Quantitative Analysis of the Micromorphology of Trampling-Induced Abrasion and Stone Tool Cut Marks on Bone Surfaces

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Research Question

Can trampling-induced abrasion be effectively distinguished from stone tool cut marks using high-resolution 3-D scanning?

Background

It has been suggested that trampling-induced bone surface modification may produce marks similar to those of stone tools [1, 2, 3], leading to controversy over claims of hominin activity in faunal assemblages. Past research has relied on 2-D microscopic analysis of the qualitative features of mark micromorphology to distinguish between causal agents with limited success [1, 2, 3, 4, 5]. This study is the first to employ high-resolution 3-D profilometry to distinguish trampling marks from stone tool cut marks, a methodology that has been shown to be effective in bone surface modification analysis [6].

Figure 1) Example of quartzite and phonolite flake and biface tools used in this study.

Methods

- Trampling marks were induced by directing cattle over fragments of long bone scattered in sandy soil sediment in a confined area.
- Cut marks were created both on long bone fragments using a standardized cutting machine with flakes and bifaces of basalt, phonolite, chert, and quartzite sourced from Olduvai Gorge as well as through actualistic experimental butchery trials.
- 3-D reconstructions of bone surface modifications were produced using a Nanovea ST400® white-light confocal profilometer. Scans were processed using Digital Surf's Mountains® software.

Results

		3-D Measurements						Profile Measurements					
		Surface Area (μm²)	Volume (μm³)	Maximum Depth (μm)	Mean Depth (μm)	Maximum Length (μm)	Maximum Width (μm)	Maximum Depth (μm)	Area (μm²)	Width (μm)	Roughness (R_a)	Angle (°)	Radius (μm)
Trample	Mean	1888323.1	45271763.2	68.1	19.2	6720.8	414.3	50.2	10354.3	395.5	2.6	147.2	1186.1
	Median	862100.0	11610000.0	57.5	15.8	6009.6	282.2	35.9	3357.5	240.0	2.1	153.5	436.9
	Standard Deviation	3458089.8	102331343.8	36.3	12.3	3496.6	443.1	39.3	18286.1	368.3	2.2	22.8	2385.8
Cut	Mean	1395677.4	33075264.6	66.4	20.8	9763.8	342.8	59.6	7723.9	265.6	2.3	126.3	498.1
	Median	842200.0	14800000.0	59.5	18.0	8674.3	294.9	52.4	5054.2	230.0	2.0	131.7	209.0
	Standard Deviation	2447711.5	70412895.7	28.7	10.7	7069.7	168.8	27.9	9190.2	154.1	1.4	25.3	1943.6
Mann-Whitney *p*-values		0.91	0.60	0.61	0.12	<0.01*	0.35	<0.01*	0.06	0.04*	0.67	<0.01*	<0.01*

Table 1) Mean, median, and standard deviation for trample and cut mark measurements (Mann-Whitney test used due to nonparametric distribution; * indicate statistical significance).

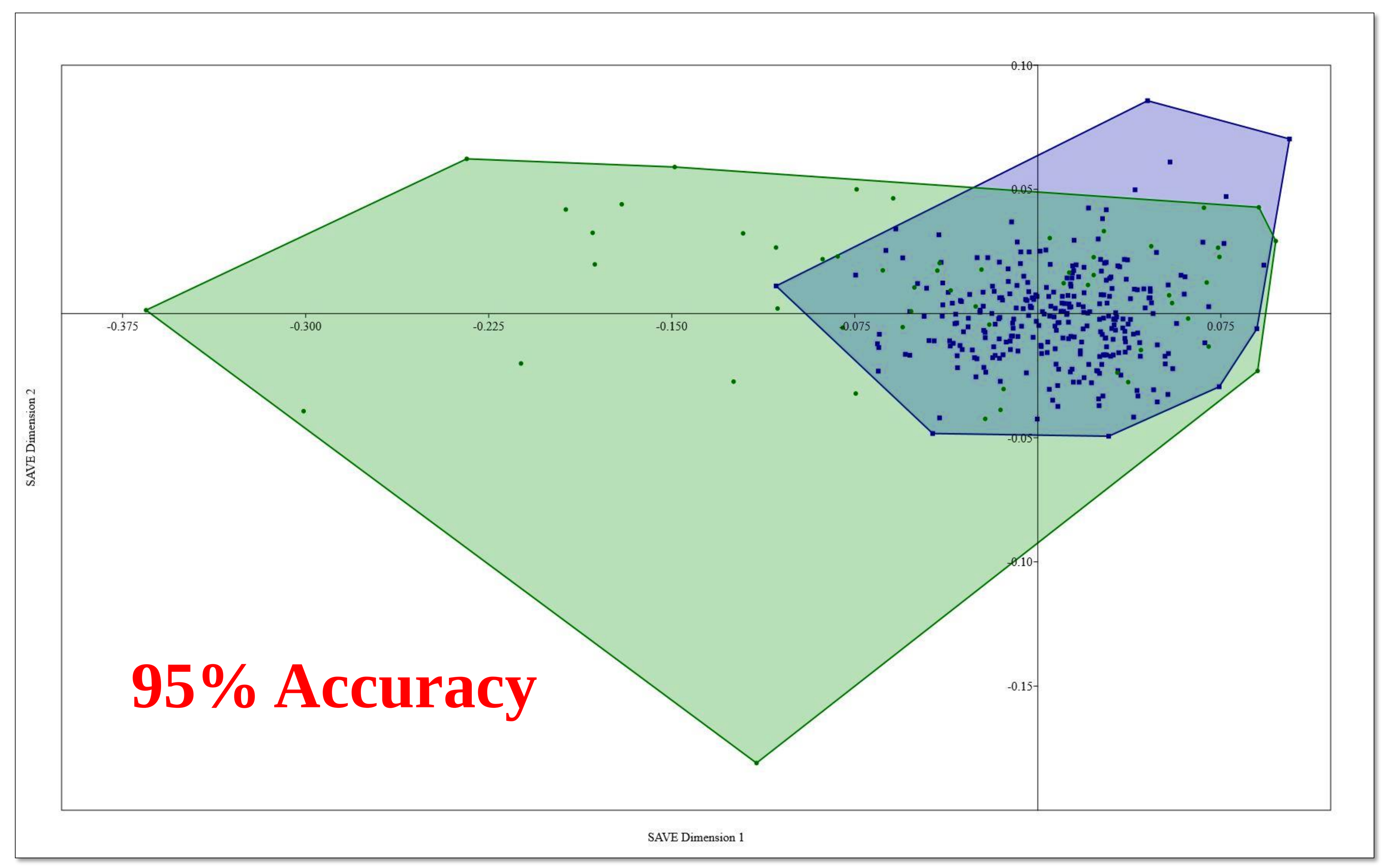

Figure 2) Discriminant analysis of trampling and cut marks. Green circles represent trampling marks and blue squares represent stone tool cut marks.

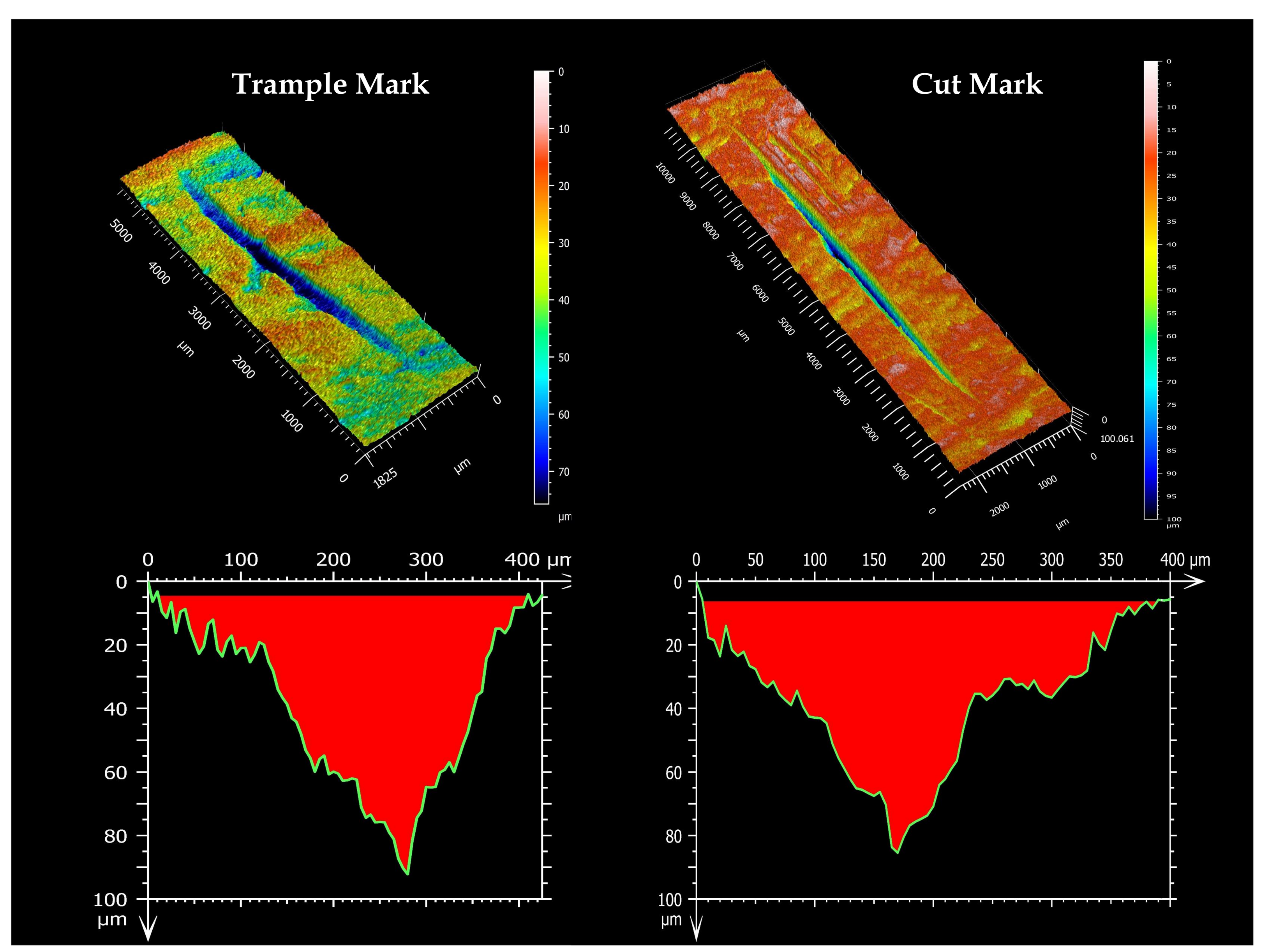

Figure 3) 3-D images of a trample and cut mark with profile views. Trample mark misclassified as cut mark in discriminant analysis.

Discussion

- The discriminant analysis was capable of distinguishing trampling marks from stone tool cut marks with 95% accuracy. When misclassified, trampling marks were most often mistaken for cut marks created by biface tools.
- Future research will expand sample sizes and include a variety of sediment types for trampling. This experimental database will also be applied to archaeological material along with data from carnivore tooth marks and percussion marks.

		Actual		
		Trample	Cut	Total
Predicted	Trample	**42**	13	55
	Cut	5	**292**	297
	Total	47	305	352

Table 2) Confusion matrix of trampling and cut marks.

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