12] *Comik* I-IV.

[13] https://englianos.wordpress.com/tag/rti/.

(Ashmolean Museum of Oxford), which has already been published online[14]. Nevertheless, the *Pa-i-to* project combines both methods for the first time, in order to produce a new integrated archaeological, epigraphic and philological edition of a targeted group of Knossian tablets. This edition will also pay attention to the materiality of the artefacts, namely the physical aspects of their formation and the tactile engagement of the tablet-kneaders and scribes with them.

1.1 3D Reproduction

3D reproduction by laser scanner is a well-known technique. It is sufficient to say that it is able to capture even the thiniest details of the clay surface, and to produce a three-dimensional mathematical model of an object with a resolution of one hundredth of a millimetre.

The three-dimensional model produced can be easily managed in virtual space using freely available software.

During our missions, we used an ultra-compact scanner called Geomagic Capture, which uses a blue LED technology. This device captures almost one million points in 0.3 seconds to create detailed models of our tablets with an accuracy of 0.034 ÷ 0.118 mm.

The acquisition phase consists in irradiating the surface with the blue LED and digitalization and representation using software simulating a virtual space, where the image can be moved and zoomed. For a correct alignment of the range-maps in the post-processing phase, a graduated rotating base was used. On this support the tablets were captured in two different positions (recto and verso), while maintaining a stable object-device distance. Each tablet was scanned every 30° during a complete 360° rotation.

The post-processing phases are: 1) Range map alignment, in order to put the two different positions (recto and verso) into a common coordinate space system using their mutually overlapping regions. 2) Range map merger (or fusion), to build a single triangulated mesh. 3) Mesh editing, to improve the quality of the reconstructed mesh. The aim of this phase is to obtain a final topologically correct 3D model without un-sampled or uncorrected areas. The mesh editing involved filling the holes.

The 3D models were exported as STL file format, which defines the geometrical information and is supported by most applications.

1.2 RTI (Reflectance Transformation Imaging)

RTI is a computational photographic technique which captures the shape and colour of an object's surface by taking multiple photographs with a stationary camera, and illuminating the object from different, known angles for each shot[15]. The number of photographs for each tablet may vary, but for an optimum result, we chose a standard number of forty-eight, that is four shots with the light positioned in a vertical plane with angles between 15° and 65° (15°, 30°, 45°, and 65°), repeated for twelve horizontal positions (Fig. 1).

During the photographic operation the light is positioned manually. The lighting information from the photographs is then digitally combined using the free downloadable program ™RTIBuilder. In this way, a virtual model of the surface is produced, that allows the user to interactively shift a light virtually projected onto the on-screen RTI image. These images can also be manipulated using ™RTI viewer, a free downloadable program[16]. The camera used is a Nikon Reflex D7000, with a Macro (Nikkor Lens, AF-S Micro NIKKOR 60mm f/2.8G ED), while the lights employed are Manfrotto adjustable LEDs (MLUMIEMU-BK Luce LED, 8 Lumimuse). The time needed to take the photographs of each tablet varies from three to five minutes.

1.3 The philosophy of the Project

First of all, we subscribe to the view advocated by Nakassis, according to which RTI technology applied to Linear B tablets «... allows us to redistribute the authority of the editor to all interested and qualified users ... for those who are interested in editorial decisions, RTI gives them the opportunity to examine

[14] http://sirarthurevans.ashmus.ox.ac.uk.

[15] A detailed description of the RTI technique can be found on the web in the following link http://culturalheritageimaging.org/Technologies/RTI/, and in S.M. Duffy, «Multi-light Imaging for Heritage Application», edited by Cultural Heritage Imaging, 2013, online.

[16] For the links see http://culturalheritageimaging.org/Technologies/RTI/.

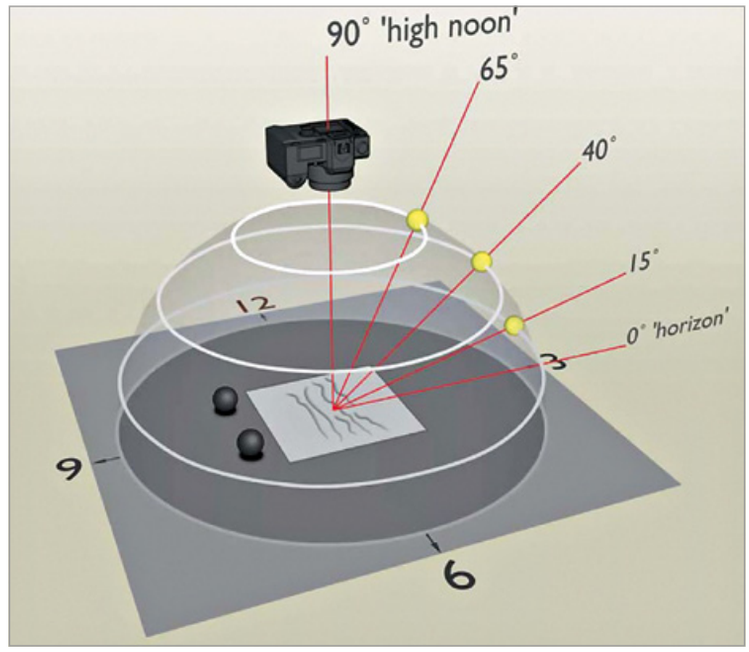

Fig. 1. Image from S.M. Duffy, "Multi-light Imaging for Heritage Application", edited by Cultural Heritage Imaging 2013 (online).

the tablets at a level of detail that would allow them to develop their own readings»[17]. The possibility of sharing and disseminating the digital files created through RTI is the most important advantage of this methodology, which further leads to a democratization of the traditional study procedure[18].

The work conducted at the Ashmolean Museum in Oxford on a limited set of Linear B Knossian tablets (44 items), and presented on the museum's website, clearly exemplifies the great potential of RTI technology for studying the Linear B inscriptions[19]. It is also worthwhile to explore how the application of these new technologies to epigraphy may redefine the guidelines for a new generation of methodological tools for epigraphic research. In particular, the RTI image quality is excellent, the zoom is considerable, and some functions of the software RTIviewer, such as *Normals Visualization* and *Specular Enhancement* (Fig. 2), make these images even more useful for the epigraphist. Furthermore, the 3D technique allows one to provide a mathematical test for the presence or absence of strokes, which in a photograph may be visible or invisible depending on the particular points of view, or can be affected by shadows. Consequently, the epigraphic interpretation of a text on the basis of a digital representation will be highly reliable, not only because of the image's high quality, but also because the 3D model can decisively demonstrate the presence or absence of a certain stroke, with a precision that in some cases not even the careful eye of the epigraphist can match (Fig. 3).

This technique has resulted in a small paleographic discovery, because it can be noted that the small strokes 5 and 6 are not the result of the erasure of two horizontal signs, but the erasure of an originally single sign, the sign that in Mycenaean indicates 10 units. The erasure made by the scribe, too superficial, erased only the central part of the sign, but not the two extremities which, as is characteristic of the *ductus* of Scribe 117, tend to be incised more deeply than the middle part. Furthermore, the identification of stroke 4, not noticed in *COMIK* and also erased by the scribe, allows a different reading of the text in palimpsest: probably the number of tens erased was eight rather than six, as reported in the *apparatus* of *COMIK*; moreover they appear to have been incised not only under the nine units overwritten on the right, but also under the overwritten circle of the hundreds, on the left.

As the technologies adopted for the *Pa-i-to* project allow identification of the slightest variations in the surface of the tablets, they obviously provide powerful new instruments not only for studying the text's content but also for conducting palaeographic analysis of it. The fundamental and seminal study of J.P. Olivier in 1967 is still the most important work on palaeography regarding the Mycenaean scribes

[17] https://mediterraneanworld.wordpress.com/2013/09/26/linear-b-in-3d/.
[18] https://mediterraneanworld.wordpress.com/2013/09/26/linear-b-in-3d/.
[19] http://sirarthurevans.ashmus.ox.ac.uk.

Fig. 2. The three RTI visualizations of the tablet KN Dp 1061. From the top: default visualization; Normals Visualization; Specular Enhancement Visualization.

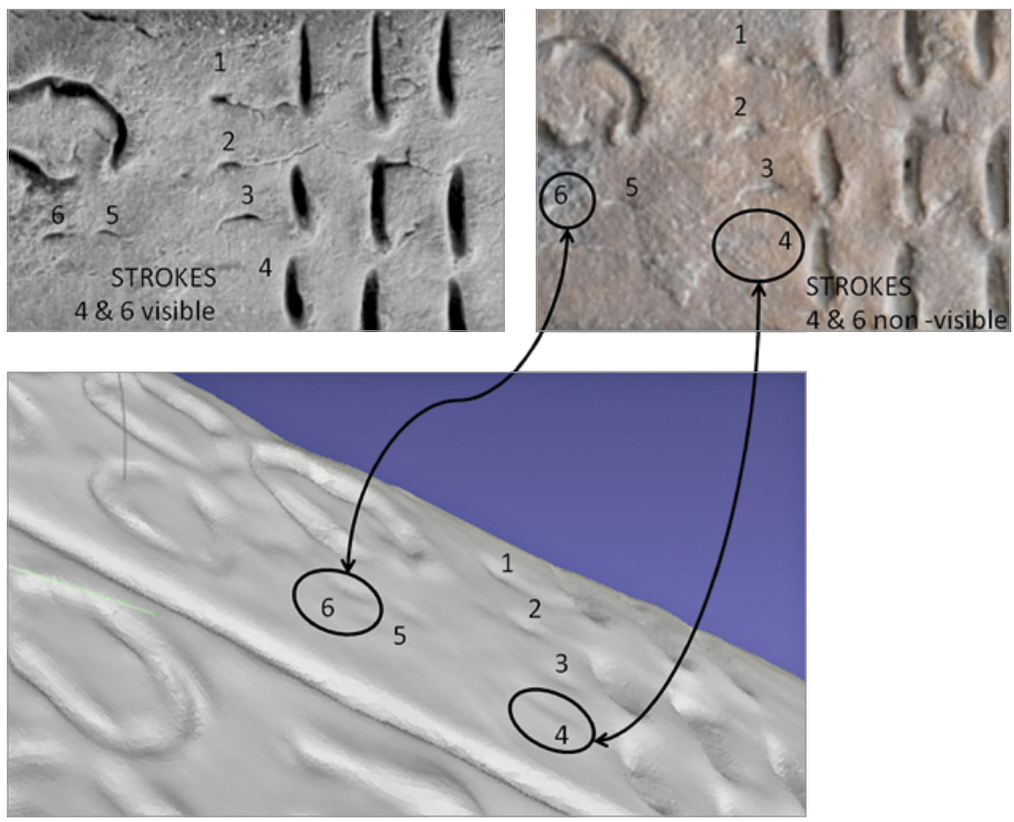

Fig 3. The strokes numbered 4 and 6 are visible from some directions in the photographs, but invisible from others. In this case, the 3D image is able to show with certainty the presence or absence of a stroke.

of Knossos[20]; but it contains only the results of the palaeographic survey made by Olivier without precise records of evidence that could justify his conclusions, and thus deprives scholars of the possibility of verifying the author's choices.

Following the fundamental monographs by Olivier (1967) and Palaima (1988)[21], the study of the tablets from the so-called "Room of the Chariot Tablets" by Driessen (2000) constitutes an outstanding work, outlining the new approach to the palaeographic study of Linear B tablets by clarifying the methods and practical tools used by the author. The traditional medium of the printed publication, though, does not enable the reader to verify the accuracy of the drawings and the choices made by different authors through the photographic and graphic documentation provided.

The new technologies allow us to fill this gap, and for this purpose – in line with the philosophy outlined by Nakassis and in accordance with the permit granted by the Greek Ministry of Culture and Sports – the primary goal of this project is to publish all the acquired RTI images and 3D digital models on a dedicated website. It is our intention that the site[22] (www.paitoproject.com) should represent an innovative and multi-disciplinary research tool for the scientific community. This should be considered as complementary and auxiliary to hands-on examination of the tablets – essentially the privilege of a few specialized researchers due to the fragile nature of the tablets; still, it will enable all interested parties to re-trace and verify step-by-step the editorial choices made by the project team, by making them always available for examination.

2. The Project team

The tablets were documented during four photographic campaigns (between October 2015 and January-February 2018)[23]. During these campaigns, the team (although not always complete) was composed of Dr A. Greco, Project director; Dr G. Flouda, archaeologist-Curator of the Heraklion Archaeological Museum, co-director of the project; Dr G. Salemi, Professor of "Sistemi Informativi Territoriali" at the University of Padova, Italy; Dr E. Faresin, postdoc researcher in the Department of Civil, Environmental and Architectural Engineering of the University of Padova; Dr E. Notti, researcher at the IULM University of Milan; G. Merlatti, illustrator.

The roles of the team members are: A. Greco: philological, epigraphic and palaeographic analysis, epigrafic drawings, photography and RTI. G. Flouda: philological analysis and archaeological presentation based on the inscriptions' physical aspects. G. Salemi and E. Faresin: 3D reproductions. E. Notti: philological, linguistic analysis, direction and creation of the website in collaboration with Dr A. Greco. A. Sacconi, Professor *Emeritus* of Mycenaean philology at the University of Rome, Sapienza: philological, palaeographic and epigraphic support. G. Merlatti, archaeological drawings.

3. The methodological approach to the digital tools employed

As mentioned in the introduction, the choice to study the group of Knossos tablets containing reference to the toponym *pa-i-to* stems from the "Phaistos survey Project" (cap. 1), and responds to the need to understand the role of Phaistos during the so-called *mono-palatial* phase. Once the group of *pa-i-to* documents was singled out, all tablets containing fragments or parts of toponyms possibly relating to *pa-i-to* were also reviewed. A few other tablets were added to the list reported in footnote 2, even if they do not mention *pa-i-to* or its ethnic *pa-i-ti-jo/pa-i-ti-ja* directly. These were chosen because during our review of the documentation on *pa-i-to* and its literature[24], some suggestions induced us to link them with the toponym.

Examples are Ap 5864 which is considered by *COMIK* as a part of Ap 639, where the *pa-i-ti-ja* women are mentioned, and the important tablet As(2) 1516. As(2) 1516, the largest tablet of the Knossian

[20] But see also Bennett 1958; 1960. The most updated work on the palaeography of the tablets from Pylos is Palaima 1988.

[21] Of course many other important papers on Mycenaean palaeography have been published: see *MT* I, 440-445, *MT* II, 89-95, *MT* III, 68-70, *PTT* II, 7-9, Godart-Tzedakis 1991; 1995; Nosch 2007; Palaima 2011.

[22] See cap. 6.

[23] The second was in June-July 2016, and the third in December 2016.

[24] Greco 2018 and *Id*. forthcoming.

assemblage, that contains only part of an ethnic,]*ti-jo*, which could be restored as *pa-i-*]*ti-jo* (As(2) 1516.12), but it also records the names *a-nu-to* and *sa-pi-ti-nu-wo*; the first connects to *pa-i-to* through X 697, while the second is recorded in connection with *pa-i-to* on tablet F(2) 841+.

For each document in this collection, all elements useful for an integrated survey and a multi-disciplinary procedure were systematically acquired. The first step was the literature-based study through KT I-V[25], *COMIK* and related updates[26], *Les Scribes de Cnossos* and other insightful studies by R. Firth, J. Melena, J. Driessen and C. Skelton[27]. Given the contextual philological study of the tablets, many publications have proved very useful to our work.

On the basis of these sources, an epigraphic data sheet was created, in order to provide a general overview of the data available for each tablet. This was used as the background for the second stage of the study, the systematic observation of the tablets at the Heraklion Museum. At this stage, a specific investigation was also dedicated to the material qualities of each tablet by focusing on physical parameters such as dimensions, type of clay, structure, intentional and non-intentional traces, useful to define the modalities of shaping the clay tablets. The data collected were recorded in specifically created data sheets.[28]

In order to perform a complete physical examination, it was finally decided to draw the tablets as though they were normal archaeological finds, and therefore with the *recto* uppermost and possibly also a view of the *verso*, if it showed signs of inscriptions or working. We also tried to highlight broken parts and those where the surface was in some way flawed or abraded to the point of preventing the identification of the incisions. Some of the incisions have been reported at the ends of the tablet to make it easier for specialists to accurately superimpose on the object the computer-produced epigraphic drawing (cap. 4.3). Transverse and longitudinal sections were also drawn[29].

Finally, RTI and 3D were performed according to the methods described above. In addition to these sets of photographs, others have been carried out, defined as "working photos" in order to have a digital documentation of the tablets including the *verso* and the sides, as well as from different points of view and perspectives aimed at focusing "sensitive" features of the document. With regard to the palaeographic surveys, they are normally conducted in two stages: the first survey is done on the digital versions, which allow a more continuous observation over time, compared to the time allowed in the museum rooms. The observations made on digital support are later checked at the museum through a hands-on-examination by the team.

4. First outcomes

4.1 Burnishing the tablets

From a "pinacological" point of view, the first result of considering the tablets as material objects was the identification of the particular technique used for preparing them and smoothing their surfaces. Most scholars generally suggest that in order to smooth the edges and surfaces of the tablets, Mycenaean clay-kneaders used to press the clay on hard flat surfaces[30], or roll the tablets out using styluses[31].

The suggestion seems confirmed by the regular shape of many tablets, which usually have regular surfaces and sides (Fig 4). They so have similar but never identical dimensions: this peculiarity is evidence against the hypothesis that the tablets were made using moulds, but the regular shape of many tablets and their extremely smooth surfaces seemed to exclude the manufacturing techniques previously proposed.

Studying the tablets in the museum, and trying to replicate them in laboratory[32] using the suggested manufacturing techniques, we found out that even if it is possible to press the clay onto a hard flat base in order to obtain a smooth surface, after detachment it is often necessary to correct the deformation of the tablet and to flatten the small bulges created by the clay adhering to the base. Although this second

[25] The consultation of these volumes was particularly useful in order to understand the "history" of the joins and quasi-joins made during the studies.

[26] 19 *Raccords*, 22 *Joins*, 98 *Raccords*, 123 *Raccords*, 175 *Raccords*, 436 *Raccords*.

[27] Firth 1996/97 [1998], Firth 2000/01, Firth 2016; Firth-Melena 1998/99; 2008; 2016a, b, c; Firth-Skelton 2016; Driessen 2000.

[28] This data-sheet was prepared in collaboration with the Linear B Laboratory of the course on Aegean Civilization of the University of Rome, Sapienza, in the academic years 2015-2016 and 2016-2017.

[29] I would like to thank G. Merlatti for his work and for his help in composing this part of the paper.

[30] Sjoquist-Astrom 1991, 13-24, Palaima 1985, 103. For a general updated discussion see Driessen 2000, 40-41, who shares the same conclusions.

[31] Godart 1988, 248-250.

[32] In collaboration with the Linear B Laboratory of the course on Aegean Civilization of the University of Rome, Sapienza, in the academic years 2015-2016 and 2016-2017.

Fig. 4. Da 1341[+]1454 +8777: the section of 1341 and its join 1454.

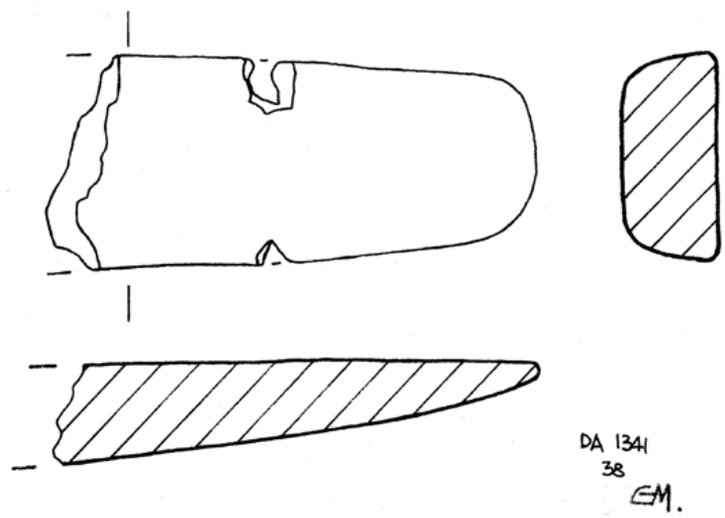

Fig. 5. Da 1341[+]1454 +8777 (Drawing by G. Merlatti of the fragment 1454).

smoothing operation can be performed with the fingers or (after L. Godart) with a stylus, we observed the following: firstly, that many tablet surfaces are too regular to have been produced even using the wider part of the stylus which, when applied to the surface, tends to create streaks about 2-3 mm wide[33]; and second, that this technique does not account for the extreme regularity of the sides (sometimes 2.3 cm thick, as in the case of As(1) 1516), the edges and the corners of many tablets, clearly visible on the sections drawn during our missions (Figs. 4-7).

We tried many times to reproduce the regularity of the edges of some tablets with a trapezoidal section by pressing clay onto a table[34], but with poor results. We then concluded that the Mycenaean clay-makers, like potters, used to burnish parts of the tablets (mainly the surface to be written on and the two sides), possibly using a spatula of wood or bone.

The technique completely avoids any problem linked to localised adhesion of the clay during detachment of the tablet from the flat base, and allows the clay to be shaped with regular edges and corners. Traces of this technique are clearly visible in the RTI images, but are mainly evident on the 3D image and the section drawings of many tablets (Figs. 6-7).

[33] The use of the flat part of the stylus is particularly evident when palimpsests occur.

[34] Following Palaima 1985, 103.

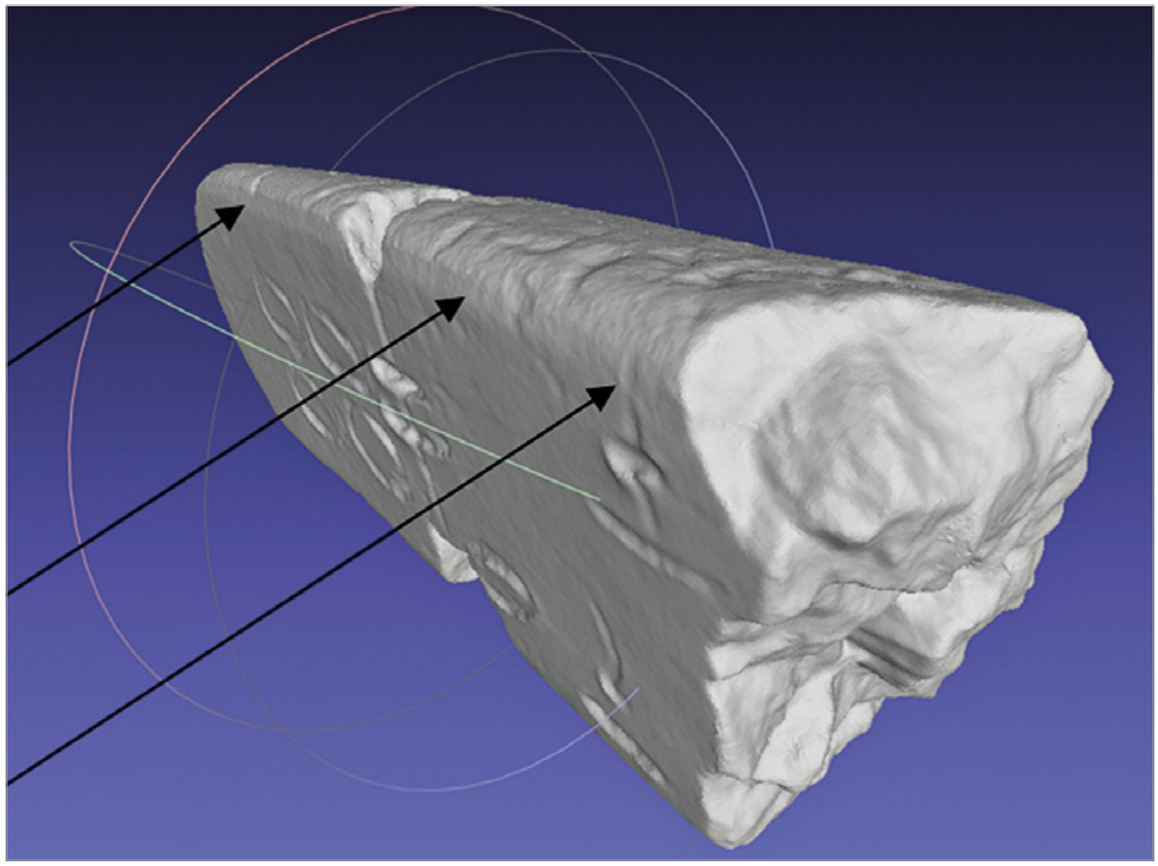

Fig. 6. Lines made by the burnishing technique (Da 1341[+]1454 +8777).

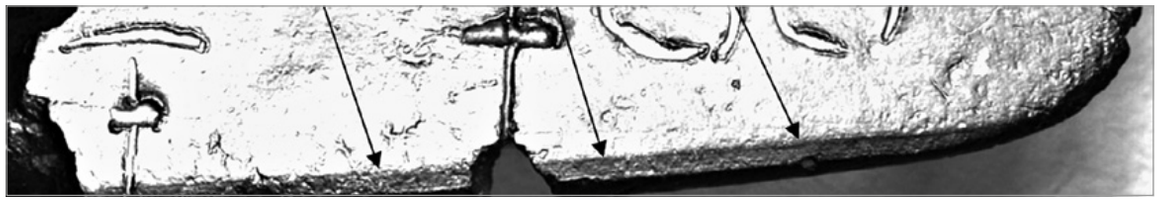

Fig. 7. Lines made by the burnishing technique (Da 1341[+]1454 +8777).

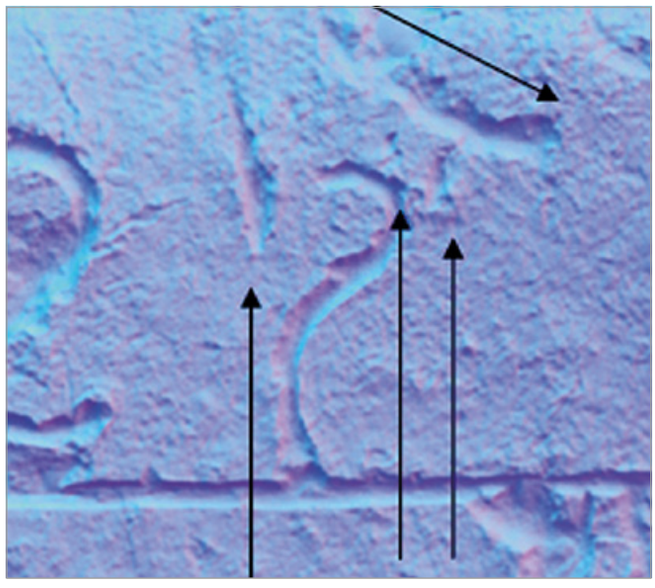

Fig 8. B36 in the first line.

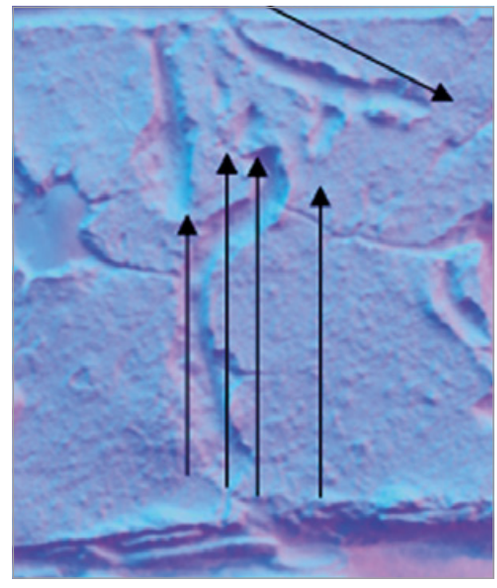

Fig 9. B36 in the third line.

4.2 New readings

Clearly, the possibility of examining files and images at any time represents the great advantage of the new technologies, which allow continuous review and control of the text readings provided or presumed. An example of the potential of an integrated traditional/digital epigraphic study of the tablets is provided by two cases of different weight and nature: the cases of syllabogram B36 -jo- on tablet F 841 and two arithmograms on tablet Dn 1094.

During the earlier philological and epigraphic study of the *pa-i-to* tablet set, no particular problem was found with the photograph, the drawing and the transcription of the tablet F 841 in *COMIK*. We only observed that in the drawing, with respect to the word *mi-sa-ra-jo* (line 4) and, in particular, its supposed final syllabogram B36 *-jo-*, the horizontal stroke that constitutes this syllabogram is missing; this absence can also be confirmed from the old photograph.

However, during the examination of the tablet, some doubts arose, as line .1.3.4 of the same tablet documents the syllabogram B36 *-jo-*, but it is regularly incised with its horizontal stroke and with two to four vertical strokes (the first, to the left, bigger than the others on the right) (Figs. 8-10).

The RTI and the 3D models confirmed the absence of both the horizontal stroke and the three vertical ones – a fundamental criterion for identifying the final syllabogram of the supposed word *mi-sa-ra-jo* – but added a new hint for a more correct reading. As shown in Figs. 11-12, in the original drawing of *COMIK* the editors probably misunderstood a fracture of the clay as part of the vertical stroke that closes, to the left, the syllabogram B36 (Fig. 13), while they omitted to draw part of a horizontal stroke that appears in the middle of the curve of the main vertical stroke.

In *COMIK*, the two syllabograms B36 present at the end of the first and fourth lines of the same tablet have been drawn without any vertical stroke to the right of the first one. This coincidence, perhaps, also convinced the scholars of the correct interpretation of the syllabogram in the fourth line. Now we can affirm with certainty that these small vertical strokes are present at the ends of both the first and fourth lines, just as in the syllabogram B36 in the third line; this facts allows us to exclude the possibility that the last syllabogram pertaining to the word *mi-sa-ra-* in the fourth line could be identified as B36.

As mentioned above, part of a stroke does exist on the left of the syllabogram, but it has a different direction to that reported in *COMIK*, that is to say a horizontal direction suggesting a more accurate reading as syllabogram B12 (*-so-*). This reading, while more correct, leaves us with a bitter aftertaste, because *COMIK* reads the word as "*mi-sa-ra-jo*" which had been interpreted[35] as an ethnic name originating from the Egyptian term "miṣr" ("Egypt"): now we must be content with the more trivial *mi-sa-ra-so*.

Some minimal corrections of *COMIK* usually have no impact regarding the general meaning of the text, but deal mostly with the epigraphic drawings. It can be noted, for example, that in *COMIK* the two arithmograms for the thousands in the lower line of tablet Dn 1094 are drawn as if they shared a common vertical sign (Fig. 14). Our investigation clarified that this detail was imprecise, since the upper arithmogram does not have the lower vertical stroke; the visible stroke is rather the upper one of the lower arithmogram, which was not transcribed by the scribe with the intent that it should also act as a stroke of the arithmogram above (Fig 15). In any case, the line is definitely shorter and less linear than that drawn in COMIK.

4.3 Drawings

Although this type of inaccuracy does not invalidate the general and particular reading of the text, it nevertheless, brings forth an important question. It has been realized, in fact, that such imperfections are not the product of real errors by the epigraphists, but rather the result of the technique used for drawing the inscriptions, and in particular of the photographs used as the basis of these drawings.

The traditional technique was to draw the strokes of syllabograms by laying tracing paper over a 2:1 scale vertical photograph. More recently, for example during the updating of the corpus of Linear A documents by M. del Freo and J. Zurbach[36], the epigraphic drawings were traced using a vectorial system, with layers superimposed on high resolution photos. Although these photographs allow image sizes to be enlarged, consequently increasing the accuracy of the drawings, photos taken with a fixed light position

[35] *DMIC*.

[36] M. Del Freo personal communication; Del Freo-Zurbach 2011.

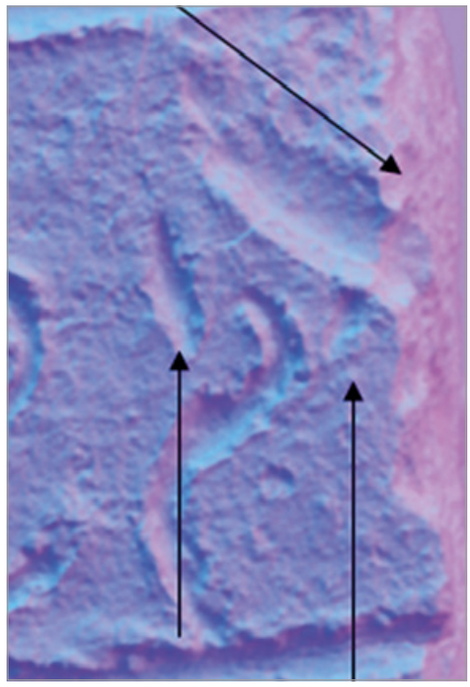

Fig 10. B36 in the fourth line.

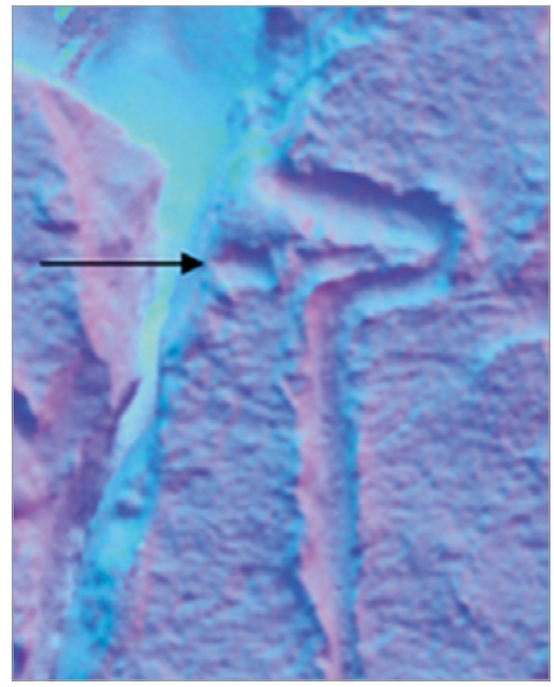

Fig 11. The supposed B36 in the fourth line.

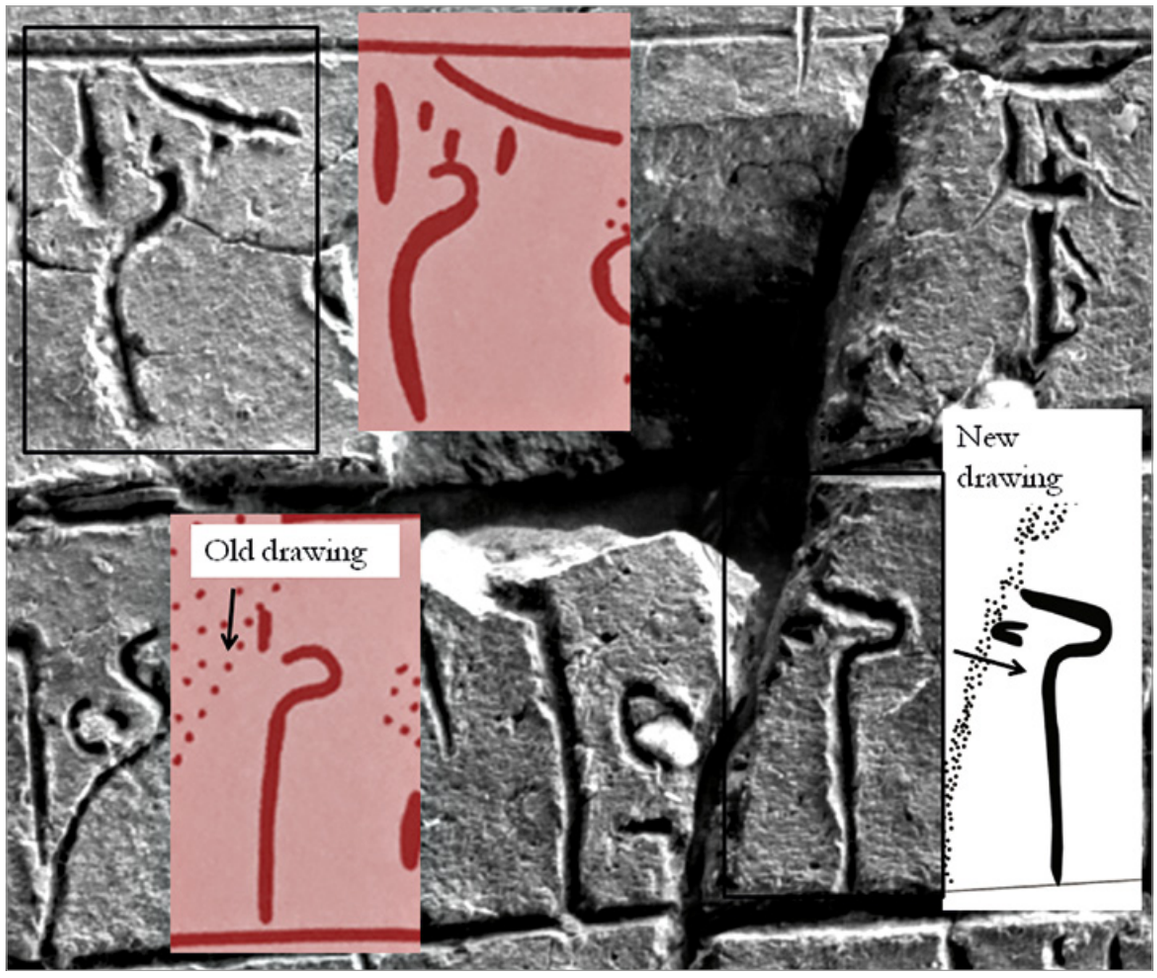

Fig. 12. Lines 3 and 4 of F841.

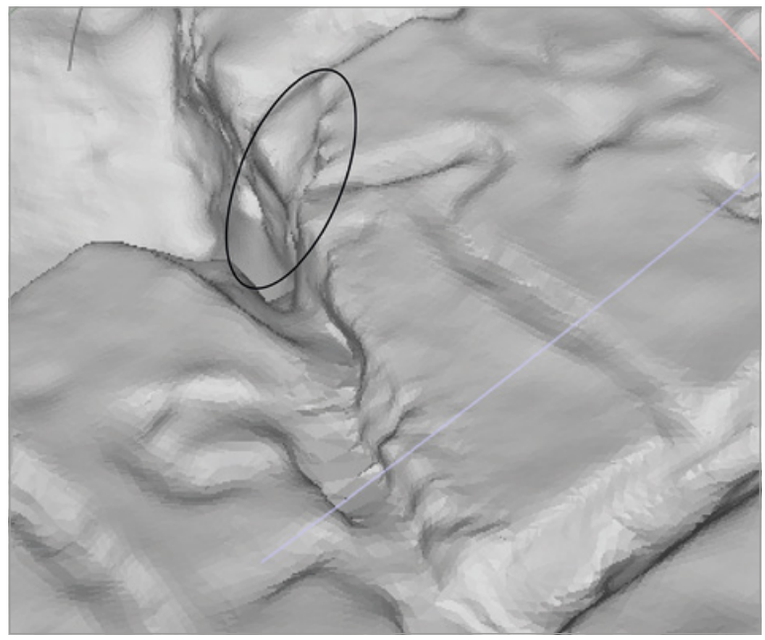

Fig. 13. Particular of the syllabogram -so-.

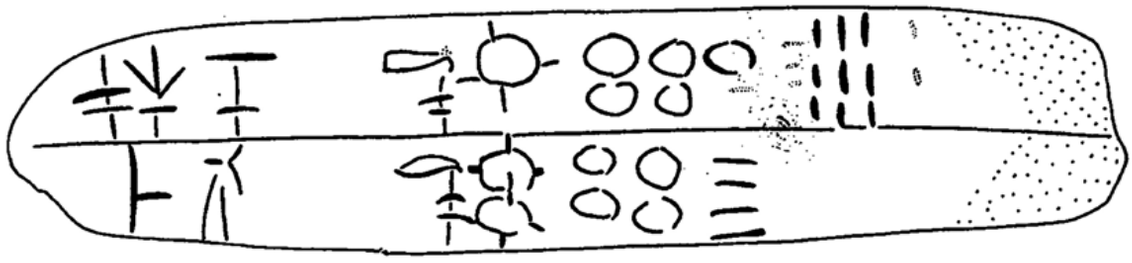

Fig. 14. Dn 1094 (*COMIK*).

Fig. 15. Normals Default Specular enhancement.

(both the old and the new ones) have a major limit, which emerged clearly when we compared them with our 3D and RTI scans.

As shown in these images (Fig. 16), it is evident that visual perception of the strokes varies with changes in light direction, and that this distortion increases when the image is enlarged. We thus realized that one of the risks of this technique is to reproduce not the physical features of the strokes themselves, but instead their shadows or deformations of their appearance determined by lighting.

In an effort to overcome this limitation, we experimented with drawing by hand directly on the RTI image, taking advantage of the possibility of shifting the angle of illumination for each stroke so as to draw it as precisely as possible. But we soon ran into a problem – namely an overabundance of information that ended up making the edges of the signs difficult to understand.

Fig 16. The same syllabogram (-pa-) seen with illumination from a different direction.

So we came up with a compromise solution: to produce multi-layer vectorial drawings based on a set of superimposed photographs, including photos with vertical lighting, photos with almost horizontal lighting and photos with lighting at 30 and 45 degrees, shot from different positions, and chosen on the basis of their quality and clarity. The drawing combines the salient elements of all the photographs in order to produce a more balanced representation of each sign.

4.4 Palaeography

Direct examination, the analysis of digital models, and the development of the aforementioned approach to the epigraphic drawings, have substantiated our view that the new techniques represent a valid support for palaeographic studies. In RTI and 3D images, the minimal variations of the surface of the tablets are easily identifiable, particularly with RTI *Specular Enhancement Visualization*, and this allows us (for example) to recognize with precision the exact direction in which the scribe moved the stylus for every stroke he traced – because, on average, at its starting point the stylus lifts up less clay than at the end point. One can comprehend with equal ease the order in which the strokes of a syllabogram were traced (Fig. 17).

In order to verify whether our hypothesis regarding the order of strokes for each syllabogram is correct, we carried out a series of laboratory tests with the collaboration of students of the Mycenaean Philology course at the University of Rome[37]. The students were asked to incise a syllabogram in clay several times, changing the order of strokes each time. We then compared the results with the original syllabogram. The correspondence was quite good; in most cases, the inscription sequence of all the strokes hypothesized on the basis of the digital models corresponded to that experimentally incised in clay in the laboratory. All this data will be collected in a database. Since the identification of individual scribal styles is based entirely on the peculiarities of syllabogram writing, the potential of such a palaeographic approach is evident.

4.5 For a history of Mycenaean Phaistos

We are also working on a historical and economic synthesis of the data contained in these documents. As is well known, the tablets record only part of the agricultural goods produced at Phaistos and destined for Knossos. They essentially give only partial information about the economy of the territory of Phaistos during the LMIII; but now we can integrate this data with palaeobotanical and palynological analyses conducted by the "Phaistos Survey Project" team. The geophysical surveys performed in recent years will also help to more accurately define how the areas of the city's hinterland were farmed with different crops,

[37] During the academic years 2015/2016 and 2016/2017.

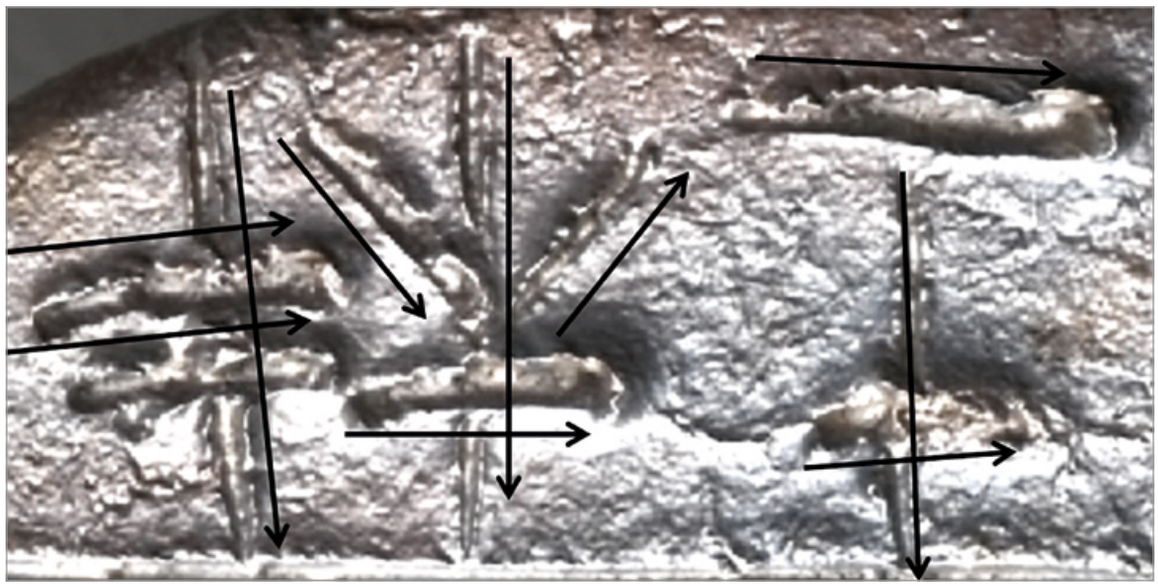

Fig 17. The direction in which the scribe moved the stylus for every syllabogram of the word *pa-i-to* (Dn 1094).

thus opening new vistas on the Phaistos area in this crucial period of its existence – as well as new opportunities for collaboration between different disciplines.

Conclusion and suggestions

in conclusion, our project not only seeks to publish a new corpus of the Linear B tablets dealing with Phaistos, but also to function as a comprehensive new edition providing the tools to understand and evaluate how the new study was conducted from a methodological point of view. For this purpose, the 3D and RTI models and the relevant palaeographic databases will be made public on a special website, now under construction (www.paitoproject.com). The website is financed by the Project «Dalla Tavoletta al Tablet. Indagini di *imaging* per applicazioni all'epigrafia e ai beni culturali» directed by E. Notti with the collaboration of A. Greco and G. Flouda, and will be soon launched.

The website is intended as a versatile instrument available both to the general public (with sections dedicated to the history of the tablets and their contents) and to specialists interested in verifying the conclusions reached and proposals made in the new corpus. The corpus will ultimately be the final product of an experiment that can be followed and analyzed by the reader at every stage of processing, while remaining open to verification (and the consequences that this entails).

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Abbreviations and Bibliography

19 *Raccords* = J.L. Melena, «19 raccord et quasi-raccords de fragments dans les tablettes de Cnossos», *Minos* 31-32, 1996-1997, 417-422.

22 *Joins* = R.J. Firth - J.L. Melena, «22 Joins of LB Fragments from Knossos», *Minos* 37-38, 2002-2003, 113-120.

98 *Raccords* = L. Godart - J.-P. Oliver, «98 raccords et quasi-raccords de fragments dans les tablettes de Cnossos», *Minos* 13.2, 1973, 113-129.

123 *Raccords* = L. Godart - J.T. Killen - J.-P. Olivier, «123 raccords de fragments dans les tablettes de Cnossos», *Minos* 10.1, 1970, 151-165.

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