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From Stone to Screen: Digital Revitalization of Ancient Epigraphy

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Abstract

This article outlines an innovative photographic technique used to digitize the Malcolm Francis McGregor Epigraphic Squeeze collection held by the Department of Classical, Near Eastern and Religious Studies at the University of British Columbia (UBC) in collaboration with a branch of the UBC library system called Digital Initiatives. The squeezes are photographed using a TTI Repro-Graphic Workstation 4060, Sinar 86H cameraback and digital CMV lenses using CaptureShop image processing software. The images undergo further processing using Photoshop CS6 and the HDR merge and Photomerge tools. The result creates a stunningly clear image which fully captures the details of the squeeze and specifically its three-dimensional quality.

Introduction

As the field of Digital Humanities grows and the interest in digital resources for teaching and research increases, scholars are finding new and innovative ways to make traditionally inaccessible or restricted material available to a wider audience. Due to the fragile nature of some teaching and research collections, especially those comprising material from the Greek and Roman worlds, curators are constantly presented with the challenge of finding photographic techniques which safely and effectively replicate the objects in digital format. Many such projects include the University of Florida's Digital Epigraphy and Archaeology project, the Smithsonian's digitization of the Freer Gallery of Art and the Arthur M. Sackler Gallery Archives and Cornell University Library's Photographs of Stones – Mysteries at Eleusis.[1] The Department of Classical, Near Eastern and Religious Studies (CNERS) at the University of British Columbia (UBC) has recently digitized such a collection, one which contains over 1000 squeezes of inscriptions from ancient Greece dating from the 5th century to the 2nd century BCE. 1

While a squeeze in general refers to a molding, cast, impression, or copy of an object or design made by pressing a pliable substance around or over it, an epigraphic squeeze in particular is the impression of an inscription on stone. This specific variety of squeeze utilizes filter paper, a porous paper for filtering liquids most often employed in the field of chemistry. The process of creating a squeeze is quite simple: first, the filter paper is dampened and placed atop the inscription. Next, a horsehair brush is used to hit the paper so that the paper is pressed into the grooves of the stone. Finally, once the paper has dried, it is carefully peeled off and a mirror copy of the inscription is revealed. [Woodhead 1981, 78–80] 2

The final product is known as an epigraphic squeeze and is an invaluable tool for research in the field of Greek and Latin epigraphy – when encountered in the field, inscriptions are most commonly located on immovable stones, either due to their substantial size or their secondary use as *spolia* (the intentional inclusion of ancient artifacts and building materials in later structures). For example, if an inscription is on a stone which is built into a church, a private residence, a wall, etc., or if the stone itself weighs several hundred pounds, the only way to study said inscription is on-site. Photographs of the stone, depending on the lighting, can obscure letters or misrepresent the incongruities of the stone. A squeeze, however, offers an affordable and practical solution to this problem: epigraphic squeezes allow scholars to 3

virtually transport the stone to research institutions worldwide. Unlike photographs, a squeeze provides three-dimensional information and is an exact replica of the original inscription. This squeeze can then be photographed, scanned, digitized, and manipulated in a variety of ways. A well-curated squeeze collection can allow for detailed and comparative study of a range of inscriptions, quickly and systematically.

4 Although the advantages of using squeezes for research far outweigh the disadvantages, there are some issues associated with their use. First, squeezes are difficult to store and to maintain long-term. While the modified filter paper does provide a mirror copy of the inscription, the paper itself is thin, fragile and prone to disintegration, tearing, water damage, and mold. Second, the squeezes themselves must be stored flat and separated into small piles of only a few squeezes so that the weight of the topmost squeezes does not flatten the letters on those below. For this reason they are commonly stored in thin drawers in customized cabinets made expressly for this purpose. Third, because the direct impression of the inscription is found on the underside of the squeeze, epigraphic squeezes are often read backwards since the letter forms are more legible on this side. The reader must then read the squeeze from right to left, using a magnifying glass to see all of the details necessary for a thorough analysis of the inscription. Finally, the curators of epigraphic collections of many museums – including one of the only epigraphic museums in the world, the Athens Epigraphical Museum – have issued a ban on the creation of additional squeezes for fear of further damaging the stone inscription The implication of this ban is that already-established squeeze collections are likely to be the only such collections that will ever exist. This fact renders the existing collections all the more precious, and the various digitization projects even more significant. The fragility of squeeze collections highlights the importance of creating digital records of these important historical documents which preserve the detail and three-dimensional nature of the squeeze and the information contained within it.

5 This article outlines an innovative photographic technique that was employed by the CNERS department at UBC, in collaboration with a branch of the UBC library system called Digital Initiatives. This technique effectively reproduces the three-dimensional quality of the squeeze. Once the images have been uploaded to the digital collections website,[2] the image can be enlarged to 100% magnification, allowing for more detailed study of the letter forms, fractures, and other incongruities. These images in the digital collection are open-access and readily available for any interested party who may want to actively engage with the study of epigraphy through digital analysis and investigation.

The Importance of the Malcolm Francis McGregor Squeeze Collection

6 The McGregor squeeze collection was donated by Dr. Malcolm McGregor, renowned scholar of Athenian history and Greek epigraphy and a former professor in the Department of Classics (before it was merged with Near Eastern and Religious Studies) at UBC. His collection largely comprises inscriptions from Attica from the 5th century BCE, some inscriptions from Nemea (approximately 100 km south-west of Athens) from the same period, and several decrees dating to the 2nd century BCE. This collection contains 1051 squeezes and, although this number includes several duplicate copies of select inscriptions, access to this large amount of material allows for the possibility of studying inscriptions from these geographic areas and periods in one place. The most notable squeezes in the collection are the squeezes of the Athenian Tribute Lists (ATLs), which were the main focus of McGregor's research for many years and the subject of his formative work: together with H.T. Wade-Gery and B.D. Merritt, McGregor authored the definitive volumes on a reconstruction of these lists which include both texts and translations of the documents (Meritt, Wade-Gery, McGregor 1939-1953). The McGregor squeeze collection at UBC is a result of the research and study carried out for these volumes. The original inscriptions are held in the Athens Epigraphical Museum and are difficult for scholars to study firsthand, as their monumental height (3.5 m at their tallest) reduces visibility.

7 The Athenian Tribute Lists themselves are enormous dedications to Athena which once stood on the Acropolis of Athens. These inscribed records list the annual *aparchai* ("first-fruits") dedicated to the goddess Athena by members of the Delian League, a group of allied cities who pooled their resources against the threat of a Persian invasion of Greece. The *aparchai* represent one-sixtieth of the overall tribute paid to the treasury to be used for this purpose [Jim 2014, 204–205]. The lists of dedications began to be inscribed in 454 BCE, when the league's treasury was moved from Delos to Athens, and the contents of the lists are often used as a way to study the development of the so-called

Athenian Empire. Because the annual *aparchai* by each member of the Delian League was re-assessed every four years, the lists trace the progression and comparative tribute exacted from these communities as well as the wealth that was placed under the control of Athens. They also provide details on revolts by particular members from the league, as the offerings from these respective members would often disappear from the list for a few years. Overall, the ATLs are an important resource for understanding the economic and political climate of the 5th century BCE Aegean.

8 The largest stone, the Lapis Primus (literally, "first stone") records the *aparchai* for fifteen years, from 454/3-440/39 BCE, and will be undergoing restoration in the next few years. The 180 fragments which constitute the Lapis Primus are currently being held together by metal rods that are deteriorating, and the current director of the Athens Epigraphical Museum, Dr. Angelos P. Matthaiou, has initiated a movement to replace the rods with superior titanium counterparts.[3] The proposed future dismantling of the ATLs will give scholars the first opportunity to examine the marble blocks in their entirety since the construction of the current display in 1927. Many experts will, for the first time, have the opportunity to examine all sides of the stones and may even propose alternative combinations of the lists for reassembly. The digitization of the McGregor squeeze collection, particularly the ATLs, will make the squeezes of these fragments available to scholars worldwide prior to the eventual dismantling of the stones. The significance in this lies in the fact that the collection also includes McGregor's original epigraphic charts – his drawings of his own reconstructions of the ATLs based on the stone fragments. This data will be made available not only to expert scholars and researchers aiming to make new discoveries with the disassembly of the Lapis Primus, but the open-access format will allow any interested party to actively engage with this collection. At a time of new developments and inquiry in the world of Greek Epigraphy – and the ATLs specifically – this new digital collection will preserve for posterity digital copies of the squeezes of the original stone fragments as they were studied and configured by Malcolm McGregor and his colleagues.

Testing Workflow Solutions

9 The greatest challenge in creating superior digital images of epigraphic squeezes is the three-dimensional nature of the squeeze as an object. The letter forms of most squeezes are only slightly indented, due to the shallow carving on the stones themselves and, as mentioned above, scholars working with the squeezes themselves generally find them easier to read by reading the underside so that the letters are raised – the implication of this methodology is that the words are read backwards, from right to left. A simple photograph of the squeeze produces a flat and often illegible image that does not allow for a detailed study of the letter forms, eliminating potential reconstructions of fragmentary inscriptions. Alternatively, flatbed scanning runs the risk of flattening the raised letters, forever altering the quality of the original squeeze. One research group attempting to digitize squeezes has pioneered the use of surface reconstruction to create a three-dimensional image from a two-dimensional photograph of the epigraphic squeeze [Barmpoutis, Bozia, Wagman 2010]. Although this procedure is affordable as it requires only a flatbed scanner and a particular computer algorithm, it relies on shape reconstruction of particular letter forms. This presents a problem for squeezes that are damaged or have fractures or incomplete letter forms. Other inscription-digitization projects have relied on laser scanners [Landon and Seales 2006] and Reflectance Transformation Imaging Systems [Earl et al. 2011] which can highlight letters and other details on the stone that have worn away through time or have been obscured through reuse of the stone for another purpose. These technologies provide detailed surface maps of the artifact in a three-dimensional model but are potentially prohibitive to a larger audience due to the need of specialized hardware and/or software to view and study the images.

10 The original goal for the digitization of the McGregor collection was to find a non-destructive process that would generate crisp, detailed images that retained the three-dimensional nature of the squeeze. In the summer of 2013, two assistants from the UBC Library's Digitization Centre (generally referred to as Digital Initiatives, or DI),[4] Lesley Field and Chris Pugh, worked with a small sample of squeezes using the TTI Repro-Graphic Workstation 4060 to determine the viability of DI collaboration on the digitization of the McGregor collection. After surprisingly little trial and error, they created a workflow that creates stunningly clear images which fully capture the details of the original squeeze.

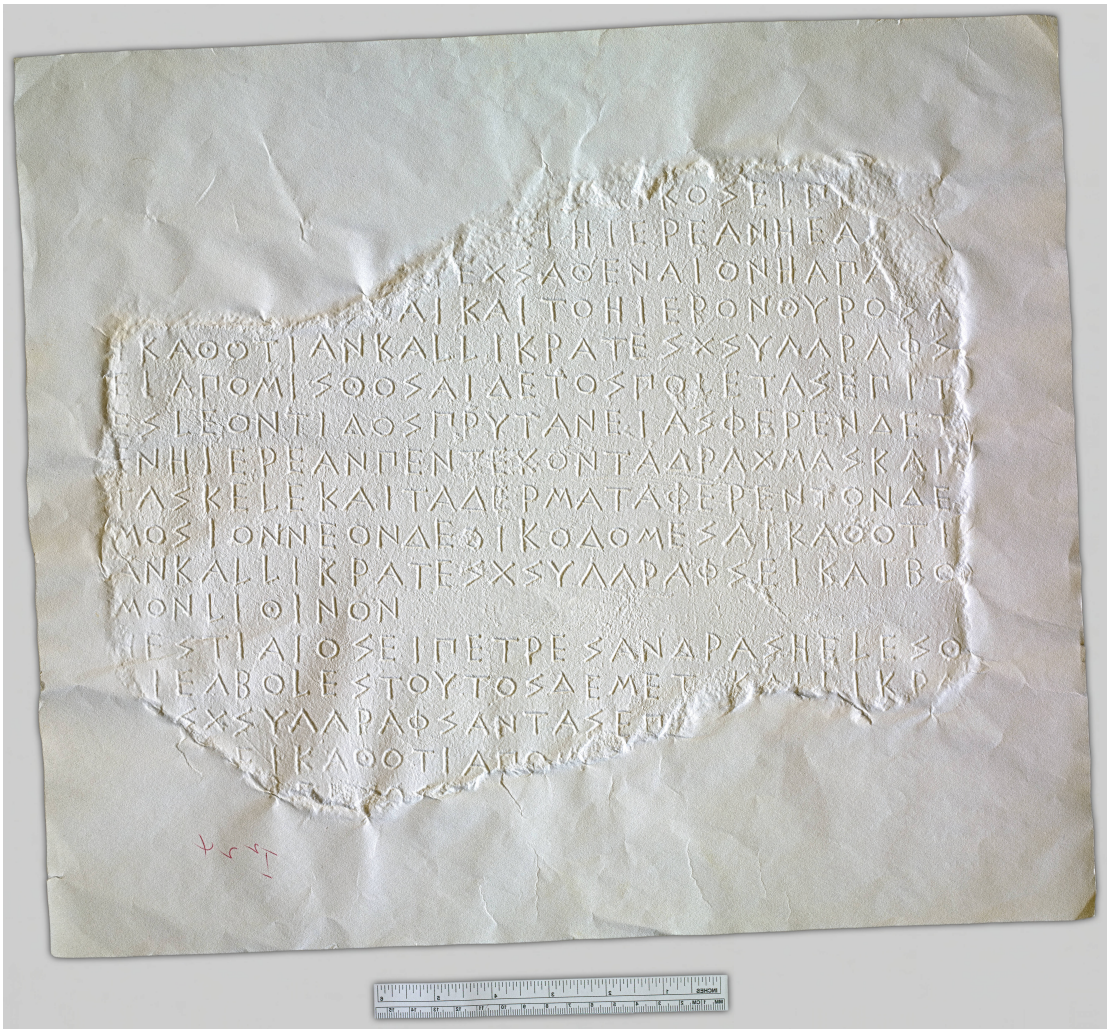

Figure 1. Digital reproduction of IG I2 24 (IG I3 35) – Appointment of the Priestess and Building of the Temple of Athena Nike (Decretum de Minervae Victorae Sacerdote Temploque). 425 BCE.[5]

The TTI workstation features a 4x6 foot vacuum table with mounted lights and a suspended camera. The underside of the squeeze is then placed facing up as this is the part of the squeeze which has come into direct contact with the stone of the inscription and thus it retains the direct imprint of the inscription. This is the most important image to capture faithfully in the digitization process. The squeeze is photographed using a Sinar 86H cameraback and digital CMV lenses which uses CaptureShop image processing software. The camera shoots four frames per image in an X-pattern, from top left to bottom right, then bottom left to top right, shifting by a single pixel per frame.

Figure 2. TTI table set up with Sinar camera

CaptureShop then merges the resulting four frames into a single image. The single pixel shift creates a composite image that is an extremely precise representation of the original item being photographed. While this is the standard procedure used by Digital Initiatives, capturing the unique three-dimensional quality of the squeezes requires clarity and definition in both the highlights and lowlights. Expanding on a technique developed for creating Polynomial Texture Maps and for Reflectance Transformation Imaging [Malzbender, Gelb, Wolters 2001] [Earl et al. 2011], this project uses High Dynamic Range Imaging - often abbreviated as HDR or HDI - an imaging technique that merges different exposures of an image to produce a greater range of shadows and highlights than a single exposure offers. For the squeezes, the bracketing options in CaptureShop are set to take three images – one overexposed, one properly exposed and one underexposed.

12

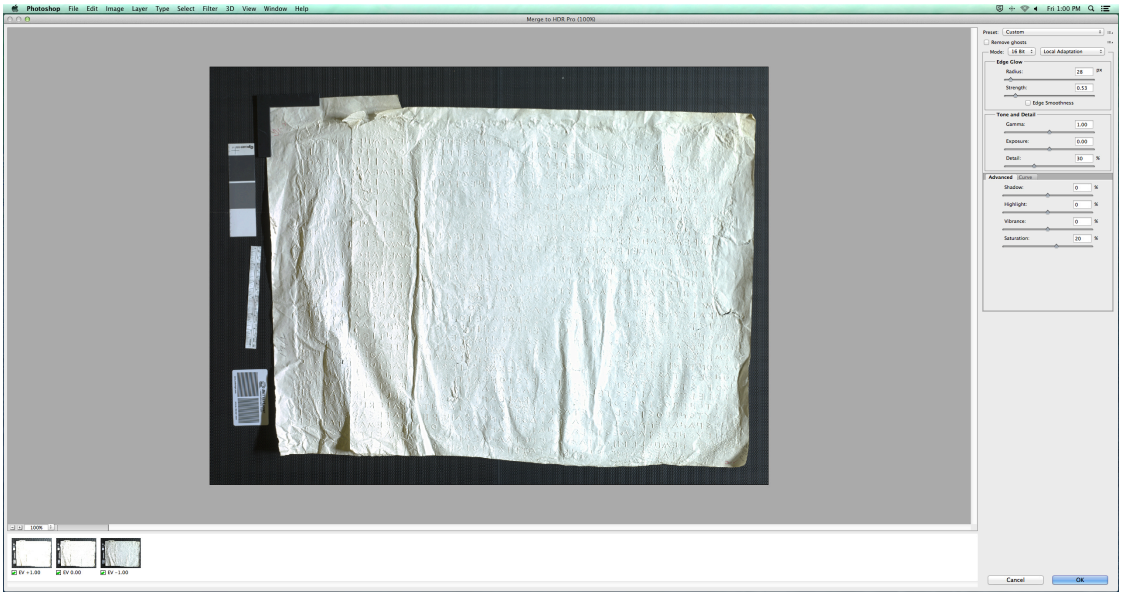

Figure 3. Screen shot of the HDR merge tool

The RAW image files are imported into Photoshop CS6 where the automated HDR merge function is used to create a single image with all of the dynamic range of the three different exposures. RAW files are used in this case because

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they retain the maximum amount of information from the captured images; compressing the image to TIF or JPG format results in both a loss of detail and images incompatible with the HDR merge tool. In the case of the larger squeezes, Photoshop's Photomerge tool was used to fully capture the original squeeze. Even though the vacuum table of the TTI measures 4x6 feet, the total area captured by the camera is much smaller even when the camera is raised to its highest level on the support arm. In these situations, a series of pictures are taken, ensuring that there is at least a 30% overlap of pixels within each image. Photoshop can then use this overlap to seamlessly stitch the images together using the Photomerge tool. It is more time-effective to take four photos with considerable overlap than to attempt this maneuver with only three photos – this often leads to insufficient pixel correlation to create a collage and one must then start over. The photographic and post-processing techniques described above create an image with the texture of the paper beautifully enhanced.

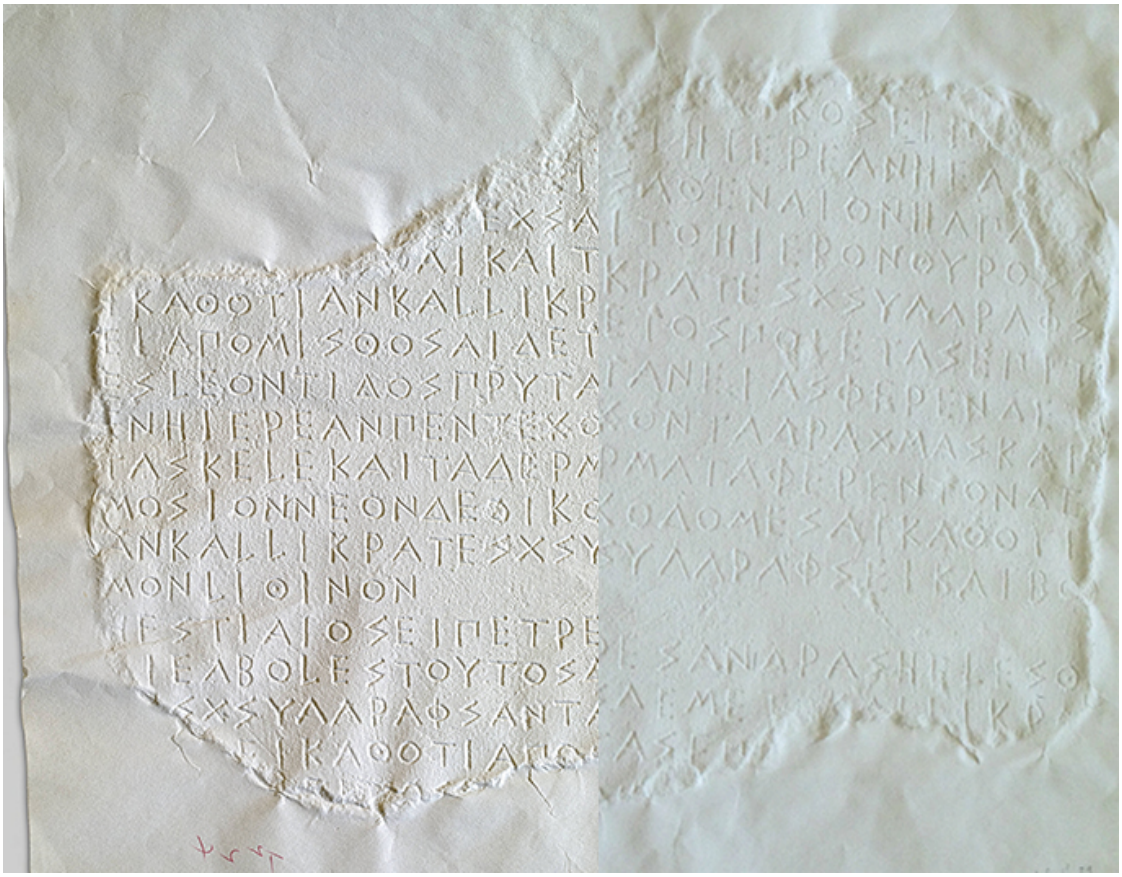

Figure 4. Digital squeeze image (left) vs. regular camera image (right)

14 Next, the image of the squeeze undergoes further editing in Photoshop: flipping it horizontally allows the letters to be read left to right and the image is straightened so the text, not the edge of the filter paper, is horizontal to the reader. While epigraphists are accustomed to reading squeezes backward, or right to left, the flipped images available on our website makes the resource more accessible to students of ancient Greek. Other edits, including the insertion of a neutral grey background and drop shadow, are purely aesthetic, but are performed to match the images in other digital collections in the University of British Columbia's library. The images are then uploaded to the library's digital collections website with basic metadata including the title of the inscription, references, date of the inscription, and number of squeezes and fragments relating to this inscription in the collection.[6]

15 The squeezes have been digitized, and we are currently expanding the metadata to include transliterations, translations, relevant bibliography, and other additional notes. Initial research by student volunteers has been focused on obtaining information about the physical stones containing the inscriptions – their dimensions, findspots and current locations. In July 2015, Chelsea Gardner obtained a permit from the Athens Epigraphical Museum to photograph some of the original inscriptions that we hold in our collection. The purpose of this collaboration was to better illustrate the squeezes

at the core of the collection, including the Athenian Tribute Lists, and select inscriptions we use most frequently for undergraduate instruction. The stones of the ATL's Lapis Primus have been reconstructed into the 3.5 meter-high replica of the original stele. While this allows the museum to showcase the inscriptions' monumental scale, this type of display makes photography of the stones decidedly difficult. Despite this, we were able to acquire the necessary images of the original stone inscriptions which will be added to our website for additional context for the squeezes. The addition of the photographs from the Epigraphical Museum will facilitate the use of the database as a comprehensive research and teaching tool for epigraphers, scholars, and students alike, since photos of many of these stones are not readily available elsewhere. By displaying the photograph and squeeze side-by-side on the website, interested parties (students, scholars, and the general public) can compare the quality of the words on the stone versus the squeeze for themselves and explore all resources available.

Benefits of Collaboration

The digital collections interface allows users the means to view and manipulate the images without requiring additional software, offering a range of file sizes to download and an impressive zoom feature for detailed study of letterforms or ambiguities.

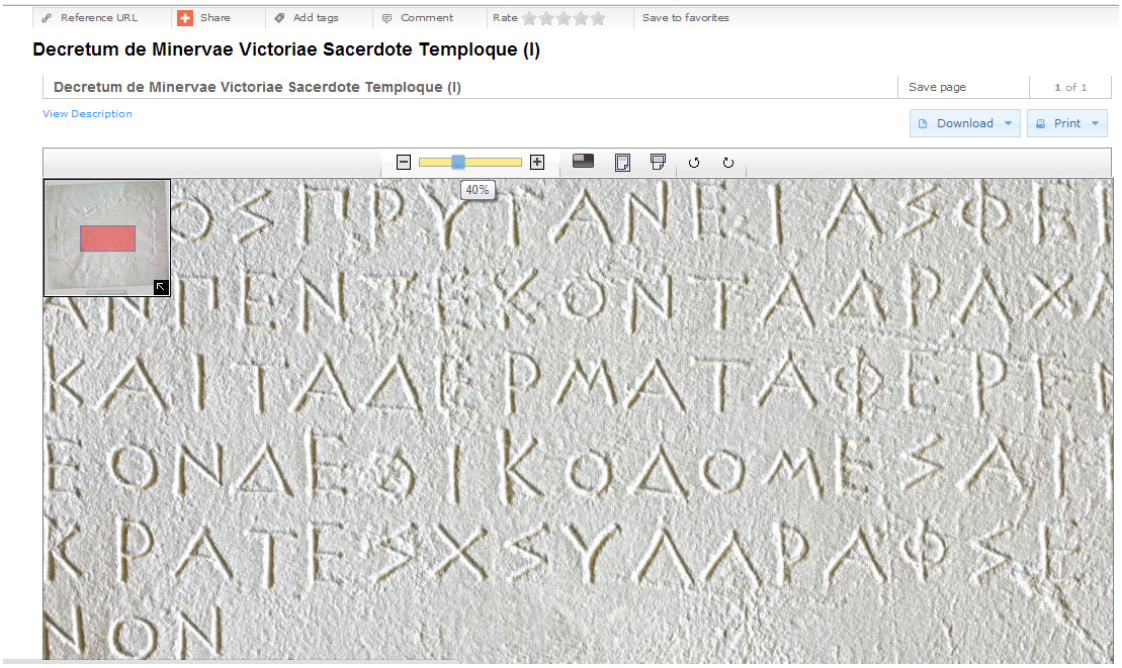

Figure 5. Screenshot of IG I2 24 (IG I3 35) at 40% Magnification

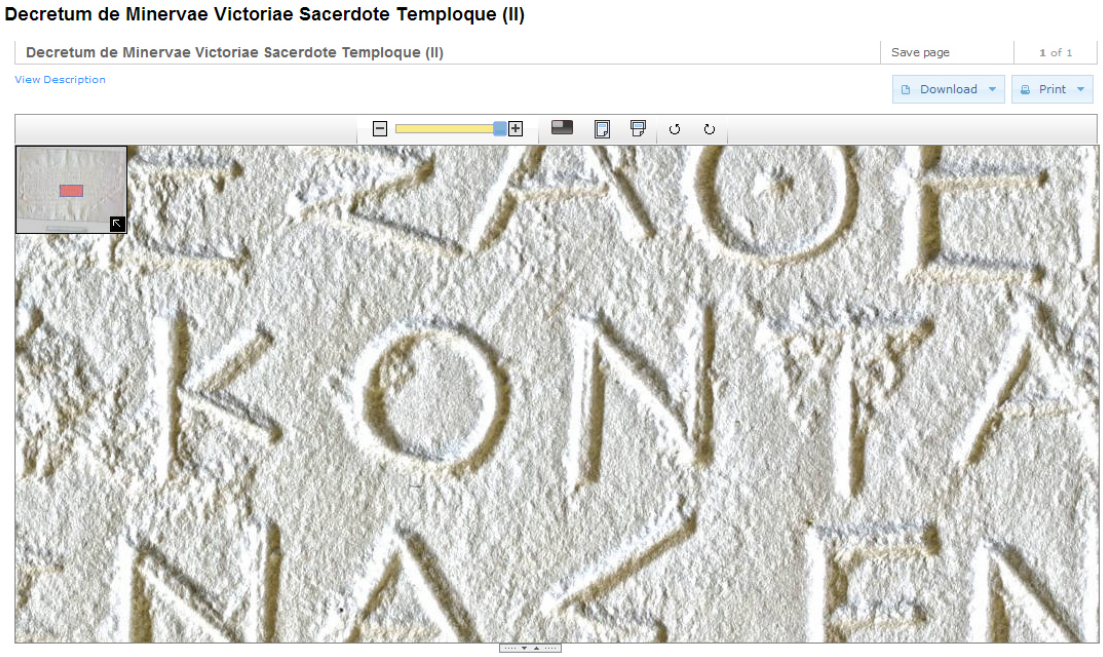

Figure 6. Screenshot of IG I2 24 (IG I3 35) at 100% Magnification

The test collection proved that the equipment in Digital Initiatives would provide both the image-quality and interface required for detailed study of the squeezes in the McGregor collection. This digitization project was fortunate enough to receive a grant from the University of British Columbia for the express purpose of making archived material digitally available through the university's library system, or in their own words "to ensure the authentic, long-term preservation of these digital holdings for the future."[7] Digital Initiatives has completed twenty-two projects to date, and currently manages twelve current projects (including the digitization of the McGregor Collection) and has two upcoming projects. The partnership between the CNERS and Digital Initiatives further ensures the longevity of the archives and their regular maintenance, as DI will manage the Epigraphic Squeeze Collection in the same manner as all other collections under their supervision. 17

Viability of Replication at other Institutions

Although the TTI Repro-Graphic 4060 assemblage used in Digital Initiatives is prohibitively expensive, we strongly believe that the quality of our images and a similar workflow could be achieved at a lower cost to anyone interested in replicating our imaging process. The camera model and light array are available at different price points and in different sizes. The vacuum table is not essential and can be replaced with any flat surface. The most important aspects for reproducing our photographic technique are a camera stand to mount the camera over the squeeze; remote shutter capabilities to ensure that there is no shadow cast on the squeeze; and a bright, neutral light array installed on one side of the camera, placed at a 45 degree angle. While CaptureShop software automates the process of taking three different exposures of the squeeze, the same process could easily be done manually. In fact, DI upgraded from CaptureShop to CaptureFlow in September of 2014, and different program features – including the loss of the automatic bracketing feature used to photograph the majority of the squeezes – forced us to find an alternative method. We completed the squeeze photography by taking a single shot with the Sinar 86H camera and created bracketed images with Photoshop by creating two duplicate files and changing the exposure settings. From there, the process is identical to what was described above. 18

Photoshop C2 or newer is essential to replicate the overall quality of the images: this was the first version of Photoshop with the HDR-Merge tool. HDR merge will combine the RAW camera files of three different exposures into a single image, while still retaining the highlights and shadows from the over- and under-exposed images. For larger squeezes, the same technique as outlined above can be applied by taking multiple photos and then stitching them together using 19

Photomerge. The process of digitally stitching images together with Photoshop is entirely automated and can be easily mastered by anyone with basic technological proficiency. Using this fundamental methodology, similar projects can replicate our process without the full technological arsenal that this project employs. DI is equipped with Photoshop CS5 and CS6, which have improved upon the early HDR-merge tool so we cannot attest to the usability or quality of merged images with earlier versions of Photoshop.

Conclusion

20 Scholars in the field of Greek epigraphy have long been able to make squeezes of inscriptions but sharing them with the broader academic community has been a continuous challenge. The earliest publications of inscriptions – for example the Supplementum Epigraphicum Graecum (SEG) and the Inscriptiones Graecae (IG) - focused on providing transcriptions of the text due to financial and practical constraints of including photographs when the field of photography was in its infancy. Thus, scholars had access to the text of the inscriptions but vital contextual and visual information was notably absent. A visual representation of object itself is necessary for a balanced appreciation of the inscription both as a text and as an archaeological artifact [Tupman 2010]. The Internet has expanded the availability of images to broader audiences but the digitization of epigraphic sources, particularly squeezes, continues to challenge the curators of epigraphic collections. For example, Oxford University's Centre for the Study of Ancient Documents (CSAD) began an early imaging project in 1997.[8] Although the challenges faced by their project are the same issues all other such projects face today – namely finding a non-destructive means of digitally rendering the images and providing access for their detailed study – CSAD's project was also confined to smaller image sizes due to server constraints that are not a problem for more recent servers.[9] Current digitization projects are not constrained in the same way, due to advances in technological capabilities and online storage facilities – full-size archival standard image files no longer present storage challenges for most users. However, the images from CSAD are nonetheless legible, and, more importantly, they represent the foundation for all other digitization projects that have followed since.

21 The imaging process presented in this article is simply the latest in a long line of predecessors; our project follows in the two-decade-old digital tradition, yet fully exploits the technological advancements and digitizing techniques used by recent projects in epigraphy, paleography, papyrology, and artifact digitization. This work undertaken by *From Stone to Screen* is part of a larger trend in the Digital Humanities scholarship towards the development of innovative methods to fully capture the three-dimensional nature of epigraphic squeezes. The development of these techniques relies heavily on scholarly collaboration and interdisciplinary discussions both within particular university communities (such as our collaboration on this project with Digitial Initiatives) and with the larger academic community. In September of 2014, the EAGLE (Europeana network of Ancient Greek and Latin Epigraphy) International Conference on Information Technologies for Epigraphy and Digital Cultural Heritage in the Ancient World met in Paris.[10] This network aims to create an e-library for Digital Epigraphy and a network of scholars, students, museum curators and any one else interested in Epigraphy and Cultural Heritage. Our project participated in the conference and we look forward to being involved in this network and future collaboration with other digital projects not only to promote and discuss our own collection and digitization methods but also to be part of the vibrant and dynamic field of digital epigraphy. To quote Charlotte Tupman, "the key to improving digital publication further appears to lie in the way in which scholars work together; the more interdisciplinarity can be encouraged, the better digital publications will become…Rather than holding back from working collaboratively, we should embrace the opportunities that technological advances present, and seek new ways to further our knowledge." [Tupman 2010, 86].

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22 This project could not be undertaken without the financial support of the Teaching and Learning Enhancement Fund and the Department of Classical, Near Eastern and Religious Studies at the University of British Columbia. The authors would also like to thank Larissa Ringham, Lesley Field, Chris Pugh, and other DI staff for their assistance in the digitizaiton process, their expertise, and their innovative problem solving for developing the digitization process. We have had tremendous support from our department faculty, notably Lisa Cooper, Kevin Fisher, Melissa Funke, Charmaine Gorrie, Nigel Kennel, Toph Marshall, Matthew McCarty, Siobhan McElduff, Dietmar Neufeld, Shelley Reid,

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Notes

[1] Digital Epigraphy and Archaeology project: www.digitalepigraphy.org Smithsonian's digitization of the Freer Gallery of Art and the Arthur M. Sackler Gallery Archives: http://www.asia.si.edu/research/squeezeproject/ Cornell University Library's Photographs of Stones – Mysteries at Eleusis: eleusis.library.cornell.edu

[2] https://open.library.ubc.ca/collections/squeezes

[3] Personal communication, February 2014.

[4] Digitization centre: http://digitize.library.ubc.ca/

[5] A translation of the text of this inscription can be found in Fornara 1983, 94-95.

[6] http://digitalcollections.library.ubc.ca/cdm/landingpage/collection/squeezes

[7] http://digitize.library.ubc.ca/documentation/ - accessed September 23, 2014.

[8] http://www.csad.ox.ac.uk/csad/

[9] http://www.csad.ox.ac.uk/CSAD/Imagebank.html - accessed September 23, 2014. Archival image standards are 600 dpi and CSAD's initial experiments worked with images of 300 dpi and 150 dpi which were then scaled down to derivative images.

[10] http://www.eagle-network.eu/about/events/eagle2014/ - accessed September 23, 2014.

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