



## Digital Archaeology's New Frontiers

Todd R. Hanneken

SEVENTEEN YEARS INTO THE “DIGITAL MILLENNIUM”—which supposedly began in 2000—it would be understandable if a certain cynicism arose for everything new, digital, high tech or cyber. Particularly in archaeology—what have digital tools really done for us that earlier, traditional tools did not? Is a digital photograph that much better than a film photograph? Does a laser distance measurer produce better archaeology than established survey tools? What does a computer 3D model do that a hand-drawn or built model cannot? Do we really understand the ancient world more clearly thanks to computers?

As a digital archaeologist, I believe I can affirm the value of digital technology for understanding ancient material culture (the physical evidence left behind by a culture).

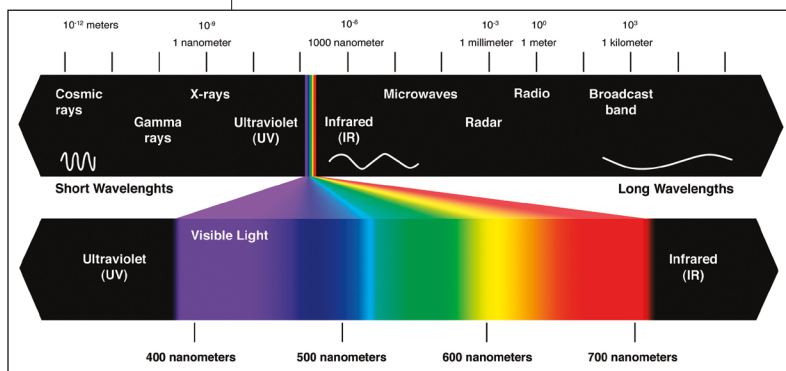
First of all, digital archaeology has the power to improve upon the human capacity for discovery. We often praise technology when it mimics human ability (e.g., artificial intelligence, virtual reality), but digital technology has the power to work well beyond the human physical and mental limitations. For example, photography has long been an essential tool for archaeologists. Digital photography could be used as a mere substitute for film photography (perhaps cheaper or quicker). Most digital cameras are designed to mimic the human eye, but some specialized cameras transcend human

perception. The human eye is limited in range and resolution of color; on the electromagnetic spectrum, the colors visible to us range from violet to red, excluding ultraviolet and infrared. Archaeologists used infrared photography to capture the reflectance of infrared light—which the human eye can't see—long before the advent of digital cameras. But the unique power of digital photography becomes clear when we consider that our color resolution is limited to three color receptors. All the colors we are able to see can be expressed as a combination of red, green and blue (RGB). When we look at a spectrum in a rainbow or prism, we see the colors in bands rather than a smooth gradient. These bands in color resolution can be compared to the “pixelation” associated with spatial resolution. A human is considered “color blind” if one of the three receptors malfunctions. Imagine the benefit of adding a fourth, fifth or sixth receptor. And now consider that today's spectral imaging systems can easily resolve 16 discrete bands of color.

The real power of digital photography for archaeology is that the entire image exists as meaningful numbers. A pixel in one photograph represents the exact same area on the artifact as in the next photograph (as long as the camera and object don't move). That pixel is represented as a number expressing how much light is reflected from that area (rather than a density of chemical reaction, as on film). For example, today's specialized cameras (such as MegaVision E7) distinguish 50 million tiny squares and rank the light reflecting from that area on a scale of zero to more than 65,000. A second photograph—and then a third and up to the 16th—could be taken with a slightly different color of light. A human looking at all these numbers would be easily overwhelmed. But crunching numbers is where digital technology excels. Statistical techniques, such as Principal Component Analysis, can easily reduce redundancy. In digital photography, this means finding and ranking the greatest contrasts detectable in the full range of data. Since different materials have different spectral signatures, spectral imaging can distinguish them even if they look identical to the human eye.

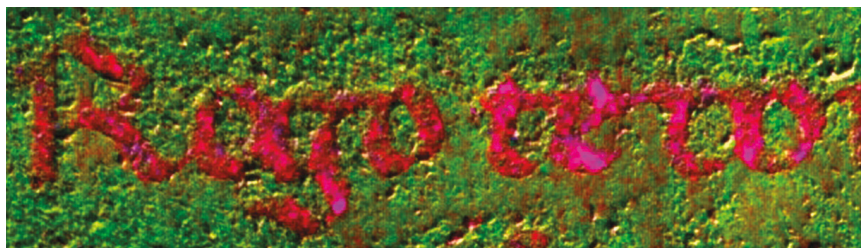
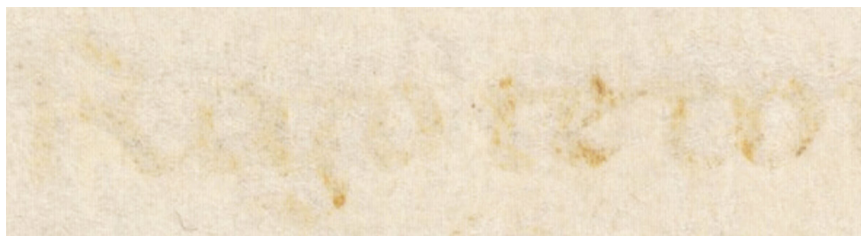
To be able to distinguish contrasts has significant

**HUMAN COLOR VISION is limited in range (excluding ultraviolet and infrared) and resolution (we see color bands rather than a smooth gradient).**



potential for archaeology. A faint trace of pigment on parchment or pottery can be difficult to read, especially if the parchment is decayed or the ink was deliberately erased (as is often the case with recycled manuscripts, or palimpsests). A forger may have matched the color of pigments in a painting as far as the eye can see, but spectral imaging can easily spot the difference. The spectral signature of a pigment from one region can be distinguished from a pigment with a similar appearance from a different region. Fundamentally, materials do not look the same to spectral imaging unless they are in fact the same.

Besides color contrast, archaeological imaging needs to capture texture. Inscriptions and coins are the clearest examples of small-scale objects in which the primary intended meaning is conveyed through texture. Archaeological publications often use line drawings or photography with a low angle of raking light (bright light shown almost parallel to the photographed object). With raking light from just the right angle, a photograph can show the texture of a cuneiform tablet through the highlights and shadows. Sometimes, however, one angle



**THE SAME SECTION** of an erased medieval manuscript is rendered in accurate color and Spectral RTI pseudocolor. It reads “*Rogo te dom[ine]*”—“I entreat you, Lo[r]d.”

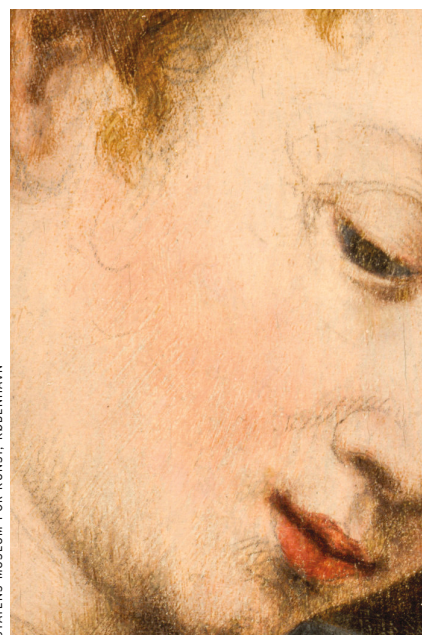
is not enough. In that case, digital texture imaging can map the entire surface, effectively creating an image in which the viewer can control the angle of light. This procedure, called Reflectance Transformation Imaging (RTI), is more demanding of the photographer, since it amounts to taking 40 or more images of the same object while moving only the angle of illumination. The end result is then a single image in which we know

not only the color of each pixel but also its texture. So far, this is not necessarily better than human perception, since a human (assuming we have access to the object) can easily move a nonvirtual flashlight to visualize the texture. But an RTI image is more than a series of raking light images. Since the texture is known on a digital level, it can be amplified or enhanced to be seen more clearly than is possible with natural observation.

Digital texture imaging has been used by archaeologists for more than a decade. In particular, the West Semitic Research Project at the University of Southern California has built the InscriptiFact Digital Image Library, including RTI texture images of many coins and inscriptions.\* Cultural Heritage Imaging, an independent non-profit, has been promoting the technology more widely.

Two other developments are more recent. First, as the spatial resolution capabilities of digital imaging increase, we can see finer texture than the relatively broad textures intended for human observation (e.g., inscriptions, coins). Today it is possible to observe the texture as fine as the corrosion of parchment due to acidic ink, such that we can read the outline of the letter even if the ink is now completely absent. We can observe the thickness of ink, the hair and flesh sides of parchment

CONTINUES ON PAGE 65



**THE COLOR IMAGE** on the left shows no evidence of tampering, but the right image with ultraviolet light shows that paint of a similar appearance but different material was used to touch up the painting.

\*See Bruce Zuckerman, Archaeological Views: “New Eyeballs on Ancient Texts,” *BAR*, November/December 2011.



<sup>3</sup> For the in-text citations, see *The Apostolic Fathers Greek Texts and English Translations*, trans. Michael W. Holmes (Grand Rapids, MI: Baker Academic, 2007). Andrew Brian McGowan, *Ancient Christian Worship: Early Church Practices in Social, Historical, and Theological Perspective* (Grand Rapids, MI: Baker Academic, 2014), p. 33.

<sup>4</sup> See Thomas J. Talley, "From Berakah to Eucharistia: A Reopening Question," *Worship* 50 (1976), pp. 115–137; Paul F. Bradshaw and Maxwell E. Johnson, *The Eucharistic Liturgies: Their Evolution and Interpretation* (Collegeville, MN: Liturgical Press, 2012), pp. 15–17.

<sup>5</sup> For the in-text citation, see *The Apostolic Fathers, Justin Martyr, Irenaeus*, vol. 1, Ante-Nicene Fathers: The Writings of the Fathers Down to A.D. 325 (Peabody, MA: Hendrickson Publishers, 1994).

<sup>6</sup> Scholars commonly emphasize that Christianity did not emerge as a uniform phenomenon; see Karen L. King, "Which Early Christianity?" in Susan Ashbrook Harvey and David G. Hunter, eds., *The Oxford Handbook of Early Christian Studies* (Oxford: Oxford Univ. Press, 2008).

<sup>7</sup> For an overview of the diversity in conduct and food at the Christian meal, see Andrew Brian McGowan, *Ascetic Eucharists: Food and Drink in Early Christian Ritual Meals* (New York: Oxford Univ. Press, 1999).

<sup>8</sup> For the in-text citation, see *Tertullian, Part Fourth; Minucius Felix; Commodian; Origen, Parts First and Second*, vol. 4, Ante-Nicene Fathers: The Writings of the Fathers Down to A.D. 325 (Peabody, MA: Hendrickson Publishers, 1994).

<sup>9</sup> For the in-text citation, see *Hippolytus, Cyprian, Caius, Novatian, Appendix*, vol. 5, Ante-Nicene Fathers: The Writings of the Fathers Down to A.D. 325 (Peabody, MA: Hendrickson Publishers, 1994).

<sup>10</sup> For an excellent overview of some of the major changes that took place in the Lord's Supper and Eucharist between the second and third centuries, see McGowan, *Ancient Christian Worship*, pp. 47–55.

<sup>11</sup> For the in-text citation, see Alistair Stewart-Sykes, *On the Apostolic Tradition: An English Version with Introduction and Commentary* (Crestwood, NY: St. Vladimir's Seminary Press, 2001).

## First Person

*continued from page 6*

<sup>1</sup> Christopher Rollston, "The Marginalization of Women: A Biblical Value We Don't Like to Talk About," *Huffington Post*, August 31, 2012 ([www.huffingtonpost.com/christopher-rollston/the-marginalization-of-women-biblical-value-we-dont-like-to-talk-about\\_b\\_1833648.html](http://www.huffingtonpost.com/christopher-rollston/the-marginalization-of-women-biblical-value-we-dont-like-to-talk-about_b_1833648.html)).

<sup>2</sup> Christopher A. Rollston, "Women, the Bible, and the Nineteenth Amendment to the U.S. Constitution," in Frances Flannery and Rodney Alan Werline, eds., *The Bible in Political Debate* (New York: Bloomsbury, 2016).

## Archaeological Views

*continued from page 29*

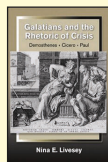
and the fine nuances of a potter's reed, a painter's brush or the technique of papyrus production. The other recent innovation combines the benefits of spectral imaging with RTI texture imaging into a single image set, such that we know both spectral signature and texture of any pixel and can enhance each in combination. This new technology, called Spectral RTI, has recently been developed by the Jubilees Palimpsest Project. Funded by the National Endowment for the Humanities, this project now aims to apply the technology to the Jubilees Palimpsest and to provide tools, documentation and training to museums, libraries and scholars throughout the United States.

Photography is only one area in which digital technology has provided benefits over its predigital counterpart (film). There is nothing wrong with

archaeology made easier through digital assistance, but digital archaeology can live up to its potential—and the hype—only when it fully embraces the potential to transcend human ability and even human categories for organizing information. One of the most profound implications of a digital archaeologist being able to see, study and discover more (not just faster) than a traditional archaeologist is that artifacts already in museums and libraries become ripe for digital "excavation." Tens of thousands of palimpsests become readable; evidence of the techniques and pigments used by ancient artisans can be digitized and compared using powerful tools. The realm of new discovery includes not only what is beyond human perception because it may be buried in dirt, but any artifact in museums and libraries that has been studied only with conventional, human perception or digitized only with conventional photography.

Some may rightly wonder if that

## Kiosk advertisement



**Galatians and the Rhetoric of Crisis**  
Demosthenes • Cicero • Paul  
By Nina E. Livesey

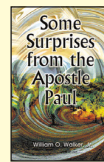
"This ground-breaking study of Paul's polemics cannot be overlooked by any serious student of the apostle and is likely to have a considerable effect on all future discussions of Pauline hermeneutics."

—Magnus Zetterholm, Lund University

Nina Livesey lays the works of Demosthenes, Cicero, and the Apostle Paul side-by-side and compares the rhetorical strategies—such as hyperbole, rebuke, and irony—that each used to win over their audiences. In doing so, she teases out the ambiguity and complexity of Paul's letter to the Galatians and challenges simplistic explanations of his relationship to Judaism.

Paperback \$26 • 6 x 9 • 284 pages.  
ISBN 978-1-59815-174-9.

Available through Polebridge and other booksellers: [www.polebridgepress.com](http://www.polebridgepress.com)



**Some Surprises from the Apostle Paul**  
By William O. Walker, Jr.

Controversial during his lifetime and ever since, the Apostle Paul is often accused of being homophobic, misogynistic, anti-Semitic, dogmatic, narrow-minded, prejudiced, and downright obtuse. Walker argues that some of the animosity toward Paul stems from ignorance of his cultural context and/or the assumption that he wrote everything attributed to him. In *Some Surprises from the Apostle Paul*, Walker addresses common misconceptions and explores what can be learned about Paul from the historical evidence.

"Walker has brilliantly succeeded in packaging ten of the more puzzling features or surprising issues that lead the reader to the heart of Pauline thought."

—David E. Aune, University of Notre Dame

Paperback \$19 • 6 x 9 • 152 pages.  
ISBN 978-1-59815-180-0.

**To advertise in this special section:**

Contact Charles Roth, Jr. • [charlie@spireads.com](mailto:charlie@spireads.com) • 516-729-3509



CROW CANYON  
ARCHAEOLOGICAL CENTER

## Explore America's ancient past

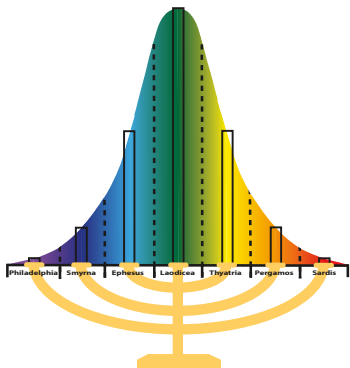


Archaeology digs in Colorado's  
Mesa Verde Country.



[crowcanyon.org](http://crowcanyon.org) | Cortez, CO  
800.422.8975, ext. 451

## In the Image of YHWH



Dallas D. Stratman

## Quantitative Theology

The key  
to  
understanding  
the  
Latter Days.

[www.afjbooks.com](http://www.afjbooks.com)

is a good thing. Do we need another avalanche of data? Anyone who can remember his or her first day wandering through the stacks of a major research library knows that information overload arrived long before the digital era. Uniform standards for categorizing and searching information existed before digital technology, and they are no less powerful with digital technology.

Perhaps the biggest obstacle to discoverability and interoperability is the human desire to protect our “property.” This, too, has a predigital counterpart in the editors who took far too long to publish information or distorted the presentation of the data to fit a skewed interpretation. Openness of intellectual property is progressing as institutions realize that a light under a bushel has less value than one that shines openly.

If previous generations erred in the direction of a few individuals hoarding control of objects of study, we may soon face a problem in which data is published online faster than anyone can study it—even if it is fully open and accessible. This problem can be solved by increasing the number of people working on interpreting the data. Fortunately, one of the fundamental features of digital information is that it can be replicated precisely and transmitted quickly and cheaply. This means that anyone in the world can now do work that was once reserved to only a few elite institutions. Democratizing access to archaeology—not just learning about it but participating in it—will certainly benefit the field and increase the global appreciation for study of ancient material culture.



Todd R. Hanneken is Associate Professor of Theology and Early Jewish Literature at St. Mary's University in San Antonio, Texas. He is the director of the Jubilees

Palimpsest Project. The project recently received a major grant from the National Endowment for the Humanities to develop a full-scale demonstration of Spectral RTI technology and make it available to museums, libraries and scholars anywhere.

## Q&C

*continued from page 10*

the heroic story about himself to cover up what he had done. I thought it might be useful to debunk this old heroic myth of Tischendorf's.

REV. LEONA IRSCH  
ROCHESTER, NEW YORK

## YOU BLOW MY MIND!

### Your Issue Is so Fine!

Thanks for this especially fine issue of **BAR** (November/December 2016). The level of excellence throughout blows my mind! **BAR** is always good, but the articles and photography of this issue stand out in my experience.

KATHLEEN DOOLEY  
JOPLIN, MISSOURI

## Classical Corner

*continued from page 24*

(1996), p. 124.

<sup>4</sup> James H. Oliver, *Greek Constitutions of Early Roman Emperors from Inscriptions to Papyri* (Philadelphia: American Philosophical Society, 1989), pp. 366–388.

<sup>5</sup> For further discussions of papyrological evidence, see R.J. Littman and M.L. Littman, “Galen and the Antonine Plague,” *American Journal of Philology* 94 (1973), pp. 243–255; Duncan-Jones, “Antonine Plague”; R.S. Bagnall, “Oxy. 4527 and the Antonine Plague in Egypt: Death or Flight?” *Journal of Roman Archaeology* 13 (2000), pp. 288–292.

<sup>6</sup> The same cessation of construction is not, however, evident in Spain or in the North African provinces outside of Egypt, possibly indicating that certain areas of the empire were more affected than others. See Duncan-Jones, “Antonine Plague.”

<sup>7</sup> Dominic Perring, “Two Studies on Roman London. A: London's Military Origins; B: Population Decline and Ritual Landscapes in Antonine London,” *Journal of Roman Archaeology* 24 (2011), pp. 249–268.

<sup>8</sup> Until recently it was thought that the Antonine Plague could possibly have been a measles epidemic. However, recent scientific data have eliminated this possibility. See Y. Furuse, A. Suzuki and H. Oshitani, “Origin of the Measles Virus: Divergence from Rinderpest Virus Between the 11th and 12th Centuries,” *Virology* 7 (2010), pp. 52–55.

<sup>9</sup> Dio Cassius 73.14.3–4; for a discussion of the smallpox pathologies, see Littman and Littman, “Galen.”

<sup>10</sup> Littman and Littman, “Galen,” p. 255.

<sup>11</sup> Perring, “Two Studies.”