J World Prehist (2016) 29:217–266
DOI 10.1007/s10963-016-9097-9

Extensive Paleolithic Flint Extraction and Reduction Complexes in the Nahal Dishon Central Basin, Upper Galilee, Israel

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Published online: 17 September 2016

Abstract Recently found open-air flint extraction and workshop sites in the Eastern Galilee, Israel, are the focus of this paper. Lithic assemblages from among a few of the thousands of tailing piles documented in a field survey, indicate mostly late Lower Palaeolithic/Middle Palaeolithic and rarely Neolithic/Chalcolithic affinities. These discoveries substantially increase our knowledge of the scope of lithic extraction and reduction in northern Israel in these periods. The new sites are located on a 25 km^2 outcrop of flint-bearing Eocene limestone indicating intensive extraction of large amounts of flint, possibly beyond immediate local consumption requirements. After describing the new sites, we discuss their relation to nearby Middle and Lower Palaeolithic sites; possible resource management scenarios; chronology and duration of the extraction and reduction activity; and the sites as possible landmarks. A key question is the extent of the flint distribution area, or, more precisely, whether this region was a dominant mega-quarry for northern Israel and/or Southern Lebanon in the periods discussed.

Keywords Palaeolithic · Acheulean/Mousterian · Flint extraction · Quarry sites · Galilee · Israel

אבסטרקט מאמר זה מתאר מרחב רחב-היקף של אתרי חציבה וסיתות צור מהתקופות הפרהיסטוריות שנמצא לאחרונה בגליל המזרחי, ישראל. ממצאי תעשיית הצור שתועדו במסגרת הסקר, בדגימה של מספר ערמות פסולת סיתות מתוך אלפים רבים של ערימות, מלמדים כי עיקר פעולות החציבה והסיתות בוצעו בתקופה הפלאוליתית התחתונה והתיכונה, ובחלק מהמקרים יש גם עדויות לפעילות בתקופה הניאוליתית-כלכוליתית. גילוי זה מרחיב במידה משמעותית את ידיעותינו על היקף תופעת החציבה והסיתות של צור בצפון ישראל בתקופות אלו. אתרים אלו, הנמצאים בשטח כולל של 25 קמ"ר על שכבת סלעי גיר איאוקני ובה צור, מעידים על פעולות חציבה אינטנסיביות של כמות צור גדולה, שהיקפה נראה גדול מזה הנדרש לצריכה מקומית. אחרי תיאור האתרים החדשים, נדון בקשר בינהם לבין אתרים ארכיאולוגיים קרובים מהפליאולית התחתון והתיכון; בתרחישים אפשריים של ניהול משאב הצור; בכרונולוגיה ובמשך פעולת החציבה והסיתות; ובאתרים כסמני נוף. שאלת

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מפתח היא מה גודלו של האיזור הגיאוגרפי שבו הופץ הצור שנחצב באזורי החציבה והסיתות המתוארים במאמר זה, ובאופן ממוקד יותר – האם היה האזור הזה מקור מרכזי לאספקת צור בצפון ישראל ו/או דרום לבנון בתקופות המדוברות.

Introduction

'Stone tools provide some of the most abundant, continuous, and high resolution evidence of behavioural change over human evolution' (Stout et al. 2015). Understanding the ways and means of getting the right raw material to make stone tools is therefore extremely important. Flint was one of the main raw materials used for making tools in the Levant and other regions in prehistoric times; consequently, flint procurement strategies are central to research on human behaviour and adaptation. Field studies on the extraction of flint from primary geological sources have a long history globally, but in Israel they have developed only recently. Lower and Middle Palaeolithic flint quarrying sites were discovered in four locations in northern Israel: the Sasa site; Site 164 in the Carmel; Sede Ilan in the Lower Galilee; and Mount Pua in the Upper Galilee, located in the Dishon area (Barkai and Gopher 2009, 2011; Barkai et al. 2002, 2006; Gopher and Barkai 2006)—the starting point for the research presented here. In some of the flint extraction and reduction complexes, dozens, hundreds and on occasion over a thousand tailing piles were recorded in what can only be described as immense Lower–Middle Palaeolithic industrial areas (Barkai and Gopher 2009; Barkai et al. 2002, 2006) This research contributes substantial information on the scale of flint extraction and reduction sites in the Lower and Middle Palaeolithic periods in northern Israel (Fig. 1). The Upper Galilee hosts a few world-famous prehistoric sites, like the Lower–Middle Palaeolithic Amud Cave and the Lower Palaeolithic Gesher Benot Yaakov, and a few less well-known, such as Baram and Yiron in the Dishon Basin, and Zuttiyeh and Shovach caves in Nahal Amud. The discovery of an extensive flint extraction and reduction area in this region enables us to examine the relations between the raw material extraction and reduction sites and the habitation sites.

Recently described wide areas of Lower Palaeolithic workshops in Messak, Libya (Foley and Lahr 2015) and the Dawadmi area, Arabian Peninsula (Jennings et al. 2015), provide our finds with a broader context of well-established human extraction and reduction activity beginning in the Lower Palaeolithic.

The objectives of this paper are to present the results of a systematic survey and mapping of flint extraction and reduction localities in the central Dishon valley in the Upper Galilee, Israel; to present selected lithic items from a single tailing pile in each extraction and reduction locality in an attempt to assign it chrono-culturally; to try to understand the scale, quantity and scope of the extraction and reduction system described; to reconstruct plausible relationships between the extraction and reduction localities and Palaeolithic sites in the region; and to briefly attempt a broader scale view of Palaeolithic flint quarrying in northern Israel.

Flint Quarrying and Extraction Sites: An Overview, Focusing on Palaeolithic Israel

Studies of mining and quarrying procedures have focused mainly on the Neolithic (e.g. Barber et al. 1999; Barkai and Gopher 2001; Field 1997; Gopher and Barkai 2006; Grosman and Goren-Inbar 2007; Pétrequin et al. 1998; Sharon and Goring-Morris 2004

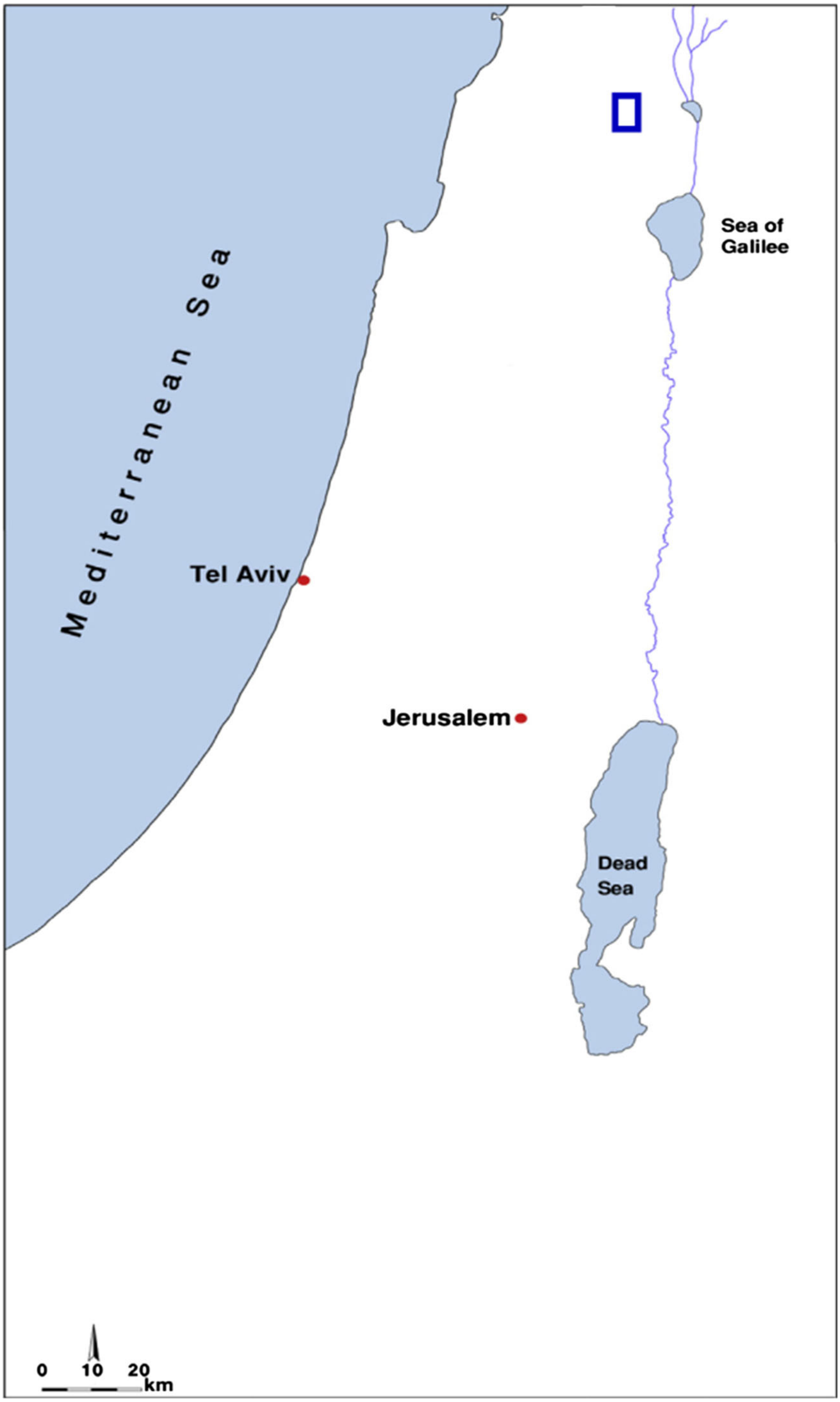


Fig. 1 Map of Israel. The research area is marked by a square

[only part of the complex is Neolithic]; Topping and Lynott 2005 and references therein; Weiner 1986). The sequence and scope of the operations, possible division of labour, quarrying tools, and other topics were central; while other studies have tried to draw conclusions about the transmission of knowledge, development of familiarity with the landscape, significance of quarrying and mining sites as prominent locales in the landscape, and more (Bradley and Edmonds 1993; Claris and Quartermaine 1989; Edmonds 1999; Elston 2013; Field 2005; Hampton 1999; LaPorta 2005; Scott and Thiessen 2005).

Research on Palaeolithic stone quarrying is limited. Lower Palaeolithic stone extraction sites, such as MNK in Olduvai, Tanzania (Stiles 1998; Stiles et al. 1974) and Isampur in India (Paddayya et al. 2000, 2002, 2006; Petraglia et al. 1999; Shipton 2013), are valuable sources concerning early stages of human procurement of stone. Research on flint extraction by Neanderthals in Western Europe has been at various levels of detail—ranging from specific sites and relatively small areas (Cauche 2012; Fernandes et al. 2008; Garcia-Anton et al. 2011; Roth and Dibble 1998) to wide-scale observation (Féblot-Augustins 1993). In southern France, Wilson devised a complex model to calculate the attractiveness of raw material sites, which she then used to examine the Middle Palaeolithic site at Bau de l'Aubesier and identify major considerations in Neanderthal decision-making (Browne and Wilson 2011; Wilson 2007a, b; Wilson and Browne 2014). Those works present possible procurement strategies, usually discussing distances from raw material sources to habitation sites. Quarrying strategies of Palaeo-Indians in North America (Beck et al. 2002; Elston 1992; Speth et al. 2013) and Polynesians in Hawaii (Bayman et al. 2004; Cleghorn 1986; Weisler 2011) contribute additional archaeological perspectives that can help elucidate the lithic procurement strategies of prehistoric groups.

Of equal importance are the studies on lithic procurement in Middle and Upper Palaeolithic flint extraction sites from conglomerates in the Nile terraces, Egypt (Vermeersch and Paulissen 1997; Vermeersch et al. 1990, 1995, 1998; Vermeersch 2002). Flint extraction and quarrying in the southern Levant remained a rather uncharted field until the 1990s, when a series of discoveries of Palaeolithic and Neolithic quarrying sites were reported (Gopher and Barkai 2006, 2011, 2014; Barkai et al. 2002; Barkai and Gopher 2009; Ekshtain et al. 2012; Quintero 1996; Quintero et al. 2002; Taute 1994; Grosman and Goren-Inbar 2007, 2016). Flint procurement from primary geological sources in the southern Levant in the Pleistocene has been indicated by field surveys (Delage 1997, 2007a, b; Ekshtain et al. 2012, 2013; Ekshtain 2014; Wilson et al. 2016); and deep, sub-surface flint quarrying of archaeological items from the Tabun and Qesem caves was demonstrated by measuring the cosmogenic isotope Be10 (Boaretto et al. 2009; Verri et al. 2004, 2005). A characteristic of quarrying activity in early extraction complexes is stone tailing piles consisting of rock waste and knapped flint items. Stone tailing piles were also recognized at the Bronze Age quarry and workshop of Har Haruvim (Shimelmitz et al. 2000). Two of us claimed previously that these piles were purposely created in these industrial areas during long-term raw material extraction and flint reduction, as part of the management of the extraction landscape (Gopher and Barkai 2014). Lower and Middle Palaeolithic flint quarrying sites were discovered in four locations in northern Israel (see above). The thousands of tailing piles at those sites vary in size from small (1 m–2 m in diameter and up to 1 m in height) to large (tens of metres in diameter and 3 m–5 m in height). The piles are concentrated within a relatively restricted area, which creates a highly visible extraction landscape that appears as an artificial mark in the natural environment. One of the most common features is the flint-knapping waste, with flint artefacts found on the surface of and within the piles. Quarrying tools are also found on and within the tailing piles, sometimes in considerable numbers (e.g. at Sede Ilan, Lower Galilee:

Barkai et al. 2006). Caching of flint artefacts underneath one of the piles has been reported at Mt. Pua (Barkai and Gopher 2011). The present study presents eight new flint extraction and reduction localities (in addition to Mt. Pua) of different scales on mountain plateaus in the Nahal Dishon Central Basin, Upper Galilee (Fig. 2: Mt. Pua marked in dotted line). As attested by the current study, and in combination with studies conducted in the 1970s and 1980s at Lower Palaeolithic Acheulean and Middle Palaeolithic Mousterian sites in the region (see below), the Nahal Dishon Central Basin appears to be a major location for human activity in the Lower and Middle Palaeolithic.

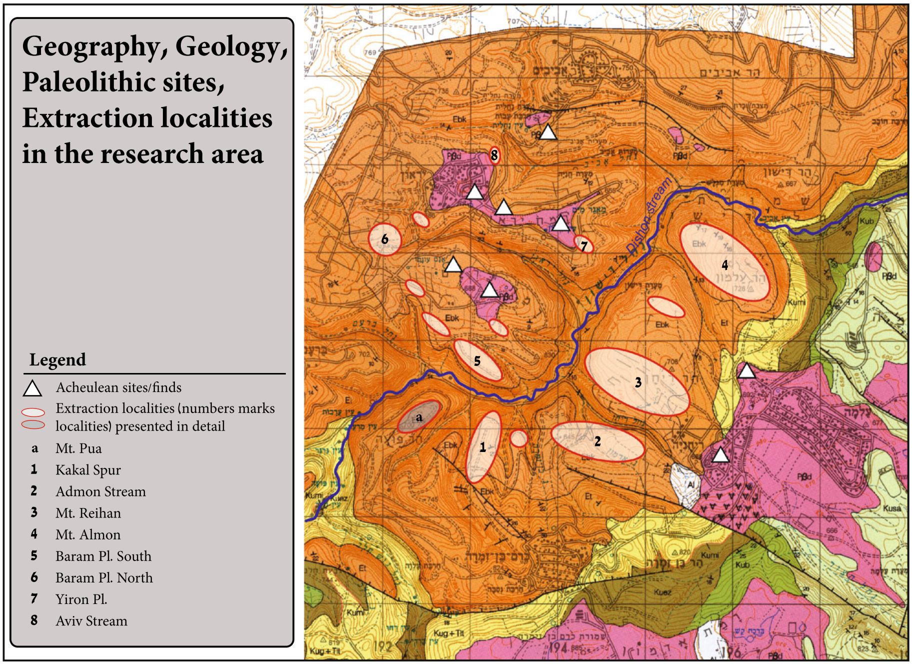
Ethnographic research provides valuable information on quarrying strategies, social organization in quarry ownership, beliefs and rituals related to stone procurement, and so forth. Evidence comes mainly from Australia (Binford and O'Connell 1984; Brumm 2010; Gould and Saggers 1985; Jones and White 1988; McBryde 1984); Papua New Guinea (Burton 1984; Hampton 1999); and North America (Clemmer 1990; Rusco and Raven 1992). We will use these examples with caution, mainly to illustrate suggestions regarding probable organizational and behavioural aspects of stone procurement, manufacturing techniques and transportation.

The Geography and Palaeolithic Prehistory of the Nahal Dishon Central Basin

Nahal Dishon (the Hebrew word for the white antelope, Addax nasomaculatus) is located on the western mountain flank of the eastern Upper Galilee (Fig. 1). The 96 km^2 drainage basin runs 32 km east from Mt. Meron to the Hula Valley (the northern part of the Jordan Valley). The stream descends 1035 m at a substantial slope averaging 3.25°, creating significant incised meanders, mainly in the central part (Yair 1962, p. 64). The area is an erosive surface divided into mountainous plateaus at altitudes of 650–750 m above sea level (MASL) and with peaks up to 830 MASL: the Baram, Yiron, Dalton and Alma Plateaus (Fig. 2). The surface is dissected by the Dishon and its tributaries running between the plateaus at elevations of 500–400 MASL in deeply incised V-shaped gorges, with occasional cliffs (Figs. 3, 4c, d).

Geologically, the study area consists of Eocene limestone. Lower Eocene limestone formation is 400 m thick and divided into the Bar Kochba formation (the upper 200 m) and the Timrat formation (also known as the Aviv formation, the lower 200 m) (Fig. 2). The upper part of the Bar Kochba formation, where flint extraction was carried out, is characterized by karren containing large numbers of flint nodules (Shlain 1961, p. 14). The few karstic caves in the upper Bar Kochba formation, none of which has thus far provided Palaeolithic findings, are mostly in the Aviv tributary (Frankel et al. 2001). The plateaus are partially covered with basalt caps, which are wider on the Dalton and Alma Plateaus on the eastern side of the stream and smaller on the Yiron and Baram Plateaus on the western side (Fig. 2).The basalt is dated to 2.51 million years ago (Mor et al. 1987).

The non-calcareous red kaolinitic soil on the upper Bar Kochba crystalline limestone is capable of holding small amounts of water, thus sustaining almost exclusively grassland flora (Fig. 4c), dominated by the *Hordeum bulbosum* and *Euphorbia hierosolymitana* association, with only small patches of trees (*Quercus calliprinos, Pistacia atlantica*, *Styrax officinalis* and *Amygdalus korschinskii*) creating an open parkland (Rabinovitch-Vin 1986, pp. 25, 58; Ohel 1986a, p. 31; Brosh and Ohel 1981, p. 28). The research area has been botanically termed the 'Galilee Desert' (Rabinovitch-Vin 1986, p. 166). The pine trees that



STRATIGRAPHY סטרטיגרפיה

SYSTEM תקופה	SERIES - STAGE סדרה / דרגה	SYMBOL סימן	THICK. m עובי מ'	LITHOLOGY מסלע	LITHOSTRATIGRAPHY ליתוסטרטיגרפיה: MAPPING UNITS יחידות מיפוי	GROUP חבורה
QUATERNARY קווטר	HOLOCENE הולוקן	Al			Alluvium אלוביום	
TERTIARY טרציור — NEOGENE ניאוגן	PLIOCENE פליוקן	Pβd			Dalton Basalt בזלת דלתון	
TERTIARY טרציור — PALEOGENE פליאוגן	EOCENE איאוקן	Ebk	200		Bar Kokhba Formation תצורת בר כוכבא	AVEDAT עבדת
		Et	200		Timrat Formation תצורת תמרת	
	PALEOCENE פלאוקן	Kug+Tlt	42-110		Ghareb & Taqiye formations תצורות ע'רב וטקייה	MOUNT SCOPUS הר הצופים
	SENONIAN סנון	Kuez	61		En Zetim Formation תצורת עין זיתים	
	TURONIAN טורון	Kub	0-30		Bina Formation תצורת בענה	
		Kuyi	0-20		Yirka Formation תצורת ירכא	
		Kuy	0-40		Yanuh Fm. תצ' ינוח	
על		Kusa	142		Sakhnin Formation תצורת סחנין	

Fig. 2 Geography, geology, Palaeolithic sites, and extraction localities in the research area (geological map: Levitte 2001)

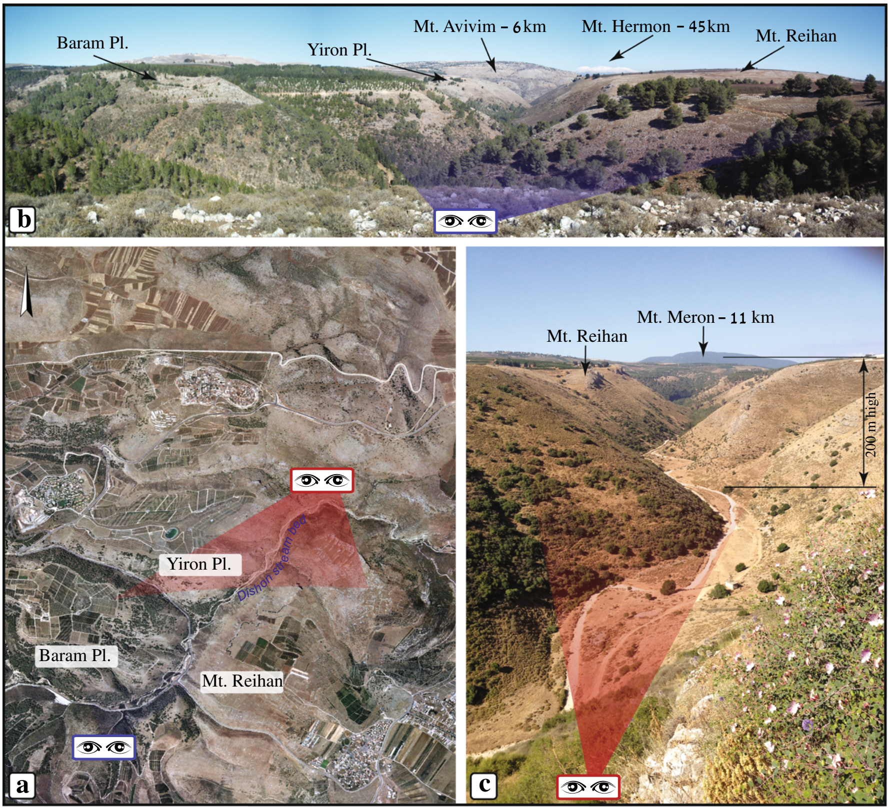


Fig. 3 **a** Arial photo of the research area; **b** panoramic view of the research area from the south; **c** view of Dishon stream from the north

appear in all pictures were planted between 1955 and 1965. The common herbivore mammals are *Sus scrofa and Gazella gazella* (Ohel 1986a, p. 32; Brosh and Ohel 1981, p. 28).

The Dishon is a perennial stream with a few springs along its course. Two springs on the plateaus near Acheulean sites are Ein Yiron and Ein Nahalit (Fig. 2). Seasonal lakes and ponds are found on the Yiron and Baram Plateaus and Mt. Reihan (Fig. 4a), the Alma Plateau, and Mt. Avivim (Fig. 4b). Palaeolithic human activity has been recorded in the vicinity of these water sources (Ohel 1986a, 1991; Ronen et al. 1974; see below). Today they retain their water until late spring. The streams flow sharply to the east due to a Late Pliocene–Early Pleistocene tectonic shift (Yair 1962, p. 128). The Dishon area underwent erosion and by the Late Pleistocene reached an advanced stage that differs only slightly from the current topography (Yair 1962, p. 195). For the purposes of our research (following Ohel 1991, p. 161; Brosh and Ohel 1981, p. 25), the surface, especially on the plateaus at the end of the Lower Palaeolithic and during the Middle Palaeolithic, is assumed to have been similar to that observed today, although the incision of the Dishon valley and its tributaries must have been shallower.

The current Mediterranean climate is characterized by hot, dry summers (maximum daily average in August: 30 °C) and chilly winters on the windy plateaus (maximum

Fig. 4 **a** Winter pond on Riehan basalt cover; **b** winter pond on Mt. Avivim basalt cover; **c** grassland and open parkland flora—view from Dishon stream bottom;**d** karstic landscape of the Dishon Stream—view from Mt. Almon to northwestern cliffs of Mt. Reihan; Yiron Plateau is visible at the rear

average in January: 10 °C with 4–5 snow events per year). Annual rainfall is 650–850 mm (Ohel 1986a, pp. 30–31;Brosh and Ohel 1981, pp. 28–29).Climatic conditions in the research area during interglacial phases were basically similar to those observed today (Ohel 1986a, pp. 30–31; Brosh and Ohel 1981, pp. 28–29). Two relatively close prehistoric sites whose palaeoclimates have been meticulously studied are Gesher Benot Ya'aqov, 15–17 km (depending on the extraction locality) southeast of the research area, where climatic and floral conditions above the Matuyama–Brunhes Boundary (MBB) (0.78 Ma) are similar to today's (Rabinovich and Biton 2011), and Amud Cave, 20–22 km south of the research area, showing conditions wetter than the current ones during MIS4–3 (70–53 Ka, Hallin et al. 2012 and references therein).

Earlier archeological works on the Palaeolithic period in the Nahal Dishon Central Basin comprise four main studies:

1. Turville-Petre surveyed Nahal Dishon and on the northern slope of the Baram Plateau found a 'factory' with bifaces, cutter, cores, flakes, points, blades, and a small cave containing mainly scrapers and blades (Turville-Petre et al. 1927).
2. Ronen's initial survey of the area (Ronen et al. 1974) reported ten Acheulean sites/findspots (Fig. 2), never below 680 MASL, and always on the basalt caps. One Neolithic site was found in the streambed. Ronen proposed that Acheulean hominins preferred the basalt caps, presumably because of the clayey basalt soil that nourished a more open type of forest than the surrounding limestone areas. The only finds described were from the Baram Plateau and included flake tools (including Levallois flakes), handaxes, unretouched flakes, cores and waste. Later on, based on preliminary finds, Ronen suggested dating the earliest human presence in the region to more than 2.5 Ma ago; however no further studies were conducted to validate this proposal (Ronen 2006).

3. Based on Ronen's survey, in the 1980s Ohel conducted intensive surveys on the Yiron and Baram Plateaus, and a smaller-scale survey on the northern bank of Nahal Aviv. (Our study refers mainly to the detailed survey reports and later papers.) A complete list of Ohel's publications in this region is referenced in his later reports (Ohel 1986a, 1991). In the first survey, conducted in 1979 on the Yiron Plateau, Ohel counted nine Acheulean sites (most located on the basalt caps); a few sites 200–300 m from its boundaries (Ohel 1986a); and two small sites on the southern bank of the Aviv Stream (Ohel 1990).The Baram Plateau survey discovered three sites around the water bodies on the basalt cap (Ohel 1991), which Ohel named after their suggested inhabitants: Early 'Lake' Acheuleans; the later and technologically more advanced 'Pond' Acheuleans (500 m east of the lake); and 'Lake' Mousterians (for the general location of these sites, see Fig. 2; for a detailed perspective on Ohel's survey, see his Fig. 30b in the discussion).
   Ohel's surveys of the Yiron and Baram Plateaus included the flint source areas presented here, including the extraction tailing piles. He described them as 'natural flint spread' or agricultural clearance waves/piles (Ohel 1991, p. 140). Ohel's suggestions concerning the flint sources of these settlements are presented in detail in the discussion.
4. The last phase of research in the Nahal Dishon Central Basin was conducted in 1997–2001 by Barkai and Gopher, who discovered the flint extraction and reduction complex at Mt. Pua (Barkai et al. 2002), located on the eastern bank of the Dishon, overlooking the Baram Plateau. This is the starting point for the research presented here. Mt. Pua and Sede Ilan in the Lower Galilee (Barkai and Gopher 2009, 2011; Barkai et al. 2002, 2006; Gopher and Barkai 2006, 2011), are the most relevant locations for this work. The basic characteristics of these extraction and reduction complexes include:

   - Location on high ground relative to the surroundings (Mt. Pua on a summit; Sede Ilan on a spur). An open view to and from the sites, and the marks created on the landscape by large tailing piles, make them visible from long distances.
   - The sites are spread across thousands of square metres and contain hundreds of tailing piles: Mt. Pua is an area of 150 m × 800 m, with nearly 1500 tailing piles; Sede Ilan is of similar size, with hundreds of piles. The piles' dimensions vary from 1 m in height on an area of several square metres to 3–5 m in height on an area of tens of square metres.
   - Both complexes are characterized by the quarrying of flint nodules from the limestone horizons of visible rock outcrops, and backfilling the exhausted extraction fronts by quarrying waste material while knapping the extracted nodules on top of the tailing piles (Gopher and Barkai 2011, 2014). The quarrying sites are fields of wasted limestone piles that contain large amounts of flint knapping debris, including nodules, tested nodules, cores at different stages of processing, flakes, bifacial tools, and Levallois cores. Basalt quarrying tools were found at Sede Ilan (Barkai and Gopher 2009) and limestone ones at Mt. Pua (Barkai et al. 2002).
   - Absolute dates for the sites are quite elusive; however, on the basis of the recurrent presence of Levallois cores and products—as well as handaxes, very large flakes and bifacial roughouts—these complexes can be safely attributed to the Lower and Middle Palaeolithic periods of the Levant (for more detail, see Gopher and Barkai 2011).

- Both complexes reveal the long-term use of an extensive industrial area, which demonstrates impressive planning and organizational capabilities (similar extraction and reduction activities were found at two more localities, Sasa and Site 164 in the Carmel; however, only preliminary study of these has been conducted: see Barkai et al. 2006 for details).

A unique phenomenon was discovered during the excavation of a 2 × 2 m test pit within a large (30 m × 12 m) tailing pile on Mt. Pua. Two similar caches were found directly on top of the exhausted extraction front and under massive stone blocks, containing 13 items each, including a Levallois core in each cache. One of the caches contained a handaxe roughout. Caching behaviour may have had a functional or symbolic purpose, but the depth and location of the deposit (70–90 cm below the surface) points to the latter: 'most probably at the end of extracting the flint nodules from this specific location and just before the stage of backfilling the spot by quarrying debris from another recently opened extraction front' (Barkai and Gopher 2011, p. 8). This is a very early example of caching behaviour and may represent symbolic behaviour related to flint extraction that developed over a long period of flint procurement in this extensive extraction area.

Additional evidence from later prehistoric periods in the region includes an Epipalaeolithic site (Shimelmitz et al. 2004); Neolithic sites (Ronen et al. 1974; Frankel et al. 2001, pp. 41–42, 96–97); Neolithic flint quarries (Barkai and Gopher 2001; Gopher and Barkai 2006) in the Dishon stream bed; and Chalcolithic sites on the plateaus (Ronen et al. 1974). An archeological survey conducted during the 1970s–1990s (Frankel et al. 2001) presented evidence from historical periods.

Methods

The field survey was conducted in 2013 and the research area was divided into eight extraction and reduction localities (Fig. 2), spread over plateaus and streams in the area. As some of the localities are covered by planted forests and others have been damaged by agricultural activity, the survey was aided by British aerial photographs taken in 1945–1946, obtained from the Israel Mapping Center Archives and aerial photographs taken in the last decade and downloaded from Google Earth. Each locality is described by size, MASL, number of tailing piles by size category: small (< 1 m in diameter); medium (1–5 m diameter); and large (> 5 m diameter). Aerial photographs were used to assess the overall size of the extraction localities and measure the distance between them and the closest basalt cover. Each extraction locality is represented by an aerial photograph, and, if possible (depending on topography, size, forest cover, and so forth), a land photograph of the locality is added.

At each extraction locality a single tailing pile (eight in total) was thoroughly surface surveyed. Each pile is described topographically and illustrated by a photograph with a human standing alongside it as a scale. A few lithic finds at each pile (bifacial tools or roughouts, Levallois cores, cores, large flakes, blades, and so forth) are illustrated in the photographs and briefly described for chrono-cultural assessment. Natural flint nodules embedded in the limestone in the vicinity (within 50 m) of some of the piles are also shown in photographs. The presence of basalt on the pile is also recorded. More comprehensive lithic studies of selected contexts are planned.

In previous field work at Mt. Pua (part of the area described here), one large extraction and reduction locality (PW3, Barkai and Gopher 2011; Barkai et al. 2006) was a target of systematic surface collection and a test excavation. A surface collection of 120 m^2 (out of a total surface area of 350 m^2) yielded 2699 knapped lithic items (Table 2). Additionally, 1146 flint items were excavated from a 1 m deep, 2 × 2 m test excavation located in the middle of the large extraction and reduction heap (Barkai and Gopher 2011). Full excavation of a small (20 m^2) extraction and reduction tailing heap (PW100) yielded 8825 artefacts (Barkai et al. 2002).These finds and figures provide us with an idea both of what a ‘typical’ extraction pile holds, and of the variation between piles in the same locality. This is Elston’s take on the issue:

> They are logistically intimidating and difficult to study because they contain so many artefacts. Fortunately, although there are vast numbers of artefacts in quarry deposits, there tend to be relatively few types. This redundancy should be taken into account when creating sampling designs, because a sufficient number of small samples will capture most of the variability present. If at all possible, type and record the artefacts in the field and leave them there (Elston 2013, p. 444).

Two of us previously discussed the dilemmas involved in this kind of archeological endeavour, which is on a completely different scale:

> … industrial complexes, large factories, sometimes spread over many acres of land. How does one excavate such sites in a way that represents them properly? How does one sample such sites? Fronts, tailing piles, open spaces, between piles? How does one consider the tons and tons of tested nodules, cores, debitage, and debris? What kind of sampling strategy would be appropriate for such assemblages? What sort of lithic studies should be carried out to describe and analyse the very primary reduction stages that are rarely found at habitation sites? (Gopher and Barkai 2014, p. 98).

We thus focused on the description of the size and intensity of the grand phenomena. Human activity in the entire extraction region of the Nahal Dishon Central Basin is assessed based on the information gathered in the survey, together with information on known prehistoric sites in the area, the geological, geomorphological and environmental setting, and supporting archaeological and ethnographic studies.

Results

There follows a description of the eight new extraction and reduction localities found in the survey.

Extraction and Reduction Locality No. 1: Kakal Spur

Kakal Spur is located on the eastern bank of the Dishon, near Mt. Pua, facing the extraction and reduction locality No. 5 on the Baram Plateau. The narrow spur is 1 km long and 200 m wide (Fig. 5a), descending from 675 MASL in the south to 640 MASL to the north. This locality contains five large tailing piles and around twenty medium ones. Flint nodules are found within the limestone on the slopes of the spur (Fig. 5d, e). Basalt was not found (nearest basalt cover is 2 km to the south: Fig. 2). Artefacts from the surveyed pile and surroundings include Levallois Cores (Fig. 6c); bifacial roughouts (Figs. 6a, 7a, b); and large retouched flakes (Fig. 6b). Three handaxes were found 20 m south of the surveyed pile (Fig. 8a–c). The artefacts attest to human activity at this locality mainly during the

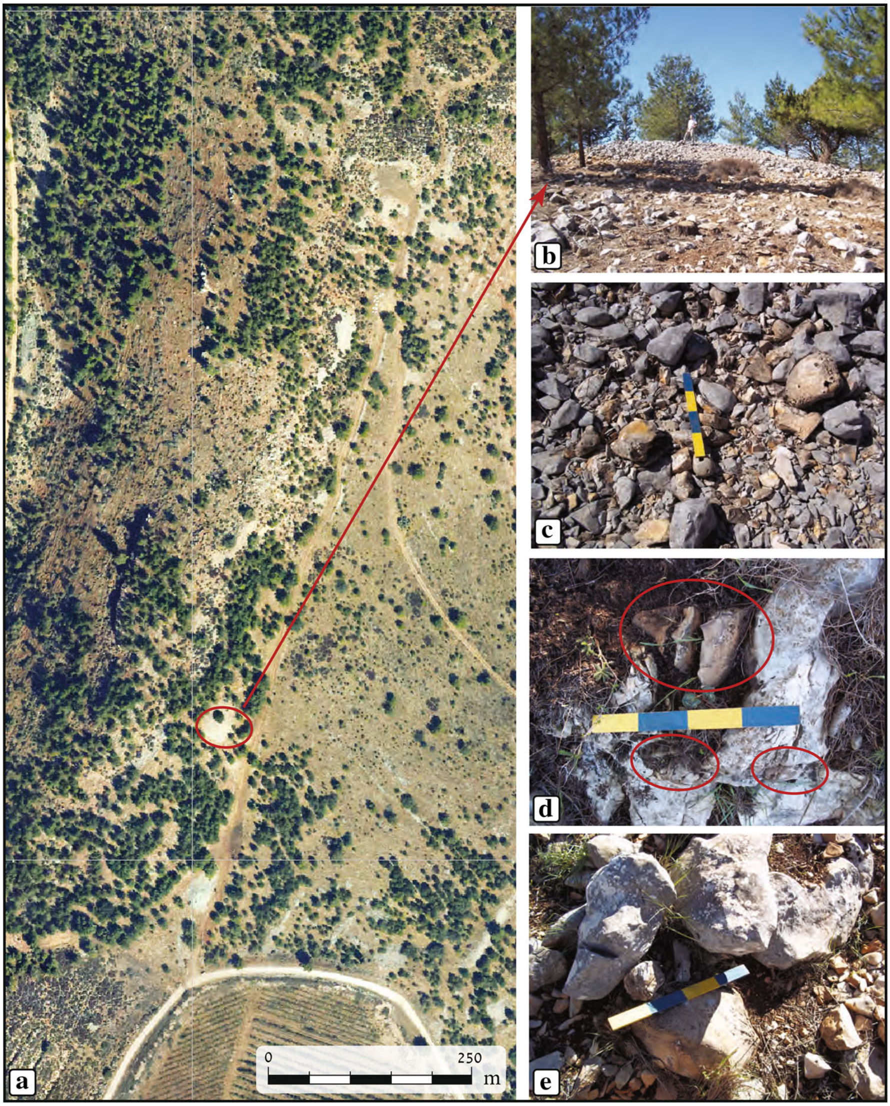


Fig. 5 **a** Aerial photo of extraction and reduction locality No. 1 –KakalSpur (*circle* marks the surveyed pile); **b** ground photo from east; **c** flint (all over) and limestone on the surveyed pile—scale = 40 cm; **d** flint nodules (*circles*) in limestone; **e** large flint nodule in limestone

Lower Palaeolithic (Acheulean) and Middle Palaeolithic (Mousterian) periods, with a possible stray later use during the Neolithic.

Extraction and Reduction Locality No. 2: Admon Stream

This locality is comprised of two small streams and the high ground between and beside them. It measures 2 km by 1 km and contains eight large tailing piles, around forty medium piles and some hundred small piles (some of the piles, specifically in the northern and

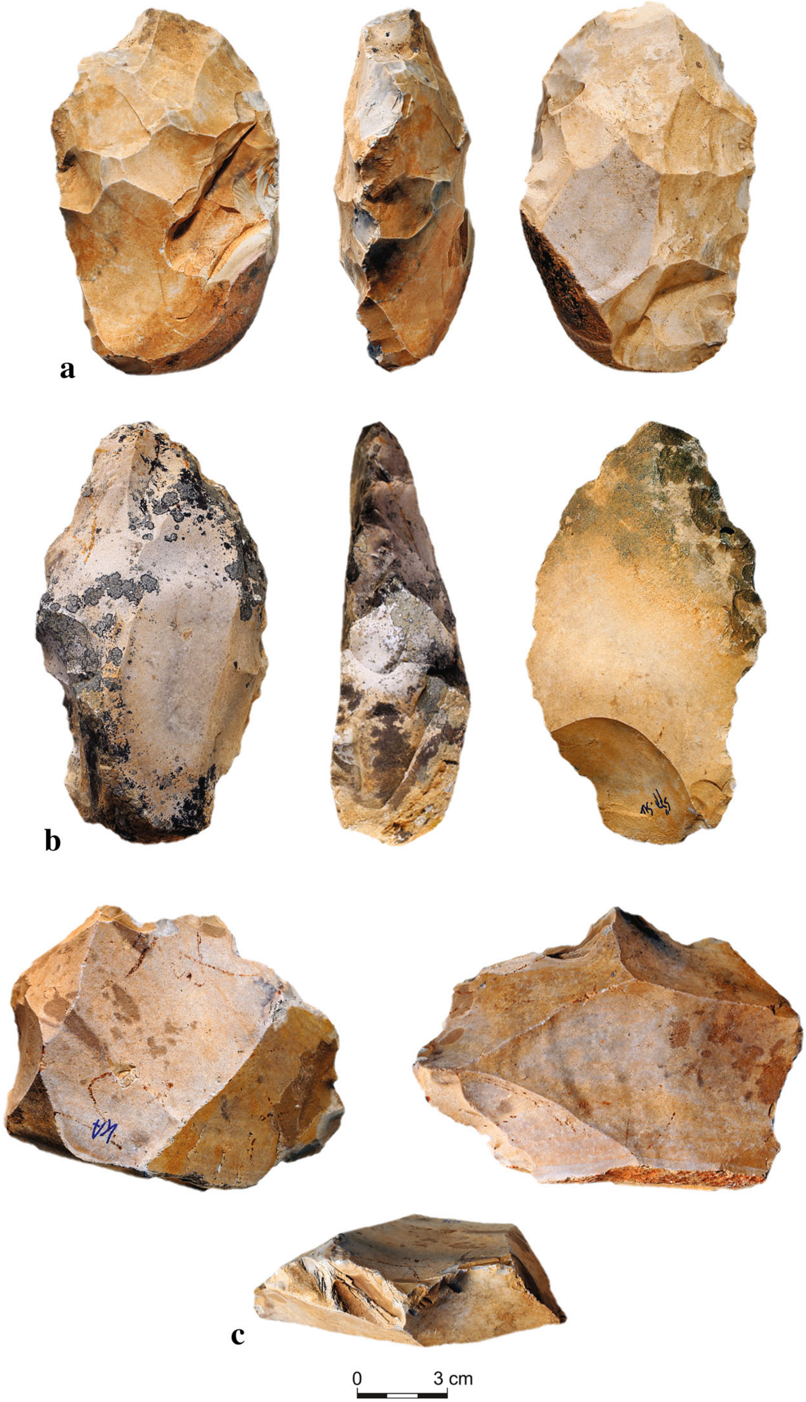


Fig. 6 Artifacts from the surveyed pile. **a** Bifacial roughout; **b** large retouched flake; **c** Levallois core

Fig. 7 Bifacial roughouts from the surveyed pile

southern areas, have been damaged by agricultural activities: Fig. 9a, b). Extraction and reduction piles are between 680 MASL on the eastern side of the locality and 615 MASL in the western side. Flint nodules are found within the limestone in the vicinity of the piles (Fig. 9f). Basalt is found on the more eastern piles, which are 600 m to the west of the nearest basalt cover, but is absent on the westernmost piles, which are 2 km from the basalt cover. Artefacts from the surveyed pile include probable Levallois cores (Figs. 10b, 12b); bifacial roughouts (Figs. 10a, 12c) adze roughouts (possibly Chalcolithic) (Figs. 10c, 11a);

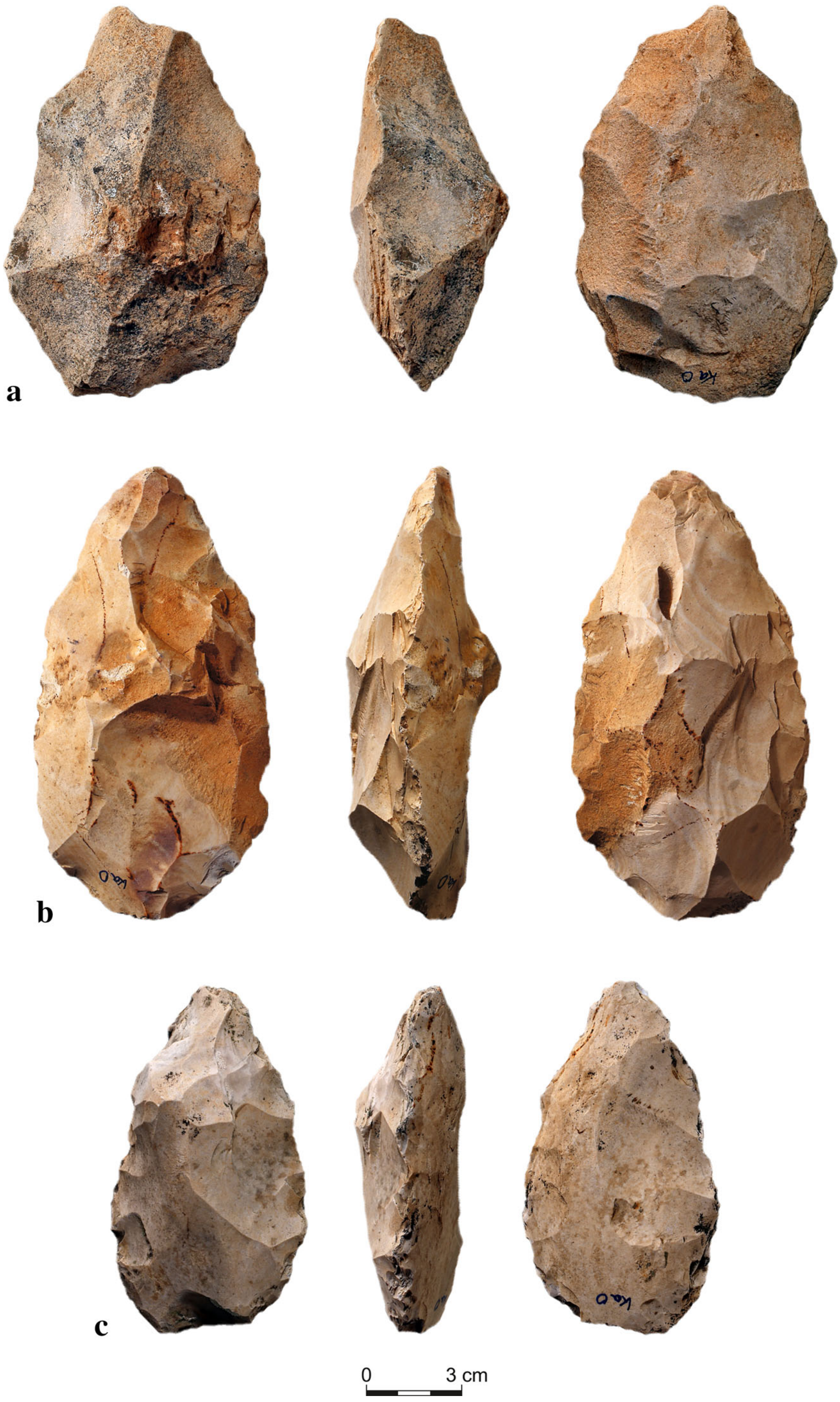


Fig. 8 Bifaces found 20 m south of the pile shown in Fig. 6

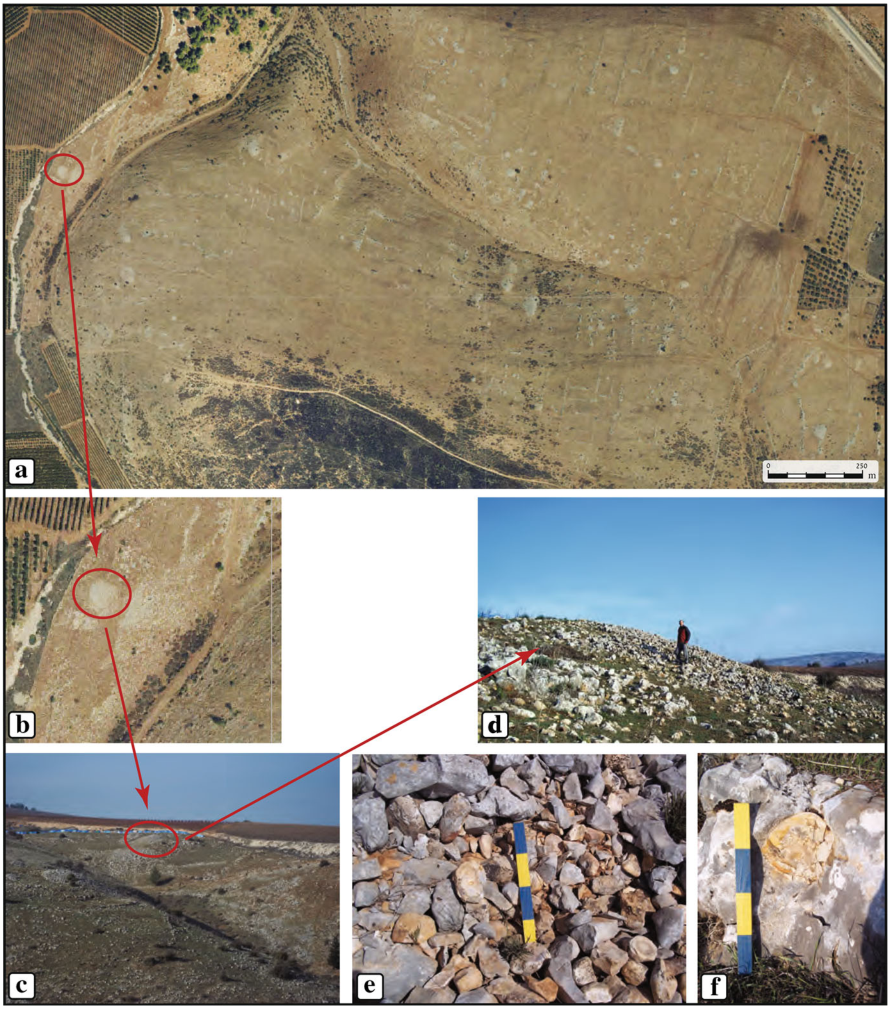


Fig. 9 **a**, **b** Aerial photo of extraction and reduction locality No. 2—Admon stream (*circle* marks the surveyed pile); **c** ground photo from northeast; **d** ground photo from south; **e** flint (all over), and limestone on the surveyed pile; **f** flint nodule in limestone

large flakes (Fig. 12a); and a retouched flake/scraper (Fig. 11b). The artefacts attest to human activity during the Lower Palaeolithic (Acheulean) and Middle Palaeolithic (Mousterian) periods, and possible stray visits during the Chalcolithic.

Extraction and Reduction Locality No. 3: Mt. Reihan

Mt. Reihan is located on the eastern bank of Nahal Dishon, flanked by the Reihan stream to the south and Mt. Almon to the north. The locality is a slight slope, 2 km long and more than 1 km wide (Fig. 13a), descending from 700 MASL in the northeast to 610 MASL in the southwest. The locality contains three areas of large tailing piles with virtually no medium or small ones. The surveyed pile is one of about ten large piles (Fig. 13b, c). The

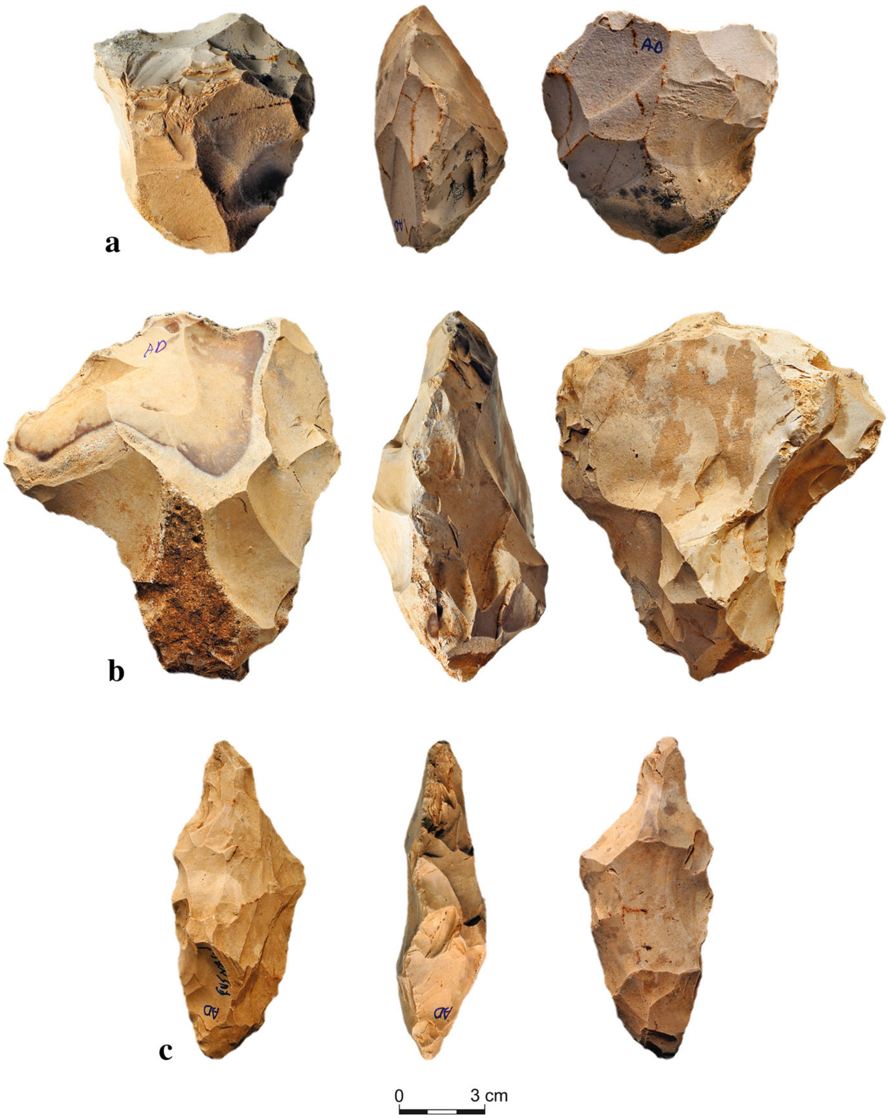


Fig. 10 Artifacts from the surveyed pile. **a** Broken bifacial roughout or Levallois core; **b** core (Levallois?); **c** adze/chisel (possibly Chalcolithic)

slope is cultivated mostly in its centre, and some of the piles have probably been disturbed and deformed for agricultural reasons. Flint nodules are found within the limestone near the piles (Fig. 13d, e). Basalt is found throughout the area and on the surveyed pile (Fig. 13f) which is 1.5 km from the nearest basalt cover (Fig. 2). Artefacts from the surveyed pile include probable Levallois cores (Figs. 14a, 15); bifaces (Fig. 14c); and a blade (Fig. 14b), attesting to human activity in the Lower Palaeolithic (Acheulean) and Middle Palaeolithic (Mousterian).

Fig. 11 Artifacts from the surveyed pile. **a** Adze (possibly Chalcolithic); **b** retouched flake/scraper

Extraction and Reduction Locality No. 4: Mt. Almon

Mt. Almon is located on the eastern bank of Nahal Dishon, above the point where it turns sharply eastward towards the Hula valley. The locality is a slope, 2 km long and more than 1 km wide, descending from 710 MASL in the northeast to 610 MASL on the southwest. The locality is the densest found in this research, including more than 50 large or elongated large tailing piles and countless medium and smaller ones (Fig. 16a). The locality is cultivated mostly in its northern and southern parts where some of the piles have been disturbed and deformed for agricultural reasons. The higher centre of the locality is basically a big limestone bed broken into numerous tailing piles. Flint nodules are found in limestone near the piles (Fig. 16e). Basalt is found on the entire plateau and on the

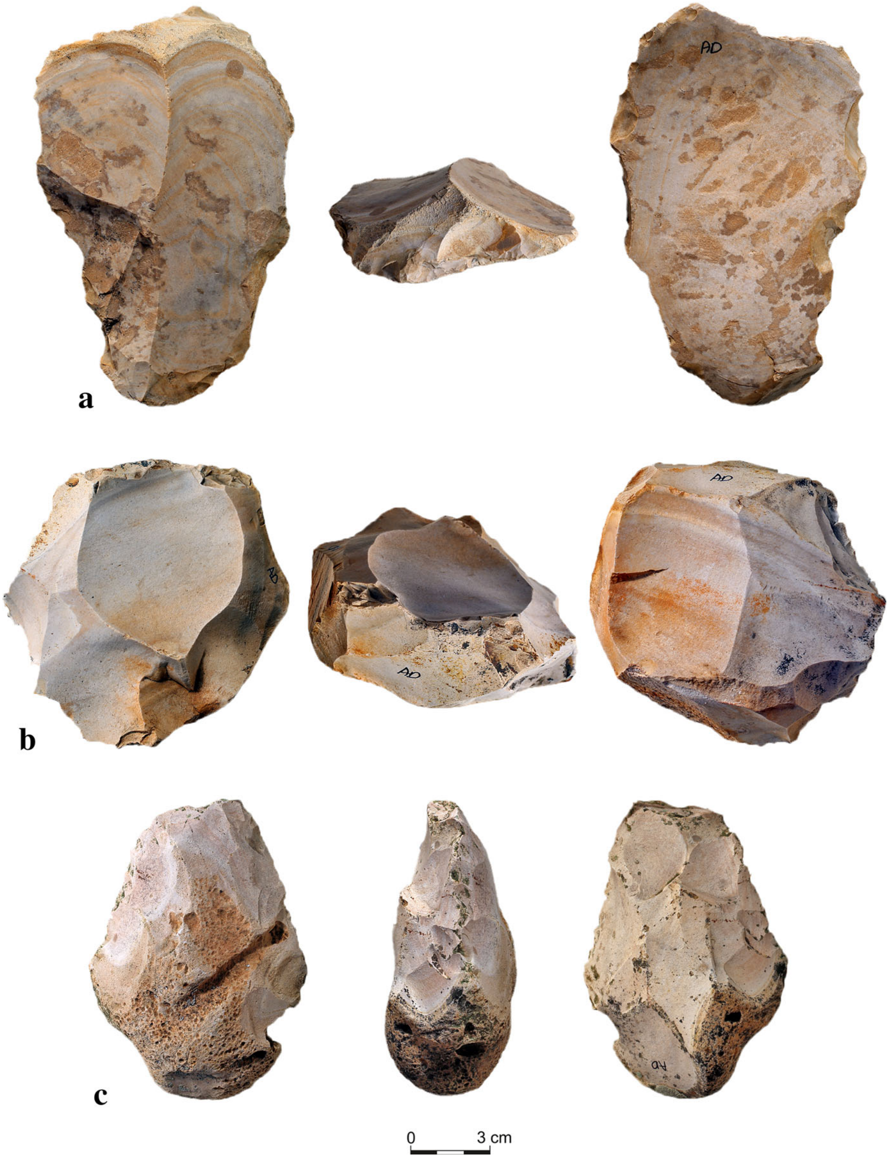


Fig. 12 Artifacts from the surveyed pile. **a** Large flake; **b** Levallois core; **c** bifacial roughout

surveyed pile (Fig. 16f) which is 1 km from the nearest basalt cover (Fig. 2). Artefacts from the surveyed pile include probable Levallois Cores (Fig. 17a); large flake cores (Fig. 18); and large flakes (Fig. 17b), attesting to human activity mostly during the the Middle Palaeolithic (Mousterian).

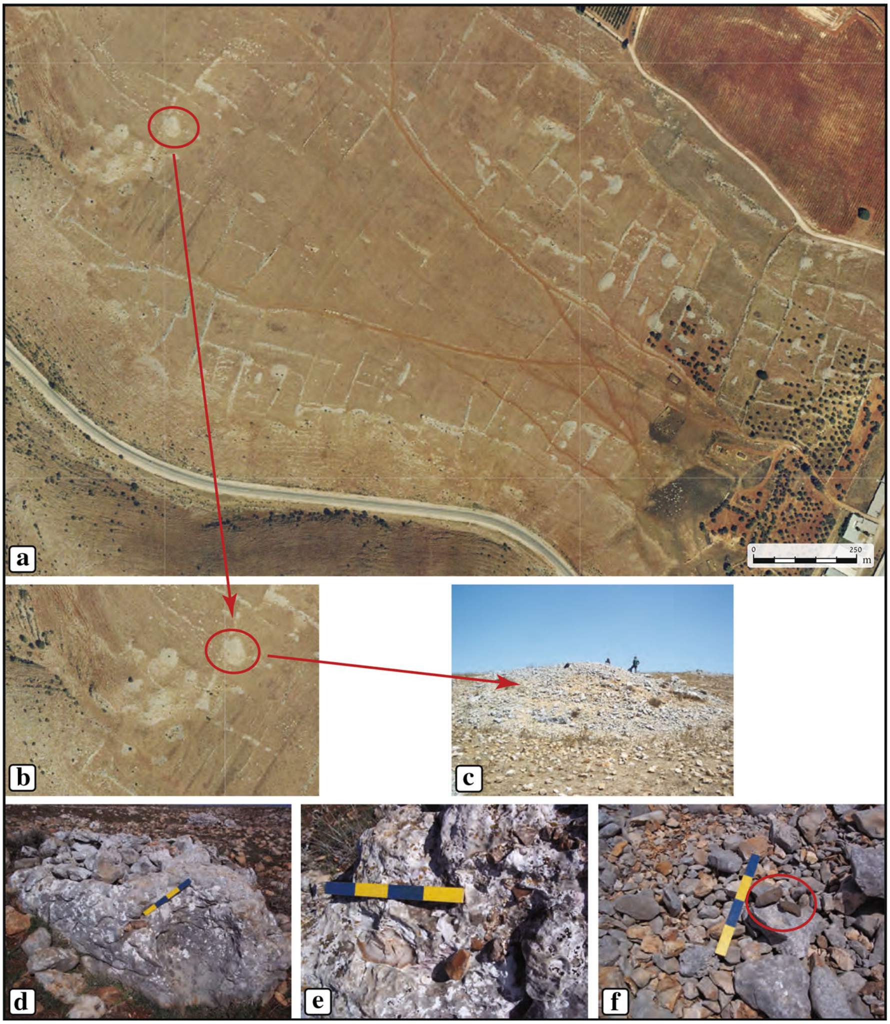


Fig. 13 **a**, **b** Aerial photo of extraction and reduction locality No. 3—Mt. Reihan (*circle* marks the surveyed pile); **c** ground photo from south; **d** flint nodule in limestone karren; **e** flint nodules in limestone; **f** limestone, flint (all over) and basalt (*circled*) on the surveyed pile

Extraction and Reduction Locality No. 5: Baram Plateau South

Baram Plateau South is located on the western bank of Nahal Dishon. The locality is a spur that continues the Baram Plateau to the east, 1 km long and 300 m wide, descending from 650 MASL in the northwest to 620 MASL in the southeast (Fig. 19a). Because of the modern pine tree cover, the exact number of tailing piles is hard to count, but it is estimated to be hundreds, mostly medium in size (Fig. 19b, c). Flint nodules are found within the limestone near the piles (Fig. 19e). Basalt is found on the entire plateau and on the surveyed pile (Fig. 19d), which is 600 m from the nearest basalt cover (Fig. 2). Artefacts from the surveyed pile include probable Levallois cores (Fig. 21b, c); bifacial roughouts

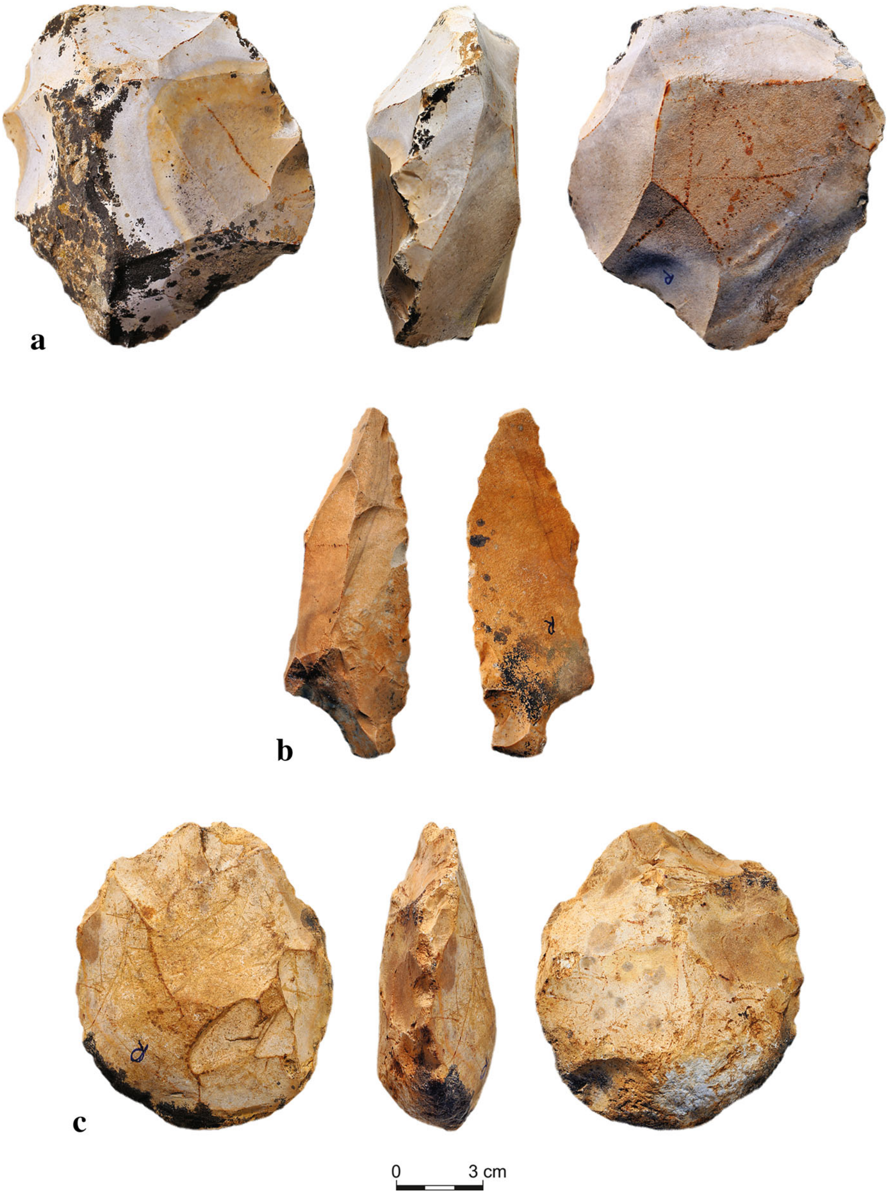


Fig. 14 Artifacts from the surveyed pile. **a** Core (Levallois?); **b** blade; **c** bifacial roughout/core

(Fig. 20a, b); and adze roughouts (possibly Chalcolithic: Figs. 20c, 21a), attesting to human activity during the Lower and Middle Palaeolithic and possibly, to a much lesser extent, in the Neolithic.

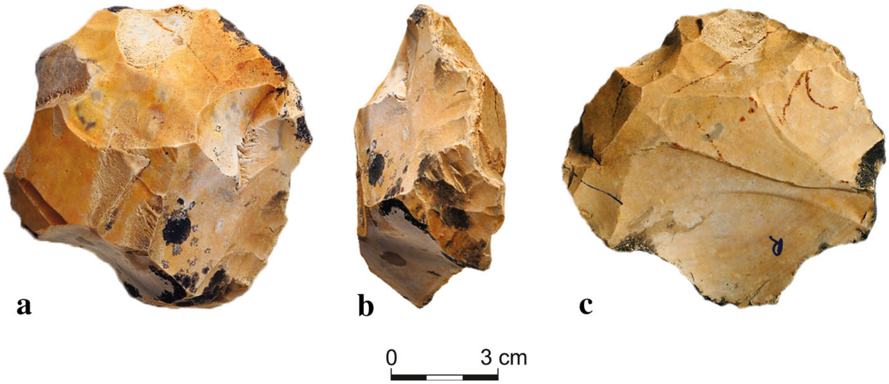


Fig. 15 Core (Levallois?) from the surveyed pile

Extraction and Reduction Locality No. 6: Baram Plateau North

Baram Plateau North is located on the western bank of Nahal Dishon. The locality is in the northwest of the Baram Plateau, 500 × 500 m in extent, and at an elevation of 675 MASL. The locality is situated in a shallow upper basin of one of the tributaries of the Yiron stream and contains 10 large or elongated–large tailing piles interspersed with a few medium tailing piles (Fig. 22a, b). Flint nodules are found on the ground near the piles (Fig. 22d). Basalt is not found at the locality, although it is less than 1 km from the nearest basalt cover (Fig. 2). Artefacts from the surveyed pile include cores (Fig. 23b); Levallois cores (Fig. 23a); and bifaces (Fig. 23c, d), attesting to human activity during the Lower Palaeolithic (Acheulean) and Middle Palaeolithic (Mousterian) periods.

Extraction and Reduction Locality No. 7: Yiron Plateau

Yiron Plateau is located on the western bank of Nahal Dishon, between the Yiron and Aviv streams. The locality is relatively small—500 m by 300 m—situated on the eastern slope of the plateau and descending from 630 MASL to 610 MASL (Fig. 24a, b). Flint nodules were not found within the limestone near the piles. Basalt is abundant because the locality is very near to the basalt cover (Figs. 2, 24d). Artefacts from the surveyed pile include cores (Fig. 25a); large flake cores (Fig. 26); probable Levallois cores (Fig. 25b, c); and bifacial roughouts (Fig. 25d), attesting to human activity during the Lower Palaeolithic (Acheulean) and Middle Palaeolithic (Mousterian) periods.

Extraction and Reduction Locality No. 8: Aviv Stream

This locality is above the Aviv stream curve on the western bank of the Nahal Dishon. The locality is relatively small—300 m by 200 m—and is at an altitude of 640–650 MASL (Fig. 27a). The locality contains three large piles and two dozen small ones. Flint nodules were not found within limestone near the piles. Basalt is abundant because the locality is very close to the basalt cover (Fig. 27c) (Fig. 2). Artefacts from the surveyed pile include mostly big flake cores (Fig. 29); and a Levallois core (Fig. 28), attesting to human activity related mostly to large flake production, most probably in the Palaeolithic; however, more precise attribution is not tenable at the moment.

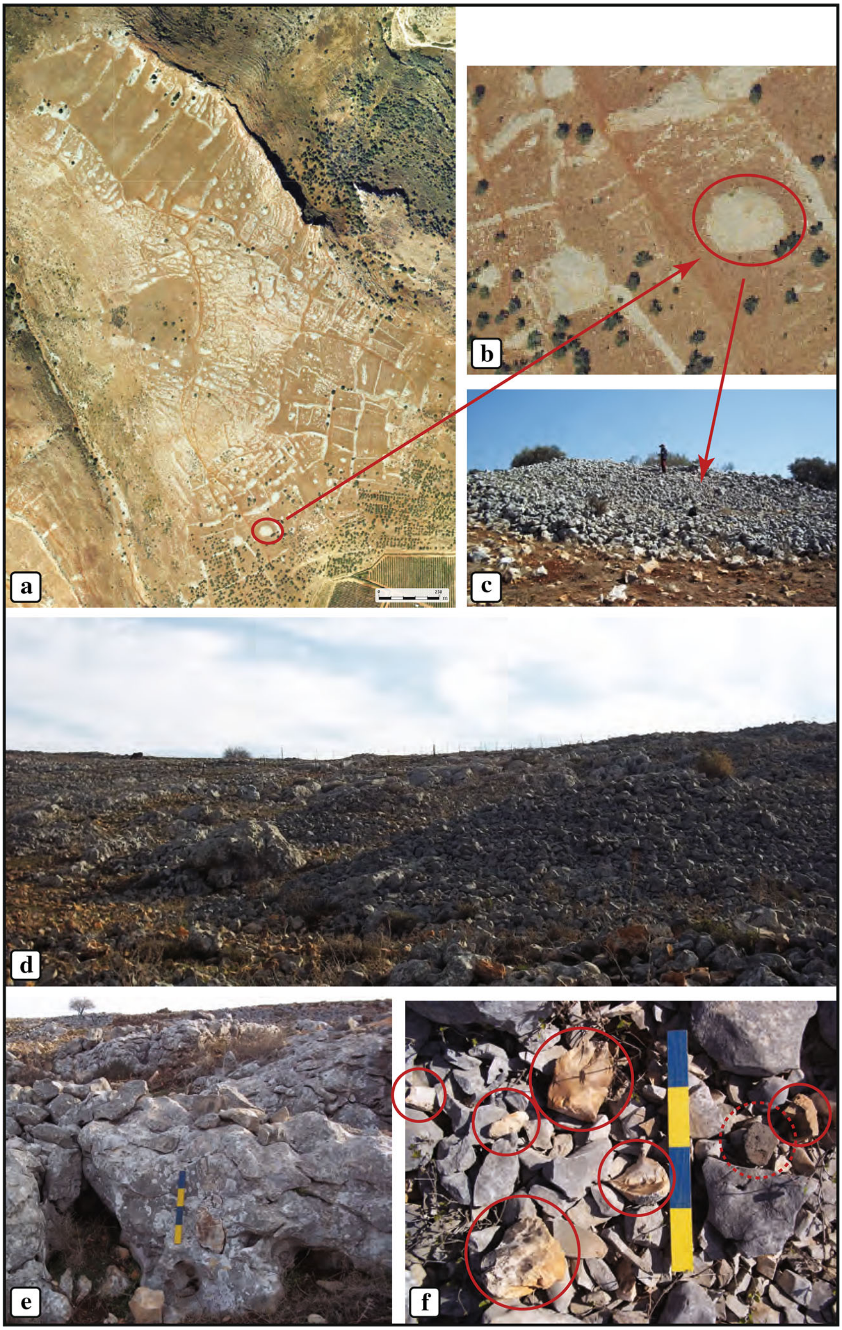


Fig. 16 **a**, **b** Aerial photo of extraction and reduction locality No. 4—Mt. Almon (*circle* marks the surveyed pile); **c** ground photo from southwest; **d** extraction piles and karren; **e** flint nodule in limestone; **f** flint (*circled*), limestone and basalt (*dotted circles*) on the surveyed pile

Fig. 17 Artifacts from the surveyed pile. **a** Core (Levallois?); **b** large flake

Density Assessment

In an attempt to establish a general level of density in piles we used quantitative data based on excavations conducted at two localities mentioned above (Mt. Pua, see Table 1) and a surface collection from the piles mentioned above (see methods section), and another recently conducted 2 × 2 m collection at a tailing heap at a third locality (Mt. Reihan, see

Fig. 18 Large flake core from the surveyed pile

Table 2). Figures show that reaching average densities for different piles is quite a complex task, requiring a suitable new methodology, and this will be studied independently within the framework of a Ph.D. dissertation focused on the study of these extraction and reduction landscapes.

The quantities of lithic material are immense, and further field work must be planned accordingly, otherwise storage facilities will be flooded by lithic material originating from extraction sites and workshops (see Gopher and Barkai 2014 for further discussion, and Elston 1992 and McBryde 1984 for similar ultra-rich extraction and reduction complexes).

Our limited attempt to evaluate lithic items' density indicates that the first impression gained by an estimation of surface density is sometimes misleading. The surface of pile PW3 looked much denser than the surface of PW100, but after comparing the excavated assemblages, the reverse was the case.

Discussion

The data presented here includes new Palaeolithic flint extraction and reduction localities in the Dishon Basin that were systematically and repeatedly exploited by early humans, probably over long periods of time, resulting in a phenomenon previously described as 'changing the face of earth' (Barkai and Gopher 2009). During the survey, eight new

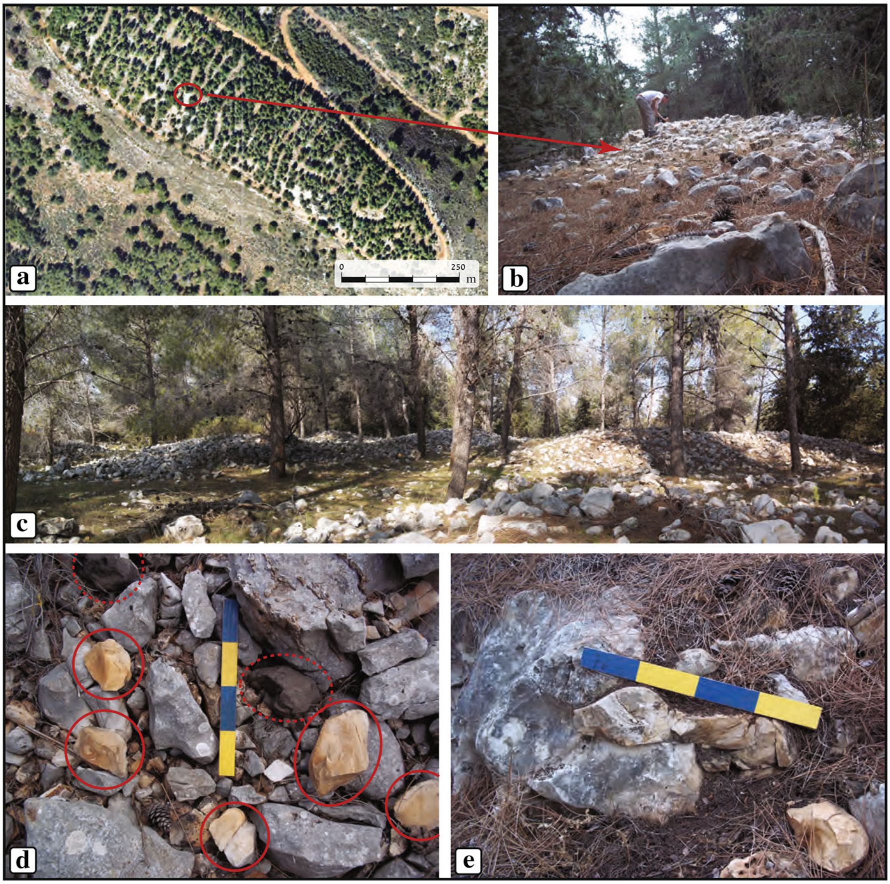


Fig. 19 **a** Aerial photo of extraction and reduction locality No. 5—Baram Plateau South (*circle* marks the surveyed pile); **b** close-up of the surveyed pile; **c** piles under the canopy—centre of the locality; **d** flint (*circled*), limestone and basalt (*circled in dotted line*) on the surveyed pile; **e** flint nodule in limestone

localities of tailing pile concentrations were described. The number of piles in each locality ranges from single digits to the hundreds, and they differ in size from large (over 100 m^2 and 4–5 m in elevation) to very small (1 m^2 and 1 m high). We estimate the presence of roughly a hundred large tailing piles, a few hundred medium piles, and most likely thousands of small ones. (At Mt. Pua alone the number of tailing piles was estimated at 1500: Barkai et al. 2002.) The artefacts found attest to human activity mainly during the Lower Palaeolithic (Acheulean) and Middle Palaeolithic (Mousterian) periods, with a possible stray use during the Neolithic or even Chalcolithic, which closely correlates to the observation at Mt. Pua (Barkai et al. 2002, 2006). Remnants of natural outcrops containing flint nodules were found in the vicinity of six of the large surveyed piles, possibly indicating the original, pre-tailing-pile extraction landscape.

We begin the discussion by comparing our findings to Ohel's finds of flint sources and Palaeolithic sites in the research area, and then discuss the flint extraction and reduction phenomena using Barkai and Gopher's findings from the Mt. Pua and Sede Ilan (Lower Galilee) extraction complexes, coupled with ethnographic observations of stone procurement.

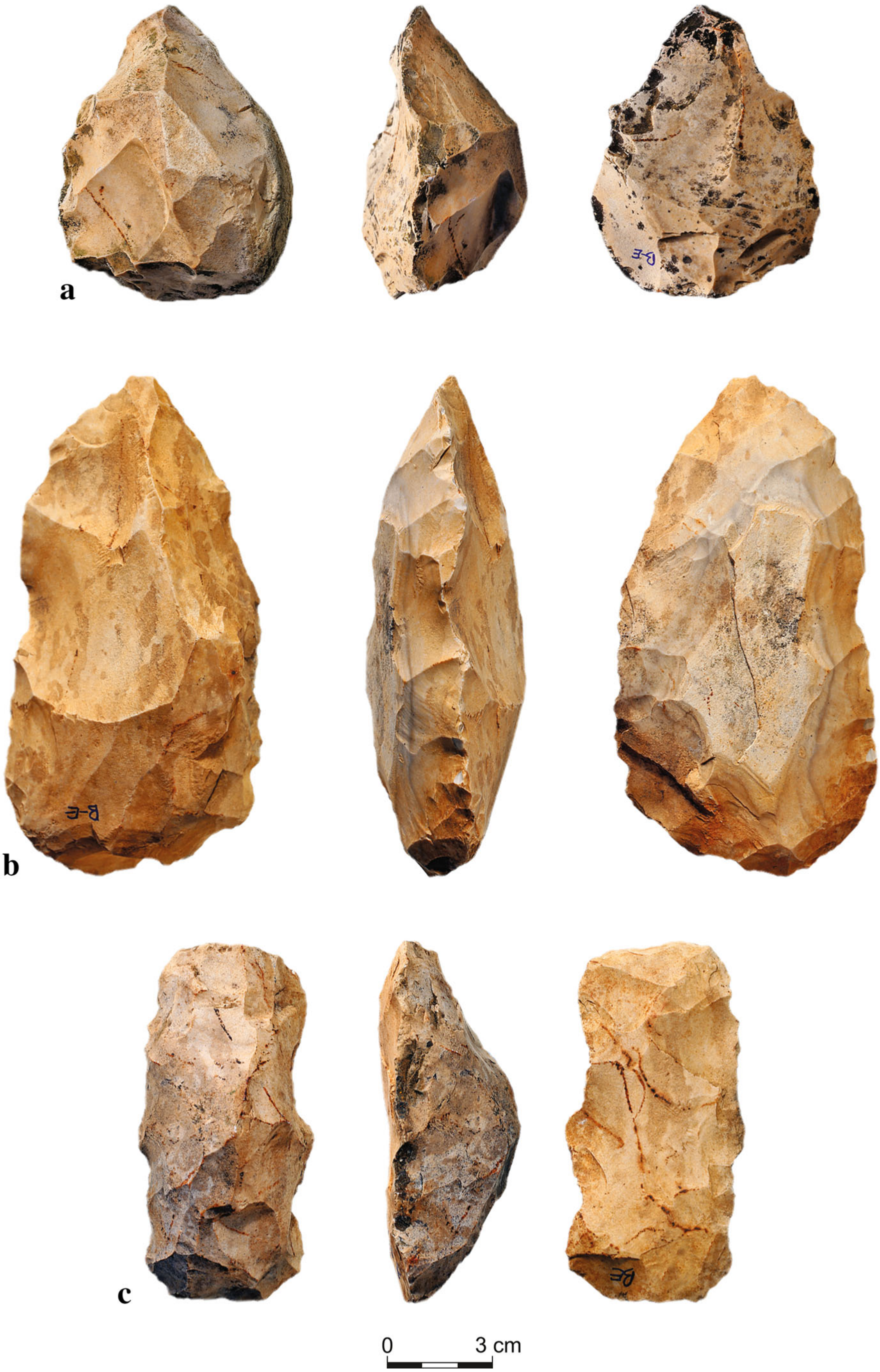


Fig. 20 Artifacts from the surveyed pile. **a** Bifacial roughout/core; **b** bifacial roughout/biface with a preferential flake removal; **c** adze roughout (possibly Chalcolithic)

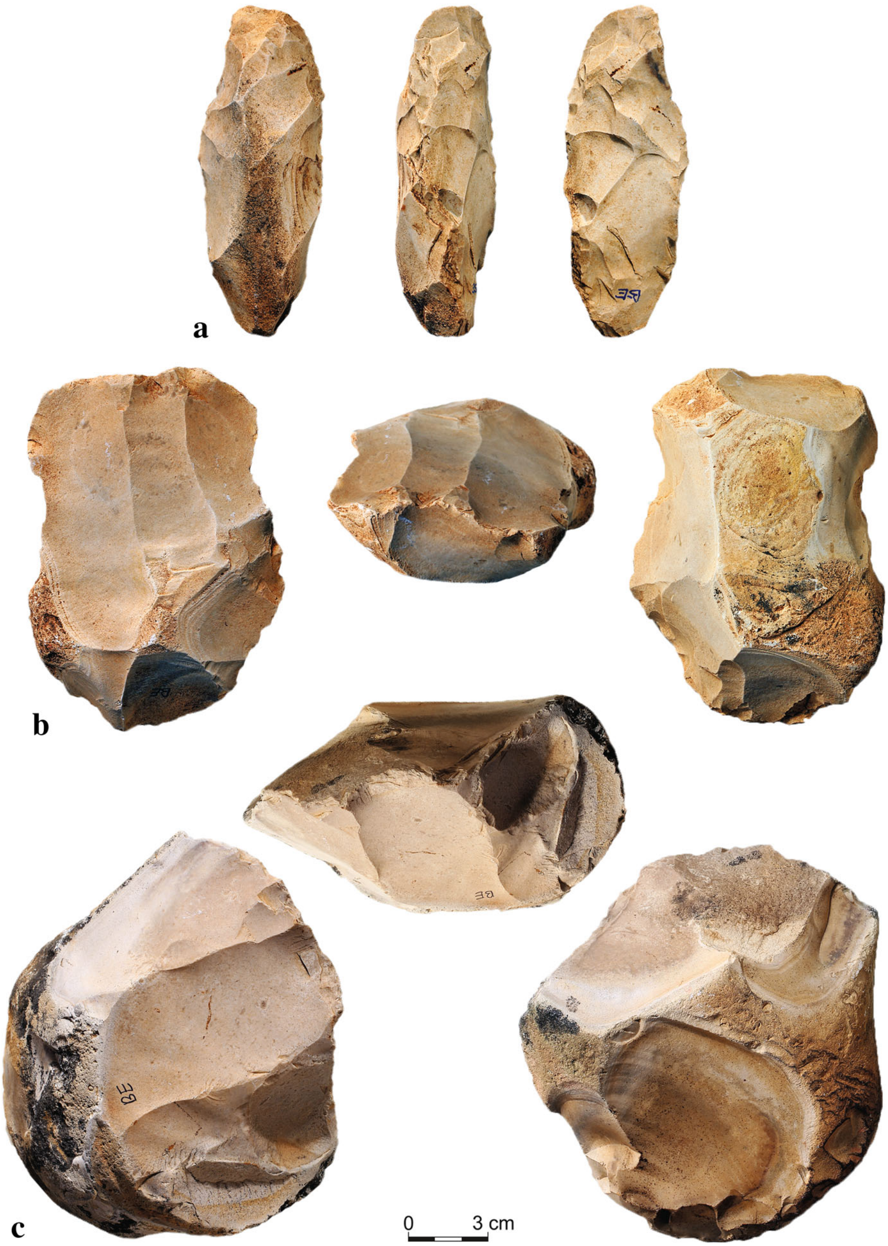


Fig. 21 Artifacts from the surveyed pile. **a** Adze roughout (possibly Chalcolithic); **b**, **c** Levallois core

The Flint Extraction and Reduction Localities in Light of Ohel's Findings

The abundant natural flint sources in the Dishon area did not go unnoticed by Ohel, and were one of the main topics of his reports. He defined 'preparatory areas' near the archaeological sites, where artefacts were produced, and large natural flint spread (NFS)

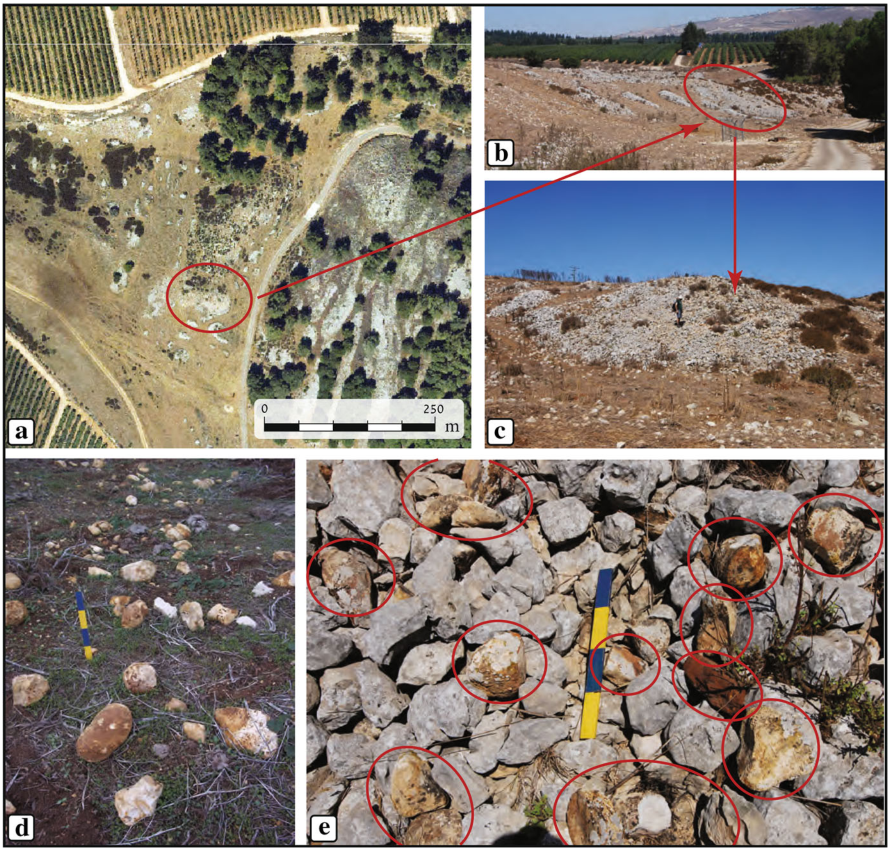


Fig. 22 **a** Aerial photo of extraction and reduction locality No. 6—Baram Plateau North (circle marks the surveyed pile); **b** ground photo from south, (*circle* marks the surveyed pile); **c** close-up of the surveyed pile; **d** flint nodules near the surveyed pile; **e** flint (*circled*) and limestone on the surveyed pile

areas containing the extraction localities that are the focus of our research. He categorized the natural flint sources in the NFS into three types (Ohel 1991, pp. 172–173). Regarding flint sources on the Yiron Plateau, Ohel noted that 'the main, if not the exclusive sort of flint utilized by the Acheuleans was in the form of loose, water transported flint pebbles of various sizes. There are hardly any signs that other kinds of flint, namely cemented or vein flint, were deliberately procured and used' (Ohel 1991, p. 173). According to Ohel, the major flint source for the occupants of the Yiron Plateau was the concentration of natural flint on the terraces in the curve of the Aviv stream (Ohel 1986a, pp. 168–187; Ohel 1991, p. 173), where extraction locality No. 8 in this survey is located. Ohel's maps (see Fig. 30a) show that he paid no attention to extraction piles on the easternmost part of the plateau (our extraction locality No.7).

Concerning the Baram Plateau, Ronen suggested in his early survey that the flint nodules on top of the basalt attest to erosion and limestone washing, and that the flint is actually found in situ (Ronen et al. 1974). Ohel rejected this scenario due to the relatively small size of flint pieces and fragments on the basalt covers (Ohel 1986a, pp. 152, 166, with further references).

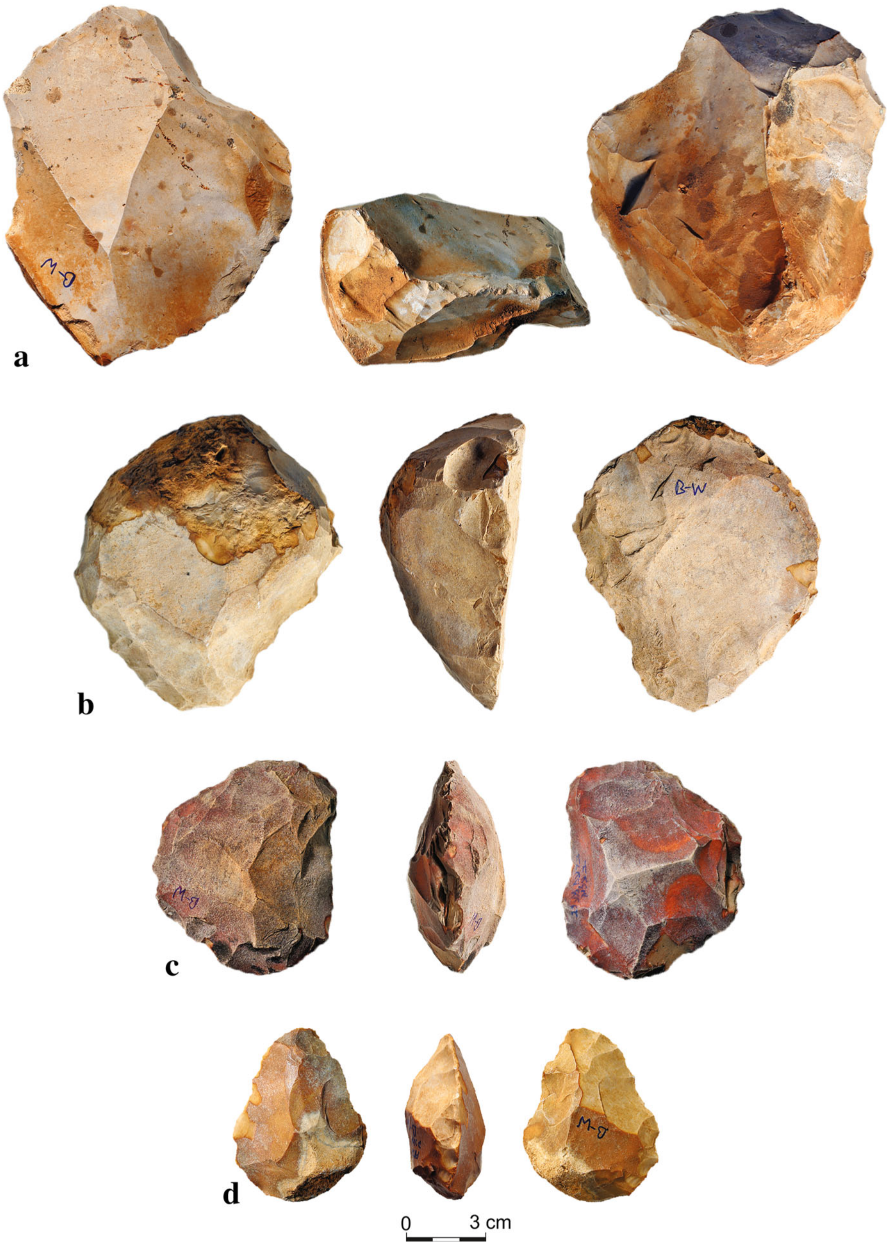


Fig. 23 Artifacts from the surveyed pile. **a** Levallois core; **b** core; **c**, **d** biface

Based on the distribution of artefacts left at the NFS, Ohel concluded that early 'Lake Acheuleans' at Baram used only water-transported flint found mainly in the western part of the plateau (Ohel 1991, p. 164). The more advanced (in Ohel's view) 'Pond Acheuleans' exploited a major area of in situ flint resources (Ohel 1991, p. 168).

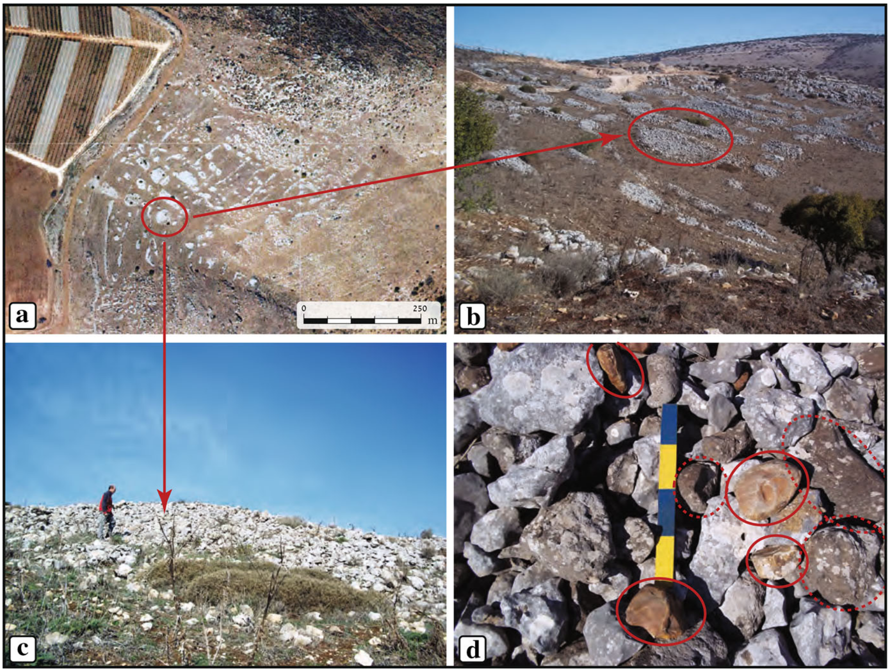


Fig. 24 **a** Aerial photo of extraction and reduction locality No. 7—Yiron Plateau (circle marks the surveyed pile); **b** ground photo from south (*circle* marks the surveyed pile); **c** close-up of the surveyed pile; **d** flint (*circles*), limestone and basalt (*dotted circles*) on the surveyed pile

On the basis of the spread of artefacts, Ohel concluded that the Mousterian foraging territory was wider than that of the Acheuleans and extended to the eastern and southern edges of the plateau. This was possible because 'natural flint resources, particularly veins of fresh flint within the limestone formation, as well as cemented flint in the limestone, are far more abundant on the southern and eastern parts of the plateau, and most easily accessible.' (Ohel 1991, p. 166).

Ohel concluded that 'on the Baram Plateau, by contrast (to Yiron), aside from the extensive exploitation of the loose pebbles, considerable extraction of fresh flint, from the veins in particular, had been practiced. Yet such fresh flint had been quarried only by the Pond Acheuleans, and particularly by the Mousterians, not by the (earlier) Lake Acheuleans' (Ohel 1991, p. 173). Because of the short distances involved, Ohel did not regard the logistics of flint transportation as an issue of importance. Flint types were similar to those on the Yiron Plateau: nine colour varieties instead of eight, the new one being pinkish. It should be emphasized that Ohel surveyed the tailing piles that we present here as extraction and workshop localities, but described them as 'clearance waves' or heaps created by agriculture activities (Ohel 1991, p. 140), although he admitted the difficulty in explaining how flint could arrive naturally en masse at the crests of these 'waves' (Ohel 1991, p. 131).

Ohel's arrows on Fig. 30b indicate presumably ancient natural flint sources and their dispersion lines on the Baram Plateau, after they were conveyed from higher localities in the east and west. He suggested that this process transported abundant flint nodules to the stream's lower banks and occasionally to the spur's crests. Ohel proposed that these puzzling finds are the result of 'a different stream regime in ancient times' (Ohel 1991, p. 142. see Fig. 30b). In our opinion, this explanation is implausible, since the east side of

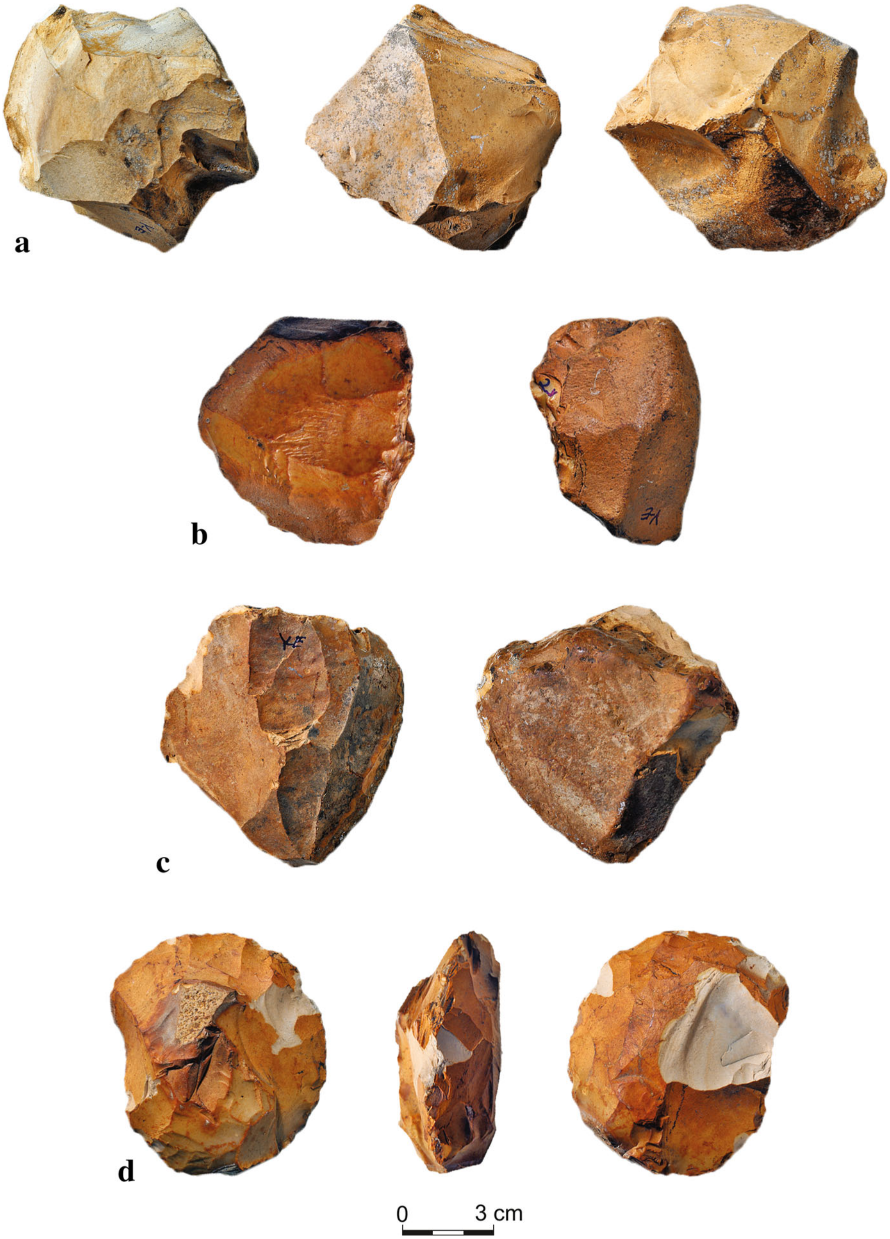


Fig. 25 Artifacts from the surveyed pile. **a** Core; **b**, **c** core (Levallois?); **d** bifacial roughout

Baram Plateau is where the ground surface begins to descend towards the Dishon stream bed, and Ohel does not suggest that the Dishon bed was higher than 700 MASL when it collected water from the streams (which are assumed to have deposited the flint-rich banks) on the western side of the plateau. Although limestone could not have been deposited on top of the basalt cover after it was formed some 2.51 Ma ago, Ohel marked some of the

Fig. 26 Large flake core from the surveyed pile

basalt covered areas as NFS as well. In his report on the Yiron Plateau he argued differently—that 'all natural flint pieces on the plateau except within the north-central zone were introduced by Man' (Ohel 1986a, p. 166). As stated, Ohel overlooked the extraction and reduction localities presented here (see circles on Fig. 30a, b), and classified them as 'natural flint spreads', although he must have noticed the piles and scattered lithic artefacts on top of them. We suggest another explanation for the flint spread concentrations: flint was extracted in situ, from the local limestone beds, mainly during the Palaeolithic. After its extraction, it was knapped and the successful end products were transported. The remaining lithic by-products and rejects were left at the extraction and reduction localities and remained there until the present (and see similar scenarios for Mt. Pua and Sede Ilan: Barkai et al. 2002, 2006; Barkai and Gopher 2009; Barkai 2011). All of the flint pieces on the basalt covers were undoubtedly brought there by humans, since no geological process can explain these findings on top of the basalt.

A word of caution concerning Ohel's identification of the tailing piles as recent clearance piles or 'waves'. Ohel himself claimed that 'it is not easy to understand how all this flint reached a somewhat more elevated platform between the wadis on both its sides, other than assuming that water covered the area during remote times' (Ohel 1991, p. 131). Some of the piles in the survey may have been disturbed by agricultural activity (Figs. 9a,

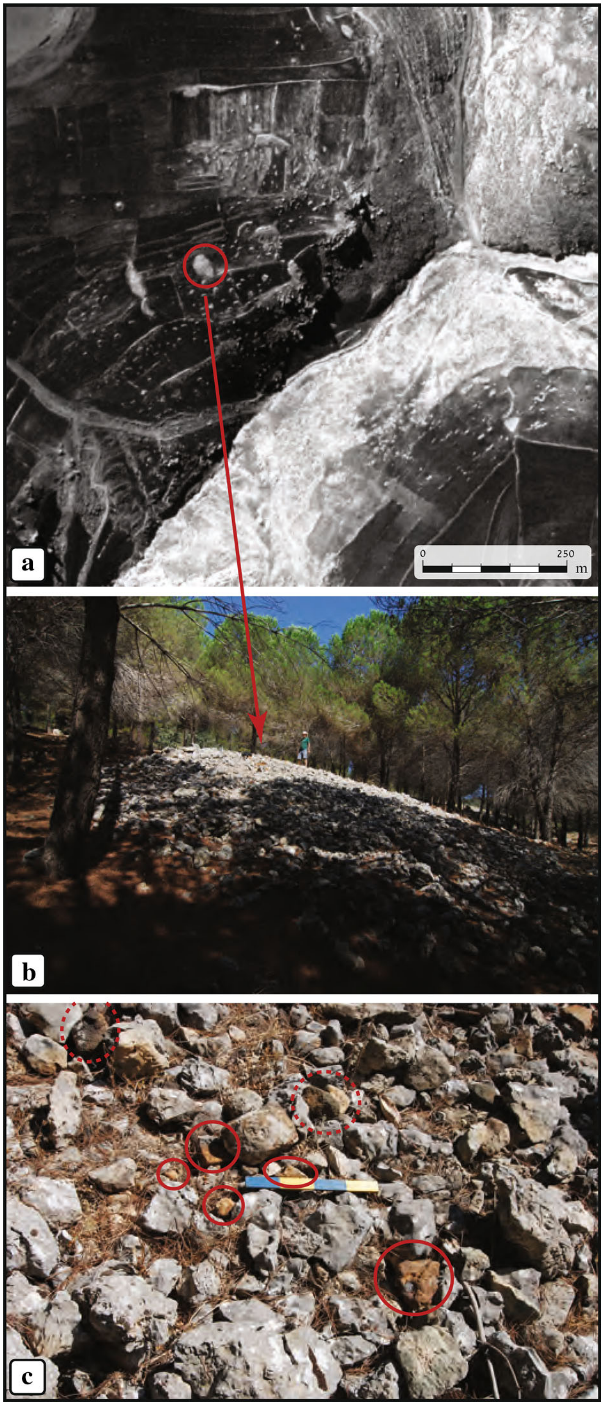


Fig. 27 **a** British aerial photo (1946) of extraction and reduction locality No. 8—Aviv stream (*circle* marks the surveyed pile); **b** ground photo from east; **c** flint (*circles*), limestone and basalt (*circles*) on the surveyed pile

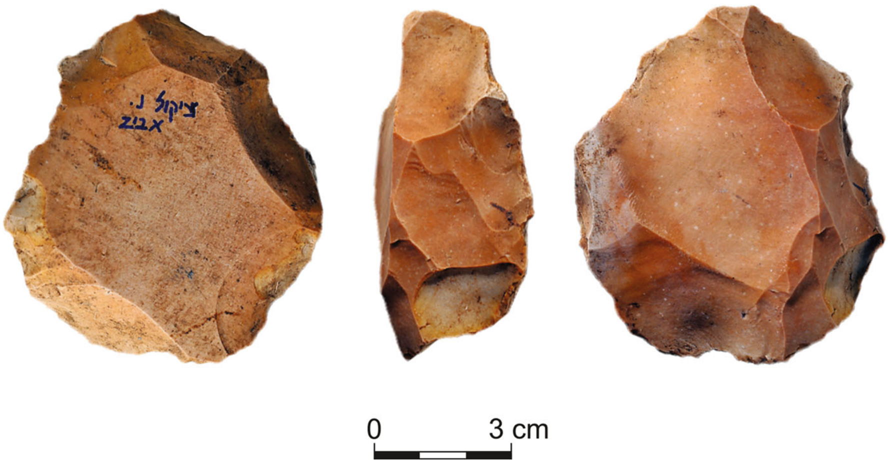


Fig. 28 Levallois core from the surveyed pile

Table 1 Assemblage composition and average numbers of items in 1 m3 in two test excavations at Mt. Pua (Barkai et al. 2002)

Category of items	Test square G 24 (PW3) 4 m^2 (total extent of PW3 is 350 m^2)	PW100 20 m^2, pile fully excavated
Cores	66 (6 %)	104 (1 %)
Flake	203 (18 %)	887 (10 %)
Blade	32 (3 %)	155 (2 %)
Shaped items	105 (9 %)	152 (2 %)
Other	723 (64 %)	7527 (85 %)
Total	1146 (100 %)	8825 (100 %)
Average for 1 m^3 of excavation	286.5	441

Table 2 Assemblage composition and average numbers of items in 1 m^2 of surface collection at Mt. Pua and Mt. Reihan

Category of items	PW3—Square G 24 (Mt. Pua) 4 m^2	PW3 (Mt. Pua) 120 m^2 out of 350 m^2	RAW100, 4 m^2 (Mt. Reihan)
Cores[a]	12 (8 %)	348 (13 %)	12 (4 %)
Flake	33 (22 %)	1201 (44.5 %)	274 (84 %)
Blade	5 (3 %)	42 (1.5 %)	16 (5 %)
Shaped items	17 (12 %)	385 (14 %)	9 (3 %)
Other	78 (55 %)	723 (27 %)	13 (4 %)
Total	149 (100 %)	2699 (100 %)	324 (100 %)
Average for 1 m^2 of surface	37	22.5	81

[a] Cores include Levallois and regular cores

Fig. 29 Large flake core from the surveyed pile

13a, 16a), but certain basic features of these localities, in addition to the flint artefacts, clearly show that they were not agriculturally driven:

- Quite a number of the localities are situated on narrow spurs and steep slopes that have no agricultural potential—in ancient or modern times (localities 1, 2, 5, 6). This is also true for Mt. Pua and Sede Ilan (Gopher and Barkai 2014). The other localities are situated on plateaus and slight slopes characterized by dense rock and sometimes boulder landscapes, which make them unsuitable for agriculture.
- In some cases, the original limestone karren are still visible in the vicinity of the extraction piles (Figs. 13d, 16d, e). Obviously the extent of the karren was originally much greater than it is today, and a significant effort had to be invested in breaking them apart. The fact that the area devoid of karren is covered with waste piles, and in some cases the area between the piles is characterized by rocky outcrops, refutes the idea that these areas were cleared for agricultural purposes.
- In many cases, the (limestone and flint) rock fragments that comprise the piles are too small to be part of any effective agricultural clearance activity (Figs. 5c, 13c, f, 16c, f, 19d, 24d).
- In many cases the space between the piles is too small for agricultural use, and even when it is sufficient, it is usually filled with large rock fragments that should have been removed if the piling were indeed the result of agricultural clearance (Figs. 13b, c, 16a—middle, c, 19a, c, 22b, 24a, b).

The artefacts that constitute the rich flint assemblages on the top of the piles are often fresh and exhibit no evidence of having been transported by water or erosion, or being residues of agricultural clearance activity. The piles on Mt. Pua and Sede Ilan lie on the top of exhausted flint extraction fronts and contain an abundance of flint artefacts prepared in situ (Barkai and Gopher 2009; Barkai et al. 2002, 2006; Gopher and Barkai 2006). The

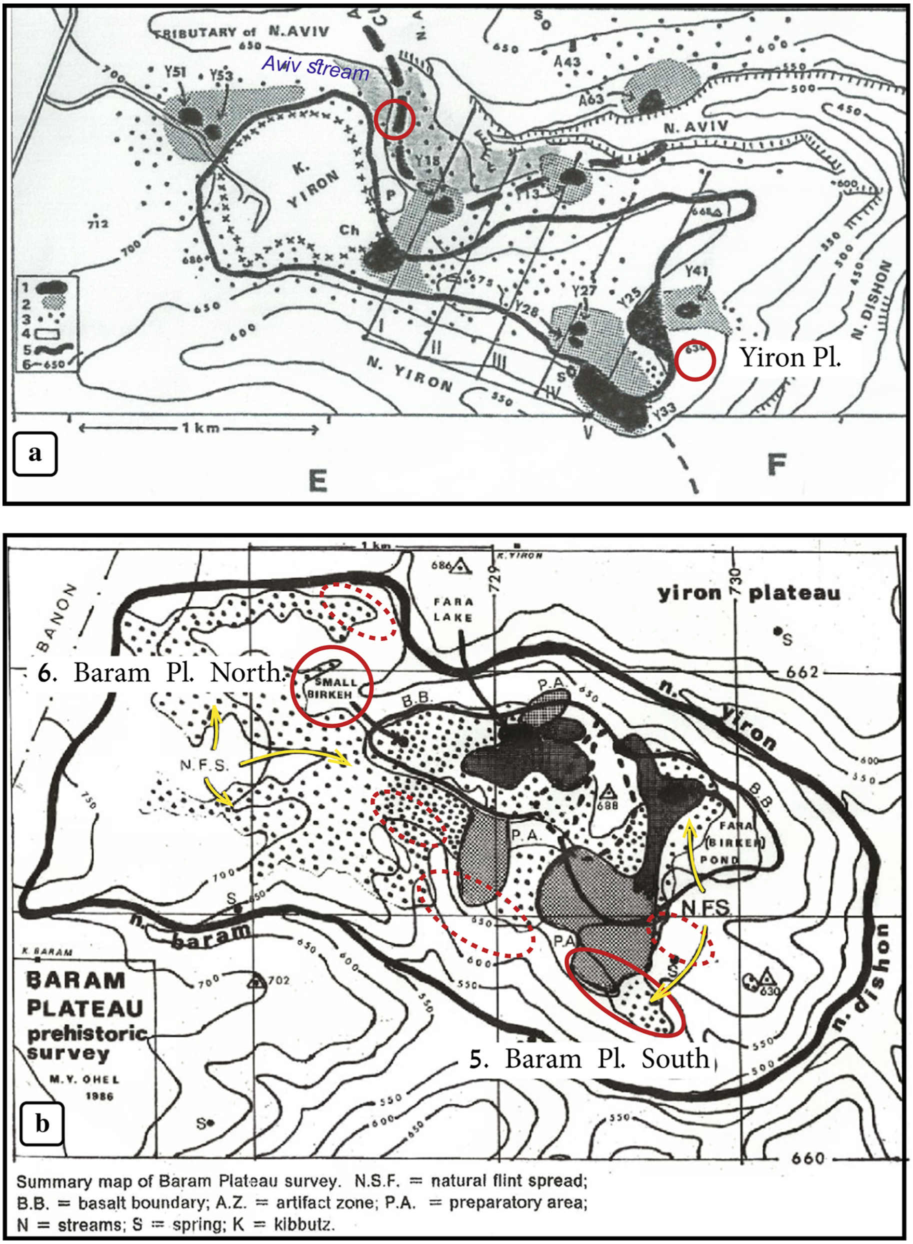


Fig. 30 **a** Ohel's map of Yiron Plateau survey. Extraction localities described in this study are marked with circles; **b** Ohel's map of Baram Plateau survey. The extraction localities presented in this study are marked with *circles*. Other areas of tailing piles, that appear but not in detail, are indicated by *dotted circles*. Sources and lines of natural flint spread are emphasized

Sede Ilan piles contain imported basalt items possibly used as wedges, and at Mt. Pua large hammerstones were found, as well as two flint caches at the base of a pile (Barkai and Gopher 2011)—all disputing the assumption that these piles are the result of modern agricultural clearance activity. Based on the artefacts at the extraction and reduction localities, and the above arguments, we believe that Ohel's suggestions regarding the nature of the tailing piles should be rejected. How were these complexes actually formed? What is seen today on the surface of the extraction and reduction localities, combined with the data from excavations conducted in the tailing piles at Mt. Pua and Sede Ilan (Barkai and Gopher 2009; Barkai et al. 2002, 2006; Gopher and Barkai 2006, 2014), suggests the following chain of operation:

- Locating the specific desired flint extraction front.
- Extracting or quarrying the flint (depending on flint nodule depth in the limestone), sometimes employing limestone or basalt tools.
- Creating stone waste piles (backfill piles) from the large amounts of broken limestone—during or immediately after flint extraction.
- The backfill piles were aligned on top of and between the exhausted extraction fronts, leaving the unexploited potential flint extraction fronts free for further use.
- Flint knapping—core shaping for later use, blank production and/or tool making—was conducted on top of the backfill piles that form the tailing piles we know today.

Thus, the tailing piles described following our survey are the result of a well-planned, organized, structurally sequenced, and knowledge-based exploitation system that enabled the long-term use of the flint sources in the Nahal Dishon Central Basin.

A Primary or Secondary Source?

Establishing whether the flint used in extraction and reduction localities was from a primary or secondary source is a major challenge. One response to this challenge is the elaborate protocol developed by Fernandes et al. (2007, 2008) using a multivariate model based on comparison between the macroscopic features of the cortex found on artefacts and the cortex in raw material sources. In the case of the Dishon area, the issue is less challenging. Beside the fact that all localities are of the same geological formation, they are also similar in elevation, climate and vegetation, and no substantial transportation of materials took place. Moreover, all extraction and reduction localities used flint nodules obtained by what is called 'surface quarrying', meaning that some of the nodules were extracted from surface karren that had been exposed to the elements, most probably long before the extraction. As a result, in some cases no significant differences in cortex will be found between the extracted and the surface-collected nodules. However, extracted nodules will be less exposed to mechanically induced damage. In our case, loose flint nodules found on the plateau and some of the exposed flint nodules embedded in the nearby limestone karren are very similar. In relation to the question of whether the phenomenon described here is the result of embedded or direct procurement (Binford, 1979, 1980; or 'special purpose': Frahm et al. 2015), we would like to note two aspects. First, in this paper we present an extensive area used for flint extraction from a single geological formation, rather than flint assemblages from occupation sites. Moreover, we have attempted to establish a preliminary connection between Palaeolithic archaeological sites in the vicinity of the extraction and reduction localities, and argued that the whole area was repeatedly visited over generations in order to procure high quality stone by extraction from primary geological sources. Hence, it was direct rather than embedded procurement. As for the cost effectiveness of the extraction, previous research at Mt. Pua, which is part of the area we describe, demonstrated very intensive quarrying and flint working operations (Barkai et al. 2002; Gopher and Barkai 2014), including the deposition of caches on top of exhausted extraction fronts (Barkai and Gopher 2011), which stand as general indications of direct procurement and as a token for the significance of these extraction and reduction landscape for Lower and Middle Palaeolithic communities.

Chronology and Duration of the Extraction and Reduction Phenomena at the Dishon Basin

The human groups who quarried, extracted, and worked the flint in the Nahal Dishon Central Basin appear to have used it as an 'industrial area' while they dwelt elsewhere. No evidence of domestic activities has yet been found at these localities. It may be supposed that the workers lived, at least during quarrying operations, in the vicinity or, alternatively, at the extraction site itself, and that evidence of their domestic activity may be discovered in the future when larger-scale excavation is conducted. Be that as it may, the localities are assumed to have been visited in order to procure flint, and to have become industrial rather than habitation sites. It also appears that most of the successful end-products of the extraction and reduction processes—bifacial roughouts, Levallois blanks and possibly cores—were transported in large quantities from the extraction sites to the sites on the Yiron and Baram Plateaus, and probably to the Alma and Dalton basaltic areas (see Ronen et al. 1974) and other Palaeolithic sites in the Galilee. The lithic assemblages found in all the extraction and reduction localities described in this study are similar to the previously described finds from the extraction and reduction complexes at Mt. Pua and Sede Ilan and to the assemblages from the Acheulean and Mousterian sites at the Yiron and Baram Plateaus (Barkai and Gopher 2009, 2011; Barkai et al. 2002, 2006; Gopher and Barkai 2006; Ohel 1986a, b, 1991). Attributing these complexes to the Acheulean and Mousterian cultural complexes of the Levant 'is based on two major elements: one, that handaxes are not found in Middle Palaeolithic Mousterian assemblages in the Levant, and two, that all Middle Palaeolithic Mousterian assemblages in the Levant show the use of the Levallois technique, while this technology is usually not found in abundance and in its fully-fledged state in Lower Palaeolithic Acheulean assemblages' (Gopher and Barkai 2014, p. 96). Moreover, as argued by Goren-Inbar and Belfer-Cohen,

> when examining traits considered to be the hallmarks of the Middle Palaeolithic lithic assemblages … several differences from the Lower Palaeolithic industries stand out quite clearly … The disappearance of tool types that were dominant in Lower Palaeolithic industries, i.e., bifaces, spheroids, and chopping-tools … Moreover, spheroids, which are typically absent from Mousterian assemblages just as bifaces are, disappear along with their particular production mode already during the latest stage of the Acheulean … though bifaces are still present at that time (2002, pp. 205–206).

The isolated Neolithic/Chalcolithic bifacial tools, such as axes and adzes, present in a few extraction localities, probably represent the remains of stray visits by local Neolithic/Chalcolithic inhabitants to the Palaeolithic complexes, rather than a late, large-scale use of these flint sources (Barkai et al. 2006).

How long did humans use these extraction and reduction localities? Barkai and Gopher argue that:

> based on the large accumulation of archaeological data from the Levant it could be suggested that these quarry complexes were in use during Lower Palaeolithic times, as early as 500kyr and even earlier, and quarrying continued during Middle Palaeolithic times between 200 and 50 kyr … In any case, the use of these flint sources was extremely long and continued for an estimated period of some half a million years (Gopher and Barkai 2011, pp. 222–223).

Foley and Lahr's (2015) study of Messak, Libya, also reconstructed a long Middle Pleistocene (0.9 to 0.125 Ma) exploitation.

Ohel tried to calculate the time of Acheulean human activity on the Yiron Plateau in a quite speculative way. He assessed the total weight of the flint pieces on the plateau at 4400 tons. He suggested that 2 kilos of new flint were brought to the plateau per week, reaching a yearly total of 64 kilos (excluding the winter period). Based on these assumptions he concluded that 'Acheulean presence in and out of the region, the Yiron Plateau included, would have lasted more than 100,000 years' (Ohel 1986a, pp. 166–168). This estimate remains speculative and difficult to support. Still, the utilisation of these flint sources was most likely long-lasting, though not necessarily continuous, and part of local traditions, perhaps resembling the way Australian aborigines revisited their stone sources over time (Binford and O'Connell 1984; Brumm 2010; Gould and Saggers 1985; Jones and White 1988; McBryde 1984). Foley and Lahr (2015) found that the average density of 75 flakes per m^2 in Messak extrapolates to a density of 7.5×107 per km^2, which is within their conservative estimate for a million years of human lithic production in Africa. In our opinion, it is unlikely that the human use of these localities was not continuous but occurred over several distinct and separate episodes, since the rediscovery of the same flint sources and the placing of the extraction and reduction localities at the exact same location by different groups at different times seems highly implausible.

The Organization of Extraction and Reduction Operations in the Nahal Dishon Central Basin Area

Four alternative scenarios for the operation and possible management of the extraction and reduction localities can be proposed: 1) procurement by a group that inhabited the Dishon Valley permanently; 2) procurement by extraction expedition parties which gathered seasonally from a broad area (Galilee and/or southern Lebanon); 3) procurement by a combination of 'foreign' extraction expedition parties and a local 'host' group; 4) procurement by extraction expedition parties from a broad area—each party managing or even 'owning' its portion of the extraction landscape.

Procurement by a Group that Inhabited the Dishon Valley Permanently

Ohel's model of the Yiron Plateau has to be addressed at the outset. He focused on interpreting Site Y-25, located on the eastern edge of the plateau, at an overlook that he named 'Mitzpeh Yiron' (Yiron lookout). Artificial basalt stone arrangements (nine 'stone formations', following Ohel), the immensity of the site (estimated at 16,000 m^2), the plethora of small points and drills, and the site's topographical position convinced Ohel that this was an 'aggregation locality' or 'aggregation node', where 'small groups assembled to concentrate on the exploitation of a relatively short-term seasonal subsistence resource' (Ohel 1986b, p. 247). Ohel suggested that Acheulean groups gathered at Site Y-25, socialized and hunted migrating storks in springtime (and maybe again in the autumn), then dispersed to smaller summer camp sites, and descended to the sites on the lower bank of the Aviv stream for the winter (Ohel 1986b, pp. 275–277).

As for the Baram Plateau, Ohel suggested that although harsh winter conditions may have prevailed, the depression where the lake is located provided a comfortable habitation (Ohel 1991, p. 164). On the basis of technological similarities between assemblages at the Baram Lake and Yiron Plateau sites, Ohel postulated that people from the Yiron Plateau made summer visits to Baram Lake (although why in summer rather than winter—when conditions on the Yiron Plateau were harsher than in the Baram Lake depression—is not explained), and that the people from Baram also visited Site Y-25 (Ohel 1991, p. 164). The Pond inhabitants used a local rock shelter, that Ohel named 'Bustan', on the cliffs northwest of the pond, when the weather became colder. This model, if accepted, should be applied to the eastern part of the research area as well, meaning that the findings on the Reihan and Alma basalt covers in Ronen's survey (Ronen et al. 1974) might represent similar settlement patterns. A major element in this procurement model is the suggestion that hominins occupied the area throughout the year, probably abandoning the colder high ground on the plateaus for temporary warmer settlements in the Aviv, Yiron and Dishon streambeds, but essentially remaining permanent inhabitants of the Nahal Dishon Central Basin. According to this model, the same human groups exploited the extraction complexes within a very familiar territory. Therefore it is not unreasonable to consider some kind of 'ownership' of the stone outcrops, as is occasionally reported in ethnographic accounts (e.g. Burton 1984; Hampton 1999; Jones and White 1988; McBryde 1984; Rusco and Raven 1992).

Procurement by Extraction Expedition Parties which Gathered Seasonally from a Broad Area (Galilee and/or Southern Lebanon)

A second procurement model assumes that human groups gathered on a regular basis (annually, whether for specific flint requirements or other purposes) from much wider areas in the Galilee and further afield for extraction and reduction activities in the Nahal Dishon Central Basin area. These industrial-related gatherings may have been limited in time and in composition of the working party. In other words, according to this model specific extraction and reduction parties arrived at the flint sources for rather short but intensive working sessions. This model appears in ethnographic accounts of recent hunter-gatherer communities (e.g. Australia—Gould and Saggers 1985, p. 121; Jones and White 1988, p. 76; Papua New Guinea—Burton 1984, p. 237; Hampton 1999, pp. 235, 239), and, as Langley notes:

> there has also been some entertainment in the literature of the idea that periodic aggregations of larger groups of Neanderthals may have occurred. Hayden in particular suggests that such gatherings could have varied between 50 people (2–3 local bands) to several hundred people (10–20 local bands) (Langley 2013, p. 622).

On the huge extraction and reduction area of Messak, Foley and Lahr write:

> Perhaps the most important of these is whether super-abundant raw material patches such as the Messak were magnets to draw communities into an area. If, as seems likely, the success of a community depended to any significant extent on its use of stone tool technology, then there would be enormous advantage in identifying, knowing and remembering such localities (they would become significant landmarks), but also advantages in controlling access to them. In this respect, the value of

the resource, ubiquitous as it is locally, increases in relation to the paucity of availability in the region (the sand seas) (Foley and Lahr 2015, p. 10).

These extraction and reduction expeditions may have camped by the sites while extracting and working the flint on the basalt caps. Although this degree of social and economic organization might exceed our expectation for Lower or even Middle Palaeolithic lifeways, the data presented here stimulates a reconsideration of the efforts and organizational mechanisms in stone procurement in the Palaeolithic. Ohel's Yiron Y-25 'aggregation locality' or 'aggregation node' casts light on this new perspective. Ohel suggests that the short-term seasonal subsistence resource focused primarily on the exploitation of migrating storks. The stork hypothesis notwithstanding, his explanation holds that human groups might have gathered at these locations on a regular basis to supply their lithic needs. If short-term gatherings were the case (due to the limited carrying capacity of the area, see above), then the workers' habitation localities should be present in the vicinity of the extraction and reduction complexes and the remains of domestic activities (fireplaces, animal bones and so forth) should have been found. Needless to say, the preservation of domestic remains in temporary, open-air Lower and Middle Palaeolithic dwelling sites is bound to have suffered severe post-depositional processes. The preferred season for such operations would probably have been spring or early summer.

Procurement by a Combination of 'Foreign' Extraction Expedition Parties and Local 'Host' Group

A third, integrated alternative may be broached: local inhabitants lived on the basalt covers for extended periods, regularly using the local flint sources, while more distant groups engaged in temporary or seasonal flint exploitation. Relatively recent ethnographic accounts, however remote in time and social structure from the Lower Palaeolithic Acheulean, can enhance our understanding of these imaginable scenarios. Such a procurement system has been documented among the Wano People at the Yeineri quarry in Papua New Guinea, where the local 'big man' made key decisions for quarry exploitation in the area under his management, and local quarrymen worked the stones for local needs and trade (Hampton 1999, pp. 223, 227–228). People from other Wano areas, individuals or groups, needed permission to quarry the stones for their own use or for trade (Hampton, 1999, p. 228). Non-Wanos were allowed to quarry for limited use only, and had to show the quarried rock and blade blanks to Wano quarry 'owners' before exiting their territory (Hampton 1999, pp. 228, 237–240). The Australian Kulin Aborigines also exhibited a form of regulatory quarrying. The owner/manager of the Mt. William quarry in Victoria, Australia was the local leader of the clan that occupied the quarry region. In addition, custodians maintained the quarry and traded stone artefacts with their kin, who sometimes travelled great distances to reach the quarry. This tradition was passed down from generation to generation. Neighbouring clans gained certain quarry rights, mainly through intermarriage, but in general, outsiders had to negotiate with the quarry owners for the desired stones (McBryde 1984, pp. 270–272). Other ethnographic evidence from Australia describes how locals hosted 'foreign' expeditions to sacred places, including quarries (Gould and Saggers 1985, p.122).

Procurement by Extraction Expedition Parties from a Broad Area—Each Party Managing or Even 'Owning' its Portion of the Extraction Landscape

A fourth integrated model assumes that some hominin groups from the Galilee and/or southern Lebanon shared area 'ownership' and gathered on a seasonal/need basis to extract flint, each group in its 'own' extraction locality. Ethnography can also illuminate this model. The Langda quarries in Papua New Guinea were divided among several head quarrymen, each owning a specific section (outsiders were permitted to look for rocks only under close supervision) (Hampton 1999, pp. 254–256). At the Papuan Tuman quarries, each quarry was owned by a different clan (Burton 1984, pp. 236–237), but exploitation was conducted simultaneously following the directions of the 'big man' (Burton 1984, p. 243). In the Tosawihi (White Knife) Quarry in Nevada, USA, which lies within the foraging range of the Western Shoshone Tosawihis, 'individual Tosawihi families "owned" the quarry pits they had created and developed' (Elston 2013, p. 440; see also Rusco and Raven 1992). Although these ethnographic accounts cannot serve as a direct analogy to the Palaeolithic period in northern Israel, the data reflects universals of human behaviour related to long-term stone extraction from designated quarry areas and is thus thought-provoking for the case under study.

Barkai and Gopher suggest that 'Sede Ilan most probably served as a major raw material source for Lower–Middle Palaeolithic communities occupying the Lower Galilee and was visited by small quarry expeditions on a regular basis for thousands of years' (Barkai and Gopher 2009, p. 181). Based on the extensive evidence for flint extraction and reduction described here, we suggest that the Nahal Dishon Central Basin had the same function for communities in the Upper Galilee and/or southern Lebanon. This suggestion accords with Langley, who states that 'while the average distance that raw materials (namely lithic raw material) were commonly transported during the Upper Palaeolithic in Europe has been calculated at 120 kms, for the Middle Palaeolithic it is only 50–60' (Langley 2013, p. 623 and references therein). A 50–60 km distance in our case would reach the Mediterranean sea to the west and the Sea of Galilee to the south.

Studies of stone quarrying in hunter-gatherer societies, as described in ethnographic accounts from Australia (Binford and O'Connell 1984; Brumm 2010; Gould and Saggers 1985; Jones and White 1988; McBryde 1984), Papua New-Guinea (Hampton 1999; Burton 1984), and North America (Rusco and Raven 1992) demonstrate that human groups repeatedly exploited the same stone sources for generations; that the pace of exploitation was quite slow and in accordance with the needs of the group; and that stone quarries were considered vital and sacred. Ceremonies were often conducted prior to and following the quarrying. This feature may be of relevance to the caches found at Mt. Pua (Barkai and Gopher 2011).

Where was the Flint from Nahal Dishon Central Basin Transported to and What Made it so Attractive?

Why were the flint sources of the Nahal Dishon Central Basin so attractive and extensively exploited? We will use a combination of the management models described above to attempt to explain flint procurement strategies in the area. These models are generally based on reconstructing the relationship between flint sources found in geological surveys and flint artefacts found at the sites where flint tools were in use. The most thorough model employed today is probably Wilson's 'attractiveness equation', which considers factors such as flint quality, extent of the source, nodule size, terrain difficulty (from source to site), extraction cost, area of the source area (AOSA), and so forth (Browne and Wilson 2011; Wilson 2007a, b). In our case, apart from the studied archaeological sites on the Yiron and Baram plateaus, which are in close proximity to the extraction localities, we are not familiar with other potential base camps in the area. Gopher and Barkai (2014) acknowledged this lacuna, and Delage's preliminary attempt to identify the flint sources for the site of Gesher Benot Ya'aqov, 15–17 km from the research area presented here, demonstrates the difficulties involved in the effort to match the sources to target sites (Delage 2007b).

The Extraction Localities as Landmarks

Open quarries, both ancient and modern, create significant artificial land features. The aerial photos and ground photos of the extraction and reduction localities and specific piles in the research area show 'marks' in the landscape, visible from a few kilometres, more clearly on the green vegetation background during winter and spring then on the yellowish summer background. Did these 'marks' play a role in Palaeolithic navigation? The term 'landscape socialization', which Langley explained in its Palaeolithic context, seems useful here:

> Landscape socialization, then, is the direct social interaction between people and topography where meaning is imbued into the physical features of the terrain by its human viewers and inhabitants … These people embark on the process of 'landscape learning' in which they locate the distribution of resources and assess accessibility and abundance. These resources … will be located at spatially discrete locations ('sites') in the landscape. … Each of these sites, whether raw material locations (such as quarries), or landmarks (such as mountains), as well as the wider region in which multiple 'sites' are contained then become 'landscape' or 'place' in the consciousness of the inhabiting (or visiting) people (Langley 2013, pp. 615–616).

Barkai and Gopher suggested that the Sede Ilan extraction and reduction area (Lower Galilee), served 'not only as a raw material source but as a landmark, a landscape beacon embedded in the collective memory and tradition of Lower–Middle Palaeolithic societies of the area'. In this case, they propose that the relatively close 'Mt. Tabor as a natural peak and Sede Ilan as a manmade "monumental landscape", were significant landmarks in the "maps" of Middle Pleistocene hominins and were most probably used to orient individuals and groups towards traditional routes' (Barkai and Gopher 2009, pp. 181–182). Foley and Lahr write that 'the Messak is a striking element of the landscape, and must have been so even in a greener Sahara … there would be enormous advantage in identifying, knowing and remembering such localities (they would become significant landmarks)' (Foley and Lahr 2015, p. 10).

The extraction area described here presents a different situation in terms of topography and visibility. Although located on high plateaus and mountain slopes, it lies essentially inside a large depression created by the Dishon stream incision processes and surrounded by higher mountain peaks such as Mt. Meron (today 1208 MASL), Mt. Maroun (in Lebanon, 950 MASL), and the closer Mt. Kerem Ben Zimra (824 MASL) (see Figs. 2, 3). The inhabitants of the Dishon central basin were probably familiar with every extraction locality and pile in their backyard and had no need of them as navigation aids. The situation is completely different when it comes to quarrying expeditions approaching from afar. In this case:

- Having to orient themselves, hominins coming from the south probably walked along the shoulders of Mt. Meron and searched north to locate the extraction area, visible from 9–12 km (or directly below them if they traversed the Dalton basalt cover to the peak of Mt. Kerem Ben Zimra).
- If they approached from the north, they would descend Mt. Maroun and travel 3–6 km south.
- Ascending the eastern Rift Valley, they probably followed the Dishon streambed. Here the first piles on Mt. Almon and the Yiron Plateau are visible from the Dishon bed where the stream swings east and the Aviv tributary joins it. Interestingly, a number of rather large extraction piles are found on the stream bottom, close to visible flint sources (Fig. 31). These piles presented a challenge to Ohel, who described the 'amazing quantities of flint pebbles, cobbles and boulders' (Ohel 1986a, pp. 179–180) as natural flint washed from the nearby slopes. However, in our view, these piles might have served not only for extraction and reduction but also as road signs.
- The absence of high ground to the west meant that hominins travelled east until they espied the black basalt cover, or piles, from a relatively short distance.

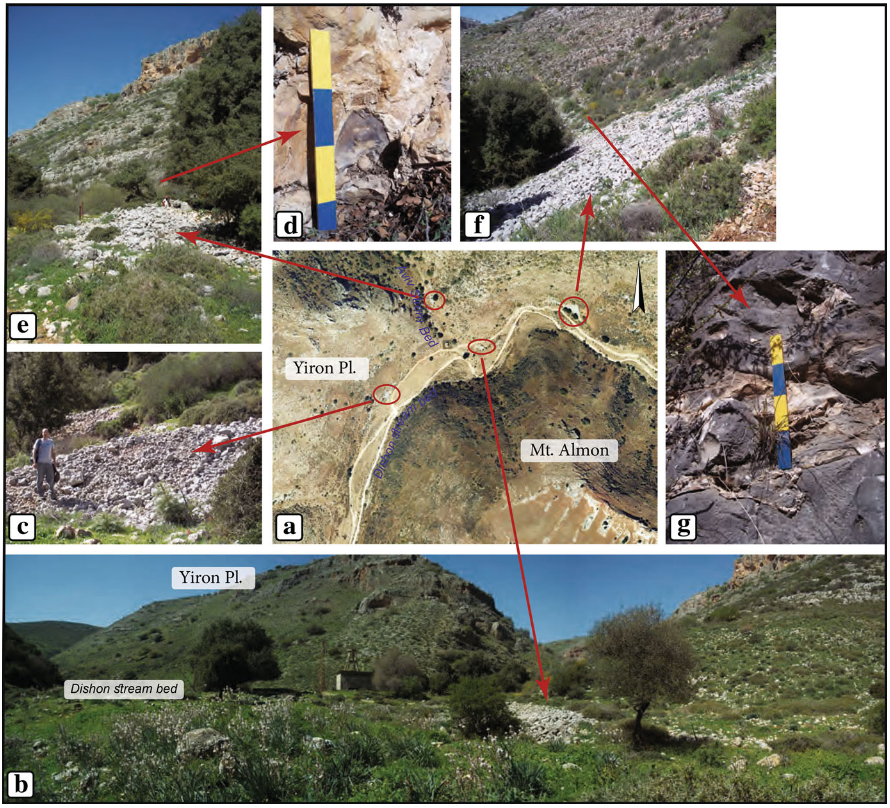


Fig. 31 Extraction and reduction piles at streams' junction; **a** Aerial photo of confluence of Aviv and Dishon; **b**, **c**, **e**, **f** piles near stream bed—all pictures were taken from the east, as seen by upstream travelers: **d**, **g** flint nodules in limestone found near the piles

Another question is how hominins maintained and transferred knowledge of the extraction area location, including details of specific extraction localities. Australian aboriginal ‘song lines’ or ‘dreaming tracks’ served as navigation aids by weaving cosmological and mythological notions with landscape features often overlooked by the modern eye, thus enabling people to learn and share navigational information on hundreds of kilometres of desert terrain, and, in a few recorded instances, on the routes to flint quarries (Gould and Saggers 1985, p. 122; Greenway 1973, p. 136). In our case, we may speculate that a similar oral method was probably the major mean of knowledge preservation and transmission. Another potential method is the use of engraved stone maps, like those found in the Upper Palaeolithic Abauntz cave (Utrilla et al. 2009) and Molí del Salt (García-Diez and Vaquero 2014) in Spain, although this is currently unknown for the Lower and Middle Palaeolithic.

Concluding Remarks

The flint extraction and reduction complexes of the Nahal Dishon Central Basin substantially increase our knowledge of the scope and scale of flint extraction and use in northern Israel. The new evidence from the 25 km^2 survey of extensive extraction and reduction activity, in conjunction with earlier available data from the same region at Mt. Pua and to the south at Sede Ilan, staggers the imagination. Many issues awaiting further research have been raised by Gopher and Barkai (2014), while the key question invoked by this research is the extent of flint extraction and its distribution. Was this area of extraction in the Nahal Dishon Central Basin a local complex or was it a dominant regional quarry area for the whole of northern Israel (and parts of southern Lebanon) in the Lower and Middle Palaeolithic? Identifying indicative characteristics of the flint found in the research area may enable cross-referencing with flint artefacts in other Lower and Middle Palaeolithic sites in the Galilee region and provide answers to the above questions. Future research will focus on geochemical analysis of the flint in the research area, in order to determine where the extraction and reduction products were transported to. Another path for future research is to try to identify common characteristics of large scale extraction and reduction areas found in the Mediterranean region, such as Messak, Libya (Foley and Lahr 2015) or the Dawadmi area, Arabian Peninsula (Jennings et al. 2015).

Acknowledgments We want to thank Pavel Srago for the studio photography, Itamar Ben-Ezra for the graphics, Natalya Solodenko and Hagai Ettinger for their wholehearted assistance in working on the figures.

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