Flint recycling in the Neolithic and Early Bronze Age: Evidence for small flakes production by means of recycling at Ein-Zippori, Israel

Yoni Parush [1,2], Richard W. Yerkes [3], Bar Efrati [1,2], Ran Barkai [1,2], Avi Gopher [1,2]

1. The Sonia and Marco Nadler Institute of Archaeology, Tel-Aviv University, POB 39040, 69978 Tel-Aviv, Israel. Email: Parush: yoniparush@gmail.com; Gopher: agopher@post.tau.ac.il; Barkai: barkaran@post.tau.ac.il; Efrati: barefrati@tau.mail.ac.il
2. Department of Archaeology and Ancient Near East Cultures, Tel-Aviv University, POB 39040, 69978 Tel-Aviv, Israel.
3. Department of Anthropology, The Ohio State University, U.S.A. Email: Yerkes: yerkes.1@osu.edu

Abstract:

This paper presents a new techno-typological analysis of a sample of small flakes that were produced through recycling from discarded blanks at the late Pottery Neolithic and Early Bronze Age site of Ein-Zippori, Lower Galilee, Israel. This study shows that the systematic production of small flakes from previously discarded blanks was not related to a scarcity in raw materials, but rather to specific decisions concerning the types of tools needed to carry out necessary tasks. These results are supported by use-wear analysis briefly noted on here and presented in more detail in a separate paper. The results further indicate the importance of reconstructing the life history of recycled items and its influence on the composition and variability of the lithic assemblages. The results indicate that recycling was a significant lithic production trajectory during the late Pottery Neolithic and in the Early Bronze Age. Recycling also contributes to the variability in the lithic assemblages of these periods. Furthermore, this study, together with earlier studies about lithic recyclying during Paleolithic times, suggest that flint recycling was a basic and long-term (continuous) perception and behavioral pattern that played an important role in lithic assmblages and in life ways of prehistoric people during Paleolithic, Neolithic and Early Bronze Age times.

Keywords: flint recycling; Wadi Rabah culture; Early Bronze Age; Southern Levant; techno-typological analysis

1. Introduction

This paper present the results of a techno-typological analysis of a sample of small flakes that were produced through recycling from discarded items at the late Pottery Neolithic (PN)

Journal of Lithic Studies (2018) vol. 5, nr. 1, p. xx-xx DOI: https://doi.org/10.2218/jls.2666

Published by the School of History, Classics and Archaeology, University of Edinburgh
ISSN: 2055-0472. URL: http://journals.ed.ac.uk/lithicstudies/

Wadi Rabah (WR) culture and Early Bronze Age (EBA) site of Ein-Zippori, Lower Galilee, Israel (Milevski *et al*. 2014).

In modern times recycling is understood as a process of turning discarded materials into new useable materials. Although it is difficult to identify recycling in pre-industrial societies, it has been shown both in archaeological and ethno-archaeological research, that recycling discarded materials has been practiced since ancient times for different reasons (Amick 2007, 2015; Camilli & Ebert 1992; Hayden & Cannon 1983; Holdaway *et al.* 1996; Vaquero *et al.* 2012, 2015). The origin of recycling behavior was related to the development of specialized technologies as a result of an increasing spectrum of daily activities (Rossell *et al.* 2015).

There is a growing body of evidence regarding lithic recycling, the majority of which is focused on the Paleolithic period of the Old World (*e.g.*, Agam *et al.* 2015; Amick 2007; Assaf *et al.* 2015; Baena-Prysler *et al.* 2015; Barkai 1998; Belfer-Cohen & Bar-Yosef 2015; Jacquier & Naudinot 2015; Lemorini *et al.* 2015; Parush *et al.* 2015; Peresani *et al*. 2015; Rios-Garaizar *et al.* 2015; Romagnoli 2015; Vaquero 2011; Vaquero *et al.* 2012; 2015). Ein-Zippori allows exploring the nature of flint recycling activities in the later Neolithic and EBA periods, and provides a unique opportunity to study lithic recycling behavior in Levantine farming communities.

The site of Ein-Zippori is located 2 km west of Nazareth in the lower Galilee, in the basin of Nahal Zippori (Figure 1). Altogether, a total area of ca. 5000 m^2 was excavated on behalf of the Israel Antiquities Authority (IAA) in 2011-2013 (Milevski *et al.* 2014; 2015a-b). The site shows a long sequence of Neolithic and Early Bronze Age occupations (see below). .

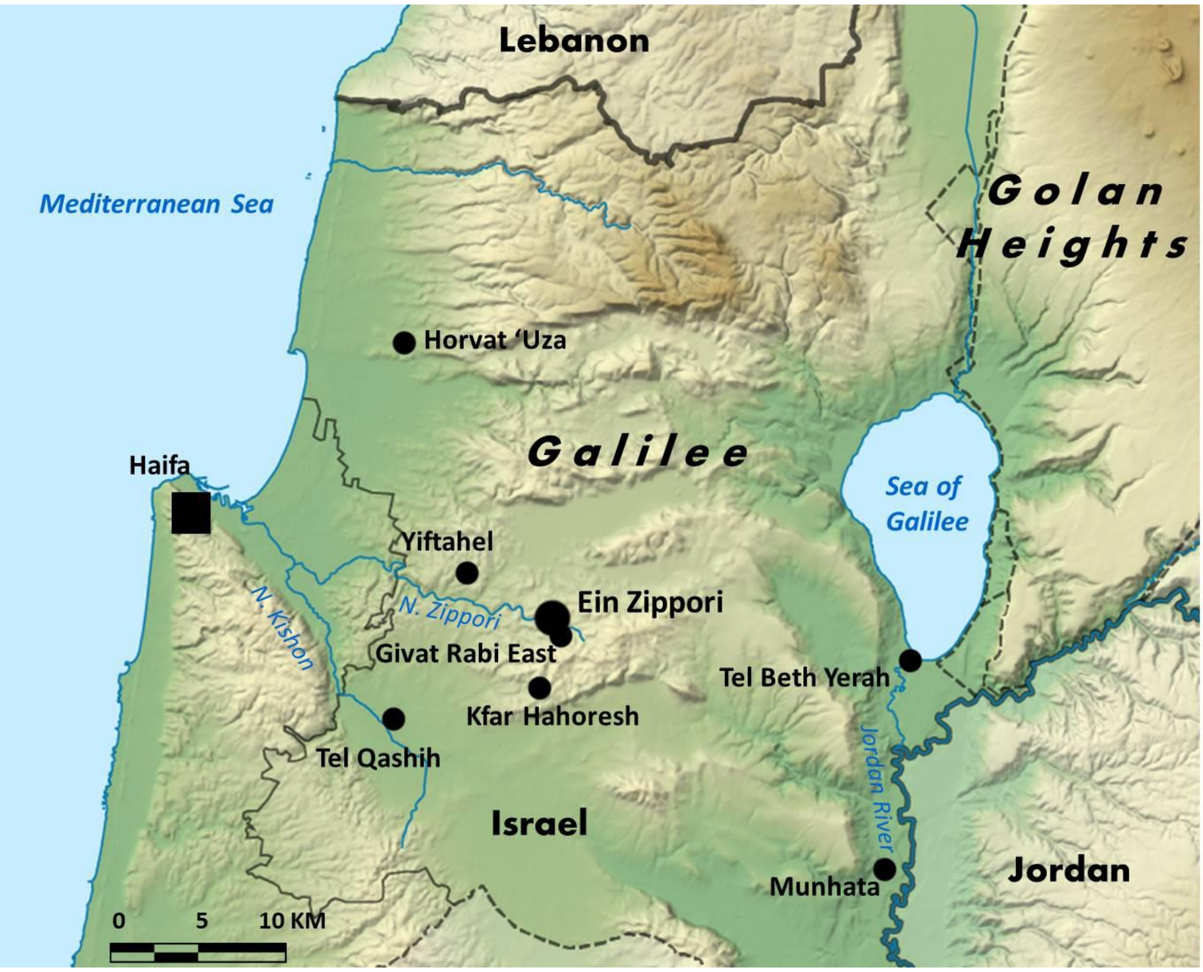

Figure 1. Location of the site of Ein-Zippori.

The aims of this paper are: (1).To present a detailed techno-typological analysis of recycled items (cores-on-flakes, COFs, *i.e.*, blanks turned into cores for the production of small flakes, see below) and the recycling products, *i.e*., blanks produced from COFs. (2). To briefly discuss the results of the techno-typological analysis in relation to the micro wear functional study of recycled items and recycling products at Ein-Zippori. And (3). To discuss the behavioral significance of lithic recycling at Ein-Zippori.

The focus of the techno-typological analysis will be on specific recycling trajectories that use discarded blanks for producing small usable flakes and blades. Notes on the function of these items will be briefly presented (see Yerkes *et al*. 2018). We will refer to raw materials selected for recycling (Agam *et al*. *in press*) and to a refitting of several recycled items (see Shechter *et al*. 2018). Our final discussion will be devoted to the significance of recycling behavior at Ein-Zippori.

2. Regional settings and archaeological context

The site of Ein-Zippori in the lower Galilee, Israel, is located in a basin created by Nahal (wadi) Zippori on the lower slopes of Givat Rabi (Figure 1). The slopes of the valley consist mostly of Rendzina and Terra-Rosa soils, originating in the dolomite and limestone formations of the Nazareth ridge and the Alonim-Shefar'am hills. The soils are rich in nutrients, very suitable for agriculture, and have been intensely cultivated in the past. (Agam *et al.* 2016; Gal 2002) and the once perennial Nahal Zippori is not flowing anymore. This rich Mediterranean zone attracted intensive occupation through the ages (known from other sites in the region such as Yiftahel, Givat Rabi, Kfar Kanna and Mitzpe Zvulun) – especially since the beginning of agriculture (Agam *et al*. 2016; Gal 2002; Milevski *et al*. 2014). While the Pre-Pottery Neolithic occupations are scarce in the 2011-2013 excavation areas, the Pottery Neolithic WR and the Early Bronze Age Ib are dominant and massive. The Neolithic and EBA sequence of the site (see above) are topped by Roman and Byzantine finds linking the site with the nearby Classical period site of Ein-Sephoris.

Lithic and other aspects of Ein-Zippori were studied in recent years (Agam *et al*. 2016; 2018a; Milevski *et al.* 2014; 2015a,b; Namdar *et al*. 2015; Schechter *et al*. 2016, 2018; Yerkes *et al*. 2016, 2018; Zutovski *et al*. 2016). This paper presents a sample of recycled items and recycling products from the WR (~7600 - ~6800 cal. BP) and the Early Bronze Age Ib (~ 5400 -~5050 cal. BP) and II (~ 5050 - ~ 4800 cal. BP) layers (Regev *et al.* 2012).

The Wadi Rabah (WR) culture is part of the late Pottery Neolithic (PN) period in the Levant (Gopher 2012). WR sites are distributed from Lebanon in the north to central Israel in the south, and the Jordan Valley in the east, with some sparse presence in the Judean desert (Gopher 2012). The architecture is characterized by long rectangular dwelling structures with field-stone foundations and a variety of rounded, plaster paved, and stone lined installations (Gopher 2012; Kaplan 1969; Perrot 1993). The WR economy reflects an established rural society based on agriculture, livestock, and the use of secondary products (milk, animal hair), with almost no hunting (Gopher 2012; Gopher & Gophna 1993).

WR lithic assemblages are well known technologically and typologically (Gopher 2012; Gopher & Barkai 2012; Gopher & Eyal 2017). Of note are trajectories of blade and (a renewed) bladelet production, rectangular types of sickle blades, a repertoire of bifacial tools dominated by adzes and chisels, and diminishing numbers of arrowheads to their actual disappearance (Gopher 2012).

The term Early Bronze Age (EBA) was to reflect the use of bronzes and an improvement in metal tools quality compared to the previous Chalcolithic Ghassulian (CHG) cooper tools. However, in the southern Levant, bronze was not used until about a thousand years after the beginning of the EBA (Ben-Tor 1992; Zutovski *et al.* *in press* a; *in press* b). EBA settlements expand into the central hilly, Mediterranean areas, leaving behind the more arid regions that were occupied in the previous Chalcolithic Ghassulian (Ben-Tor 1992; Finkelstein & Gophna 1993; van den Brink 2011; Zutovski *et al.* *in press* a; *in press* b). The EBA witnessed the rise of formation of complex urban societies based on agriculture and trade (Finkelstein & Gophna 1993).

The EBA flint assemblages of Ein-Zippori are in many ways similar to assemblages of other sites in theSouthern Levant. They comprise a major *ad hoc* component including tools such as retouched flakes, blades, notches and denticulates as well as a somewhat more elaborate local production of awls and borers, burins and scrapers. The presence of standardized industries of Canaanean sickle blades, tabular, or fan scrapers and bladelets, probably represents trade or exchange of items produced by specialized knappers (Rosen 1997: 106-107; Zutovski *et al.* *in press* a; *in press* b).

3. The recycling phenomenon

3.1. Recycling defined

Recycling is defined as a behavior implying successive cycles of modification and use of an artifact for different purposes with a phase of discard between them (Vaquero *et al.* 2012). Recycling is not extention the use life of an artifact, like resharpening a tool, but rather represents the beginning of a new use life (Parush *et al.* 2015; Vaquero 2011; Vaquero *et al.* 2015).

Although identifying lithic recycling may sometimes be difficult, due to the subtractive nature of lithic technology, and some researches are sceptical concerning the utility of this concept (Odell 1996), understanding its role in lithic assemblage variability has significant implications as it offers a glimpse into the histories and morphological change of artifacts (Dibble 1991; Vaquero 2008; Vaquero *et al.* 2012). Reconstructing the life histories of recycled items improves our understanding of human behavior regarding raw material management, raw material availability, accessibility, and constraints; settlement patterns; organization of lithic technology and knapping methods; artifacts use life; and decision-making processes (*e.g.*, Amick 2007; 2015; Ashton 2007; Baena-Prysler *et al.* 2015; Bamforth 1986; Dibble & McPherron 2006; Hiscock 2009; 2015; Holdaway *et al.* 1996; Odell 1996; Parush *et al.* 2015; Peresani *et al.* 2015; Rios-Garaizar *et al.* 2015; Romagnoli 2015; Vaquero *et al.* 2012; 2015).

For example, several studies suggested that lithic recycling would be more likely to occur as a consequence of relative scarcity of raw materials and, therefore, a need to maximize the profitability of lithic resources (Amick 2007; Close 1996; Dibble & Rolland 1992; Galup 2007; Hiscock 2009; Kelly 1988). Recycling can however be present in areas where there is an abundance of raw material, and relate to various socio-cultural aspects (Agam *et al*. 2016; Assaf *et al.* 2015; Baena-Preysler *et al.* 2015; Parush *et al.* 2015; Vaquero 2011; Wilson *et al.* 2015). In the Ein-Zippori case presented here, lithic recycling is present throughout the site's occupation sequence despite the fact that raw materials were, and still are, found in abundance in the close vicinity of the site (Agam *et al.* 2016). This provides an opportonity to examine other aspects of recycling, rather than constraints and scarcity.

3.2. Identifying recycling in the archaeological record

In recent years it has been recognized that lithic recycling contributes to assemblage variability, and should be included in interpretations of lithic assemblages and human behavior. Recent studies show that aspects technological and typological characteristics, as well as spatial distribution of lithic finds, may be related to recycling (*e.g.*, Agam *et al.* 2015;

2018; Amick 2007; Galup 2007; Hiscock 2009; 2015; Jacquier & Naudinot 2015; Lemorini *et al.* 2015; Parush *et al.* 2015; Vaquero 2011; Vaquero *et al.* 2012; 2015; Wojtczak 2015).

In order to identify recycling in the archaeological record, researchers look for two main indicators: evidence for a time lapse, and a functional change between the original production and use of the item and its later (recycled) use. Time lapse may be identified through chemically or mechanically altered surfaces on the recycled item *i.e.*, double patina facilitating the distinction between cycles in the artifacts history (Amick 2007; Barkai *et al.* 2009; Debenath 1992; Galili & Weinstein-Evron 1985; Mora *et al.* 2004; Nishiaki 1985; Parush *et al.* 2015; Peresani *et al.* 2015; Sergant *et al.* 2006; Vaquero *et al.* 2012). This is the criterion most commonly used for identifying recycling in Paleolithic assemblages. Double patina was also observed in later periods and interpreted as evidence for the use of old discarded items (Galili 1987; Galili & Weinstein-Evron 1985; Gopher 1990; Hole 1959; Kuijt & Russell 1993; Makkay 1992; Rosen & Gopher 2003; Stekelis 1950; Wreschner 1977). Secondary modification can be clearly differentiated on an older patinated surface (Vaquero 2011; Vaquero *et al.* 2012). Fire damage too can be a temporal marker showing a time lapse (Vaquero 2011; Vaquero *et al.* 2012 and see Amick 2015; Barkai *et al.* 2009; Belfer-Cohen & Bar-Yosef 2015; Débenath1992; Galili & Weinstein-Evron 1985; Mora *et al.* 2004; Nishiaki 1985; Peresani *et al.* 2015; Romagnoli 2015).

When no apparent time gap can be established from observations on the surface condition of the artifacts, functional change must be demonstrated in order to identify recycling. The new use and purpose of the recycled item must be different from its original purpose and use. For instance: bifaces recycled into cores (Agam *et al.* 2015; Barkai 1999; DeBono & Goren-Inbar 2001; Parush *et al.* 2015; Rollefson *et al.* 2006; Thiébaut *et al.* 2010); discarded blanks recycled into cores (Agam *et al.* 2015; 2018; Parush *et al.* 2015; Rios-Garaizer *et al.* 2015; Vaquero *et al.* 2015; Wojtczak 2015); cores recycled into hammers (Baena-Preysler *et al.* 2015) or other tools (Romagnoli 2015), may be all considered as recycled items. In case different stages of use were identified, but the use itself did not change, the process will be considered as reuse and not recycling.

This paper focuses on one specific recycling trajectory - discarded blanks that were recycled into cores-on-flakes (COFs). We analyzed a sample from Ein-Zippori that included both the (parent flakes) COFs and the blanks produced from COFs (recycling products) (see below for definitions).

3.3. Recycling trajectories at Ein-Zippori

Lithic recycling at Ein-Zippori is characterized by five main trajectories. A brief description of the four of them is presented here followed by a detailed analysis of the fifth trajectory: recycling discarded flakes into COFs for the production of small sharp blanks.

3.3.1. Bifaces recycled into cores

This trajectory is considered recycling since there is a change in the function of the item, *i.e.*, a new use life. The recycling of bifacial tools into flake cores has been noted in prehistoric sites since the Lower Paleolithic Period (Agam *et al*. 2015; Debeno & Goren-Inbar 2001; Parush *et al*. 2015; Rollefson *et al.* 2006; Shimelmitz 2015).

Recycling bifaces includes: 1. The production of a single or a few large preferential flakes from a biface (*e.g.*, DeBono & Goren Inbar 2001; Shimelmitz 2015), which is more likely to occure in the Lower Paleolithic; 2. Recycling old bifaces into prepared (Levallois) cores for the production of predetermined blanks (Barkai & Marder 2010); and 3. The recycling of bifaces into simple flake cores (Agam *et al.* 2015; Ashton 1988; Barkai 1998; Woodman 1992).

At Ein-Zippori, despite the abundance of raw material in the vicinity of the site, bifaces were recycled into cores (Figure 2:1-2). A sample of 230 bifaces from different parts of the site, includes 17% (N=38) that are recycled bifaces. At least two ways of recycling bifacial tools were identified: one is using broken bifacial tools as cores (74% of recycled bifacial tools, N =28) with a striking platform on the broken surface of the tool; the second is using complete bifacial tools as cores (26%, N =10) with a striking platform on the surface of the biface (*i.e.*, the ventral face, the cutting edge, the base, *etc.*, for details see Efrati *et al. in press*). Thus, while a bifacial tool may have needed remodeling for various reasons (Barkai 1998), recycling it into a core represents a new cycle of use life.

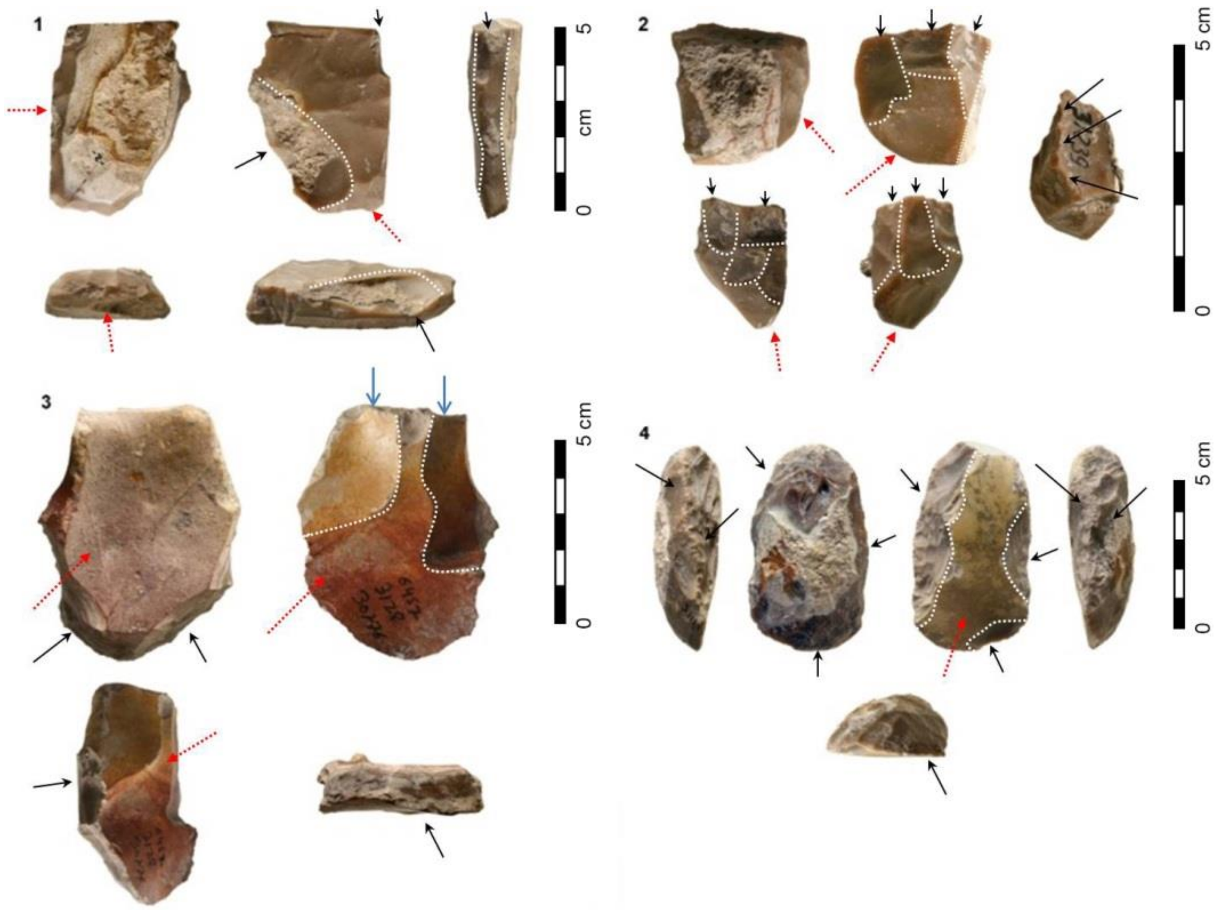

Figure 2. Examples of recycled items: (1 & 2) broken polished bifaces (the polish surface indicated by dotted red arrows) recycled into cores, as the removals are conducted from the broken surface and cut the bifacial scars (the removals are indicated by black arrows; dotted white line outlines the scars of removals after the biface were broken); (3) a patinated large flake recycled as a core-on-flake (COF) (the COF removals are indicate by blue arrows. The flake was produced,, probably discarded, then covered with red patina (the patina indicated by dotted red arrows) and in a later stage recycled as a core-on-flake and then again, as a scraper as indicate by post patina retouch (post patina retouch is indicated by black arrows). The post patina removals indicate a time gap, which perhaps imply that the item was collected and recycled by a different group from the original one that discard of it; (4) a large patinated flake that was probably discarded, covered with yellow patina (the patina is indicated by dotted red arrows), and then recycled into a biface as indicated by the post patina bifacial retouch (the post patina bifacial retouch is indicated by black arrows). This case, as well, shows a time gap between the time of discard of the flake, its patination, and the collection of the item and the recycling of it into a biface, probably by different group than the original group who discarded the large flake.

3.3.2. Recycled fan scrapers

Fan (or tabular) scrapers are a diagnostic tool type in Chalcolithic Ghassulian and EBA lithic assemblages from the southern Levant, but they are also found in WR assemblages

(Barkai & Gopher 2012; Bar-Yosef *et al.* 1977; Rosen 1983a; Zutovski *et al.* 2016). In general, fan scrapers are large scrapers or knives, manufactured on flat cortical flakes that vary considerably in size and shape (Rosen 1983a).

At Ein-Zippori several aspects of recycling were observed regarding fan scrapers:

1. Patinated blanks recycled into Fan scrapers. The dorsal or ventral face of the scraper is patinated, but the scraper retouch is fresh, indicating that it was made on an old discarded flake that became patinated before it was collected, recycled, and shaped into a scraper (Zutovski *et al.* 2016).
2. Fan scraper recycled into cores. Small flakes were removed from the ventral or dorsal faces of the fan scrapers. It can represent an initial stage of maintenance of a fan scraper's working edge; or a mode of recycling fan scrapers into cores for the production of small flakes (*i.e.*, COFs); or for making Clactonian notches (*e.g.*, "a notch produced on an artifact by a single blow. The notch is generally void of any retouch" in: Ohel 1979) (see also Lemorini *et al*. 2015; Zupancich *et al.* 2015).
3. Fan scrapers recycled into notched flakes. Some fan scrapers exhibit one to three notches postdating the scrapers' edge shaping (Zutovski *et al.* 2016)(Figure 3: 1-2). In some cases, fan scrapers were recycled into notched flakes or blades. However, notches could have been added to fan scraper's edges while still in use as scrapers (Zutovski *et al.* 2016).
4. Fan scrapers recycled into burins. Some fan scrapers show a removal of one or more burin spalls from the scrapers' working edges (Zutovski *et al.* 2016)(Figure 3:3-4). However, it is possible that this spall represents maintenance of the fan scraper itself (Zutovski *et al.* 2016).

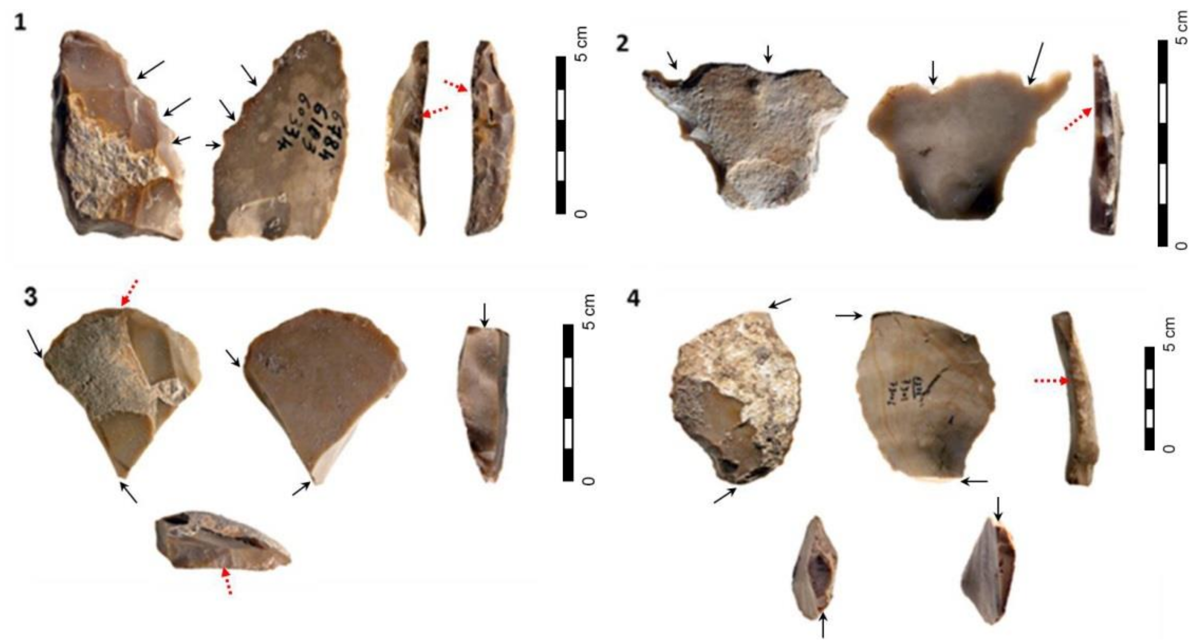

Figure 3. Examples of recycled Fan scrapers. In all the cases presented here, items are Fan scraper due to the cortex, contour and retouch, that were discarded, selected again and show post scraper removals: (1&2) show notch removals (*i.e.*, the scrapers were recycled into notched flakes); while (3&4) show burin removals (*i.e.*, the scrapers were recycled into burins). Black arrows indicate post scraper removals (*i.e.*, the recycling procedure); Red dotted arrows indicate the scrapers retouch (*i.e.*, the previous stage of the items before the recycling procedure).

3.3.3. Recycled 'Canaanean blades'

Long thin regular “Canaanean” blades are used primarily as sickle inserts and are common in EBA lithic assemblages of the Levant (Ackerfeld *et al*. *in press*; Rosen 1983b). At Ein-Zippori, sometimes sickle blade segments were recycled as threshing sledge inserts (10% of the sample of Canaanean blades; see Figure 4)(Ackerfeld *et al. in press*; Yerkes *et al. in press*). Recycling sickle blades as threshing sledge inserts is also known from other EBA sites in Mesopotamia and the Levant (Anderson 1994; 1998; 2003; Anderson & Chabot 2001; Anderson *et al*., 2004; Yerkes *et al. in press*).

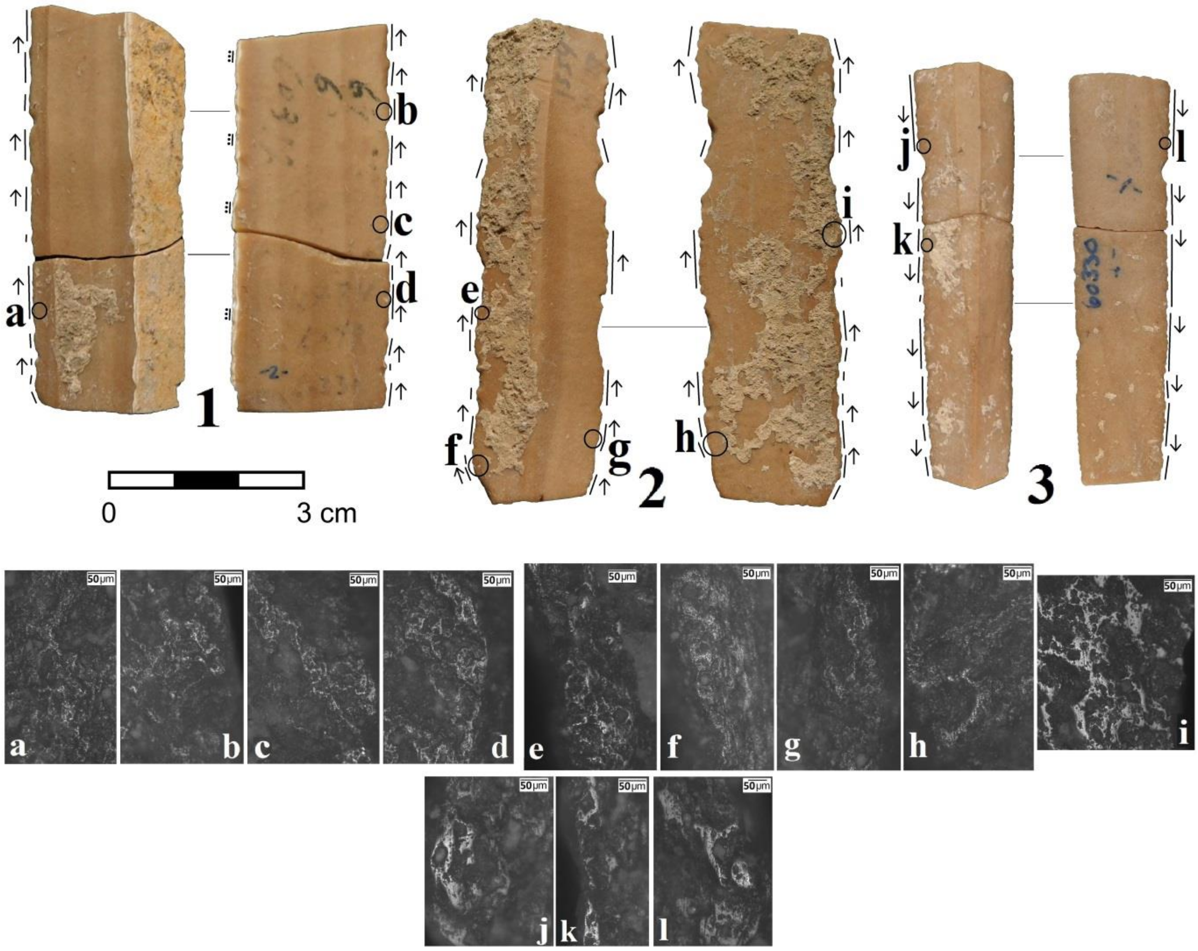

Figure 4. Microwear traces on retouched and broken Canaanean blades recycled as threshing sledge inserts. Arrows show orientation of wear traces, lines with three dots mark hafting traces. Circles (a-l) are where photomicrographs were taken (see Yerkes *et al. in press*). Scalebars on the photomicrographs are 50 μm.

3.3.4. Recycling of patinated blanks

This recycling trajectory includes items that exhibit double patina. We classified patinated items as items “*that have been modified again, thus leaving newer scars in unpatinated, or less patinated, condition*” (Goodwin, 1960, p. 68). These items were produced (used) and discarded, then covered by patina, then collected and modified again. Their new scars expose the "fresh" (unpatinated) surface with the natural colour of the flint, or a different kind of patina (in a different colour), alongside old scars covered with older patina. That is to say that only items with patinated surfaces that show signs of a new (post patina) modification were considered as recycled items while those without post-patina modifications were not. The recycled panitated blanks are diverse including flakes that were removed from patinated cores showing paination on their dorsal face, cores with post patina removals, core triming elements with patina on their dorsal face, and shaped items with retouch removing the patination (see for example Figure 2:3-4).

3.3.5. Recycling discarded blanks into COFs for the production of small flakes

This recycling trajectory relates to blanks selected from the array of old "parent" blanks found on-site (e.g., cortical items, non-cortical flakes and blades, core trimming elements, special spalls and tools). These were turned into what we called COFs and used for the production of small items with specific morphologies and sharp edges. We believe that "parent" blanks (COFs) were not planned and intentionally produced to be used as cores, but rather collected from the variety of available blanks on-site and transformed into COFs. Another view that find unsuitable to explain the phenomenon we present here is ramification (Bourguignon *et al.* 2004). Ramification, as mostly defined in Middle Paleolithic West European contexts is a planned and intentional reduction strategy in which products of a primary reduction are secondarily exploited in order to obtain additional (other) blanks. As will be detailed below, the "parent" blanks selected for further use as COFs in the case of Ein-Zippori show a variety of blank types (see above), varying in shape and size. These blanks could not have been intentionally produced for a specific purposes and we suggest that they were rather collected on-site (and out of the site too) as part of a recycling behaviour practiced at the site. This is not the place to go in to a detailed discussion; suffice is to say that while this debate is on-going, more and more technological studies indicate that the aim of selecting these blanks was to produce desired smaller blanks – end products of a recycling process using old discarded blanks as COFs (Agam *et al.* 2015; 2018; Ashton 2007; Ashton *et al.* 1991; Barsky *et al*. 2015; Goren-Inbar 1988; Nishiaki 1985; Parush *et al*. 2015; Schroeder 2007; Shimelmitz 2015; Solecki & Solecki 1970; Vaquero *et al.* 2015; Wojtczak 2015). We will show here that at Ein-Zippori, the desired end product of this recycling trajectory are the small blanks produced from the COFs and that these were used for various purposes on-site.

The Ein-Zippori sample presented here includes both the parent flake (COFs, Figure 5), and the blanks produced from these parent flakes (Figure 6). The COFs were classified by removal location. The produced blanks were classified according to their morphology and technological attributes. The following sections elaborate on the techno-typology of both the COFs and the blanks produced from COFs.

4. Materials and methods

We analysed recycled items from WR and EBA layers of Ein-Zippori. They are treated here as one assemblage since no clear differences were identified between the WR and EBA assemblage in both the types and the frequencies of recycled items (COFs) and recycling products. A detailed list of our sample can be found in Supplement 1.

The sample presented here consists of 301 COFs and 330 blanks produced from COFs. The analysis includes observations on raw material, technology, typology, and use wear as well as a note on some refitted recycled items.

Categories of recycled items and products of recycling were studied following a list of attributes (Supplement 2). The results section concentrates on major sub categories only.

5. Results

The following sections will elaborate on the technology and typology of COFs and the blanks produced from them.

Figure 5. Group of cores-on-flakes (COFs).

Figure 6. Group of blanks produced from cores-on-flakes (COFs) (Some show former flaking, see analysis below).

5.1. Core-on-flake (COF)

The blanks selected for COFs include cortical elements (31% of analysed COFs, n=93), flakes (24%, n=73), blades (1%, n=3), core trimming elements (10%, n=29), special spalls (1%, n=3) and shaped items (26%, n=79). In addition, 7% (n=21) of the analysed COFs exhibit post-patination removals (Figure 7: 5-6).

COFs vary in size and 72% of them are complete (n=197) and measurable. The size ranges from very small flakes, 1.1cm in length, to large flakes, 7.8cm in length but most COFs are between 3 cm to 5 cm in length. The average size of all COFs is 4.2 cm in length and 3.7 cm in width. COFs with ventral removals tend to be smaller than COFs with dorsal removals and combined removals (see Table 1).

Table 1: Metrics of COFs. Average values with standard deviation in parentheses.

Metrics of COFs	**Length (cm)**	**Width (cm)**	**Thickness (cm)**	**Weight (g)**
COF with Ventral removals	4.2 *(1.1)*	3.7 *(1.2)*	1.5 *(0.4)*	25.6 *(17.0)*
COF with Dorsal removals	4.3 *(1.2)*	3.9 *(0.9)*	1.8 *(0.6)*	30.9 *(18.3)*
COF with Combined removals	4.4 *(1.0)*	3.7 *(0.9)*	1.7 *(0.3)*	28.0 *(13.3)*

The blanks selected and used as COFs at Ein-Zippori do not show any indication of being intentionally fashioned to be transformed into COFs (*i.e.*, ramification, see Bourguignon *et al.* 2004 and our notes above), due to the high variability of blank types as well as sizes and patination. They appear to be selected from the lithic products that were available at the site as well as blanks brought to the site from elsewhere (*e.g.*, blanks that show patina probably created in different conditions than the patina created on site).

COFs were classified by referring to the face used for the removal of the small flakes. The detachment can be either on the ventral face or on the dorsal face or on both faces (ventral and dorsal). Out of 301 COFs, 75% (n=226) exhibit removals on the ventral face, 13% (n=38) exhibit removals on the dorsal face and 12% (n=37) show removals from both faces (Table 2). For details see Supplement 3.

Table 2: Location of removals on COFs.

COFs	**no.**	**%**
Ventral removals	226	75%
Dorsal removals	38	13%
Combined (ventral + dorsal) removals	37	12%
Total	**303**	**100%**

It should be noted that some studies consider items as COFs only when “three or more blanks were removed” (Hovers 2007, p.45; Malinsky-Buller, 2014; Malinsky-Buller *et al.*, 2011), while in many other studies, including the one presented here, a single removal is considered sufficient (Agam *et al.* 2015; Ashton 2007; Dibble & McPherron 2007; Goren-Inbar 1988; Parush *et al.* 2015; Schroeder 1969: 396-397; 2007; Shimelmitz 2015; Vaquero *et al.* 2015). In the studied sample, 37% (n=112) of the COFs have a single removal (Figure 7:1-4) while 63% (n=189) show multiple removals (Figure 7:5-8).

Small flakes removed from all directions of the COFs: distal end (16% of all COFs, n=47), proximal end (12%, n=37), and lateral edges (38%, n=113). COFs with multiple removals also show combination of different directions.

Removals were usually straightforward, with or without platform preparations, and devoid of truncations serving as striking platforms – *i.e.*, most of the removals were struck without any platform preparations, from both plain (52% of total COFs, n=157) or cortical (18%, n=53) surface; only 16% (n=48) of the COFs show modification on the striking platforms. The modification can be made in order to shape a striking platform before the removal of the small flake, or, it may be an “old” retouch on a recycled tool. As mentioned above, 26% (n=79) of the COFs were tools before being recycled and their shape and condition were taken advantage of.

Figure 7. COFs: 1-4 are COFs with single removal; 5 & 6 are COFs with multiple removals on patinated flakes; 7 & 8 are COFs with multiple removals. Dotted white lines denote the scars contour; black arrows denote the direction of removals.

5.2. Flakes and blanks produced from COFs - recycling products:

Flakes and blanks were removed from the dorsal or ventral face, and from all directions including lateral removals. A reduction of the thickness of the flake appears too (see section 5.2.3, Exploitation of the thickness of the flake, *i.e.*, Tabun Snap). While blanks produced from the dorsal face of COFs are not easily identified (and thus, not presented here), small blanks produced from the ventral face of COFs exhibit a specific morphology that can be recognized. A flow chart describing the recycling of COF and the flakes and blanks produced from them is presented in Figure 8. These blanks were divided into 5 types (Table 3) based on 3 distinct production trajectories:

- Removals from the ventral face of the COF: Regular items (53% of total blanks produced from COFs, n=176); or double bulb (DB) of Kombewa type (12%, n=40) with two bulbs of percussion (see section 5.2.1).
- Removals from the lateral edge of the COF: Lateral items (25%, n=81); or DB lateral items (14%, n=14) (see section 5.2.2).
- Removals exploiting the thickness of the COFs: The Tabun snap has two bulbs of percussion (6% of total blanks produced from COFs, n=19; see section 5.2.3) too.

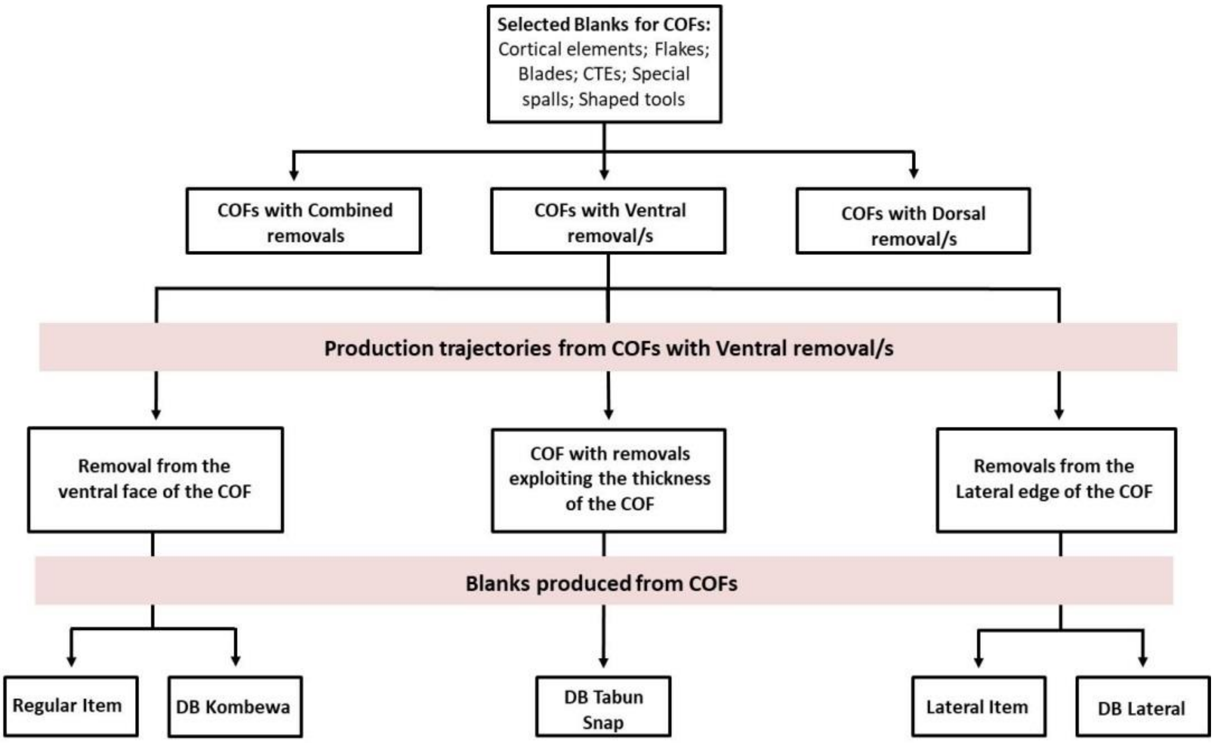

Figure 8. A flow chart describing the recycling of blanks into COFs and the products of recycling - flakes and blanks produced from the COFs.

Table 3: Types of Blanks or Flakes produced from COFs.

Blanks or Flakes produced from COF		no.	%
Removals from the ventral face of COF	Regular items	176	53%
	DB Kombewa	40	12%
Removals from the lateral edge of COF	Lateral items	81	25%
	DB Lateral	14	4%
Exploiting of the thickness of COF	DB Tabun Snap	19	16%
	Total	**330**	**100%**

5.2.1. Removals from the ventral face of the COF

Regular items (Figure 9) are the most common category among the blanks produced from COFs (53%, n=176, Table 3, Figure 9). These items exhibit two ventral faces – one is the ventral face of the “parent” blank (the COF) and the second is that of the removal itself. The bulb of percussion is observed only on the actual ventral face while the original ventral face of the COF is without its bulb of percussion. Most of these items are fan shaped (42%, Figure 9), followed by round and pointed shapes (25% and 14%, respectively; Figure 9).

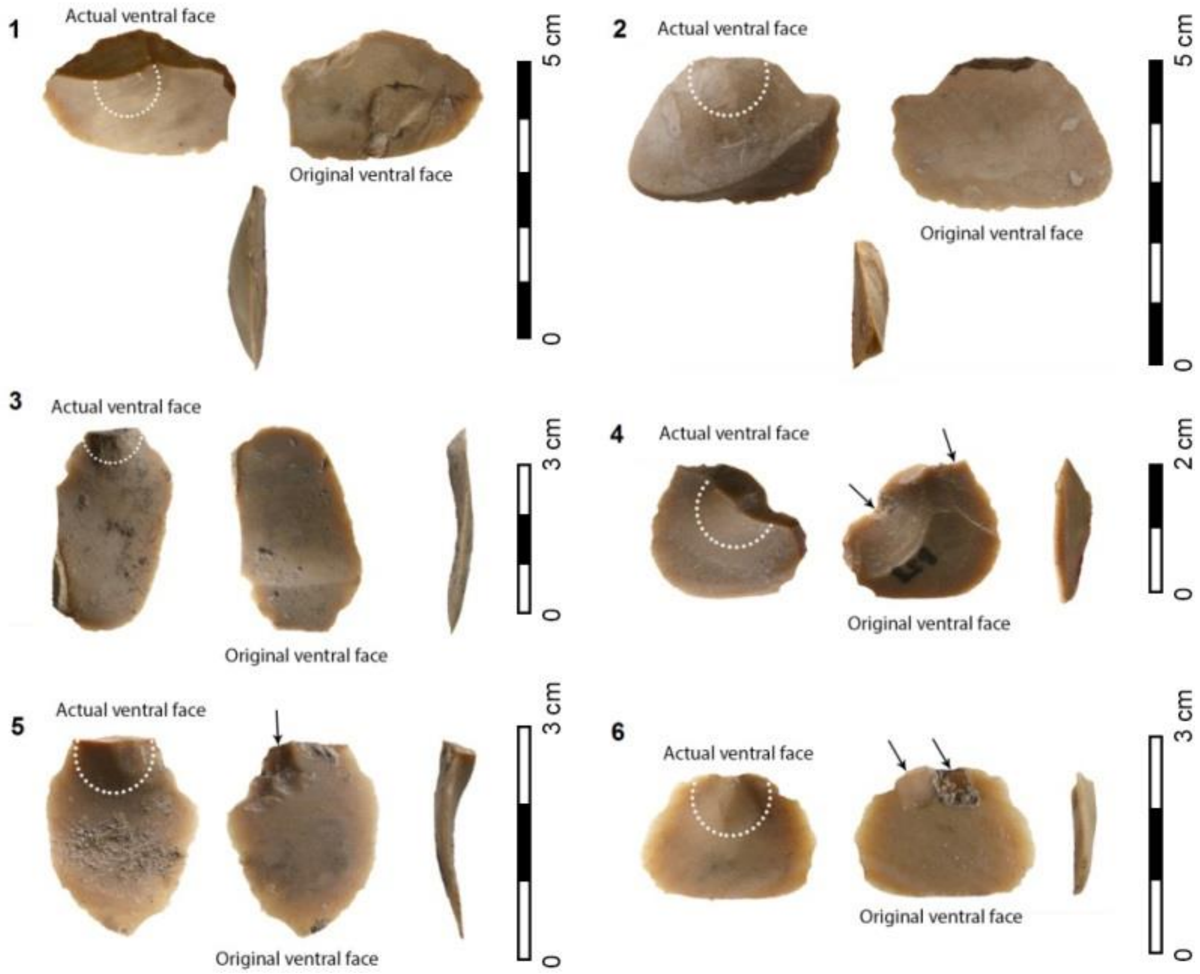

Figure 9. Regular items: 1-3 are regular items with plain dorsal face; 4-6 are regular items with previous removals. Dotted white line denotes the bulb of percussion while black arrows denote previous removals.

Regular items incline to have flat dorsal faces (the original, ventral face of the COF) and rather sharp edges. A total of 101 regular items (57%) show plain dorsal faces devoid of any scars (Figure 9:1-3), while 75 regular items (43%) show at least one scar on their dorsal face (Figure 9:4-6). The scars indicate previous removals from the same COF, *i.e.*, a late removal of an item that removed part of the scar of a previous removal as well as part of the original ventral face of the COF indicating repetitive flake production of small items from the same COF. For 18% (n=31) of the regular items there was patination on the dorsal face, implying that there was a time gap between the first use of the parent flake and its recycling into a COF.

In 68% of the regular items (n=119) lateral edges are sharp, on the right or left side or both. For 6% (n=11) the sharp edge is only on the distal end, while 23% (n=40) have sharp edges on both the distal and lateral edges.

More than half of the regular items end with hinge terminations (56%, n=98), since the force of the blow was directed towards a flat surface devoid of ridges that would have guided the blow. This, coupled with the fact that most of the sharp edges are on the lateral edges, on the right or left side or both, suggests that although many items show a hinge termination the items still have sharp and usable edges. Feather and step termination are also present.

Regular items tend to have modified or plain striking platforms (44%, n=78; 32%, n=56, respectively), typically between 3-6mm in size. Modification on the striking platforms of these items may suggest that, the items were removed from previously discarded tools or alternatively, the modifications were prepared before the removal of these items which is sometimes hard to distinguish. Nonetheless, modification suggests intentionality and planning aimed at a precise removal of specific small and sharp flakes. Additionally, the use of plain and cortical striking platforms suggests that the knappers were able to successfully remove this type of items using an existing surface of the COF without pre-removal preparation.

In all, 40 items removed from the ventral face of COFs were classified as DB Kombewa items (12% of total blanks produced from COFs, Table 3, Figure 10). These items have two ventral faces and two bulbs of percussion, one bulb on each of the ventral faces. They were removed from the ventral face of the parent COF along with the original bulb of percussion (Figure 10). These items resemble blanks first described by Owen (1938) and later by Newcomer and Hivernel-Guerre (1974, original in French) as "flakes in which the two bulbs of percussions are proximally located, and they are small, thin and circular in shape, with the morphology of the ventral face of the larger flake or the core-on-flake is slightly convex, which leads the waves during the removal of the smaller flake."

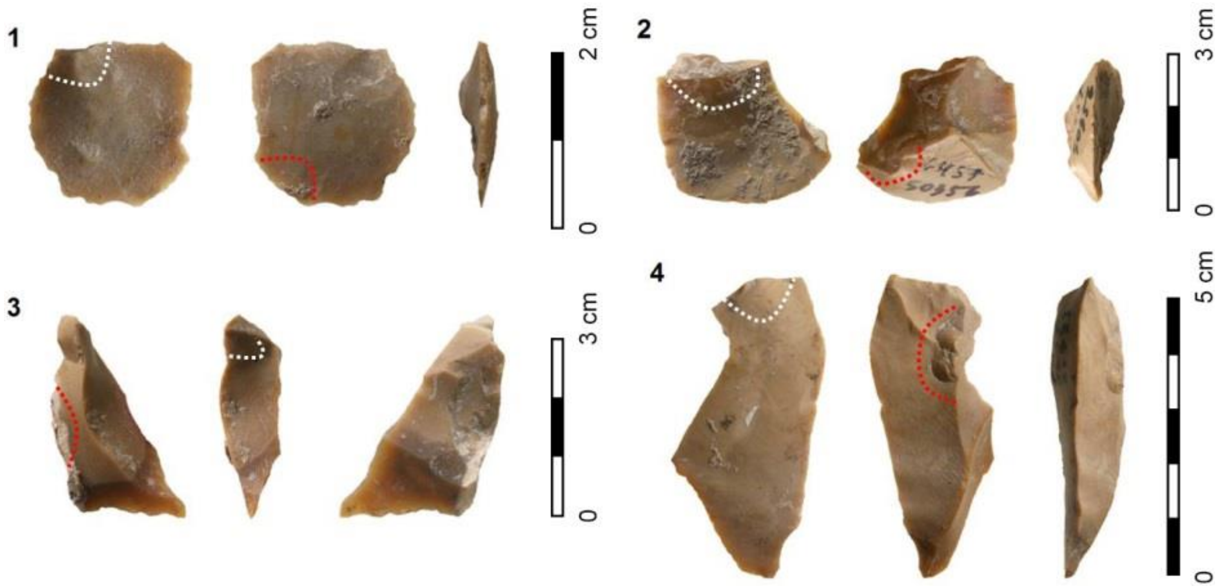

Figure 10. Double bulb (DB) items: 1 & 2 are DB Kombewa items; 3 & 4 are DB Tabun Snap items. Dotted red lines denote the original bulb of percussion on the COF; dotted white lines denote the actual bulb of percussion on the DB blanks.

These items are small (less than 3 cm in length), round or fan in shape (Figure 10; Table 4), creating a double convex profile with sharp edges along their entire circumference except for the area of the original striking platform of the COF. Nearly two-thirds (65%, n=26) of the DB Kombewa blanks show no modification on their striking platforms, and there is no specific size of striking platforms.

Table 4: Average metrics of blanks produced from COF, Standard deviation is in parenthesis.

Metrics of flakes and blanks	Length (cm)	Width (cm)	Thickness (cm)	Weight (g)
Regular items	2.4 *(1.0)*	2.7 *(1.0)*	0.7 *(0.3)*	5.2 *(5.4)*
DB Kombewa	2.7 *(0.8)*	2.5 *(0.7)*	0.8 *(0.4)*	7.2 *(6.9)*
Lateral items	3.5 *(1.0)*	1.8 *(0.7)*	0.9 *(0.3)*	7.0 *(6.1)*
DB Lateral	3.9 *(1.2)*	1.4 *(0.4)*	1.2 *(0.5)*	7.0 *(3.7)*
DB Tabun Snap	4.0 *(0.9)*	2.0 *(0.7)*	1.3 *(0.5)*	11.6 *(6.7)*

Some 43% (n=17) of the DB Kombewa items were removed at an upright (vertical) angle from the original production axis of the COF. The two bulbs of percussion are oriented 90 degrees from one another. Another 33% (n=13) were removed at a horizontal angle to the production axis of the original COF, while 18% (n=7) were removed at an angle between 40-60 degrees.

Most of the DB Kombewa items show feathered terminations (70%, n=28), while hinge terminations are less common (26%, n=10).

For 18% (n=7) of the DB Kombewa items, there was patination on their dorsal face. Only 15% (n=6) had previous retouch on their dorsal face. In addition, half of the DB Kombewa items exhibit previous removals on their dorsal faces, implying that multiple flakes were struck from the same COF.

5.2.2. Removals from the lateral edge of the COF

Lateral items are the second most common category among the blanks produced from COFs (25%, n=81). These are items with two ventral faces removed from the lateral edge and removing part of the ventral face of the COF (Figure 11). The bulb of percussion is observed on the actual ventral face of the item. The removals are longitudinal, in an obtuse angle, removing part of the lateral edge of the COF. The removal angle of these items resulted in an intersection between the original ventral face of the COF and the actual ventral face of the item. This angle tends to be between 30-60 degrees. While the obtuse angle – the angle between the actual ventral face and the dorsal face of the lateral item, tends to be over 90 degrees.

More than half (54%, n=44) of the lateral items are laminar; 64% (n=52) of them exhibit straight angled cross-sections, creating a naturally backed knife (NBK) type of item with a cortical back – which provides a comfortable grip and a rather sharp edge on the opposite side making it quite suitable for a cutting tool.

Nearly three-quarters (72%, n=58) of the lateral items are complete, while 10% (n=8) are broken at the proximal end, and 16% (n=13) are broken at the distal end.

For 42% (n=34) of the lateral items, striking platforms are plain, while modified and cortical striking platforms are less common (28%, n=23 and 16%, n=13, respectively). Plain and modified striking platforms tend to be large in size, while cortical striking platforms tend to be of medium sized. Medium (between 3-6mm) and large (more than 6mm) sized platforms are more common than thin platforms (between 0-3mm). This may be due to the force needed to successfully remove this type of blank.

Most of the lateral items end with feathered termination (42%, n=34), while hinge termination is less common (31%, n=25). Overshot terminations are rare (9%, n=7), and 19% (n=15) of the items are broken at the distal end.

Most lateral items (60%, n=49) show a plain dorsal face devoid of any scars (Figure 11: 1-2), but 40% (n=32) of the lateral items show scars on their dorsal faces from the same direction of the removal of the items, implying repetitive production from the same COF (Figure 11:3 & 5).

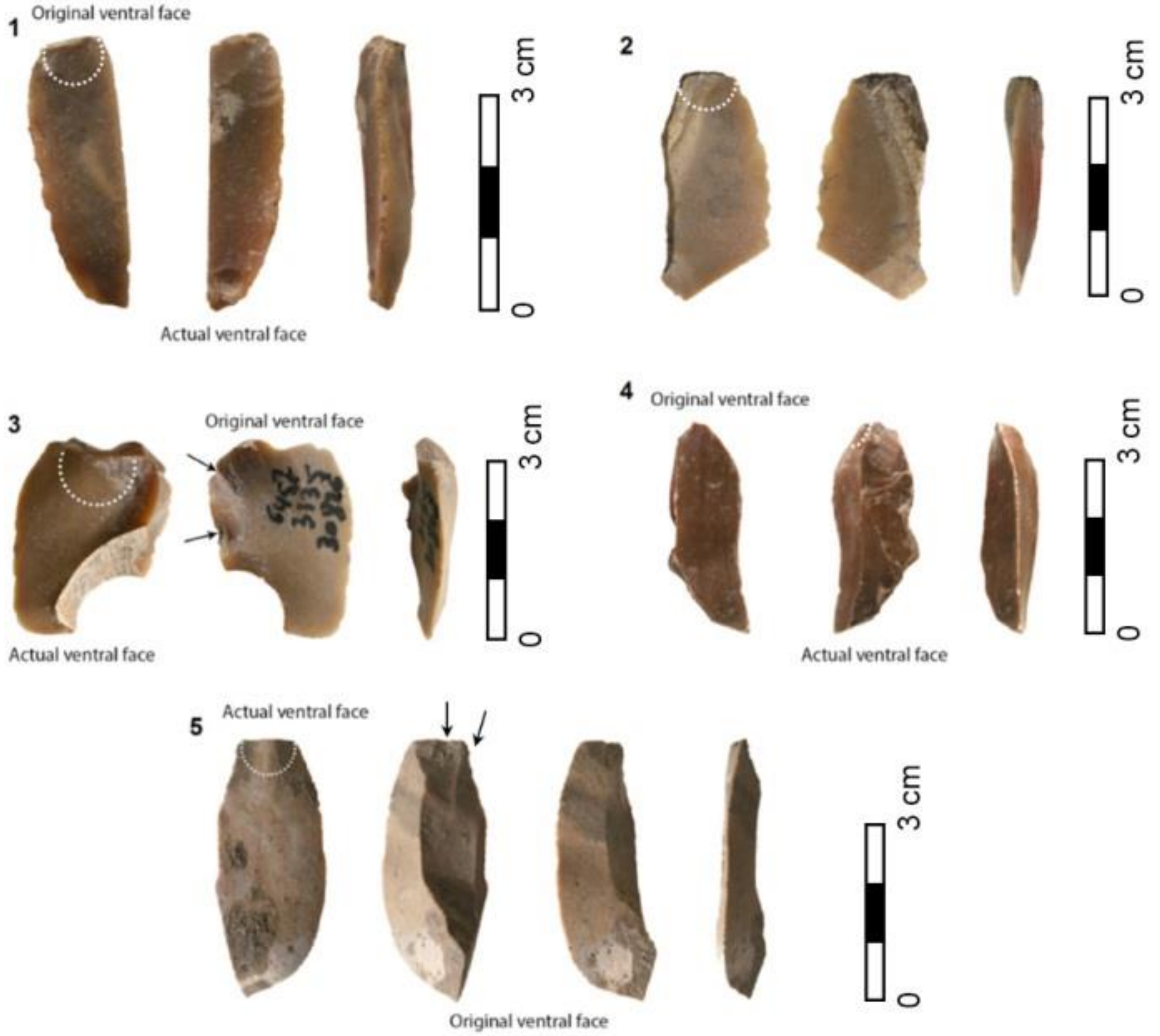

Figure 11. Lateral items: 1 & 2 are lateral items with plain dorsal faces; 3 & 5 are lateral items with previous removals on their dorsal faces; 4 is a lateral item with previous retouch. Dotted white lines denote the bulb of percussion; black arrows denote previous removals.

In addition, many lateral items (40%, n=32) show previous retouch, indicating that they were removed from older shaped tools (Figure 11:6). The old retouch may have been one of the reasons why these tools were chosen as blanks for COFs, since it formed a ridge that could guide the removal of the lateral item.

Some 28% of the lateral items show patination on their dorsal face indicating that they were detached from old patinated blanks selected for use as COFs. This recycling cycle begins with a blank that was produced, maybe used, and then discarded. It became patinated before it was chosen as a COF.

Only 14 items were identified as double bulb (DB) lateral items (14% of the recycling products). When detached, these items removed parts of the lateral edge and original ventral face of the COF including its original bulb of percussion. Thus, these items display two ventral faces and two bulbs of percussion one on each face.

Unlike the DB Kombewa items, these blanks are not double-convex, rather the two ventral faces intersecting with one another create a sharp edge angle between 40-80 degrees opposite to an obtuse edge angle between 90-100 degrees.

Most DB lateral items are also laminar, reduced along the longitudinal axis of the COF (86%, n=12). They are straight angled and triangular in cross-section (79%, n=11), creating a NBK.

Most DB lateral items exhibit opposite bulbs of percussion as a result of their removal from the distal end of the COF (64%, n=9). They can however also be removed from the same side as the COF (36%, n=5) as indicated by the close location of the two bulbs of percussion.

Most of them end with feathered terminations (43%, n=6). Overshot terminations are also fairly common (36%, n=5). Items with overshot termination usually removed a relatively large portion of the ventral face of the COF.

The majority of the DB lateral items have plain platforms (57%, n=8) which tend to be small (0-3mm) or medium (3-6mm) sized.

Most DB lateral items (71%, n=10) bear no traces of previous removals on their dorsal faces. Two items have previous retouch on their dorsal face, which was originally on the COF. Only three items exhibit patination on their dorsal face, suggesting a time gap between the first original use and the recycling.

5.2.3. Exploiting the thickness of the COF

There are 19 blanks (16%) classified as Tabun Snap items (Table 3, Figure 10). The Tabun snap, first described by Shifroni & Ronen (2000) following their work at Tabun Cave, is a technique where flakes were detached from the lateral side along the transversal axis of the COF. This snap produce flakes with two bulbs of percussion that differ from Kombewa flakes in their form, method of production and probably their function. Instead of thinning the butt area as in the Kombewa method, the Tabun snap often creates a thicker butt on the detached flake (Shifroni & Ronen 2000). These items also differ from DB lateral items in the location of the removal on the COF. DB lateral items are removed along the longitudinal axis of the COF, while DB Tabun Snap items are removed along the transversal axis at the bulbar area of the COF.

Since Tabun Snap items were removed along the transversal axis of the COF by a blow from the dorsal face (Figure 10), both angles (the angle between the two ventral faces and the angle between the ventral face of the blank and the dorsal face of the COF) tend to be acute (less than 90°), with semi-trapezoidal cross-sections. The resulting blanks are either flakes (32%), primary blades (32%), or other blades (16%).

No clear preference for a striking platform type was observed, 42% (n=8) of the items have plain platforms and 37% (n=7) have modification on their platforms.

5.3. Metrics of flakes and blanks removed from COFs

Metric categories include maximum length, width and thickness of the items (weight in grams is given in Table 4). Only complete items were measured, and averages are shown in Table 4. Metrics of different types are summarized below:

- <u>Regular items</u> - 84% of the regular items are complete and were measured. They are the smallest among the blanks produced from COFs, ranging from 0.7cm to 5.4cm in length, with an average length of 2.4cm, and from 0.7cm to 6.2cm in width, with an average width of 2.7cm.

- <u>DB Kombewa items</u> - 88% are complete. DB Kombewa items are a little larger than regular items, with an average length of 2.7cm.

- <u>Lateral items</u> - 72% are complete, with an average length of 3.5cm. They are mostly laminar, ranging from 1.7cm to 6.1cm in length and 0.6cm and 3.7cm in width.

- DB Lateral items- 93% are complete, with an average length of 3.9cm. DB Lateral items also tend to be laminar ranging from 2.4cm to 6.6cm in length and 0.9cm to 2.2cm in width.

- DB Tabun Snap- 95% are complete. DB Tabun Snap items are larger and heavier than the other types of blanks.

Although, Regular items are small (less than 3 cm), their morphology and very sharp edges makes these tools razor sharp and very efficient for specific cutting activities. The same can be say regarding the lateral items, which although they are long, on average they are thin (less than 2 cm), which may make it harder to hold the items during the activities. Nevertheless, their rather sharp and straight lateral edge makes the, efficient for specific tasks (Lemorini *et al.* 2015; Venditti 2017; Yerkes *et al.* 2018). Meaning, that although the items produced from COFs tend to be on the small, the hominin took advantage of their morphology and used these items for different activities.

In addition, it seems that the items removed from the ventral face of the COFs (*i.e.*, Regular items and DB Kombewa items) are smaller than the items removed from the lateral edge of COFs. This implies that COFs with ventral face removals show little change in volume and shape while COFs with lateral edge removals show a more significant change in volume and shape. In addition, it seems that DB items are bigger than Regular and Lateral items, which may suggest a more powerful strike, and more knapping mistakes.

5.4. Functional analysis

Microwear analysis on a sample of 69 recycling products was conducted by Richard Yerkes (Yerkes *et al.* 2018). A few brief points are presented here:

- Cores-on-Flakes: a sample of 25 COFs all with ventral removals was analysed. Microwear traces were visible on only three of the COFs (12%). Two had very little use wear, one, has possible prehension traces, and was apparently used to scrape meat or fresh hide off bone (light butchering) and the second seems to have been used to scrape dry hide and stone. The third COF had better-developed traces of meat or fresh hide scraping, or light butchering, use wear. Due to the location of use wear found on the COFs, it is hard to say if the use was conducted before or after the use of the items as COFs. In case the use was pre-COF, then the blank was a tool used (recycled) as a COF, and in case the use was post COF, then the (plain) blank was recycled into a COF, and then recycled again to become a tool (for more details see Yerkes *et al*. 2018).

- Blanks produced from COFs: of the 44 blanks that were included in the microwear sample, 19 (43%) were utilized. Microwear traces were visible in all types of blanks produced from COFs, each was used for several different tasks:

    - Regular Items - were the most common type, and nine of the 20 (45%) show microwear traces (56%). Five were used for light butchering, 2 were used to cut meat and work wood. The other 2 were used to cut and scrape (or whittle) bone or wood.

    - DB Kombewa items - microwear traces were found on two of the five DB Kombewa items (40%). One was used for cutting and scraping meat or fresh hide and bone (light butchering). The use wear on the other was not well-developed. Apparently it was used for scraping (or whittling) and engraving wood.

- <u>Lateral Items -</u> three of the seven Lateral items were utilized (43%). One of the items was used to cut and scrape meat or fresh hide (light butchering). One was used to cut, scrape and engrave wood. The third showed only generic weak microwear traces (possibly meat cutting).

- <u>DB Lateral items -</u> three of the five DB Lateral items in the sample were utilized (60%). Two were used to cut and scrape (or whittle) meat, bone, and wood, while the third item was used to scrape (or whittle) and engrave soft wood.

- <u>DB Tabun Snap -</u> two of the six DB Tabun Snap items show microwear traces (33%). One was used for cutting and scraping meat or fresh hide and bone (light butchering). The use wear on the other was not well-developed. Apparently it was used for scraping (or whittling) soft wood.

To sum up, blanks produced from COFs seem to have been used as expedient flake tools, in an *ad hoc* fashion, and each type of blank was used for several different tasks. There was no strong correspondence between the form of the blank produced and their functions (Yerkes *et al.* 2018). Since COFs were less utilised than the blanks produced from COFs, the fact that COFs that do show use, tend to show use not on the new edge created by the removals of the small flakes and blades (recycling products), suggests, that these items are better interpreted as cores rather than tools.

5.5. Raw material

A study aimed at classifying lithic raw materials at Ein-Zippori as well as locating their potential sources was carried out recently (Agam *et al*. *in press*). Nearly 7,000 flint artifacts were classified, and 43 flint types were identified (A to AQ). The classification was based on visual characteristics, such as variation in color, characteristics of cortex, sub-cortical layers, unique patterns (*e.g.*, circles, stripes, spots, *etc*.), degree of homogeneity and of translucency, presence of impurities, visible fossils, *etc.* Petrographic thin sections and a geological survey were conducted as well. The five most frequent flint types, are strongly related, and probably represent variations of the same flint, account for 92.6% of the sampled items. A field survey around of the site shows that these five common flint types are highly abundant in very close proximity to the site (from 100 m to 2 km distant) (Agam *et al*. *in press*).

A total of 479 recycled items was examined during the raw materials study, including 128 COFs and 351 blanks produced from COFs of which 96.0% (n= 460) are made of local raw material up to 2 km from the site. A strong correlation was found between the raw materials of COFs and their products. The five most common flint types constitute 88.1% of the sample. The distribution of lithic types detected within COFs and recycling products is very similar to that of the general lithic sample of the site implying that there was little or no selection of particular flint types to be recycled, and that the people of Ein-Zippori recycled whatever lithic pieces available and suitable for recycling (Agam *et al*. *in press*).

5.6. Refitting

A refitting project was performed on a lithic assemblage from a WR bifacial waste refuse pit (L. 8071) found on the western outskirts of the site (Schechter *et al.* 2018) during which a sequence of three double ventral flakes was refitted (Figure 12), showing remnants of thin cortex on the striking platform of the parent flake.

These three items represent an intermediary stage in the reduction sequence from the ventral face of a parent flake (COF) and are numbered in Figure 12 according to the removal order. Dorsal scars on the upper and lowermost flakes reflect previous and intermediate removals (before flake 1 and between flakes 2 and 3, see Figure 12:1). The scar apparent on the proximal end of flake 2 seems to be spontaneous, caused by the use of a hard hammer (see below).

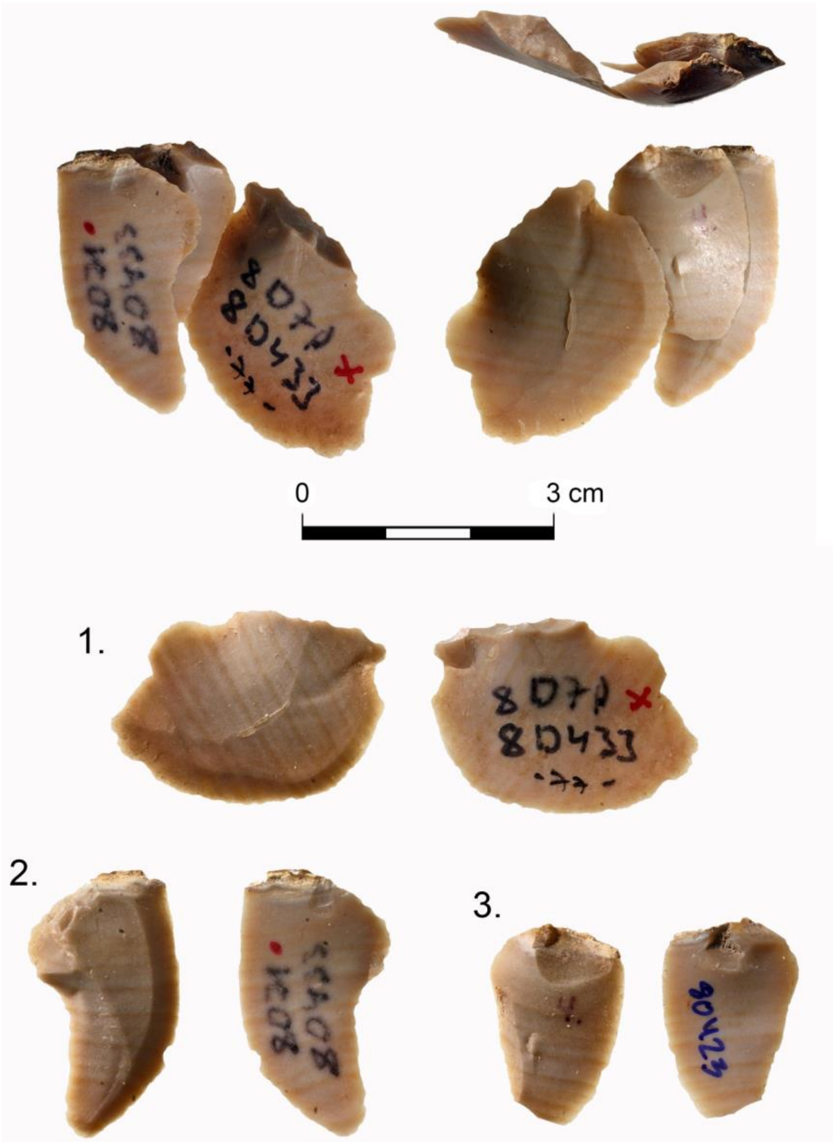

Figure 11. The refitting sequence of blanks produced from COFs.

The three flakes show different preparation of the striking platform. Spontaneous flake scars and bulb cracks may reflect the use of a hard stone hammer in this reduction sequence.

The refitted sequence clearly identifies these items as products of recycling – the production of small flakes from the ventral face of COFs. This is not possible when examining each of the items on its own. For example, flakes 1 and 3 retain only a very small part of the original ventral face which makes their identification as part of a recycling sequence quite a difficult task. Flake 2, on the other hand, is clearly a product of recycling as it carries the bulb of percussion of the COF (a double bulb Kombewa item).

The most important contribution of this refitted sequence to the current analysis of recycling is that products of recycling may not always be identifiable and thus they are underrepresented in the assemblages, indicating that recycling was more common than we suggested.

6. Discussion and conclusion

The data and analysis presented are part of the first detailed study of lithic recycling in the Pottery Neolithic Wadi Rabah culture and the Early Bronze Age period at the Ein-Zippori. While various types of lithic recycling at the site were briefly described, the analysis focused on a specific recycling trajectory that uses old discarded flakes for the production of smaller flakes and blades.

When a flake is transformed into a core (COF), it becomes a source of raw material for the production of new flakes and blanks. Flakes can be removed from the COF in several different ways: from the ventral face, dorsal face, lateral side or from the thickness of the COF. This requires technological adjustments, or a new, distinctive reduction technique for producing desired end products. Central to this recycling process are the COFs, or "parent" flakes selected to be recycled, and the blanks produced from them, the recycling products.

This mode of production is considered recycling as it displays modification of an already discarded item be it a flake (cortical or plain), blade, CTE or a shaped tool, transforming it into a new type of item for a task different than its original one. The new stage of modification indicates a beginning of a new use life of the artifact as a COF. The "parent" blanks, were selected from the available discarded blanks on-site (or brought in from the outside), given that they have suitable surfaces and angles. The variability of blank types used as COFs supports this statement and so does the size of the blanks, their different patinations, the fact that some of them show previous retouch, and the functional analysis indicating use wear mainly on the small produced blanks (recycling products), rather than on the COFs themselves.

The production of new flakes or blades from discarded blanks is the final stage of a *chaîne opératoire*, just prior to the final discard of the COFs. The COFs differ in size and shape, and there is no indication that they were made with an apparent preconceived intention to be used as COFs (*i.e.*, ramification).

Technologically recycling products and removal in a straightforward manner, without, or with little, preparation beforehand. The produced blanks are distinctive and morphologically homogeneous, Regular items tend to be of a fan or regular shape with a distal hinge termination while Lateral items tend to be more laminar in dimensions. While blanks removed from the dorsal face of COFs are difficult to distinguish from other flakes, the blanks removed from the ventral face of the COFs have specific morphologies and characteristics. These were separated into three distinctive production trajectories: (1) from the ventral face, or (2) from the lateral edge of the COF, or (3) a trajectory that exploits the thickness of the COF (Figure 8).

Removals from the ventral face of COFs (regular items and DB Kombewa items) are small and sharp items with two ventral faces, with double-convex cross-sections (DB Kombewa) or plano-convex cross-sections (regular). DB Kombewa items, often remove significant parts of the COF and it seems that this was a predetermined technique in which the bulb area of the COF was removed. In contrast, regular items had only a minor effect on the thickness of the COF, with relatively little preparation and force needed for the removal. In addition, although both regular and DB Kombewa items are usually of small-size (less than 3 cm on average), functional analysis shows that they were used as ad hoc tools for different tasks. The lack of hafting traces (and the presence of possible prehension traces on some of them) indicates that these small items were most probably hand-held (for more details see Yerkes *et al.* 2018).

Removals from the lateral side of the COFs (lateral items and DB lateral items) are characterized by an elongated morphology displaying a sharp regular edge with an opposite back enabling comfortable grip. The similarities in the general morphology of the two types, might suggest that DB lateral items are the result of knapping mistakes while producing lateral items. In addition, there is not much difference in microwear traces on the two types of blanks, however, the small sample size may suggest that such knapping mistakes were relatively rare.

Exploiting the thickness of the COF - the Tabun Snap – is a distinct and different approach for removing small blanks from a COF. This trajectory is not used for thinning an item, but rather for the production of specific items with two bulbs of percussion that differ from Kombewa flakes in morphology and perhaps in function too. Nevertheless, the small sample of items analysed makes it hard to functionally separate DB Kombewa items from Tabun Snap items.

Notably, there were less microwear use traces on COFs (12% of the sample) than on the blanks produced from COFs (43% of the sample). This suggests that the desired end products in this production trajectory are the blanks and not the COFs themselves. Moreover, COFs may bear traces of their former use. This is quite similar to the use wear traces observed on a sample of 103 COFs and 134 blanks produced from COFs from late Lower Paleolithic contexts at Qesem Cave, Israel, where only 15% of the analysed COFs showed use wear compared to 44% of the analysed blanks produced from COFs (Lemorini *et al.* 2015).

Nevertheless, unlike Qesem Cave, where the recycling products show specific functions for specific blank types [regular items were mainly used for cutting meat while lateral items were used mostly for cutting and processing plants (Lemorini *et al.* 2015)], at Ein-Zippori there is no clear correspondence between the type of blank produced and a specific function. We may "blame" the insufficient sample and the relatively low number of items analysed in each category and speculates that a larger sample would entertain a possibility that a more specific function for each type would have been recognized. However, this is not a productive avenue. Clearly, the nature of activities performed at each of these two sites is different. Ein-Zippori is an open-air, large, sedentary site of farmers of the Pottery Neolithic WR culture and EBA, while Qesem Cave is a mobile hunter-gatherer base camp of the Late Lower Paleolithic period. The two sites are separated in time by hundreds of thousands of years and differ so dramatically in their settlement layout and organization that an attempt to compare the nature of activities and the tools used for various activities is far from logical. Yet, while recycling products in the deep past were clearly directed towards selected activities, at Ein-Zippori they seem to have been used more "freely" and were *ad hoc* in nature as far as function goes. Their techno-typological aspects on the other hand seem to indicate a long and deep tradition.

The data showing that raw materials were, and still are found in abundance in the vicinity surrounding of the site, suggests that recycling behaviour was not related to raw material constraints, but probably to other decision making processes. To us, it seems that flint recycling activities described herein were directed towards quickly producing items for immediate needs from available, easily collected old, discarded items. This mode of production reflects in our view a recycling process aimed at producing desired end products with sharp edges and a morphology (*i.e.*, cortical edge, bulbar area), that facilitated their use as hand-held tools (no hafting traces were found).

This study of recycled flakes from Ein-Zippori allows us to explore the nature of recycling activities in late prehistoric periods, and provides a unique opportunity to explore lithic recycling behavior in farming and urban societies, something that has never been done before. The results are important for a more accurate reconstruction technological systems and the composition of lithic assemblages.

Acknowledgements

The excavations at Ein-Zippori were conducted on behalf of the Israel Antiquity Authority and were funded by the National Company of Roads. We would like to thank the staff of the excavation, and Pasha Shrago for the photos of flint items.

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