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An experimental approach on dynamic *Occlusal Fingerprint Analysis* to simulate use-wear development and localisation on Palaeolithic stone tools

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Introduction

Since the origin of the genus *Homo*, stone tool-based technologies were an important component in the toolkit of past humans. Studying the evidence left on stone tools is one of the key areas in archaeology for understanding the evolution of human behaviour. Information about the use of stone tools in the past is encoded in the wear patterns left on the tool's surface after its use. To decode this information, use-wear analysts investigate the mechanisms involved in the formation of diagnostic wear traces.

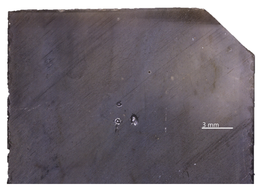
Occlusal Fingerprint Analysis (OFA)

Occlusal Fingerprint Analysis (OFA) is a well-established method in dental macrowear studies[1] to simulate chewing actions and thus to locate and quantify kinematics on dental wear facets (contact areas between opposing teeth). In this pilot study, we apply, for the first time, the OFA method to a set of experimentally produced stone tools. In this proof-of-concept study, we investigate whether contact areas simulated from the software correspond to the use-wear traces we observe. The overarching goal is directed at **building expectations as to where wear traces should develop based on the morphology of stone tools and the type of action performed**.

Controlled experiments

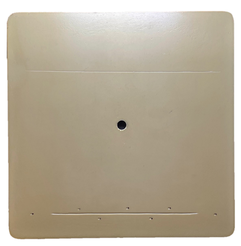
A series of second-generation mechanised cutting experiments[2] with four experimental sample sets was performed: Two samples had a standard, saw-cut morphology, while the other two were knapped and retouched. One sample of each type was used on a synthetic bone plate[3] while the other was used to cut wood. All samples were scanned with a high-resolution 3D scanner. The 3D scans are loaded into the OFA software and the trajectory, identical to that of the experimental setup, is simulated. During this trajectory, OFA records and quantifies all contact areas by collision detection algorithms occurring between the 3D models of the tool and the contact material. In parallel, the experimentally produced micro use-wear (i.e., polish) is documented with a digital, and an upright light microscope. Macro use-wear (i.e., edge damage) is recorded by comparing the 3D scans from before and after experimentation using a cloud mesh comparison software (CloudCompare).

Sample sets and workflow



Natural tool morphology + wood plate

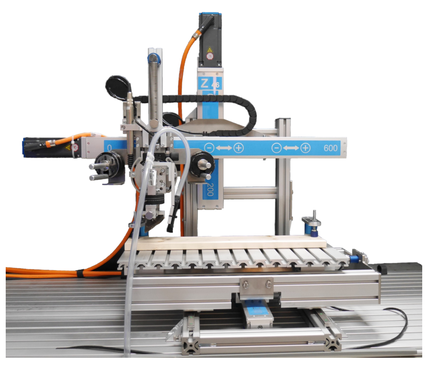
Saw-cut morphology + wood plate



Natural tool morphology + synthetic bone plate

Saw-cut morphology + synthetic bone plate

2000 unilinear cutting strokes with controlled variables:
velocity= 600 mm/s
acceleration= 4000 mm/s²
cutting length= 140 mm
5 kg dead weight for force



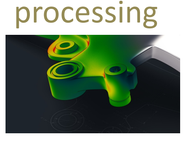
cleaning

3D scanning

microscope imaging

use-wear recording

3D processing



OFA simulation

Results

Experimentally produced use-wear (i.e., edge damage and polish) overlap with contact areas calculated in the OFA software.

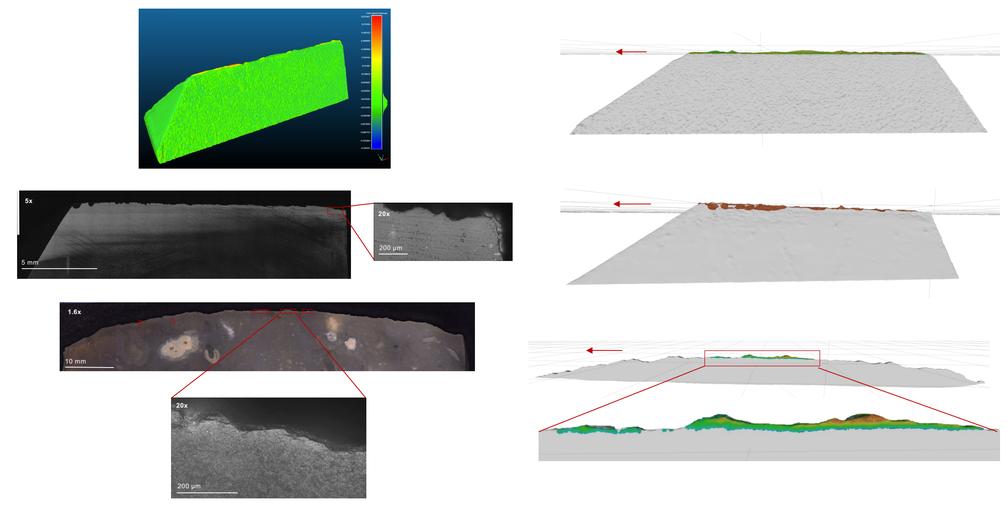


Figure 1 Edge damage on sample FLT8-1 (top left) and contact areas calculated in the OFA software (top right). Polish and contact areas in OFA on sample FLT8-13 (middle) and FLT13-1 (bottom).

Saw-cut flakes cut the contact material throughout experimentation in a more consistent manner compared to knapped blades, implying that tools with a simpler geometry cut contact material in a more regular way.

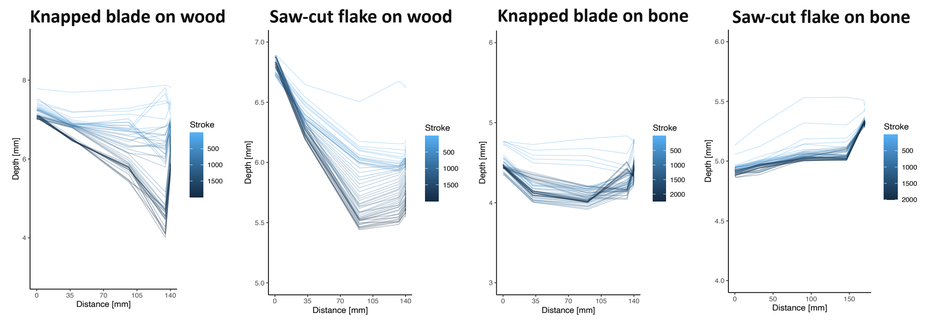


Figure 2 Penetration depth of samples in their contact material throughout experimentation. Lines illustrate every 40th cutting stroke of the whole experiment– the darker the shade, the higher the stroke number.

In comparison to the knapped samples, these tools also correlate with heightened contact areas in OFA, suggesting that for these tools, a larger surface area is involved in the cutting process.

Table 1 Maximum contact area on the tool across the OFA simulation.

	Knapped blade	Saw-cut flake
Wood	9.26 mm²	11.02 mm²
Bone	8.61 mm²	11.91 mm²

Conclusions

This proof-of-concept study has demonstrated that the **OFA method can be used to predict where use-wear develops on stone tools depending on their morphology and the action performed**. By incorporating other types of raw- and contact materials, this method will be further developed and prove important for answering larger research questions. The OFA method for stone stones can **address questions on site formation processes** because it generates expectations for the location of use-wear traces, allowing differentiation between traces from use and those from post-depositional processes. In addition, this method may **answer questions on tool performance** based on contact areas simulated in the software.

1 O. Kullmer/U Menz/L. Fiorenza 2020, Occlusal Fingerprint Analysis (OFA) reveals dental occlusal behavior in primate molars. In: T. Martin/W. von Koenigswald (Eds.), Mammalian Teeth – Form and Function (Munich) 25-43.
2 J. Marreriros/I. Calandra/W. Gneisinger/E. Paixão/A. Pedergnana/L. Schunk 2020, Rethinking Use-Wear Analysis and Experimentation as Applied to the Study of Past Hominin Tool Use. Journal of Paleolithic Archaeology 3, 475-502.
3 L. Schunk/W. Gneisinger/I. Calandra/J. Marreiros 2023, The role of artificial materials in experimental use-wear studies: A controlled proxy to understand use-wear polish formation. Journal of Archaeological Science: Report 47, 103737.

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