Flint Procurement and Exploitation Strategies in the Late Lower Paleolithic Levant

A View from Acheulo-Yabrudian Qesem Cave (Israel)

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Chapter 1

Introduction

Introduction

The Late Lower Paleolithic of the Levant is a significant stage in human prehistory, characterized by changes in subsistence, technology and social structure, most likely accompanied by the appearance of a new human lineage (Barkai and Gopher 2013). The Acheulo-Yabrudian Cultural Complex (AYCC), the latest cultural entity of the Lower Paleolithic period in the Levant, has yielded remarkable discoveries, including evidence for the habitual use of fire (Blasco *et al.* 2016a; Shahack-Gross *et al.* 2014; Shimelmitz *et al.* 2014), repetitive lithic recycling (Assaf *et al.* 2015; Parush *et al.* 2015), and the systematic production of blades (Barkai *et al.* 2009; Shimelmitz *et al.* 2016) and Quina and demi-Quina scrapers (Lemorini *et al.* 2016; Shimelmitz *et al.* 2011; Zupancich *et al.* 2016a,b). The multi-layered, well-preserved AYCC site of Qesem Cave stands out with its extraordinary finds and research potential. This book examines patterns of flint procurement and exploitation within the extensive lithic assemblages of Qesem Cave (henceforth QC) during its long AYCC occupation history.

The study of flint procurement and exploitation strategies can teach us a great deal about issues such as familiarity with the landscape, mobility patterns, the transportation of lithic materials, and the techno-economic organization of early human societies (Beck *et al.* 2002; Braun *et al.* 2008a,b; Delage 2007; Wilson 2007a,b; Wilson and Browne 2014). Human lithic materials-related behaviours have therefore been studied in many archaeological contexts in the past few decades (e.g. Beck 2008; Brantingham 2003; Braun *et al.* 2008b; Browne and Wilson 2011; Dibble 1991; Ekshtain *et al.* 2014; Metcalfe and Barlow 1992). However, no detailed studies have been performed so far for the AYCC of the Levant (but see Druck 2004; Narr and Lass 1995). The rich and well-preserved assemblages of QC can serve as an excellent platform for a thorough study of raw materials and their geological sources in the area, which may allow, in turn, a better understanding of human behaviour in this important site of the AYCC.

The archaeological contexts

The Acheulo-Yabrudian site of Qesem Cave stands at the center of this study (Figure 1.1). The following section describes the Acheulo-Yabrudian Cultural Complex (AYCC) and QC in detail.

The Acheulo-Yabrudian cultural complex

The Middle Pleistocene Acheulo-Yabrudian Cultural Complex (AYCC) is the final stage of the Lower Paleolithic period in the Levant. It was originally defined by Rust (1950), following his excavation at Yabrud I in Syria during the 1930's. Stratigraphically, the AYCC of the Levant consistently postdates the Lower Paleolithic Acheulian and predates the Middle Paleolithic Mousterian (Barkai and Gopher 2013). Radiometric dates repeatedly date it to between ca. 420,000 and 200,000 years ago (Bar-Yosef 1994; Falguères *et al.* 2016; Gopher *et al.* 2010; Mercier and Valladas 2003; Mercier *et al.* 2013; Rink *et al.* 2004; Valladas *et al.* 2013; for an alternative

Figure 1.1: Qesem Cave and other relevant archaeological sites, divided into Acheulo-Yabrudian sites and Acheulian sites.

chronology see Valladas *et al.* 2013, and for a discussion concerning the AYCC chronology, see Falguères *et al.* 2016).

The AYCC is also well-defined in space. AYCC sites are known only from the central and southern Levant. AYCC sites have been found between the Syrian coast to the El Kowm basin in the north, through the Galilee in northern Israel and southwards to Tel Aviv, with Qesem Cave being the southernmost AYCC site known thus far (Barkai *et al.* 2018). Other known AYCC sites are Yabrud I (Rust 1950; Solecki and Solecki 1986), Misliya Cave (Valladas *et al.* 2013; Weinstein-Evron *et al.* 2003; Zaidner *et al.* 2006), Tabun Cave (Garrod 1956, 1970; Jelinek 1975, 1990; Shimelmitz 2015; Shimelmitz *et al.* 2014), Zuttiyeh Cave (Gisis and Bar-Yosef 1974), Dederiyeh Cave (Nishiaki *et al.* 2011), Jamal Cave (Zaidner *et al.* 2005), El Masloukh (Skinner 1970), the el Kowm sites in Syria (Jagher and Le Tensorer 2011; Le Tensorer *et al.* 2006) and the Adlun sites - Bezez Cave and Abri Zumoffen rockshelter, in Lebanon (Copeland 2000; Roe 1983). AYCC sites have been found in both caves and open-air settings; however, most of them are located in caves or in rock-shelters.

The AYCC has been subdivided into three major lithic industries:

The Acheulo-Yabrudian - characterized by the production of flakes, bifaces and scrapers.

The Yabrudian – a flake industry characterized by the production of Quina scrapers made on thick flakes with stepped retouch (resembling the scrapers known from the European Middle Paleolithic Mousterian), alongside the appearance of demi-Quina scrapers.

The Amudian (Pre-Aurignacian) - characterized by the production of blades.

Rust (1950) and Garrod (1956) suggested that each of these industries represents a different culture, or a different group of people. Copeland (1983), on the other hand, viewed these industries as reflecting different activities within the same cultural complex. The latter hypothesis is further supported by recent observations made at QC, where Yabrudian (scraper dominated) and Amudian (blade dominated) assemblages show spatial differentiation within the same stratigraphic units. This suggests the coexistence of Amudian and Yabrudian industries at QC (see also Gopher *et al.* 2016; Shimelmitz *et al.* 2016). This hypothesis is further supported by the existence of technological similarities between scraper and blade production within the Amudian and the Yabrudian industries. Indeed, it seems that the differences are mostly quantitative rather than qualitative (Assaf *et al.* 2015; Parush *et al.* 2016).

The AYCC is characterized by a set of several sophisticated behaviors, including the constant and systematic use of fire (Blasco *et al.* 2016a; Shahack-Gross *et al.* 2014; Shimelmitz *et al.* 2014), complex strategies of procurement and exploitation of lithic materials (Agam 2020; Boaretto *et al.* 2009; Verri *et al.* 2005; Wilson *et al.* 2016), intensive and systematic flint recycling (e.g. Assaf *et al.* 2015; Lemorini *et al.* 2015; Parush 2014, Parush *et al.* 2015; Shimelmitz 2015; Wojtczak 2015), technological innovations such as blade and Quina scraper production (Lemorini *et al.* 2016; Shimelmitz *et al.* 2011; Zupancich *et al.* 2016a,b), systematic fallow deer group hunting and butchering (Stiner *et al.* 2009, 2011; Blasco *et al.* 2016a), and the sharing of meat (Stiner *et al.* 2009).

The habitual use of fire was common and wide-spread during the AYCC (Shahack-Gross *et al.* 2014; Shimelmitz *et al.* 2014). Earlier evidence of fire in the Levant is currently known only from the Acheulian site of Gesher Benot Ya'aqov (Alperson-Afil 2008; Alperson-Afil *et al.* 2007; Goren-Inbar *et al.* 2004). Starting from the AYCC onwards, indications of fire use are commonly found in archaeological sites, often used for the roasting of meat (and possibly of other foods as well) (Barkai *et al.* 2017).

Human skeletal remains from AYCC sites are few. A part of a skull, known as the 'Galilee Man', was found at Zuttiyeh Cave during the 1920's (Turville-Petre 1927). There is no agreement as to which hominin is represented by this skull: some argue for *Homo neanderthalensis* (McCown and Keith 1939), and others for late *Homo erectus* or early *Homo sapiens* (Freidline *et al.* 2012; Zeitoun 2001). In addition, thirteen human teeth have been discovered at QC, and were described as closer to the later populations (e.g. Skhul/Qafzeh) of this region, rather than to *Homo erectus* (*sensu lato*), although they also bear some Neanderthal traits (Fornai *et al.* 2016; Hershkovitz *et al.* 2011, 2016; Weber *et al.* 2016).

Following the disappearance of elephants from the Levant some 400,000 years ago and the growth in the presence of fallow deer in faunal assemblages, and based on the innovations that characterize the lithic assemblages, in addition to the features of the human teeth found at QC, a bio-energetic model explaining these changes has been suggested by Ben-Dor et al. (2011). According to this model, after the disappearance of elephants there was a nutritional need to hunt smaller and faster animals in greater numbers. This necessity led to an evolutionary process from which lighter, more agile, cognitively capable hominins emerged.

Amudian laminar production

The systematic production of blades should be viewed as a local AYCC innovation (Barkai *et al.* 2018). The Amudian industry is characterized by the production of laminar items, divided into three sub-types: central blades, cortical blades, and elongated naturally backed knives (NBKs) (Shimelmitz *et al.* 2016). Two laminar production trajectories have been identified within the QC assemblages: The first is associated with the '*débitage frontal*' concept, using flat nodules with two straight and parallel sides, producing the blades by exploiting the entire length and width of the block (Shimelmitz *et al.* 2011). This method involves a careful selection procedure aimed at locating flat and narrow flint slabs suitable for this production procedure (Shimelmitz *et al.* 2016). The second trajectory was more flexible, using rounded and irregular nodules.

In a study comparing the blade production in the AYCC sites QC, Tabun Layer E and Yabrud I, Shimelmitz et al. (2016) demonstrated that blades were produced using hard hammer percussion. This study further showed that the same technological procedures of laminar production appeared in all three sites, implying that AYCC knappers shared the same 'know-how' concerning blade production and similar concepts regarding the properties of the selected lithic materials and the products (Shimelmitz *et al.* 2016). Moreover, the AYCC laminar production trajectory was demonstrated to be a predetermined and systematic technology (Shimelmitz *et al.* 2011).

The Quina technique

Following Bordes' definitions, Quina and demi-Quina scrapers are characterized by a developed scalar retouch (Bordes 1961; Verjoux and Rousseau 1986). They are well-known from the European Middle Paleolithic (Hiscock *et al.* 2009). The Quina and demi-Quina retouching techniques were designed to create broad working edges, with specific functional characteristics, such as sharp cutting edges on a thick blank (Lemorini *et al.* 2016). Quina scrapers are often made on cortical transversal flakes (Bordes 1961), and often lack striking platform preparation (Preysler and Santafé 2003). Demi-Quina scrapers are commonly produced on thinner blanks compared to Quina scrapers (Gopher *et al.* 2005; Lemorini *et al.* 2016). Quina scrapers probably had complex 'life-histories', and their function may have changed over time, as is implied by the wide variety of activities and materials processed with them, detected during several use-wear analyses (Lemorini *et al.* 2016; Zupancich *et al.* 2016a, 2016b).

The AYCC Quina production clearly predates that of Europe, while the Quina *chaîne opératoire* is completely absent from Levantine Middle Paleolithic Mousterian postdating the AYCC (Barkai *et al.* 2018). In the AYCC of the Levant, Quina and demi-Quina scrapers are usually made on thick flakes, with invasive stepped retouch (Zupancich *et al.* 2016a, 2016b). Such scrapers have been detected in all Acheulo-Yabrudian sites, including Tabun Cave (Jelinek 1982), Yabrud I (Solecki and Solecki 2007), Zuttiyeh Cave (Gisis and Bar-Yosef 1974), Misliya Cave (Zaidner and Weinstein-Evron 2016), Jamal Cave (Zaidner *et al.* 2005), El Masloukh (Skinner 1970), and Qesem Cave (Gopher *et al.* 2005; Lemorini *et al.* 2016; Zupancich *et al.* 2016a, 2016b).

Handaxes in the Acheulo-Yabrudian cultural complex

Handaxes are considered to be the *fossile directeur* of the preceeding Acheulian. Within the AYCC, handaxes appear mostly in the Acheulo-Yabrudian industry (alongside the production of flakes), but they have also been found, in lower proportions, in Amudian contexts at AYCC sites, such as QC, Tabun Cave and Yabrud I (Barkai *et al.* 2013). While handaxes appear in low quantities at QC (see below), they are more prominent within the Acheulo-Yabrudian of Tabun Cave (Gisis and Ronen 2006; McPherron 2003; Shimelmitz *et al.* 2017), Misliya Cave (Zaidner *et al.* 2006) and Hayonim Cave (Meignen and Bar-Yosef 2020).

The production of bifacial tools is accompanied by the manufacture of indicative waste products, and especially of the highly indicative thinning flakes (*éclat de taille de biface*) (Shimelmitz *et al.* 2017). However, at least in two AYCC sites, QC (Agam *et al.* 2019; Barkai *et al.* 2013) and Tabun Cave Layer E (Shimelmitz *et al.* 2017), byproducts of biface production are rare. Based on this, Shimelmitz et al. (2017) suggested that the AYCC handaxes of Tabun Cave were produced outside the site. In the case of Yabrud I, Rust (1950) suggested that bifaces were not manufactured in the AYCC level from which they were yielded, but, rather, were retrieved from older, biface-rich layers.

Some AYCC handaxes were further recycled into cores (Shimelmitz *et al.* 2017), a phenomenon also known from the Acheulian (e.g. Barkai and Marder 2010; DeBono and Goren-Inbar 2001; Marder *et al.* 2006). Handaxes are completely absent from the Middle Paleolithic Mousterian of the Levant, making the AYCC the final cultural stage in which they were present.

Qesem Cave

Qesem Cave is a sediment-filled karst chamber, situated 12 km east of the current Mediterranean coast of Tel Aviv, Israel, on the western slopes of the Samaria hills, at an elevation of 90 m a.s.l. (Figure 1.1). The cave was discovered in October 2000 during road construction work, and has been excavated since 2001, under the direction of A. Gopher and R. Barkai of Tel-Aviv University, revealing rich faunal and lithic assemblages (Barkai and Gopher 2013; Gopher *et al.* 2005). The cave, situated in a rich Mediterranean zone, had several large springs close by (Barkai *et al.* 2018), and many rich flint sources surrounding it (Wilson *et al.* 2016), making it a favorable location for human settlement.

During the excavation at QC, some 80 square meters were exposed, yielding a volume of approximately 140 cubic meters. In the excavation method applied, every 1 square meter of the QC grid was divided into four sub-squares of 0.25 m^2, excavated in arbitrary levels of a maximum depth of 5 cm each. All sediments were sieved using a 2.4 mm mesh. Assemblages were defined and separated from one another by spatial changes in sediments. All flint and bone finds were collected and stored from all excavated assemblages. Various selected assemblages have been analyzed typo-technologically, and for their raw materials.

The stratigraphic sequence, which has not reached bedrock yet, includes two main parts: the lower sequence, which is over 6.5 m thick, consisting of clastic materials, gravel and clay; and the upper sequence, which is about 4.5 m thick, of cemented materials and a significant ash component (Barkai *et al.* 2018), which was deposited in a fairly open and well-lit space (Karkanas *et al.* 2007). The entire QC sequence has been assigned to the Acheulo-Yabrudian cultural-complex (AYCC) of the Lower Paleolithic of the Levant, dated to between ca. 420,000 and 200,000 years ago (Barkai *et al.* 2003, 2005, 2009; Falguères *et al.* 2016; Gopher *et al.* 2010; Mercier *et al.* 2013).

Systematic and repetitive use of fire has been recognized at the site, dated to as early as ca. 400,000 years ago (Karkanas *et al.* 2007; Shahack-Gross *et al.* 2014; Stiner *et al.* 2009, 2011). A hearth was repeatedly located in the same location, acting as a focal point for human activities (Blasco *et al.* 2016a; Stiner *et al.* 2009). The high proportion of burnt bones found in all the cave's layers implies that the diet of the cave's inhabitants was based mainly on roasted and cooked meat (Barkai *et al.* 2017), supplemented by vegetal foods (Hardy *et al.* 2016). A recent study revealed the use of ashes at the site for the preservation of foods for delayed consumption, as well as that of hide, for delayed processing (Lemorini et al. 2020). Finally, Agam et al. (2020) demonstrated the use of fire at the site for the intentional and controlled heat treatment of flint nodules specifically for the production of blades.

Based on the data yielded from the site's assemblages, the emergence of novel knowledge transmission mechanisms has been suggested (Assaf *et al.* 2016; Barkai *et al.* 2017). These are related to the emergence of a new set of innovative behaviours: new lithic technologies (i.e. the Quina technique, blade production, systematic lithic recycling), novel hunting techniques, focusing mainly on prime-aged fallow deer, sophisticated butchering procedures, and the habitual use of fire (firewood collection, fire production, fire maintenance, cooking and roasting techniques, ventilation of the cave). These probably required the formation of new knowledge transmission mechanisms, different than those applied during the preceding Acheulian culture (Barkai *et al.* 2018). The massive quantities of flint, animal remains and firewood which were brought to the cave, in addition to the rarity of evidence of carnivores' presence at the site, suggest that there was a prolonged and repetitive human presence at the cave during the AYCC, most probably in the form of multiple recurrent visits (Barkai *et al.* 2018).

The faunal remains at Qesem Cave

The faunal assemblages of QC are very rich in finds, and are strongly dominated by the remains of fallow deer. Other taxa detected within the cave's faunal assemblages are red deer, horse, aurochs, wild pigs, wild ass, goats and roe deer, in addition to a rare representation of carnivores (Blasco *et al.* 2016a; Stiner *et al.* 2009, 2011). These prey animals were butchered, shared, and cooked by the Qesem hominins (Karkanas *et al.* 2007; Stiner *et al.* 2009, 2011). The age profiles of the fallow deer demonstrate a pronounced presence of infants and young individuals, implying a seasonal specialized hunting (Blasco *et al.* 2016a). Among the small prey, the presence of birds and tortoise is of note (Blasco *et al.* 2016b; Sánchez-Marco *et al.* 2016), as well as the possible use of feathers (Blasco *et al.* 2019). Forty bone fragments were recycled and used as bone retouchers (Blasco *et al.* 2013a).

In the cave there are several rich concentrations of micro-vertebrate remains, containing approximately 250,000 specimens, most probably accumulated by barn owls (Maul *et al.* 2011, 2016; Smith *et al.* 2013, 2016). This accumulation is composed of both micro-mammals, such as hyraxes, squirrels and bats, and reptiles, such as lizards, chameleons and agamas. The composition of the micro-vertebrate assemblage implies a mosaic of open paleo-environment with thin vegetation and Mediterranean wooded zones (Maul *et al.* 2016).

The lithic industries of Qesem Cave

QC is characterized by rich and dense lithic assemblages, with up to 6100 artifacts per $1m^3$ in some cases (Gopher *et al.* 2016). Most of the lithic assemblages found at QC can be assigned to the Amudian industry, dominated by blades (Barkai *et al.* 2005, 2009; Gopher *et al.* 2005; Shimelmitz *et al.* 2011). The Yabrudian industry, which appears in three spatially and stratigraphically distinct areas within the cave, is dominated by Quina and demi-Quina scrapers (Barkai *et al.* 2009). The Acheulian industry is virtually absent from the QC lithic assemblages, and only a few isolated handaxes have been found (Gopher *et al.* 2005; Barkai *et al.* 2013).

Another significant phenomenon at the cave is the systematic recycling of flint, aimed mostly at the production of small sharp flakes and blades from parent flakes and blades (Assaf *et al.* 2015; Barkai *et al.* 2010; Parush 2014; Parush *et al.* 2015). Use-wear data suggest that these products of recycling were used mainly for the processing of soft to medium materials, primarily associated with the cutting of meat (Barkai *et al.* 2010, and see Lemorini *et al.* 2015). In addition, a few spheroids have been found, made in most cases of limestone (Assaf *et al.* 2020; Barkai and Gopher 2016).

The blades of Qesem Cave

The Amudian industry at QC demonstrates an early well-established blade production technology, which was systematically used for the sequential manufacture of predetermined laminar artifacts (Shimelmitz *et al.* 2011). Tens of thousands of blades have been uncovered in Amudian assemblages at the cave. Blades have also been found in small numbers in the Yabrudian assemblages, produced by the same technology used in the Amudian assemblages (Barkai and Gopher 2013). Use-wear analyses of blades and blade tools from QC mainly indicate activities related to meat cutting (Lemorini *et al.* 2005). Shimelmitz et al. (2016) point to similarities between the technology of blade production at QC, Tabun Cave and Yabrud I.

The handaxes of Qesem Cave

At Qesem Cave 17 bifaces and bifacial knapping-related artifacts have been uncovered in a variety of stratigraphic contexts. These consist of 12 handaxes, or bifaces, three bifacial roughouts, one trihedral, and one bifacial spall (a ridge removed from one of the sides of a biface). No other waste related to the production of bifaces has been detected at the site to date. This small assemblage of bifaces stands in strong contrast to the abundance of blades and Quina and demi-Quina scrapers.

One giant roughout of a biface (item number 13 of the bifaces in this present research, see Table 2.4), was found in an almost horizontal position, a little north of the hearth, buried under a collapse of massive blocks. Barkai et al. (2013) studied this roughout in detail and described its depositional history. This giant biface postdates the hearth and is part of an Amudian assemblage covered by the collapse. The deposition of the large biface was dated to between 280,000 and 250,000 years ago. This roughout did not present any use-wear, suggesting that it was never used.

It is as yet unclear whether handaxes were produced at the site. Barkai et al. (2013) have suggested, based on the presence of the bifacial roughout, that biface production was indeed practiced at the site, although only rarely. Bifacial knapping waste, however, seems to be absent from the site's assemblages, reducing the likelihood of this procedure taking place inside the cave. New Results, presented further below, suggest that indeed the QC bifaces were brought to the site in their current state.

Quina and demi-Quina scrapers at Qesem Cave

Over 1000 side scrapers of all types, and especially Quina and demi-Quina scrapers, have been found in all excavated areas of QC, in both Yabrudian and Amudian assemblages (Boaretto *et al.* 2009; Gopher *et al.* 2005; Lemorini *et al.* 2016; Parush *et al.* 2016; Zupancich *et al.* 2016a). Quina and demi-Quina scrapers are prominent in the Yabrudian assemblages (Barkai *et al.* 2009; Parush *et al.* 2016), while being less frequent within Amudian assemblages. *Débitage* related to the production sequence of the Quina and demi-Quina scrapers is missing from the site's assemblages, suggesting that flake blanks or the complete scrapers were imported to the site (Lemorini *et al.* 2016). Maintenance of scrapers did, however, take place at the site, as indicated by the presence of Quina resharpening flakes (Venditti 2017). Some of the exploited blanks were collected from outside the cave, as indicated by the patina on their surfaces. Wilson et al. (2016) demonstrated that scrapers were often produced of Type K (11.4% of the analyzed scrapers in that study), a light grey-brown slightly translucent flint type, which is completely absent among other flake-tools.

Quina and demi-Quina scrapers were mainly used to scrape and cut both soft and medium-hard materials. Scrapers shaped by Quina retouch were often used for the processing of medium-hard materials. These scrapers are characterized by durable edges, which are hard to break, and which are well adapted to the processing of resilient materials, such as dry hides. Demi-Quina scrapers were more versatile, and were used in a variety of activities, such as cutting meat and fresh hide. One Quina scraper and one demi-Quina scraper provided compelling evidence of bone processing, presenting some of the earliest evidence of bone working using stone tools (Zupancich *et al.* 2016b).

The human remains

To date, the cave has yielded 13 human teeth. Based on their morphology, they cannot be classified as *Homo erectus* (*sensu lato*), but, rather, have some similarities to the local Upper Pleistocene populations of Skhul and Qafzeh, while also having some traits associating them with Neanderthal populations (Fornai *et al.* 2016; Hershkovitz *et al.* 2011, 2016; Weber *et al.* 2016). The unique traits of these teeth, in addition to the multiple innovative cultural transformations detected at QC, imply the emergence of a new local, post-Acheulian human lineage (Ben-Dor *et al.* 2011).

Previous studies of lithic procurement and exploitation at Qesem Cave

In QC and in Tabun Cave, Verri et al. (2004, 2005) used ^{10}Be (Beryllium-10) contents in Upper Acheulian and Acheulo-Yabrudian artifacts to identify flints collected from the surface or by shallow mining, versus flints extracted from deep underground sources (more than 2 meters deep), or, alternatively, collected from a primary geological source soon after it was eroded. The results indicated that both surface and deeper mining procurement strategies were used by the inhabitants of both sites. Furthermore, results showed that some of the quarried flints found at QC were used for the production of specific tool types, such as scrapers and handaxes (Boaretto *et al.* 2009).

Wilson et al. (2016) published a preliminary study comparing flint procurement and exploitation patterns in Amudian and Yabrudian assemblages at QC. Fifty-one flint types were classified during that research (since then more flint types were identified, as elaborated below), and 15 potential geologic sources of flint were located throughout the landscape (again, more sources have been found since – see below). The study showed that the Qesem hominins used specific flint types for the production of specific blanks or tool types (e.g. blade production, scraper production, lithic recycling, etc.), although in various frequencies in the different assemblages. As for the potential flint sources, while most of the flint used at QC came from local Turonian sources, five types, constituting between 4.4% and 6.8% of the examined assemblages, were identified as Campanian flint of the Mishash formation (for its potential sources see below). These five types were found to be common mainly in specific typo-technological categories (e.g. recycled items, tool spalls [burins, scrapers, bifaces]) (Wilson *et al.* 2016).

Geological background

What is flint?

Flint is a sedimentary rock which forms in limestone, composed mainly of interlocking grains of microcrystalline quartz, SiO_2, also called silica (Shepherd 1972: 29). It started forming on Earth at least as early as 3.5 billion years ago, and was still forming as recently as the Pleistocene (Luedtke 1992:17). Some variants of flint are also known as chert, opal, jasper, chalcedony and microgranular quartz (e.g. Deer *et al.* 1992:468; Flexer 1991:145; Williams *et al.* 1982:398). However, for the sake of consistency and simplicity, I use in this study only the word 'flint' for the description of all rocks composed mainly of microcrystalline quartz.

Flint makes up less than 1% of earth's sedimentary rocks' total volume (Blatt 1982:381). However, it is widely exposed and available throughout the world in general (Luedtke 1992:17; Shepherd 1972:19), and in the Levant specifically (Bar-Yosef 1991:235; Lees 1928). It occurs as rounded, irregular-shaped or tabular nodules or thin elongated lenses embedded in limestone or dolomite, as layers or massive beds or sheets, and can also be found in alluvial deposits within river beds (Aliyu 2016:33; Flexer 1991:145; Luedtke 1992:17; Shepherd 1972:20).

The formation of flint

While there are many theories concerning the process of flint formation, its exact genesis procedure remains unknown (Aliyu 2016:31; Shepherd 1972). The formation of sedimentary rocks in general is usually associated with the compaction of deposited materials, caused by a mechanical stress, followed by a stage of cementation, which, in turn, is produced by the diffusion of varied solutions between the grains of the deposited materials (Flexer 1991:127). However, flint is generally almost entirely not composed of primarily-deposited sedimentary grains. Instead, flint is formed under deep and shallow seas, in lakes, or even on land, most likely by the chemical precipitation of silica (Luedtke 1992:17), through either biogenetic or diagenetic replacement processes (Flexer 1991:147-148).

The diversity of contexts in which flint is found reflects the complexity of its formation processes (Luedtke 1992:17). Some suggest that the biodegradation of organic materials within water environments may cause the release and deposition of silica, creating favorable conditions for the precipitation of flint (e.g. Bennett *et al.* 1988). Others propose that the force of crystallization and depression is the force leading to the formation of flint (e.g. Minguez and Elorza 1994). The frequent association of flint and breccia structures suggests that cracking and fragmentation are also common stages in the diagenesis of siliceous rocks (Singh 2011).

It should be stressed that different formation environments may lead to different formation processes, thus complicating our ability to establish one clear general process of formation (Aliyu 2016:32). Rather, flint is often considered a polygenetic rock, which forms in various processes, influenced by numerous factors (Flexer 1991:147).

The composition of flint

As flint forms in close association with other rocks, sediments, minerals, and organic remains, it is rarely composed of pure silica, but, rather, often has some impurities in it (Luedtke 1992:35). These impurities, and the resulting chemical composition of the flint, can directly contribute to our ability to identify the geologic source of a flint sample. Most of the impurities found in flint are clay minerals, iron oxides, and organic substances and residues, including mainly carbonates, hydrogen, nitrogen, oxygen, and various marine fossils (Luedtke 1992:36, 42). It has been suggested that the crystallites of flint are separated from one another by water-filled voids (Folk 1980:83; Witthoft 1974). The water within the flint contains dissolved ions which contribute to the geochemical composition of the flint, as well as influencing the crystal shapes and sizes. These water-filled voids are occasionally used in the study of heat treatment of flint (e.g. Patterson 1984; Patterson and Sollberger 1979; Schmidt *et al.* 2012, 2013).

The mechanical traits of flint

Flint breaks with conchoidal fracture, in which the fracture runs parallel to the direction of the shock wave caused by the blow, without following any natural cleavages of separation (Cotterell *et al.* 1985). This tendency makes the fracture of flint controlled and predictable, turning flint into a material attractive for the production of stone tools (Purdy 1975). The size of the quartz grains in flint has a significant effect on its fracture characteristics (Luedtke 1992:24). Three main factors are known to affect the size of these quartz grains: the density of nucleation sites; the rate of crystal growth; and the temperature of formation. The size of grains may affect the strength, hardness, abrasivity and elasticity of the rock (Aliyu 2016:51). Another trait which may affect the mechanical features of flint is the nature and composition of the impurities within the flint (Luedtke 1992:35).

The texture and structure of a flint specimen may influence the degrees of flakeability and durability of that flint piece (Bustillo *et al.* 2009), and, as a result, its attractiveness and the likelihood of it being chosen for knapping. A high degree of homogeneity, for example, is generally associated with better flakeability (Whittaker 2001:12). Thus, it is likely that differences in the mechanical traits of flint influenced the choices of prehistoric knappers, as well as the knapping technique applied for each flint type. Furthermore, these mechanical traits also influence the way flint gets worn or damaged during use (Luedtke 1992:73), further adding to the considerations which may have affected the choices of prehistoric people concerning which flint type to use in a given situation. Indeed, recent studies have demonstrated that the original shape and size of the knapped material may have an influence over the durability and efficiency of the tool (e.g. Ditchfield 2016; Key and Lycett 2015, 2017; Terradillos-Bernal and Rodríguez-Álvarez 2017).

The visual traits of flint

Flint is extremely variable in its appearance, and may vary in colour (appearing in practically any colour, including white and black), texture, degree of translucency, degree of homogeneity, unique patterns, and fossils present (Luedtke 1992:59). These variations may occur at every scale – between formations, within formations, and even within nodules. As quartz, the main component of flint, is colourless, and has a glassy luster, the variation in the appearance of flint is probably the result of the impurities in it (Luedtke 1992:59, 71). The size of grains, in turn, affects the luster and texture of flint, which are both also related to the mechanical traits of flint (Luedtke 1992:71-72). As recent flint knappers are known to use the visual traits of stones to evaluate their quality, it is probable that prehistoric societies did the same (Luedtke 1992:59). The visual traits of flint analyzed in this current study are fully described in the Methodology chapter.

The geo-settings of Qesem Cave

Qesem Cave (hereinafter QC) is a karstic cave, which is a part of larger karstic system (Frumkin *et al.* 2009, 2016), situated 12 km east of the Mediterranean coast of Tel Aviv, Israel, between the modern cities Kafr Qassem and Rosh HaAyin, on the northern bank of Wadi Rabah (Figure 1.1) (Frumkin *et al.* 2016). It is situated in the Cretaceous Judea Group Turonian limestone of the B'ina Formation, in the low hills of South-western Samaria, which forms the transition between the coastal plain to the west and the Samaria ridge to the east (Frumkin *et al.* 2016; Hildebrand-Mittlefehldt 2011).

The Turonian limestone of the area is rich in dissolution cavities, many of which are still currently active (Smith *et al.* 2016). Like other cavities in the area, the cave was naturally filled with colluvial deposits of terra-rossa when the hillslope above it was stripped of vegetation sometime during late Quaternary times (Frumkin *et al.* 2016). This filling process probably cannot be associated with any tectonic events, as the region seemingly has been tectonically stable at least since the early mid-Pleistocene, prior to the occupation of the cave (Ryb *et al.* 2013).

The regional drainage system comprises fluviokarst-type gorges generally flowing westward, towards the Mediterranean Sea (Frumkin *et al.* 2016). The current climate of the area is dry Mediterranean, with moderately cool rainy winters and dry, hot summers, and with vegetation of sparse shrubs, termed 'batha' (Frumkin *et al.* 2016). The average annual precipitation is approximately 600 mm, and the average annual temperature is about 19ºC (Frumkin *et al.* 2016). The paleoclimate of the region during the Mid-Late Pleistocene was mostly wetter and cooler than nowadays (Fischhendler and Frumkin 2008).

Flint-bearing outcrops around QC

The Turonian limestone of the Bi'na Formation, of the Judea Group, which surrounds the cave, is rich in primary outcrops of flint (Wilson *et al.* 2016; Figure 1.2). Moreover, the cave is surrounded by dry stream beds (wadis), many of which are secondary sources for flint nodules and pebbles, most likely originating from various geologic formations, which accumulated through alluvial, and/or colluvial processes. They might have been eroded from primary geologic sources lying to the east, and then been carried westwards by the then-active dry streams, towards the Samaria hills and further away to the west. The high frequency of both primary and, mainly, secondary sources in the immediate environment of the cave might have been a major factor in the decision to inhabit this cave. The exploitation of secondary flint sources does not require any quarrying or mining activity, and flint could be readily

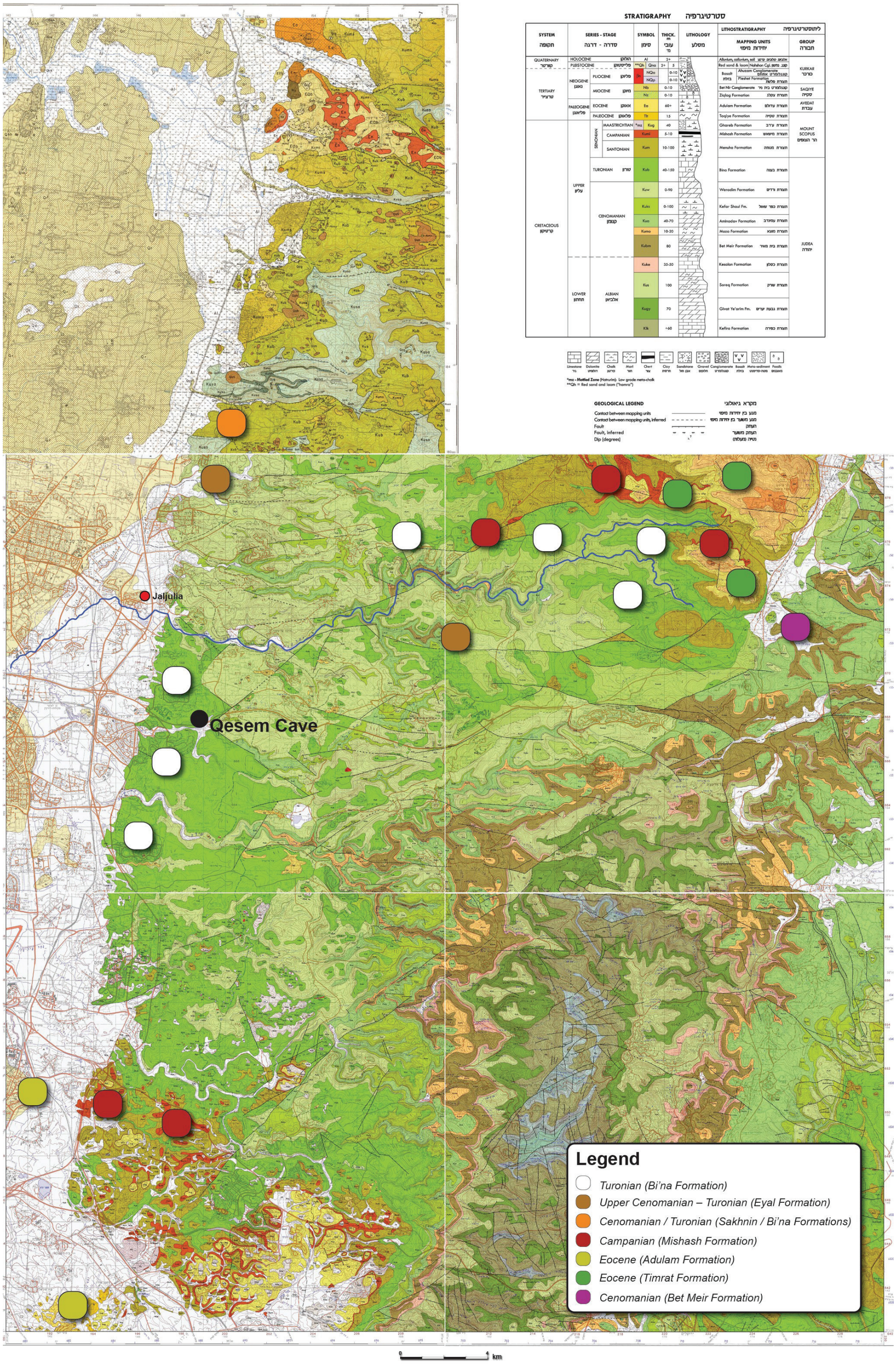

Figure 1.2: Flint-bearing outcrops around QC.

procured from such sources. However, the quality and size of the nodules available within these secondary sources may have been inferior to those available in primary sources, and, as a result, they may have been less suitable for knapping, due to the rounding, cracking and weathering caused by their transportation (Ekshtain 2014). Alternatively, stream processes can winnow out or break down the inferior nodules, leaving only the toughest ones intact.

Approximately 12 km north of the cave, there are both primary and secondary flint-bearing outcrops, of medium to coarse-grained Cenomanian limestone of the Sakhnin Formation, also of the Judea Group (Ilani 1985). East of the cave the rocks consist primarily of Cenomanian and Cenomanian-Turonian chalks and dolomites, with some small outcrops of younger conglomerates and basalt. Further to the east, approximately 25-30 km from the cave, the geological map of Israel shows exposures of Eocene limestone of the Timrat Formation (of the Avedat Group) and Cenomanian limestone of the Beit Meir Formation (Judea Group), both of which supposedly contain nodules of flint (Sneh and Shaliv 2012). Outcrops of Campanian flint of the Mishash Formation (Mount Scopus Group) are also known to exist about 30 km east of the cave (Sneh and Shaliv 2012). These distant eastern sources were not available for survey during this study because of logistical and security issues. Thus, I have no personal knowledge of these potential flint sources, but, rather, only knowledge based on the geologic map of the area (Sneh and Shaliv 2012).

To the west, the Samarian hills give way to plains covered in Holocene and Pleistocene alluvial and colluvial deposits (Hildebrand-Mittlefehldt 2011). The Turonian limestones extend southward of Qesem Cave for about 15 km, where they are covered by Senonian (Upper Cretaceous) levels. These include the Santonian Menuha Formation chalks, and the flint-bearing Campanian Mishash Formation (both of the Mount Scopus Group), exposed mainly in the Ben-Shemen Forest (Yechieli 2008).

Archaeological raw material studies

The reliability of macroscopic flint type classifications

Macroscopic flint type classification is a common tool in the process of archaeological lithic raw material studies, though its reliability is often questioned (Boulanger *et al.* 2005; Gurova *et al.* 2016; Luedtke and Myers 1984; Milne *et al.* 2009; Moreau *et al.* 2016). This section briefly presents some of the studies which examine the reliability of the macroscopic classification of rocks.

Bustillo et al. (2009) compare the results of petrological and macroscopic analyses performed for flints taken from the Neolithic Casa Montero mining complex (Madrid, Spain). Their results suggest that the macroscopic rock analysis tends to over-divide flint types which are grouped by the petrological study, reflecting a wide macroscopic variability, but that macroscopic evaluation is useful for distinguishing between different nodules. Furthermore, macroscopic assessment may also provide some useful technological data.

Gurova et al. (2016) test the reliability of macroscopic observations by comparing them to both petrographic thin sections and laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) analysis, applied to flints from Bulgaria and Serbia. Their results show that at least in cases in which there are a limited number of potential sources, macroscopic analyses can be a useful instrument. In addition, some flint types have very similar characteristics in macroscopic and micro-petrographic analyses, which further supports the usefulness of macroscopic evaluation.

To determine the provenance of chert found on Southern Baffin Island, Canada, Milne et al. (2009) use a combination of four different research methods, including a macroscopic visual evaluation, petrographic analysis, bulk trace element analysis and secondary ion mass spectrometry. Their study shows that almost half of the macroscopic classifications were incorrectly assigned, implying that macroscopic analysis is an insufficient method by itself. They do, however, state that the macroscopic evaluation is needed 'to bring some order to an otherwise random aggregation of rocks'.

Due to the problematic reliability of macroscopic analysis of rocks, Crandell (2005, 2006) suggests a set of descriptive and detailed definitions of visual characteristics for the macroscopic classification of chert, aimed at creating a standardization in macroscopic rock type classification. Colour, for example, is a criterion which is known to be highly subjective. Thus, Crandell suggests that for its description the Munsell colour system should be used. For the appearance of the rock, he recommends the use of the degree of homogeneity, lustre, degree of translucency, the feel of the rock, and the size of grain. In addition, patterns (spots and lines, for example), created by the distribution of materials within the chert, and traits of cortex (nature, aspect, colour, thickness and transition) should also be analyzed in detail.

The few examples provided above show that the use of macroscopic analysis in raw material studies is problematic but, in most cases, unavoidable. Further below the macroscopic classification of flint types is tackled using a blind test evaluation, in order to identify consistencies and weaknesses within the visual classification scheme.

Lithic procurement and exploitation strategies in the archaeological record of the levant

Studies of lithic raw material procurement and exploitation have recently become a common instrument in the process of understanding early human behaviours, evaluating issues of mobility, settlement patterns, resource transportation and technological-economic choices during prehistoric times. Many such studies have been performed concerning Africa (e.g. Braun *et al.* 2008a, 2008b; Goldman-Neuman and Hovers 2012), Europe (e.g. Browne and Wilson 2011; Doronicheva *et al.* 2016; Kuhn 2004, 2011; Wilson 2007a, 2007b; Wilson and Browne 2014) and North America (e.g. Amick 1996; Beck 2008; Loosle 2000), while fewer studies have dealt with the Paleolithic period of the Levant (e.g. Hovers 1990; Meignen 1998; Turq 1992). Some of the recent studies examining lithic material procurement and exploitation strategies in Levantine Paleolithic sites are presented below.

Bar-Yosef stated that flint 'is available almost everywhere in the Levant' (Bar-Yosef 1991:235). However, while flint is indeed abundant in the region, and while availability was probably a major factor in lithic procurement (Luedtke 1992:73), availability was often demonstrated to be but one consideration out of many influencing early humans' lithic material choices. Indeed, some studies have demonstrated a clear selectivity in raw material choices (e.g. Bar-Yosef and Goren-Inbar 1993; Ekshtain *et al.* 2014; Wilson *et al.* 2016), revealing a profound familiarity of early humans with the geologic resources of their surroundings, as well as significant efforts invested in acquiring specific lithic materials.

At the site of Ubeidiya, dated to ca. 1.4 mya, a clear association between lithic raw materials and certain tool types was detected (Bar-Yosef and Goren-Inbar 1993:111; Belfer-Cohen and Goren-Inbar 1994). Generally, core-choppers from Ubeidiya tend to be made of flint, subspheroids of limestone, and bifacial tools of basalt. This pattern does not seem to be related to the degree of availability of these raw material types. Such selectivity in the exploitation of lithic material was suggested to be a distinctive trait of the Acheulian culture (Belfer-Cohen and Goren-Inbar 1994).

A clear correlation between types of raw materials and specific morphotypes was also detected at the Acheulian site of Gesher Benot Ya'aqov (Saragusti and Goren-Inbar 2001). Basalt was clearly preferred for the production of bifacial tools (both cleavers and handaxes), flint for the manufacture of cores, flakes, and flake tools, and limestone for the production of chopping tools. This pattern was detected in all the lithic assemblages of Gesher Benot Ya'aqov. All three types of raw materials are widely available in the surroundings of the site.

Generally, the place of basalt in the Early and Middle Acheulian of the Levant is of note. Basalt was used in significant proportions in three Acheulian sites in the Jordan Valley: Ubeidiya, Gesher Benot Ya'aqov and the North of the Bridge Site. It was used at these sites for the manufacture of ordinary tools for daily use, including flakes, cores, handaxes and cleavers (Ronen 2010). Interestingly, Ronen points to a halt in the use of basalt, starting from the Late Acheulian, and until the Levantine Epipalaeolithic, where basalt was used mainly for the manufacture of grinding implements, a pattern which is associated by Ronen with some symbolic significance of the basalt from this period onwards.

In the site of Bizat Ruhama, an Oldowan-like site, the exploitation of secondary sources was suggested, based on a significant degree of erosion of the flint cortex (Zaidner 2003). The entire lithic assemblage is composed of small-sized flint artifacts, without bifacial tools, a different pattern from what is known from other contemporaneous Acheulian sites. The selection of small-sized flint nodules, even though larger pieces of limestone and brecciated flint were also available in the vicinity of the site, is interpreted by the author as the result of a cultural or functional choice.

Sharon (2008) argued that the morphology and size of the naturally available nodules used during the Acheulian of the Levant and Africa did not play a significant role in the blank production process, nor in the variability in size and shape of the LCTs (Large Cutting Tools). Rather, he suggested that Acheulian toolmakers used the raw materials available to them in a reduction sequence which accorded well with their technological worldviews, aimed at producing similar bifaces without being significantly influenced by the original shape, size and raw material type from which they were manufactured.

During the Lower Paleolithic Acheulian and the Middle Paleolithic Mousterian of the Levant, complex and intensive processes of flint acquisition took place in the form of large-scale flint extraction and reduction industrial complexes (e.g. Barkai and Gopher 2009; Gopher and Barkai 2011, 2014). These industrial complexes of extraction, characterized by the presence of massive tailings piles, reflect a large-scale, repetitive phenomenon. It seems that humans repeatedly came back to the same places in order to quarry and collect flint, reflecting a deep familiarity with the geology surrounding them.

Additional data concerning such extraction and reduction complexes was recently published by Finkel et al. (2016, 2018, 2020), who discovered an extensive complex of flint extraction and reduction localities in the Upper and Eastern Galilee, Israel, further expanding the scope of this phenomenon. These localities were assigned, based on the indicative lithic tools found in them, to the late Lower Paleolithic and Middle Paleolithic, with some evidence of Neolithic/ Chalcolithic activity as well. The results suggest that these complexes were systematically and repeatedly exploited by early humans, over prolonged periods of time (Finkel *et al.* 2016, 2018).

A recent significant study was performed for the late Middle Paleolithic site of 'Ein Qashish (Ekshtain 2014; Ekshtain *et al.* 2014). The study used visual observations, geochemical analyses (ICP-MS, ICP-AES), and statistical methods, and demonstrated that flints from various distances were brought to the site. Materials from relatively near-by sources were knapped on-site, while flint from more distant sources was brought to the site as prepared end-products, implying a complex pattern of raw material exploitation, combining several different provisioning strategies. In a broader view, the research showed that geochemical techniques can be used to differentiate between flints and their original geologic formations, and that visual features can be linked to geochemical traits.

In the Mousterian site of Hummal (El Kowm, Syria) it was demonstrated that high quality primary-sourced flint, located ten to fifteen kilometers from the site, was significantly preferred over secondary flint deposits (Hauck 2011; Wojtczak 2015). Generally, the proportion of primary lithic materials within the site's assemblages ranged between 70% and 100%, although secondary flint sources, identified by weathered cortex or neocortex, were also used. Also worth mentioning is the exploitation of flint items left by the previous occupants as raw materials for the manufacture of new tools.

Delage (1997) investigated the flints of the Mousterian (and Natufian) layers of Hayonim Cave and the flint sources around it. His results demonstrated that the number of flint types identified at the site is significantly lower than that of potential sources identified in the immediate vicinity of the site, suggesting selectivity in raw material choices by the site's occupants, in an environment where flint is plentiful and varied.

Provenance research was performed for the Middle Paleolithic sequence of Mislyia Cave (Weinstein-Evron *et al.* 2003), where a preference for local flint sources, located within a radius of up to 2.5 km of the site, was observed. More distant sources were also exploited, although less frequently. For the handaxes, it was demonstrated that the better-prepared handaxes were made of high quality, thin nodules of local materials, coming from two to three km north of the site, while the less carefully prepared handaxes came from more distant sources, up to 20 kilometers away (Zaidner *et al.* 2006).

At Middle Paleolithic Amud Cave, two subunits dated to between ~55,000 and ~68,000 years ago revealed complex procurement and transport strategies, executed by Neanderthals

(Ekshtain *et al.* 2017). While local materials dominate the examined assemblages, non-local flints, originating from over 60 km away from the site, appear in significant proportions as well (30-40%), especially in the older assemblage. As the data imply that many different distant sources were visited by the site's occupants, it was suggested that a certain degree of logistic mobility was applied, and that complex social and cultural considerations affected the lithic procurement behaviour of the Neanderthals that lived at the site.

In his M.A thesis, Druck (2004) examined the pattern of flint exploitation by the inhabitants of the Nahal Me'arot sites, Tabun and El-Wad, starting from the Lower Paleolithic and up until the Late Natufian. Druck mapped the flint outcrops in the area of Mount Carmel, expanding Delage's (2001, 2003) research on flint sources in this area. Three patterns of flint exploitation were detected by Druck: during the Lower Paleolithic the local flint of the Nahal Me'arot basin was mainly used; during the Middle and Upper Paleolithic the local Shamir formation was preferred; and during the Natufian, once again, the flint of the local Nahal Me'arot basin was mostly used. The presence of Eocene flint, originating from the more remote Manasseh hills, in all of the periods examined suggests, according to Druck, either relatively long-distance movement, or, alternatively, the existence of exchange relations between groups.

Lithic procurement and exploitation strategies in the ethnographic record

Recent hunter-gatherers rarely use lithic materials for tool production anymore. Other materials, such as glass, iron and steel, have taken over the place of lithics (but see Arthur 2010, 2018). There are, nonetheless, several reports documenting lithic procurement habits among such societies. This section reviews some of these examples, focusing on the procurement of lithic materials, the transportation and division of the procured materials, and the social and cosmological worldviews related to the procurement of natural materials among recent hunter-gatherers.

Although the ethnographic record can illuminate some aspects of the archaeological record, it should be used cautiously (Goring-Morris and Belfer-Cohen 2008, and see Kelly 2013). Thus, ethnographic data are not used here as a direct analogy to the AYCC, but, rather, as a background to general ideas about strategies of resource procurement and exploitation, as well as to draw some possible implications concerning patterns identified within the archaeological record.

Burton (1984) described the procurement of hornfels by quarrying and mining for axe manufacture, as was performed by the Tungei people from Papua New Guinea. According to Burton, several groups of axe makers stayed in enclosed camps in what he termed 'factory areas', in special communal expeditions. The quarrying involved the use of simple tools, using lithic extraction waste as hammerstones, in addition to the exploitation of wooden stakes or wedges. Interestingly, while economic demand dictated the production of these axes, social factors controlled the timing of these expeditions. The Tungei associate their ability to successfully quarry stones with the purity of their rituals, including the segregation from women, and with the use of the right magic before procurement. Following the quarrying, the material was equally distributed between sub-clans, regardless of the personal physical strength of each of the working men.

Gould and Saggers (1985) wrote that while stone-tool making among the Western Desert Aborigines (Australia) was performed by both women and men, special journeys aimed at the procurement of lithic materials were conducted exclusively by men. This is related, in part, to the sacred nature of some of the procurement localities, which only men with specific affiliations were allowed to enter. Organized lithic procurement was one of the few activities demonstrating such a strict division of labor. Other procurement activities were usually performed by women, but with the men also taking an active part. Distance travelled to the exploited stone quarries ranged from 0.8 to 45 kilometers, though materials were later transported over greater distances, either as part of long-distance movements, or as a part of long-distance social networks, facilitating the sharing of materials.

While many scholars present lithic procurement as an activity mainly associated with men, Arthur (2010) argues otherwise. Based on interviews and observations, she demonstrates that the Konso women of Southern Ethiopia specialize in the manufacture of scrapers for the processing of animal hides, and procure rocks from long-distance resources for their production. The *Konso* women mainly prefer chalcedony, distinguishing it from other microcrystalline rocks, and travel up to 25 kilometers to acquire the desired materials. The women have a profound knowledge of the traits of the procured lithic materials. At the quarries, they break the nodules in order to evaluate their quality and size, searching for clear and smooth material. They leave the knapping process itself to their homes. The acquired pieces are carried, in most cases, within their skirts, with the edges of the skirts tucked into their waistbands.

The social and symbolic role of stone tools among recent hunter-gatherers is also of note. Lithic sources are often integrated into the cosmological worldviews of stone-using hunter-gatherers (e.g. Arthur 2010; Brumm 2004; Davidson *et al.* 2005; Taçon 2008). According to Gould (1977), for example, Western Desert Aboriginal groups in Australia quarry stone in totemic 'dreaming' places, which are considered sacred places, associated with their ancestors. In Northern Australia Aboriginal groups consider stone tools as responsive, often dangerous, ritual matters, made of the Ancestors who have transformed into rocks (Brumm 2004).

McBryde (1986) demonstrated, based on the distribution of axes throughout the Southern Australia landscape, that greenstone from Mt Williams was preferred for the production of axes over other comparable materials. This suggests that axes had a unique symbolic role for Aboriginal groups in Southeastern Australia, which goes beyond straightforward economic reasoning, but, rather, involves complex social relations between groups. Brumm (2010) further demonstrated that, based on local oral traditions, Mt Williams indeed had a special role in the local mythology, as it fills its axes with great power. Thus, Brumm suggests that the manufacture and exchange of stone axes in Southeastern Australia is embedded in Aboriginal cosmological beliefs related to the symbolic significance of certain places throughout the landscape, and to their connection to ancestral forces.

The procurement of natural resources is well-embedded within the social and cosmological worldviews of Peruvian and Bolivian indigenous Quechua-speaking societies as well (Salas-Carreño 2017). According to Salas-Carreño, indigenous Andean groups view mountains as intentional agents that act as vital members of society. Thus, underground mining of minerals is perceived as an offensive activity which threatens the well-being and fertility of the mined mountain, and its ability to provide food and sustain life. Therefore, when these groups became involved in the mining of underground resources, they performed practices involving the giving of goods to the earth-beings from whom the minerals have been extracted, in the form of food, coca and alcohol.

It seems, then, that the procurement of lithic materials among recent indigenous societies is a complex process, often involving social and cosmological considerations, alongside economic ones. Such considerations, which might have existed in prehistoric times as well, often do not leave physical traces. Therefore, it is hard to ascertain the exact nature and expressions of these considerations in prehistory. They should, however, be included when discussing lithic-related behaviours among past societies.

Lithic direct procurement versus embedded procurement

Lithic raw material procurement strategies are often divided in a dichotomic manner into two main types: direct procurement, which is the forming of forays aimed specifically towards the acquisition of lithic materials; and embedded procurement, in which lithic materials acquisition is integrated into other subsistence activities (Binford 1977, 1979, 1980). The dominance of local lithic materials within archaeological assemblages was interpreted by Binford (1979, 1980) as the reflection of the application of embedded procurement, while selectivity in raw materials preferences, as well as significant presence of distant materials, are occasionally associated with the direct procurement of lithic materials (e.g. Ekshtain *et al.* 2014; Lengyel 2015).

Therefore, in order to better understand the way prehistoric societies procured lithic materials for tool production, we must first explore the history of research concerning lithic procurement strategies. This section presents the many different views of various scholars discussing the issue of embedded versus direct procurement throughout time, and presents some of the main terms and opinions.

Lewis Binford (1979) was one of the first to approach the issue of embedded versus direct procurement. Based on data retrieved from his extensive Nunamiut research, he claimed that the procurement of lithic materials is usually embedded in other subsistence activities. 'Very rarely', he wrote, 'and then only when things have gone wrong, does one go out into the environment for the express and exclusive purpose of obtaining raw material for tools' (1979:259). He claimed that lithic materials are 'normally obtained incidentally to the execution of basic subsistence tasks' (Binford 1979:259), and suggested that an embedded procurement strategy saves the costs of the journey to the different lithic sources, 'since this distance would have been traveled anyway' (Binford 1979:260). Moreover, Binford suggested that the composition of lithic assemblages is entirely controlled by other subsistence activities.

Based on studies of Western Desert Aboriginal groups in Australia, Gould and Saggers (1985) generally agreed with Binford's view 'that raw material procurement by mobile hunter-gatherers occurred incidentally in relation to other subsistence activities' (Gould and Saggers 1985:117), but also provided some insights suggesting otherwise. According to Gould and Saggers, Aboriginal groups differ from the Nunamiut studied by Binford by the 'clear and openly stated primary goals of these [lithic] resource-procurement trips and the fact that they occurred frequently and not simply during emergencies or at times when the raw materials were scarce' (Gould and Saggers 1985:120). Furthermore, they described task-specific journeys aimed at the procurement of distant lithic materials which are mechanically less efficient than the local materials, implying a more complex set of considerations.

Seeman (1994) further supported the view of direct procurement of lithic materials. Based on a study on Early Paleoindians in North America, he suggests that the data 'are consistent with a lithic-procurement model emphasizing multiple strategies, and which included the 'disembedded' supply of large sites in some situations' (Seeman 1994:284).

A major indication often used in the evaluation of raw material procurement strategies is the relative proportions of local and non-local materials. The dominance of local raw materials is often attributed to embedded procurement, while a pronounced presence of non-local materials is associated with direct procurement. The presence of small amounts of non-local lithic materials in archaeological assemblages, on the other hand, has been generally interpreted as the application of embedded lithic procurement strategies (Delage 2007).

Binford (1980) suggested a separation between two mobility patterns: logistic mobility, and residential mobility. According to Binford, logistic mobility is the movement of individuals or small groups from their home base towards resources, while residential mobility is the movement of entire groups from one camp to another. Kelly (1983) suggested a connection between the lengths of logistic movements and the duration of occupation at a certain site. During long occupations, he claimed, resources in the vicinity of a site tend to deplete. As a result, longer logistic trips are required, in order to reach other useable resources. However, Kelly (1983) argued that the association of logistic movements and direct procurement is not as clear-cut as usually suggested. Rather, logistic forays, he claimed, often include the acquisition of other resources, in addition to the 'declared' ones. The presence of non-local materials was also suggested to be related, at least in some cases, to long-distance social networks (e.g. Gould and Saggers 1985).

It is often suggested that the acquisition and transportation of any resources to archaeological sites should be measured by cost-effectiveness considerations. Optimal foraging theories (e.g. Arroyo 2009; Jeske 1992) and central-place foraging models (e.g. Beck *et al.* 2002; Hodder and Orton 1976) are strongly related to such views. Bamforth (1986), for example, emphasizes the importance of efficiency in procurement and production of stone tools, suggesting that these activities should be 'time-efficient'. According to Bamforth, the procurement and manufacture of lithic artifacts should be 'integrated into cultural behavior as a whole' (Bamforth 1986:39). Similar notions regarding the importance of efficiency in lithic procurement have been made by other scholars as well (e.g. Beck *et al.* 2002; Elston 1992; Jeske 1992; Torrence 1989). Later on, however, Bamforth (2006) also claimed that even if procurement of lithic materials is indeed embedded in other activities, it may nonetheless be a costly process, and a planned-in-advance one, if, for example, quarrying or mining are required.

Andrefsky (1994) argues that Aboriginal groups have been known to travel great distances in order to procure tool-quality lithic raw materials. However, he further explains that whenever lithic raw materials were abundantly available in the vicinity of habitation camps, the Aboriginal groups tended to use the available materials for production of all types of tools, as the ease of procurement outweighs, in his view, any other factor.

Generally, availability is often strongly connected to lithic provisioning strategies (e.g. Bamforth 1986; Dibble and Rolland 1992; Hiscock 2009). However, as there was probably no shortage of flint in the Levant during Paleolithic times (Bar-Yosef 1991), availability cannot be used as a sole, or even a main, explanation for the formation of Levantine Paleolithic lithic assemblages.

Random movements throughout the landscape for purposes of resource procurement, called 'Lévy Walks' (e.g. Hong *et al.* 2008; Raichlen *et al.* 2014; Rhee *et al.* 2011), are occasionally suggested for both prehistoric groups and modern hunter-gatherers. This pattern of movement is commonly associated with a wide range of animal species (e.g. Dai *et al.* 2007; Schreier and Grove 2010). Generally, Lévy walks are referred to in scenarios according to which foragers are searching for certain resources whose locations are not known in advance, so they have to search in a random pattern (Horwitz and Chazan 2015). Such random movement patterns are claimed to be associated with 'special-purpose activity groups in a logistical foray' (Brantingham 2006:437).

In 2003, Brantingham published a so-called neutral model, reflecting 'random walks', whose results were said to be in accordance with archaeological patterns that he detected. Based on these results, Brantingham suggested that the optimization of foraging strategies might have been performed for resources other than lithic materials, and that 'stone raw material procurement was completely embedded within other foraging activities' (2003: 504). The same assumption was used by Brantingham again in 2006. However, Pop (2016) argued that a revision of Brantingham's neutral model is in order. By reconstructing Brantingham's simulation, with some modifications, Pop suggested that 'while Brantingham's neutral model correctly simulates raw material procurement and transport behaviors, ... it stops short of modeling how such behaviors translate into archaeologically visible patterns' (Pop 2016:33).

Some scholars, on the other hand, attest to the complexity of pin-pointing the use of one specific lithic procurement strategy during prehistory. Kelly claimed, for example, that 'hunter-gatherers rarely leave a residential location in order to accomplish a single task' (1983:298). Speth et al. (2013) argued, based on various ethnographic accounts, that 'hunters and gatherers gained access to non-local materials, including toolstone, in many different ways, embedded procurement involving an entire social group and some form of down-the-line exchange being but two of these' (Speth 2013:118).

Given this cultural, archaeological and geologic background, and the brief review of the relevant ethnographic data presented above, Qesem Cave offers an exciting opportunity to enrich our understanding of prehistoric lithic procurement.

Research goals

The study of flint procurement and exploitation strategies can teach us a great deal about issues such as familiarity with the landscape, mobility patterns, lithic material transportation, and the techno-economic organization of early humans (e.g. Beck *et al.* 2002; Braun *et al.* 2008a, 2008b; Delage 2007; Wilson 2007a, 2007b; Wilson and Browne 2014). Human raw material-related behaviours have therefore been studied in many archaeological contexts in the past few decades (e.g. Beck 2008; Brantingham 2003; Braun *et al.* 2008b; Browne and Wilson 2011; Dibble 1991; Ekshtain *et al.* 2014). However, no detailed studies have been performed thus far for the AYCC of the Levant (but see Druck 2004; Narr and Lass 1995).

Therfore, in this study my goal is to contribute additional information concerning lithic materials, expanding our knowledge concerning patterns of acquisition and exploitation of flint at QC specifically, and by Levantine late Lower Paleolithic societies in general. The rich and well-preserved lithic assemblages of QC serve as an excellent platform for a thorough study of raw materials and their potential geological sources, which may allow a better understanding of human behaviour at this important AYCC site.

This work assumes, first of all, that the frequency of flint types within archaeological lithic assemblages can provide data about human lithic preferences in prehistoric times. Several studies dealing with lithic material procurement and exploitation have shown that early humans demonstrated selectivity in raw material choices as early as during the Oldowan (e.g. Braun *et al.* 2008a, 2009; Goldman-Neuman and Hovers 2012). Thus, it is not unlikely that the types of flint in the lithic assemblages at QC reflect specific patterns of preference, resulting from a series of complex considerations, such as the quality of flint, its morphological features (i.e. size, shape, angularity, etc.), and, of course, its availability. The main objective of this study is, therefore, to identify and define these patterns of procurement and exploitation, and to determine some of their possible implications concerning the behaviour of AYCC hominins.

A second assumption is that the archaeological records of the AYCC in general, and that of QC in particular, reflect innovative cultural behaviours, as reflected by the systematic production of blades and Quina scrapers, the habitual use of fire, the procurement of flint from primary sources, and more. Therefore, a better understanding of the flint choices of the QC hominins may help us to assess the considerations that led these people to act in some ways, and to reconstruct their processes of lithic techno-economic planning. Furthermore, the possible intra-site diachronic change and synchronic variation in raw material choices may enhance our understanding of cultural, behavioural and technological processes that took place in the Levant during this significant period.

In order to deal with these issues, this study uses a macroscopic evaluation of flint types, a geologic survey of potential flint sources, a petrographic analysis of flint thin sections of both archaeological and geologic samples, and, to a limited extent, a geochemical analysis of archaeological and geologic samples. In addition, a blind test was performed to evaluate and improve the reliability of the macroscopic classification. Each of these methods is described in detail in the Methodology chapter.