‘Blind’ perspectives on microwear formation on southern African lithic raw materials

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Abstract

The African archaeological record incorporates a wide range of stone tool raw materials that present both opportunities and challenges to use-wear analysts. While previous works have highlighted the variable responses of different rocks to mechanical stress and the need for tailored reference collections, the extent to which use-wear diagnostic criteria can be transferred between raw materials has rarely been formally investigated through blind tests. We present here the results of a blind test that included 22 flake tools in five raw materials relevant for southern African archaeology: quartz, quartzite, hornfels, silicified mudstone, and dolerite. The test employed stereomicroscopy and incident light microscopy and reference material in flint and quartz. Difficulties were encountered in attempting to infer worked materials for silicified mudstone and hornfels based on the flint reference due to their differential resistance to fracture and abrasion. The quartz reference proved relevant for interpreting wear on quartzite, but the discontinuous distribution of microwear posed a challenge to the untrained eye. Dolerite developed flint-like wear only marginally, and tool motion and contact material could not be reconstructed for any of the test tools. Biases derived from the analyst’s previous training and the composition of the available reference collections were clearly illustrated throughout the test. Our exploratory blind test thus corroborates the need to invest in raw material-sensitive experimental programmes and analyst training to ensure high-quality functional data.

Keywords

Use-wear, quartz, quartzite, silicified mudstone, hornfels, dolerite, blind tests

1 Introduction

Africa is a vast continent with a varied geology that translates into an archaeological record characterised by a multitude of stone tool raw materials. While early ground-breaking efforts towards method-building in lithic use-wear analysis touched upon a wide range of different rocks (see e.g. contributions in Hayden, 1979) and pioneering works to adapt use-wear analysis methods to southern African lithic raw materials quickly followed (Binneman, 1983; Binneman and Deacon, 1986), a large part of the research between the 1960s and 1980s focused on flint and chert (Keeley, 1980; Odell, 1981; Semenov, 1964; Tringham et al., 1974; Vaughan, 1985; but see Broadbent and Knutsson, 1975; Fullagar, 1986; Knutsson 1988a, 1988b; Richards, 1988). This has led to an overall bias towards flint in method development (Asryan and Rots, 2024). For the part of Africa, the situation is gradually being mended through experimental and archaeological research focused on the local industries and stone tool raw materials (e.g. Bello-Alonso et al., 2019, 2020, 2021; Beyries and Roche, 1982; Binneman, 1994, 1997; Binneman and Beaumont, 1992; Binneman and Deacon, 1986; de la Peña et al., 2018; Djellal et al., 2025; Galland et al., 2024; Igreja and Porraz, 2013; Keeley and Toth, 1981; Lemorini et al., 2014, 2019; Lombard, 2005, 2006; Lombard et al., 2004; Pargeter, 2011; Pargeter et al., 2017; Porraz et al., 2013, 2020; Rots et al., 2017; Sussman, 1987; Taipale and Rots, 2019; Taylor and Barham, 2025; Tomasso, 2021; Wadley and Binneman, 1995; Wurz and Lombard, 2007).

Amidst the sustained interest in wear formation on ‘non-flint’ rocks, contrasting views have been expressed in recent studies about the extent to which reference collections need to be tailored to each individual archaeological context, and to what degree wear descriptive and interpretative criteria can be transferred between different stone tool raw materials. Some analysts have drawn upon petrographic characterisation of lithic raw materials and emphasised significant differences in use-wear formation not only between but also within raw materials (e.g. Bello-Alonso et al., 2020; Pedergnana et al., 2017, 2018; Richards, 1988), whereas others have advocated for a broad convergence in wear formation and the suitability of flint-based reference collections for basic interpretation (Aleo, 2022).

We present here the results of a multi-raw material blind test focused on five southern African lithic raw materials: silicified mudstone, hornfels, quartz, quartzite and dolerite. The test was designed to investigate the possibilities and pitfalls in attempting to interpret wear features on previously unencountered raw materials using reference collections based on other rocks. The test results and complementary analysis allowed us to detect both overlapping and divergent patterns in the formation of macroscopic and microscopic wear. They advise against the use of ‘universal’ (often flint-based) interpretative frameworks without a careful consideration of the variable responses of lithic raw materials to mechanical stress at multiple scales.

2 Study design

2.1 Raw material selection and classification

We selected five raw materials that were used at southern African sites during the Stone Age: xenomorphic (vein) quartz collected in South Africa, quartzite and silicified mudstone deriving from outcrops in the vicinity of the archaeological site Kalambo Falls in Zambia, and dolerite and hornfels from near the site of Sibhudu Cave in South Africa.

Raw material identification was based on macroscopic field evaluation and preliminary comparisons between geological samples and lithics from the relevant archaeological sites and has not been verified through laboratory analysis. Because the aim here is to examine the transferability of microwear diagnostic criteria between raw materials in a broader perspective, we settle with applying these field labels. As the accuracy of field classification of African rocks by archaeologists can be variable (see e.g. Sifogeorgaki et al., 2023; Tarriño et al., 2023), future petrographic characterisation of the varieties included in this blind test can be recommended to obtain a more in-depth understanding of wear formation (cf. e.g. Bello-Alonso et al., 2020; Pedergnana et al., 2017).

We use here the term ‘quartzite’ in the broad sense (cf. Prieto et al., this volume). The pieces included in the test present some variation but represent unmetamorphosed quartz arenites and orthoquartzites (see Clark, 2001 for a description of the varieties). Grain size varies from c. 0.1mm to 1mm. The rocks are compact and fracture dominantly (but not exclusively) through the grain. Of non-quartz minerals, at least iron oxides and unidentified black minerals appear to be present in small portions.

The silicified mudstone has a chert-like appearance, but upon preliminary inspection, its fracture surfaces are matte and somewhat powdery, and it may be softer than the varieties present in the archaeological assemblage from Kalambo Falls (see Clark, 2001).

The dolerite pieces included here represent different varieties, ranging from the coarsest sort that is composed of relatively large crystals with very little matrix in between to ones characterised by a finer-grained texture and abundant matrix that binds together dispersed large crystals (**Figure 1**). Some varieties present weathered grains embedded in the structure.

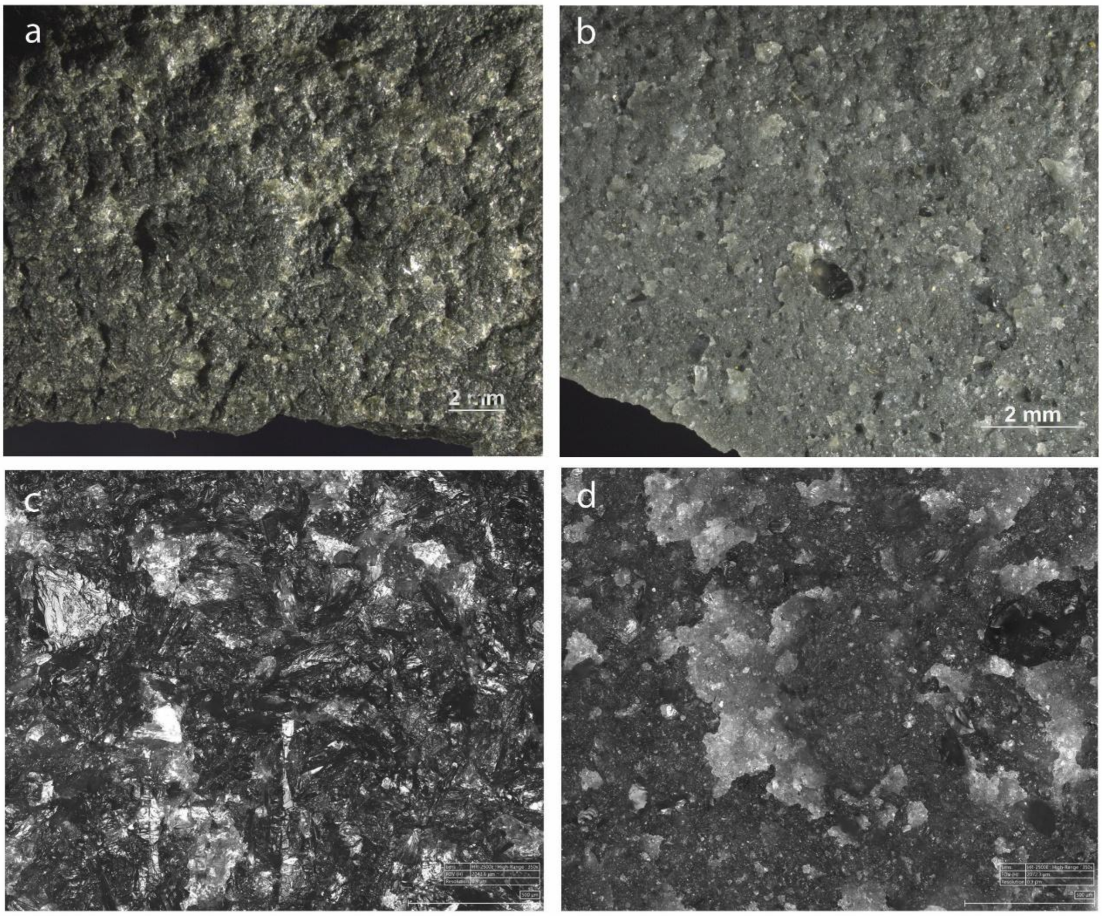

Figure 1 *Examples of coarse (large crystal-dominated) and fine (matrix-dominated) varieties of dolerite included in the blind test set.* ***a*** *Stereomicroscope view of BT10/02, coarse dolerite (11.2×)* ***b*** *Stereomicroscope view of BT10/34, fine dolerite (11.2×)* ***c*** *Digital microscope view of BT10/02, coarse dolerite (coaxial light; stitched images captured at 350× digital magnification, scale bar 500 µm, horizontal field of view 2043.6 µm)* ***d*** *Digital microscope view of BT10/34, fine dolerite (stitched images captured at 350× digital magnification, scale bar 500 µm, horizontal field of view 2072.3 µm).*

2.2 Blind test set-up

Thirty flake tools were produced in the five raw materials described above (silicified sandstone, hornfels, quartz, quartzite, dolerite) by CL, an experienced knapper and stone tool user. All the tools had unretouched working edges to maximise the visibility of scars and rounding. The only exception was tool BT10/15 where the distal extremity of the active edge was retouched lightly for a stretch of 17mm to regularise the outline. Basic morphometric data for the flake tools is provided in **SI**.

The tools were used for 15–20 minutes in six different activities to provide comparable sets of tools across the raw materials (**Table 1; SI**). Judging from the development of wear on flint and quartz tools in the reference collections available to us (Rots, 2021; Taipale 2012), these use durations are short. Brief use was opted for to gain a preliminary understanding of the formation and interpretability of wear on the previously unexamined raw materials and to identify potential differences in the speed of initial wear development. Among the 30 used pieces, 22 were selected for a blind test (VR) and handed over to the analyst (NT) after cleaning. No information about the tools was shared beforehand.

Table 1 *Set of 22 flake tools included in the blind test (for full data, see SI).*

Tool ID	Raw material	Action	Worked material	Duration of use
BT10/01	Hornfels	Digging	Dry loess	20'
BT10/02	Dolerite	Scraping	Dry wood	20'
BT10/03	Quartz	Cutting	Common reed	20'
BT10/04	Quartzite	Butchery	Wild boar leg	15'
BT10/05	Dolerite	Scraping	Dry bone	20'
BT10/06	Silicified mudstone	Digging	Dry loess	20'
BT10/07	Hornfels	Scraping	Dry hide	20'
BT10/08	Quartz	Scraping	Dry wood	20'
BT10/09	Silicified mudstone	Cutting	Common reed	20'
BT10/10	Hornfels	Butchery	Wild boar leg	15'
BT10/11	Quartzite	Scraping	Dry hide	20'
BT10/12	Quartz	Scraping	Dry bone	20'
BT10/13	Dolerite	Digging	Dry loess	20'
BT10/14	Quartzite	Scraping	Dry wood	20'
BT10/15	Hornfels	Cutting	Common reed	20'
BT10/20	Silicified mudstone	Scraping	Dry bone	20’
BT10/23	Hornfels	Scraping	Dry wood	20’
BT10/25	Quartz	Scraping	Dry hide	20’
BT10/27	Silicified mudstone	Scraping	Dry hide	20'
BT10/28	Quartzite	Scraping	Dry bone	20'
BT10/29	Silicified mudstone	Butchery	Wild boar leg	15'
BT10/30	Quartzite	Digging	Dry loess	20'

At the time of the test (2021), NT had previous experience in analysing flint, chert, and radiolarite (several years) and quartz (less than a year), limited experience in analysing quartzite (beginner), and no experience with silicified mudstone, hornfels, or dolerite. Among the raw materials, the silicified mudstone is the closest to flint, followed by hornfels. Dolerite, a volcanic rock, was the furthest from the analyst’s previous experience. The reference material used to aid the test was limited to the flint component in the TRAIL reference collection (Rots, 2010, 2021) and to a small experimental sample in quartz (Taipale, 2012).

The test was conducted in two steps. The tools were first examined only under low magnification using a stereomicroscope and the preliminary interpretations were handed in. The second step was completed by combining observations made under high magnification with those made with the stereomicroscope. A Zeiss Stemi 2000-C stereomicroscope with external oblique lighting and a Zeiss Imager.A2 Vario incident-light microscope equipped with four objectives (Zeiss EC EPIPLAN 5x/0,13 HD 422030-9961, Zeiss EC EPIPLAN 10x/0,25 HD 422040-9961, Zeiss LD Epiplan 20x/0,4 ∞/0 422850-9900 and Zeiss LD Epiplan-NEOFLUAR 50x/0,55 DIC ∞/0 422472-9900) were used in the test, primarily operating at magnification range between 100× and 500×.

The test was marked by giving one point for a correct answer for each of the following four categories: identifying the tool as used/unused; locating the used edge; determining the action (direction of tool movement); and identifying the contact material. Half a point was given for partially correct answers. For worked material identification, narrowing the contact material down to its relative hardness and/or abrasiveness earned a full point in low magnification analysis considering that this method is usually not capable of identifying exact contact materials (Odell and Odell-Vereecken, 1980). Half a point was given in marking the combined part of the test if relative hardness/abrasiveness was inferred correctly but the detailed identification failed. For reed that is a relatively soft but resistant plant, ‘soft’ and ‘medium-hard’ interpretations were both considered correct answers.

2.3 Post-test analysis and additional experiments

After the test, the tools were re-examined by NT in the light of the tool use details. At the same time, the eight tools that were left out of the blind test set were analysed to attain fully comparable sets for each task and raw material. Five more flake tools were made and used by CL for a longer duration, 40 minutes, to account for poorly developed wear on some of the test tools. The blind test sample and the test results were additionally revisited in 2025 after NT had gained more experience in the analysis of quartzite, and the wear on the test tools documented in further detail.

The use-wear was imaged during and after the test under low magnification with a Zeiss Axio Zoom.V16 (objectives PlanApo Z 0.5x/0.125 FWD 114mm and PlanApo Z 1.0x/0.25 FWD 60mm), microscope camera AxioCam ICc 5 and software Zeiss AxioVision, using Helicon Focus for z-stacking (method B, smoothing 1, radius 8–10). The Zeiss Imager.A2 Vario incident-light microscope (for lens details, see above) equipped with a Zeiss Axiocam 305 Color microscope camera and the Zeiss software AxioVision and Zen Blue were used for high-magnification image acquisition and Helicon Focus for z-stacking (same settings as above).

Additional images of dolerite surface textures and wear features were acquired with a digital microscope Hirox HRX-01 (objective HR 2500-E, high range, 350× digital magnification) under coaxial light using the 3D tiling function of the Hirox HRS-3DT software package. Some of the wear was further imaged with a scanning electron microscope JEOL IT300 in secondary electron mode at 20kV and 40Pa on uncoated samples.

Contrast and brightness of the microscope images were adjusted in Adobe Photoshop (version 27.5.0) when judged necessary to enhance the visibility of relevant features. Annotations were likewise added in Photoshop.

3 Results

When all 22 tools are considered, the combined use of low and high magnification performed better on average in the test (**Table 2**; **SI**), consistent with the findings of our previous blind tests on flint and quartz (Rots et al., 2006; Taipale et al., 2023). However, when the results are examined per raw material, contrasting patterns emerge. For quartz, quartzite and dolerite, incorporating high magnification observation improved the relative success rate, whereas for silicified mudstone and hornfels, the effect was reversed due to the frequent failure to identify exact contact materials that was expected in combined analysis (**Table 2**). The differences are minor, but for these two raw materials, low magnification observation that aimed at determining the tool motion and relative hardness of the worked material produced more reliable results than high magnification analysis that was hoped to provide further details. We interpret this as deriving from the low development (sometimes absence) of microscopic wear (smoothing/polish) recognisable within a flint-based reference framework.

Table 2 *Comparison of blind test relative success rates for different raw materials, calculated by dividing the average of scores in different categories (use status, used edge, action, worked material) by the number of test tools, reported with the simple averages of the relative success rates. Full results in* ***SI****.*

Raw material	**Low magnification success rate (/1)**	**Low and high magnification success rate (/1)**	**Test tool count**
Silicified mudstone	0.88	0.80	5
Hornfels	0.85	0.80	5
Quartz	0.41	0.72	4
Quartzite	0.35	0.50	5
Dolerite	0.21	0.25	3
Average	*0.54*	*0.61*	*22*

The analyst's previous experience significantly influenced the test result. The error rate shown in **Figure 2** was calculated by summing up the relative proportion of wrong interpretations in each of the following categories: 1) use status (used/unused), 2) location of used edge, 3) action (tool use gesture), and 4) the worked material (relative hardness at low magnification level, detailed identification in combined analysis).

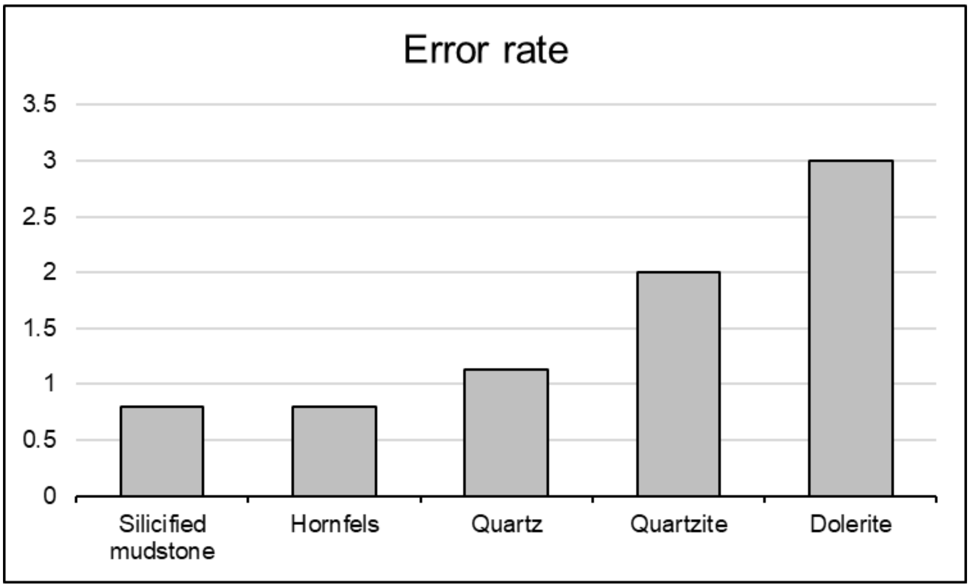

Figure 2 *Blind test error rate (out of maximum of 4) calculated for each raw material by summing up the relative proportion of wrong identification in the four categories examined (use status, used edge, action, worked material).*

Silicified mudstone and hornfels that can develop scar patterns roughly comparable to flint posed the least challenge to low magnification analysis and yielded the lowest error rates overall. Quartz follows as the third raw material, consistent with the analyst's previous (limited) experience and the small reference collection available during the test. For quartzite, errors were more frequent in identifying the action and worked material compared to quartz, and the score for combined analysis systematically lower, although worked edges could be located slightly more frequently on quartzite as opposed to quartz under low magnification. Finally, dolerite clearly stands out with the highest error rate (**Figure 2**) and the lowest scores in the test for the identification of used edges, tool motion, and worked material, independent of the analytical technique (**Table 3**). We will discuss the results in further detail below for each raw material, attempting to explain the patterns visible in **Tables 2 and 3**.

Table 3 *Relative proportion of correct identifications (out of 1) for the five raw materials in different parts of the test (low magn. = low magnification, comb. = combined low and high magnification analysis).*

Raw material	**Used/unused**		**Used edge**		**Action**		**Worked material**		**Σ tools**
	Low magn.	*Comb.*	*Low magn.*	*Comb.*	*Low magn.*	*Comb.*	*Low magn.*	*Comb.*	
Silicified mudstone	1.0	1.0	1.0	0.9	0.7	0.7	0.8	0.6	5
Hornfels	1.0	1.0	1.0	1.0	0.7	0.7	0.7	0.5	5
Quartz	0.4	0.8	0.5	0.8	0.5	0.8	0.3	0.6	4
Quartzite	0.6	0.6	0.6	0.6	0.1	0.6	0.1	0.2	5
Dolerite	0.5	0.7	0.3	0.3	0.0	0.0	0.0	0.0	3

3.1 Silicified mudstone

The used edge could be identified correctly on all the blind test tools made from silicified mudstone (n=5) under low magnification. For the butchery tool (BT10/29), a tentative proposition was added during high magnification analysis that both lateral edges might have been used, which was incorrect. The wear on the left edge mistaken for use may derive from prehension (see Rots, 2010), but considering the short duration of use, this remains to be investigated though further tests.

Two mistakes were made in inferring tool use gesture: the digging tool (BT10/06) was interpreted as having been used in transverse motion and the tool used on dry hide misinterpreted as having been used longitudinally (see **SI**). While the microwear on the hide-working tool (BT10/27) was judged to lack clear linearity when examined after the test, and the oblique orientation of some of the scars (**Figure 3a**) may be considered somewhat misleading, the edge damage pattern (position of scars and rounding) was considered informative enough of transverse motion. The errors made at the level of tool motion therefore derive from lack of attention to all available evidence during the test rather than poor development of characteristic fracture and edge rounding attributes.

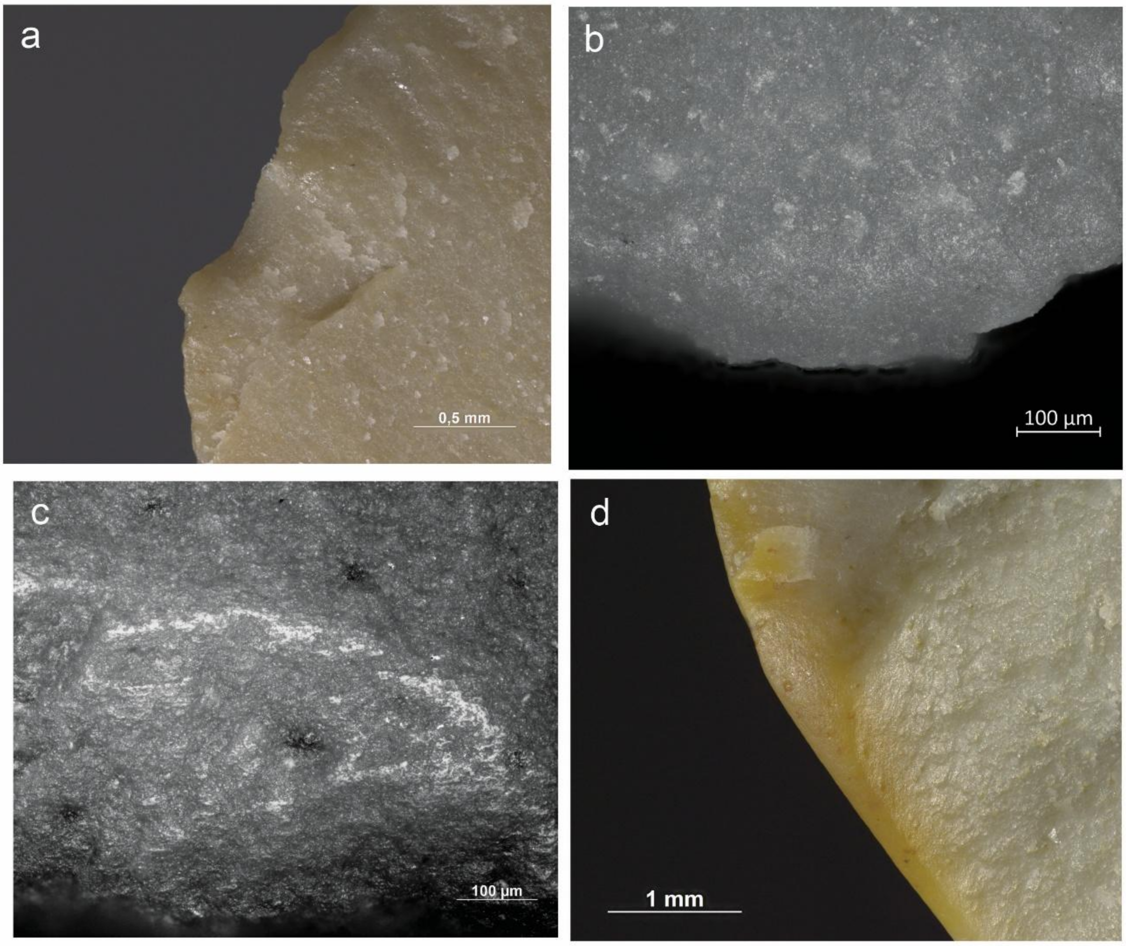

__Figure 3__ Wear on silicified mudstone blind test tools. a Obliquely oriented bending-initiated step-terminated scar on the rounded edge of BT10/27, used for scraping dry hide (80×) ***b*** *Edge rounding and limited polish on BT10/27 used for scraping dry hide (200×)* ***c*** *Polish concentrated on ridges on BT10/09, used for cutting reed (200×)* ***d*** *Edge rounding on BT10/06 used for digging loess (50×).*

Mistakes in identifying worked materials were more frequent. The analysis of the butchery knife was the closest to success, with the combined low and high magnification analysis concluding that the test tool had made contact with at least soft animal tissue and possibly harder material (**SI**). The initial 'plant/wood' interpretation was speculative and based on the detection of potential bright polish under low magnification, which turned out to be finger grease or other handling contaminant when examined under high magnification.

The tool used for working dry hide (BT10/27) was judged as potentially having been used for butchery as well, which is an understandable error considering that dry raw hide can vary in resistance even within a single piece and lead to variable wear. However, the homogenous edge rounding present on parts of the edge can be considered comparable to dry hide wear on flint even though polish is much more limited (**Figure 3b**).

Bone (BT10/20) could be characterised in the test as 'hard organic material', but fully informative microwear was judged to be lacking.

The reed-cutting tool (BT10/09) was identified as having been used for cutting soft plants during low magnification analysis based on the combination of scarring, edge rounding, and bifacially distributed polish visible under the stereomicroscope. In high magnification analysis a closer inspection of the polish led to changing the interpretation to ‘wood’, as the polish was considered too concentrated on the high points of the microtopography to fit with soft plant material (**Figure 3c**).

Loess (sediment) could not be identified as a contact material in the test (BT10/06). The TRAIL reference collection (Rots, 2010, 2021) includes digging tools in flint, but these bear strong soil sheen that was absent on the mudstone test tool. A ‘dry hide’ interpretation was offered during the test due to the strong edge rounding (**Figure 3d**), but microscopic abrasion features associated with it were limited and uninformative.

In sum, the flint reference produced reasonably good results for the silicified mudstone due to overlapping scar patterns. In contrast, differences in the formation of polish became evident. Its limited development can be hypothesised to relate to the comparatively low strength of the material that results in continuous, cyclical rejuvenation of the surface through the removal of particles above the size of those resulting in polish formation. The continuous removal of larger particles is testified by the relatively quick development of macroscopic rounding. This hypothesis should, however, be investigated through further experimental work. Whether the relative weakness of the rock might relate to its lower silica content remains to be determined through petrographic analysis.

3.2 Hornfels

On hornfels, edge damage visible under low magnification formed readily enough for all the used edges (n=5) to be detected after 15–20 minutes of use. The interpretability of the scars varied from one experimental tool to another and was strongly affected by the degree of metamorphosis of the rock. On some tools, the attributes (initiations, terminations) of the scars could be described using the framework developed for flint, as the structural features of the raw material did not significantly interfere with crack propagation (**Figure 4a**). However, in other cases, the partially incomplete metamorphosis had preserved the sedimentary layering of the parent rock, which resulted in fractures being partly guided by the natural layers. This produced initiations that cannot be described on the usual bending–cone continuum. Scar patterns on these varieties appear to derive from the removal of small blocks of material on the tool edges (**Figure 4b**). The quick development of edge rounding (**Figure 4c**) probably relates to the relative softness of the variety of hornfels included in the test.

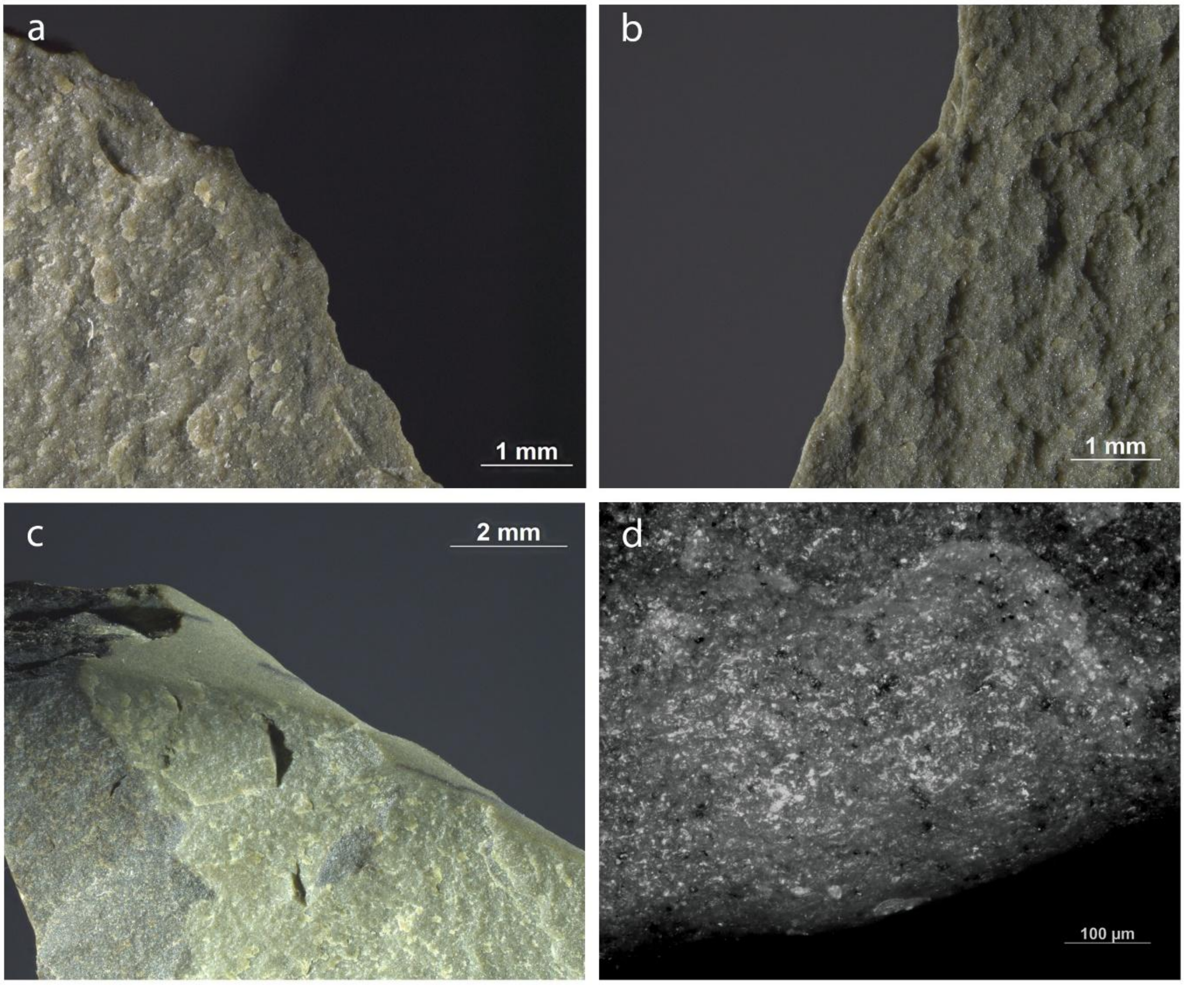

Figure 4 Wear on hornfels blind test pieces. ***a*** *Scars, some with clear bending initiations, on BT10/07, tool used for scraping dry hide (32×)* ***b*** *Scars guided by the layered structure of the rock on BT10/15 used for cutting reed (32×)* ***c*** *Strong edge rounding on the loess-digging tool BT10/01 (20×)* ***d*** *Localised polish on BT10/15 used on reed (200×).*

Two mistakes were made in the final test interpretations regarding tool motion. The first, identifying longitudinal use for the digging tool (BT10/01), can be considered a partial error. The second mistake was more severe and involved wrongly identifying the hide-scraping tool (BT10/07) as having been used in a longitudinal motion. This was inferred from the partly oblique orientation of some of the scars and limited linear features observed under high magnification. In the post-test re-evaluation of the tool, the scar pattern was considered bifacial but the scars largely perpendicularly oriented and therefore not diagnostic of a longitudinal motion. One spot of striated polish with transverse orientation that was missed during the test was identified on the ventral aspect of the tool, but the wear was very limited. In such cases, the accuracy of the interpretation depends almost exclusively on a careful evaluation of the patterning of scars and edge rounding, which failed here.

Attempts to identify the worked material for the hornfels tools were unsuccessful apart from the butchery knife (BT10/10) where a distinct combination of obliquely oriented scars with mixed initiations and frequent step terminations, rounding, and light crushing or cracking on the distal tip and adjacent edge allowed proposing that the tool made contact with both soft and hard contact material in a dominantly longitudinal motion. Butchery was recorded as the most plausible activity accounting for the combination of traces. Microwear on the tool was limited to rounding and striations, which did not significantly strengthen or challenge the low magnification interpretation.

The dry hide scraping tool included in the test (BT10/07) was interpreted as likewise having been used on both soft and hard animal tissue and was recorded as another potential butchery tool. Scars on the tool were nevertheless noted to be small and not entirely consistent with this activity. The high magnification analysis did not improve the interpretation due to the limited development of microwear (see above). Confusing dry hide wear as a mix of wear from soft and hard animal tissue is not a drastic error, considering the variable resistance of dry raw hide that often translates into a mixed wear pattern.

In contrast, a more informative mistake was the misidentification of wood wear (BT10/23) as dry hide wear. Here, scars were noted that did not fit well the ‘hide’ interpretation and the possibility of a harder contact material was put forward during low magnification analysis, but the rounding was judged to be the most significant feature and consistent with heavily abrasive, relatively soft material. High magnification analysis revealed more features with clearly transverse linearity, but no polish. In post-test analysis, the wear was considered heavily attritional, with again no clearly observable polish. Nevertheless, upon re-examination the wear distribution was judged consistent with a material harder than hide, and part of the issues therefore related to the lack of care in putting together the final interpretation (here, the combination of scars and rounding together with their extension and distribution with respect to edge and surface topography).

The plant-cutting tool (BT10/15) was estimated to show scarring and rounding suggestive of relatively resistant material, together with polish that was considered well-developed but not extensive enough to fit with softer plant materials (**Figure 4d**). The combined pattern was interpreted as wood wear, a mistake very similar to that made for the corresponding mudstone tool. In addition, here the susceptibility of the hornfels to edge damage formation led to the overestimation of the hardness of the worked material.

Finally, the digging tool (BT10/01) could only be identified as having been used on soft abrasive material, with ‘dry hide’ offered as a very tentative proposition. This again relates to the analyst’s limited experience with wear from digging activities at the time of analysis and the lack of hornfels in the available reference collection.

To summarise, the interpretation of the hornfels test tools was complicated by 1) the interference of the natural structure (the sedimentary stratification of the rock in the case of poorly metamorphosed samples) in the formation of use-related scars and their diagnostic attributes, 2) the fast development of edge rounding irrespective of contact material, leading to the overestimation of their abrasiveness, and 3) the near absence of polish comparable to that forming on flint tools that hindered the identification of typically “polishing” contact materials such as siliceous plants and wood.

3.3 Quartz

For quartz (n=4), the analyst failed to identify one test piece as used even when combining low and high magnification microscopy. This was the tool used for scraping dry bone for 20 minutes (BT10/12). A comparable tool in the reference sample, used for 15 minutes on dry bone, displayed strongly developed wear, including plastic deformation (Knutsson et al., 2015, fig. 3g). In post-test analysis, the blind test tool was observed to show limited microwear overlooked previously (abrasion of ridges by microchipping behind the used edge, possible limited polish and/or plastic deformation) that, nevertheless, could not be described as characteristic of bone. Whether this derived from observational difficulties (e.g. highly irregular microtopography in relevant areas) or low degree of microwear development (due to e.g. larger-scale, irregular chipping of the worn area towards the end of the use cycle) remains to be determined.

For the second tool, one used on dry hide for 20 minutes (BT10/25), low magnification examination failed to locate the used edge, but this was mended during high magnification analysis.

In all three cases where wear was successfully detected, the direction of tool movement could also be determined accurately. Worked material was identified correctly in two cases out of three (soft plant and wood) when using the combined approach. For the wood-working tool (BT10/08), an initial ‘dry hide’ interpretation was proposed due to the heavily abrasive nature of the wear observed under low magnification (**Figure 5a**), but this mistake was mended by incorporating high magnification observation and re-evaluation of the low magnification evidence. The edge rounding was ultimately judged too limited in distribution to be consistent with hide, and the polish was estimated to better correspond with wood (**Figure 5b**). However, it was noted that both on the test piece and a reference scraper, striations comparable to ones documented on wood saws (Knutsson et al., 2015) were very scarce (**Figure 5c**), and the incompleteness of the wear pattern added some caution to the interpretation.

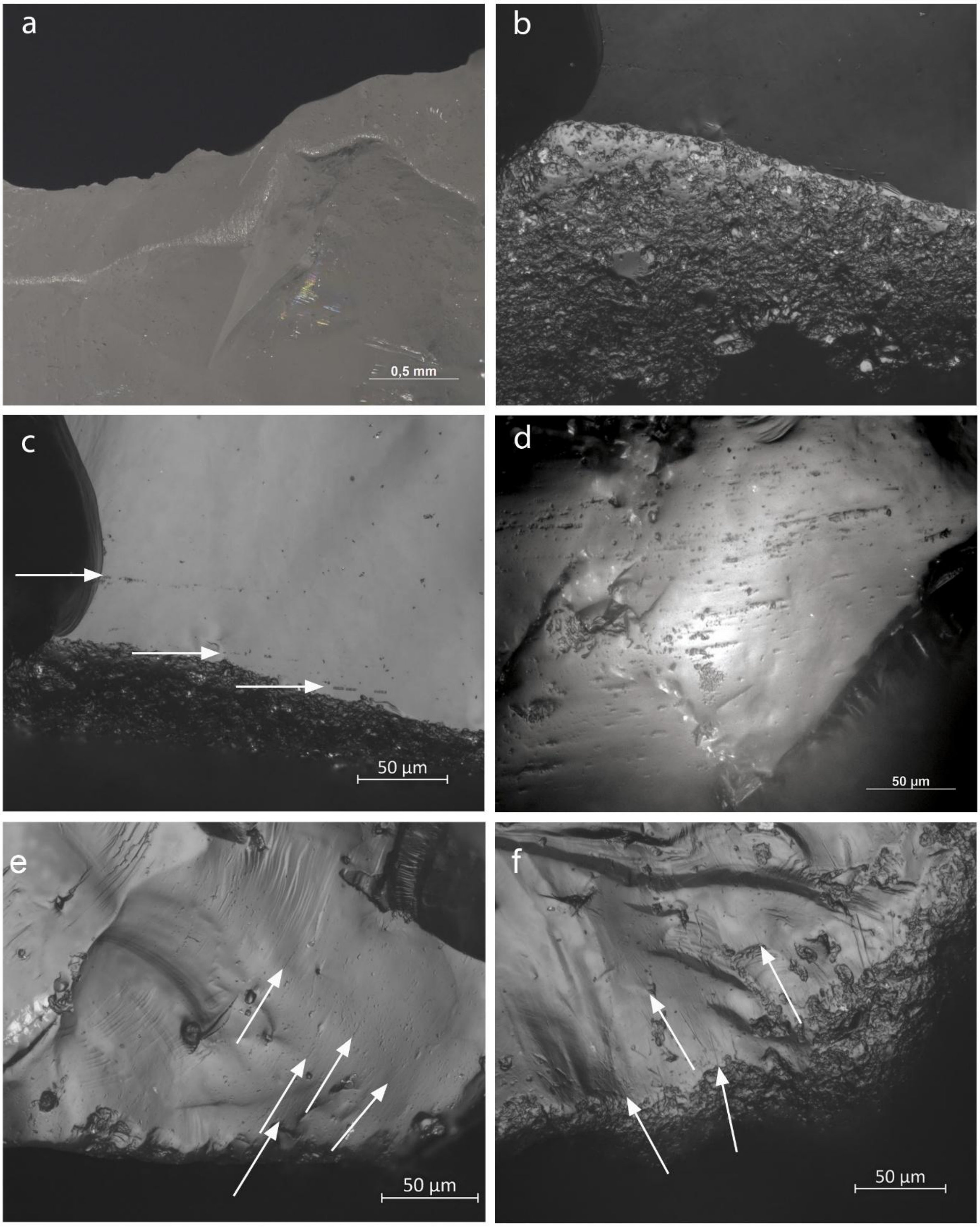

Figure 5 *Wear features on quartz blind test tools and reference collection.* ***a*** *Heavy edge rounding with transverse linearity from scraping dry wood on BT10/08 (80×)* ***b*** *Polish associated with the rounding shown in a (dry wood) (500×)* ***c*** *Scarce striations parallel to the rounded, polished edge shown in a and b (dry wood) (500×)* ***d*** *Polish and striations on BT10/03, used to cut reed (500×)* ***e*** *Polish, linear features and impact pits from dry hide scraping on BT10/25 (500×)* ***f*** *Microchipping, polish and sleeks on reference tool used to scrape dry vegetal-tanned leather (Exp. 3 in Taipale, 2012) (500×).*

For the last piece, a tool used on dry hide (BT10/25), only a generic ‘soft material’ interpretation could be offered after combined analysis. Due to the intensity of polish (smoothing), (fresh) plant material was considered as a possibility, but the typical striations (documented on another test piece, **Figure 5d**) were noted to be absent. Fresh hide was proposed as an alternative hypothesis, acknowledging the partial overlap between plant and hide wear demonstrated in previous statistical analysis (Knutsson et al., 2015, fig. 4; data from Knutsson 1988a) and the lack of fresh hide working tools in the reference sample available during the analysis (Taipale, 2012). In post-test analysis, linear features (faintly visible irregular striations, short straight-sided striations, sleeks; terminology from Knutsson, 1988a) co-occurring with numerous impact pits were documented in association with the clearly visible polish (**Figure 5e**).

Previous dry hide scraping experiments report occasional polish (smoothing), commonly occurring irregular striations, and abundant plastic deformation and abrasion areas (Knutsson, 1988a, fig. 54), a pattern that corresponds only very partially with the blind test tool. Work on tanned hide produced less frequent smoothing, more variable striations, and fewer plastic deformation features (Knutsson, 1988a). From this previous knowledge, it might have been possible to attribute the blind test tool to the general ‘hide’ category, but the closest matches for this contact material in the available physical reference collection were a tool used for scraping an oil-ochre mix into dry leather (Knutsson et al., 2015, fig. 3f) and a tool used for thin-scraping dry vegetal-tanned leather, on which the wear pattern (**Figure 5f**), together with similar wear documented archaeologically (Knutsson et al., 2015, fig. 7j), differs significantly from the wear on the test piece.

To summarise, the four quartz test tools demonstrate the usefulness of the combined approach in tool use diagnostics. Most difficulties were linked to the identification of the exact worked materials. The confusion created by the dry hide microwear highlights the relevance of sufficiently large reference collections in wear interpretation and draws attention to the previously identified, partial overlap of wear from working plant and animal-based materials. As observed in pioneering experimental work (Knutsson, 1988a), the differences in combinations of wear features that make up distinct patterns can be subtle, and further exploration of complementary quantitative approaches (Lundin et al., 2025; Pedergnana et al., 2020) to increase the resolution of recording of e.g. linear features, together with further experimental work to address the overlaps observed thus far, can be recommended.

3.4 Quartzite

For quartzite (n=5), two tools were erroneously judged as unused in the test. In examining the one used for scraping dry hide (BT10/11), the attention was mistakenly directed to the distal right edge, which showed two small, crushed areas that were considered to possibly derive from contact with hard material, although it was noted that the contact may not have been use-related. Under high magnification, the edge was recorded to show microscarring and abrasion of ridges, but the wear was inconclusive, and use could finally not be confirmed. The distracting features on the right edge led to a failure to detect the actual use-wear on the left lateral edge.

The second tool misidentified as unused (BT10/04) was used for butchery for 15 minutes. Under low magnification, the edges were noted to be abraded but without a clear pattern. High magnification analysis found some scarring and abrasion of fractured grain edges and one location with irregular striations (cf. Knutsson, 1988a) parallel to the edge, but as these were limited in number and occurred in isolation, they could not be reliably attributed to use. After the test, the used edge was examined in a high level of detail, which yielded observations of limited polished areas and sporadic irregular and discontinuous striations with random orientations, one of them curved. While these observations are consistent with previously reported meat wear on quartz (Knutsson, 1988a, figs. 54, 60b), clear bone wear was lacking, and the limited development and scattered distribution of the wear features posed challenges for interpretation. A quartz tool used in the same activity for the same duration (BT10/19), not included in the test, was analysed to establish whether the two rocks reacted differently. It presented equally sparse wear that was judged undiagnostic of any particular contact material.

After the test, another quartzite tool (BT10/32) was used in the same activity for 40 minutes to better understand wear development. Also on this artefact, clear bone wear was lacking, and the microscopic features were restricted to limited spots of polish and fractured quartz grain edges, with clear linear indicators missing.

Previous butchery experiments with quartzite tools describe the development of continuous polish associated with extremely rare linear features on the edges of tools used in skinning and dismembering activities for over 30 minutes. The same tests found that defleshing produced limited wear consisting of loss of material at the edge and very rare striations, with clear polish lacking (Pedergnana and Ollé, 2017). The experimental tools discussed here corroborate these findings and point to potential challenges in identifying quartzite tools used for short durations in butchery activities in archaeological contexts.

For the three tools that could be correctly identified as used during the test, the used edge was correctly located under low magnification, and the direction of tool movement could be established when integrating high magnification observation. The digging tool (BT10/30) showed clear rounding and smoothing. The wood-scraping tool (BT10/14) showed rounding on the active edge that was proposed to potentially derive from a longitudinal motion, and the bone-scraping tool (BT10/28) was reported to display abrasion and potential scarring. The latter was difficult to differentiate with certainty from the naturally variable topography of the edge.

The failure to infer transverse tool motion under low magnification for BT10/14 and 28 used on relatively resistant materials stems from the analyst's lack of experience and from the irregular fracturing of quartzite tool edges during use that often results in removals that are difficult to characterise using flint-based frameworks (see Ollé et al., 2016, fig. 3 for sequential SEM imaging of use-related chipping). Further methodological development is needed to examine the diagnostic value of microscopic scar patterns on quartzite tool edges and to adapt the descriptive frameworks to better accommodate the structural properties of these rocks.

For BT10/14, 10/28 and 10/30, the erroneous identification of tool motion could be mended through high magnification analysis thanks to the clear linearity of microwear features (BT10/28; **Figure 6a**) or the preferentially ventral position of the microwear (BT10/14). Subtle but numerous linear features confirming the transversal motion could be found on BT10/14 in post-test analysis (**Figure 6b**). Direction of tool use for the digging tool (BT10/30) was characterised as 'mixed', which is as expected.

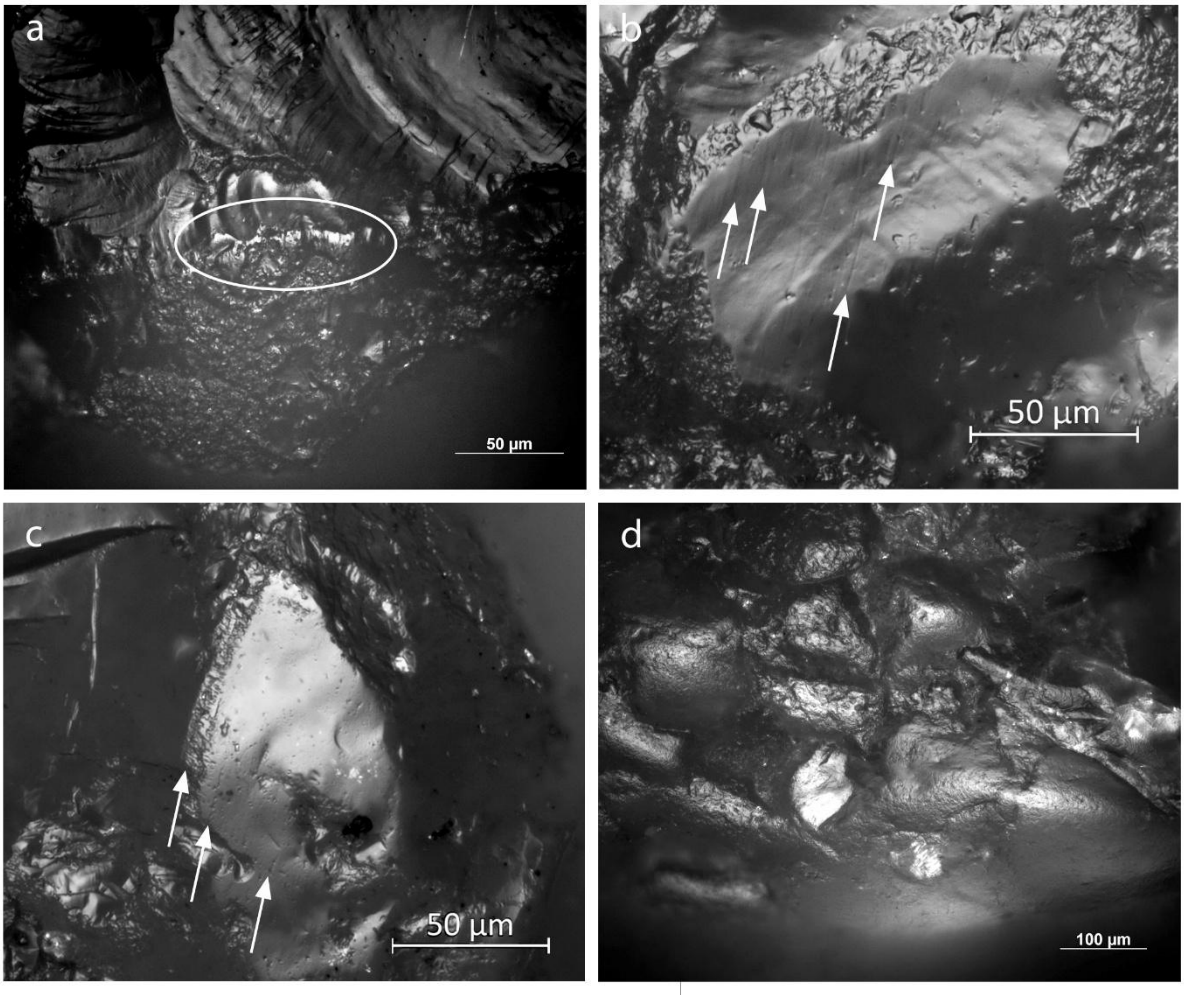

***Figure 6** Wear on quartzite blind test tools. **a** Bone wear with transverse linearity on BT10/28 (500×) **b** Chipping and polish on a ridge, associated with faintly visible linear features on BT10/14, used on dry wood (500×) **c** Polish and linear features from scraping dry hide on BT10/11 (500×) **d** Rounding, polish and impact pits on BT10/30, used for digging loess (200×)*

Notably, worked material could not be identified correctly for any of the three tools. As the linear features on BT10/14 were missed during the test, the evaluation of worked material properties relied on trying to match the microchipping and polish to wear seen previously, which resulted in a very tentative 'fresh hide' hypothesis. Had the macrowear been more interpretable, this wrong hypothesis would have been easy to rule out based on differences in contact material hardness. When the full microwear pattern, documented after the test, is examined, the combination of polish, striations, and sleeks matches the combined set of features recorded on the five quartz tools used on dry wood in the reference set, although the combinations of features vary quite considerably as a function of tool use gesture and the duration of use (Taipale, 2012 table 1).

The tool used on dry bone (BT10/28) presents an interesting case. During the combined analysis, the test piece was interpreted as having had limited contact with bone and was marked down as a possible butchering tool. Re-analysed after the test, the bone-like wear features were judged to be too well-developed to derive from incidental contact, but diagnostic wear was concluded to be very limited in extension, which contributed to its sporadic appearance. Here, while bone contact was correctly inferred based on the quartz reference, its isolated occurrence was interpreted as having derived from limited contact when it actually relates to the variable microtopography of the quartzite, leading to highly discontinuous microwear particularly in the case of hard contact materials.

The active edge of BT10/11, used on dry hide and overlooked during the test, was later discovered to display relatively well-developed polish associated with linear features (**Figure 6c**). Even though continuous microsurfaces are more limited in extent on quartzite than on quartz due to the granular nature of quartzite, the wear patterns are similar (**Figure 5e**). Therefore here, the same limitations of the existing reference sample that were outlined in the previous section also apply.

Again, the loess-digging wear (BT10/30) could not be identified correctly due to the lack of reference tools used in similar activities. The distribution of the wear was reported to correspond with soft contact material, and the closest – even if remote – form of wear in the available reference collection was estimated to be extremely well-developed hide wear. A tentative ‘hide’ interpretation was consequently proposed. Upon a more recent (2025) re-evaluation, the microwear (**Figure 6d**) is similar to some forms of experimentally produced sediment abrasion (Galland, 2022; Galland et al., 2024) and bears little resemblance to hide wear on the test tools and the reference collection. The linearity of microwear is vague at best.

In sum, the identification of the used edges and the worked materials was complicated by the ambiguous appearance of microscopic scarring on the quartzite test tools, the diagnostic value of which requires further investigation. Worked material identifications were further biased by the patchy, discontinuous nature of microwear, which was often missed or only partially observed, and in other cases (bone wear) underestimated in terms of the extent and intentionality of contact when compared with wear on quartz. The remaining issues were related to the limitations of the analyst’s experience and the (quartz) reference collection.

3.5 Dolerite

The dolerite blind test sample, despite being very small (n=3), revealed serious challenges in the interpretation of wear when relying on the flint and quartz reference for both macroscopic and microscopic wear. Observations on four additional pieces included in the complete set (**SI table**) helped understand the difficulties encountered.

Of the three test pieces, two could be identified as used, but in one case, the attention was guided to the wrong edge. On BT 10/02, the distal edge was used for scraping wood, but the left lateral edge was judged used during the test based on the presence of edge rounding (**Figure 7a**). Upon evaluation after the test, around 10 discontinuous, possibly use-related scars (**Figure 7b**) were spotted on the used edge that were either not noticed or were interpreted as irregular fracturing during blank detachment. They were accompanied by very limited microwear features (**Figure 7c**), none of which correspond to wood wear on flint or quartz. Currently we interpret this as confusion between prehension wear from hand-held use and use-wear, but neither of the worn edges presents well-developed features that would allow further evaluating this hypothesis.

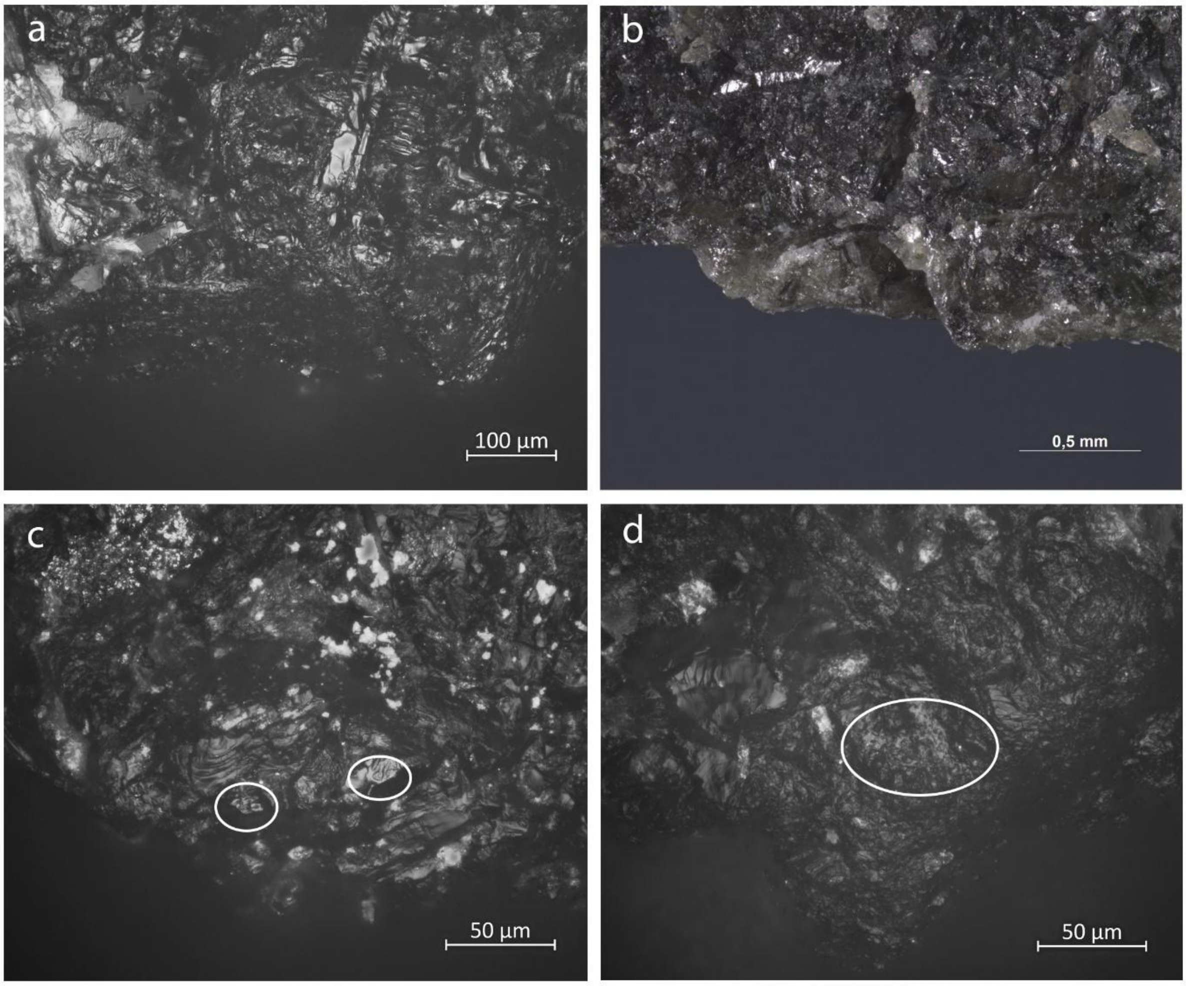

Figure 7 *Wear on dolerite blind test tools.* ***a*** *Rounding mistaken for use-wear in the test on BT10/02, used hand-held for scraping dry wood (200×)* ***b*** *A step-terminating scar with an indeterminate initiation from wood-working on the used edge of BT10/02 (80×)* ***c*** *Small spots of possible wood polish on the used edge of BT10/02 (500×)* ***d*** *Rounding and limited polish on BT10/05, used for scraping dry bone (500×).*

For BT10/05, used for scraping dry bone, light rounding without clear directionality was recorded on the right lateral edge under low magnification. This was associated with limited polish observed under high magnification (**Figure 7d**). Scars, a total of 8 of which could be counted after the test, were overlooked due to their irregularity and dispersed nature.

Previous studies on basalt have reported certain correlations between scar attributes and tool use tasks (Bello-Alonso et al., 2020; Richards, 1988), although Richards's (1988) experimental study involved in large part "vitreous" varieties of basalt that can be expected to fracture differently from the coarse-grained volcanic rocks discussed here. A post-blind test examination of the attributes of the scars recorded on the dolerite test pieces BT10/02 and BT10/05 (**Table 4**) reveals several issues that hindered their identification during the test. First, the initiations of the scars can be described using the bending/cone continuum only in two cases out of 16. The single cone initiation is not entirely clear and is better characterised as punctual. The 14 initiations classified as 'indeterminate' are affected by the irregular fracturing of the dolerite that prevents using terms created to describe smooth fracture surfaces in homogenous, cryptocrystalline materials.

Table 4 *Attributes recorded for the scars on two dolerite blind test tools (BT10/02 and BT10/05) after the test.*

Scar initiation	Bending	1
	Cone/punctual	1
	Indeterminate	14
Scar termination	Feather	1
	Step	7
	Hinge	2
	Snap	1
	Complex	1
	Indeterminate	4
Whole grain removal		2
Total nr of removals		*16*

When terminations are examined, the proportion of indeterminate cases is lower. Steps, however, are overrepresented. While this may partly derive from the relative hardness of the contact materials (bone and wood), the distribution may be further biased by the better visibility of step terminations as opposed to feather, considering that the initiations of the scars are irregular and that scars with non-abrupt terminations may go entirely undetected or be considered as features of the naturally irregular surfaces and edges.

Finally, two occurrences were recorded where entire grains formerly embedded in the matrix had been removed from the active edge (**Figure 8**). Such removals cannot be characterised using attribute systems developed for cryptocrystalline raw materials but could hypothetically contribute to determining e.g. the relative resistance of the worked material.

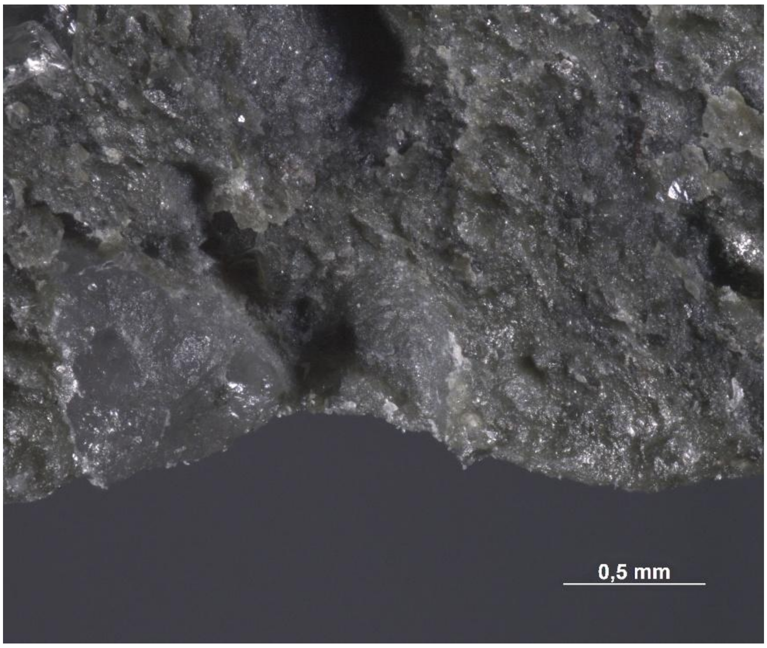

Figure 8 *Negative of a detached, rounded grain on the edge of BT10/05 used on dry bone (80×)*

The scarcity of well-defined scars and the lack of clear linear wear on the wood and bone-working test tools is comparable to recent data published for coarser varieties of basalt following sequential experiments. The same experiments report a modest degree of edge rounding and near absence of polish on tools used on these contact materials for short durations (<30 min) (Asryan and Rots, 2024). A similar pattern seems to explain the difficulties in interpreting the traces on the blind test tools.

After the test, the wood-scraping experiment was repeated, this time increasing the duration of the activity to 40 minutes. This produced pronounced edge rounding with clear macroscopic linear indicators (**Figure 9a**), even if polish remained limited (**Figure 9b**). Even in its well-developed form, this wear pattern is hard to attribute to wood based on the flint reference.

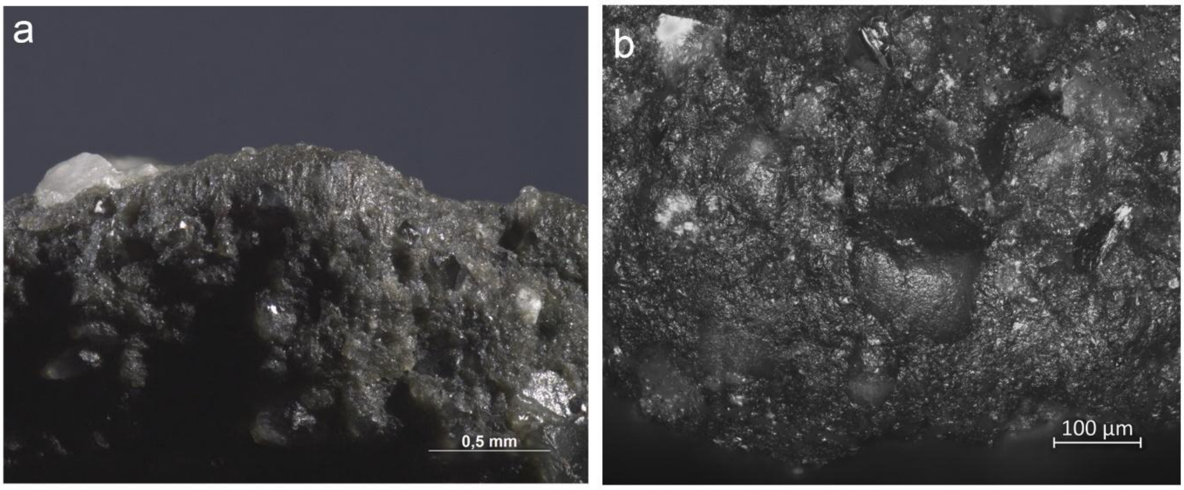

Figure 9 *Wear on 40-minute dolerite wood-working tool (BT10/31).* ***a*** *Edge rounding with transverse linearity (90×)* ***b*** *Edge rounding with limited polish (200×).*

The loess-digging tool in the blind test (BT10/13) could not be identified as used even when combining low and high magnification analysis. The edges were judged fresh in appearance. Possible spots of polish were recorded on the left lateral edge, but they did not combine into a clear pattern and were located away from the used edge (distal). After the test, slight rounding could be detected on the active edge and imaged with the SEM. Another tool (BT10/34) was subsequently used in the same activity for 40 minutes. It represents a fine-grained variety of dolerite, and developed rounding faster (cf. Asryan and Rots, 2024) (**Figure 10**). The linearity of the wear is also readily visible in SEM images in contrast with BT10/13.

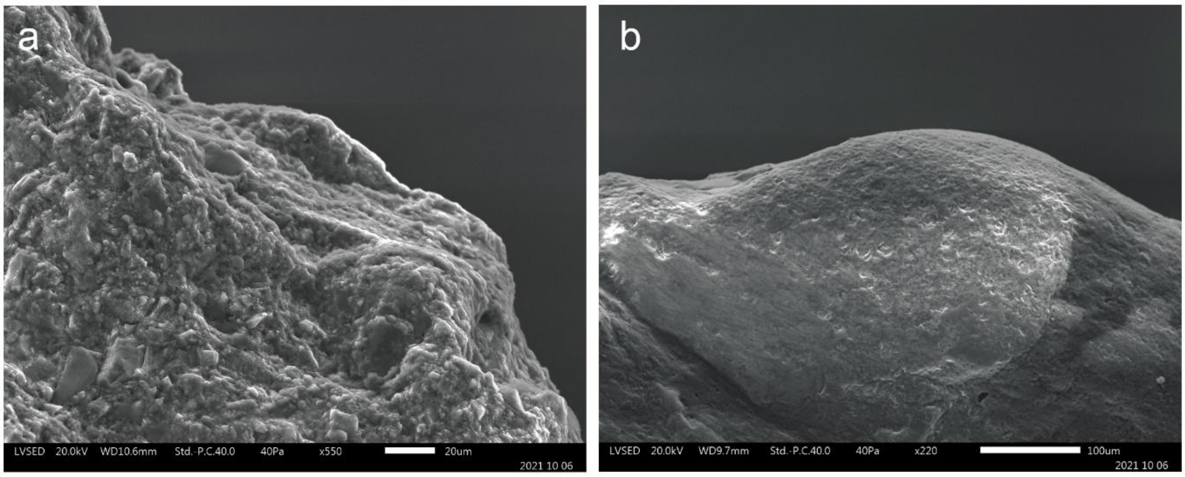

Figure 10** Wear on two dolerite flakes imaged with the SEM.* ***a *Subtle rounding on BT10/13, coarse-grained dolerite, after 20 min of digging loess (550×)* ***b*** *Well-developed rounding with linearity on BT10/34, fine-grained dolerite, after 40 min of digging (220×)*

Of the three 15–20-minute tools not included in the test, the tool used for scraping dry hide (BT10/18) presented rounding visible under low magnification and some polish that was considered to resemble hide polish on flint but was limited. The butchery tool (BT10/22) showed edge rounding and scars (**Figure 11a**) under low magnification, accompanied with several spots of microwear with longitudinal orientation and variable characteristics, visible under incident light. Finally, the plant-working tool (BT10/24) displayed well-developed, bright polish (**Figure 11b**), together with edge rounding and potentially use-related scars with irregular fracture surfaces. It presents the only case of a high degree of polish development in the dolerite sample and will be discussed further below.

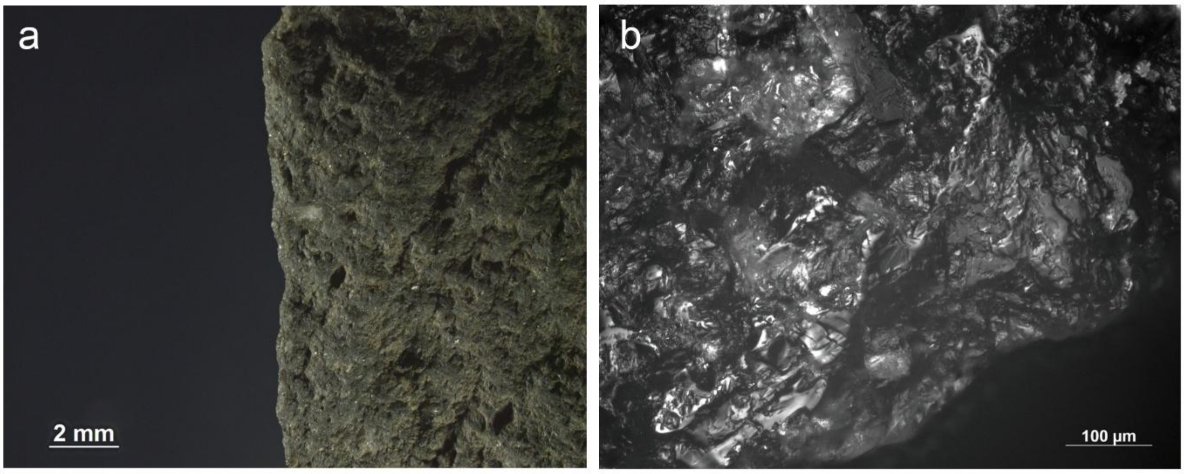

Figure 11 *Wear on dolerite blind test tools.* ***a*** *Scars and rounding on BT10/22 used in butchery (12.5×)* ***b*** *Polish from reed-cutting on BT10/24 (200×).*

Put together, the test and the subsequent analysis reveal better visibility of edge rounding as opposed to chipping on dolerite to the untrained eye, and very variable and often absent development of polish on tools used for short durations, both consistent with earlier results on dolerite, basalt, and rhyolite (Asryan and Rots, 2024; Bello-Alonso et al., 2020; Brito-Abrante and Rodríguez-Rodríguez, 2024; Huidobro Marín, 2018: 179; Richards, 1988).

While the wear on BT10/02 was challenging to detect and interpret, none of the tools – despite their short use duration – lack wear features. Rather, attention was biased towards certain features (well-defined, multiply occurring scars with clear attributes; continuous microscopic polish) following flint-based expectations. This repeatedly resulted in a failure to detect used edges and to reconstruct the details of tool use.

The blind test results and complementary analysis indicate that for dolerite(s), the matter is not as simple as short use durations producing too little wear. The plant polish was well-developed, and the butchery tool displayed both macroscopic and microscopic wear. It rather seems that if use duration is kept constant, certain activities (here, plant-cutting, butchery, hide-scraping) have a higher visibility than others (here, particularly wood-working and bone-working), and this does not relate to the relative hardness of the contact materials. As the harder worked materials produced the most ambiguous wear, it seems reasonable to conclude that more attention should be devoted to macroscale fracturing and its attributes to allow detecting these activities in “expedient” tool use situations.

4 Discussion

4.1 Rates of wear formation

The blind test provided several insights into differential rates of wear formation within and between the five raw materials. The flake tools used for digging loess all display edge rounding after 20-minute use, but to drastically different degrees. The loss of volume is extreme on hornfels, clearly noticeable on mudstone, moderate on quartz and quartzite, and nearly non-existent on dolerite (**Figure 12**), where the rounding was not spotted in the blind test. The higher resistance of dolerite to abrasion is consistent with previous comparisons with hornfels (Wadley and Kempson, 2011). The present experimental set confirms that it is crucial to consider the susceptibility of each stone tool raw material to abrasive wear before drawing conclusions about the role of different rocks in lithic toolkits based on the relative degree of development of wear traces.

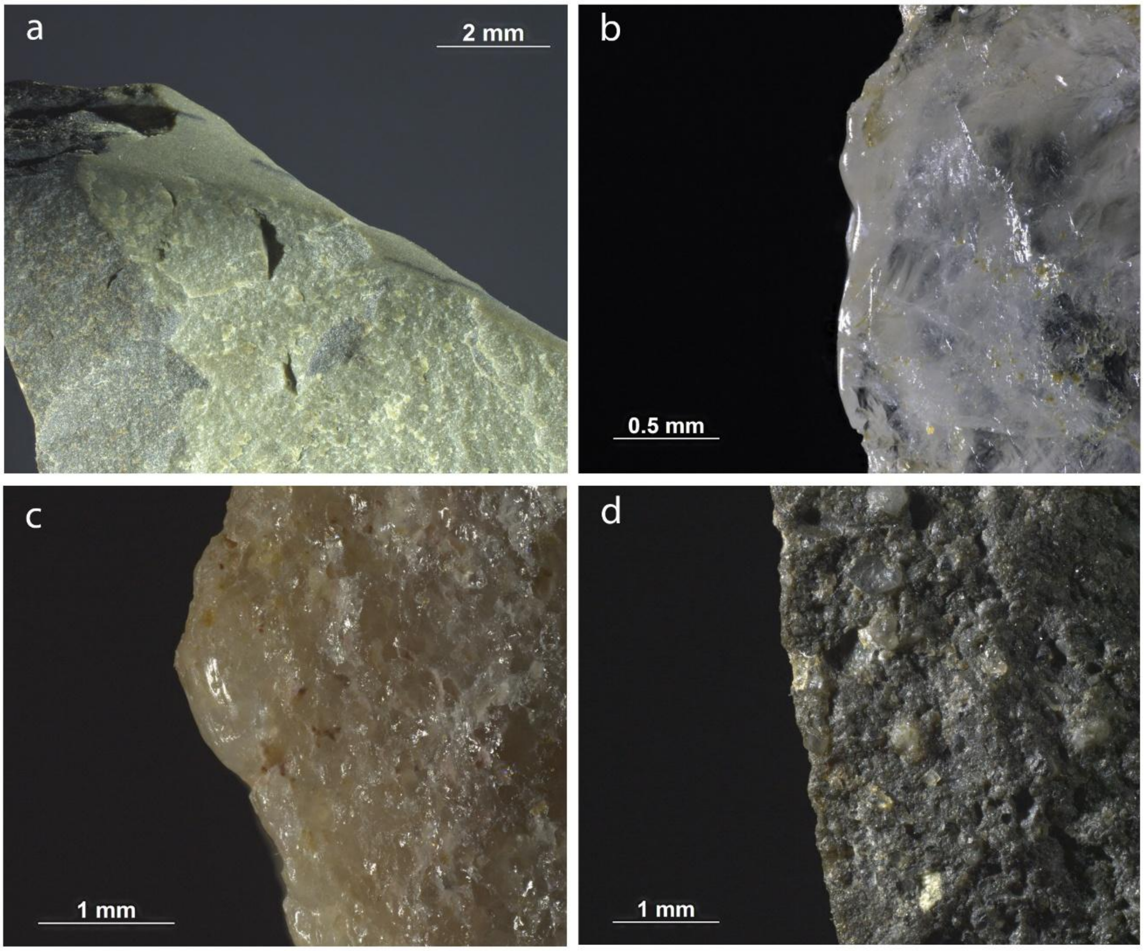

***Figure 12** Different intensities of edge rounding on blind test tools used for digging loess for 20 min. **a** Hornfels (20×) **b** Quartz (80×) **c** Quartzite (50×) **d** Dolerite (40×).*

A comparison of butchering knives in silicified mudstone and hornfels as opposed to quartz and quartzite provides another illustrative example of the relative visibility of different tool use tasks across variable stone tool raw materials. The mudstone and hornfels butchery knives could be identified already under low magnification, whereas the quartz and quartzite tools were considered to show very limited wear lacking clear linearity even after longer (40 min) use. The analyst's previous experience in analysing flint butchery knives showing varying degrees of wear development (Taipale and Rots, 2021) may have provided an advantage in identifying comparable tools in silicified mudstone and hornfels and thus biased the test results. Nevertheless, the subtility of butchery wear on the quartz and quartzite test tools suggests relatively lower visibility of these tasks when compared with e.g. plant-working for tools used for short periods of time.

Plant-working, on the other hand, presents a case of relative convergence in the formation of microscopic wear (smoothing/polish) across the raw materials included in the test. It was the only activity that produced easily detectable polish on all the rocks considered here, including the dolerite on which polish was otherwise evasive (for similar findings on plant wear on dolerite and basalt, see Aleo, 2022; Bello-Alonso et al., 2020), hornfels, and silicified mudstone. Yet, the hornfels and mudstone tools could not be correctly attributed to soft plant working due to the more restricted extension and/or development of polish that did not conform to the flint-based expectations.

4.2 Transferability of use-wear diagnostic criteria between raw materials

The reference material available to the analyst during the blind test was limited to flint and quartz. Importantly, there was a heavy bias towards flint both in terms of the volume and diversity of the reference collection and the analyst's previous experience at the time of the test, reflected in the moderate success with quartz in the test results (**Figure 13**). Silicified mudstone and hornfels presented characteristic edge damage in short (15–20 min) use that was readily detectable and interpretable under low magnification (**Table 2-3**, **SI**) using a flint-based framework (**Figure 13**). For these two raw materials, the flint reference performed consistently even if not satisfactorily. The two tools used in butchery could be identified relying on previous knowledge of comparable wear on flint. Mistakes in interpreting dry hide wear on the two raw materials were also nearly identical. For both raw materials, wear from cutting reed was misinterpreted as wood wear due to the limited extension and/or development of polish and the exaggerated edge damage deriving from the relative softness of the rocks compared to flint. Notably, characteristic bone microwear could not be recorded on the mudstone test tool, due to which the worked material identification remained at the level of relative hardness.

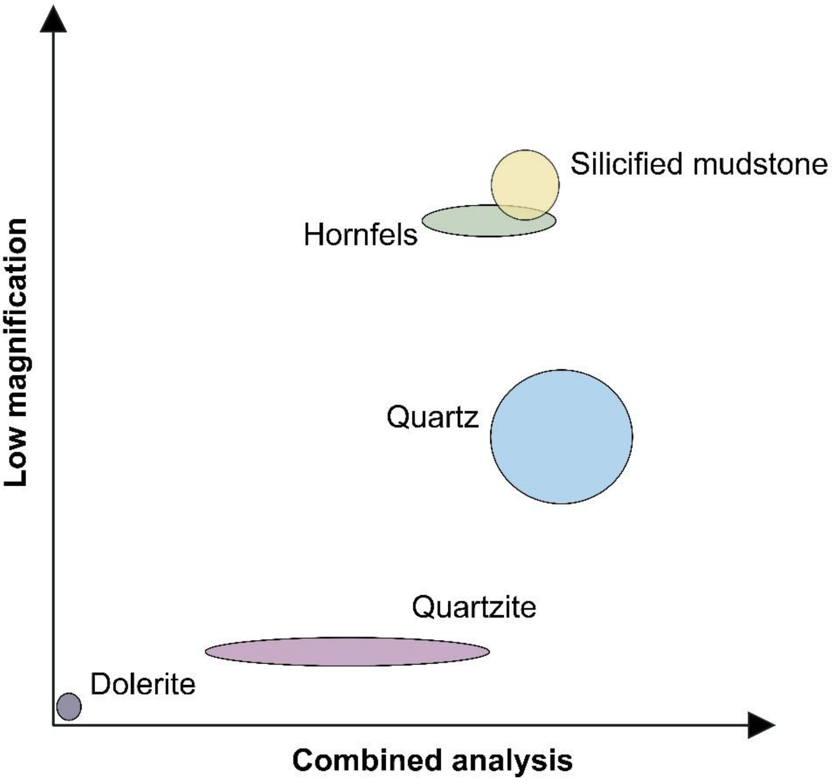

Figure 13 *Approximate visualisation of the relative performance of low magnification and combined low and high magnification analysis in identifying tool use motion and worked material with the help of an extensive flint and limited quartz reference collections. Data from* ***Table 3****.*

These findings demonstrate that while the flint reference may be sufficient to guide the interpretation to the right general direction (here, approximate hardness category, and in some cases, animal vs plant-based contact materials), it presents clear limitations. We can therefore recommend at least basic tool use experiments when dealing with new "flint-like" rocks to estimate differences to existing flint/chert reference collections and to calibrate wear identification criteria prior to attempting detailed archaeological interpretations (see Odell and Odell-Vereecken, 1980 for a similar recommendation).

When quartz and quartzite test pieces are compared, low magnification evidence was more interpretable on quartz than on quartzite (**Figure 13**). This is visible in the analyst's higher success rate in inferring tool motion in the first part of the test (**Table 2**, **SI**). To what extent this has to do with more readily observable or interpretable scar patterns on quartz and to what extent with the analyst's lengthier experience with quartz as opposed to quartzite at the time of the test remains to be determined. The presently available observations indicate that the flint/quartz framework was insufficient to effectively use low magnification use-wear features on quartzite in tool use diagnostics.

Further quartz/quartzite comparisons revealed that microwear forms comparably on the varieties included in the test, demonstrated by the dry hide working and butchery tools. However, the test results showed that detecting these features on quartzite posed a challenge to the analyst with limited experience with the raw material.

In the case of wood, edge damage was not sufficiently informative or could not be detected and characterised, and some microwear features were missed. The latter probably derives from the challenges of analysing surfaces composed of fractured quartz grains that are variably inclined with respect to each other. This leads to both uneven contact with the worked material, resulting in patchy wear, and to the need to frequently re-orient the sample under the incident light microscope to gain a complete view of the surfaces. In the case of bone, the localised nature of the microwear was taken to indicate only intermittent (incidental) contact with the worked material.

Such mistakes highlight the need to adapt the analytical strategy from quartz to quartzite regardless of the very similar response of the two rocks to wear on microscale (within individual quartz grains). Idiosyncrasies in wear formation between different varieties of quartzite highlighted in previous works (Pedergnana et al., 2018) further call for variety-specific testing before archaeological conclusions.

Finally dolerite, the greatest challenge in the test, made clearly visible the pitfalls of transferring use-wear identification criteria between families of rocks. The analyst’s ability to record scars on the edges of the tools representing the coarser varieties only after having been informed which edge was used is an illustrative example. The same struggle was reflected in the systematic failure to reconstruct tool use gesture and worked material properties even when combining different scales of magnification (**Figure 13**). This calls for the expansion and elaboration of interpretative systems based on fracture attribute recording to accommodate raw materials that present chipping of their edges but rarely clear conchoidal fracture.

4.3 Use vs prehensile wear

Two blind test pieces, one in silicified mudstone (BT10/29) and one in dolerite (BT10/02), gave reason to suspect that prehension wear deriving from hand-held use can in some cases be confused with use-wear on non-flint rocks. While both cases should be confirmed through further tests where the tool edges and surfaces are imaged before use and the grip is documented carefully, these initial observations may shed further light on intra-raw material variability in wear formation. They also highlight the need to consider the formation of wear from hafted and hand-held use side by side with use-wear in future experimental programmes.

5 Conclusion

The exploratory blind test demonstrated differences in the visibility of different tool use tasks within and between the examined raw materials, including the poorer visibility of butchery activities on quartzite and quartz as opposed to silicified mudstone and hornfels, and the relatively higher visibility of plant-working compared to other tasks across the five raw materials, with implications for research into site function and raw material economy.

Silicified mudstone and hornfels developed macroscopic wear (particularly rounding) faster and microscopic wear (polish) less easily than flint, which led to complications in characterising worked materials. Microwear features on quartz and the varieties of quartzite included in the test largely converged, but the discontinuous, localised distribution of microscopic features on quartzite resulted in failures to locate and interpret the wear using the quartz reference. The flint/quartz reference performed poorly in locating and/or characterising edge damage on quartzite and dolerite. The development of edge rounding at the expense of other forms of wear on dolerite, consistent with the findings of previous studies on volcanic rocks, further highlights the need to adjust the analytical approaches.

The obtained results demonstrate that the validity of transferring use-wear identification criteria between raw materials should be investigated by experimental comparisons to avoid biases in archaeological interpretation. Comprehensive reference collections, sufficient time invested in training, and rigorous data collection systems are in a key role in ensuring the reliability and high resolution of archaeological data.

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Author contributions: CRediT

NT: Conceptualization, Formal analysis, Investigation, Visualisation; Writing – original draft; Writing – review and editing; CL: Resources, Methodology, Data curation; VR: Conceptualisation, Methodology, Investigation, Funding acquisition, Project administration, Supervision, Writing – original draft; Writing – review and editing

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