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# Comparing the Formation and Characteristics of Use-Wear Traces on Flint, Chert, Dolerite and Quartz

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**ABSTRACT**
Use-wear traces are considered to be material specific. The use of an appropriate reference collection is thus fundamental for interpreting tools' function. To test whether a flint reference collection can be used to interpret the function of non-flint tools, I conducted experiments using chert, dolerite, and quartz endscrapers and flakes. I compared wear traces obtained during the experiment with use-wear on experimental flint tools exposed to the same variables (motion, contact material, time). The results highlighted strong similarities in the characteristics and distribution of traces on chert and flint. Dolerite and quartz differ from flint, especially regarding the distribution and appearance of use-polish. However, shared traits were observed in all the raw materials involved in this experiment, demonstrating a certain degree of comparability between use-wear traces on flint and non-flint rocks. Based on the data, a flint reference collection can allow a basic interpretation of use-wear also on different rocks.

**KEYWORDS**
Non-flint rocks; use-wear traces; experimental archaeology; South African lithics

## Introduction

Use-wear analysis is becoming more and more part of mainstream methodologies in archaeological research across the world. The method greatly developed since its conception 60 odd years ago (Evans et al., 2014; Marreiros et al., 2020 and references therein). Traceology refers to the study of macro and microscopic wear traces on the edges/surfaces of objects. By studying the characteristics and distribution patterns of wear traces it is possible to infer past tools' functions. Experiments form a fundamental component of use-wear studies. Based on experiments, archaeologists can infer past tool function and production in light of the similarities between corresponding attributes of archaeological and experimental use-wear (Van Gijn, 2010). Hence, the interpretation of wear traces is strongly influenced by the available comparative reference collection. One research hiatus is that comparative collections of non-flint knapped tools are still rare. With this study, I want to explore how traces on different lithic raw materials compare to detect whether flint tools can be used as a reference collection for non-flint artifacts.

Non-flint materials, and coarse rocks in particular, generally attract little scientific attention, and technological and typological frames derived from flint have often been applied to them (Knutsson, 1998). The same holds for functional studies. However, raw material proprieties not only influence knapping attributes, but also the distribution and appearance of the wear traces. Hence, we can expect tools made on different rocks to exhibit different patterns of use-wear traces (Clemente Conte et al., 2015). Despite the frequency of flint tools, there are regions where good quality flint is scarce or unavailable, and is replaced by other rock types with similar knapping properties, for example quartz and quartzite (Aubry et al., 2016; Knutsson et al., 2016). Outside Europe, numerous fine- and coarse-grained rocks, like chert, quartzite, and silcrete, are used in tool production instead of flint (e.g. Douglass et al., 2016; Holdaway & Douglass, 2015; Nami, 2015; Will, 2021).

The identification and interpretation of use-wear traces on quartzose and heterogenous rocks are often considered problematic. Recently, several experimental programs aimed to broaden our knowledge on the mechanical responses to stress caused by the use and wear formation process on non-flint rocks were created (e.g. Bello-Alonso et al., 2019; Bello-Alonso et al., 2020; Fernández-Marchena & Ollé, 2016). Concurrently, new

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analytical techniques, such as scanning electron microscope (SEM) and laser scanning confocal microscope, improved the detection and recognition of wear traces on these highly reflective and irregular rocks (e.g. Ollé et al., 2016; Pedergnana et al., 2020). The application of these methods to archaeological materials highlighted the feasibility of functional interpretation of lithic assemblages composed of non-flint artifacts (e.g. Lemorini et al., 2019). In these recent advances, the authors stressed the need to use rock-specific reference collections. Comparisons to use-wear traces on flint are problematic due to significant differences in the raw material proprieties which influence wear formation (see for example Bello-Alonso et al., 2019).

It is certainly true that wear traces are in part material specific, but there are also similarities in the types of wear analysts encounter (Clemente Conte et al., 2015). Because building a comprehensive raw material-specific reference collection is not always an option, I set out to test the extent to which we can rely on a reference collection of flint tools to interpret the wear traces of non-flint knapped materials. To do so, I designed a systematic experiment in which the same activity, with the same use duration, is performed with flint tools and tools made of other lithologies. As my overarching research interest includes South African lithics, I focused on well-known resources from there: chert, quartz and dolerite. A description of macro- and micro-wear traces resulting from the work of different materials, was provided for chert, dolerite, quartz, and flint artifacts. After that, I performed a comparative analysis between experimental traces on flint and non-flint tools to investigate which differences in the characteristics of wear traces can be observed and how these influence the interpretation of tools' function.

## Materials and methods

### *Experimental tools: raw materials, tool types*

Experimental flake tools and endscrapers were made on rock types that are generally found in the South African archaeological record: chert, dolerite, and quartz (Table 1, rocks descriptions SI). All flint tools are non-cortical and made of fine-grained European flint (Fig. SI1). The tools were made by expert flint knappers, using soft and hard hammer stones. The chert and dolerite rocks were collected in Lesotho and the Kwazulu-Natal province of South Africa. The quartz cobbles are store-bought and collected from locally river-beds in the Netherlands. All chert tools are made of fine- to medium-grained chert and are non-cortical (Fig. SI2). Due to the shortage of good quality quartz and dolerite, and the small dimension of the available nodules, tools were made from both cortical and non-cortical flakes (Fig. SI3, SI4). The quartz cobbles had a smooth, rounded cortical exterior with weathering limited to some sheen over the surface. The dolerite cortical exterior is angular and rough.

The scrapers were retouched to endscrapers and hafted by side-mounting them at one end of a pine wood handle with the aid of a compound adhesive made of pine resin, beeswax, and ochre (Fig. SI5). The hafting design and adhesive recipe are representative for hafted tools in the African Middle Stone Age (MSA) and Later Stone Age (LSA) (Deacon & Deacon, 1980; Lombard, 2007; Wadley, 2005).

In the experiment, I used the hafted scrapers in a transverse scraping motion. The flakes remained unretouched and were handheld. They were used in longitudinal motions (cutting and sawing).

### *The experiments: contact materials, motion, and time*

The experiment can be considered a generalized reference experiment (Van Gijn, 1990). These types of experiments are aimed to reproduce and study a wide range of used tools, and it was not my goal to replicate specific tasks or archaeological objects.

I used the tools to process animal and plant materials (Table 1). The contact materials ranged from soft to medium-hard and consisted of fresh deer hide (*Cervus elaphus*; soft), green reeds (*Phragmites australis* Trin.; soft-medium), and fresh deer bone (*Cervus elaphus*; medium-hard). I selected these materials because they represent a plausible counterpart of the raw materials that could have been exploited during the MSA and LSA. Reeds are widely known in the ethnographic record for being used as shafts for bone-tipped arrows (Deacon, 1992) and may have been used for the same purpose in the past. Red deer was chosen to replace African medium-sized ungulates (Steele & Klein, 2013).

The hide and bone raw materials were scraped and cut with the scrapers and flake tools respectively. In the hide scraping experiment, the hafted tools were placed perpendicular to the hide and pulled towards the hide-worker (see as reference Konso hide-workers in Ethiopia; Rots & Williamson, 2004) (Figure 1(a)). The endscrapers were used to clean fresh skins which were cut with flake tools. The cutting motion was done unidirectionally (Figure 1(b, c)). A downward motion was also applied in the bone working experiments, where endscrapers were used to deflesh and scrape the surface of fresh bones (Figure 1(d)). The bone-cutting experiments were conducted on the same bones after they had been cleaned and scraped in the previous experiment. The bones

**Table 1.** Overview of the experimental tools and the variables tested in the experiment.

| Experiment nr. | Raw material | Tool type | Cortex on the used edge | Handling | Motion | Contact material | Use-duration (min) |
|---|---|---|---|---|---|---|---|
| 2558 | Flint | Endscraper | No | Hafted | Scraping | Hide | 30 |
| 665 | Flint | Endscraper | No | Handheld | Scraping | Hide | 60 |
| 2555 | Flint | Flake | No | Handheld | Cutting | Hide | 30 |
| 2556 | Flint | Flake | No | Handheld | Cutting | Hide | 60 |
| 207 | Flint | Endscraper | No | Handheld | Scraping | Bone | 30 |
| 1810 | Flint | Endscraper | No | Handheld | Scraping | Bone | 60 |
| 48 | Flint | Flake | No | Handheld | Sawing | Bone | 30 |
| 2557 | Flint | Flake | No | Handheld | Sawing | Bone | 60 |
| 428 | Flint | Flake | No | Handheld | Cutting | Reed | 30 |
| 183 | Flint | Flake | No | Handheld | Cutting | Reed | 60 |
| 3827 | Chert | Endscraper | No | Hafted | Scraping | Hide | 30 |
| 3826 | Chert | Endscraper | No | Hafted | Scraping | Hide | 60 (2*30) |
| 3831 | Chert | Flake | No | Handheld | Cutting | Hide | 30 |
| 3830 | Chert | Flake | No | Handheld | Cutting | Hide | 60 (2*30) |
| 3824 | Chert | Endscraper | No | Hafted | Scraping | Bone | 30 |
| 3825 | Chert | Endscraper | No | Hafted | Scraping | Bone | 60 (2*30) |
| 3828 | Chert | Flake | No | Handheld | Sawing | Bone | 30 |
| 3829 | Chert | Flake | No | Handheld | Sawing | Bone | 60 (2*30) |
| 3832 | Chert | Flake | No | Handheld | Cutting | Reed | 30 |
| 3833 | Chert | Flake | No | Handheld | Cutting | Reed | 60 (2*30) |
| 3855 | Dolerite | Endscraper | No | Hafted | Scraping | Hide | 30 |
| 3807 | Dolerite | Endscraper | No | Hafted | Scraping | Hide | 60 (2*30) |
| 3809 | Dolerite | Flake | Yes | Handheld | Cutting | Hide | 30 |
| 3808 | Dolerite | Flake | No | Handheld | Cutting | Hide | 60 (2*30) |
| 3806 | Dolerite | Endscraper | No | Hafted | Scraping | Bone | 30 |
| 3805 | Dolerite | Endscraper | No | Hafted | Scraping | Bone | 60 (2*30) |
| 3813 | Dolerite | Flake | No | Handheld | Sawing | Bone | 30 |
| 3811 | Dolerite | Flake | Partially | Handheld | Sawing | Bone | 60 (2*30) |
| 3812 | Dolerite | Flake | Yes | Handheld | Cutting | Reed | 30 |
| 3810 | Dolerite | Flake | No | Handheld | Cutting | Reed | 60 (2*30) |
| 3816 | Quartz | Endscraper | No | Hafted | Scraping | Hide | 30 |
| 3814 | Quartz | Endscraper | No | Hafted | Scraping | Hide | 60 (2*30) |
| 3821 | Quartz | Flake | No | Handheld | Cutting | Hide | 30 |
| 3823 | Quartz | Flake | Yes | Handheld | Cutting | Hide | 60 (2*30) |
| 3817 | Quartz | Endscraper | No | Hafted | Scraping | Bone | 30 |
| 3815 | Quartz | Endscraper | No | Hafted | Scraping | Bone | 60 (2*30) |
| 3822 | Quartz | Flake | Yes | Handheld | Sawing | Bone | 30 |
| 3819 | Quartz | Flake | Yes | Handheld | Sawing | Bone | 60 (2*30) |
| 3818 | Quartz | Flake | Yes | Handheld | Cutting | Reed | 30 |
| 3820 | Quartz | Flake | Partially | Handheld | Cutting | Reed | 60 (2*30) |

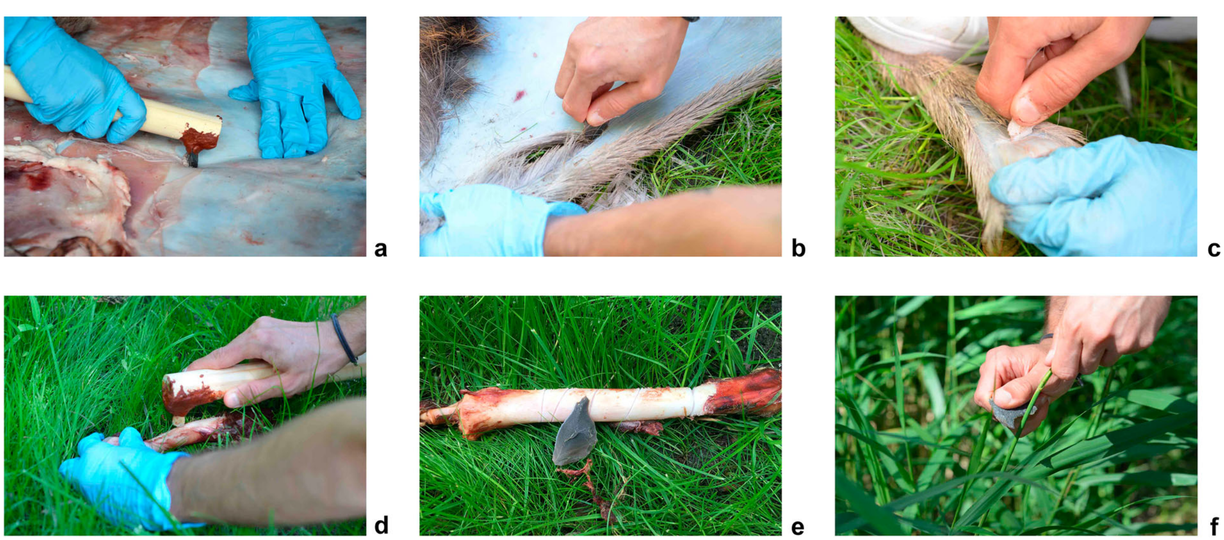


**Figure 1.** Experimental activities carried out. (a) Scraping a fresh deer hide with a hafted endscraper. (b, c) Cutting fresh deer hide with handheld flakes. (d) Scraping a fresh deer bone with a hafted endscraper. (e) Deep incisions on a fresh deer bone from sawing with a handheld flake. (f) Cutting green reeds with a handheld flake.

were cut, creating deep incisions against the grain of the bone but never cutting through it (Figure 1(e)). A bidirectional longitudinal sawing motion was applied. Reeds were only cut with flake tools and not scraped. Fresh reeds were cut by placing the flake perpendicular to the reed's stem and using a unidirectional motion (Figure 1(f)).

Each experiment was conducted twice, at two time intervals: 30 and 60 min (Table 1). With this sequential experiment, the progression of use-wear traces through the use was documented (cf. Ollé & Vergès, 2014). Only one active side or area of the tool was used, concentrating potential wear formation to a specific edge. All activities were carried out by the same person (AA) to reduce the variables related to the experimenter. Regarding the flint tools, I conducted experiments 2555, 2556, 2557, and 2558. The others were selected from the available Laboratory for Material Cultural Studies reference collection which comprises more than 4000 experimental tools.

### *Methods: sample preparation, microscopy and wear analysis*

To capture the development of the traces, all intended active surfaces of the tools were examined and photographed prior to the experiments. I analyzed the tools after the 30-minute interval and again after the last 60 min interval. I aimed to photograph the same locations after each use-session. However, because of edge-removals and crushing during some of the activities, several spots were lost. When that occurred, I selected new photo locations where traces had already started to develop.

Before microscopy, the tools were cleaned under running water and in an ultrasonic bath with water and soap for 10 min. This was to remove use-residues that hindered the analysis. Some tools needed a further 20 min cleaning treatment. During the analysis under high magnification, all pieces were cleaned with a 96% alcohol solution to remove any finger grease from handling.

Macroscopic traces were visually analyzed using a Leica M80 stereomicroscope with an external light source and magnifications ranging from x7.5 up to x60. Images were taken using a Leica MC120 HD camera. Microscopic traces were observed with a Leica DM6000 M metallurgical microscope with incident light and bright field illumination and magnifications ranging from x50 up to x500. Images were captured with a Leica DFC450 camera and microscopy z-stacking software to overcome the problem of low depth of focus.

For each implement, I recorded the location, distribution and association of the use-wear on the tool's surface, using a system of polar coordinates (Fig. SI6; Van Gijn, 1990). I recorded the following variables: edge-damage (edge-removals, crushing, edge-reduction), edge-rounding, polish, striations, and abrasion. Abrasion corresponds to the disappearance of part of the original surface of crystals due to use. The degree of abrasion and the shape and size of the hollows ("pecking") are indicators of the type of the worked material (Clemente Conte et al., 2015; Clemente Conte & Gibaja Bao, 2009; Ollé et al., 2016). Edge-removals were evaluated based on their distribution along the edge and the orientation of the scars. The former is informative of the hardness of the material worked, the latter of the use-motion (Semenov, 1964; Tringham et al., 1974). Polish was described by means of various attributes namely: distribution, texture, topography, brightness and degree of linkage. Polish distribution is influenced by the worked material, the use duration and applied motion. Polish texture and topography are related to the worked material as well as brightness. The description of the micro-polish follows the terminology and methodology developed by Keeley (1980) and further developed by others (Van Gijn, 1990; Van Gijn, 2014, 2010; Vaughan, 1985). The orientation of the striations in relation to the used edge was recorded. I described the development of edge-rounding, polish, and abrasion as light, moderate, or heavy. The degree of rounding was visually assessed based on the extent of rounding of the used edge caused by working a specific contact material. For polish and abrasion, I observed the extension of the surface area affected by alteration. For the former, I also considered the degree of linkage in the polish. Considering that use-wear traces do not always develop in the same way along the edge, the degree of wear of a specific trace may vary depending on its location.

Finally, a comparative analysis was undertaken to identify shared similarities in the characteristics and distribution pattern of traces. With the aim to explore the possibilities and limitations of using the reference collection of flint tools to infer the function of non-flint tools.

## Results

### *Flint*

The results of the use-wear analysis are listed in Table 2. *Hide*: Working fresh hide resulted in edge-rounding, rare edge-removals, which occurred only during the cutting activity, and a greasy polish developed in a characteristic band along the edge. The polish is bright and invasive and follows the profile of the working edge exactly (Figure 2(a, b)). The texture of the polish is either pitted or cratered. Polish on the endscrapers display a

**Table 2.** Overview of the production and use-wear traces recorder on the experimental tools.

| Exp. | Exp. Type | Traces | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Production | Use | | | | | | | | |
| | | | Edge-removals | Edge-rounding | Polish development | Polish distribution | Polish texture | Polish topography | Polish brightness | Abrasion | Striations |
| 2558 | Flint/Scr/Hide/30 | -striations<br>-polish<br>-edge-damage | - | -light | -light<br>-moderate | -band along the edge<br>-invasive | -rough and greasy | - | -bright | - | - |
| 665 | Flint/Scr/Hide/60 | - | - | -moderate | -moderate | -band along the edge<br>-invasive | -rough and greasy | -cratered | -bright | - | - |
| 2555 | Flint/Cut/Hide/30 | - | -isolated | -light<br>-moderate | -light<br>-moderate | -band along the edge<br>-invasive | -rough and greasy | -pitted-cratered | -bright | - | - |
| 2556 | Flint/Cut/Hide/60 | - | -isolated | -moderate | -moderate | -band along the edge<br>-invasive | -rough and greasy | -pitted | -bright | - | - |
| 207 | Flint/Scr/Bone/30 | - | -isolated | -light | -light | -line along the edge | -smooth and matt | -domed | -bright | - | - |
| 1810 | Flint/Scr/Bone/60 | - | -isolated | - | -moderate | -line along the edge<br>-isolated spots | -smooth and matt | -domed<br>-flat | -very bright | - | - |
| 48 | Flint/Saw/Bone/30 | - | -close | - | -light<br>-moderate | -isolated spots | -smooth and matt | -domed | -very bright | - | -longitudinal |
| 2557 | Flint/Saw/Bone/60 | - | -close<br>-scalar | - | -moderate<br>-heavy | -isolated spots | -smooth and matt | -domed<br>-flat<br>-pitted | -very bright | - | -longitudinal |
| 428 | Flint/Cut/Reed/30 | - | -isolated | -light | -moderate | -band along the edge<br>-invasive | -smooth and matt | -domed | -very bright | - | - |
| 183 | Flint/Cut/Reed/60 | - | -isolated<br>-close | -light | -moderate<br>-heavy | -band along the edge<br>-invasive | -smooth and matt | -flat<br>-domed | -very bright | - | - |
| 3827 | Chert/Scr/Hide/30 | - | - | -light | -light | -band along the edge<br>-invasive | -rough and greasy | -pitted<br>-cratered | -bright | - | - |
| 3826 | Chert/Scr/Hide/60 | - | - | -light | -light<br>-moderate | -band along the edge<br>-invasive | -rough and greasy | - | -bright | - | - |
| 3831 | Chert/Cut/Hide/30 | - | -rare<br>-isolated | -light | -light | -band along the edge<br>-invasive | -rough and greasy | - | -bright | - | - |
| 3830 | Chert/Cut/Hide/60 | - | -isolated | -light | -light<br>-moderate | -band along the edge<br>-isolated spots<br>-invasive | -rough and greasy | - | -bright | - | - |
| 3824 | Chert/Scr/Bone/30 | - | -single | -light | -light<br>-moderate | -line along the edge<br>-isolated spots | -smooth and matt | - | -very bright | - | - |
| 3825 | Chert/Scr/Bone/60 | - | -isolated | -light | -light<br>-moderate | -line along the edge | -smooth and matt | -pitted | -very bright | - | - |
| 3828 | Chert/Saw/Bone/30 | - | -close | - | -light | -isolated spots | -smooth and matt | -domed | -very bright | - | - |
| 3829 | Chert/Saw/Bone/60 | - | -close | - | -moderate | -isolated spots | -smooth and matt | -domed | -very bright | - | -longitudinal |
| 3832 | Chert/Cut/Reed/30 | - | -close | -light | -light<br>-moderate | -band along the edge<br>-invasive | -smooth and matt | -domed | -very bright | - | - |
| 3833 | Chert/Cut/Reed/60 | - | -close | -light | -moderate | -band along the edge<br>-invasive | -smooth and matt | -domed | -very bright | - | - |
| 3855 | Dole/Scr/Hide/30 | -polish | - | -light | -light<br>-moderate | -band along the edge<br>-isolated spots<br>-invasive | -granular | -flat | -very bright | - | - |
| 3807 | Dole/Scr/Hide/60 | - | - | -moderate | -light<br>-moderate | -band along the edge<br>-isolated spots | -granular | -flat | -very bright | - | - |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | -invasive | | | | | |
| 3809 | Dole/Cut/Hide/30 | - | -isolated | -light | -light | -isolated spots | -rough and greasy<br>-granular | -flat | -very bright | - | - |
| 3808 | Dole/Cut/Hide/60 | - | -isolated | -light | -light | -isolated spots | -granular | -flat | -very bright | - | - |
| 3806 | Dole/Scr/Bone/30 | - | -isolated | -light | -light | -isolated spots | -smooth and matt | -domed | -bright<br>-very bright | -light | -transverse |
| 3805 | Dole/Scr/Bone/60 | - | -isolated | -light | -light | -isolated spots | -smooth and matt | -domed<br>-pitted | -bright<br>-very bright | -light | - |
| 3813 | Dole/Saw/Bone/30 | - | -close | - | -light | -isolated spots | -smooth and matt | - | -bright | - | - |
| 3811 | Dole/Saw/Bone/60 | - | -close | -light | -light | -isolated spots | -smooth and matt<br>-granular | -domed | -bright<br>-very bright | - | - |
| 3812 | Dole/Cut/Reed/30 | - | -isolated | -light | -light<br>-moderate | -isolated spots<br>-invasive | -smooth and matt | -domed | -very bright | - | - |
| 3810 | Dole/Cut/Reed/60 | - | -isolated | -light | -light<br>-moderate | -isolated spots<br>-invasive | -smooth and matt | -domed | -very bright | -light | - |
| 3816 | Quartz/Scr/Hide/30 | - | -rare<br>-isolated | -light | -absent | - | - | - | - | - | - |
| 3814 | Quartz/Scr/Hide/60 | - | -rare<br>-isolated | -moderate | -light | -isolated spots | -rough and greasy | - | -bright | -light | - |
| 3821 | Quartz/Cut/Hide/30 | - | -isolated | -light | -absent | - | - | - | - | - | - |
| 3823 | Quartz/Cut/Hide/60 | - | -isolated | -light<br>-moderate | -light<br>-moderate | -band along the edge<br>-invasive<br>-isolated spots | -rough and greasy | - | -dull<br>-bright | -light<br>-moderate | - |
| 3817 | Quartz/Scr/Bone/30 | - | -isolated | - | -absent | - | - | - | - | - | - |
| 3815 | Quartz/Scr/Bone/60 | - | -isolated | -light | -light | -isolated spots | -smooth and matt | - | -bright | -moderate | - |
| 3822 | Quartz/Saw/Bone/30 | - | -isolated<br>-close | -light | -light | -isolated spots | -smooth and matt | - | -very bright | - | - |
| 3819 | Quartz/Saw/Bone/60 | - | -close | - | -light<br>-moderate | -isolated spots | -smooth and matt | -domed<br>-pitted<br>-comet tails | -very bright | -moderate | - |
| 3818 | Quartz/Cut/Reed/30 | - | -isolated | -light | -moderate | -band along the edge<br>-invasive | -smooth and matt | -domed | -very bright | - | - |
| 3820 | Quartz/Cut/Reed/60 | - | -isolated | -light | -light<br>-moderate | -band along the edge<br>-invasive | -smooth and matt | -domed | -very bright | - | - |

Note: The description of the experiment type (Exp. type) is compiled as follows: raw material, motion (scraping or cutting/sawing), contact material, time (30 or 60 min). Production traces are grouped together. The detailed description of the single experiments is given in the SI.

transverse directionality. The degree of edge-rounding varies between light to moderate, and it is never heavily developed even after 60 min of use. As already demonstrated in previous studies (cf. Collin & Jardon-Giner, 1993; Loebel, 2013; Rots, 2005), working fresh hide creates a less pronounced rounding of the edge and a greasier and brighter polish compared to dry hide.

*Bone*: Traces produced by contact with fresh bone consist of edge-rounding, edge-removals, and polish. Scraping fresh bone resulted in a slightly developed rounding, a few edge-removals, and a smooth polish distributed in a thin line along the edge (Figure 2(c)). Sawing caused more edge-removals and no rounding. The associated polish is smooth and matt, it has a localized distribution and a clear longitudinal directionality (Figure 2(d, e)). Tiny pits are visible in the polish. Longitudinal striations, indicative of the use-motion, were documented on both cutting tools. No striations were documented on the endscrapers, but the polish displays a transverse directionality.

*Reed*: Cutting fresh reeds produced a slight edge-rounding, unevenly distributed edge-removals, and a band of well-developed highly linked polish (Figure 2 (f)). The polish has a smooth and matt texture and both domed and flat topography. Well-developed spots of polish generally display a flat topography rather than domed. The brightness is very intense, and the polish exhibits a clear longitudinal directionality.

### Chert

*Hide*: Traces from contact with fresh hide consist of edge-rounding, edge-removals, and polish. Scraping and cutting resulted in a light edge-rounding. Edge-removals occurred only on tools used for cutting. A rough and greasy polish developed on all scraping and cutting tools. On endscrapers, a continuous band of polish – with transverse directionality – formed (Figure 3(a)). While on cutting tools, the polish has a more localized distribution but, it is still invasive (Figure 3(b)). Pits and craters in the polish were documented on one endscraper.

*Bone*: Scraping fresh bone caused a very light edge-rounding and a few edge-removals. A smooth and matt polish is distributed at the very edge of the endscrapers, while a lightly developed greasier polish extends more into the piece (Figure 3(c)). Sawing caused more edge-removals than scraping. The continuous crushing of the edge inhibits the formation of edge-rounding. Bone polish developed in isolated spots and has a smooth and matt texture and a domed topography. Tiny pits are visible in the polish (Figure 3(d, e)). The polish is bright and has a clear longitudinal directionality. Striations parallel to the edge were documented on one flake.

*Reed*: Working fresh reeds resulted in edge-removals, lightly developed edge-rounding, and a wide band of polish with a smooth and matt texture and domed

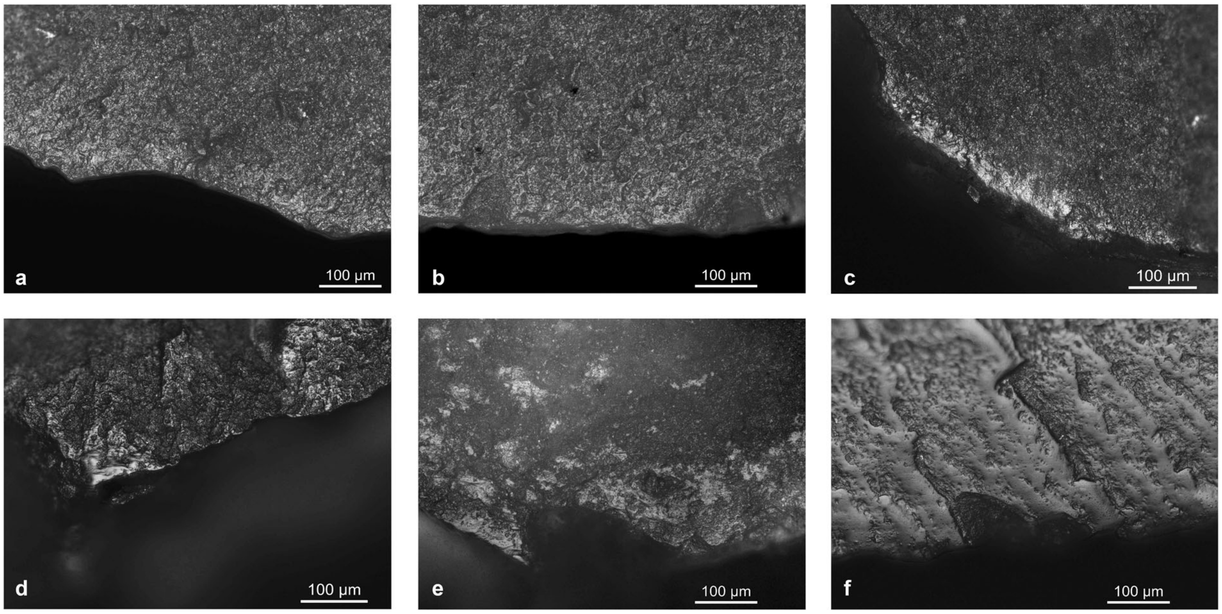


**Figure 2.** Selection of use-wear traces on experimental flint tools. (a) Light edge-rounding and greasy band of polish from scraping fresh hide (200x). (b) Edge-rounding, isolated edge-removals and band of polish from cutting fresh hide (200x). (c) Line of polish and light rounding from scraping fresh bone (200x). (d) Domed polish with longitudinal directionality from sawing fresh bone (200x). (e) Edge-removal with longitudinal orientation and flat smooth polish from sawing fresh bone (200x). (f) Edge-removal oriented longitudinally and highly-linked band of polish from cutting reeds (200x).

topography (Figure 3(f)). The polish is very bright and displays a longitudinal directionality. The degree of linkage of the polish is higher on the flake used for 60 min.

## *Dolerite*

*Hide*: Traces from contact with fresh hide are edge-rounding, edge-removals, and polish. Edge-removals were documented only on cutting tools. Hide polish developed on endscrapers and flakes and its distribution is not uniform along the used edge. Polish developed in isolated patches with a granular texture and a flat topography (Figure 4(a, b)). On endscrapers, the polish is distributed more continuously along the used edge than on flakes. Hide polish developed both on crystals and on the matrix.

*Bone*: Working fresh bone resulted in edge-removals, edge-reduction, polish, abrasion, and striations. A light edge-rounding was observed on both endscrapers, while on the flakes, it developed only on the one used for 60 min. Severe edge damage occurred during the sawing activity. On both endscrapers and flakes, the polish has a localized distribution and it developed on the most protruding areas of the edge. The polish has a smooth and matt texture and a domed topography (Figure 4(c, e)). Pits are occasionally visible in the polish. Fine and small striations perpendicular to the working edge are visible on the surface of a worn protruding crystal on endscraper 3806 (Figure 4(d)). On both endscrapers, abrasion of the crystals is visible. Abrasion is lightly developed since no very abrasive materials were worked. The hollows are mostly medium-sized and irregular in shape in line with what has been reported in the literature for tools used to process medium and hard materials (cf. Clemente Conte et al., 2015).

*Reed*: Traces from contact with fresh reeds consist of rare edge-removals, light edge-rounding, smooth and matt polish with a domed topography, and abrasion (Figure 4(f)). The polish is invasive and distributed in isolated spots along the working edge. The polish lays on top of the crystals and grains of the matrix, the brightness is very intense, and the polish displays a clear longitudinal directionality. Abrasion is visible on a few crystals along the edge and is lightly developed.

## *Quartz*

*Hide*: Traces from contact with fresh hide consist of edge-removals, edge-rounding, polish, and abrasion. The degree of rounding varies between light to moderate (Figure 5(a)). Edge-removals are rare and isolated. Hide polish did not develop on all tools. When present, the polish is distributed in isolated spots or a band along the edge and has a rough and greasy texture

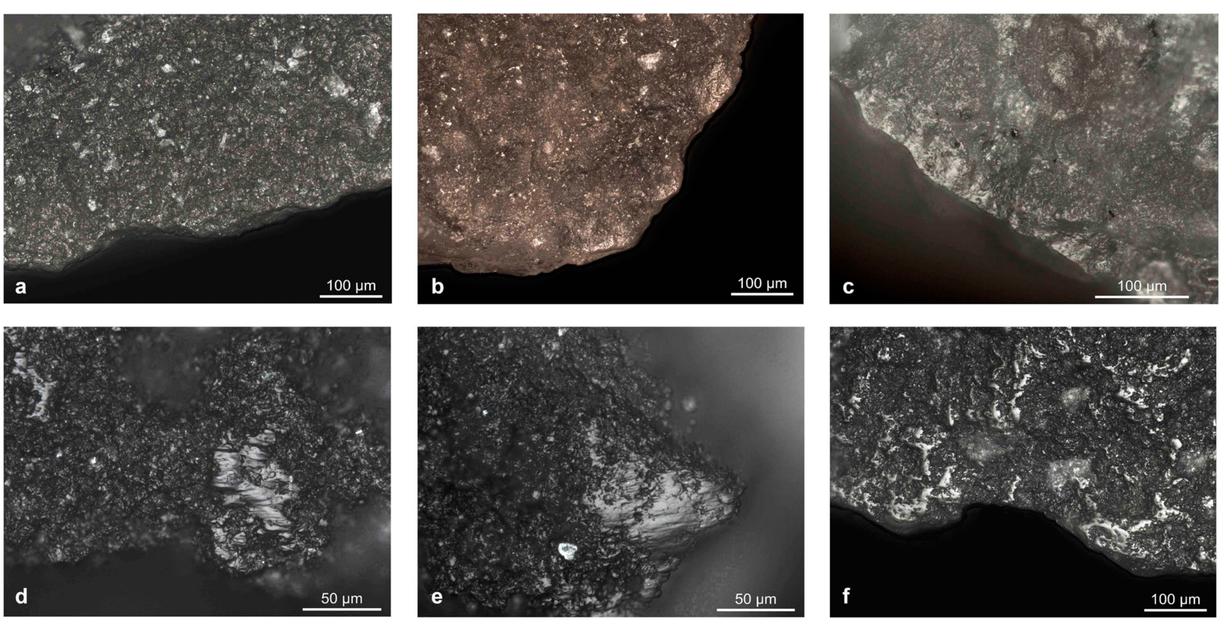


**Figure 3.** Selection of use-wear traces on experimental chert tools. (a) Edge-rounding and greasy band of polish from scraping fresh hide (200x). (b) Edge-rounding and polish from cutting fresh hide (200x). (c) Line of polish from scraping fresh bone (300x). (d) Isolated spots of polish with longitudinal directionality from sawing fresh bone (500x). (e) Edge-removals and smooth spot of polish with longitudinal directionality and tiny pits from sawing fresh bone (500x). (f) Edge-removal oriented longitudinally, edge-rounding and invasive smooth polish from cutting reeds (200x).

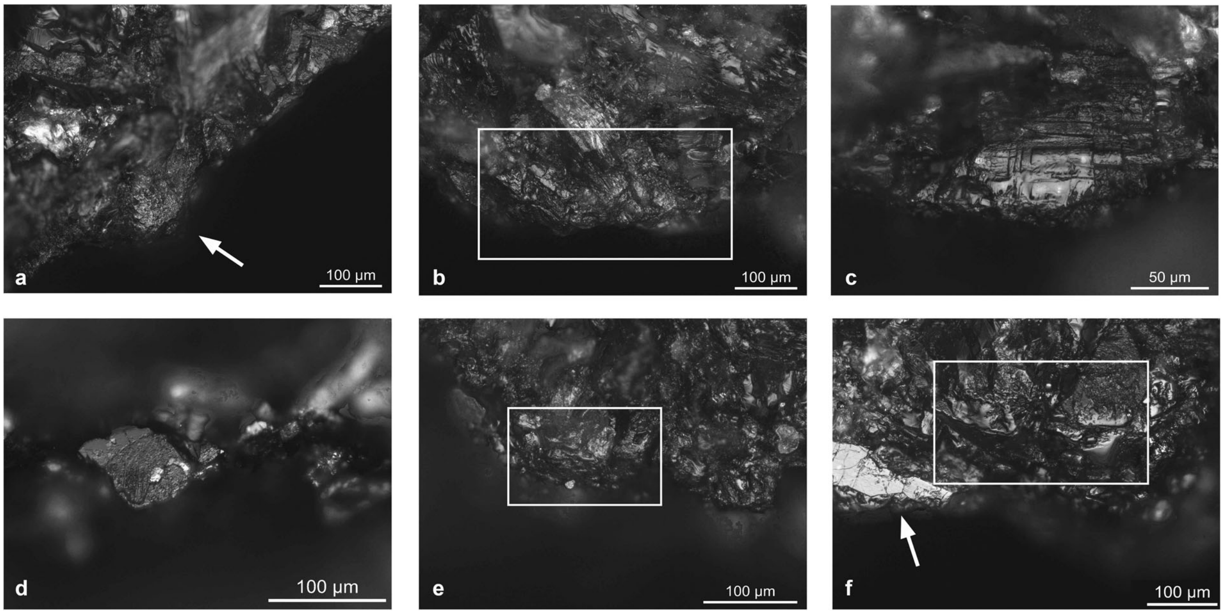


**Figure 4.** Selection of use-wear traces on experimental dolerite tools. (a) Edge-rounding and polish with granular texture (white arrow) from scraping fresh hide (200x). (b) Edge-rounding and granular polish from cutting fresh hide (200x). (c) Smooth polish with transverse directionality from scraping fresh bone (500x). (d) Abrasion and striations perpendicular to the edge on a protruding crystal from scraping fresh bone (300x). (e) Edge-rounding and domed polish with longitudinal directionality (white square) from sawing fresh bone (300x). (f) Edge-damage, invasive smooth polish (white square) and light abrasion (white arrow) from cutting reeds (200x).

(Figure 5(c)). Polish is mostly located on the dorsal cortical exterior of the flake used for cutting hide. Abrasion developed on endscrapers and flakes (Figure 5(b)). Due to the state of the worked material (fresh hide) the degree of abrasion is mostly light with small-sized hollows (cf. Clemente Conte et al., 2015).

*Bone*: Fresh bone traces – consisting of edge-removals, edge-rounding, polish, and abrasion – did not develop on all tools. Only one endscraper displays traces of use. Scraping fresh bone caused a light edge-rounding and isolated edge-removals. Polish – with transverse directionality – developed in isolated spots at the very edge and abrasion was documented in a few locations (Figure 5(d, e)). Cutting produced more edge-removals than scraping and very light rounding. A smooth polish, with pits and comet tails, developed on the cortical exterior of one cutting tool and has a localized distribution (Figure 5(g)). The degree of abrasion is higher on tools used to work bone compared to those used on hide, and the hollows are medium-sized and irregular in shape (Figure 5(f)) (cf. Clemente Conte et al., 2015).

*Reed*: Cutting fresh reeds resulted in isolated edge-removals, light rounding, and a band of smooth and matt polish with a domed topography (Figure 5(h, i)). The brightness of the polish is very intense and displays a longitudinal directionality. Reed polish is clearly visible both on the cortical exterior and crystalline surface of the tools. However, on the crystalline surface, the polish distribution is less uniform due to the uneven topography, but it is still invasive.

## Tool effectiveness

Raw materials proprieties (such as hardness, roughness, toughness) and the shape of the tools can influence tool efficiency, and this is directly related to edge maintenance. For use-wear analysis, this means that some raw materials and tool types may have a limited or typical build-up of use-wear. For example, in a brittle raw material, working edges with wear traces may continuously collapse resulting in a limited accumulation of traces. Therefore, I also recorded the degree of tool effectiveness.

I did not observe differences in the effectiveness of flint and chert tools while processing different materials. Flake tools and endscrapers were highly effective in the various activities. Only one chert flake used to cut fresh hide was ineffective. However, chert's lower efficiency depended mainly on the convex shape of the working edge, which is not particularly suited for cutting. The development of edge modifications did not significantly affect the performance of tools.

Not all the dolerite tools proved effective. I noticed a clear difference in effectiveness between retouched and unretouched implements. Endscrapers were overall less

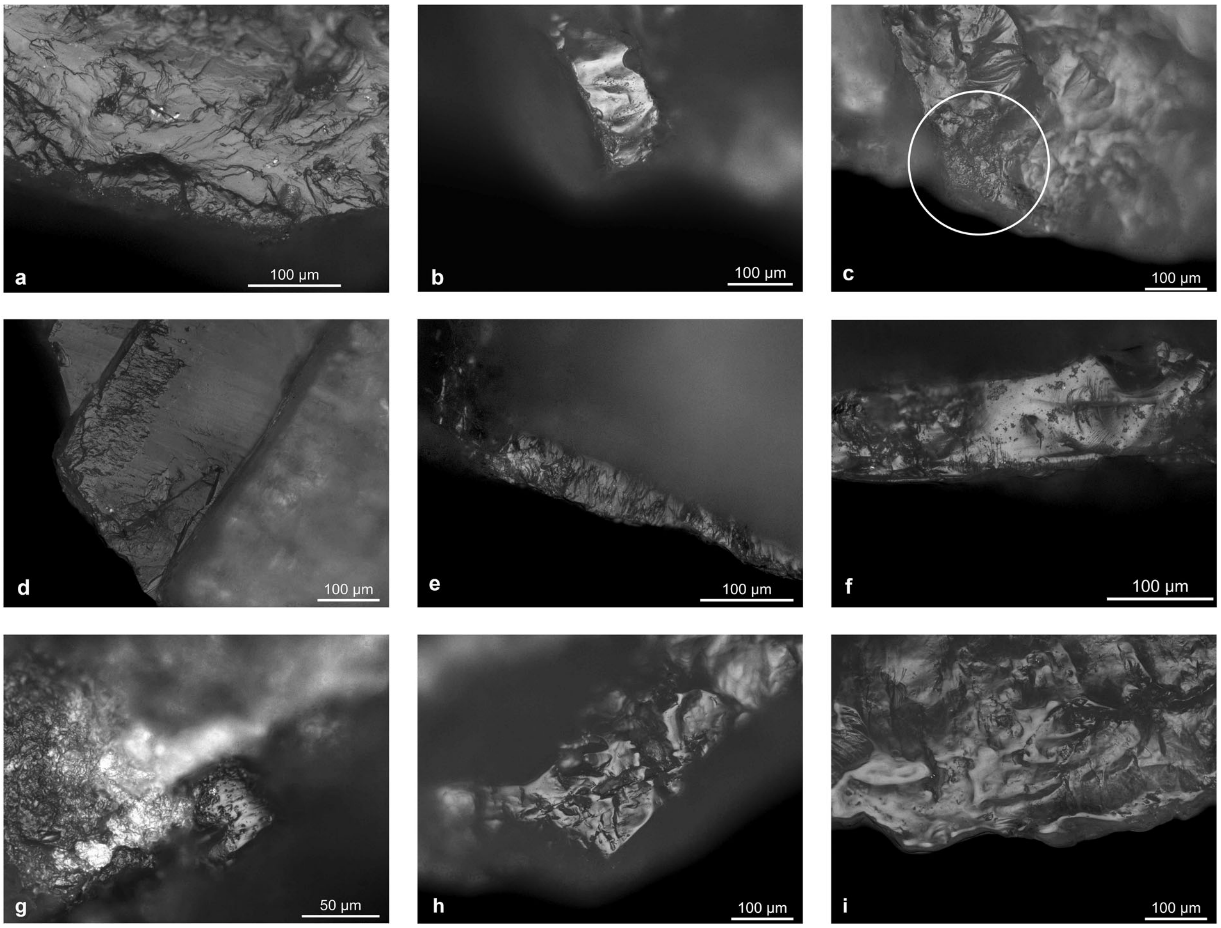


**Figure 5.** Selection of use-wear traces on experimental quartz tools. (a) Edge-rounding and polish from scraping fresh hide (200x). (b) Polish and abrasion from cutting fresh deer hide (200x). (c) Polish (circle) from cutting fresh hide (200x). (d) Edge-rounding and moderately developed abrasion from scraping fresh deer bone (200x). (e) Polish and linear features with transverse orientation from scraping fresh bone (300x). (f) Edge-removals and moderately developed abrasion from sawing fresh bone (300x). (g) Moderately developed spot of polish displaying tiny pits/comet tails (500x). (h, i) Edge-removals and fluid polish from cutting reeds (200x).

effective than flake tools and thick scraper-heads performed worse than thin ones. Endscraper effectiveness further decreased during use since edge-rounding and edge-reduction caused a rapid increase of the active edge angle. Conversely, unmodified flakes were effective cutting tools. However, the effectiveness of flakes used to saw bones rapidly declined during use due to continuous edge-crushing. Edge modifications were mainly caused by the loss of grains rather than fracturing (cf. Gibaja Bao et al., 2009).

Quartz tools were overall effective in the different activities, except for two cutting tools. Exp. 3822 was selected to process fresh bone. However, this tool has a granular internal structure, and during the use, the edge quickly crumbled. The convex indented lateral edge of exp. 3823 was unsuitable for cutting fresh hide. The efficiency of the latter depended mainly on the shape of the active edge rather than on the characteristics of the raw material. Due to the hardness of quartz, edge-rounding and edge-reduction formed slower compared to other rock types. That allowed quartz tools to retain their efficiency for a longer period of use. However, the edges tend to break prematurely compared to flint and chert.

## Discussion

### *Comparisons between non-flint and flint tools*

#### *Flint – chert comparison*

Chert and flint are both microcrystalline varieties of quartz. Due to their similarities, the development of and the traces themselves are thus expected to be similar (SI). According to Nieuwenhuis (2002), the characteristics of use-wear traces on chert, especially coarse-grained chert, were to some extent different from flint. The result of her experiment showed that traces on chert tools are comparable with those on flint tools, but less extensively developed, especially polish (Nieuwenhuis, 2002, p. 36). My study underlines this

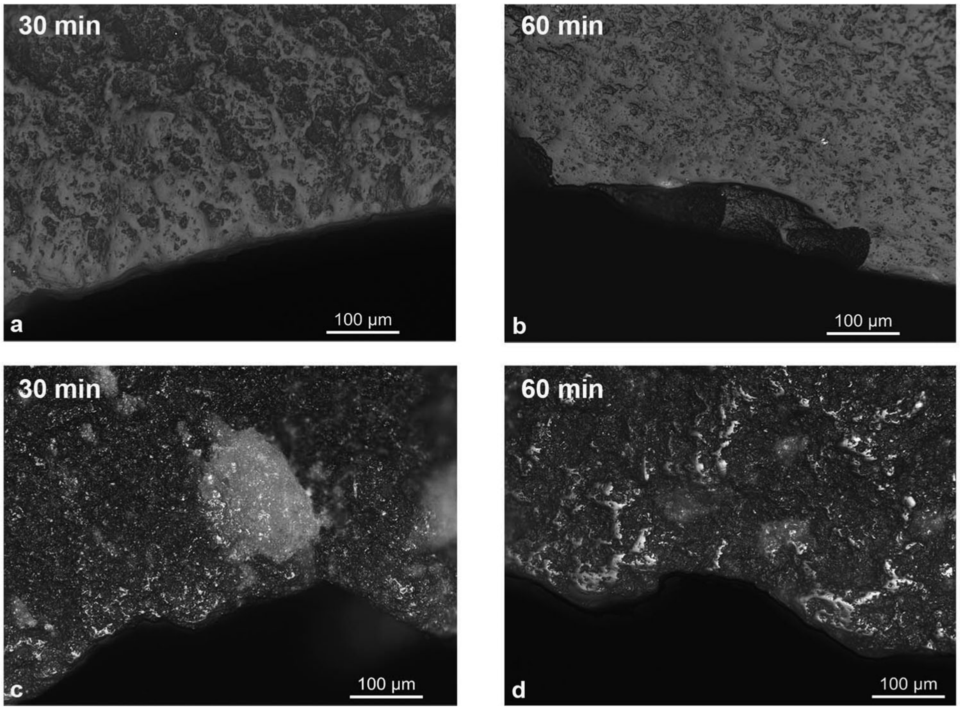


**Figure 6.** Comparison between reed polish on flint (top a–b) and chert (bottom c–d) distribution and degree of linkage after 30 and 60 min of use. Magnification 200x.

conclusion. Due to the uneven micro-topography of chert, especially on tools used to process medium and medium-hard materials (reeds and fresh bone), the polish started to develop on the higher areas of the micro-surface and extended gradually on the lower parts through use. Therefore, polish spots have a more localized distribution and a lower degree of linkage when compared to polish on flint (Figure 6).

Polish distribution, texture, and topography on chert tools are consistent with flint (Figure 7(a–c)). However, polish distribution on chert hide-cutting tools differs slightly from what was observed on flint tools. Instead of a continuous band of polish along the edge, a few spots of moderately developed polish were documented on protruding locations, while a light polish is more spread along the edge (Figure 7(a)). On both rock types, hide polish has a rough and greasy texture, while bone and reed polishes have a smooth and matt texture (Figure 7(b)). Deep craters in the polish, associated with hide as a contact material (Van Gijn, 1990), were documented only on tools used to scrape hide. Tiny pits in the polish are visible both on hide working and bone working tools. Bone and reed polishes mainly display a domed topography. Only on flint, some heavily developed spots of bone and reed polish have a flat topography (Figure 7(c)). The difference in polishes observed on experimental chert tools is thus quantitative rather than qualitative. Experimental traces on chert tools can be interpreted based on the ones observed on the flint reference collection, although a specific chert reference collection would be preferred.

### *Flint – dolerite comparison*

Despite their great abundance, specific studies on wear traces on dolerite tools are rare. Dolerite, like quartzite, is a heterogeneous rock therefore, data were interpreted in the light of studies conducted on other heterogeneous rocks and the few available on dolerite and basalt (e.g. Bello-Alonso et al., 2019, 2020; Clemente Conte et al., 2015; Clemente Conte & Gibaja Bao, 2009; Huet, 2006; Lemorini et al., 2019; Pedergnana & Ollé, 2017). On heterogeneous rocks, such as dolerite, edge removals – considered indicative of the hardness of the worked material (Tringham et al., 1974) – are less clear than on flint. When the scars are present, their morphological characteristics such as shape, initiation, and termination are not easily recognizable due to surface reflectiveness, micro-topography unevenness, and, secondarily, problems in the depth of field (cf. Pedergnana & Ollé, 2017). Rounding developed on the tool only after the active edge had stabilized. Prior to that, the continuous microflaking of the edge hindered the formation of rounding (cf. quarzite tools, Clemente Conte & Gibaja Bao, 2009). Other experiments conducted with the *Dolérite du Trieux* (a formation from the North Armorican Massif, France) pointed out the relative fragility of dolerite tools' cutting edges. Mechanical tests showed that hardness measurements are much lower on dolerite compared to flint and quartz, which

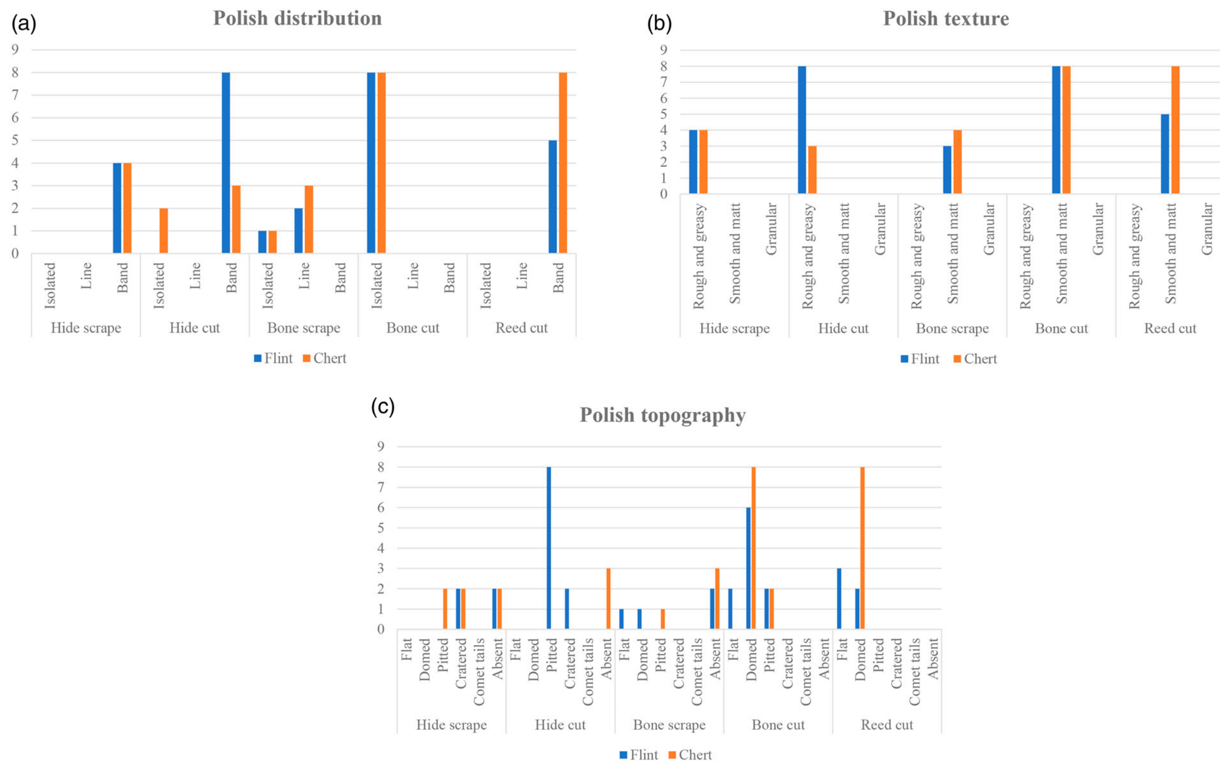


**Figure 7.** (a) Column charts displaying polish distribution on experimental flint and chert tools. (b) Column charts displaying polish texture on experimental flint and chert tools. Polish texture is consistent between flint and chert. (c) Column charts displaying polish topography on experimental flint and chert tools. On both rocks, craters occur only in hide polish, while pits on hide and bone polish. A domed polish is characteristic of bone and reed as contact materials on both rocks. Numbers represent the sum of locations on the tool (see Materials and Methods) where the polish characteristic was observed. Polish distribution is consistent between flint and chert tools except for chert hide-cutting tools on which the polish has a more localized distribution.

results in a rapid deterioration of the used edge (Huet, 2006) (also see SI). Regarding micro-wear, both from my experiment and the literature (Clemente Conte et al., 2015; Clemente Conte & Gibaja Bao, 2009), I can conclude that polish develops on dolerite slower than on flint, and its distribution is usually localized or restricted to small areas since only higher reliefs of the surface are in direct contact with processed material. The main difference between flint and dolerite concerns hide polish (Figure 8).

On flint, hide polish is distributed in a continuous band along the used edge. However, on dolerite tools, hide polish developed in isolated spots, both on the crystals and the matrix. A continuous band of light polish is visible only on hide-scrapers (Figure 9(a)). On dolerite, hide polish is mainly characterized by a granular texture while on flint is mostly rough and greasy (Figure 9(b)). Hide polish topography is flat on dolerite tools, and the characteristic pits or deep craters observed on hide polish on flint are absent (Figure 9(c)). On dolerite bone working tools, polish formed only on top of crystals and grains on the highest locations of the surface. While, on tools used to cut reeds, the polish developed in isolated spots on the crystals and the matrix and extends inside the piece (Figure 9(a)). On both flint and dolerite, the texture of both bone and reed polishes is mostly the same (Figure 9(b)). Dolerite bone-cutting tools mainly display no topography features since polish spots are usually not large enough to display topographical features. On endscrapers, a domed topography was documented. On flint, a domed topography and tiny pits are considered characteristic of bone as contact material (Keeley, 1980; Van Gijn, 1990). In the comparison, reed polish displays a similar domed topography (Figure 9(c)).

The characteristics of macro and microwear traces on dolerite tools partially overlap with those on flint. Micro polishes develop in general slower than on flint, and because of the irregular microtopography of the surface, the distribution is isolated, and degree of linkage limited. The difference in bone and reed polishes on dolerite is mainly quantitative (less polish in localized areas), while for hide polish is quantitative and qualitative (also a different appearance). Although hide polish texture and topography are different from flint, the invasiveness of the polish, its location both on high and low locations

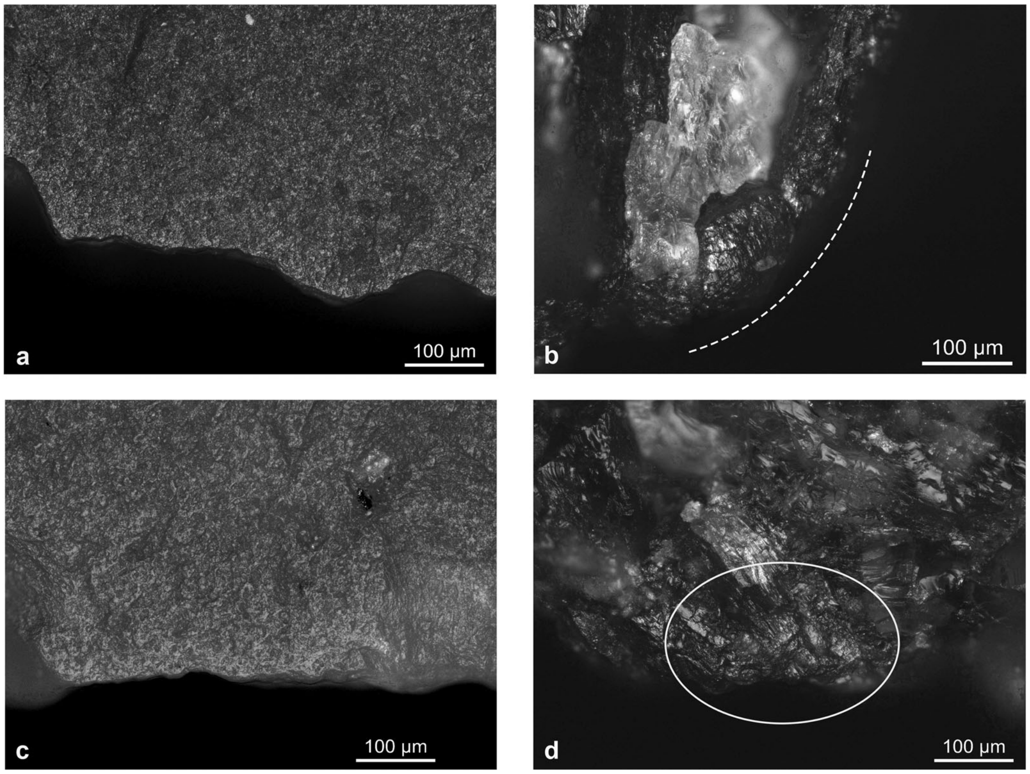


**Figure 8.** Comparison between fresh hide polish on flint endscraper (right, a) and flake tool (right, c) and dolerite endscraper (left, b) and flake tool (left, d). Magnification 200x.

of the edge, and the association with rounding all point unmistakably to soft materials processing. The greasy appearance of some spots of polish recalls animal materials rather than vegetal. Thus, the identification of the type of contact material remains feasible. A flint reference collection is useful in the identification of wear traces on dolerite tools. However, in some cases, additional specific experiments may be necessary for a more confident interpretation of the worked material mainly because of the variation of dolerite rocks composition and grain size which can affect wear traces.

### *Flint – quartz comparison*

Due to their differences in structure and mineralogical composition, quartz and flint have very different responses to mechanical stress (SI). That affects use-wear traces formation on these rocks. The experiment highlighted a clear difference between traces on the quartz crystal surface and the unflaked cortical exterior. Polishes, with very similar characteristics to flint, mostly form on the cortex/neo-cortex (Figure 10), while the quartz crystal surface mainly displays plastic deformations, linear features, and abrasion. As reported in the literature (Clemente Conte & Gibaja Bao, 2009; Knutsson et al., 2015), micro-polishes occur on quartz less frequently and much slower than on flint except for activities involving silica-rich materials, which result in a considerable amount of polish development. Therefore, unlike flint, where use is predominantly identified based on polish characteristics, the use of quartz tools must be identified based on other evidence as well.

The main difference concerning polish distribution is represented by hide polish. On flint, hide polish tends to develop in a continuous band along the used edge, while on quartz, on small and isolated spots. However, on the cortical side of hide-cutting tools, polish distribution is more continuous (Figure 11(a)). No differences in polish texture were noticed between flint and quartz (Figure 11(b)). Hide polish displays a rough and greasy texture, while bone and reeds polishes are smooth and matt. Polish topography is mainly absent, especially on tools used to process fresh hide. A few spots of polish on the cortical exterior of the bone-cutting tool have a domed topography. Pits and come tails, which are characteristics of bone as a contact material on flint (Keeley, 1980), were documented. Reed polish topography is domed on both rocks (Figure 11(c)).

Use-wear traces on quartz display distinctive characteristics, which are hard to interpret using only a flint comparative collection. By comparing the degree of edge-rounding and the amount of edge damage on quartz and flint tools, it may be possible to assess the hardness of the worked materials (cf. Semenov, 1964). But for a more precise interpretation of the contact

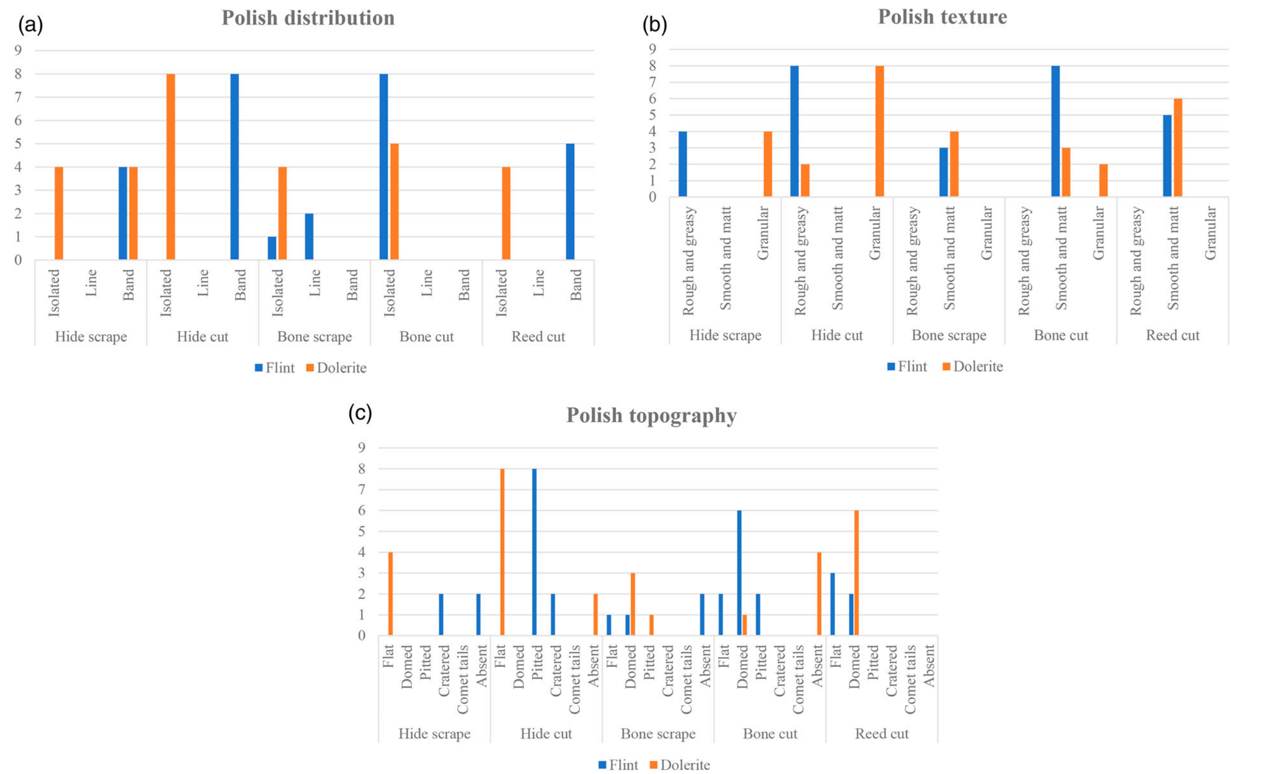


**Figure 9.** (a) Column charts displaying polish distribution on experimental flint and dolerite tools. On dolerite tools used on hide and reeds, the polish is mainly distributed in isolated spots, while on flint in a continuous band along the edge. (b) Column charts displaying polish texture on experimental flint and dolerite tools. On dolerite hide-working tools, the polish has mainly a granular texture, while on flint is rough and greasy. Polish on flint and dolerite tools used on bone and reed displays a domed topography. (c) Column charts displaying polish topography on experimental flint and dolerite tools. On dolerite hide-working tools the polish has mainly a flat topography, while on flint is either pitted or cratered. Polish topography on dolerite tools used on bone and reeds is consistent with flint. Numbers represent the sum of locations on the tool (see Materials and Methods) where the polish characteristic was observed.

materials based on quartz-specific wear traces (i.e. abrasion and striations), separate experiments are needed. Nevertheless, the results highlight the value of analyzing also the cortical surface of quartz tools. Micro-polishes that develop here are comparable with the ones on flint tools and can aid interpretation.

### *Functionality*

As pointed out in the results, tools made of different rocks varied in effectiveness in the same activities. The recognition of existing differences in tools' efficiency may have influenced prehistoric populations' choices in the selection of the raw materials for their tools. Flint and chert tools were overall the most effective. These rocks are easy to knap and produce implements with sharp edges easy to shape and maintain. Dolerite unretouched flakes were more effective than endscrapers. The presence of flakes with natural indented edges makes them particularly suited for cutting even though these edges became blunted soon when used to process hard materials. The degree of effectiveness of dolerite endscrapers was closely related to the shape of the functional edge. Scraper-heads were difficult to retouch and shape precisely because dolerite, like other though and coarse-grained rocks, is prone to crushing rather than fracturing, making it difficult to control the direction of the removals (Wadley & Kempson, 2011). Because of that, dolerite may have been preferred for unmodified tools rather than retouched ones. That is the case of Sibudu Cave, where unretouched implements were mostly made of dolerite, while retouched tools with hornfels and quartz (Wadley & Kempson, 2011). Despite their small dimensions, quartz flakes and endscrapers were functional in all the activities. No differences in functionality between unretouched and retouched tools were observed. From good-quality blocks of quartz, it is possible to obtain tools with sharp and robust functional edges. Quartz endscrapers proved effective even though the obtuse angle of the scraper-heads. This was because endscrapers remained sharp and functional due to the slow progression of wear damage on the

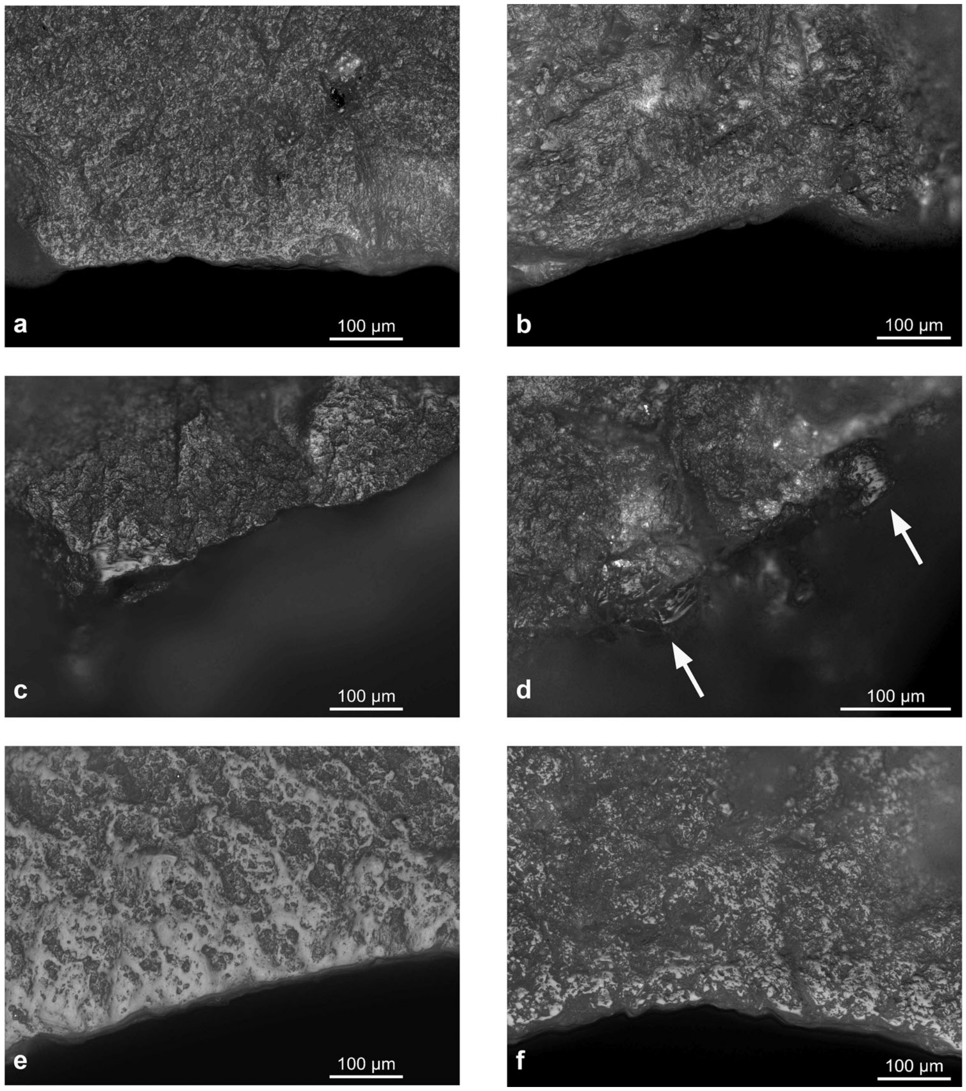


**Figure 10.** Comparison between polishes on experimental flint tools (a, c, e) and on the unflaked cortical exterior of experimental quartz tools (b, d, f). (a–b) Fresh hide polish. (c–d) Fresh bone polish. (e–f) Fresh reed polish. (a, b, c, e, f) Magnification 200x. (d) Magnification 300x.

working edge. A limitation in the use of quartz as raw materials for tools may lie in the small dimensions of the products due to its high fragmentation proneness during knapping (Tallavaara et al., 2010).

### *Limitations and archaeological visibility of traces*

My experiments showed that use-wear traces, especially polishes, develop slower on non-flint rocks than on flint, especially on dolerite and quartz. Hence, archaeological non-flint tools briefly used may not display sufficiently developed use-wear to allow a functional interpretation.

That applies particularly to dolerite and tools made from brittle rocks in general, where the continuous crushing of the active edge affects the formation and recognition of use-wear traces since they are constantly removed during use and preserved only on little spots. Due to that, even artifacts with a long use life may display only light evidence of use or no wear traces (cf. Pedergnana & Ollé, 2017). For flint and chert, we can expect traces to accumulate through use unless they are intentionally removed by resharpening. A loss of wear traces can happen during the processing of hard contact materials. However, edge-damage rarely removes all the evidence of use. For quartz, the slow formation rate of wear traces may lead to a misidentification or misinterpretation of expedient tools.

In addition, my experiment showed that the edges of dolerite tools wore down rapidly, and resharpening sessions were needed to extend their use cycle. However, in areas where lithic raw materials were abundant, flakes may have been quickly abandoned and replaced when dull, especially if made of non-homogeneous rocks unsuited for retouching. That is the case, for instance

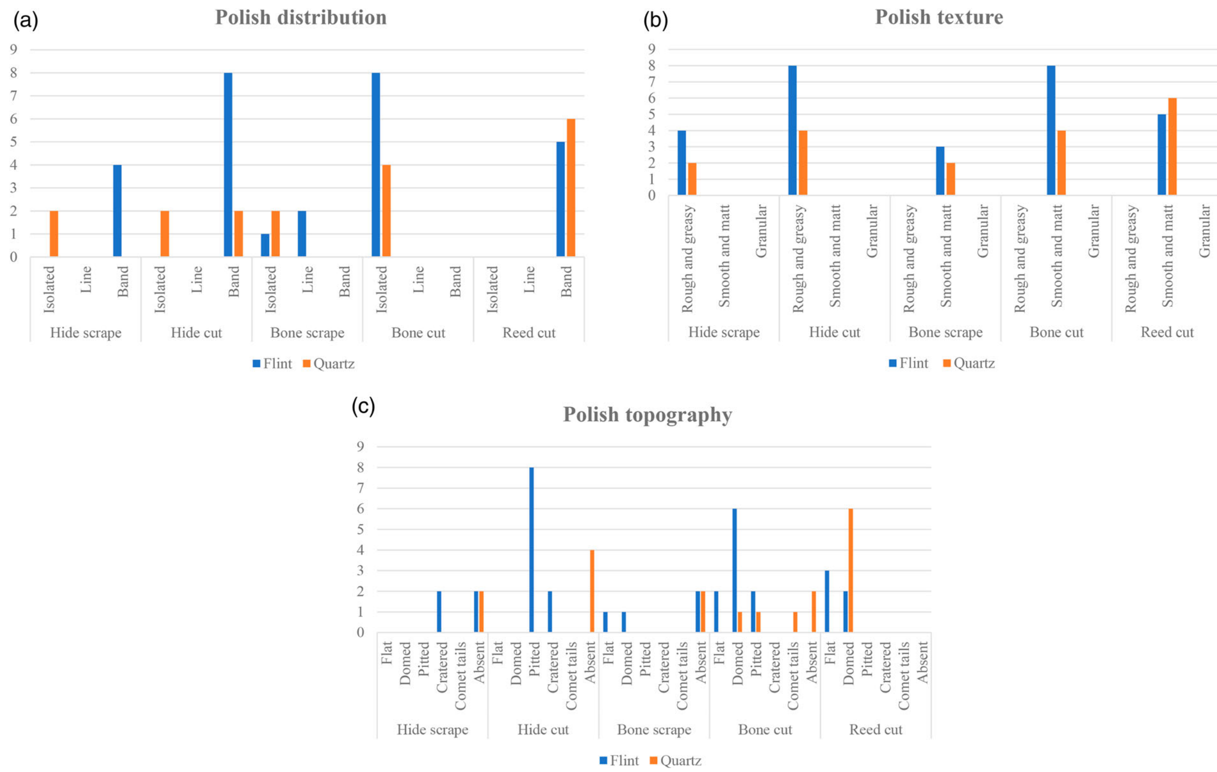


**Figure 11.** (a) Column charts displaying polish distribution on experimental flint and quartz tools. On quartz hide-working tools the polish is mainly distributed in isolated spots, while on flint in a continuous band along the edge. (b) Column charts displaying polish texture on experimental flint and quartz tools. Polish texture is consistent between flint and quartz tools. (c) Column charts displaying polish topography on experimental flint and quartz tools. Polish topography is mainly absent on quartz tools except for the ones used to cut reeds. Polish from contact with reeds displays a domed topography. Numbers represent the sum of locations on the tool (see Materials and Methods) where the polish characteristic was observed.

in New South Wales, Australia, where knappable raw materials, like silcrete, quartz and quartzite, are locally available. Ethnographic accounts have shown that Australian Aboriginals prefer to replace their quartz tools when exhausted rather than invest time in rejuvenating them (Holdaway & Douglass, 2015). Even though resharpening tends to remove traces from previous use sessions, well-developed spots of use-wear may survive in between resharpening scars (e.g. Loebel, 2013). Conversely, discard of tools in an early stage of use means traces remain poorly developed. In addition, when used to process hard materials, dolerite and quartz tools displays small localized areas with traces that can be easily missed during the analysis. As already stated in the literature (e.g. Clemente Conte et al., 2015), the examination of wear-trace characteristics on single crystals and grains within the matrix requires higher magnifications compared to flint and possibly other analytical techniques such as SEM and digital microscopy. Thus, the analysis of heterogenous rocks is more time consuming than of flint. Furthermore, mechanical or chemical post-depositional alterations may remove or obliterate traces of use (Van Gijn, 1990). However, several studies showed that quartz appears more resistant to post-depositional modification than flint highlighting the potential of this material in contributing to our knowledge on the activities of prehistoric people (Clemente Conte et al., 2015; Lazuén et al., 2011; Venditti et al., 2016). Therefore, it is likely that the number of used non-flint artifacts is underestimated. The state of preservation of the material but also the mineralogical composition and mechanical proprieties of rocks featuring the lithic assemblage are all factors that could favor the identification of traces of use on knapped stone tools or explain their absence, and they should be considered by the analyst.

## Conclusion

This experiment tested the possibility of using a flint reference collection to interpret use-wear on different rock types. Experimental wear traces on European flint tools were compared with wear traces on chert, dolerite and quartz. No major differences between flint and chert were observed. Use-wear on chert can be confidently interpreted using a reference collection of flint tools if the wear traces are developed enough. Even though I noted several differences in the distribution and characteristics of wear traces between dolerite and flint, a flint reference collection can allow a general interpretation of the use motion and hardness of the worked material. The precise interpretation of the contact material may be more problematic except for dolerite tools used to process siliceous plants. I observed strong similarities between the use-polish on quartz cortical exterior and flint. However, the function of quartz tools cannot be inferred only using a flint reference collection. The degree of edge-rounding and abrasion and the frequency and distribution of edge-removals can help in the identification of the hardness of the contact material, but specific experiments are required for a more precise interpretation of the worked material.

Flint and chert tools performed best in all the various activities. The edges retained their functionality for a longer period of use, and wear traces developed sufficiently to allow a confident interpretation. Dolerite unretouched tools were more effective than retouched ones. Yet the edges of dolerite tools were the most fragile overall. They wore and crumbled, resulting in wear traces that were scattered and limited to isolated spots. Quartz tools were effective and wore slower compared to flint, chert and dolerite. However, the performance of quartz tools is influenced by the structure of the block. Internal discontinuities, micro-fractures or inclusion may lead to premature breaking of the working edge.

The direct comparison of use-wear on tools made from different rocks allowed me to observe how traces from the same contact material developed at different rates based on the tool's raw material. In addition, the observation of rock-specific mechanism of wear (e.g. continuous edge-crushing on dolerite) helped explain the limited presence or absence of wear traces on used tools. The study shows that a partial overlap exists between the use-wear features on European flint and chert, dolerite, and quartz. These need to be considered in light of the different proprieties and characteristics of the rocks to achieve a correct functional interpretation.

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## Disclosure statement

No potential conflict of interest was reported by the author(s).

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