Leather Degradation: An experimental approach using pXRF

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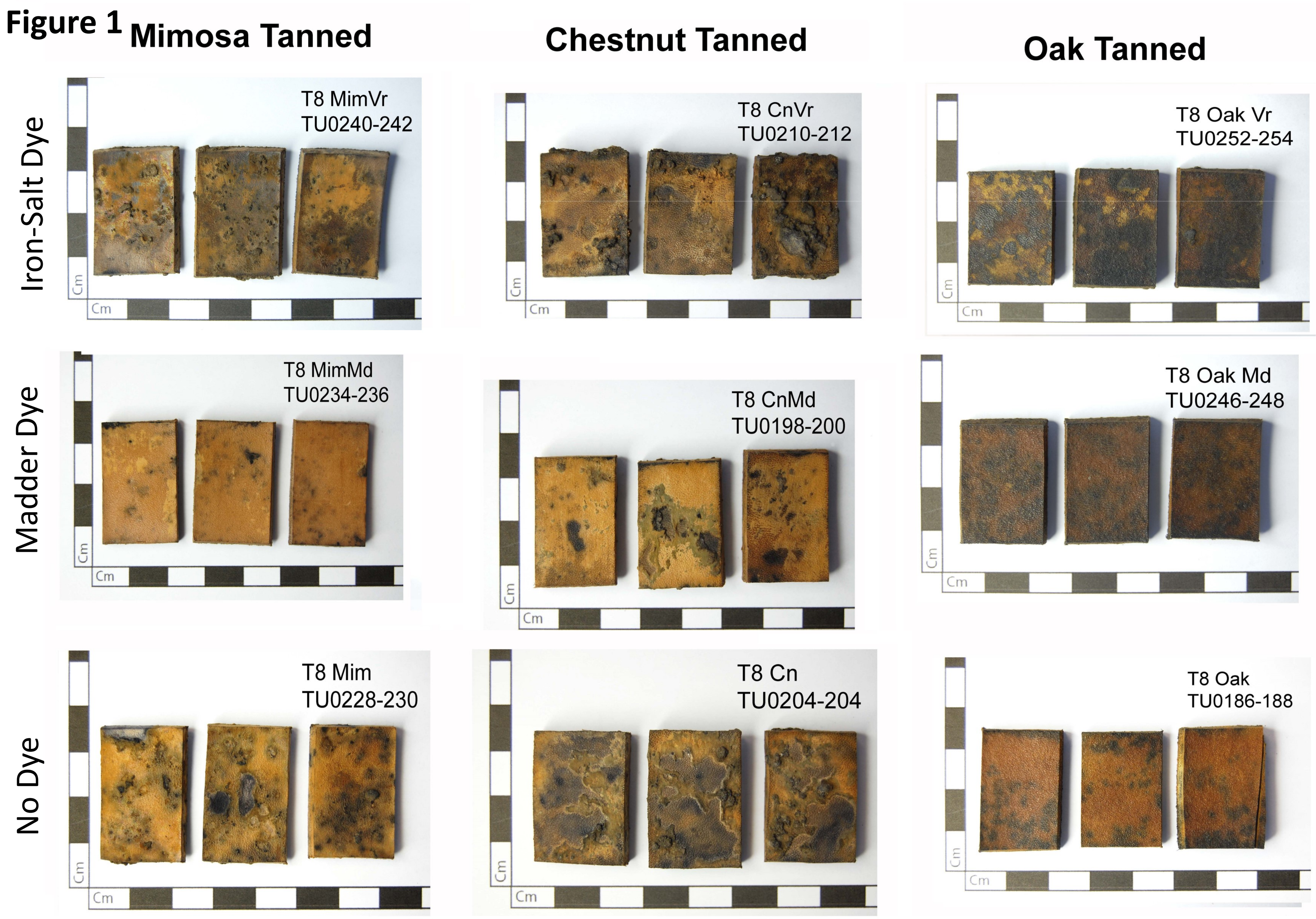
Introduction

This poster presents a subset of results from a laboratory-controlled burial experiment using traditionally tanned leather, portable X-Ray Fluorescence Spectroscopy (pXRF) and visual assessment. We focus on the relationship between leather degradation and its elemental composition in wet archaeological soil and present conclusions that may bear importance for archaeological leather characterisation and conservation.

Burial Experiment and Visual Assessment

Leather samples were tanned with oak- mimosa- and chestnut- tannins (Table 1) using traditional methods and subsamples dyed with madder and iron salts. Leather samples were buried in laboratory-based microcosms under controlled conditions in soil obtained from Vindolanda, a Roman archaeological fort site in Northumberland, England. Samples were excavated after 2, 4, 6 and 8 months of burial.

Visual assessment was carried out by eye, using a modified version of an assessment scale developed by Suenson-Taylor[1] for wet archaeological leather (2001). A cumulative degradation score (VisCDS) was calculated from the assessed values and normalised to a scale from 0-1, with 1 being the most degraded.



Results and Discussion

Figure 1: Examples of oak-, mimosa- and chestnut-tanned leather samples and variants dyed with madder and iron salts after 8 months of burial. On average, oak-tanned samples had the lowest VisCDS scores after burial and chestnut-tanned samples the highest (Figure 2). The presence of madder dye appears to have slowed down the degradation process, while iron salt dye had the opposite effect.

Type	Vegetative Material	%	Tannin Type
Oak-Tanned	Ground Oak Bark	60	Condensed
	Valonia Oak commercial tannin	20	Hydrolysable
	Ground Valonia Oak Acorn Cup	10	Hydrolysable
	Vanolia Oak Acorn beard	10	Hydrolysable
Mimosa-Tanned	Mimosa wattle	70	Condensed
	Chestnut	15	Hydrolysable
	Myrabulans	15	Hydrolysable
Chestnut-Tanned	Chestnut	70	Hydrolysable
	Mimosa	15	Condensed
	Myrabulans	15	Hydrolysable

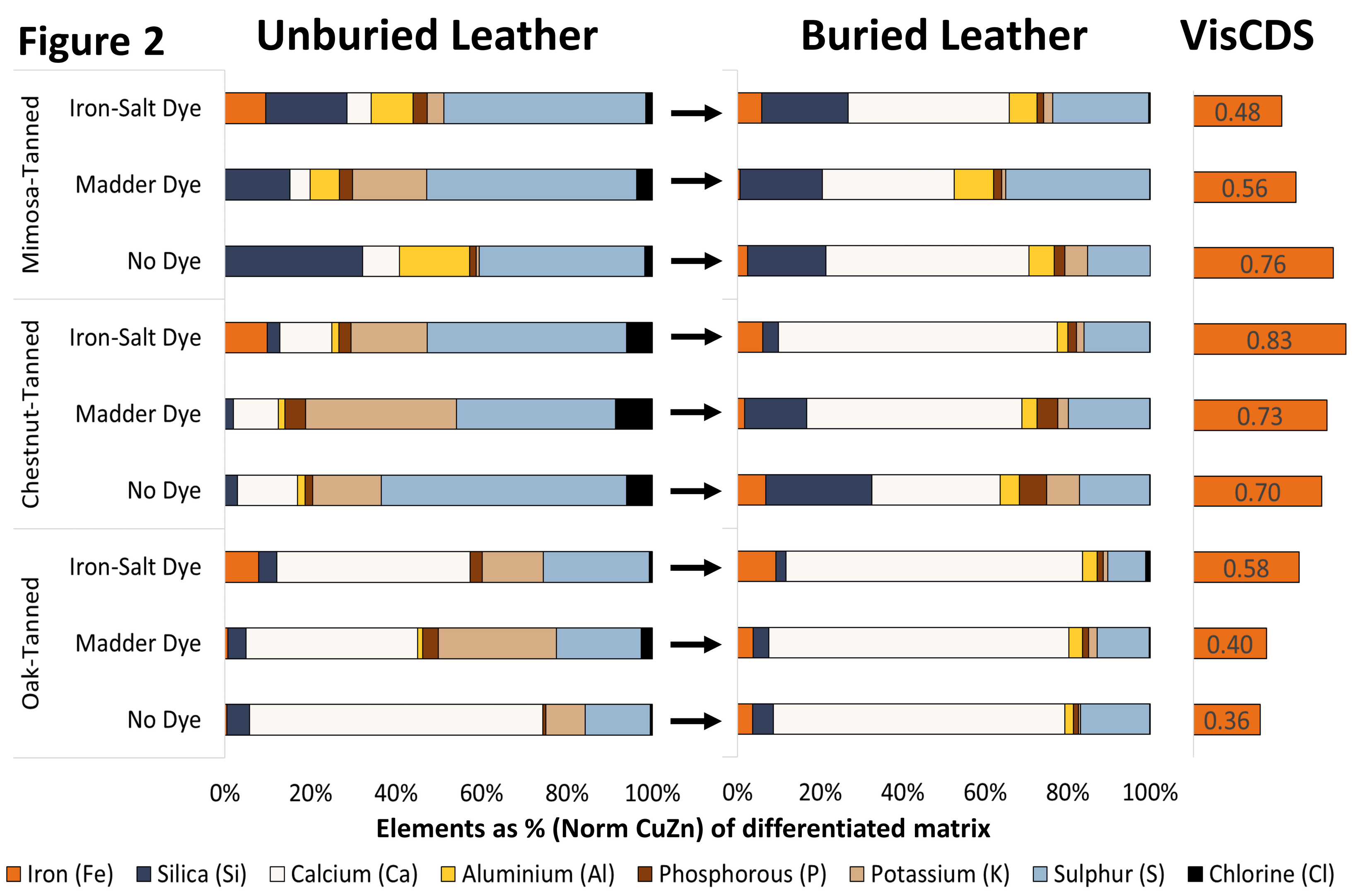
Table 1

Tannin compositions of the three types of buried leather. Chestnut leather tannins are predominantly hydrolysable, while the mimosa- and oak-leather tannins are primarily condensed.

Elemental Analysis (pXRF)

Leather samples from the burial experiment were scanned at the outer surface (grain) using a Niton XL3t900 GOLDD analyser, with an AG anode and 6-50kV,0-200µA X-ray tube. To counter issues of non-infinite thickness, matrix heterogeneity and differing sample sizes, results were normalized to sample thickness (mm), average density (1.1) and the matrix attenuated coefficient of a known Copper-Zinc background[2].

A more detailed methodology is available upon request.



Results and Discussion

Figure 2: Higher amounts of Calcium and Aluminium were observed in oak-tanned and mimosa-tanned leather respectively, both before and after burial. The relative concentration of Calcium increased for all leather samples with burial time, despite relatively low values in the burial medium. Iron-concentrations were highest for samples dyed with iron salts, but were present in all samples after burial, leaching in from the burial environment.

Summary and Conclusions

Possible role of Calcium and Aluminium in leather preservation: Better preservation (lower VisCDS scores) appears correlated with higher amounts of both Ca and Al in the original leather (Figure 2). While Al is known to increase leather stability in modern industry[3] , Ca is not. However, a relationship between calcite crystal formation and good preservation has been observed before in bone and eggshell[4].

Tannin type influences elemental exchange: VisCDS scores were notably highest for chestnut-tanned leather (Figure 2), which had the lowest amount of Ca and Al. In addition, chestnut-tanned leather was tanned using higher amounts of hydrolysable tannins (Table 1), which have a higher affinity to metal ions than condensed tannins[3].

Elemental variability specific to tannin-type: The main variability after 8 months of burial in the pXRF concentrations can be associated with differences in original leather manufacture. This indicates that each type of leather goes through a different degradation process, and that these differences can be picked up with nondestructive pXRF analysis. However, differences in soil type may overtake the extent of this endogenous variability, especially within archaeological timescales. The effect of different soil environments is currently under investigation, as well as a case study of an archaeological site.

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References:
1: Suenson-Taylor (2001) *Leather Wet and Dry*, 1-10. 2: Sitko (2009) *Spectochimica Acta* vol 64, 1161-1172. 3: Covington (2009) *Tanning Chemistry:The Science of Leather*. 4: Demarchi *et al.* (2016) *eLife* vol 5, 1-50.