

Applications of Reflectance Transformation Imaging for the Documentation and Study of Etruscan Material Culture at Poggio Colla

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Poggio Colla

Poggio Colla is an Etruscan site located about 32 kilometers northeast of Florence, occupying what would have been a strategic location at the juncture of the Mugello basin and the Val di Sieve. Since 1995, ongoing excavations by the Mugello Valley Archaeological Project (MVAP) have revealed evidence of a hilltop sanctuary and associated settlement and industrial zones. Based on these excavations, Poggio Colla appears to have been inhabited from at least the seventh century B.C.E. until its destruction in the second century B.C.E.

RTI at Poggio Colla

In 2014, the MVAP conservation laboratory undertook a pilot program to assess the applicability of Reflectance Transformation Imaging (RTI) as a field documentation tool for artifacts excavated at Poggio Colla. RTI is a computational photographic method that produces high resolution, dynamic images that can be used to record and examine artifact surfaces. It is especially well-suited for imaging surfaces with low relief¹ which have traditionally been examined with raking light in order to best observe subtle topographic variation. Many of the artifacts excavated at Poggio Colla have low relief diagnostic features which have been at least partially obscured by deterioration and alteration of surface topography. Excavation at the site has unearthed large quantities of fragmentary ceramic artifacts, in which a variety of wares, manufacture dates, and vessel types are represented. Many of the excavated ceramics have worn, weathered, and sometimes flaking surfaces. This deterioration can impede interpretation of decorated surfaces, especially reading of worn stamped imagery and burnishing marks on bucchero and impasto buccero fragments, and incised marks on ceramic and stone surfaces. The 2014 pilot program at Poggio Colla created RTI documentation for a small group of ceramic and stone artifacts with low relief surface decoration and varying degrees of deterioration.

The most commonly employed form of RTI is based on the polynomial texture mapping technique developed at Hewlett-Packard Laboratories in 2000². RTI capture, building, and viewing techniques have been refined and promoted by Cultural Heritage Imaging (CHI), a nonprofit organization committed to advancing digital capture and documentation practices for cultural heritage³. Polynomial texture maps have been successfully used to document a range of archaeological artifacts and surfaces, and continue to gain currency as a tool for documenting cultural heritage⁴. Each pixel of a polynomial texture map stores information about color and surface normals, vectors perpendicular to the object surface⁵. CHI's free open-source RTI software combines this information from a series of digital photographs of the same object taken under a sequence of lighting conditions. The array of lighting positions needed to create an RTI file can be achieved via a fixed dome lighting rig or with the highlight method, in which a mobile light source is moved around a stationary object positioned with reflective spheres within the camera's field of view⁶. With the highlight method, RTI software uses the highlights recorded on the sphere's surface to calculate the direction of illumination. The resulting file enables the user to manipulate the angle of surface illumination while viewing the object with different rendering modes that emphasize and enhance features not easily discernable with traditional examination techniques. Rendering modes apply mathematical transformations to the surface normal and RGB color data to create enhanced views of the object's surface, and include: diffuse gain, specular enhancement, normal unsharp masking, image unsharp masking, luminance unsharp masking, coefficient unsharp masking, static multi light, dynamic multi light, and normals visualization.

Conclusion

RTI files were successfully created for a range of artifacts which included burnished, stamped and incised buccero ceramic vessel fragments, an inscribed stone statue base, and a mold-made ceramic architectural fragment. Project staff members were able to carry out RTI documentation with standard excavation digital photography and image processing equipment, and to perform the work in the rural conservation laboratory setting. Image processing was the most time-consuming aspect of the project, though adoption of appropriate naming conventions and establishment of an efficient way to convert RAW image files streamlined the procedure. The 2014 RTI campaign has created new avenues for the preservation and study of material culture from Poggio Colla. The ability to virtually relight artifact surfaces and to examine them with different rendering modes provides conservators with another tool to monitor condition changes over time, and provides off site scholars with an additional way to study artifacts from Poggio Colla.

¹ Payne 2012, 20-21.

² Earl, Martinez and Malzbender 2010, 2040.

³ Cultural Heritage Imaging 2014.

⁴ Earl, Martinez and Malzbender 2010, 2040.

⁵ Payne 2012, 18.

⁶ Mudge et al. 2006, 198.

⁷ Perkins 2012.

⁸ Perkins 2007, 9.

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Materials and Procedures

Most of the materials used for the RTI project were appropriated directly from Poggio Colla's field laboratory. Work was performed in teams of two in a space adjacent to the lab in which there was good control over ambient light.



To create a stationary photographic set-up that eliminated vibration, the lab's Canon G10 digital camera was mounted to a copy stand and used with remote capture; a completely stable and unchanging system for image capture is necessary for processing. A QP card was used to create a custom white balance for each set of images and to provide reference values for post-processing.

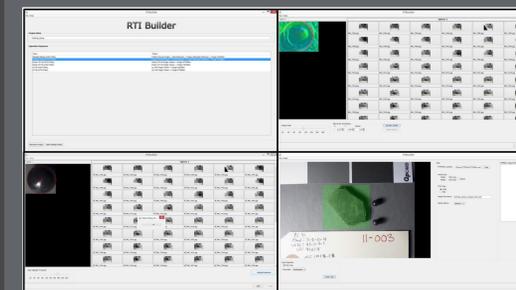


A desk lamp from the lab was disassembled and repurposed to serve as the movable light source. The lamp was kept at a fixed radius as it was moved around the object by tethering it to a string measured to roughly 4x the object's diameter.

Highlights were captured with 1/4" and 7/16" silicon nitride (Si₃N₄) ceramic balls used for ball bearings, purchased from Boca Bearing Company. Sphere sizes were selected based upon estimated object dimensions. Benchmark wax, plasticine molding clay and bamboo skewers aided in positioning and mounting the reflectance spheres, which were placed in frame near the object. The spheres constituted the only preparatory purchase prior to the field season.



With the object and processing items (spheres, QP card, scale, label, etc.) positioned and focused in frame, all light in the room was turned off and shut out, leaving just the illumination from the movable light source. One team member proceeded to capture the images as the other moved the light source along imaginary transects of an "umbrella" around the object. Within about 20 minutes, the team obtained a series of 80-120 RAW images which highlighted the object under a range of raking light angles.



RAW image files were first converted into jpegs using Photoshop CS 5, though an equivalent image processing software can be used. RTIBuilder guides the user through a simple procedure in which a new project is created from the imported series of jpegs. Information about the position of the light source in each frame is reflected in the spheres, which the RTIBuilder software uses to compile the final interactive RTI file. After highlights are detected on the reflectance spheres, images are cropped, and the RTI file is generated.

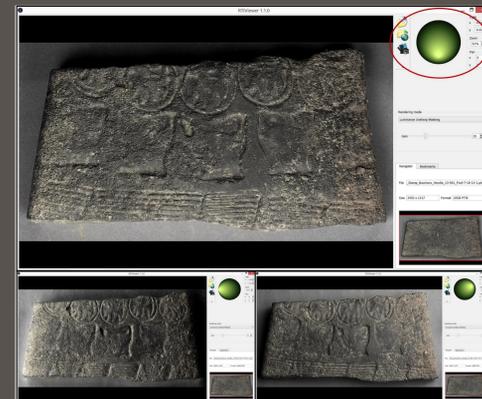
RTIBuilder, as well as RTIViewer (which navigates the final product) are free programs available for download on CHI's website.

Results

RTIViewer



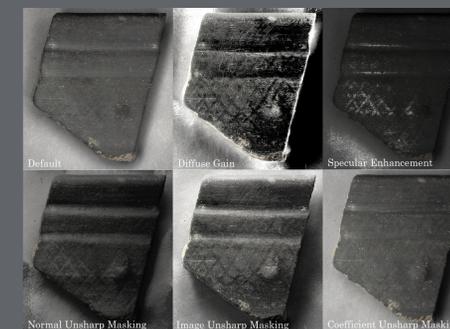
The final RTI file is accessed using RTIViewer, with which the user can zoom in and out of a high resolution image, light the surface from any angle, take a snapshot of the field of view, and play with rendering modes available in the dropdown menu—useful for interpreting worn surfaces like that of this terra cotta architectural fragment (inv. PC 10-224).



RTIViewer gives the user control over a "virtual torch" in the form of a sphere located in the upper right corner of the user interface. By using the mouse to move the reflection in the sphere, the user views the object under the various raking light conditions recorded in the photographs. A variety of raking light angles is helpful for examining a surface with multiple stamped designs best viewed under different lighting conditions, like those on the handle fragment above (inv. PC 13-001).



This buccero sherd (inv. PC 11-003) is decorated with a small stamp thought to depict a rare scene of a woman giving birth⁷. Because of the stamp's small scale and surface deterioration, study of its worn imagery requires magnification and raking light. RTI provides both, allowing the stamp to be studied with ease from afar. Above are snapshots of the stamped surface lit from different angles, viewed in Luminance Unsharp Masking mode.



Burnishing marks on buccero vessels are subtle but diagnostic features⁸. Reticulate burnishing marks, like those seen on this buccero fragment (inv. PC 14-062) can be virtually imperceptible under ambient lighting conditions (see "Default"). This fabrication technique is often only viewable when the sherd is maneuvered under specific angles of light, or during aqueous cleaning when its wet surface catches the light. RTI imaging distinguishes the extent and topography of the burnishing lines.



RTI documentation of an inscribed stone base (inv. PC 05-105) facilitates remote study of the inscription and decreases the need to handle the object. In addition to studying photographs and drawings, researchers can view carved characters and tool marks with the range of lighting and rendering options offered by RTIViewer, including Diffuse Gain, Normal Unsharp Masking and Specular Enhancement.



A weathered stamp on a buccero fragment (inv. PC 13-098) gains contrast and definition when examined using different rendering modes and angles of light in its RTI file. Though it is only a partial stamp, the remaining features have become more legible under modes like Specular Enhancement and Image Unsharp Masking. RTI imaging also aids examination of the incised guilloche design.

Troubleshooting

- When converting RAW image files into jpegs, it is important to note that only lowercase ".jpg" files are recognized because of a bug in the PTM fitter software that does not work with uppercase ".JPG" file names. Also, RTIBuilder software cannot process folder or file names containing spaces, hashtags, or other characters.

- In the few instances that RTI files were not successfully generated, it was found to be directly related to interruptions during image capture. Movement caused inconsistencies between images that the software could not reconcile, and photography needed to be performed again. It is necessary to have a completely stationary and unchanging photographic set-up for the duration of image capture.

- Several of the RTI files appeared to have grainy bright areas when viewed in Specular Enhancement mode. Current hypotheses as to what caused these phenomena include an insufficiently diffuse light source, incorrect exposure, and/or crystalline inclusions in the artifact surface.

- It is recommended that users review the *Guide to Highlight Image Capture and Highlight Image Processing* provided by CHI, which outlines all aspects of creating RTI files. Users can further consult their forum (<http://forums.culturalheritageimaging.org/>), which is an excellent resource for help and support in the process.