Comparing X-ray Computed Tomography Images of Corroded Coins with the Results from Traditional Cleaning

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Abstract

Traditional methods of cleaning corroded metal artifacts involves the physical removal of corrosion products, which can cause damage to the highly mineralized original surface.It is believed that X-ray computed tomography (XCT), a non-destructive imaging technique could provide images which would be as identifable or more so than the results from mechanical cleaning methods. This technique was used to study Greco-Roman coins from the Diniacopoulos Collection at Queen's University, a collection jointly held by the Art Conservation Program and Department of Classics. A CT scan is conducted by acquiring a series of two-dimensional x-ray projection images captured at different rotation angles (Figure 1). Copper alloy sample coins were created to determine how the alloy content affected the XCT imaging process. The cleaned Diniacopoulos coins and the sample coins were digitally photographed and compared to the XCT scans.

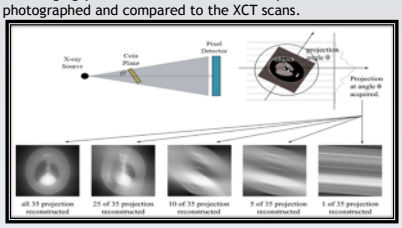


Figure 1: X-ray CT theory schematic. Contrast in the reconstructed model is a result of differences in material attenuation coefficients and density between the corrosion product and the underlying metal.

Experimental

- Sample coins of three different copper alloys; pure copper, low lead content, and high lead content were produced in the Mechanical Engineering Department using a coin press (Figure 2).
- The sample coins were force corroded through electrochemical means by wrapping each coin and a graphite electrode in copper wire, burying both in potting soil mixed with 100mL of 3.5% salt water and allowing 1.5 volts to run through the system.
- XCT images sample and Diniacopoulos coins were acquired using an Xradia MicroCT-400 (Figure 3)
- Both sample and Diniacopoulos coins were cleaned using mechanical methods with a No. 15 Feather scalpel, pin tool and ethanol.

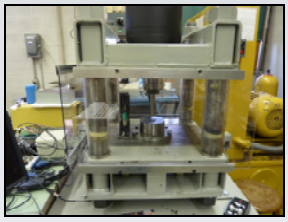


Figure 2: Coin press used to produce samples.

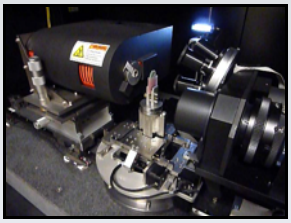


Figure 3: Interior view of Xradia MicroCT-400.

Results

Observations

It appears that the results from XCT imaging and traditional cleaning are comparable in terms of identifiable features. The major difference in image quality for the XCT scans seemed to depend upon the metals present in the alloy of the coin. The pure copper coin had a very sharp XCT image, with all identifiable features being easily recognized. The sample coin with the higher lead content produced a softer XCT image that did not alloy all identifiable features to be recognized. The lines wrapping the XCT images of the samples coins were the remains of the copper wire, which was used to pass the electric current through the coins while they were suspended in the soil.

Conclusions and Further Research

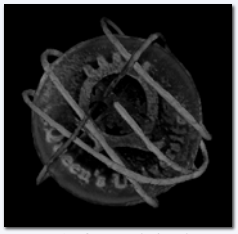
XCT is an excellent technique for the identification of coins, provided that the alloy of the coins is made from a type of metal which can be penetrated by x-rays. Further work should be done to compare XCT scans with other types of imaging techniques, such as reflectance transformation imaging (RTI). Experiments could also be continued to determine if there is a method of forcing corrosion which can offer a more accurate representation of archaeological corrosion.

Sample Coins

The corrosion product produced on the sample coins should not be considered to be an accurate representation of the corrosion produced after centuries of burial. The corrosion product consisted mostly of soil and was found to be very soft. These samples do, however offer insight into how the alloy type affects XCT imaging.

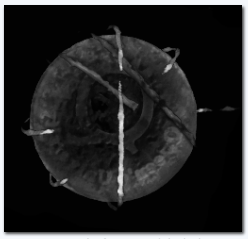
Figure 4: Pure copper sample coin before corrosion process.

Figure 5: Pure copper sample coin after forced corrosion.



Figures 6 : XCT image of side A of pure copper sample coin.

Figure 7: XCT image of side B of pure copper sample coin.



Figures 8:XCT image of the high lead content sample coin. Note how the features are less distinct than the XCT image of the pure copper coin.

Figure 9: High lead content coin after cleaning

Diniacopoulos Coins

While both mechanical cleaning and XCT scans produce results which could be interpreted by numismatists, the XCT scans provide much more detailed images. Figure 13 below clearly show more detail in the wing than became visible during cleaning (Figure 15). Figure 12 shows the inscription which follows the edge of the coin. This is not visible on the cleaned coin (Figure 14).

Figure 10: Side A of coin AA 1980 before cleaning.

Figure 11: Side B of coin AA 1980 before cleaning

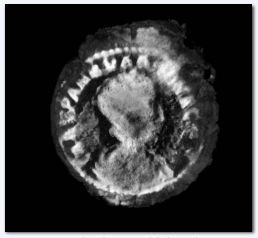


Figure 12: XCT scan of Side A of coin AA 1980

Figure 13: XCT scan of Side B of coin AA 1980

Figure 14: Side A of coin AA 1980 after cleaning

Figure 15: Side B of coin AA 1980 after cleaning

Acknowledgements

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