SUPPLEMENTARY MATERIAL

The production of a glass toggle: Iron Age craft specialisation along Scotland's western seaboard

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Extended Depth of Field Digital Microscope Photography

Details of the toggle bead that may deliver information concerning the manufacturing technique used for its production were observed using a Leica M125 stereomicroscope. Magnification of 8×, 10×, 12.5×, 32× and 50× was used in order to visualise these features with higher definition. However, because of the three-dimensionality of the object, it was not possible to focus the entire object at once. The depth of field (ie the distance between the nearest and farthest portions in an object that appear sufficiently sharp in an image) becomes progressively shallower with increasing magnification. In order to overcome this problem, a technique called focus stacking was therefore used. Focus stacking extends the depth of field by combining a number of images taken at different focus distances. Between 15 and 25 images were acquired using a Canon EOS 550D camera attached to the stereomicroscope through 1.6× adapter, gradually incrementing the focusing distance across the subject. Photographs were taken using both reflected and transmitted light. The stack of images was then reconstructed using the program Helicon Focus. The individual shots were aligned so

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that their content was overlaid pixel by pixel, and a composite image was created based on the sharpest regions from each of these separate photos. The resulting digitally post-processed image displayed, thus, a greater depth of field, which included every visible part of the object.

LA-ICP-MS instrumental set-up and quantification procedure

The analyses were carried out using an Agilent 7700 quadruple ICP-MS coupled to an ESI New Wave Research NWR 193 Ar:F excimer laser. A gas blank was collected for 20s prior to the start of each ablation. A short pre-ablation pass (typically a few individual bursts) was performed before the start of each ablation in order to clean the surface of the specimen from contamination and potentially weathered superficial layers. Each spot was ablated for 50s using a spot size of 70µm, with a repetition rate of 10Hz and a fluence of approximately 3 to 3.5 Jcm^{-2}. Ar (~1.1 $l\ min^{-1}$) and He (~0.5 $l\ min^{-1}$) were used as carrier gases to transport the particulate produced by the laser into the mass spectrometer. Quantification of LA-ICP-MS data was performed using the Internal Standard Independent method with sum normalisation (Bertini et al 2013). The standards used for calibration were the standard reference material NIST (National Institute of Standards and Technology) 610 and 612, and CMG (Corning Museum of Glass) A, B, C and D. The nominal amount of trace elements in each standard was obtained from a collection of published values (Brill 1999; Vicenzi 2002; Jochum et al 2011; Wagner et al 2012; Bertini et al 2013). The normalisation was performed to a value of 97.8% rather than 100%, which accounts for an average stoichiometric oxygen contribution of the trace elements present, which are calculated as ppm element rather than w/o oxide. Accuracy and precision were calculated upon repeated measurements of CMG B, which is the standard that most closely matched the matrix of the glass under investigation. Accuracy, calculated as the bias between measured and accepted values, normally comprised between

0.5 and 5% and generally below 10%. Precision was always better than 3%, with the exception of those elements in exceedingly low concentrations (ppb range), which suffered from heterogeneous distribution at the scale of sampling. Limits of Detection (LoD) were calculated as 3 times the standard deviation of the blank signal, quantified according to the methodology proposed by Longerich et al (1996). LoD were always in the ppb range, with the exclusion of Na_2O, SiO_2, CaO, K_2O, P and Fe, for which LoDs were in the range of a few ppm.

µCT: instrument and conditions

The internal structure of the toggle bead was imaged via µCT, in order to identify features that may be related to the manufacturing process and validate the hypothesis for local manufacture through the analysis of some of the tentative clues observable by the naked eye or a low magnification. The instrument used was a Nikon HMXST 225. The scan was performed with X-ray energy equal to 150kV, at 100uA, with an exposure time of 708ms. The sample, carefully wrapped in cellophane and lodged in a holder stuffed with cotton wool to keep it in position during the analysis without need for any adhesive, was rotated 360° to obtain 3,142 projections. The resolution obtained was 8.3µm. The image stack was saved as bitmap files using VG studio Max. The renderings were produced using the freeware Drishti.