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How depositional environments impact the microwear preservation of quartz artifacts: insights from the Oldowan of the Shungura Formation (Ethiopia)

Aline Galland^{1,2*}, Ignacio Clemente-Conte³, Anne Delagnes¹

¹ UMR PACEA 5199, Université de Bordeaux, Bât B2, Allée Geoffroy St Hilaire, CS 50023 33615 PESSAC Cedex, France

² Laboratorio de Arqueología del Pleistoceno (LAP), IH-CCHS, CSIC, Albasanz, 26-28, 28037, Madrid, Spain

³ Archaeology of social dynamics, Institució milà i fontanals de estudios en humanidades (IMF), CSIC, C/ de les Egipcíaques 15, 08001, Barcelona, Spain

*Corresponding author

Correspondence: aline.galland@cchs.csic.es

ORCID:

Aline GALLAND: 0000-0003-0719-4496

Ignacio CLEMENTE-CONTE: 0000-0002-3190-215X

Anne DELAGNES: 0000-0001-6579-4217

ABSTRACT

The function of Oldowan tools is a key aspect of early hominin subsistence in Eastern Africa. The rarity of the sites, the preservation of the assemblages and raw materials are limiting factors in the functional study of Early Pleistocene assemblages. The archaeological occurrences from Member F of the Shungura Formation (Ethiopia) have a precise chrono-stratigraphic framework (2.324 ± 0.020 Ma to 2.271 ± 0.041 Ma), a detailed reconstruction of depositional environments, and artifacts produced mainly from small quartz pebbles that are highly resistant to chemical and mechanical alterations. The studied archaeological material comprises artifacts from 12 occurrences and three environmental contexts (floodplain, point bar and channel lag). As a baseline for distinguishing taphonomic damage from use-wear, and for assessing the preservation of use-wear in the archaeological record, we characterize macroscopic and microscopic surface alterations resulting from fluvial transport and aeolian abrasion experiments. Despite the good preservation of the lithic assemblages at a macroscopic scale, variations are observed at a microscopic level corresponding to the depositional environment. Understanding the link between taphonomic alterations on quartz and the type of deposits leads to better recognition and interpretation of potential use-wear on these ancient artifacts.

Keywords: Oldowan, Shungura Formation, Taphonomy, Microwear analysis, Experiments, Quartz

1. Introduction

37 The intentional knapping of rocks during the Plio-Pleistocene is considered to be the pivotal moment
38 that marks the beginning of prehistory. The Oldowan techno-complex represents the first evidence of a
39 material culture spread across eastern Africa between ca. 2.8 to 1.5 million years ago (Plummer et al., 2023;
40 Texier, 1995). The functionality of these early stone tools remains a key question in the study of Early Stone
41 Age assemblages (Isaac, 1969, 1971; Leakey, 1934). In the East African Rift System, Oldowan sites are
42 mostly located in fluvio-lacustrine environments, often in close proximity to mineral resources (Plummer,
43 2004; Rogers et al., 1994; Schick and Toth, 2006). Substantial work has been done on the management of
44 raw materials (Braun et al., 2009, 2008; Delagnes et al., 2011; Goldman-Neuman and Hovers, 2012, 2009;
45 Harmand, 2009, 2004; McHenry and de la Torre, 2018; Stiles, 1991; Stout et al., 2005) and the typo-
46 technology of Oldowan assemblages (Braun et al., 2019; Chavaillon, 1970, 1979; de la Torre, 2004; de la
47 Torre & Mora, 2018; de Lumley & Beyene, 2004; Delagnes & Roche, 2005; Gallotti & Mussi, 2015; Kibunjia,
48 1990; Leakey, 1971; Mora & de la Torre, 2005; T. Plummer et al., 1999; Roche et al., 1999; Roche &
49 Tiercelin, 1980; Semaw et al., 1997; Stern et al., 1993; Stout et al., 2010; Texier, 1995; Toth, 1985; Yustos
50 et al., 2015). However, research on the function of flaked artifacts has been limited (Beyries, 1993; de
51 Francisco Rodríguez, 2019; Galland, 2022; Keeley and Toth, 1981; Lemorini et al., 2019, 2014; Plummer et
52 al., 2023; Sahnouni et al., 2013; Sussman, 1987). Functional analyses have often been hindered by poor
53 preservation of the assemblages due to differential preservation of raw materials (Beyries, 1993) and the
54 remobilization of assemblages, mainly by fluvial dynamics (Delagnes et al., 2023; de la Torre et al., 2017;
55 Hovers, 2003; Maurin et al., 2017; Petraglia and Potts, 1994; Schick, 1986). The characterization of post-
56 depositional surface modifications on lithic surfaces is therefore fundamental for the identification of
57 functional use-wear in these ancient contexts.

58 This article aims to evaluate the preservation of lithic assemblages from the Shungura Formation, a
59 significant Oldowan site complex in southwestern Ethiopia. This Plio-Pleistocene formation is divided into
60 12 members marked chronologically and stratigraphically by volcanic tuff horizons that span the entire
61 sequence (Bonnefille et al., 1973a, 1973b; de Heinzelin, 1983). The earliest archaeological occurrences in
62 this sequence are located in Member F (2.324 ± 0.020 Ma to 2.271 ± 0.041 Ma) (Kidane et al., 2014;
63 McDougall et al., 2012) which is characterized by a succession of fluvial deposits (channel lags, point bars,
64 proximal and distal floodplain) from the meandering paleo-Omo river. The lithic assemblages are
65 dominated by quartz artifacts which are well-preserved macroscopically (Maurin et al., 2017). However, in
66 order to interpret their function, it is necessary to describe the taphonomic microwear on quartz, an aspect
67 for which there is still limited understanding.

68 Hominins have exploited quartz and quartzites from primary and secondary sources throughout the
69 Oldowan period (Delagnes et al., 2011; de Lumley and Beyene, 2004; Goldman-Neuman and Hovers, 2009;
70 Gowlett et al., 2022; Leakey, 1971; Merrick and Merrick, 1976; Plummer et al., 2023; Semaw et al., 2003;
71 Texier, 1995). The importance of raw material is critical in this study because quartz is resistant to chemical
72 and mechanical weathering (Goldich, 1938). In traceological use-wear analyses, the wear produced by
73 post-depositional weathering on quartz materials differs from that on other rocks, such as chert. In stark
74 contrast to flint artifacts, which have been extensively studied (Caspar et al., 2003; Chu et al., 2015;
75 Clemente-Conte and Pijoan, 2005; Levi Sala, 1986; Michel et al., 2019; Plisson and Mauger, 1988; Prost,
76 1989), there has been little focus on taphonomic microwear on quartz and quartzite artifacts. Knutsson
77 and Lindé (1990) conducted a pioneering wind abrasion experiment on quartz tools, which was analyzed
78 using a scanning electron microscope (SEM). Knutsson's research further investigates the different types
79 of weathering in archaeological contexts using SEM (Knutsson, 1988a, 1988b). The other experimental
80 work on post-depositional weathering of quartz artifacts focuses on motion-related weathering within the
81 sandy sedimentary matrix (Venditti et al., 2016). However, no experiments have yet been conducted to
82 assess the microwear from fluvial transport on quartz materials. In eastern African Plio-Pleistocene
83 contexts, the fluvio-lacustrine depositional environments and the weathering of artifacts after the erosion
84 of their deposit are the main factors that deteriorate the traces of use-wear on the surface of artifacts. The
85 paleo-Omo River was the main agent of sediment deposition and burial of faunal and lithic assemblages in
86 Member F (de Heinzelin, 1983). The sediments transported by the river had a significant impact on the
87 alteration and preservation of artifacts. It is widely accepted that the energy of a river and the size of the
88 sand grains causes varying degrees of weathering on archaeological assemblages (Chu, 2016; Frings, 2008;

89 Petraglia and Potts, 1994; Schick, 1986). That is why we established a specific experimental protocol with
90 a primary focus on fluvial transport. Another experiment focused on aeolian abrasion due to the exposure
91 of artifacts on the surface, before deposition and following the erosion of the surrounding deposits in a
92 semi-arid environment (de Heinzelin, 1983).

93 A detailed assessment of the integrity of sites, the homogeneity of lithic assemblages and the degree
94 of preservation of tool edges are all prerequisites for understanding the subsistence strategies deployed
95 by human groups. This paper stems from doctoral research (Galland, 2022) and presents taphonomic
96 experiments aimed at understanding the variability of quartz artifact alterations from the fluvial
97 depositional environments of Member F of the Shungura Formation. The fundamental objective of these
98 experiments is not to faithfully reproduce the post-depositional alterations seen on these artifacts, but
99 rather to recognize and differentiate them from the functional use-wear that is the main focus of our
100 research. The end goal is to provide a solid basis for interpreting human subsistence behaviors during the
101 Oldowan in the Shungura Formation.
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103 2. Materials and Methods

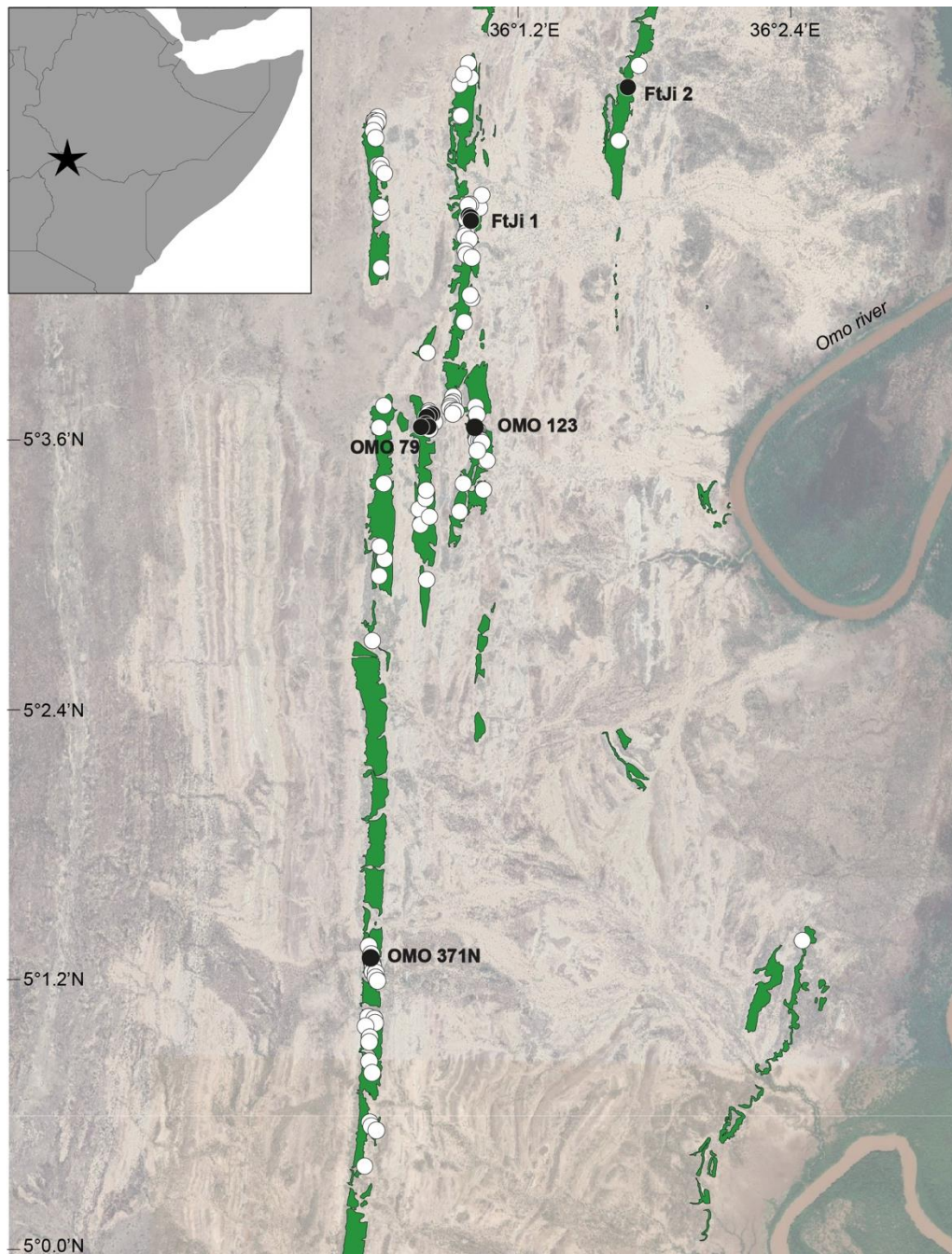
104 2.1. Archaeological material

105
106 The early Oldowan assemblage from Member F is dominated by sharp-edged flakes knapped from small
107 quartz pebbles (Chavaillon, 1976; Merrick et al., 1973). These pebbles were selectively chosen from a
108 variety of raw materials available in the area (Delagnes, 2011). The functional study of these artifacts was
109 first conducted by C. Sussman as part of the International Omo Research Expedition (IORE) in the 1970s.
110 Sussman's preliminary report on 19 artifacts from Member F yielded inconclusive results (IORE archives).
111 Our work includes material from the IORE and from the Omo Group Research Expedition (OGRE), which
112 has been working on the Shungura Formation since 2008. We selected 12 occurrences of over 100 artifacts
113 located in five major site complexes in Member F (Table 1, Fig. 1). The selection of the archaeological
114 assemblages reflects the diversity of fluvial depositional environments (channel lag, point bar, floodplain)
115 in Member F (Table 1, Fig. 2), which is essential for characterizing the traces of alteration specific to these
116 contexts.

117 Within Member F of the Shungura Formation, the occurrences located in channel lags are characterized
118 by coarse sand and sand layers in secondary deposits (*in situ* or surface). Seven occurrences were selected
119 in channel lag contexts. The first site complex, FtJi1, has 3 main occurrences, OMO FtJi 1_A16, A17, and
120 A18, excavated by the IORE team in the 1970s at the base of a coarse sand layer above tuff F' in the FtJi 1
121 site complex (Merrick et al., 1973). The second site complex, OMO 79, evidences several phases of
122 occupation in the lower deposits of Member F (Delagnes et al., 2023). The selected occurrences are OMO
123 79_A42, A81, A112 and A129, with surface materials collected by the OGRE team in 2014; they represent
124 two distinct phases of occupation redistributed in coarse sand deposits (Delagnes et al., 2023).

125 The selected occurrences in point bar deposits are mainly in silty sediments and are considered primary
126 contexts. This includes two occurrences: OMO 79_A43, excavated during the 2018 campaign, representing
127 the third phase of occupation at OMO 79 (Delagnes et al., 2023), and OMO 371N_A167, excavated in 2019.

128 Lastly, three occurrences found in proximal floodplain deposits were selected (no archaeological
129 evidence in distal floodplain deposits was found during the extensive surveys performed by the OGRE
130 team) (Maurin et al., 2017). OMO FtJi2_A2 was excavated by H. Merrick in 1973 from a silty clay deposit
131 with carbonated concretions, 6 meters above tuff F' (Merrick et al., 1973). OMO 79_A82 is considered the
132 fourth phase of occupation at OMO 79 (Delagnes et al., 2023). Around 400 m to the west of OMO 79 is the
133 OMO 123 site complex, in which OMO A13 is the richest occurrence in Member F, excavated by J.
134 Chavaillon from 1973 to 1976 (Chavaillon, 1976).
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137 Figure 1: Location of selected occurrences (black dots) within their associated site complex in the Shungura Formation,
 138 Member F.

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Site complex	Occurrences	Context	Deposit type	Depositional environment	Number of artifacts (>2 cm)	<i>In situ</i> artifacts	Surface artifacts	Total number of artifacts
FtJi 2	A2	Primary, <i>in situ</i>	Silty clay	Floodplain	76	236	128	373
OMO 123	A13	Primary, <i>in situ</i>	Silty clay	Floodplain	208	1011	241	1099
	A16	Secondary, <i>in situ</i>	Coarse sand	Channel lag	72	299	0	299
FtJi 1	A17	Secondary, <i>in situ</i>	Coarse sand	Channel lag	111	0	206	206
	A18	Secondary, <i>in situ</i>	Coarse sand	Channel lag	65	0	120	120
OMO 79	A42	Secondary, surface	Coarse sand	Channel lag	62	0	165	165
	A43	Primary, <i>in situ</i>	Clay and silt	Point bar	47	125	127	248
	A81	Secondary, surface	Coarse sand	Channel lag	68	0	150	150
	A82	Primary, <i>in situ</i>	Clay	Floodplain	75	2	318	320
	A112	Secondary, <i>in situ</i>	Coarse sand	Channel lag	57	0	129	129
	A129	Secondary, <i>in situ</i>	Coarse sand	Channel lag	91	0	201	201
OMO 371N	A167	Primary, <i>in situ</i>	Silt	Point bar	105	199	198	378
Total					1037	1872	1983	3688

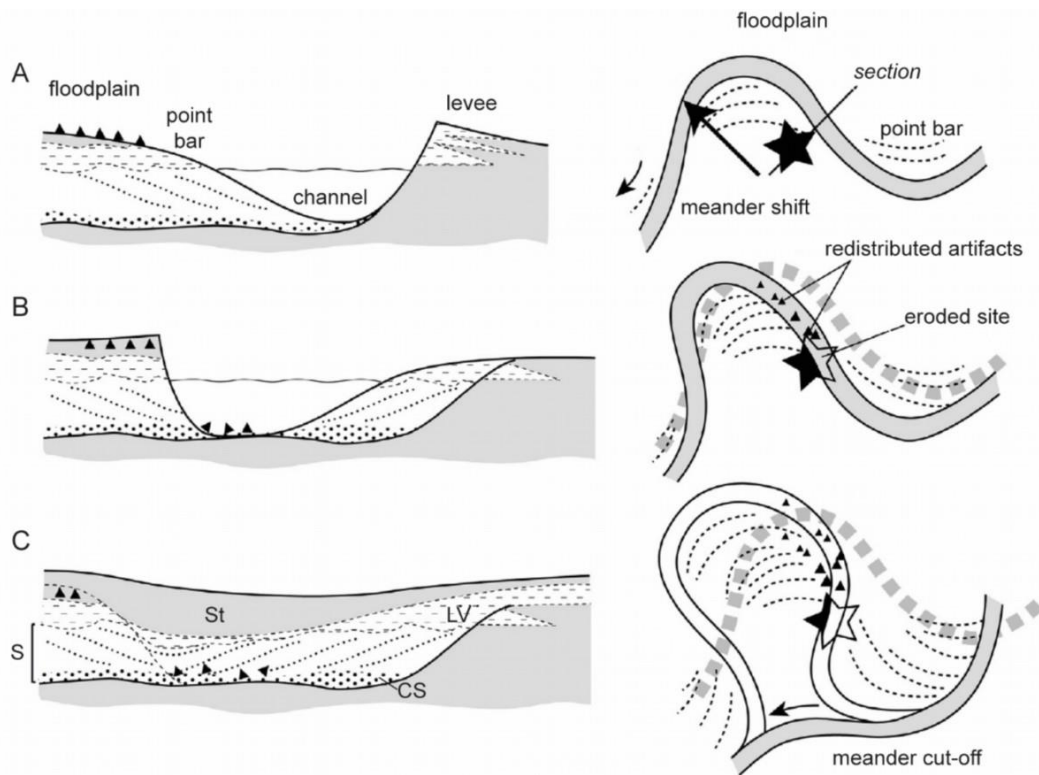
148 Table 1: Inventory and description of the selected archeological occurrences. Only artifacts longer than 2 cm (pebbles not
149 included) are included in the analysis.

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151 The complex post-depositional history of Member F sites led to the classification of archeological
152 occurrences according to their “primary” or “secondary” contexts. The notion of primary context refers to
153 the preservation of archaeological remains in their original depositional sediment. In the case of fluvial
154 sedimentation, silty and clayey deposits correspond to primary contexts. Regardless of the nature of the
155 sediments, we assume that all Member F occurrences in a primary context have undergone varying degrees
156 of post-depositional deformation, such as vertical remobilization of pieces by argilliturbation (Duffield,
157 1970; Eswaran et al., 1999; Eswaran and Cook, 1988), that hinder any attempt at intra-site analysis based
158 on the spatial distribution of artifacts. On the other hand, the concentrations of artifacts found in primary
159 contexts can be used without difficulty to reconstruct the depositional environments where hominins
160 settled. In secondary contexts, artifacts were remobilized by fluvial dynamics that redeposited them
161 elsewhere within the sandy matrix of channel lags (Merrick et al., 1973; Schick, 1986). In this case, when
162 occurrences are in small concentrations spreading downstream within a single sandy deposit, the transport
163 distance of the remains is impossible to assess, as are the type and location of the original occupation sites.

164 The positioning of the remains *in situ* or on the surface is another important criterion in the
165 characterization of the occurrences. Tectonics and tilting of the sedimentary deposits of the Shungura
166 Formation have exposed cut fronts along which erosion is active, notably via runoff, wind, and
167 bioturbation. Objects eroding from the tops or slopes of sedimentary hills are sometimes evidence of an
168 occurrence still largely preserved *in situ*, i.e., within the primary or secondary sedimentary deposit
169 (Delagnes, 2012). Occurrences are considered *in situ* when one or more artifacts are found either, in place
170 in the sediment, associated with surface artifacts attributable to the same original archeological level due
171 to their distribution (Delagnes, 2012; Delagnes et al., 2023), or associated by the nature of the adhering
172 sediment (Archer et al., 2020). Surface occurrences correspond to concentrations of remains closely
173 associated spatially with the same stratigraphic unit, with sediment adhering to the pieces, and without a
174 preserved archeological horizon. Occurrences associated with recent secondary deposits (e.g., the bottom
175 of present-day ravines or recent sedimentary slumps) are excluded from this research (Delagnes, 2012;
176 Delagnes et al., 2023).

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179 Figure 2: Hypothetical site formation process along the paleo-Omo River (right: plan view, left: cross-section). (A) Main
 180 occupation (black star) in a meander, (B) meander shift, erosion of the site, and transport of the artifacts (black triangle) as
 181 bedload in the channel, and (C) meander cut-off and burial of the site by flood deposits; St: Silt, S: sand, CS: coarse sand, LV:
 182 levee deposits (modified from Maurin et al., 2017).

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184 2.2. Taphonomic experiments

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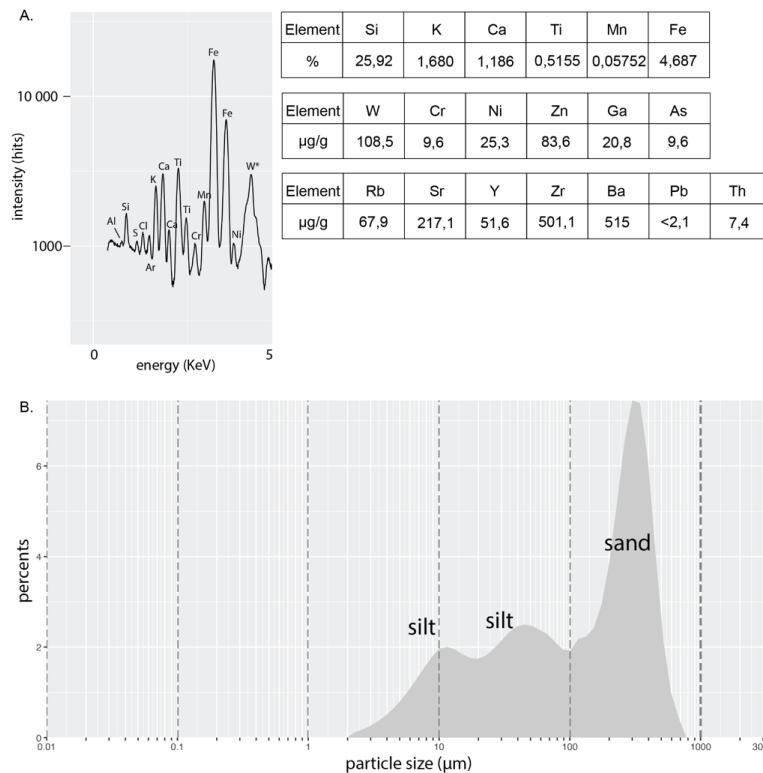
186 Since the paleo-Omo river was a major factor in site formation processes and that erosion of the deposit
 187 caused artifact exposure to weathering, the taphonomic experiments focused on fluvial transport and
 188 aeolian abrasion. The knapping of experimental artifacts was the first step of the experimental protocol.
 189 The goal was to produce sharp flakes from quartz pebbles collected in the Shungura Formation channel lag
 190 deposits. In total, 24 pebbles were knapped, 6 of which came from Member F. The scarcity of quartz
 191 pebbles within Member F deposits (Delagnes et al., 2011) led us to use 16 pebbles from Member B which
 192 has a similar fluvial depositional environment. The knapping session involved both bipolar and freehand
 193 percussion, and produced 392 artifacts longer than 1 cm, which were given a unique inventory number,
 194 stored individually and used in the following experiments.

195 *Fluvial experiment*

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197 The second step in the experimental protocol was to better characterize the grain size and composition
 198 of the sandy deposits from Member F in order to build an adequate protocol and to understand the impact
 199 of this specific fluvial sediment on the lithics. Thus, analyses using a laser particle size analyzer and an X-
 200 ray fluorescence spectrometer were performed on sand samples from Member F, collected near the OMO
 201 123 archeological complex. The paleo-Omo river sand collected in Member F is composed mostly of
 202 volcanic rocks and very little quartz (Silicon = <50%) which is due to erosion of the volcanic substrates
 203 upstream from the valley (Butzer and Thurber, 1969). The particle size analysis showed sand is the main
 204 component, with a minor silt component (Fig. 3).

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Figure 3: Detail of the analyses made on a sand sample from a channel lag deposit in Member F. A: Analysis by X-Ray fluorescence showing the composition of elements within the sand (Si: Silicon, K: Potassium, Ca: Calcium, Ti: Titanium, Mn: Manganese, Fe: Iron, W: Tungsten, Cr: Chromium, Ni: Nickel, Zn: Zinc, Ga: Gallium, As: Arsenic, Rb: Rubidium, Sr: Strontium, Y: Yttrium, Zr: Zirconium, Ba: Barium, Pb: Lead, Th: Thorium). B: Size sorting analysis showing a minor silt component and a major sand component.

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The equipment used to reproduce fluvial transport was a combination of three rubber polishing barrels with a capacity of 500 grams each (®Lortone, inc.) and a rotation speed of 60 rpm. The content ratio was one third sand (100mL) and two thirds water (200mL) to mimic the conditions within the Omo river. Then a series of sequential tests were set up to evaluate the development of weathering traces. Abrasion time was established based on data from the available bibliography (according to the synthesis of Chu, 2016) at 3h, 6h, 12h, 24h, 48h, 72h and 100h. Two artifacts for each time interval were used to assess the variability of weathering.

220 *Aeolian experiment*

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The aridity of the Shungura environment makes the aeolian alteration of artifacts following surface exposure possible before and/or after burial. This type of experimentation has only been undertaken once (Knutsson and Lindé, 1990) on quartz artifacts. It was therefore necessary to establish a protocol adapted to the context of the study. For this purpose, we used a closed-circuit sandblasting machine (®Finimac) from the *Centre d'Études Nucléaires de Bordeaux Gradignan* (CENBG) (Fig. 4). The air pressure was set at 14 psi, equivalent to 1 bar, and to the estimated pressure on Earth with an average wind speed of 5 m/s (the calculated average wind speed for Shungura) (Laity and Bridges, 2009). The distance required to obtain this wind speed from the jet to the artifact was then determined as 10 cm, which avoids completely degrading the surface of the experimental flakes. A total of six flakes were placed so that the largest, flattest surface was parallel to the air flow, and two were positioned perpendicularly. We did not have the opportunity to modify the abrasive used by the machine, which is composed of standardized silica sand. The duration of exposure was varied between 1 to 5 minutes. Beyond that time, the force of the machine led to an opacity and smoothing of the experimental flake surfaces which is not seen in the archaeological record.

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Figure 4: Closed-circuit sandblasting machine, external view on the left and internal view on the right.

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After experiments, the pieces were cleaned separately in an ultrasonic tank with demineralized water and neutral soap for 15 minutes and then with only demineralized water for another 15 minutes. Afterwards, the surfaces were cleaned with alcohol (90%) during observation under the microscope.

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2.3. Microwear analysis

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The macrowear and microwear of the selected archeological sample were directly compared in order to obtain surface alteration data across a multi-scale range (Fig. 5). The metallographic microscope Olympus BHM equipped with differential interference contrast was used in the observation of taphonomic wear. The archaeological material stored in the National Museum of Ethiopia in Addis Ababa was observed directly under the microscope without making molds. Non-destructive analyses started with the cleaning of the artifacts using 90% alcohol and ultrasonic cleaning using neutral soap and demineralized water for 15 minutes and with only demineralized water for another 15 minutes. Then 200x and 400x magnification was used to examine the artifacts from their edges to the central surfaces along the widest surface of each product type. No cortical surfaces were examined. This work focused on the general preservation of an artifact to evaluate the impact of post-depositional processes on the assemblages. To do so we focused on the macroscopic and microscopic abrasion on edges and ridges of the artifacts. What characterizes the microscopic taphonomic alterations is the randomness of their location and orientation on the artifact surfaces and edges. We choose to qualify this kind of abrasion as microfracturing because the origin of the alteration, whether mechanical and/or chemical, is unknown. This alteration was divided into three levels, both at macroscopic and microscopic scale, based on the work previously done on Shungura, Member F material (Delagnes et al., 2023; Galland, 2022; Maurin et al., 2017) (Fig. 5).

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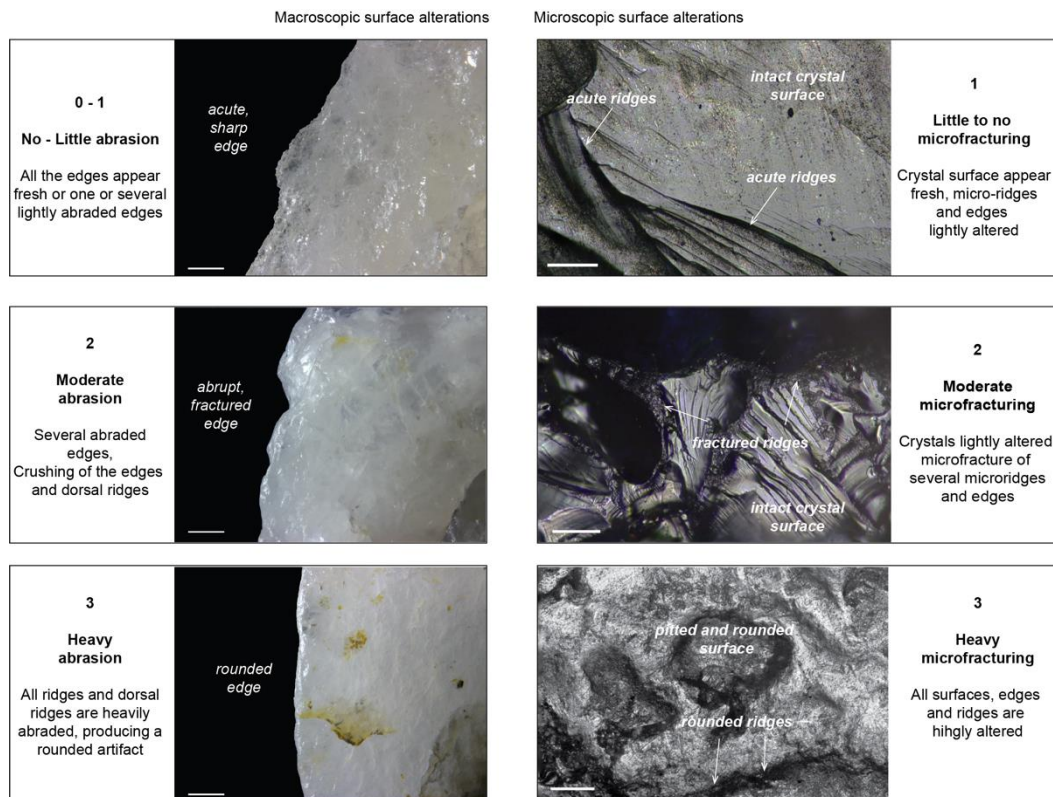
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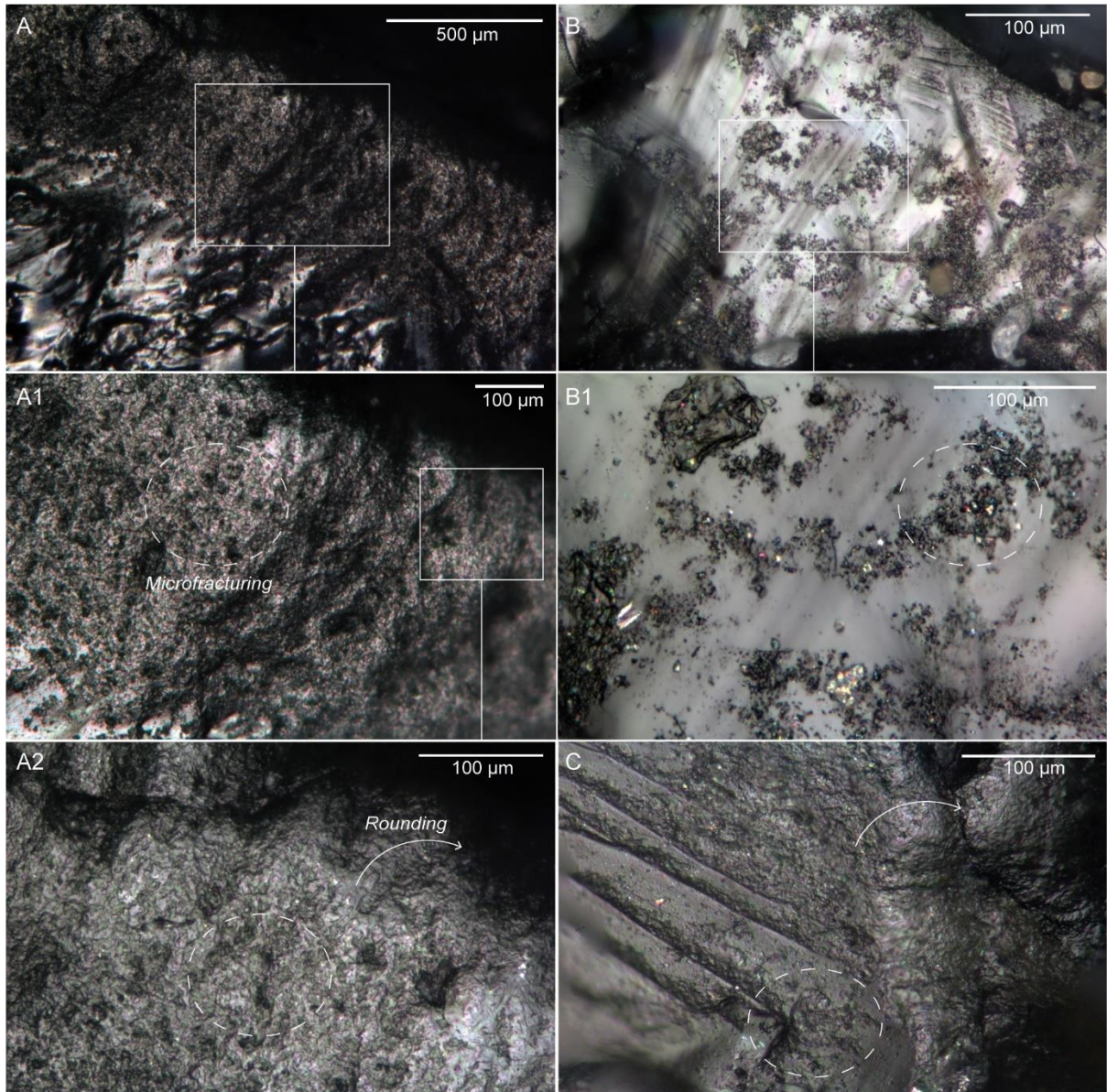
261 Figure 5: Classes of alteration on quartz artifacts. Description of the alteration levels at macroscopic and microscopic scales
 262 (macroscopic scale is 1mm; microscopic scale is 100µm) (modified from Delagnes et al., 2023).

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264 3. Results

265 3.1. Water transport

266 Due to the high resistance of quartz materials to mechanical alteration, alteration due to sand and water
 267 movements can only be observed on the experimental pieces after 72 hours. Microfracturing was evident
 268 through more or less continuous irregular pits on the surface of the quartz crystals, and rounding on the
 269 ridges and edges (Fig. 6). A clear limit can be seen between the altered edge and the fresh crystal.

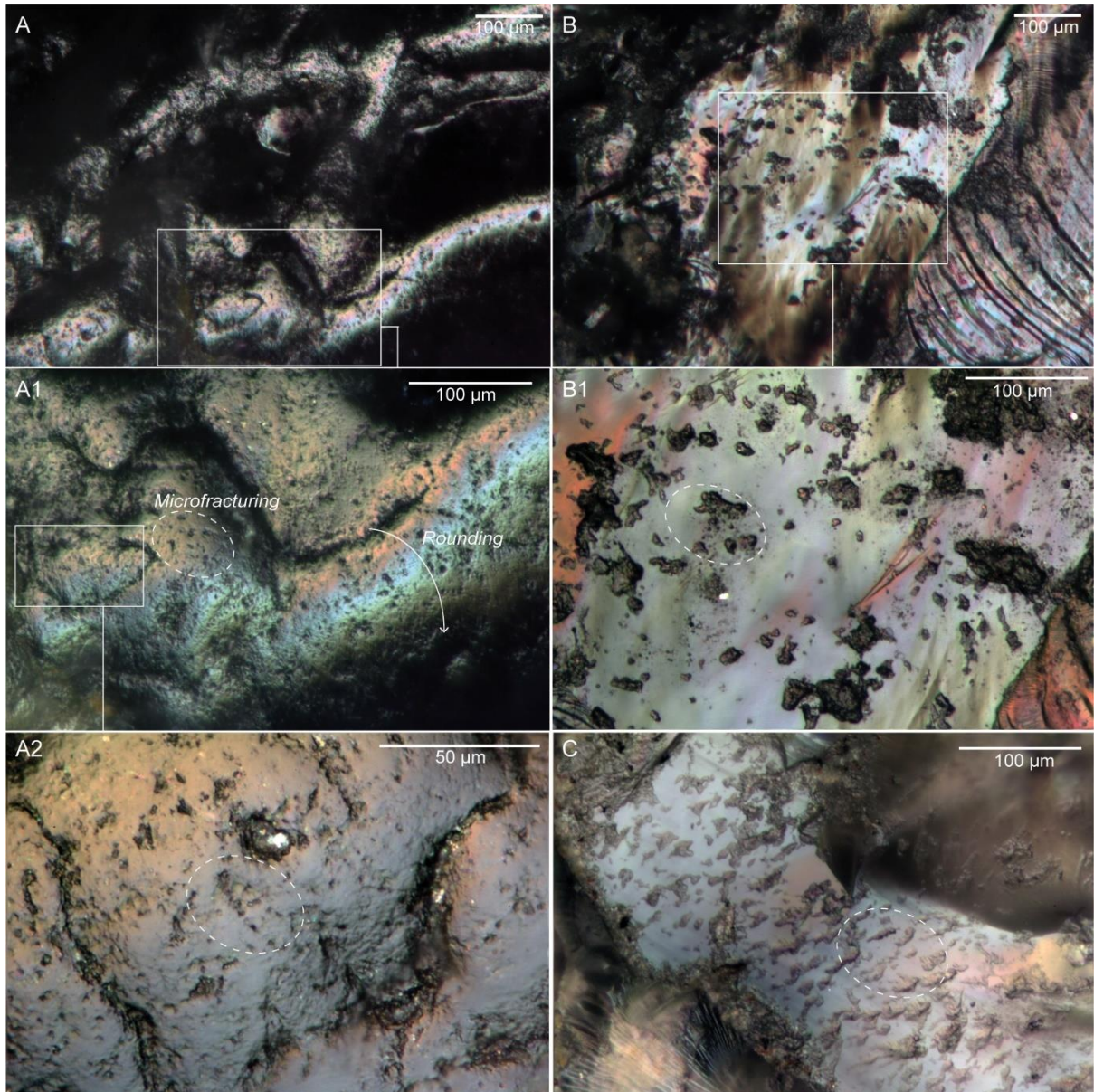


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271 Figure 6: Experimental taphonomic wear from fluvial transport (72h) in a sandy matrix from Member F. A to A2 show a
 272 rounded edge with continuous and pitted microfracturing. B and B1: scattered microfracturing on a crystal surface. C:
 273 rounding and microfracturing on the top part of the topography.

274 We also tested the alteration of experimental pieces in tumbling barrels with silty sediments (Fig. 7) and
 275 clayey sediments (Fig. 8) obtained from the sieving of sand samples from Member F. These tests proved
 276 productive, as alteration changes according to sediment grain size. Grains from silty sediments cause
 277 microfracturing of quartz crystals similar to that caused by sand (Fig. 6). As silt is finer than sand, the
 278 alteration was observed after 100 h in the tumblers. The edges and micro-ridges were heavily rounded,
 279 and the crystals were coarsely pitted in the form of circular and/or oval impacts.

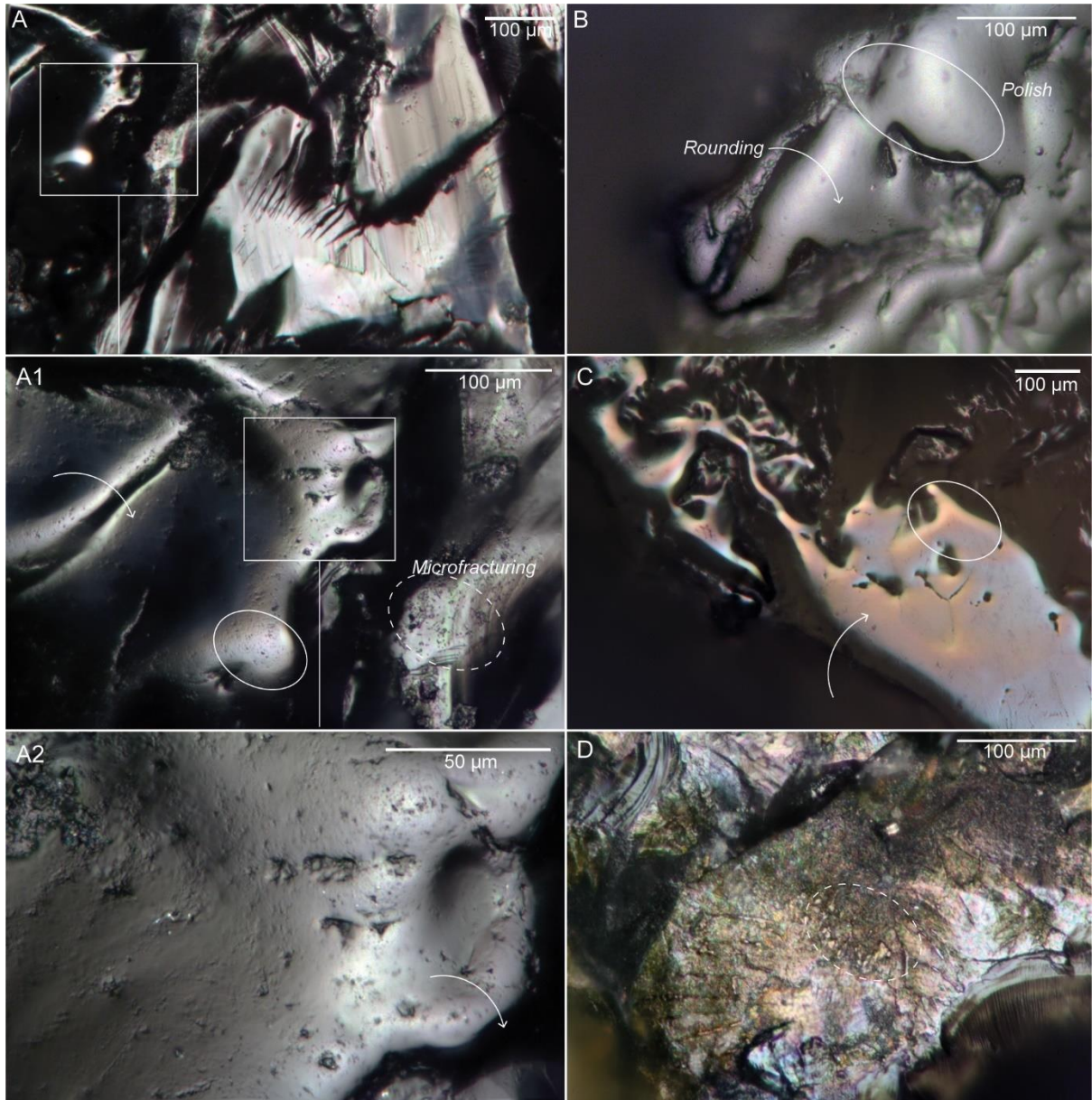
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282 Figure 7: Experimental taphonomic wear from fluvial transport (100h) in a silty matrix from Member F. A to A2: rounding
 283 and circular pitting corresponding to impact marks of the sediment grain. B, B1, C: pitting of the crystal surface with no
 284 rounding.

285 The alteration caused by the clay sediment is very different from that described above. Edge rounding is
 286 highly developed and even shiny, while surface pitting is rare (Fig. 8: A, B, C). There are, however, areas
 287 where microfracturing is abundant and continuous which creates a rough surface on the quartz crystals
 288 (Fig. 8: D).



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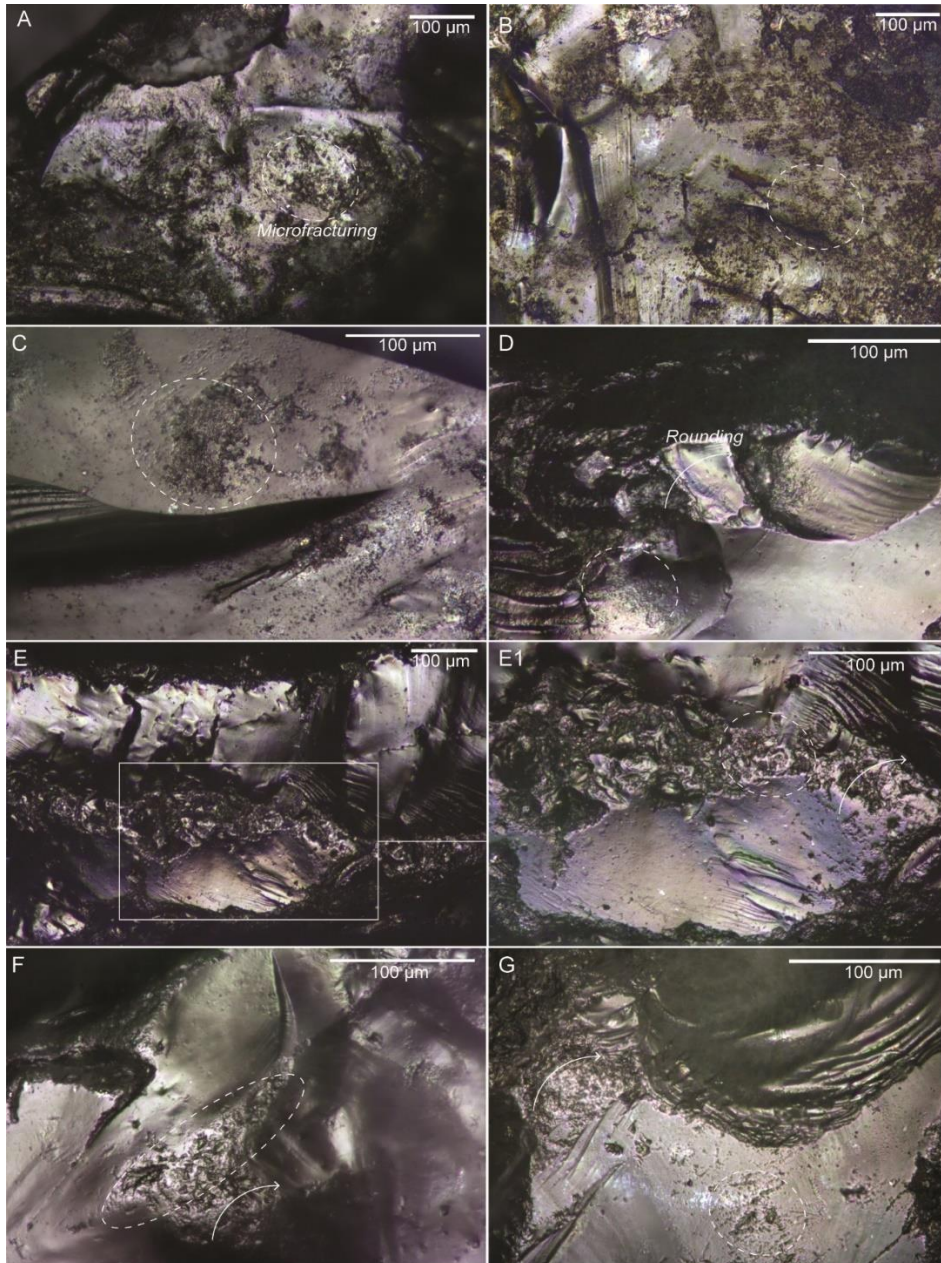
290 Figure 8: Experimental taphonomic wear from fluvial transport (100h) in a clayey matrix from Member F. A to A2: developed
 291 rounding with scattered pitting. B and C: heavy rounding, smoothed and bright polish. D: continuous microfracturing on a
 292 crystal surface.

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294 3.2. Taphonomic wear of archaeological assemblages

295 Occurrences in channel lag deposits

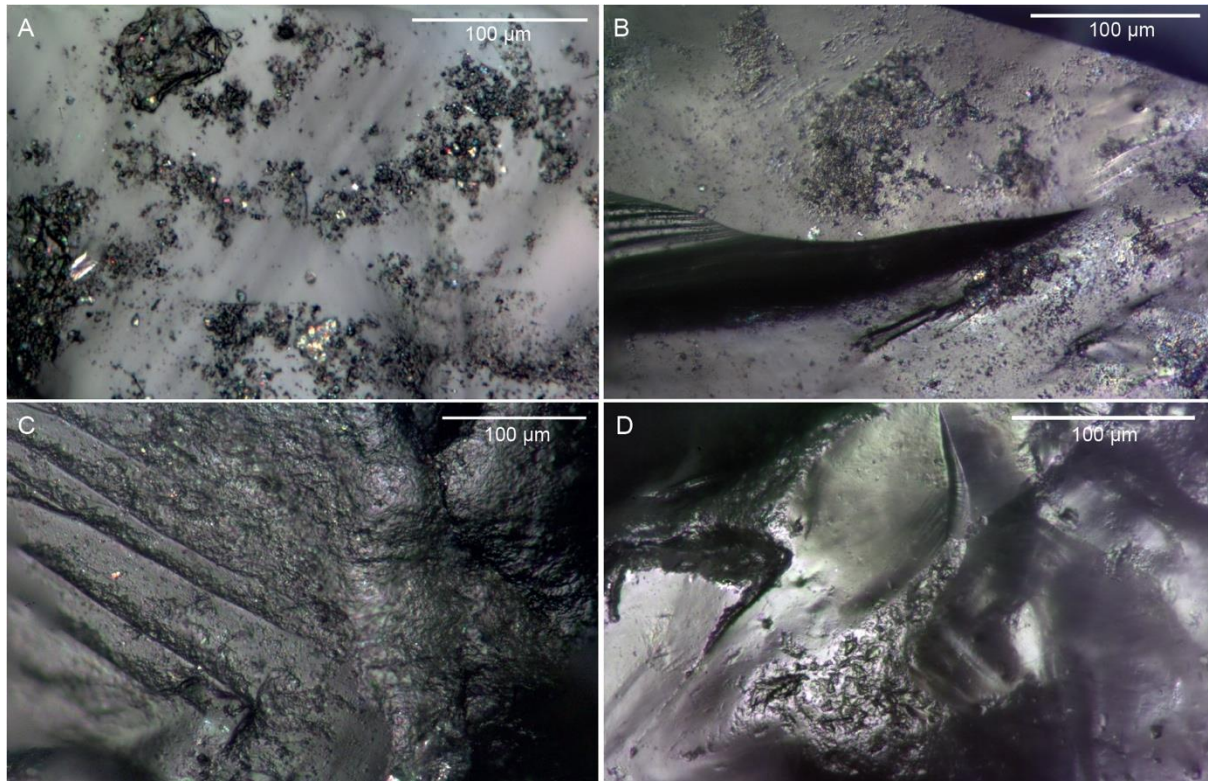
296 The macroscopic observation of artifacts show that the material is well preserved; less than 5% were highly
 297 abraded. This is explained by the strong resistance of quartz to alteration and potentially due to the short
 298 remobilization of artifacts in time and space before burial. The relative freshness of artifacts at a
 299 macroscopic scale is balanced by the heterogeneity of microscopic surface alterations. Artifacts showing
 300 minimal microfracturing represent 50 to 60% of the assemblages, except at OMO 79_A81 where this rate
 301 is close to 70%. However, up to 10% of the artifacts in channel lag assemblages show heavy microfracturing
 302 (Fig. 16).



303

304 Figure 9: Taphonomic wear of archaeological artifacts in channel lag deposits. A to C: irregular microfracturing on the internal
 305 part of the crystals (OMO FtJi1_A16); D to G: the microfracturing is mainly localized on the top of the topography with light
 306 rounding of the ridges (D to F: OMO FtJi1_A17, G: OMO 79_A82).

307 The taphonomic microfracturing characteristic of sandy sediment alteration is observed in the
 308 archaeological material. It is distributed on the whole piece, with a light rounding of microridges which
 309 could indicate short duration transportation. This rounding appears alongside coarse and irregular pitting,
 310 also equivalent to what was observed experimentally on artifacts transported in sandy sediment (Fig. 10).

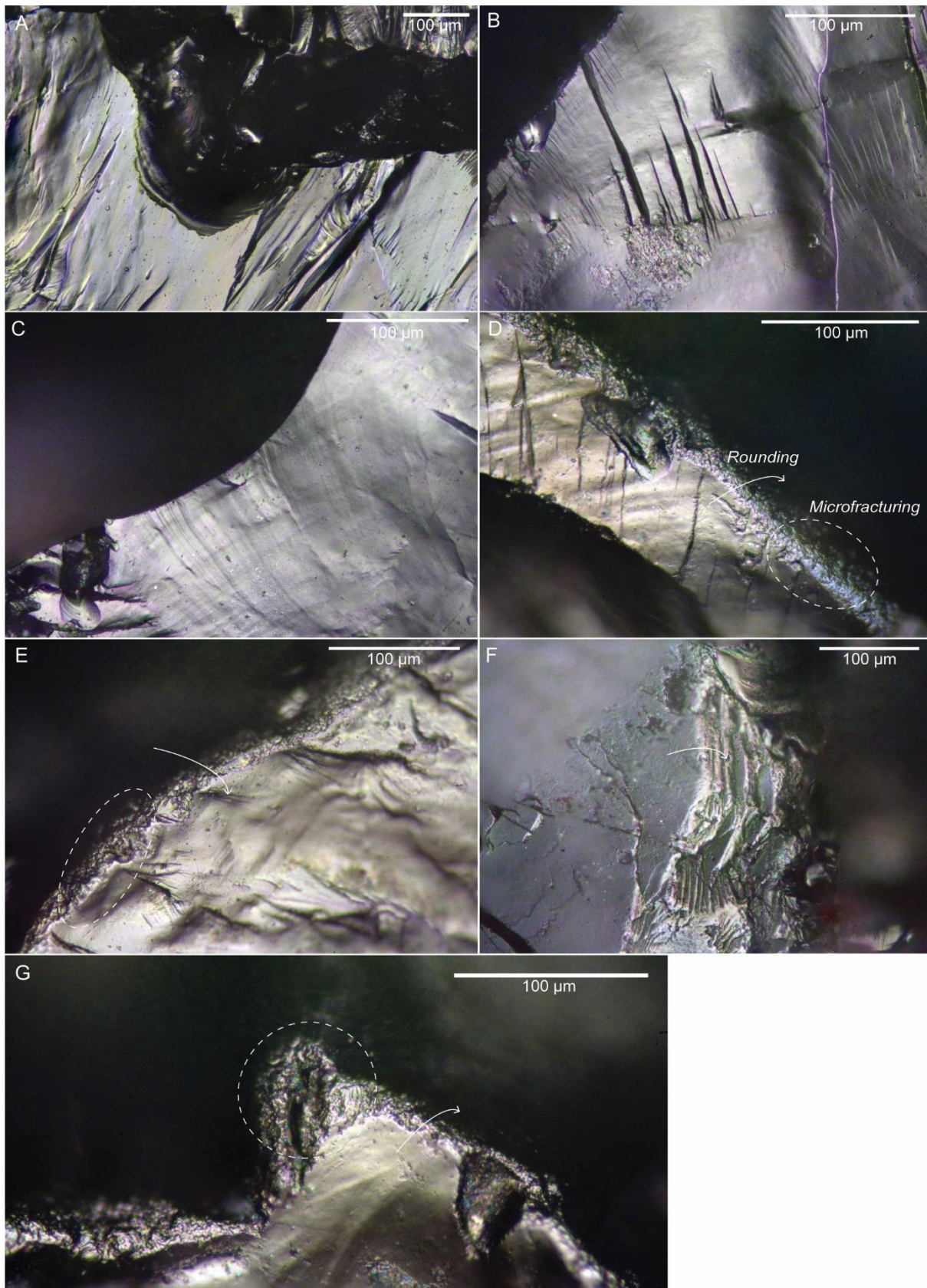


311

312 Figure 10: Comparison of wear produced by the fluvial transport experiment (A and C) and the wear present in the
 313 archaeological record from artifacts in channel lag deposits (B and D).

314 ***Occurrences in point bar deposits***

315 As with the channel lag occurrences, artifacts are well preserved on a macroscopic scale, with a very low
 316 proportion of artifacts showing significant abrasion (Fig. 16, see supplementary information (SI) for
 317 detailed tables of artifacts at <https://doi.org/10.5281/zenodo.11204868>). Microscopically, the lithic
 318 assemblages are also generally well preserved, with the proportion of artifacts with little to no
 319 microfracturing at over 60% for both occurrences (OMO 79_A43 and OMO 371N_A167) (Fig. 16).
 320 Microwear related to taphonomic alteration is poorly developed compared with channel lag deposits.
 321 Crystal edges and surfaces are very well preserved overall, with sharp edges and crystals showing clearly
 322 visible technological features (Fig. 11: A, B and C). Less than 10% of the point bar assemblages are impacted
 323 by general rounding and the microfracturing is mostly limited to the edges and ridges (Fig. 11: D to G).



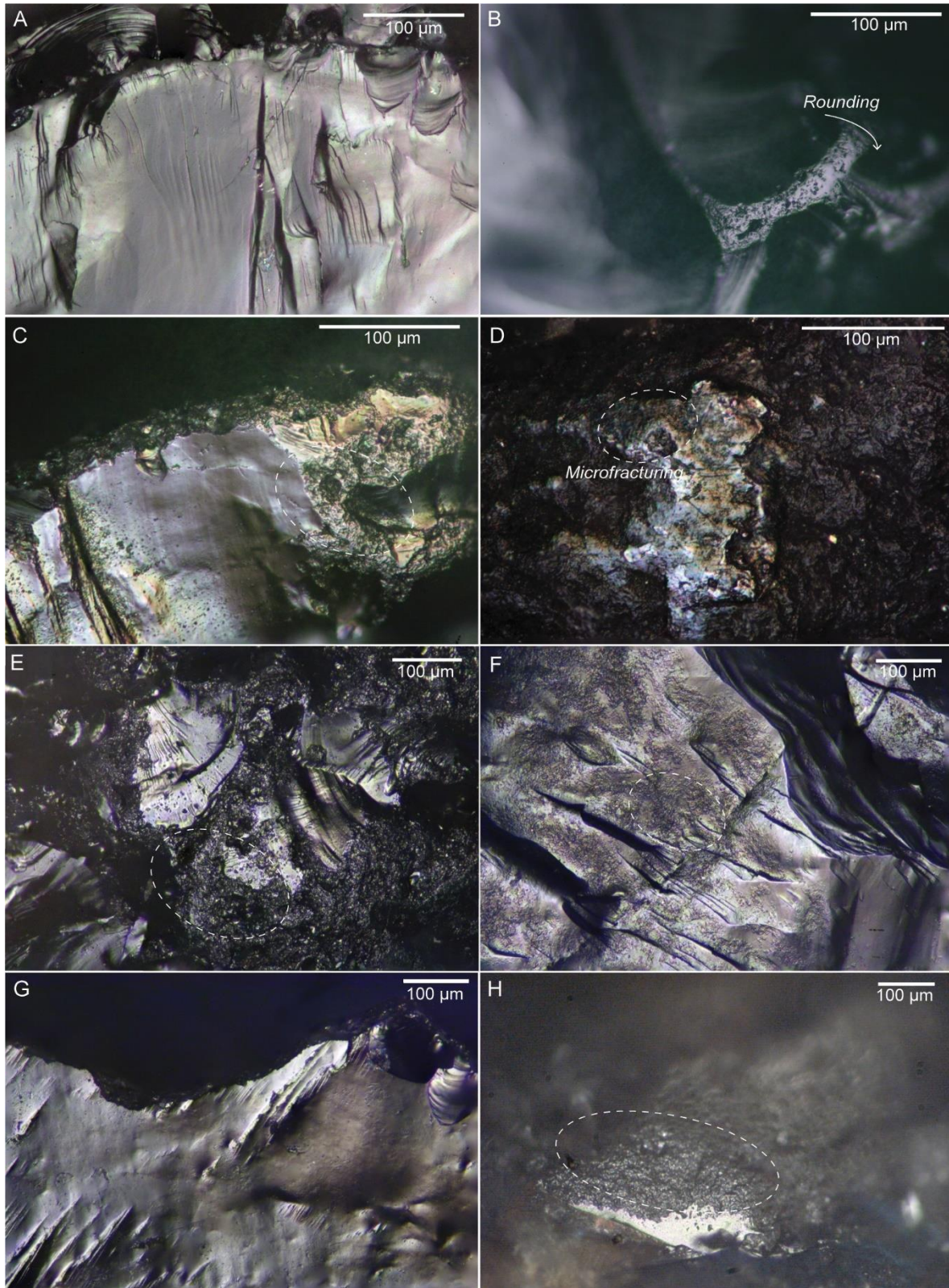
324

325 Figure 11: Taphonomic wear of archaeological artifacts in point bar deposits. A to C: sharp edges with unaltered crystals (A:
 326 OMO 79_A43; B and C: OMO 371N_A167); D to G: microfracturing and rounding limited to the edges and the
 327 topography (D, E, G: OMO 79_A43; F: OMO 371N_A167).

328 ***Occurrences in proximal floodplain deposits***

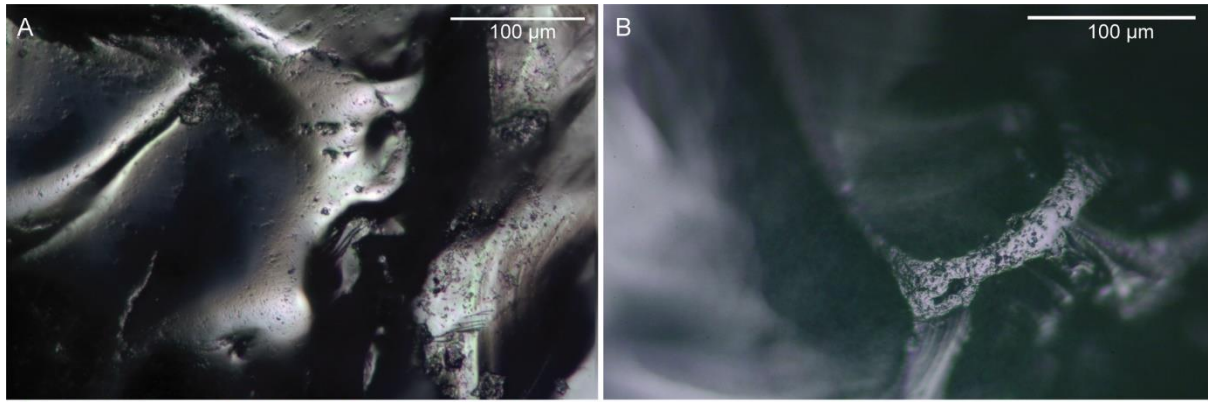
329 Macroscopically, artifacts are well preserved with a low proportion of heavy abrasion (Fig. 16, see SI)
330 and a predominance of sharp edges (Fig. 16, see SI). However, differences in preservation between
331 the proximal floodplain assemblages emerges at the microscopic scale. OMO 79_A82 has the highest
332 microfracturing rate of the entire corpus, with 63 % of pieces showing a moderate to high amount of
333 microfracturing. OMO 123_A13 has 44 % of pieces with moderate to high microfracturing, compared
334 with 33 % at OMO FtJi 2_A2 (Fig. 16). These high microfracturing rates can be explained by the
335 predominantly clayey matrix, which was subject to argiliturbation. This process of repeated seasonal
336 swelling and shrinkage of the clays leads to compression of the sediments which induces the formation
337 of slickensides, and multi-decimeter or sometimes even multi-meter vertical cracks, into which the
338 artifacts can fall (Duffield, 1970; Eswaran and Cook, 1988; Eswaran et al., 1999). Although all three
339 occurrences are located in the same type of clay deposit, argiliturbation must have been more
340 extensive at OMO 79_A82, leading to greater alteration of the artifacts.

341 The assemblages found in clayey matrices show stronger and more heterogeneous alterations than
342 those found in silty deposits. These alterations are characterized by extensive and continuous
343 microfracturing affecting both the edges and the inner surfaces of the crystals (Fig. 12: D, E, H), and
344 strongly altering the microtopography. In silty deposits, the microfracturing is only present in the
345 upper parts of the microtopography in a coarse, irregular pattern, accompanied by rounding (Fig. 12:
346 B, C, F). This rounding can sometimes take the form of a shiny, smooth polish, which is exclusive to
347 this type of sediment (Fig. 12: B). Added to this are artifacts with preserved crystals (Fig. 12: A), but
348 edges affected by abrupt crushing (Fig. 12: G).



349

350 Figure 12: Taphonomic wear of archaeological artifacts in proximal floodplain deposits. A (OMO FtJi2_A2): unaltered crystal;
 351 B (OMO 123_A13): heavy rounding, the center of the flake surface is almost polished, it is similar to the alteration resulting
 352 from the experiments using clay (see figure 8); C (OMO 79_A82) and G (OMO 123_A13): abrupt microfracturing of the edge,
 353 without reaching the internal surface of the crystal; D, E (OMO FtJi2_A2) and H (OMO 123_A13): heavy microfracturing,
 354 reaching the internal part of the crystals; F (OMO 123_A13): moderate microfracturing located on the crystal and not
 355 impacting the nearest ridges.



356

357 Figure 13: Comparison of wear produced by the fluvial transport experiment (A) and the wear in the archaeological record
 358 from artifacts in proximal floodplain deposits (B). A: polish produced by fluvial transport in clay, B: taphonomic polish away
 359 from the cutting edge (OMO 123_A13).

360

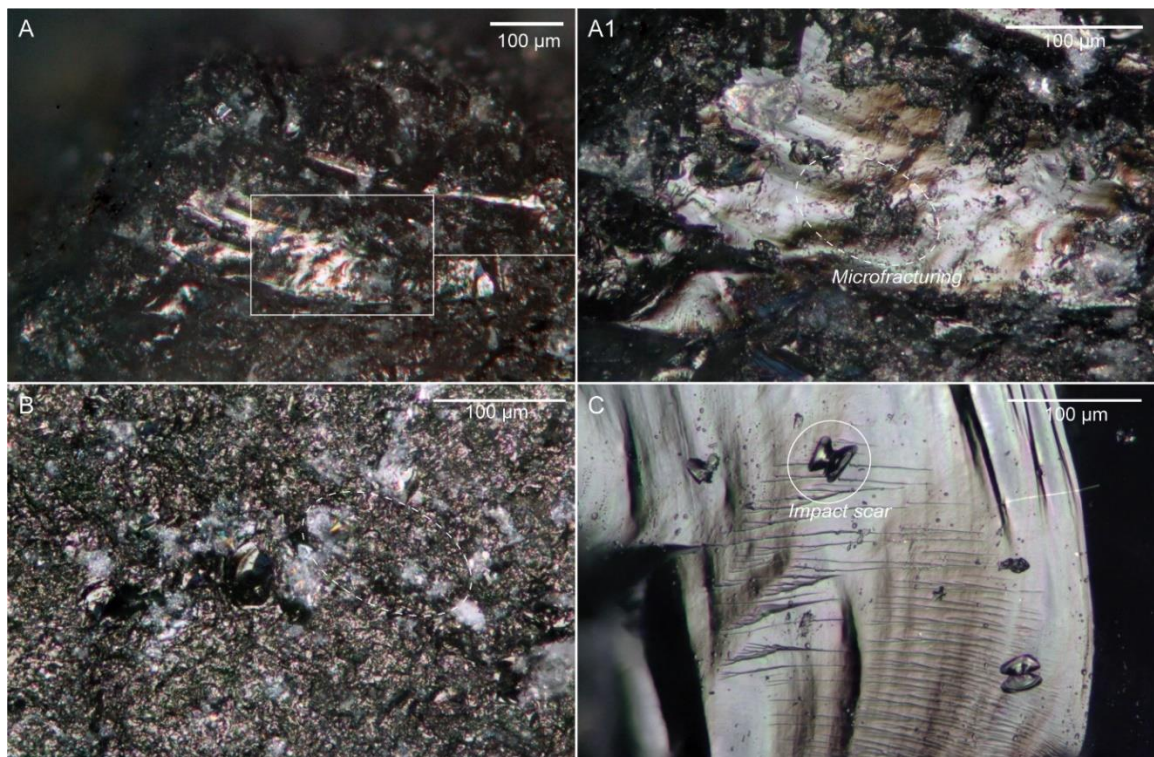
3.3. Aeolian Experiments

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363 The traces observed on the flakes were very different according to the duration of exposure to the
 364 particle jet. At 1 minute of exposure, the crystals showed no developed microfracturing, and identifiable
 365 traces resembled hourglass-shaped impact points on the crystal surface (Fig. 14, C). However, after 5
 366 minutes, the surface becomes unrecognizable, and the resultant heavy microfracturing over the entire
 367 surface made it impossible to identify the technological and functional characteristics of the flake (Fig. 14,
 368 A and B).

369

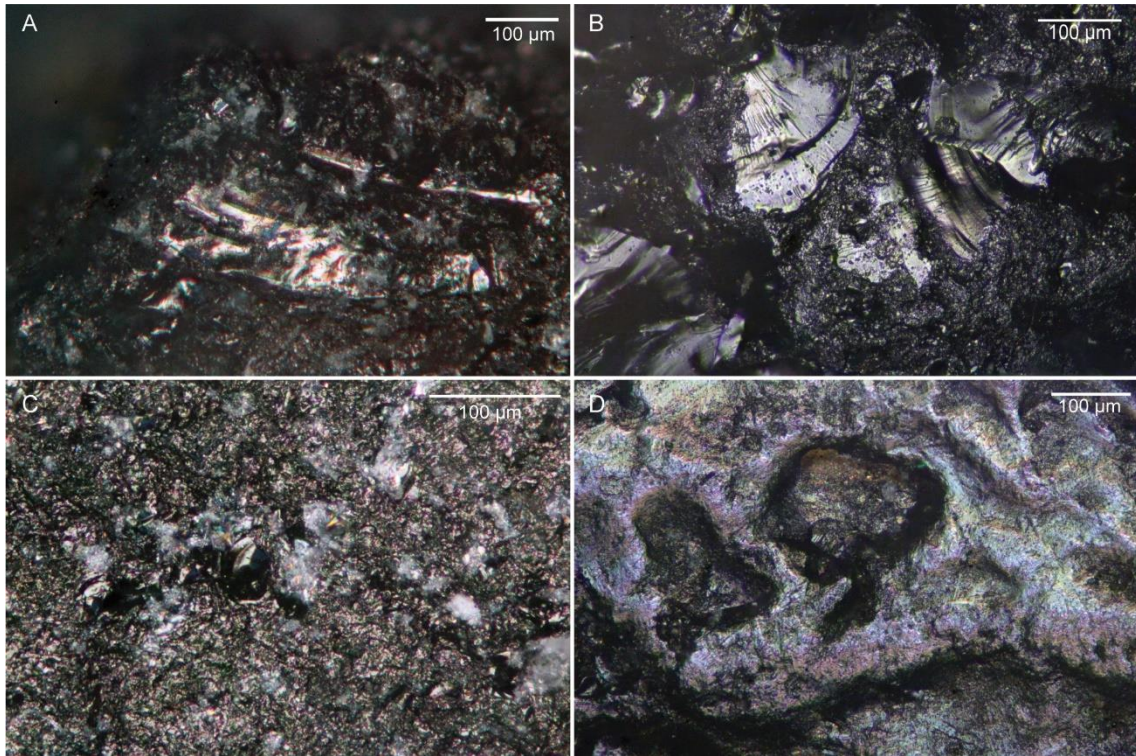


370

371 Figure 14: Experimental taphonomic wear from aeolian abrasion. A and B: wear resulting from 5 minutes of aeolian abrasion.
 372 The surface is highly damaged by impacts, the original crystals are not preserved. C: wear resulting from 1 minute of aeolian
 373 abrasion. The surface is almost intact with minor traces of impact on the surface of crystals.

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 Aeolian abrasion experiments do not produce wear similar to those found in the archaeological record. The isolated hourglass-shaped impacts produced after 1 minute of exposure are not observed in the archaeological material, and the severe microfracturing of experimental flakes subjected to long exposure has no equivalent in the archaeological record, even when compared to heavily weathered pieces (Fig. 15). The microfracturing produced by aeolian abrasion is rough and continuous across the whole flake surface contrasting with the archaeological alterations which mostly show a generalized rounding with continuous microfracturing across the ridges and inner surfaces of the crystals.



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Figure 15: Comparison of wear produced by the aeolian abrasion experiment (A and C) and the wear seen in the archaeological record on heavily altered artifacts (B and D). A and C: quartz flake surfaces after 5 minutes of aeolian abrasion; B: heavy alteration in a floodplain deposit (OMO FUj 2_A2); D: heavy alteration with rounding in a floodplain deposit (OMO 123_A13).

388

389 3.4. Synthesis of the results

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391

The taphonomic experiments produced five main results.

392

1. Fluvial experiments led to the formation of different types of microfracturing, depending on the grain size of the sediment. The coarser the sediment, the more continuous, wide and coarse the microfracturing. Conversely, the finer the sediment, the smaller, finer and more homogenous the microfracturing.

396

2. The presence of rounding and pitting is consistent in fluvial experiments, with no specific orientation, whatever the particle size of the sediment used.

397

3. The fluvial experiments using a very fine sediment created a developed, shiny and rounded polish that can be equivalent to that created by working fresh plant material (Bello-Alonso et al., 2019).

398

4. The aeolian experiment had a very significant impact on the crystals in a very short space of time. The crystals are highly pitted, with no rounding or polish.

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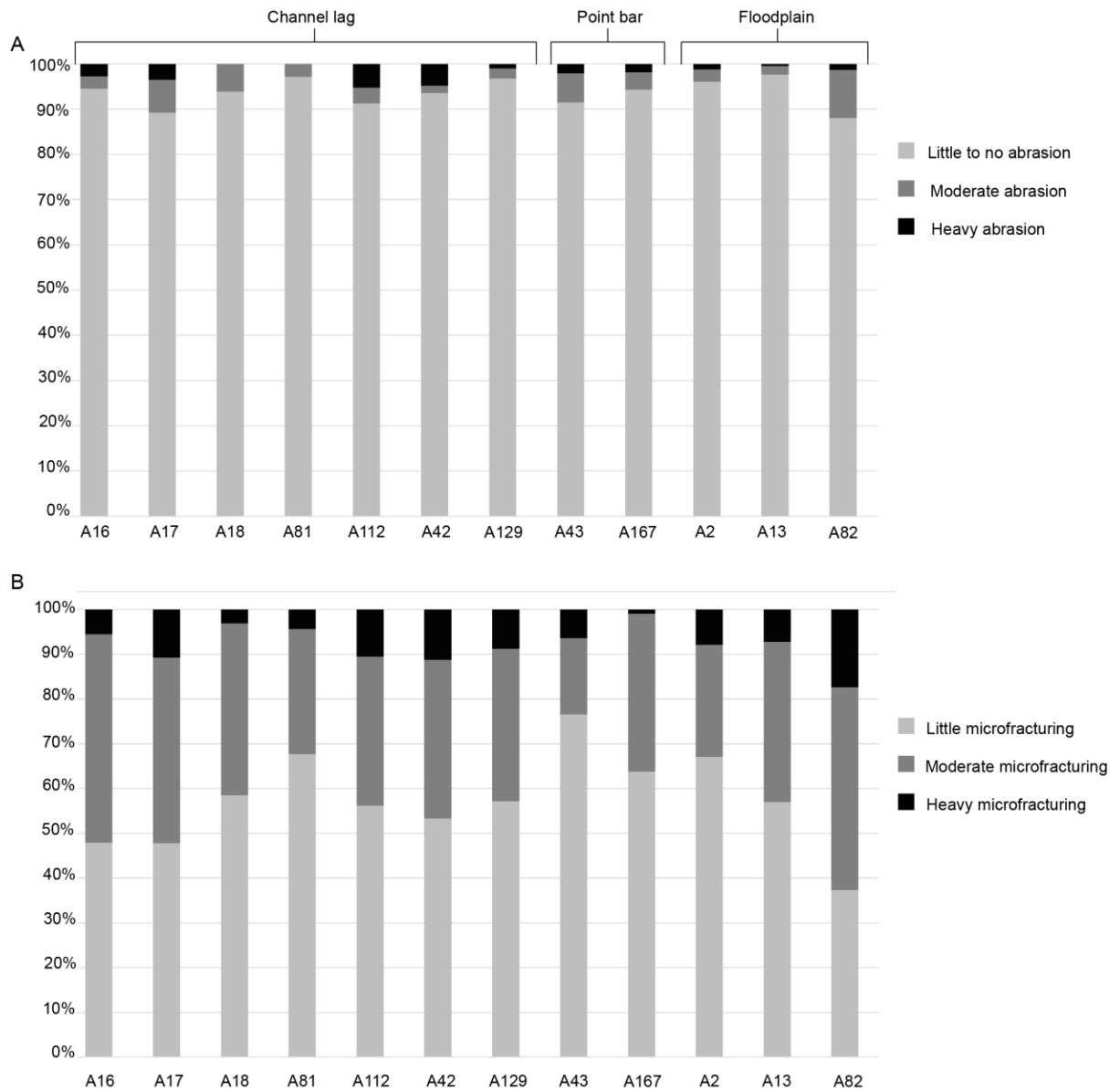
403 5. The fluvial and aeolian experiments carried out did not lead to the formation of striations on
 404 the artifact surfaces. From the five types of microwear found on quartz (scarring, rounding,
 405 microfracturing, polish, striations), striations are the only one absent from our observations.
 406

407 To provide an overall comparison of the wear produced by these experiments and the depositional
 408 environment in archaeological contexts, a summary table (Table 2) lists the wear morphologies according
 409 to the presence (+) and absence (-) of traces and their degree of abundance (+ scarce, ++ abundant and
 410 +++ very abundant).

Context	Microwear				
	Striation	Scarring	Rounding	Microfracturing	Polish
Fluvial transport_Sand	-	+	+++	+++	-
Fluvial transport_Silt	-	-	+++	+++	-
Fluvial transport_Clay	-	-	+++	+	+++
Aeolian abrasion (1min)	-	+	-	-	-
Aeolian abrasion (5min)	-	++	-	+++	-
Channel lags	-	++	++	+++	-
Point bar	-	+	+	++	-
Floodplain	-	++	++	+++	++

411 Table 2: Synthesis of taphonomic microwear types and their frequency, comparing experiments and the depositional
 412 environments in the archaeological record. Presence (+), absence (-), and relative abundance (++ abundant, +++ very
 413 abundant).

414 The depositional environments produce specific microwear on the surface of artifacts. In channel
 415 lag deposits, the microscopic preservation is moderate (Fig. 16), with the presence of sandy sediment
 416 fluvial transport alteration as characterized in the experiments. The alteration observable on the
 417 archaeological material is distributed on the whole piece with a light rounding of the ridges associated with
 418 a coarse and irregular pitting, sometimes in a circular shape (Fig. 9). The assemblages located in the silty
 419 sediments of point bar deposits are better preserved, as evidenced by low alteration at both macro- and
 420 microscopic scales (Fig. 16). The fracturing and rounding are present mostly on the micro-ridges and do
 421 not reach the internal surface of the quartz crystals. Finally, the lithic assemblages recovered from
 422 floodplain deposits, characterized by clayey sediments, have a heterogeneous preservation with a high
 423 degree of microfracturing and rounding of ridges (Figs. 11 and 16). This heterogeneity is not found at a
 424 macroscopic scale, as the artifacts mostly show little to no abrasion. One of the occurrences from the clayey
 425 deposit in a floodplain environment, **OMO 79_A82** stands out from the others because of its high level of
 426 taphonomic alteration (Fig. 16). Aeolian abrasion was not detected in the archaeological record. The
 427 taphonomic microwear related to these specific depositional environments show a tendency towards
 428 better preservation of archaeological material in point bar (i.e. silty sediments) deposits, compared to the
 429 preservation of material in floodplain and channel lag deposits. However, this is context specific and should
 430 not be accepted as a diagnostic and universal feature for all archaeological sites that have this depositional
 431 history. In fact, channel lags and floodplain deposits can still be taken into account for use-wear analyses
 432 when the taphonomic microwear is well characterized. In this case, the microwear observed in the
 433 experiments can be considered as diagnostic for the archaeological material; for example, the presence of
 434 homogenous circular pitting, and rounding scattered on the whole surface of the artifact indicates fluvial
 435 transport in sandy sediments.



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Figure 16: Cumulative histograms of alterations at macroscopic (A) and microscopic (B) scales for each of the selected occurrences according to their depositional environments. Detailed table of the artifacts in SI.

4. Discussion

440 This work emphasizes the significance of taphonomic experiments in comprehending the preservation
441 of lithic assemblages, at both macro- and microscopic scales, in relation to their depositional environments.
442 Quartz and quartzite are known for their resistance to physical and chemical alteration (Baesemann, 1986;
443 Boudeulle et al., 1979; Caruana et al., 2014; Knutsson, 1988a), unlike volcanic rocks and cherts, which are
444 often not well-preserved enough for functional analysis in Oldowan contexts (Beyries, 1993). The material's
445 hardness, rated at 7 on the Mohs scale, is comparable to chert. However, unlike chert, quartz materials are
446 not affected by the various patinas that often develop on it (Ollé et al., 2016). Although more resistant and
447 chemically stable, quartz materials are subject to specific types of fracturing and abrasion (Knutsson,
448 1988a; Tallavaara et al., 2010; Venditti et al., 2016). The identification of alteration traces on quartz and
449 quartzite is crucial in distinguishing between anthropic and taphonomic traces (Knutsson and Lindé, 1990;
450 Venditti et al., 2016). Therefore, conducting taphonomic experiments is essential to gain a better
451 understanding of these traces and their characteristics. This experimental work highlights new criteria for
452 the discrimination between taphonomic and use-wear in quartz materials. Adapted to the context of the
453 paleo-Omo meandering river, our observations could serve as a baseline for other African contexts in
454 similar environments. The lack of striations evidenced in fluvial transport and aeolian abrasion adds to our
455 understanding of taphonomic wear and opens promising perspectives for forthcoming functional analyses.
456 The main wear produced is rounding and pitting of the crystal ridges and surfaces induced by movement
457 of water and impact of sediment grains. In addition, a word of caution is necessary when identifying polish,
458 as fluvial transport in clay could produce the same kind of polish as working fresh plants and tubers (Bello-
459 Alonso et al., 2019), which has never been evidenced before. Making this distinction is facilitated by
460 analysis of wear location and organization in relation to other alterations on the whole surface of quartz
461 artifacts.

462 Each depositional environment has a particular impact on artifact preservation. The channel lag
463 deposits dominated by sand produce moderate alterations to artifact surfaces, which can be explained by
464 a low energy and/or short fluvial transport duration. Point bar deposits, dominated by silt, best preserve
465 the assemblages and artifact surfaces, whereas artifacts in floodplain deposits, composed mainly of clay,
466 have the worst preservation at the microscopic scale. This high level of alteration can seem paradoxical
467 when considering their primary context (the same for the three proximal floodplain occurrences); *in situ*
468 and in a fine-grained clayey matrix. This unfavorable preservation is caused by argilliturbation (Duffield,
469 1970; Eswaran et al., 1999; Eswaran and Cook, 1988) where compression and the gravitational
470 movements undergone by artifacts have played a major role in creating post-depositional alterations. The
471 presupposition that artifacts would be better suited for use-wear analysis within fine sediments does not
472 hold in this type of context, even if size sorting analysis shows that small debris were not washed away and
473 that macroscopic edge damage is low (Maurin et al., 2017). In contrast, occurrences in a secondary context
474 in coarse sediments may present good preservation conditions for functional analyses because this
475 taphonomic microwear is clearly identifiable. The secondary context of these artifacts, while having a more
476 complex taphonomic history, is not a hindrance to a good understanding of hominin tool-assisted activities
477 (Chu, 2013), and brings complementary data to the primary contexts of the Shungura Formation. This is
478 particularly important to consider as most of the archaeological occurrences in Member F are located in
479 secondary contexts. In addition, the fact that quartz represents more than 95% of the assemblages
480 (Delagnes et al., 2011) is another favorable factor in the preservation of use-wear in coarse-grained
481 sediments as this raw material is more resistant to alterations. These observations also open interesting
482 new research possibilities as the Eastern African Early-Middle Pleistocene is dominated by archeological
483 settings in fluvial deposits (Asfaw et al., 1992; Barsky et al., 2011; Gallotti and Mussi, 2018; Hovers
484 et al., 2021; Semaw et al., 2018).

485 5. Conclusion

486 The identification of traces of functional use-wear on the cutting edges of flakes relies on the necessary
487 characterization of taphonomic wear prior to functional analysis. This work therefore focuses on setting up

488 taphonomic experiments, enabling us to determine the preservation of lithic assemblages in relation to
489 different depositional environments within alluvial plain settings, like those observed in the Shungura
490 Formation (Member F). We were thus able to confirm that each sediment type produces characteristic
491 wear that can be differentiated from one another and distinguished from anthropogenic use-wear, which
492 will be the focus of a future publication. Point bar deposits best preserve artifact surfaces, as opposed to
493 channel lags and floodplain deposits. The methodological added-value of characterizing taphonomic traces
494 could be further enhanced by additional experiments coupled with in-depth characterization of the traces
495 observed, in particular for the impact of movements undergone by artifacts in clay deposits, which have
496 yet to be analyzed using a dedicated experimental protocol. This could be accompanied by quantified
497 characterization using confocal microscopy, whose potential has already been demonstrated for flint (Borel
498 et al., 2021; Caux et al., 2018; Evans and Donahue, 2008; Galland et al., 2019; Ibáñez et al., 2016, 2014)
499 and looks promising for quartz (Itamiya et al., 2021). The analysis of taphonomic signatures associated with
500 various depositional environments shows that the age of Oldowan assemblages does not restrict the
501 applicability of functional analyses to quartz materials.

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511 **Data, scripts, code, and supplementary information availability**

512 The Supplementary information detailing the attributes of artifacts for each occurrence is available
513 online at <https://doi.org/10.5281/zenodo.11204868>

514 **Conflict of interest disclosure**

515 The authors declare that they comply with the PCI rule of having no financial conflicts of interest in relation
516 to the content of the article. Anne Delagnes is a recommender for PCI archaeology.

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