Journal of Archaeological Science 36 (2009) 867–872

Contents lists available at ScienceDirect

Journal of Archaeological Science

journal homepage: http://www.elsevier.com/locate/jas

Point/counter point: the accuracy and feasibility of digital image techniques in the analysis of ceramic thin sections

Patrick C. Livingood [a,*], Ann S. Cordell [b]

[a] Department of Anthropology, University of Oklahoma, 455 W. Lindsey, Room 521, Norman, OK 73072, United States
[b] Florida Museum of Natural History, UF Dickinson Hall, Box 117800, Gainesville, FL 32611, United States

ARTICLE INFO

Article history:
Received 25 August 2008
Received in revised form
10 November 2008
Accepted 11 November 2008

Keywords:
Ceramics
Petrography
Digital image analysis
Ceramic temper

ABSTRACT

Digital Imaging Analysis has been proposed as an efficient alternative to traditional petrography for some applications. This paper tests that proposition in the measurement of temper size and abundance in four pottery thin sections from the Pevey Site, Mississippi. The findings of both studies are presented here and the relative merits of the two techniques are evaluated in terms of accuracy, precision, cost, and time.

Digital Imaging Analysis (Gonzalez and Woods, 2007; Russ, 2006) has been proposed as an efficient alternative to traditional petrography for some applications (Hansen, 2000; Livingood, 2002, 2003, 2004, 2007;Velde and Druc, 1998; Whitbread, 1991; see Reedy, 2006 for review of applications). Advocates of each method decided to join forces to put this supposition to the test in the measurement of temper size and abundance in pottery thin sections. Both digital imaging analysis and traditional petrographic point counting were conducted on a small sample of grog- and shell-tempered Mississippi-Period pottery (Cordell and Livingood, 2004) from the Pevey site (22Lw510), Lawrence County, Mississippi (Livingood, 2006). The test sample consists of four thin sections that were selected from a larger sample of twenty-nine analyzed using digital image analysis (Livingood, 2007). The sample for this paper was randomly selected to cross-cut the common temper types in the larger study: two are grog- and shell-tempered, one is primarily grog-tempered, and one is primarily shell-tempered. The findings of both studies are presented here and the relative merits of the two techniques are evaluated in terms of accuracy, precision, cost, and time.

1. Digital imaging analysis

For this study the thin sections were scanned using an inexpensive consumer-quality Epson Perfection 1640 flatbed scanner with a transparency adapter. Scanning was set at the highest resolution offered, which was 3200×1600 dpi, extrapolated to 3200×3200 dpi. This resolution is such that silt-sized particles appear to be between .5 and 8 pixels wide, while sand-size particles are 8–126 pixels wide, using the Wentworth scale (Rice, 1987:38). Therefore this scanning resolution is appropriate for detecting and measuring temper inclusions such as grog and shell, but it is difficult to differentiate very fine and fine birefringent particles, and it is impossible to resolve silt. Each thin section was scanned three times. The first scan was a plane-polarized image, the second a cross-polarized image, and the third a cross-polarized image with the sample rotated 90°. The polarizing filters were low-cost plastic polarizing filters purchased from Edmund Optics.

A variety of software tools are available to conduct image analyses (for an evaluation of different software packages for petrographic application see Reedy and Kamboj, 2004a,b; Reedy and Vallamsetla, 2004a,b). For this project, Livingood used the Image Processing Toolkit (Russ, 2006) by Reindeer Graphics which are a set of Adobe Photoshop-compatible plugins. After the three scans were aligned by hand in Adobe Photoshop the Image Processing Toolkit functions were used to manipulate the image to improve the visibility of selected features and ultimately to isolate them. During this process, the thin section was mapped (Fig. 1) into the following categories: shell-temper, grog-temper, highly-birefringent particles, matrix, and voids. Leached shell voids were included with the shell counts following the standard for petrographic point-count analysis.

Macros were created that combined multiple image transformation to produce maps of the constituent categories. The macro-created maps were treated as rough drafts and were subsequently

* Corresponding author. Tel.: +1 405 397 0215.
E-mail address: patrickl@ou.edu (P.C. Livingood).

0305-4403/$ – see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jas.2008.11.015

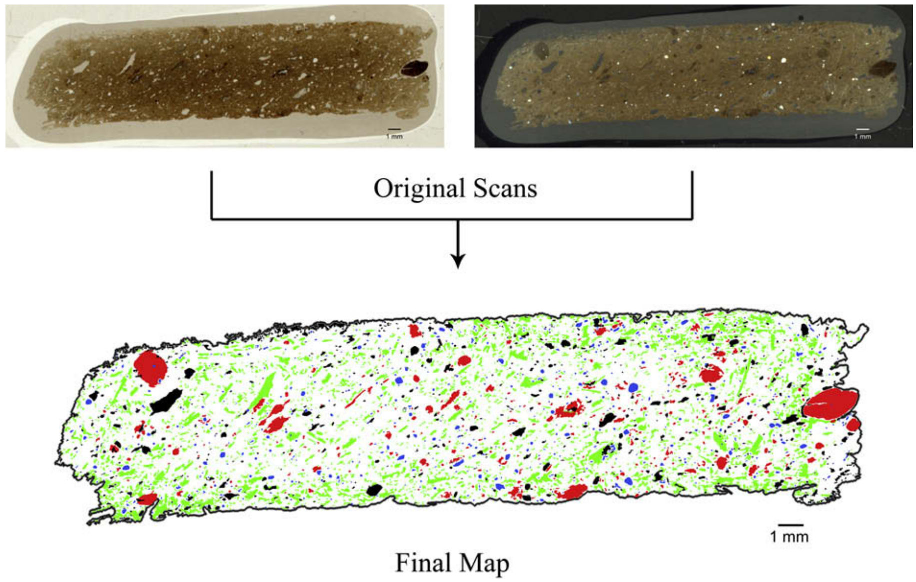

Fig. 1. Sample 19 original scans and final temper map.

edited by hand. Some constituent categories, because of their high visual contrast, were easy to identify using automated processes, while others required substantial hand editing. The sample boundary, voids, and birefringent particles were identified by the macros with nearly 100% success. In microscopic petrography an analyst makes a judgment call to determine which voids are from leached shell inclusions. With the digital approach, all voids with length to width ratios of three or more and a breadth not exceeding .5 mm were initially mapped as leached shell voids. The automated macros were approximately 75% successful in correctly mapping shell and shell voids. The most significant manual editing was required for samples with high enough densities of shell-temper that the shell or shell voids appeared to be nearly adjacent in the digital images. In those cases, the generated maps tended to lump together shell inclusions that were in reality separate pieces. Such problems could be overcome with higher image resolution. Finally grog, which can be challenging to identify even by a trained analyst using a standard microscopic approach (Di Caprio and Vaughn, 1993), was only mapped with about 25% accuracy by the macros and required extensive hand editing. The macros could have been refined to increase the success rate of all automated recognition but such refinements were not necessary with this small test sample. After the identifications were complete the software used the category maps as input to generate over fifty measurements on every identified feature, including color, location, nearest neighbor information, and geometric measurements such as length, breadth, area, perimeter, aspect ratio, symmetry, and convexity.

2. Petrographic point-count analysis

Petrographic techniques borrowed from the earth sciences have been applied to archaeological pottery since the 1930s. Petrographic point counts are made for quantifying relative abundance of inclusions. In this study, a petrographic microscope with a mechanical stage was used to conduct the Glagolev-Chayes point-counting procedure (Galehouse, 1971:389), following recommendations by Stoltman (1989, 1991, 2000). A counting interval of 1 mm by .5 mm with 10× magnification was used in which the mechanical stage advanced along the length of the thin sections at 1 mm intervals, but advanced across the width of the thin sections at .5 mm intervals. This counting interval was chosen as a compromise between the small particle sizes of matrix constituents and larger sizes of the grog- and/or shell-temper. Each point or stop of the stage was assigned to one of the following categories: clay matrix, non-temper voids, silt particles, grog-temper, shell-temper, including shell-temper voids, and very fine through medium aplastics of varying compositions, primarily quartz. Size of aplastics was estimated with reference to the Wentworth Scale (Rice, 1987:38). For one case in which fewer than 200 points were counted, the thin section was rotated 180° on the mechanical stage and counted a second time (after Stoltman, 2000:306).

The data generated by this method are actual counts of tempers and aplastics within specified size ranges (Table 1). Percentages can be calculated to estimate particle abundance and for comparison between samples. Temper and matrix compositions were also determined. In this study, two of the thin sections were found to represent micaceous clays. Given the minute particle size of the mica inclusions, the micaceous character of the pottery might not be obvious to the unaided eye. The petrographic analysis also permitted identification of accessory constituents and peculiarities of some tempers. For example, multigenerational grog-temper, i.e. recycled grog particles from pottery that was itself grog-tempered, was observed (Fig. 2). Some grog-temper contains shell, indicating that shell-tempered sherds were recycled as grog-temper. In another example, a micaceous grog-temper particle was present in a clearly non-micaceous matrix.

Table 1
Raw petrographic point counts.

Sample number	Total count	Voids	Matrix	Total aplastics	Shell	Grog	Silt	Very fine quartz	Fine quartz	Medium quartz	Quartzite	Other
7	338	22	232	106	27	21	16	33	5	–	3	1
19	427	25	293	134	86	9	14	12	7	2	1	3
22	218	42	160	58	–	16	13	22	3	1	–	3
27	391	24	252	139	43	1	34	54	2	–	3	2