Mobility and the Importance of Bone and Bulb Retouchers in the Middle Palaeolithic of the Swabian Jura

Mobilität und die Bedeutung von Knochen- und Bulb-Retoucher im Mittelpaläolithikum der Schwäbischen Alb

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ABSTRACT

Modifying the form of lithic artifacts through retouch represents a central technological feature of the Middle Palaeolithic, and retouchers made of a variety of materials appear frequently in the archaeological record. Bone and bulb retouchers are the most common types. The first, are often described as ad hoc tools with short use-lives, while researchers have tentatively identified the second as curated artifacts included in the mobile toolkit. Here we present two bulb retouchers from the Middle Palaeolithic layers VIII/VII of Sirgenstein Cave in the Ach Valley of the Swabian Jura, and discuss their general characteristics together with bone retouchers recovered from the same archaeological layers. The data on bone and bulb retouchers from Sirgenstein support the proposed complementary uses of the two types of retouchers. We suggest that the intrinsic properties of bone and flint, together with other aspects specific to the *chaînes operatoires* of these two materials, played a major role in determining the retouchers' suitability within toolkits, and can help to explain the high variability in retouching techniques encountered in the Middle Palaeolithic record. Based on these considerations, our study highlights the importance of the organization of technology and the potential of retouchers for reconstructing past mobility and settlement dynamics.

Keywords: retouchers, mobility, personal gear, curation

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ZUSAMMENFASSUNG

Die Veränderung der Form lithischer Artefakte durch das Retuschieren ist ein zentrales technologisches Merkmal des Mittelpaläolithikums, und Retuscheure aus verschiedenen Materialien tauchen in den archäologischen Hinterlassenschaften häufig auf. Knochen- und sogenannte *Bulb Retoucher* (D = Bulbus Retuscheur: Steinabschläge, deren Bulbus zum Retuschieren genutzt wurde) sind die häufigsten Typen. Erstere werden oft als Ad-hoc-Werkzeuge mit kurzer Nutzungsdauer beschrieben, während Forschende die zweite Kategorie vorläufig als Artefakte identifizieren, die zum mobilen Werkzeugsatz gehören. Wir stellen hier zwei *Bulb Retoucher* aus den mittelpaläolithischen Schichten VIII/VII der Sirgensteinhöhle im Achtal der Schwäbischen Alb vor und diskutieren ihre allgemeinen Merkmale. Dies geschieht gemeinsam mit Knochen-Retuscheuren, die aus denselben archäologischen Schichten geborgen wurden. Die Daten zu Knochen- und Bulb Retoucher aus dem Sirgenstein unterstützen die vorgeschlagene komplementäre Verwendung der beiden Arten von Retuscheuren. Wir vermuten, dass die Eigenschaften von Knochen und Feuerstein, zusammen mit anderen Aspekten, die für die *chaînes opératoire* dieser beiden Materialien spezifisch sind, eine wichtige Rolle bei der Bestimmung der Eignung von Retuscheuren innerhalb der Werkzeugsätze gespielt haben . Ein Verständnis dafür kann dazu beitragen, die große Variabilität der Retuschier-Techniken zu erklären, die im Mittelpaläolithikum auftreten. Auf der Grundlage dieser Überlegungen unterstreicht unsere Studie die Bedeutung der Organisation der genutzten Technologie und des Potenzials von Retuscheuren für die Rekonstruktion vergangener Mobilität und Siedlungsdynamik.

Schagwörter: Retuscheure, Mobilität, persönliche Ausrüstung, Kuratieren

Introduction

Among the most important changes occurring toward the end of the Lower Palaeolithic (LP), is the diffusion of the practice of fine retouching of lithic blanks and the development of specific tools for this purpose: retouchers. Although known in several LP contexts, it is with the beginning of the Middle Palaeolithic (MP) that retouchers became a frequent component of the archaeological record. The best-known and most widespread type of MP retouchers are bone retouchers (Daujeard et al. 2018; Hutson et al. 2018; Moigne et al. 2016; Rosell et al. 2015; van Kolfschoten et al. 2015), followed by bulb retouchers (Centi et al. 2019; Mathias et al. 2023), pebbles (Cuartero and Bourguignon 2022; Nicoud 2010; Raynal et al. 2005; Veselsky 2008) and other stone retouchers (e.g., handaxes and cores; Thiébaut et al. 2010). Other types of retouchers, such as antlers, are only sporadically documented in the MP (Bello et al. 2016; Daujeard et al. 2018; Vitezović 2018), while the use of hardwood, which is reported ethnographically (e.g. Martellotta et al. 2021, 2022), cannot be ruled out based on the archaeological record. The high variability in retouching techniques during the MP represents a topic that has seldom been investigated. As a consequence, a full understanding of what factors led a knapper to adopt one type of retoucher instead of another has yet to be reached. Independent studies based on empirical observations and in-depth analysis of their features link bone and bulb retouchers to dif-

ferent mobility strategies and modes of site use. Bone retouchers have been interpreted as ad hoc tools used in residential contexts, while bulb retouchers are thought to be part of the toolkit used while on the move (Centi et al. 2019; Daujeard et al. 2014, 2018).

In the present study, we characterize bone and bulb retouchers to examine how mobility influences variability observed in MP retouching techniques. In addition, we report on a newly discovered assemblage of bulb retouchers from the MP layers VIII/VII of Sirgenstein, in the Ach Valley of the Swabian Jura in southwestern Germany. Bulb retouchers have been reported so far from a few sites in Western Europe, Orgnac 3 (level 6), La Combette, Brive-Laroche-Aérodrome and Vergisson in France, and Buhle and Balver Höhle in Germany (Jöris, pers. comm.; Mathias and Viallet 2018; Mathias et al. 2020, 2021, 2023; Pelegrin and Texier 2004), all ascribed to the MP. The Sirgenstein assemblage thus provides an important addition to the current dataset. We describe in detail Sirgenstein bulb retouchers and compare them with the bone retouchers from the same archaeological units based on published information (Münzel and Conard 2004; Toniato et al. 2018). The goal of this paper is to test the possible role of retouchers as proxies for types of occupation and mobility strategies and to understand whether, and to what extent, the characteristics of Sirgenstein retouchers fit into the framework described above. If bulb retouchers are indeed characteristic of mobile toolkit components and bone retouchers represent ad hoc tools, researchers could use these observations to help reconstruct past mobility and past technological systems.

Bone and bulb retouchers general traits and mobility

Although bone retouchers have been known from the Swabian Caves and in other regions for many decades (Taute 1965), it was not until the 1990s that they became the focus of more intense systematic research. This class of tools exhibits a widespread geographic distribution and has been reported from numerous MP and Middle Stone Age sites in Europe, Asia, Africa, and the Levant (Deujeard et al. 2014; Doyon et al. 2018; Hutson et al. 2018; Baumann et al. 2020; Turner et al. 2020). Paleolithic hunters and gatherers usually used long bone shafts as retouchers, although they occasionally employed other skeletal elements, including teeth (Abrams et al. 2014; Rendu et al. 2023). In most archaeological contexts, faunal elements selected for use as retouchers reflect the composition of the whole assemblage, suggesting that they were collected from the food waste available at the sites (Alonso-García et al. 2020; Costamagno et al. 2018; Daujeard et al. 2014, 2018; Hutson et al. 2018; Mallye et al. 2012; Moigne et al. 2015). The only constraints that seem to have played a role in the selection of bone blanks are linked to functional requirements (Costamagno et al. 2018; Daujeard et al. 2018; Mateo-Lomba et al. 2019; Rosell et al. 2015), such as the need for a comfortable grip on the tool and the resistance to percussion and pressure. The first requirement typically led to the selection of long bone shafts, and the second requirement led to the selection of thick bones and bone fragments. After the selection of bone blanks, Paleolithic hunter-gatherers generally used the bones as retouchers without further modification, although specific *chaînes opératoires* for the manufacture of such tools are documented in rare cases (Abrams et al. 2014; Mozota 2009). Several actualistic experiments

show how the active areas of bone retouchers rapidly wear out after the production of just a single scraper-like retouched edge (Chase 1990; Mallye et al. 2012; Mozota 2018). This suggests that these tools were likely used for short retouching sessions and subsequently discarded, often close to where they were used. Based on these features, including patterns of opportunistic raw material procurement, lack of specific *chaînes opératoires* for their production, and short use-life, Daujeard and colleagues suggested that bone retouchers were most likely used in contexts of residential camps, where human occupations were intense and prolonged and where, considering the fast pace of exhaustion of these type of tools, bone raw materials suitable for retouching activities were readily available (Daujeard et al. 2014, 2018).

Bulb retouchers are flaked lithic artifacts whose bulb of percussion was used to strike and modify other blank edges (Adler 2002). This kind of artifacts and similar items have been currently reported from a few contexts in the final stages of the LP (Mathias et al. 2023; Venditti et al. 2023), but, similarly to bone retouchers, appear to become more common in the MP . The presence of these tools does not seem to be connected to any specific occupation context (e.g., open-air sites or cave sites), to any techno-complex, or to any particular geographical location, as their distribution ranges from the Caucasus to the Levant, North Africa, and Europe (Centi et al. 2019). Their geographical distribution, especially the areas where they are missing, likely reflects a research bias. Despite having been described for the first time some 70 years ago (Longo and Skakun 2005; Semenov 1953; Praslov 1968), bulb retouchers remain a poorly known phenomenon among researchers up to this day. So far researchers have identified bulb retouchers in archaeological contexts characterized by high frequencies of retouched artifacts, representing short episodes of human occupations in contexts of high mobility. Blanks used as bulb retouchers are in most cases intensely retouched artifacts (Fig. 1; Stepanchuk and Sytnyk 1999), often made of non-local raw materials and that often exhibit signs of multiple episodes of transformation. An experiment conducted by Centi et al. (2019) showed that even after the production of several scraper-like retouched edges and hundreds of strikes, the bulbar surfaces used as retouchers were still pristine and that a single retoucher could be used for the production of several retouched tools. Contrary to what was suggested until recently, these characteristics indicate that bulb retouchers were artifacts with relatively prolonged use lives, often transported by groups moving about the landscape.

The general characteristics of bone and bulb retouchers (Table 1) suggest that an important dichotomy exists between these two artifact categories: Bone retouchers likely represented ad hoc tools with low mobility, used and discarded in the same location; bulb retouchers more likely represented curated artifacts with long use-lives, often included in the mobile toolkit of hunter-gatherers.

The case study

Sirgenstein Cave is located in the Ach Valley between the towns of Blaubeuren and Schelklingen and stands ca 35 m above the valley bottom (Fig. 2). R.R. Schmidt (1910, 1912) excavated the site in 1906 and identified a sequence of 8 archaeological layers spanning from the MP to the

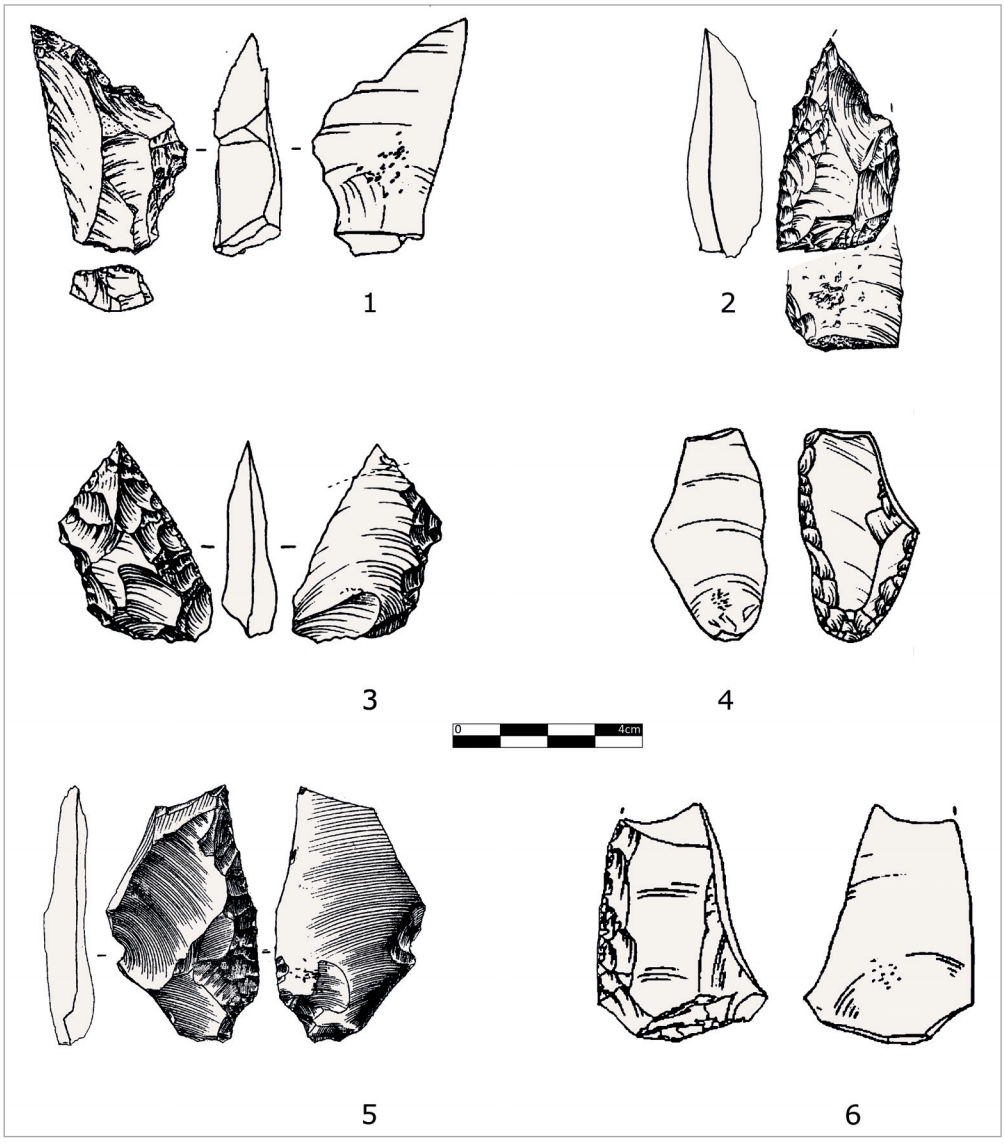

Fig. 1: Examples of bulb retouchers from various MP contexts. Note that all blanks are intensely retouched. 1-Alyonshim Grot, 2-Chokurcha I; 3-Rojok; 4-Prolom II; 5-Retaimia, 6-Pronyatyn. Illustrations modified after Chabai 2004; Kolosov and Stepanchuk 1997; Praslov 1968; Stepanchuk 1993; Tixier 2000; Stepanchuk and Sytnyk 1999.

Abb. 1: Beispiele für *Bulb Retoucher* aus verschiedenen MP-Fundkontexten. Zu beachten ist, dass alle Rohlinge stark retuschiert sind. 1-Alyonshim Grot, 2-Chokurcha I; 3-Rojok; 4-Prolom II; 5-Retaimia, 6-Pronyatyn. Illustrationen verändert nach Chabai 2004; Kolosov und Stepanchuk 1997; Praslov 1968; Stepanchuk 1993; Tixier 2000; Stepanchuk und Sytnyk 1999.

Table 1: General characteristics of bone and bulb retouchers.
Tabelle 1: Allgemeine Charakteristika von Knochenretuscheuren und Bulb Retouchern.

Bone retouchers	Bulb retouchers
The blank selection reflects the faunal composition	Emphasis on retouched blanks
Locally available raw material	Exogenous raw materials
Rapid deterioration of the active area	Durable active area

Magdalenian. Layers VIII and VII are attributed to the MP and are the object of the present study. Each of the two layers yielded a single hearth and a small assemblage of lithic artifacts and faunal remains. The most common animal species identified is cave bear (*Ursus spelaeus*), followed by horse (*Equus sp.*), and, in minor number, by giant deer (*Megaloceros giganteus*) and reindeer (*Rangifer tarandus*; Münzel and Conard 2004). The density of lithic artifacts is low at 20 artifacts/m^3, suggesting low intensity of site use and high mobility of the human groups responsible for the accumulation of the archaeological materials (Conard et al. 2012). Most lithic artifacts were manufactured with the Levallois method, exploiting local Jurassic chert (Cęp 1996).

Materials and Methods

Several criteria can identify bulb retouchers: the most prominent and important feature for their identification is the presence of pitting marks on the ventral face, usually on the bulbar area, although not necessarily on the most prominent part of the bulb (Centi et al. 2019; Mathias et al. 2023). The pitting marks include elongated pits that often exhibit a preferred orientation, amorphous pits, crushing marks, and occasionally incipient cones. Bulb retouchers may also exhibit striations oriented perpendicularly or parallelly to the pits, and, less often, polishes. For this study, we screened the entire collection of lithic artifacts from Sirgenstein layers VIII/VII by eye, to identify potential bulb retouchers based on macroscopic traces such as pitting marks. The MP lithic assemblages of layer VIII/VII from Sirgenstein are housed in the collections of the Department of Early Prehistory and Quaternary Ecology at the University of Tübingen and contain 704 artifacts. We examined and documented the bulb retouchers' active areas and associated macroscopic traces, using an Olympus SZX7 stereomicroscope at the Material Culture Laboratory (MCL) of the Department of Early Prehistory and Quaternary Ecology, University of Tübingen. We then described the bulb retouchers according to qualitative and quantitative attributes.

Sirgenstein bulb retouchers

Among the artifacts, we identified one bulb retoucher (item 603), and one artifact interpreted as a possible bulb retoucher (item 608), exhibiting remarkably similar characteristics. Although patinated, the two artifacts lack pseudo-retouch, abrasions, and other macroscopic post-depositional alterations (Fig. 3). In both cases, the pitting marks are identified on the bulbar area of

Fig. 2: The geographical location of Sirgenstein, in the Ach Valley. Local Jurassic chert sources are marked in dark grey on the map, and secondary sources of Muschelkalk chert are in pink. Digital elevation model made available by Copernicus Land Monitoring Service 2021, European Environment Agency. Map created with Q-GIS.

Abb. 2: Die geografische Lage des Sirgenstein im Achtal. Lokale Hornsteinvorkommen aus dem Jura sind auf der Karte dunkelgrau markiert, sekundäre Vorkommen von Muschelkalkhornstein sind rosa eingefärbt. Digitales Höhenmodell zur Verfügung gestellt von Copernicus Land Monitoring Service 2021, Europäische Umweltagentur. Die Karte wurde mit Q-GIS erstellt.

the ventral face (Fig. 4). No other pitting or crushing marks are present on the rest of the ventral and the dorsal face of the two artifacts. Item 603 exhibits both linear elongated and amorphous pits, while the few pits identified on item 608 are all linear and elongated along a main axis (Fig. 5). Both appear on side-scrapers, one characterized by inverse retouch (Fig. 3). Both scrapers present regular, invasive, and intense retouching, suggesting that the tools might have

Fig. 3: Sirgenstein. Bulb retouchers from layer VIII/VII, frontal, lateral and back view. Raw material: Muschelkalk chert. 1. find number 603, 2. Find number 608.

Abb. 3: Sirgenstein. Bulb Retoucher aus Schicht VIII/VII, Frontal-, Seiten- und Rückenansicht. Rohmaterial: Muschelkalk-Hornstein. 1. Fundnummer 603, 2. Fundnummer 608.

been resharpened multiple times during their long use-life, before being discarded at the site. Both blanks are thick and robust, with a dense bulbar area particularly well-suited to be used for retouching. Their elongated shape with elongation indexes of 1.7 and 1.9 respectively might have facilitated a firm grip during retouching (item 603: 53 mm axis length, 32 mm axis width, 17 mm thickness at mid-point, weight 32.9 g; item 608: 42 mm axis length, 22 mm axis width, 22 mm thickness ad mid-point, weight 14.37 g).

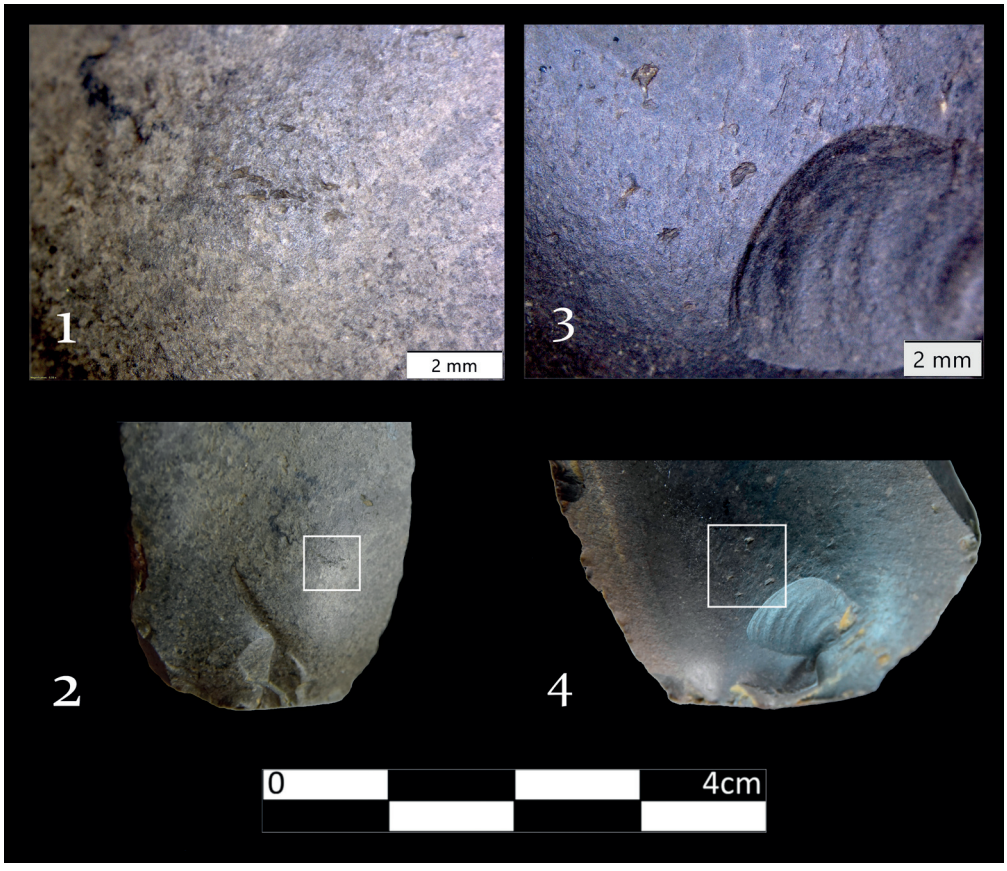

Fig. 4: Sirgenstein. Bulb retouchers layer VIII/VII. The white rectangle shows the location of the light and sparse pitting marks originating from retouching. 1-2: find 608, pitting marks location and macrograph, 16x; 3-4: find 603, pitting marks location and macrograph, 10x.

Abb. 4: Sirgenstein. Bulb Retoucher Schicht VIII/VII. Das weiße Rechteck zeigt die Lage der hellen und spärlichen Pickspuren, die vom Retuschieren herrühren. 1-2: Objekt 608, Auftreten der Pickspuren und Makroaufnahme, 16x; 3-4: Objekt 603, Auftreten der Pickspuren und Makroaufnahme, 10x.

Both artifacts are made on the same raw material, the *Muschelkalk* chert, which is abundant in secondary deposits in the Neckar riverbed. An alternative smaller secondary source is represented by deposits of the Brenz riverbed, where this type of chert has been sporadically observed (Çep 1996). Both sources are located ca 30-40 km away from Sirgenstein (Fig. 2). The two artifacts were likely not used intensively as retouchers, as they both bear only one active area with sparse pitting marks (Figs. 4 and 5) and lack the surface crushing often observed on particularly exhausted bulb retouchers (Centi et al. 2019).

The experiment conducted by Centi et al. (2019) highlighted, however, that bulb retouchers can be used for the production of multiple edges with a continuous scraper-like retouch before

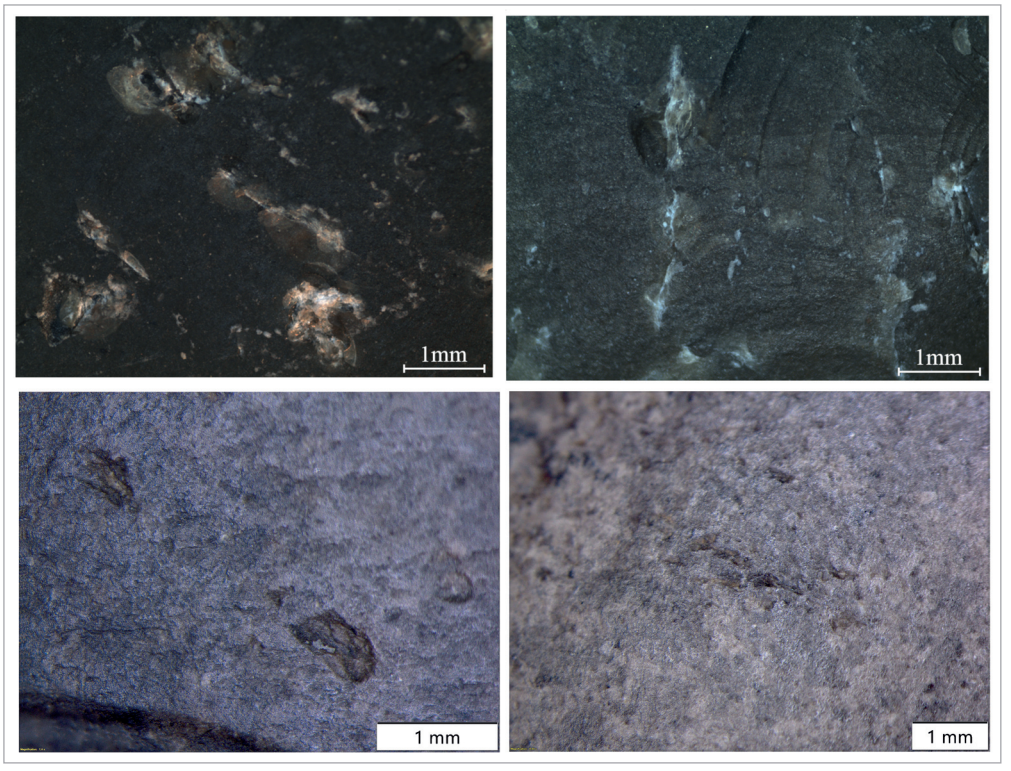

Fig. 5: Top: macrographs of amorphous and elongated pits on experimental tools obtained by Centi et al., 2019 (photo credit: Iris Groman-Yaroslavski, Wear Analysis Laboratory, Zinman Institute of Archaeology, University of Haifa). Bottom: details of the elongated pits on Sirgenstein artifacts left) item 603, 40x; right) item 608, 25x

Abb. 5: Oben: Makrografien amorpher und länglicher Pickspuren auf Versuchswerkzeugen von Centi et al. 2019 (Bildnachweis: Iris Groman-Yaroslavski, Wear Analysis Laboratory, Zinman Institute of Archaeology, University of Haifa). Unten: Details der verlängerten Pickspuren auf Sirgenstein-Artefakten links) Objekt 603, 40x; rechts) Objekt 608, 25x.

the first pitting marks start to develop on the bulbar surfaces, indicating that, despite their relatively low level of use marks, the bulb retouchers from Sirgenstein could have been used to produce or resharpen several tools.

While item 603 is more readily identifiable as a bulb retoucher, the fact that item 608 only bears the traces of a few pitting marks, makes its interpretation less obvious. However, the relatively good preservation of Sirgenstain material allows us to exclude post-depositional processes as the origin of the pitting marks. In addition, the location of the pitting marks exclusively on a small portion of the bulbar area and their elongated shape, reflect the ones observed in most archaeological bulb retouchers and the ones obtained experimentally (Centi et al. 2019; Mathias et al. 2023), allowing us to conclude that both Sirgenstein artifacts are likely the result of human retouching activity.

Discussion

Sirgenstein bulb and bone retouchers

The characteristics of the bulb retouchers from Sirgenstein fit well with what observed so far in other assemblages of bulb retouchers. Both bulb retouchers are intensely retouched artifacts, reflecting a trend observed in the majority of the sites where they have been identified so far (Fig. 1 and Table 2). The selection of blanks with a thick bulbar area is also common within assemblages of bulb retouchers, as this feature ensures that the retoucher will not break under the mechanical stress caused by strikes or the application of pressure. In addition, bulb retouchers from Sirgenstein occur on two of the very few artifacts in the lithic assemblage made from *Muschelkalk* chert, a raw material most likely deriving from non-local sources located at a distance of ca 30-40 km from the site. In the MP of the Swabian Jura Neanderthals typically used

Table 2: Frequencies of bulb retouchers and retouched artifacts in different MP sites including Sirgenstein. * Number of bulb retouchers to be considered as a minimum.

Tabelle 2: Häufigkeit der Bulb Retoucher und retouchierter Artefakte in verschiedenen mittelpaläolithischen Fundstellen, darunter Sirgenstein. *Anzahl der Bulb Retoucher, die als Minimum betrachtet werden.

Site	Layer	Bulb retouchers		Retouched Bulb retouchers		Retouched artifacts		Total artifacts	Sources
		n	n/total (%)	n	n/bulb retouchers (%)	n	n/total (%)		
Nesher	I	9	0.19	9	100	379	8	4,710	Centi et al. 2019
	IIA	14	0.29	13	93	347	7	4,833	
	IIB	133	0.59	119	89	2,730	12	22,510	
	III	17	0.15	14	82	1,226	11	11,160	
Quneitra	3	13	0.10	11	85	3,103	24	12,737	Centi et al. 2019
Ortvale Klde*	6	3	0.05	3	100	669	10	6,494	Adler 2002
	7	1	0.02	1	100	359	8	4,231	
	9	3	0.96	3	100	71	23	311	
	10	3	1.09	0	0	67	24	276	
Alyoshin Grot	2	5	0.37	4	80	105	8	1,348	Kolosov and Stepanchuk 1997
Kiik-Koba	Upper/IV	1	0.05	1	100	417	20	2,041	Stepanchuk 1993
Pronyatyn	/	11	0.26	10	91	295	7	4,304	Stepanchuk and Sytnyk 1999
Chokurcha I	IV-I	1	0.63	1	100	79	50	158	Chabai 2004
Gabo*	/	2	0.03	?	?	606	9	6,535	Praslov 1968
Orgnac 3	6	1	0.04	0	0	337	15	2,249	Mathias and Viallet 2018
Sirgenstein	VIII/VII	2	0.28	2	100	27	4	704	

locally available Jurassic chert for tools. Artifacts made on non-local raw materials, such as the *Muschelkalk* chert, are rare not only at Sirgenstein but also in other MP sites of the area (Çep 2013), further reinforcing the hypothesis of their introduction as finished tools part of mobile toolkits. This observation is in line with what has been recorded so far in other assemblages of bulb retouchers, with high frequencies of these tools occurring on non-local raw material. This is the case, for example, at Quneitra and at Nesher Ramla, where the raw materials originate from 10 and > 20 km from the site respectively (Centi et al. 2019; Hovers 1990).

Besides the two bulb retouchers described above, Sirgenstein layers VIII/VII yielded an assemblage of four bone retouchers studied and described in Münzel and Conard (2004) and Toniato et al. (2018). This should be viewed as a minimum number, since the excavation methods and recovery in 1912, were far from today's standards and because part of the faunal assemblage excavated in 1906 has been lost (Münzel and Conard 2004; Bertacchi et al. 2021). The bone retouchers occur all on ungulates bones, two on bone shafts of equids (*Equus* sp.) and two on bone shafts of cervids (*Megaloceros giganteus*), respectively the second and third most common families represented at the site. The most common animal remains at Sirgenstein belong to cave bears (*Ursus spelaeous*); however, most of these remains are likely derived from animals that naturally died during hibernation in the cave (Münzel and Conard 2004). The selection of bones from animals who died from natural causes, or from animal remains accumulated by carnivores is, in general, rare or absent during the MP (Daujeard et al. 2014). This observation likely reflects the preference for using fresh bones, still maintaining their elasticity for retouchers (Hutson et al. 2018; Mallye et al. 2012; Rosell et al. 2011; Sévêque and Auguste 2018; Vincent 1993). At Sirgenstein, older bones of cave bears were likely not selected since they were not of optimal preservation to use as retouching tools. Blanks used as bone retoucher at Sirgenstein reflect the freshly killed faunal assemblage, a pattern common to most of the other known MP bone retoucher collections (Costamagno et al. 2018; Daujeard et al. 2014, 2018). The choice of elongated bone shafts also fits with what was observed in other assemblages, where these types of blanks were commonly selected by virtue of their better ergonomic and grip qualities (Costamagno et al. 2018). Only one of Sirgenstein bone retouchers exhibits a single active area, while the others present marks on two or three different locations, suggesting more intense use. This data departs from what is generally observed, as bone retouchers frequently exhibit a single active area (Daujeard et al. 2018). Mallye and colleagues point out that even the most intensely used areas of bone retouchers might have been used for the production of a maximum of one scraper, as, due to the poor mechanical resistance of bone at impact with stone, the active area of these tools deteriorate quickly (Mallye et al. 2012; MacGregor and Currey 1983). It is thus possible, that the bone retouchers from Sirgenstein might have been used to produce just a few retouched edges.

The data reported here show that bulb and bone retouchers from Sirgenstein are consistent with what has been generally observed for the MP. The bulb retouchers fit well within the definition of curated artifacts, transported over long distances and with relatively long use-lives, while bone retouchers likely served as ad hoc tools, selected from the fresh food waste available at the site, and used and discarded in the same location.

Retouchers and mobility

A mobile toolkit or "personal gear" represents a set of tools that hunter-gatherers carried with them while moving in the landscape, to cope with unforeseen situations or to meet predicted needs (e.g., procurement of animal resources whose time and location can be highly anticipated; Binford 1977, 1979; Kuhn 1992, 1994; Nelson 1991). Gearing-up represents a planned behavior, that mobile groups put in place to mitigate the effect of raw material and/or time stress. The fact that mobile toolkit components are transported (Kuhn 1994) implies that they might remain in circulation for a longer time compared to ad hoc tools and that they must possess some qualities that make them suitable for transportation. As a consequence, mobile toolkit components should be light weighed and not bulky, and provide a good ratio of utility per weight (Close 1996; Kuhn 1994; Nelson 1991; Shott 1986). In addition, as only a limited number of artifacts can be transported from one location to another, they should be versatile (i.e., effective for carrying out a variety of tasks) and flexible (i.e., suitable for shifting function in the course of their use-life; Bousman 1993; Kelly and Todd 1988; Kuhn 1995; Shott 1989). Bulb retouchers, mostly occurring on retouched formal tool types, indeed possess several of these qualities. Retouched artifacts were the type of tools most commonly transported over long distances during the MP, as attested by the high incidence of "exotic" raw material within this artifact class in numerous contexts (Costamagno et al. 2006; Kuhn 1995). Retouched flint blanks were often large and thick, allowing their owners to repeatedly re-sharpen them prolonging their use-lives, and to modify their shape and function in response to new needs (flexibility). The intentional selection of such blanks for transportation implies a certain degree of planning. The suitability of MP-retouched artifacts (including bulb-retouchers) for different purposes is further supported by use-wear studies highlighting traces relative to a wide array of tasks (Beyries 1987, 1988; Centi et al. 2019; Shea 1991). Finally, the mechanical properties of flint assured that the bulb retouchers' active areas could have been used repeatedly before being worn out and that breakage during use would only rarely occur. Bulb retouchers, and retouched blanks in general, possess thus a high utility/weight ratio, making them ideal tools for the mobile toolkit of hunter-gatherers (Kuhn 1994, 1995).

On the contrary, bone retouchers lack most of the qualities of a good mobile toolkit component. Although being light weighed and not bulky, the utility/weight ratio for this type of tool remains low. Bone shafts were not employed in other tasks besides retouching, and their shape was not modified to serve other purposes. In addition, the rapid pace at which bone surfaces wear out shortens the use-life of the single bone retoucher specimens, implying that a large number of spares should have been transported to face unexpected retouching needs, making impractical and unlikely their inclusion in the mobile toolkit (Costamagno et al. 2018; Daujeard et al. 2014, 2018; Hutson et al. 2018; Mallye et al. 2012; Martellotta et al. 2020; Moigne et al. 2016).

Despite the economic advantages provided by the higher durability of bulb retouchers, their number in archaeological assemblages remains quite low (usually < 1% of total lithic artifacts; see also Table 1), while bone retouchers appear to have been more commonly employed (in res-

idential contexts their number can surpass 5% of the total bones recovered; Daujeard et al., 2014). In addition, although flint blanks functional as bulb retouchers – i.e. large, thick and with blunt edges – could have been easily procured in most sites, they were rarely used for this purpose. *Why choose less economically advantageous bone retouchers if blanks with a longer potential use-life were readily available?* A possible explanation for this pattern is that bone retouchers possess, compared to bulb retouchers, critical mechanical qualities that enhance their effectiveness. It is indeed suggested that the high elasticity of fresh bone would represent an important advantage for obtaining a fine, flat, invasive retouch (Costamagno et al. 2018; Daujeard et al. 2014; Hutson et al. 2018; Mallye et al. 2012; Mateo-Lomba et al. 2019; Sévêque and Auguste 2018), particularly suited for the resharpening of tool edges. It is thus possible that, whenever raw material was abundant and easily procurable, and a high utility/weight ratio would not be beneficial, bone retouchers might have been preferentially employed. The eventual drying out of bone shafts, and their consequent loss of elasticity - the main advantage of this material – might represent another factor that affected the degree of low mobility and short use-lives of these tools.

Bulb retouchers, curated or opportunistic artifacts?

At this stage of research, as detailed information on bulb retoucher assemblages is still rare, it is difficult to define if blanks used as bulb retouchers were curated because they were multiple-purpose tools or because they were particularly suitable for retouching. At the moment two main hypotheses can be put forward:

1. Bulb retouchers seem to have been curated because the blanks that were used in the retouching activity were curated in the first place. If bone retouchers performed better than bulb retouchers, then the latter would have been used only in contexts where fresh shafts of bone would not have been available, like in logistical forays away from the residential camp. Hunter-gatherers moving about the landscape would have thus used for their retouching needs readily available tools, i.e., flint blanks part of their mobile toolkit. In this sense, the use of bulb retouchers can be seen as opportunistic behavior.
2. Bulb retouchers were curated to be retouchers. It is possible that thick blanks with a pronounced, dense bulb of percussion were set aside and selected specifically for transportation in advance, in this case denoting a certain degree of planning and the awareness that retouching activities might take place once away from the main habitation hub. These blanks were nonetheless used also for other activities as multi-purpose tools.

The main difference between these two hypotheses is the intentionality. In both cases, we expect a preference for multi-purpose tools to be transported as part of the mobile toolkit, i.e., large blanks, suitable to be used in different activities and for resharpening. In both cases, we expect that mobile toolkit components were used for retouching activities while away from the residential camp when better-suited bone retouchers would not be readily at hand. Yet, according

to the first hypothesis, individuals opportunistically exploited multi-purpose mobile tools for retouching to cope with an unforeseen need. In the second hypothesis, individuals predicted a possible need for retouchers where fresh bone would not be available and intentionally selected for transportation blanks with thick and dense enough bulbs to be possibly used in retouching activities. Summarising, we are dealing with a juxtaposition between an opportunistic behavior *sensu* Nelson (i.e., not planned 1991: 65), and a programmed strategy. More data on bulb retoucher assemblages and their contexts is needed in order to fully understand which of these two hypotheses is closest to reflecting the behavior of MP people.

Conclusions

Several lines of evidence suggest that, bulb and bone retouchers may have been used in a complementary way, according to the different mobility strategies adopted by hunter-gatherers. Bone retouchers tend to be present in residential settings occupied for prolonged periods, where the in situ consumption of animal resources would have resulted in abundant fresh bone fragments available for use. Bulb retouchers may have been used during logistical forays or in contexts of high residential mobility, where individuals relied more heavily on a provisioning of individuals rather than a provisioning of place strategy and were more likely to be equipped with tools characterized by the high return of utility and weight. The possible role of bulb retouchers in the mobile toolkit is suggested by the intensity of the retouch visible on most of the blanks and by the exotic raw material in which they were manufactured. Sirgenstein bulb retouchers fit well in the proposed scenario and their characteristics met the expectations in terms of blank selection and raw material use. The fact that Sirgenstein bulb retouchers possess similar characteristics to the ones from other geographically and chronologically separated contexts (e.g., Nesher Ramla and Quneitra in the Levant) suggests that these are not affected by the local contingencies of the Ach valley, but rather that the use of retouched, multiple-purpose tools in retouching activities while away from the residential camp was a relatively widespread behavior, as was common the use of bone retouchers in habitation sites. The possible complementary use of organic and inorganic retouchers has roots in the latest stages of the LP, where, bulb and other stone retouchers have been documented alongside organic ones at Qesem Cave in the Levant (Blasco et al. 2013; Mathias et al. 2023; Rosell et al. 2015) and Schöningen in Germany (Julien et al. 2015; van Kolfschoten et al. 2015; Venditti et al. 2023; Voormolen 2008). This technological milestone occurred concurrently with the diffusion of fine-retouching of lithic tools, which prompted a boost in the diversification of tool types and retouching techniques, an advantageous behaviour that would consolidate during the MP.

While bone retouchers have been widely investigated in the last decades with numerous dedicated works and conferences, and their role as ad hoc, expedient tools is generally accepted by the scientific community, detailed reports on bulb retoucher assemblages remain rare, and their role as mobile toolkit components has only been documented in a limited number of cases, to which Sirgenstein represents a welcomed addition. Even though bulb retouchers patterns of blank selection are usually reported or can be inferred from pictures and drawings in the pub-

lications (see Fig. 1), other types of information useful for their identification as mobile toolkit components, such as raw material composition, intensity of the pitting marks, and possible instances of change of function of the items (i.e., recycling) are seldom available. In addition, direct comparisons between frequencies of bulb and bone retouchers from reported assemblages are currently problematic: in some cases, data on faunal assemblages have not been published, or studies were conducted before the identification of bone retouchers became a common praxis in faunal analysis, or again, faunal assemblages are partially biased, as excavations occurred when systematic collection of findings and wet sieving were not routinely done (Yeshurun et al. 2018).

More detailed studies on these two categories of tools are needed to better understand the suggested dichotomy between bulb and bone retouchers, and their complementarity. Studies involving assemblages from sites excavated with modern techniques, and differently interpreted in terms of both residential camps and short-term stays are essential for testing the premises discussed here. Finally, future investigations on Palaeolithic retouchers would profit from addressing the influence of the mechanical properties of different raw materials on their performance. This research would contribute to clarifying some key aspects of the scenarios proposed here and would help to illuminate the sources of variability in retouching techniques. More generally, such nuanced work on the link between technology and mobility will allow researchers to determine better how Palaeolithic hunters and gatherers produced and curated their tool kits, while adding important insights into the organization of complementary organic and inorganic technologies in Stone Age contexts.

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