Ancient adhesives – A window on prehistoric technological complexity

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Permit specific information

Aim and rationale

This is a permit application to export 3 stone tools from Steenbokfontein Cave, Western Cape. The research outlined here is part of the Ancient Adhesives Project (see brief overview at the end of this section). The aim of this project is to illuminate the production and use of prehistoric glues. The Steenbokfontein tools are studied through the wear patterns and microscopic remains (residues) that are left after production, use and deposition. This traceology approach allows us to determine not only for what stone tools were used, but also if they were hafted and with what adhesives.

The first step in the Ancient Adhesives Project is identify tools with prehistoric glues and subsequently reconstruct the glue ingredients, the production process, and the manner in which the tools with adhesives were used. The Steenbokfontein tools were found promising as they show large adhesive remains, similar to the remains of compound glues found at flagship sites like Sibudu [e.g. 1]. By analysing 3 special finds with adhesives from Steenbokfontein we lay the groundwork to illuminate regional and geographical continuity of adhesive technology during the South African Stone Age.

The material

Steenbokfontein Cave is located in the Western Cape, South Africa. The mostly in situ stratified cave site contains five occupation layers, dated between ~2000 and ~8300 years ago [2]. The total of 9493 stone artefacts are stored at the University of Cape Town, Department of Archaeology. Previously, two adhesive finds were described in detail: a stone adze embedded in a large adhesive clump, and a cigar-shaped adhesive object [3]. The original excavator, dr Jerardino, observed adhesives on 31 additional stone tools from all stratigraphic units (Jerardino pers. comm 2016).

In collaboration with dr Jerardino we analysed the 31 Steenbokfontein tools with mastic residues and we selected 3 tools for additional detailed analyses (see objects description).

Table 1: Overview of the methods that will be applied to the Steenbokfontein tools.

Description	Method	Aim	Reference/cf.
Morphological analysis of wear and residues	-Light and digital microscopy -3D scanning/CT-scan	Reconstruct how the stone tools were made and used. Identify adhesives.	[4-6]
Spectrographic analysis of residues	-XRD: X-ray diffraction -FTIR: Fourier-transform infrared spectroscopy	Reconstruct glue ingredients.	[7-11]

Methods

Work package 3 of the Ancient Adhesives Project is concerned with reconstructing the life-history of objects with glue remains (see project description at the end of this document). To this end, we will conduct a full traceology analysis of prehistoric objects with glue remains, including: 3D scanning, light and electron microscopy, X-ray diffraction (XRF), Fourier-transform infrared spectroscopy (FTIR). The combination of methods as described in Table 1 will create a deep understanding of how the objects were made and used.

The stone tools will first be 3D-scanned using the CT-scanner at the Faculty of Geosciences (Delft University of Technology). This will create a permanent record of the object with adhesive. The objects will then be studied with a range of light and electron microscopes to map traces of (re)use and production: micro-wear and micro-residues. From this study we will be able to infer contact materials and motions of use. This part will be conducted in collaboration with dr Dominique Ngan-Tillard.

The tools and adhesive residues will then be studied with optical microscopy, XRF, and micro-FTIR. These analyses help the reconstruction the contact materials and motions used on the tools, and the reconstruction of the organic and inorganic components of the adhesives, for example ochre. The

analysis will be conducted by Alessandro Aleo and Paul Kozowyk, Delft University of Technology, Faculty of Mechanical, Maritime and Materials Engineering.

Data mangement

When the tools are returned to the University of Cape Town, they will include the following information: Analysis form with details of the traceology study, photo collection of the use-wear and residues, 3D files with scan data. These data will be provided in hard copy and as data files on a flash drive.

Output in the form of publications are scheduled to appear before the end of the project (2023). The raw results from the analysis and 3D scans will be made available before the end of the project on a stable open repository like 4TU.ResearchData (Delft University of Technology general repository).

Logistics

The stone tools will be couriered to the Netherlands (DHL). The samples will be returned also either in hand luggage or by courier. At the Delft University of Technology, the artefacts will be stored in a designated and locked storage facility in my office (Mekelweg 2, Building 34, office H4-340, Delft, NL). During analysis the objects may be stored in a locked facility at Leiden University, Laboratory for Material Culture Studies (Einsteinweg 2, Leiden, NL).

Executive summary
Ancient Adhesives: A window on Prehistoric Technological Complexity
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The problem and research objectives
How to reconstruct ancient thought processes is a major challenge in Palaeolithic Archaeology. (250-30 000 years ago). *AncientAdhesives* will develop a method to help resolve this crucial question and create a new window on the development of behavioural and cognitive sophistication. Complex technology is most suitable to trace behavioural complexity.

Adhesives are the oldest known examples of highly complex technology (dated to at least 200 000 years ago). They are known from both Neandertal and from early modern human contexts, and they are currently at the heart of debates on Neandertal and modern human cognition [12-18]. Unfortunately, there is no agreement about what makes adhesives complex. Moreover, there is no generally agreed upon method to assess the complexity of a technology.

Ancient glues, used to haft lithic artefacts to organic handles, are the oldest known highly complex technology. Finds in Tuscany dated to 200 000 years ago demonstrate that Neanderthals used a chemically transformative complex distillation process to acquire birch tar [19]. South African sites from 65 000 years ago preserve evidence for a different complex process to produce resin-based adhesives [e.g. 20, 21]. These finds reinforce the idea that both early modern humans and Neanderthals were able to make ingenious use of chemical processes [cf. 22]. This makes adhesives the best suited archaeological find category to document changing technological complexity.

The aim of the *AncientAdhesives* project is to develop an entirely novel archaeological method to determine the complexity of a technological process, and to facilitate reliable comparisons between similar *and* different technologies. To do this, *AncientAdhesives* will collect the first comprehensive body of knowledge on adhesive production and use, including expanding the archaeological data set and documenting steps in the production sequence and the context of the adhesive makers (**Objective 1**). The team will then apply modelling to Neandertal and modern human adhesive types (**Objective 2**). Finally, *AncientAdhesives* will reassess the development of hominin technological complexity across species and through time (**Objective 3**). *AncientAdhesives* is groundbreaking in that it develops an innovative and universal archaeological method, and provides reliable measurements of Neandertal and modern human technological complexity.

Building an adhesive frame of reference - materials
AncientAdhesives will collate and produce the myriad of data required for the models. This results in a comprehensive frame of reference that is much-needed to contextualise current *ad hoc* generalisations on adhesives, based on scant finds. The frame of reference will consist of three pillars: ethnography, information on material properties and archaeology.

Work packages – methods
Work package 1: Ethnography (PI, PhD, technician, postdoc 1)
Literature review of historic and ethnographic literature. Material analysis of ethnographic objects with adhesives. Ethnographic fieldwork.

Work package 2: Material properties (PI, postdoc 1, postdoc 2, technician)
Production, performance and preservation experiments on experimental adhesives in the lab and field.

Work package 3: Archaeology (PI, PhD, postdoc 2, technician)
The **PhD** candidate and **PI** in collaboration **prof. dr Van Gijn** (traceology expert at Leiden University, the Netherlands) will study the wear and production marks and residues on Middle Palaeolithic and Later Stone Age tools from five sites in Europe and South Africa. Light microscopy and 3D scanning are applied to map the production and use-lives of the tools and adhesives [cf. 5, 23]. Part of the archaeological and experimental adhesives are sampled and analysed for ingredients using XRF/XRD, Raman, SEM-EDS, GC-MS, and FTIR [cf. 7, 8-10, 24].

Work package 4: Process modelling (PI, postdoc 3)
Map and model the context of the technology, and the production and use of ethnographic and experimental adhesives, using e.g. Petri nets and BPMN models [25, 26].

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