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Exploring 3D modeling, fingerprint extraction, and other scanning applications for ancient clay oil lamps

Eric Lapp [a,*], Joe Nicoli [b,1]

[a] Department of Earth and Planetary Sciences, Johns Hopkins University, Baltimore, MD 21218, USA
[b] Direct Dimensions, Inc., Owings Mills, MD 21117, USA

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ABSTRACT

Ancient clay oil lamps provide an invaluable source of information for archaeologists as indicators of ritual, chronology, clientele, trade, and origin. Since the late seventeenth century, they have been drawn, painted, and photographed for antiquarian and scientific publications. The purpose of this paper is to explore various applications of 2D and 3D digital modeling and laser scanning of ancient clay lamps using the Steiblicher Comet L3D Blue Scanner. It encourages widespread adoption of this method for the creation of highly accurate archaeological illustrations, 3D lamp typologies, 2D and 3D lamp documents, and museum quality reproductions. Most notably, this study confirms laser scanning as an effective method for extracting fingerprints from lamp surfaces to make possible the identification of ancient lampmakers.

1. Introduction

Since the earliest scientific publications on ancient oil lamps, various methods have been used to illustrate these clay, metal, and stone lighting vessels. Lamp illustrations have always been subject to available contemporary methods of media technology, including woodcut-prints, copperplate engravings, watercolors, pen-and-ink drawings, and photographs (Fig. 1). In recent years 3D digital modeling and laser scanning technology has become a more widely adopted method for imaging archaeological artifacts (Bowman and Brady, 2005; MacDonald, 2011: 6-8). This is not the case for ancient clay oil lamps. Although an occasional 3D lamp model appears in publication or on a museum website, the consistent and widespread adoption of 3D and 2D scanning for clay lamp imaging has not yet materialized. For example, plates in final excavation reports and field journals still widely employ pen-and-ink drawings and black-and-white photographs for lamps, but not 2D scanned images. When a digital lamp image does appear in an electronic or paper medium, it is typically lumped together with other types of small objects (such as coins and seals) and is treated as an accessory to broader archaeological topics. Contemporary digital and conventional archaeological projects do not focus specifically on the broader applications and potential for 2D and 3D scanning and modeling of ancient clay oil lamps. This is problematic given the significance of clay lamps as a commonly found archaeological artifact type and their widespread use by archaeologists for dating strata, tracing trade interactions, and gauging intra-regional demographic shifts. By contrast, scholarly literature is far more replete in the uses of 3D digitization of non-lamp, wheel-thrown common ware pottery (e.g. Mara and Kampel, 2003; Mara and Hecht, 2006; Mara, 2009).

Ancient bronze lamps fare better than clay ones in terms of 2D and 3D imaging. For example, a bronze lamp with a conical shape and dating to 100 CE was 3D scanned using a ZScanner 800 and several supporting software programs (ZScan 3.1, Geomagic Studio 11.SR2, Photoshop 7.0, Magics 14.0, Rhinoceros 4.0, and 3D PDF from Rhino V2.0)(Kajaa et al., 2011: 24–26, Figs. 4 and 5). The lamp was excavated at Emona, Slovenia. Four clay lamps were also reportedly laser scanned, but their respective images do not appear in the publication (Kajaa et al., 2011: 24).

A further published study reports the application of 2D and 3D neutron imaging of a bronze hanging lamp with two nozzles and a bronze dog figurine using the CG-1D prototype beamline at the High Flux Isotope Reactor (HFIR)(Ryzewski et al., 2013: 347–379, Fig. 2). Both artifacts date to the Roman period. The study reports that neutron imaging produces three-dimensional information on archaeomaterials, especially "qualitative, quantitative, and visual data on impurities, composition change, voids, and structure on macro-scale levels" (Ryzewski et al., 2013). The focus of the Oak Ridge analysis, however, was the application of neutron imaging on rare "bronze artifacts" (Ryzewski et al., 2013: 345, 347, 350), not on common, everyday clay lamps which is the focus of this paper.

Also, recent advances in virtual reconstruction of ancient illumination environments and ancient flame light simulation have contributed significantly to our understanding of the use of ancient light (Gonçalves et al., 2013: 116–128; Happa et al., 2010: 155–182). Using high dynamic range technology, Roman flame

* Corresponding author. Tel.: +1 410 243 1079.
E-mail addresses: eric.lapp@verizon.net, elapp@jhu.edu (E. Lapp), jnicoli@dirdim.com (J. Nicoli).
[1] Tel.: +1 410 998 0880.

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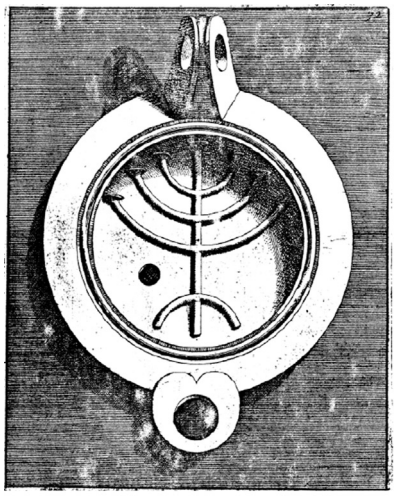

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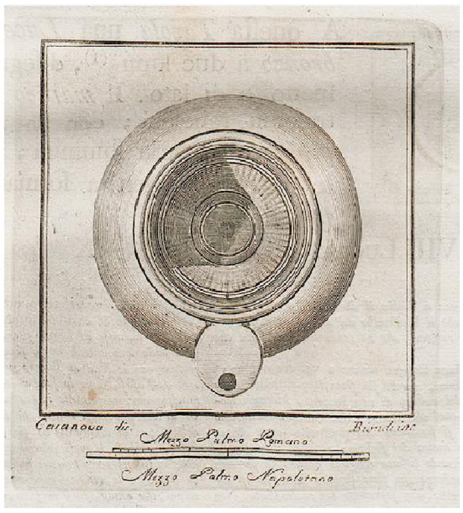

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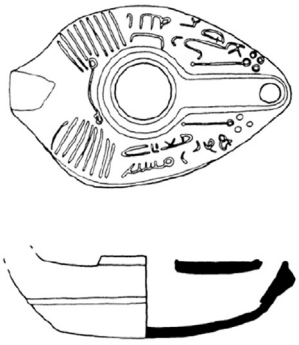

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Fig. 1. Various methods used for clay lamp illustrations over three centuries of archaeological research. (1) A late 17th-century woodcut print of a discus lamp with a seven-branched menorah. Broneer XXV. 3rd century CE. Rome, Italy (after Bartoli, 1691). (2) An 18th-century engraving of a Roman discus lamp. Broneer XXV. 3rd century CE. Herculaneum, Italy (after Weber, 1792: 130, Tavola XXV. Courtesy of the Universitäts-Bibliothek Heidelberg). (3) An early 19th-century watercolor of a *Firmalampe*. Late first to second century CE. Unknown provenience (after Townley, 1814: album sheet 53. Courtesy of The British Museum). (4) An early 19th-century copperplate etching of a "frog" lamp. 3rd–4th century CE. Probably the Fayoum, Egypt (after Description de l'Egypte, 2002). (5) Modern digital color photograph of a lamp sherd of the Bethany Ovoid type. 3rd–5th century CE. Aqaba, Jordan. (6) Modern pen-and-ink drawing of an early Islamic "channel-nozzle" lamp with an Arabic inscription. Ca. 661–750. El-Lejjun, Jordan (after Parker, 2006: 351, Fig. 16.74).

illumination in the "House of the Fountains" of Conimbriga, Portugal, has been explored virtually with important implications. Ancient lighting characteristics were replicated in a 3D model, and low intensity environmental light was found to affect the subjects' perception of ancient artifacts (Gonçalves et al., 2013: 117).

Taking into account the importance of ancient clay lamps, and the lack of widespread digitalization of these lighting vessels, this paper explores applications of 2D and 3D laser scanning and modeling to address specific lamp-related issues. First, it tests the feasibility of the Steiblicher Comet L3D Blue Scanner for digital