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Flint Procurement and Exploitation Strategies in the Late Lower Paleolithic Levant: the case of Acheulo-Yabrudian Qesem Cave

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by

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Chapter 1: Introduction

1. 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 PhD study 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.

1.1. The Archaeological Contexts

The Acheulo-Yabrudian site of Qesem Cave stands at the center of this study (Fig. 1). In addition, two Late Acheulian Levantine sites, Revadim and Jaljulia, used as comparative cases, are presented and analyzed here to a limited extent. The following section describes the Acheulo-Yabrudian Cultural Complex (AYCC) and QC in detail, and provides short overviews of the Levantine Acheulian cultural complex, and of the sites Revadim and Jaljulia. I start from the older cultural complex, the Acheulian, and the sites of Revadim and Jaljulia, and continue with the later AYCC and QC.

Fig. 1. Qesem Cave and other relevant archaeological sites, divided into Acheulo-Yabrudian sites and Acheulian sites.

1.2. The Acheulian Cultural Complex

The Acheulian is the main cultural entity associated with the Lower Paleolithic of the Levant, dated to between 1.5 to 0.4 mya, and usually attributed to *Homo erectus* (sensu lato) (Bar-Yosef and Belmaker, 2011). Acheulian lithic assemblages are usually characterized by the production of flakes and flake-tools, accompanied, in variable proportions, by the manufacture of bifaces, known as handaxes, or Large Cutting Tools (e.g., Barkai, 2009; Bar-Yosef et al., 1993; Lycett and Gowlett, 2008; Machin, 2009; Sharon, 2009, 2010). In recent years, the systematic production of small flakes (smaller than 2-3 cm) from old "parent" flakes, mostly by means of lithic recycling, but possibly also as part of what is known as "ramification", has also been detected in Acheulian sites (e.g., Agam et al., 2015; Aureli et al., 2015, 2016; Barsky et al., 2015; Chazan, 2013; Santucci et al., 2016; Zaidner, 2013), suggesting that this component should also be considered as an integral part of the Acheulian repertoire, alongside the production of large flakes (e.g., Mishra et al., 2010; Sharon, 2007, 2008, 2010; Shipton et al., 2014).

Acheulian faunal assemblages are characterized by the dominance of large and medium-sized mammals, including deer, bovids, equids, and wild boar (e.g., Rabinovich and Biton, 2011; Ronen et al., 1998; Tchernov et al., 1994). In addition, megafauna, including hippopotamus, rhinoceros and especially elephants, also appear in notable proportions within Acheulian faunal assemblages (e.g., Goren-Inbar et al., 1994; Rabinovich et al., 2012; Tchernov et al., 1994). The repeated association of elephants and handaxes during the Acheulian is of special interest (Boschian and Saccà, 2015; Finkel and Barkai, 2018; Goren-Inbar et al., 1994; Solodenko et al., 2015).

The Acheulian cultural complex is commonly referred to as a stagnant cultural entity, with relatively few behavioral and technological changes in comparison to later periods (Bar-Yosef, 1994, 2006). However, while persistence of traditional ways does appear to be the norm during the Acheulian to a certain degree, especially concerning the production of handaxes (see below), this may reflect the suitability of Acheulian technologies to Lower Paleolithic lifeways, rather than being a limiting factor (Hopkinson et al., 2013). Moreover, significant transformations in human behaviour (such as the use of fire, colonization of new landscapes, big-game hunting and more) as well as diversity and variability in lithic technology (e.g., the development and adoption of ~~the ~~a proto-Levallois ~~method~~production, systematic lithic recycling, the use of soft hammers) have been identified throughout the Acheulian and particularly towards the end of the Lower Paleolithic period (e.g., Hopkinson et al., 2013; Nowell and White, 2010).

1.2.1. Handaxes

Handaxes are bifacially knapped and shaped artifacts, which are considered the hallmark of the Acheulian cultural complex. They repeatedly appear throughout the entire Old World, starting from 1.8 mya, and until ca. 200,000 years ago in the Levant, with the emergence of the Levantine Middle Paleolithic Mousterian, and even later in Europe. Due to the fact that they continuously present the same general morphology, using the same production technology, they are often viewed as the expression of a technological stagnation (e.g., Elias, 2012; Renfrew and Morley, 2009). However, while there are some general traits appearing in all handaxes, at least to some extent, handaxes vary widely in terms of size, shape, applied technology, the type of the selected blank, and degree of regularity (Wynn and Gowlett, 2018). It should also be noted that the production of handaxes was accompanied by several technological innovations, such as the development and adoption of the Levallois method (Adler et al. 2014; Nowell and White, 2010), and the production of small flakes by means of lithic recycling (e.g., Agam et al., 2015; Shimelmitz, 2015). These innovations, however, were not as widely distributed in time and space as the Acheulian handaxes (Finkel and Barkai, 2018).

While the nature of the function(s) for which handaxes were used is still debated, Wynn and Gowlett (2018) describe the form of the handaxes as being "over-determined", meaning that the Acheulian knappers invested more effort in the shaping of the handaxes than was necessary for their functionality. This suggests that there are considerations other than functionality affecting the manufacture of handaxes.

~~Within the AYCC, handaxes are found mostly in the Acheulo-Yabrudian industry (alongside the production of flakes). They are, however, also found, in lower proportions, in Amudian contexts at AYCC sites, such as Qesem Cave, Tabun Cave and Yabrud I (Barkai et al., 2013). Handaxes disappear from the archaeological record of the Levant with the emergence of the Levantine Middle Paleolithic Mousterian some 200,000 ago (Falguères et al., 2016; Mercier and Valladas, 2003; Valladas et al., 2013).~~

~~*1.2.3.*~~*1.2.2.* ***Revadim***

Revadim Quarry is an open-air site located on the southern Coastal Plain of Israel, ~40 km southeast of Tel Aviv, within the Mediterranean vegetation belt, at an elevation of 71-73 m above sea level (Fig. 1; Marder et al., 1999). Four seasons of excavation were conducted during the years 1996-2004 on behalf of the Israel Antiquities Authority and the Hebrew University of Jerusalem, under the direction of O. Marder (Marder et al., 1999, 2011).

The site was preliminarily dated by paleomagnetic analyses of the geological sequence, showing normal polarity, indicating that the entire sequence is younger than 780,000 years (Marder et al., 2011). Additionally, Uranium series dating of carbonates covering flint artifacts was carried out, dating them to between 300,000 and 500,000 years ago (Malinsky-Buller et al. 2011a), providing a minimum age for these artifacts. The lithic assemblages are strongly dominated by flakes and flake-tools, in addition to a notable handaxes component (Agam et al., 2015; Barkai and Marder, 2010). Also, prepared cores were found within the site's assemblages, including both ~~the~~ proto-Levallois ~~method~~ production and the Discoid method (T. Rosenberg-Yefet, personal communication). Based on the lithic and faunal assemblages, and supported by the radiometric dates, the entire anthropogenic assemblage is assigned to the Late Acheulian of the Levant (Marder et al., 2011; Rabinovich et al., 2012). Revadim's faunal assemblage includes thousands of animal bones, dominated by *Palaeoloxodon antiquus*, *Bos primigenius*, and *Dama cf. mesopotamica*, in addition to other mammalian species and micro-vertebrates (Rabinovich et al., 2012). Cut marks were identified on two ribs and the scapula of a straight-tusked elephant, indicating that elephants were butchered at the site. Of special note are elephant bones shaped as tools (Rabinovich et al., 2012).

The excavations at the site focused primarily on Areas B and C. In total, seven archaeological layers were exposed, labelled A through G (Marder et al., 2006). Area C was divided into two sub-areas: C East and C West, located 8 m apart (Malinsky-Buller et al., 2011b). In Area C West, which covers an area of 33 m^2, five superimposed archaeological layers were exposed, labelled C1 to C5, from top to bottom (Malinsky-Buller et al., 2011a). Layer C3 in Area C West, the layer used in this current study, is the densest layer at the site, in terms of both flint artifacts and bones (Marder et al., 2006). The density of lithic artifacts in Layer C3 is 5,316 items per 1 m^3 (Agam and Barkai, 2018a).

Residue and use-wear analyses of items from Area B at the site revealed use-signs as well as fat residues on a handaxe and a scraper, found in association with the remains of a butchered elephant (Solodenko et al., 2015). These results provide some of the earliest direct evidence for meat and hide processing and consumption by early humans in the Levant.

~~1.2.4.~~1.2.3. *Jaljulia*

Jaljulia is a newly discovered Late Acheulian site, located between the towns of Jaljulia and Yarhiv, in the Central District of Israel (Shemer et al., 2018). Two seasons of excavation at the site in 2017, directed by M. Shemer of the Israel Antiquities Authority, revealed rich archaeological layers, containing a plethora of flint artifacts, along with a few isolated animal bones: these were concentrated solely in Area D, and have not been analyzed to date. The archaeological deposits, found at depths varying between 2 and 5 meters below the modern surface, are estimated to spread over an area of at least 10 hectares, representing a dynamic fluvial depositional environment. An ancient stream, possibly related to the adjacent Wadi Qanah, came from the mountains to the east of the site, creating a flood-plain. Water activity was identified throughout the geological sections, implying a transition between a slowly flowing fluvial environment and a swamp (Shemer et al., 2018).

The environment surrounding the site offered a favorable locality for the activity of early hominins, as is indicated by the vast distribution of archaeological deposits, which are currently considered to be the result of several repeated occupations, possibly over a long period of time. Six areas, labelled A through G, extending over ca. 60 sq. meters, were excavated at the site. In Area G multiple horizons were revealed.

A preliminary analysis of the lithic assemblages indicates that they are composed mainly of flakes and flake tools, with a significant component of handaxes, and a notable presence of prepared cores. These prepared cores reflect the application of both the Levallois method and the Discoid method (T. Rosenberg-Yefet, personal communication). The characteristics of the lithic assemblages have led to the preliminary assignment of Jaljulia to the Late Acheulian, while chronometric dating results are still pending.

1.3. 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 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~~significant innovations~~, 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 (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 controlled 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 known only from the Acheulian site of Gesher Benot Ya'aqov (Alperson-Afil, 2008; Alperson-Afil et al., 2007; Goren-Inbar et al., 2004). The ~~nature of use of this~~function of fire at the site, however, is as yet undetermined. 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* (Zeitoun, 2001; Freidline et al., 2012). 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, and more cognitively capable hominins emerged.

1.3.1. Amudian Laminar Production

The systematic production of blades should be viewed as a local AYCC innovation~~, which was later replaced by the Levallois method~~ (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).

1.3.2. 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,b).

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,b). 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,b).

1.3.3. Handaxes in the Acheulo-Yabrudian Cultural Complex

Handaxes are considered to be the *fossile directeur* of the 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 Qesem Cave, 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), ~~and~~ 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 (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.

1.4. 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. (Fig. 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).

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).

1.4.1. 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 (Stiner et al., 2009, 2011; Blasco et al., 2016a). 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). 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).

1.4.2. *The Lithic Industries of Qesem Cave*

QC is characterized by rich and dense lithic assemblages, with up to 6,100 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 (Barkai and Gopher, 2016).

1.4.2.1. *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.

1.4.2.2. 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 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.

1.4.2.3. 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. It should be mentioned here that 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).

1.4.3. 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).

1.4.4. 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).

In addition, 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 we have identified some more, 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).

1.5. Geological Background

1.5.1. 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).

1.5.2. 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 scholars 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).

1.5.3. 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).

1.5.4. 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).

1.5.5. 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.

1.5.6. The Geo-settings of the Qesem Cave~~The Geology of the region~~

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 (Fig. 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).

1.5.7. 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; Fig. 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 ~~locate the site at~~inhabit this cave. The exploitation of secondary flint sources does not require any quarrying or mining activity, and flint could be readily 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.

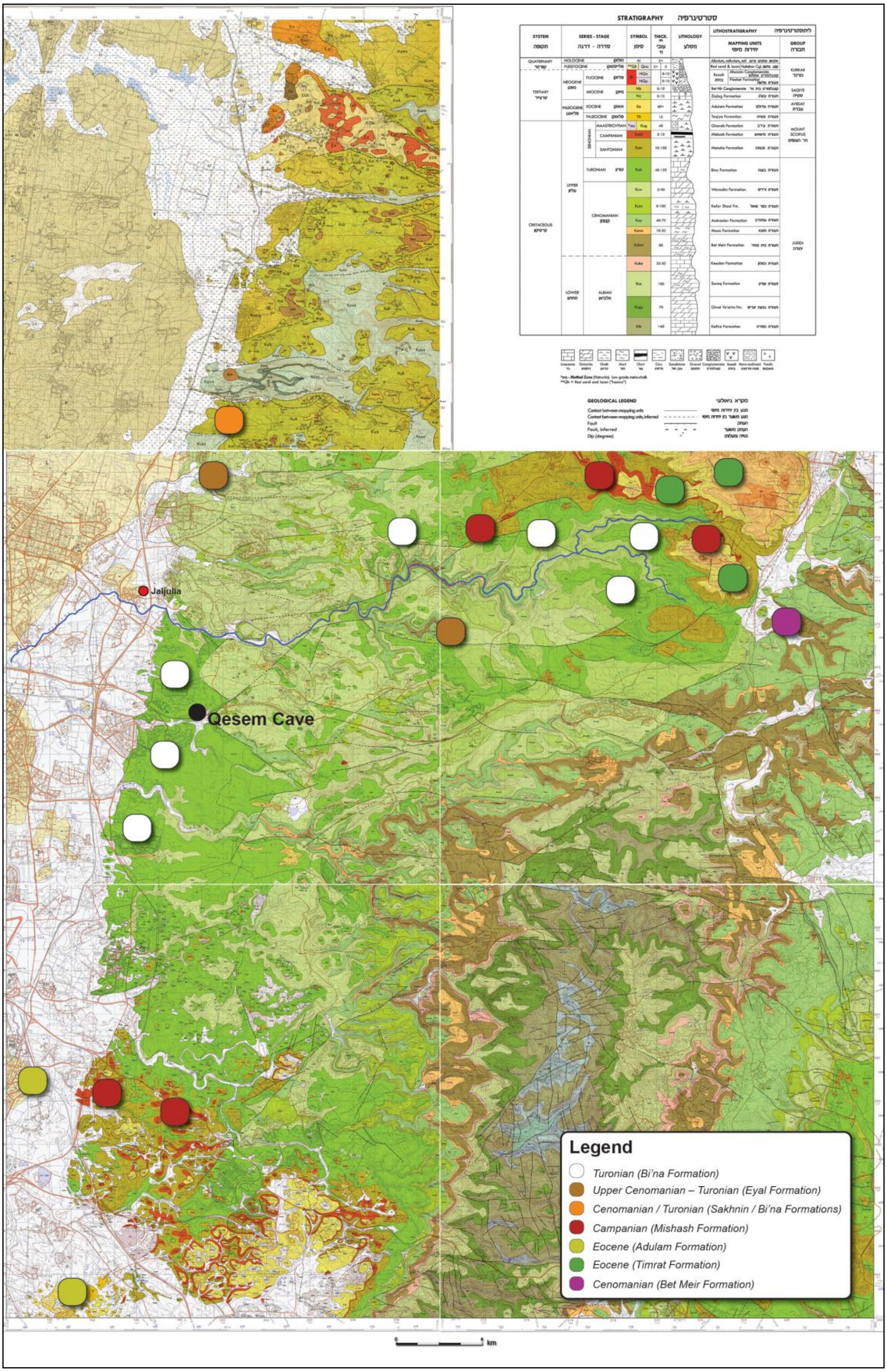

Fig. 2. Flint-bearing outcrops around QC.

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). In addition, 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, we 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).

1.6. Archaeological Raw Material Studies

1.6.1. 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 our visual classification scheme.

1.6.2. 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,b, 2009; Goldman-Neuman and Hovers, 2012), Europe (e.g., Browne and Wilson, 2011; Doronicheva et al., 2016; Kuhn, 2004, 2011; Wilson, 2007a,b; 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, sub-spheroids 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 ~~another Acheulian~~ site, the exploitation of secondary sources was suggested, based on a significant degree of erosion of the flint cortex (Zaidner, 2003, 2014). 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, 2018a), 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, 2018a).

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.

In a yet-unpublished work, we (A. Agam, L. Wilson, A. Gopher and R. Barkai) examined of flint procurement and use in the Neolithic to Early Bronze Age site of Ein Zippori (Lower Galilee, Israel). Using visual identifications and thin-section analysis, we saw that while Ein Zippori is located at an abundant source of flint, which was abundantly used, the assemblages also contain flint from more distant sources. We also identified differences in use of flint types by tool type and through time, which indicate some selectivity in flint choices, even for flint from local sources.

1.7. 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 certain 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 aborigines in Australia quarry stone in totemic "dreaming" places, which are considered sacred places, associated with their ancestors. In Northern Australia aborigines 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. Thus, 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.

1.8. 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 (Binford, 1979, 1980), 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 Aborigines 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, the Aborigines 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) argued that aboriginal groups have been known to travel great distances in order to procure tool-quality lithic raw materials. However, he further explained that whenever lithic raw materials were abundantly available in the vicinity of habitation camps, the aborigines 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 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 (2015) 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. I now present my own study, starting with the goals of this research.

1.9. 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,b; Delage, 2007; Wilson, 2007a,b; 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).

Thus, 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 certain 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 certain 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.

Chapter 2: Materials and Methods

2. Materials

The lithic assemblages of QC are rich in flint artifacts. Artifact density in some of the assemblages reaches more than 6,100 items per $1m^3$ (Gopher et al., 2016). The flint used for the manufacture of these artifacts may have come from various potential flint sources near QC and beyond (Wilson et al., 2016). Moreover, flint types from different geologic sources, possibly with different visual/mechanical traits, may have been used in different ways, affected by a variety of considerations. Thus, understanding the strategies of procurement and exploitation of these different flint types may shed light on issues related to the preferences of the QC hominins, their patterns of movement throughout the land, and the different relations between the QC hominins and their lithics. The following section describes the materials and research methods applied in this study.

2.1. The Selected Assemblages

In this research, 12 different lithic assemblages from various contexts at QC were analyzed (Tables 1 and 2), with between 455 and 2,790 artifacts from each assemblage classified into flint types, using selection and classification procedures described in detail below. In total, 21,102 artifacts were analyzed. In this study the term *débitage* includes the following categories: flakes, primary flakes, naturally backed knives, core trimming elements, recycled items (Cores-on-Flakes) and recycling products (the blanks produced from these Cores-on-Flakes), primary blades, blades, cores, special spalls (which include burin spalls, bifacial spalls, scraper spalls and tool spalls), and bladelets. Shaped items were also analyzed and are included in all of the studied assemblages. The debris category, which was not analyzed, includes chunks, chips, and micro flakes.

Table 1: The assemblages analyzed, the sample size (number of items), sediment volume, and artifact density.

Num.	**Assemblage**	**Affiliation**	**Size of Sample**	**Size of *débitage****	**% of *débitage** analyzed**	**Sediment Volume (m^3)**	**References**
1	Top Level Amudian	Amudian	2,654	2,904	91.4%	46.33	-
2	Top Level Yabrudian	Yabrudian	455	459	99.1%	4.58	-
3	K-10	Amudian	965	1,270	76.0%	0.80	Assaf, 2014; Assaf et al., 2016; Barkai et al., 2009
4	Hearth	Amudian	2,092	3,323	63.0%	1.73	Blasco et al., 2014, 2016a; Falguères et al., 2016; Shahack-Gross et al., 2014
5	South of hearth	Amudian	2,648	2,884	91.8%	2.20	Blasco et al., 2016a
6	G-19/20	Amudian	1,558	1,568	99.4%	1.50	Assaf, 2014; Assaf et al., 2015; Barkai et al., 2005, 2009; Shimelmitz , 2009; Shimelmitz et al., 2011
7	South-Western Yabrudian	Yabrudian	1,306	1,389	94.0%	2.40	-
8	The Southern Area	Amudian	2,094	6,145	34.1%	5.81	Assaf, 2014; Assaf et al., 2015, 2016
9	Yabrudian Below the Shelf	Yabrudian	1,971	4,292	45.9%	8.48	Falguères et al., 2016; Parush, 2014; Parush et al., 2015, 2016
10	Amudian Below the Shelf	Amudian	1,991	7,389	26.9%	3.46	Falguères et al., 2016; Parush, 2014; Parush et al., 2015, 2016
11	Amudian (Shelf)	Amudian	578	793	72.9%	1.77	-
12	Deep Shelf – Unit I	Yabrudian	2,790	3,373	82.7%	4.16	-
	Total	-	**21,102**			**83.22**	-

* including shaped items.

Table 2: A breakdown of the analyzed assemblages by technological categories.

Number	Assemblage	Flakes	Shaped items	Cortical Flakes[1]	Naturally Backed Knives	Core Trimming Elements	Recycled Items[2]	Cortical Blades[1]	Blades	Cores	Special Spalls[3]	Bladelets[4]	Total
1	Top Level Amudian	1132 (42.7%)	345 (13.0%)	437 (16.5%)	148 (5.6%)	154 (5.8%)	16 (0.6%)	104 (3.9%)	115 (4.3%)	123 (4.6%)	23 (0.9%)	57 (2.1%)	2654 (100%)
2	Top Level Yabrudian	168 (36.9%)	108 (23.7%)	54 (11.9%)	14 (3.1%)	25 (5.5%)	29 (6.4%)	14 (3.1%)	14 (3.1%)	9 (2.0%)	8 (1.8%)	12 (2.6%)	455 (100%)
3	K-10	437 (45.3%)	121 (12.5%)	95 (9.8%)	77 (8.0%)	65 (6.7%)	0 (0.0%)	2 (0.2%)	97 (10.1%)	18 (1.9%)	7 (0.7%)	46 (4.8%)	965 (100%)
4	Hearth	514 (24.6%)	149 (7.1%)	589 (28.2%)	296 (14.1%)	65 (3.1%)	183 (8.7%)	120 (5.7%)	59 (2.8%)	83 (4.0%)	34 (1.6%)	0 (0.0%)	2092 (100%)
5	South of Hearth	1131 (42.7%)	131 (4.9%)	525 (19.8%)	89 (3.4%)	111 (4.2%)	246 (9.3%)	90 (3.4%)	76 (2.9%)	79 (3.0%)	49 (1.9%)	121 (4.6%)	2648 (100%)
6	G-19/20	277 (17.8%)	535 (34.3%)	101 (6.5%)	20 (1.3%)	114 (7.3%)	80 (5.1%)	134 (8.6%)	195 (12.5%)	45 (2.9%)	28 (1.8%)	29 (1.9%)	1558 (100%)
7	South-Western Yabrudian	537 (41.1%)	255 (19.5%)	140 (10.7%)	88 (6.7%)	55 (4.2%)	88 (6.7%)	20 (1.5%)	48 (3.7%)	38 (2.9%)	28 (2.1%)	9 (0.7%)	1306 (100%)
8	The Southern Area	1042 (49.8%)	159 (7.6%)	335 (16.0%)	125 (6.0%)	257 (12.3%)	0 (0.0%)	36 (1.7%)	39 (1.9%)	88 (4.2%)	0 (0.0%)	13 (0.6%)	2094 (100%)
9	Yabrudian Below the Shelf	358 (18.2%)	645 (32.7%)	189 (9.6%)	298 (15.1%)	159 (8.1%)	190 (9.6%)	0 (0.0%)	0 (0.0%)	42 (2.1%)	90 (4.6%)	0 (0.0%)	1971 (100%)
10	Amudian Below the Shelf	232 (11.7%)	203 (10.2%)	175 (8.8%)	305 (15.3%)	250 (12.6%)	312 (15.7%)	155 (7.8%)	135 (6.8%)	72 (3.6%)	109 (5.5%)	43 (2.2%)	1991 (100%)
11	Amudian (Shelf)	166 (28.7%)	110 (19.0%)	77 (13.3%)	53 (9.2%)	41 (7.1%)	39 (6.7%)	26 (4.5%)	42 (7.3%)	5 (0.9%)	17 (2.9%)	2 (0.3%)	578 (100%)
12	Deep Shelf – Unit I	943 (33.8%)	564 (20.2%)	462 (16.6%)	150 (5.4%)	55 (2.0%)	0 (0.0%)	286 (10.3%)	163 (5.8%)	69 (2.5%)	60 (2.2%)	38 (1.4%)	2790 (100%)
Total		**6937 (32.9%)**	**3325 (15.8%)**	**3179 (15.1%)**	**1663 (7.9%)**	**1351 (6.4%)**	**1183 (5.6%)**	**987 (4.7%)**	**983 (4.7%)**	**671 (3.2%)**	**453 (2.1%)**	**370 (1.8%)**	**21102 (100%)**

[1] Cortical flakes and blades are flakes or blades with at least 30% cortex on their dorsal face.
[2] This category includes Cores-on-Flakes and the blanks produced from Cores-On-Flakes.
[3] The special spalls category includes burin spalls, bifacial spalls, scraper spalls and tool spalls.
[4] Bladelets are defined as artifacts with their length being less than 2 cm, and at least two times their width.

The typo-technological characteristics of all of the selected assemblages had already been analyzed, and most of them have been published (see references in Table 1). They all come from clear, well-dated archaeological layers, from both Amudian and Yabrudian contexts. All categories except debris were examined (see Tables 1 and 2).

According to Holton and Burnett (1997), "*one of the real advantages of quantitative methods is their ability to use smaller groups… to make inferences about larger groups that would be prohibitively expensive to study*" (Holton and Burnett, 1997: 71). Therefore, the question of what sample size can be considered sufficient is crucial, as it can influence the identification of significant differences, relationships or interactions (Peers, 1996). According to Bartlett et al. (2001: Table 1), in the case of categorical data (data which may take on one out of a limited, usually fixed, number of possible values), a sufficient sample size taken from a population size of between 400 and 1,000 may range between 21% and 62%, while samples of populations between 1,000 and 4,000 may range between 5% and 40%. Population sizes between 4,000 and 10,000 require a sample size of between 2.5% and 14%. In this study, the samples taken from the three assemblages smaller than 1,000 artifacts, the Amudian (Shelf) and the Top Level Yabrudian, form 72.9% and 99.1% of the assemblage, respectively; samples from assemblages of between 1,000 and 4,000 pieces range between 26.9% and 99.4%; samples taken from assemblages which are larger than 4,000 artifacts range between 26.9% and 45.9%. Therefore, as all samples are within the suitable size range, all samples taken in this study may be considered sufficient.

Indeed, in some of the assemblages we have a sample size far greater than what is required. In order to eliminate any biases created by these large samples, when analyzing the entire general sample as a whole, each assemblage was normalized and weighed following a calculation derived for this study from the various statistical weighing models (Boonstra, 2004; Börsch-Supan et al., 2004; Schonlau et al., 2004). To accomplish this, the sample from each assemblage received a factor based on the ratio between its size and the size of the sample taken from the Top Level Yabrudian assemblage (n=455), which is the smallest sample included in this study. By this method, the "Top Level Yabrudian" assemblage, for example, got a factor of 1; the next assemblage in line, the Amudian (Shelf), with 578 artifacts, got a factor of 0.79 (455/578=0.79), and so on, bringing each assemblage, when summed up, to a virtual sum of 455 artifacts. In this manner, when values are summed, they are not biased by the proportions of the larger assemblages.

The samples were selected by organizing the boxes of each typo-technological category next to each other, and picking a box arbitrarily, analyzing the entire selected box. As we lacked any indicative data concerning the nature of the artifacts inside the box (other than their typo-technological category), we consider this sampling procedure to be sufficiently random.

All of the selected assemblages originate from secure contexts, and both Amudian and Yabrudian assemblages are represented. In the following paragraphs I describe the assemblages included in this study, organized and numbered from the youngest assemblage to the oldest (Fig. 3). For each assemblage, information concerning stratigraphy, sedimentology and significance is provided.

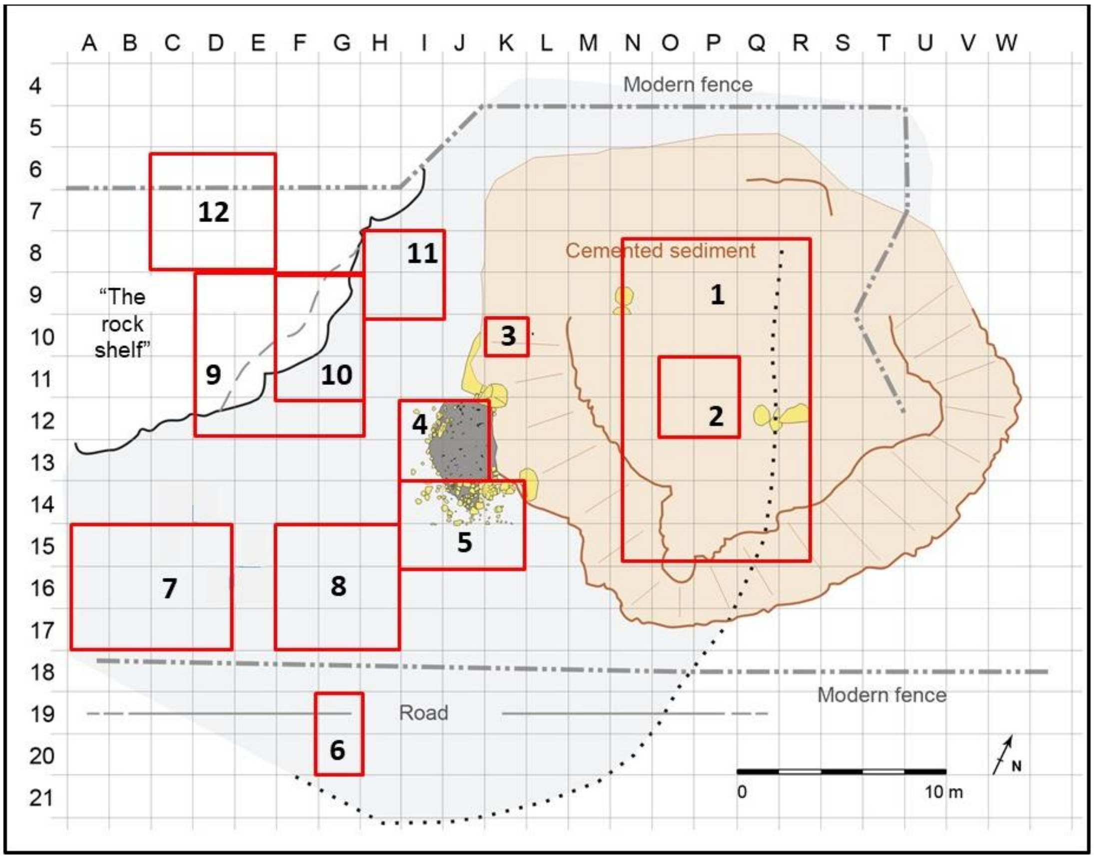

Fig 3. Spatial distribution of the analyzed assemblages (and see details in Tables 1 and 2).

1. Top Level Amudian: The youngest Amudian assemblage excavated at QC, situated at the eastern part of the cave. It includes squares N-R/8-15 at elevations 115 and

200 cm below datum. The sediment is gray-brown with a significant component of cemented sediments (Karkanas et al., 2007). The entire lithic assemblage is composed of 16,310 artifacts (*débitage* and shaped items: 2,904), with 352 artifacts per $1m^3$. This assemblage has not yet been published. Almost all the *débitage* and shaped items (n=2,654; 91.4%) were analyzed for this study. The remaining 8.6% were separated out of the assemblage during earlier studies, and therefore were not analyzed here.

2. Top Level Yabrudian (unit I): This is the youngest Yabrudian assemblage excavated at QC, situated in the eastern part of the cave. It includes squares O-P/11-12 at elevations of between 125 and 170 cm below datum. This layer is a patch of red-brown to gray sediment. The state of preservation of the lithic artifacts found in this layer is not as good as in other areas of the cave, with many of them broken (Y. Parush, personal communication). The entire lithic assemblage is composed of 1,681 artifacts (*débitage* and shaped items: 459), with 367 artifacts per $1m^3$. This assemblage has not yet been published. Almost all of the *débitage* and shaped items (n=455; 99.1%) were analyzed for this study.
3. K-10: This is an Amudian assemblage, in the upper sequence of the cave (Assaf et al., 2016). It includes part of a single excavated square, K-10, at elevations of between 300 and 420 cm below datum. It is dated to about 250,000 years ago (Mercier et al., 2013), and is characterized by a thick (~80 cm) layer of very soft sediments extremely rich in lithic artifacts and fauna embedded between two thick and hard layers of cemented archaeological sediments, which are also rich in finds. It is a "classical" Amudian assemblage, with a high frequency of laminar items (Assaf et al., 2016). The entire assemblage is composed of 4,693 artifacts (*débitage* and shaped items: 1,270), which would equate to 5,866 artifacts per $1m^3$ (Gopher

et al., 2016). A sample of 965 artifacts (76.0% of the *débitage* and shaped items) was analyzed for this study. The rest of the *débitage* and shaped items were not available for analysis.

4. The Hearth: This context represents a series of superimposed, centrally located hearths which were repetitively used as a focus for human activities, starting at least as early as ca. 300,000 years ago (Falguères et al., 2016). The assemblage includes most of the $4m^2$ of the hearth (I-J/12-13). Some of the sub-squares included in this assemblage (I/12a; J/12b; I/13a) do not fully belong to the hearth, while some parts of squares I/14 and J/14, which do belong to the hearth, are not included in this unit, but, rather, were included in the area south of the hearth. These affiliations are the result of them not being separated during fieldwork. The faunal remains from this context were previously analyzed and published by Blasco et al. (2014, 2016). The entire lithic assemblage consists of 10,599 artifacts (*débitage* and shaped items: 3,323), with 6,144 artifacts per $1m^3$ (Gopher et al., 2016). A sample of 2,092 items (63.0% of the *débitage* and shaped items) was analyzed for this study. The rest of the *débitage* and shaped items were not available for analysis.
5. South of Hearth: This assemblage comes from squares I-K/14-15, at elevations of between 545 and 600 cm below datum. This assemblage includes the southern edge of the hearth, in addition to the squares just to the south of it, and has dark-brown sediments. This area is characterized by the presence of large flat rocks in some parts (Shahack-Gross et al. 2014). This assemblage is the closest to the hearth, which was at similar elevations (Gopher et al., 2016). The faunal remains from this context were analyzed and published in Blasco et al. (2016a). The entire lithic assemblage consists of 8,252 artifacts (*débitage*, and shaped items: 2,884),

with 3,751 artifacts per $1m^3$ (Gopher et al., 2016). A random sample of 2,648 items (91.8% of the *débitage* and shaped items) was analyzed for this study.

6. G-19/20: G-19-20 includes squares G-19-20 at elevations of between 525 and 600 cm below datum. This rich assemblage originates from a well-defined stratigraphic horizon which was identified during the 2001 salvage excavation in an area that is now under the modern highway (Figure 1). It is a "classical" Amudian assemblage, with a high frequency of laminar items (Assaf et al., 2016). The entire lithic assemblage consists of 2,560 artifacts (*débitage* and shaped items: 1,568), with 1,707 artifacts per $1m^3$ (Gopher et al., 2016). Almost all of the *débitage* and shaped items (n=1,558; 99.4%) of this assemblage were analyzed for this study. The few missing artifacts (0.6%) were separated out of the assemblage during previous studies, and therefore were not analyzed here.
7. South-Western Yabrudian: The Yabrudian assemblage of the south-western area is stratigraphically distinct, located in squares A-D/15-17, at elevations of between 540 and 630 cm below datum. Its sediments are orange to light brown, and have a significant component of rocks of various sizes. The entire lithic assemblage is composed of 6,225 artifacts (*débitage* and shaped items: 1,389), with 2,594 artifacts per $1m^3$ (Gopher et al., 2016). Almost the entire number of *débitage* and shaped items was analyzed (n=1,306; 94.0% of the *débitage* and shaped items) for this study.
8. The Southern Area: This Amudian assemblage comes from squares F-H/15-17, at elevations of between 590 and 730 cm below datum. It dips from east to west at an approximately 45 degree angle. The assemblage was divided into three stratigraphic/spatial units, all of which are assigned to the Amudian industry. Unit I, “the brown layer”, lies at the bottom, and is composed of thin levels of

compressed dark-brown sediment with a distinctive component of moist clay (Assaf et al., 2016). Some of these levels are rich in microfaunal remains. Unit II, located directly above Unit I, is composed of hard, compressed brown-white sediment. Unit III lies at the western part of the area. It is composed of soft dark-brown sediment mixed with angular rock fragments of various sizes which might represent a roof collapse, or some other post-depositional event. This assemblage contains a high frequency of cores, with lower levels of laminar items and shaped items, compared to other Amudian assemblages (Assaf et al., 2016). A detailed analysis of the assemblage allowed Assaf et al. (2016) to identify different levels of knapping skills, and interpret them as representitive of teaching (knowledge transmission) processes related to flint knapping. The entire lithic assemblage consists of 22,474 artifacts (*débitage* shaped items: 6,145), with 3,868 artifacts per $1m^3$ (Gopher et al., 2016). A random sample of 2,094 items (34.1% of the *débitage* and shaped items) was analyzed for this study.

9. <u>Yabrudian Below the Shelf:</u> The Yabrudian assemblage Below the Shelf, more than 300,000 years old (Falguères et al., 2016), spreads over squares D-G/9-12, at elevations of 520 to 700 cm below datum (Gopher et al., 2016). It is located directly above the Amudian Below the Shelf assemblage, and is composed of a mixture of soft and hard brown sediments (Parush et al., 2016). At the top of this layer is a soft, lighter-coloured sediment, which was almost sterile. In a similar manner to the Amudian Below the Shelf, this layer also dips from northeast to southwest and from south to north. The assemblage has been studied in detail and also provides evidence of systematic lithic recycling (Parush 2014; Parush et al., 2015, 2016). The entire lithic assemblage consists of 10,947 artifacts (*débitage* and shaped items: 4,292), with 1,291 artifacts per $1m^3$ (Gopher et al., 2016). A sample

of 1,971 artifacts (45.9% of the *débitage* and shaped items) was analyzed for this study. The rest of the *débitage* and shaped items were not available for analysis.

10. Amudian Below the Shelf: The large Amudian assemblage from Below the Shelf comes from a thick layer in squares F-G/9-11, at elevations of between 535 and 655 cm below datum. It is older than 300,000 years (Falguères et al., 2016), and stratigraphically distinct, with grey, partially cemented sediments. It is located directly below the Yabrudian Below the Shelf assemblage (Parush et al., 2016) (see below). This layer dips strongly from northeast to southwest and from south to north. The assemblage has been studied in detail, providing evidence of systematic lithic recycling (Parush 2014; Parush et al. 2015, 2016). The entire lithic assemblage consists of 18,315 artifacts (*débitage* and shaped items: 7,389), with 5,293 artifacts per $1m^3$ (Gopher et al., 2016). A random sample of 1,991 artifacts (26.9% of the *débitage* and shaped items) was analyzed for this study.
11. Amudian (Shelf): Another Amudian assemblage from Below the Shelf, older than 300,000 years, came from squares H-I/8-9, at elevations of between 365 and 515 cm below datum. This layer is located above the Amudian Below the Shelf and the Yabrudian Below the Shelf, and was assigned to the base of the upper stratigraphic sequence of the cave (Gopher et al., 2016). The sediment in which the assemblage was found is light brown and cemented. The entire lithic assemblage consists of 2,111 artifacts (*débitage* and shaped items: 793), with 1,193 artifacts per $1m^3$ (Gopher et al., 2016). A sample of 578 artifacts (72.9% of the *débitage* and shaped items) was analyzed for this study. The rest of the *débitage* and shaped items were not available for analysis.
12. Deep Shelf – Unit I: The Rock Shelf area lies in the North-Western part of the cave. This is the oldest assemblage excavated at QC thus far. It is situated at the

northernmost part of the cave, under the rock shelf, and includes squares C-E/6-8 at elevations of between 800 and 1130 cm below datum. The sediments of this layer are dark-brown, moist, with small (up to 10 cm in diameter) and medium (up to 20 cm in diameter) rocks (Y. Parush, personal communication). The entire lithic assemblage is composed of 7,287 artifacts (*débitage* and shaped items: 3,373), with a density of 1,751 artifacts per $1m^3$. This assemblage has not yet been published. A sample of 2,790 items (82.7% of the *débitage* and shaped items) was analyzed for this study.

2.2. The Quina and demi-Quina Scrapers Sample

In addition to the large general sample, another separate sample of 75 Quina scrapers and 133 demi-Quina scrapers, taken from several different contexts at QC (Table 3; Fig. 4), was analyzed, by the same process as that described further below for the general sample. The Quina and demi-Quina scrapers discussed here were previously analyzed by A. Zupancich, who performed a detailed use-wear analysis for his PhD, involving the application of both low and high-power approaches, to investigate both edge damage and micro-wear (see Lemorini et al., 2016; Zupancich et al., 2016a, b). It should be stressed that the scrapers analyzed here do not represent all Quina and demi-Quina scrapers from these assemblages, but, rather, only those randomly selected by A. Zupanchic for his use-wear analysis, out of over 1000 side scrapers of all types that have been found at QC. Also note that the 208 Quina and demi-Quina scrapers which are included in this sample were not included as part of the general sample.

Table 3: The scrapers analyzed: scraper type, assemblage and the industry associated with the assemblage.

Assemblage	**Industry**	**Quina scrapers**	**demi-Quina scrapers**	**Total**
B-F-6-9 740-1135 ("Deep Shelf")	Yabrudian	22	50	72
C-G-7-12 460-725 ("Yabrudian of the Shelf")	Yabrudian	15	18	33
G-6-7 600-780 ("Amudian of the Shelf")	Amudian	11	13	24
H-J-6-7 410-540	Amudian	4	12	16
C-F-13-17 530-650 ("South-Western Yabrudian")	Yabrudian	8	7	15
F-G-9-11 525-685	Amudian		12	12
E-G-8-9 615-800 ("Amudian (Shelf)")	Amudian	6	4	10
I-J-14-16 570-600 ("South of Hearth")	Amudian	3	6	9
I-J-13 575-605 ("Hearth")	Amudian		4	4
G-I 19-22 625-725	Amudian	2	2	4
H-14-16 568-635 ("The Southern Area")	Amudian	2	1	3
O-11-12 145-160 ("Top Level Yabrudian")	Yabrudian		2	2
H-I 8 370-515	Amudian	2		2
K-L 8-10 ("K-10")	Amudian		1	1
H-9 507-515	Amudian		1	1
Total		**75**	**133**	**208**

* The name of an assemblage is provided only if the assemblage is included within the twelve assemblages included in this study

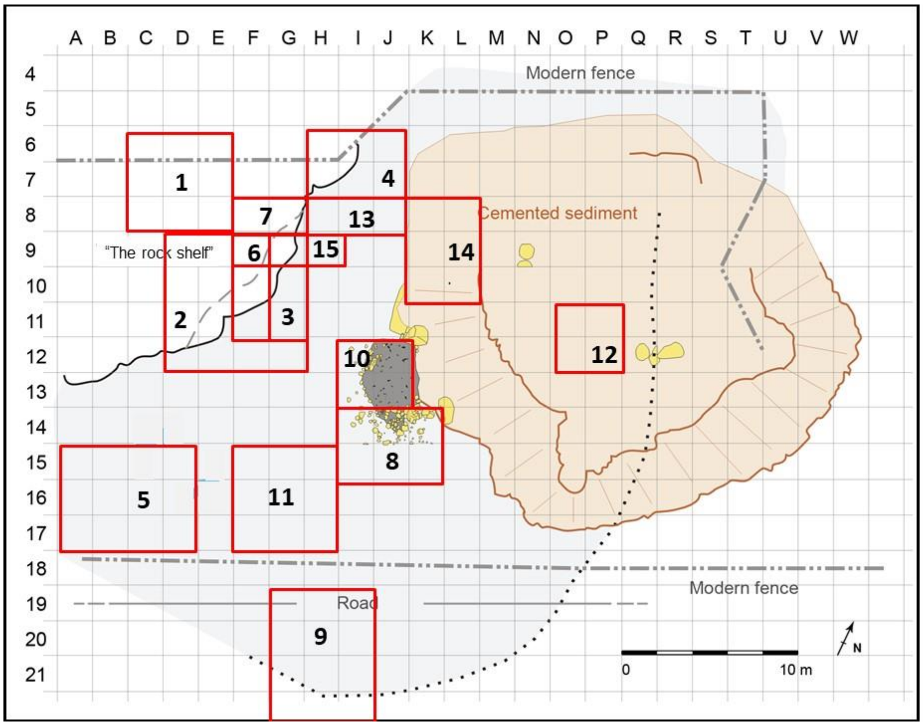

Fig 4. Spatial distribution of the assemblages of the Quina and demi-Quina assemblages (and see details in Table 3).

Scrapers from two assemblages, the Deep Shelf and the Yabrudian of the Shelf, are presented and discussed separately, in addition to their inclusion in the sample of the 208 scrapers presented in Table 3. These two assemblages are located below the rock shelf found within the cave, and are both older than 299 kya (Gopher et al., 2016~~.~~). These are the two oldest Yabrudian assemblages found at the cave to date, and have yielded the highest quantity of Quina and demi-Quina scrapers (n=72 and n=33, respectively).

2.3. The Bifaces Assemblage

The small QC bifaces assemblage includes 17 bifacially knapped artifacts (Table 4; Fig. 5). These artifacts can be divided into four typo-technological sub-groups: handaxes (n=12), bifacial roughouts (n=3), a trihedral (n=1), and a bifacial spall (n=1). These items originate from various assemblages, without any vertical or horizontal clustering. As in the case of the Quina and demi-Quina scrapers, the bifaces are not included in the general sample, but, rather, are analyzed and presented separately. One of the bifaces was previously analyzed and published (Barkai et al., 2013; item number 13 among the bifaces in this current study).

Table 4: The bifaces assemblage of Qesem Cave, with their stratigraphic origin, the assemblage to which they are assigned, and their sub-category.

number	**Square**	**Elevation**	**assemblage**	**Type**
1	I15	605-615	South of Fireplace	handaxe
2	M9	150-160	Northern Section	handaxe
3	Top of cave	-	-	handaxe
4	D12b	650-655	Yabrudian Below the Shelf	handaxe
5	C10d	724-724	-	handaxe
6	D7c	1070-1075	Deep Shelf (Unit I)	handaxe
7	E7c	925-930	Deep Shelf (Unit II)	handaxe
8	I7b	440-448	-	handaxe
9	E21	635-635	Unit V	handaxe
10	D8b	950-955	Deep Shelf (Unit II)	handaxe
11	D16b	570-575	Yabrudian in Southern Area	handaxe
12	P14c	177-177	Top Most Amudian	handaxe
13	J11a	525-530	Gigantic bifacial assemblage	roughout
14	G22	815-815	G-I/19-22	roughout
15	E16a	575-580	South-West Amudian	roughout
16	C7d	1070-1075	Deep Shelf (unit I)	trihedral
17	J11a	520-525	Gigantic bifacial assemblage	bifacial spall

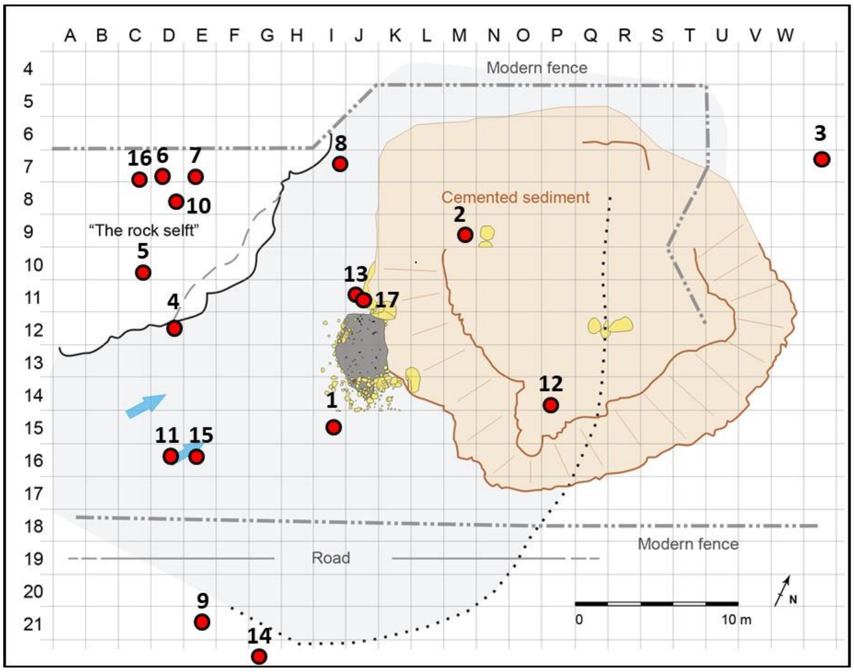

Fig 5. Spatial distribution of the QC bifaces (and see details in Table 4).

2.4. The Samples from the Late Acheulian Sites of Revadim and Jaljulia

In order to be able to view the results of this study on QC in a broader context, a limited analysis was also conducted of assemblages from the Late Acheulian sites of Jaljulia and Revadim (Table 5). This part of the research is aimed at detecting some possible similarities and/or differences (change) between the Late Acheulian of the Levant and the AYCC of QC. Two assemblages from Jaljulia (from Areas B and D) and one from Revadim (Layer C3) were randomly sampled and analyzed, based on the proportions of each typo-technological category, using the same procedure as that described above for QC. The samples studied from each of these Late Acheulian sites were however smaller as they are not the main focus of this study, and they were aimed at providing comparative data and a chronological perspective. For the selection of these random samples, I organized the bags of archaeological material in a row, and picked every third bag, which was fully analyzed, until reaching a sample of at least 200 artifacts from each assemblage (completing the analysis of the final bag), using the same criteria used for QC, based on the same parameters described in detail below.

Table 5: The breakdown of the analyzed samples from Revadim and Jaljulia.

category	Revadim	Jaljulia			
	C3	**B**	**D**	**Total**	**Total**
Shaped Items	167	78	87	165	332
Flakes	100	50	32	82	182
Cortical Flakes	70	18	29	47	117
Cores	47	24	31	55	102
Core Trimming Elements	60	10	6	16	76
Bifaces	12	30	30	60	72
Cores-on-Flakes and their products	94	13	16	29	123
Blades	19	1		1	20
Cortical Blades	14	2	2	4	18
Special Spalls[1]	-	8	-	8	8
Total	**583**	**234**	**233**	**467**	**1050**

[1] Including tool spalls and thinning flakes.

From Layer C3 at Revadim, 583 items were analyzed, out of an assemblage of 28,439 items, including débitage, shaped items and debris, with 18,053 items of *débitage* and shaped items (3.2% of the débitage and shaped items, within the range mentioned above concerning populations of over 4,000). This assemblage was fully analyzed and published in the past, and includes a significant component of small flakes produced by means of lithic recycling (Agam and Barkai, 2018a; Agam et al., 2015).

Jaljulia, which was discovered and excavated during 2017, has not been published to date, and the analysis of the lithic assemblages from Areas B and D is still underway. Thus, we do not yet know the exact size of each assemblage. Area B is currently being typo-technologically analyzed by T. Rosenberg-Yefet and B. Efrati. Out of hundreds of analyzed artifacts from Area B, I analyzed a random sample of

234 artifacts into flint types in the same process as described for Revadim above. The typo-technological analysis of Area D, on the other hand, has not yet started. I therefore selected a random sample out of the dozens of boxes of unsorted lithic material of Area D, by arbitrarily picking boxes of unsorted material, without knowing the nature of their content. I then typo-technologically classified the entire content of the selected boxes, and then classified it into flint types. In total, I analyzed a sample of 233 artifacts from Area D (giving a total sample of 467 artifacts from Jaljulia). As the raw materials analysis of the material from Jaljulia and Revadim is only preliminary at this stage, a sample of 200 artifacts from each assemblage was considered sufficient at this point. Future work will enlarge these samples.

3. Methods

3.1. Macroscopic Classification

At the base of every lithic materials study lies the macroscopic classification of flint artifacts into flint types, based on their visual traits (e.g., Delage, 2001; Ekshtain et al., 2014; Fiers et al., 2019; Milne et al., 2009). It should be stressed right from the beginning that the macroscopic classification of flint is problematic. The broad variation in colours of flint specimens, even within the same geologic sources, and sometimes even within one nodule, in addition to the subjectivity of some of the parameters of the classification process, can strongly affect the results (and see Bustillo et al., 2009; Malyk-Selivanova et al., 1998; Milne et al., 2009). For instance, classification based on colour may be affected by weathering, and may vary in cases where more than one person conducts the classification, or even where the same person performs the analysis under varying light conditions (Browne and Wilson, 2011).

Given all this, macroscopic classification should ideally be used only as the basis for further higher-resolution analysis (e.g., petrographic analysis, geochemical analysis, or both). In order to confront these weaknesses, we performed a blind test aimed at evaluating and improving the reliability of the macroscopic classification process (see the Blind Test chapter below). This is, of course, in addition to the petrographic and geochemical analyses performed during this study, as elaborated below.

In the current study, archaeological material from QC was visually classified into flint types, and labeled alphabetically, by order of identification. At least one example of each flint type was selected and set aside for use in comparing and assigning subsequent pieces to flint types. Also, geologic samples collected from the potential flint sources around the site were visually evaluated. Both groups of samples (archaeological and geologic) were classified following meticulous procedures, as described below.

In addition, each item analyzed was weighed. As some of the assemblages were sampled rather than being fully analyzed (see description above), weight was used to reflect only the proportion of each flint type within the assemblage, and not the total amount brought to the cave.

Different flint types are defined in this study by the presence of distinctive morphological and visual features. The visible traits of flint are defined as those visible to the human eye, either with or without magnification (Luedtke, 1992: 59). The differences in colour, texture, fossil presence and other visual characteristics are in many cases the expression of different geologic origins (Allan and Bolton, 2017; Malyk-Selivanova et al., 1998; Milne et al., 2009). Furthermore, texture, shape and structure may influence the quality and degree of flakeability of a flint piece (Bustillo et al., 2009), and thus its attractiveness and the likelihood of it being chosen for knapping by prehistoric people.

It should be stressed that as a first step of this study the analyzed material was divided into as many flint types as possible. This is done in the full knowledge that many of the types will turn out to be merely variants of each other. However, we did this for two main reasons. First of all, noting every variation avoids the danger of combining types which should be kept separate. Variants can be easily added together later, but cannot be separated without repeating the identification work. Secondly, creating a maximum number of types allows us to preserve information concerning the variety of flint brought to the site which might have been of importance to the early hominins we study. The different flint types were then grouped, based on common traits (e.g., stripes, circles, specific fossils, etc.).

3.1.1. Criteria for Macroscopic Classification

The classification of the archaeological artifacts into flint types was based on macroscopic visual characteristics, with the use of a 10X hand lens, taking into consideration the following characteristics:

1. Colour: The colour of flint, caused by the impurities within it, as well as by its chemical composition and physical structure, is one of the most obvious characteristics of a flint type (Luedtke, 1992: 61), allowing, at least in some cases, for certain flint types to be traced back to potential geologic sources. As this parameter tends to be affected by weathering processes and burning, we were careful to distinguish between flint types based on variations between hues. We identified the basic colour of the examined samples, the variation in hues (dark/medium/pale), and indicated the presence of patinated surfaces. We

also took into consideration any indications of burning, which influences the colour of the specimens.

2. Texture: This trait refers to both the size of quartz grains within the examined piece and the organisation of the grains. Since flint is essentially microcrystalline quartz, its grains are usually less than 0.05 mm in size, and therefore cannot be detected by the naked eye (Luedtke, 1992: 65). Flint may also contain spots, stripes or zones of more coarsely crystalline quartz, including grains up to a size which can be seen by the naked eye. The texture of an examined artifact is influenced by its porosity (with a porous flint defined as coarse-textured), and by the presence or absence of macroscopically visible clusters of macro-quartz, or any other substances (Luedtke, 1992: 65). In this study I use the appearance (how even or uneven it looks) and the feel of a surface (how smooth it is) of a specimen to evaluate the texture of a flint type, divided into three values: fine-textured, medium-textured, and coarse-textured.
3. Size and shape of the nodule: In some of the cases, the original size and shape of the nodule can be determined, which can be used to assign the flint to its geologic origin (e.g., rounded, flat, elongated, amorphous).
4. Homogeneity: The homogeneity of flint, in terms of both colour and texture, is the result of the absence of impurities. Here it is divided into three sub-groups: homogenous (without any macroscopically visible impurities), moderately homogenous (with minor macroscopically visible impurities), and heterogeneous (with major macroscopically visible impurities).
5. Translucency: translucency is the degree to which light goes through a material without being absorbed or reflected (Luedtke, 1992: 63). This value is

also affected by the presence and distribution of impurities within the flint. Based on Luedtke's definition (1992: 63), a material is considered translucent if some light passes through it (as opposed to "transparent", through which all light passes). Here we define flint types as semi-translucent in cases in which very little light passes through; and opaque, in cases of flint types which do not allow any light to pass through. It should be noted that the degree of translucency is affected by the thickness of the piece examined (Luedtke, 1992: 63).

6. Traits of cortex: The cortex is the outer surface of the nodule, between the flint and its enclosing limestone matrix. The cortex of flint may thus contain data useful in the identification of its origin. Indicative fossils, for example, may be preserved and may suggest a provenance for the source rock (Wilkinson et al., 2008). For each type, we classified the cortex according to thickness (in mm), colour, and texture (e.g., rough, smooth, worn).
7. Sub-cortical layers: These layers are located between the cortex and the flint itself, and are evaluated here by their thickness (in mm), colour and degree of translucency.
8. Unique visual patterns: These patterns are related to the formation process of the flint, and may be accentuated by weathering processes. These include stripes, circles, spots, etc.
9. Fossils: The fossils found in hand samples of flint are linked to the environment in which that flint formed (Allan and Bolton, 2017). These environments vary across space and throughout time, and may be highly indicative of the formation and geologic age of the flint (Wilson, 2007a, b; Wilson et al., 2010). Hence, fossils may be used as indicators of the

environment, chronology, and provenance of flint, allowing us to infer patterns of resource selection, procurement strategies and mobility among prehistoric societies (Allan and Bolton, 2017). Allan and Bolton (2017) stress the value of identification of the origin of flint samples based on macro-fossils, as a cheap, non-destructive, analytical method which does not cause any invasive alterations to the sample. Typical fossils which may be identified within flint include sponge spicules, foraminifera, ostracods, gastropods, mollusk shells, etc. As described below, even more information about microfossils can be obtained when thin sections of the rocks can be made.

3.1.2. Analysis of the Quina and demi-Quina Scrapers

The 208 Quina and demi-Quina scrapers studied here were compared to the collection of flint types in the general sample, and each was matched to a flint type, if possible. If none of the previously defined flint types matched a scraper, a new flint type was defined. In cases in which an examined scraper was too weathered or burnt to be classified into a flint type, it was registered as "unidentifiable". In addition, each scraper was assigned to its likely source(s) of origin, and to a group of potential sources, in accordance with the classification performed for each flint type. Also, each scraper was documented for its degree of homogeneity (scaled from 1 to 3); texture, from fine to coarse (represented by degrees, from 1 to 3); and degree of translucency (from 1 to 3). While each piece received one value for homogeneity, in the cases where scrapers were produced from heterogenous flint, a range of values was provided to describe the textures and the degrees of translucency of the different sections within the piece. Any indication of recycling (i.e., post-patina removals), was also recorded. This part of the study includes the use of the results of a detailed use-wear analysis performed by A. Zupancich. Therefore, I use also indications concerning the activities performed with the Quina and demi-Quina scrapers, as well as data concerning the worked materials, where available.

3.1.3. Analysis of the Bifaces

As with the Quina and demi-Quina scrapers, the bifacial artifacts were compared to the collection of flint types from the general sample, and assigned to suitable flint types, whenever possible. They were then assigned to groups of types and to potential geologic sources, in accordance with the classification performed for each flint type. In addition, all bifacial artifacts were measured and weighed. As the QC bifaces were not found in clusters, but, rather, were mostly found as isolated artifacts, the analysis was not performed by assemblages. Instead, the bifaces were treated as a separate group.

3.2. Geologic Flint Sources Survey

Fieldwork was undertaken in order to locate potential sources of flint, following the flint-bearing outcrops, guided by the 1:50,000 geologic maps of Hildebrand-Mittlefehldt (2011), Yechieli (2008) and Ilani (1985). Most of the field work was performed by Lucy Wilson and me. On other occasions, I was accompanied by members of the prehistory lab at Tel-Aviv University. We started the survey in the immediate surroundings of the site, with the flint-bearing Turonian limestone of the Bi'na Formation. We then explored more distant formations: the Cenomanian Eyal Formation (closest exposure being located about 12 km north of the cave; Ilani, 1985), the Campanian Mishash Formation (closest exposure approximately 15 km south of the cave; Yechieli, 2008), and the Eocene Adulam Formation (closest exposure about 30 km south of the cave; Yechieli, 2008).

Some non-Turonian potential flint sources are known to exist 25-30 km to the east of QC. These sources, however, were not surveyed during this study due to logistical and security issues, as they are located beyond the Green Line. Therefore, the abundance of these sources, as well as their extent, nature and variety, are currently unknown. In addition, construction of roads and buildings has most likely removed some of the potential flint sources which existed in the area in prehistory. Therefore, we can never know the exact number and extent of potential sources which were available to the QC hominins. These limitations should be kept in mind when discussing the potential flint sources around QC, as our knowledge of the true distribution of potential flint sources around the cave is lacking.

However, while indeed we could not map all the potential sources around QC, the distribution of the sources which we did locate during our survey may provide useful data concerning patterns of flint procurement at QC. As the cave is surrounded by rich flint sources, which yielded informative macroscopic, petrographic and geochemical data, useful insights concerning lithic-related human behaviours at QC were gained, as presented below.

For each source found, the following features were recorded and described: location (including geographic coordinates), geologic age and formation, Euclidean distance from the cave, the type of deposit (outcrop or alluvial), the abundance and density of the materials available at the source, the estimated extent of the source, size(s) of the available nodules, shapes of available pieces, colours of the available pieces, translucency/opacity, traits of cortex, and estimated suitability for flint knapping. This classification follows the methods provided in Wilson (2007a) and Browne and Wilson (2011). From each source we took as many representative samples as we could, with a minimum of ten pieces from each source. In most cases, a larger quantity was collected, to cover all visible variations, as well as to allow the use of some of the collected pieces for thin sectioning and geochemical analysis. In cases in which less than 10 pieces were found at the source, all pieces were collected. The occasional presence of isolated knapped pieces within some of the sources was also documented. Those, however, appeared only in very low quantities, and were not indicative concerning their cultural origins.

The QC flint types were later compared to the geologic samples, focusing on the visual traits described in detail above. Potential matches for each flint type were recorded. Flint types could be assigned to more than one potential source, if there was more than one potential match.

No work concerning the potential geologic sources was undertaken for the Late Acheulian Revadim assemblage in this study. The Late Acheulian Jaljulia sample, on the other hand, was compared to the potential flint sources for QC, as the two sites are located only 5 km apart. In the case of Revadim, I evaluated only the variability in the flint types exploited and the choices for specific tool types and blanks.

3.3. Petrographic Thin Section Analysis

An important instrument in lithic raw material analysis is the interpretation of flint thin sections. Flint thin sections may provide information concerning indicative micro-fossils and minerals, thus allowing the identification of their geologic age and their potential geologic origin(s) (Wilson, 2007b). Therefore, thin sections of samples from both the QC assemblages and the potential geologic flint sources were prepared and analyzed following the procedure described below. The analysis was preceded by a course I participated in during May 2016, focusing on petrography, mineralogy, and the interpretation of petrographic thin sections. This two-week-long intensive lab-based course was given by Prof. L. Wilson, at the Geoarchaeology laboratory at the University of New Brunswick in Saint John, New Brunswick, Canada.

For the thin sections, we selected archaeological samples based on the frequency of that flint type within the assemblages, any special traits (e.g., fossils, presence of any visible disturbances and impurities, unique patterns [stripes, circles, spots], etc.), and their suitability for thin sectioning, based on their size and thickness. Samples from geologic flint sources were selected based on the geologic sources they originate from, the archaeological flint types they resemble, and their suitability for thin sectioning, also based on their size and thickness. The thin sections were produced in the Thin Section Shop at the Department of Earth Sciences, University of New Brunswick, Fredericton, N.B., Canada. All thin sections are 30 µm thick (0.03 mm), and are attached to a glass slide using epoxy. In total, 105 flint thin sections were produced and analyzed, 67 from QC, and 38 from the potential geologic flint sources.

The thin sections were analyzed by optical microscopy in both plane-polarized and cross-polarized light, using a ZEISS Axio Scope.A1 Polarized Light Microscope in the Prehistory lab at Tel-Aviv University, Israel, and a Leitz Wetzlar monocular polarising petrographic microscope in the Geology lab at the Saint John Campus of the University of New Brunswick, Canada. The photographs of the thin sections appearing throughout this work were taken using a 5 megapixels Zeiss Axiocam 105 colour digital camera attached to the Zeiss microscope at Tel-Aviv University.

Each thin section was examined and analyzed based on the following characteristics:

- <u>Minerals</u>: minerals were identified and described in as much detail as possible, including the shape of their crystals, their size, their colour in both plane and crossed polars, their cleavage, and their extinction angles, as appropriate.

- Size of grains: each thin section was classified as extremely fine-grained (up to 0.01 mm), fine-grained (up to 0.03 mm), medium-grained (up to 0.05 mm), or coarse-grained (more than 0.05 mm), based on the size of grains within the groundmass.
- Micro-fossils: fossils were described in as much detail as possible, down to the level of genus (e.g., Nummulites, Nodosaria, etc.), whenever possible. Other parameters taken into account include the size, degree of preservation, orientation of view, abundance, structure (e.g., serial chambers, chains, etc.), mineral content, etc. In addition, they were assigned to their geologic age, whenever possible. The identification of the micro-fossils was performed with the help of Prof. Chaim Benjamini of the Ben-Gurion University, Israel.
- Degree of homogeneity: disturbances within a specimen were described in detail, including the materials, their density, their frequency throughout the specimen, etc.
- Any other materials visible within the sample: these materials are impurities within the matrix, such as iron, clay, carbonates, etc.
- Texture: This parameter is related to the formation process of the flint. It may include, for example, spherulites, stripes, spots, bands, pores, zoning, circles, etc. Texture can also be influenced by diagenesis processes.

- Diagenetic processes: these relate to the formation and the post-formational changes to the rock, and include, for example, processes of silicification, crystallization, disintegration, cementation, etc.

3.4. Geochemical Analysis

As flint always contains some impurities derived from its depositional environment (Luedtke, 1992), these impurities may assist in identifying the origin of a sample. To this end, ICP-MS (Inductively coupled plasma mass spectrometry) and ICP-AES (Inductively coupled plasma atomic emission spectroscopy) geochemical analyses of samples taken from archaeological artifacts from QC and geologic potential sources were conducted. The main goal of this part of the study is to establish a geochemical signature for the potential flint sources around QC, in order to test whether regional geochemical differences can be detected, focusing mainly on the local Turonian Bi'na Formation sources. Since flint is composed mainly of nearly-pure microcrystalline or cryptocrystalline silica, geochemical analysis has to be used carefully, as any inclusions within a flint sample may cause significant shifts in the results, even for two pieces from the same source (Wilson, 2007b; Wilson et al., 2010).

For the geochemical analysis, I selected 30 flint samples from six different potential geologic sources around the cave (five samples from each source; Table 6), and 17 archaeological flint samples from QC, representing 13 different flint types (between one and three samples of each; Table 7). As we also examined secondary geologic sources, we realize that some of the geochemical signatures may reflect the different geologic sources which were naturally gathered within these secondary sources. However, as the QC hominins most likely exploited the secondary sources around the cave, we wish to verify whether mapping the geochemical variability within such secondary sources might also be of use. The average weight of the geologic samples is 46.0 grams, with a minimum of 10 grams per sample, while the average weight of the archaeological samples is 20.2 grams, with a minimum of 1 gram per sample.

Table 6: The geologic samples for the geochemical analysis.

Source and Origin	Sample	Weight of ground material (in grams)	Description
Horashim Forest (Turonian)	HF1	36	Light grey opaque fine-grained flint, with some minor darker grey zones.
	HF2	34	Grey to light grey heterogenous fine-grained opaque flint.
	HF3	47	Light brown opaque heterogenous flint, with some zones of lighter, coarser-grained brown, and with a dark orange thin rough cortex.
	HF4	26	Light brown fine-grained opaque flint
	HF5	29	Light brown semi-translucent fine-grained flint, with some darker brown zones.
South of Qesem Cave (Turonian)	S of QC 1	44	A breccia of light grey, white and dark brown clasts, opaque and fine to medium-sized grains, with patina of red and orange.
	S of QC 2	26	A breccia of light grey slightly translucent flint, and dark brown opaque matrix, with some zones of beige opaque matrix.
	S of QC 3	32	Light grey opaque fine-grained flint, with some surfaces covered in dark brown patina.
	S of QC 4	17	A breccia of fine-grained slightly translucent flint and dark brown, medium-grained opaque matrix.
	S of QC 5	17	Distinctively striped flint, with dark brown, white and pink stripes, opaque and fine-grained, with a thin rough orange cortex.
Under the Fort (Turonian)	UF1	19	Distinctively striped opaque flint, in grey and dark brown.
	UF2	41	Distinctively striped flint, in grey, white and dark brown, with some pink zones. It is mainly opaque, with rough cortex, orange on the surface and white beneath it.
	UF3	37	Finely striped flint, varies between light brown and darker brown to pink, fine-grained and opaque, with thin white rough cortex.
	UF4	31	Distinctively striped, coarse-grained grey to dark brown opaque flint, with some orange to pink surfaces.
	UF5	18	Dark brown finely striped semi-translucent fine-grained flint.
East of Qesem Cave (Turonian)	E of QC 1	90	Heterogenous fine- to medium-grained opaque brecciated flint, with pockets of light brown opaque matrix, with some slightly translucent areas, and with a thin rough orange cortex.
	E of QC 2	147	Light brown to dark brown heterogenous opaque flint, with orange weathered smooth cortex.
	E of QC 3	37	A brecciated light grey semi-translucent fine-grained flint, dark brown opaque coarse-grained matrix.
	E of QC 4	13	A breccia of grey fine-grained semi-translucent flint and light brown opaque matrix.
	E of QC 5	52	Distinctively striped coarse-grained light grey to dark brown opaque flint, with thin rough dark orange cortex
Eyal Forest In Situ (Cenomanian / Turonian)	EFIS1	30	Light brown fine-grained opaque flint, with a dark brown 1-2 mm thick sub-cortical layer, and a thin white cortex.
	EFIS2	38	Light brown opaque fine-grained flint, sporadically zoned with dark brown, with thin, orange to beige rough cortex.
	EFIS3	10	Light brown opaque fine-grained spotted flint, with pockets of coarser grained light orange chalky flint.

	EFIS4	39	Light brown fine-grained semi-translucent flint, with a thin, white, coarse cortex.
	EFIS5	32	Brown opaque fine-grained homogenous flint, with thin white rough cortex.
Ben-Shemen (Campanian)	BS1	65	Brecciated dark-brown translucent fine-grained flint, with light brown opaque fine-grained matrix, and with a thin white cortex.
	BS2	99	Brecciated dark-brown translucent fine-grained flint, with some lighter brown zones.
	BS3	46	Brecciated dark-brown translucent fine-grained flint, with small zones of light brown opaque medium-grained matrix, and some red patinated surfaces.
	BS4	65	Brecciated dark-brown heterogenous translucent fine-grained flint, with zones of light-brown opaque matrix, and thin light orange cortex.
	BS5	164	Brecciated light-brown to dark brown heterogenous fine-grained semi-translucent flint, with some zones of opaque lighter-brown matrix.

* For a full description of these sources, see the chapter concerning the potential flint sources.

Table 7: The archaeological samples for the geochemical analysis.

Number	Assemblage	Square	category	type	type group	Weight of ground material in grams)	Suggested origin
1	Deep Shelf	D7b 1095-1100	MB-FL	M	1b	10	Turonian
2	Deep Shelf	D8a 950-955	NMB-FL	AD	14	27	Turonian
3	Deep Shelf	D6b 1120-1125	MB-FL	M	1b	24	Turonian
4	Deep Shelf	D7b 1120-1125	MB-FL	BP	13	23	undetermined
5	Deep Shelf	D7b 1120-1125	MB-FL	BT	12	16	undetermined
6	Deep Shelf	E7d 955-960	NMB-FL	O	5	20	Turonian
7	Deep Shelf	D7b 1125-1130	MB-FL	AF	16a	48	Campanian
8	Deep Shelf	E8d 800-825	NMB-FL	K	3	24	Turonian
9	Deep Shelf	E8d 800-825	NMB-FL	W	9	19	Turonian
10	Deep Shelf	D7d 1115-1120	MB-FL	S	26	31	Cenomanian
11	Deep Shelf	E8b 900-905	NMB-FL	T	6	39	undetermined
12	Deep Shelf	D7c 1025-1030	MB-FL	AF	16a	22	Campanian
13	Deep Shelf	D7c 1025-1030	MB-FL	A	1a	4	Turonian
14	Deep Shelf	D7c 995-1000	MB-FL	AF	16a	7	Campanian
15	Deep Shelf	D7b 1080-1085	MB-FL	AQ	16b	11	Campanian
16	Deep Shelf	D6d 1120-1125	MB-FL	BJ	31	18	undetermined
17	Deep Shelf	D7d 1095-1100	MB-FL	M	1b	20	Turonian

All of the archaeological material taken for the geochemical analysis originates from the Deep Shelf – Unit I assemblage. This was done only out of convenience considerations, as this assemblage was the assemblage analyzed during the preparation for the geochemical analysis, and as it had pieces which sufficiently represented the flint types of interest, as described above.

As some of the samples are brecciated flint pieces, I tried to take only the siliceous matrix, without the clasts, in order to avoid biases caused by these impurities. However, as the breccia also occurs on a microscopic level (see the thin sections chapter), such clasts are likely to be present and will, nonetheless, affect the results.

The cortex was removed from all samples using a geological hammer, to avoid any biases caused by differences between the chemical composition of the calcareous cortex and the inner part of the flint sample. The samples were then crushed and ground, first using a Retsch Jaw Crusher BB 100, and then using a Retsch Vibratory Disc Mill RS 200 for finer processing, grinding the samples into a powder.

The samples were then taken for analysis to the Geochemistry lab in the Institute of Earth Sciences in the Hebrew University of Jerusalem, Israel. There, approximately 0.1 grams (or more) of each sample was measured and dissolved in a combination of two strong acids: nitric acid (HNO_3) and hydrofluoric acid (HF). It was then heated at 80°C for 24 hours, to digest and dissolve the sample. After evaporation, each sample was dissolved again in a weak (1%) nitric acid and diluted to a level suitable for ICP-MS analysis.

The samples were then analyzed geochemically, in order to detect major elements (by ICP-AES), and trace elements and rare-earth elements (by ICP-MS). The results were statistically analyzed. For more information concerning the geochemical analytical procedure see Ekshtain (2014), Ekshtain et al., (2014), Finkel et al. (2018b); Nathan et al., (1999), Olofsson and Rodushkin (2011), and Segal et al. (2005).

Chapter 3: The Blind Test Evaluation

4. Blind Test Evaluation of Consistency in Macroscopic Lithic Raw Material Sorting

The basis of this study is the macroscopic classification of lithic assemblages into flint types. Before presenting the results of this study, the issue of the reliability of such a classification must be addressed. In order to do so, I present the results of a blind test we conducted, aimed at evaluating the consistency and reliability of macroscopic lithic raw material sorting. Note that in this chapter I refer only to the flint types and groups of flint types which are of relevance to the blind test. The method used for their classification is detailed in the "Methodology" chapter, while all the flint types and flint type groups are fully described in sections 5.2.1 and 5.2.2, and in the supplementary material volume (Tables 1 and 2). This chapter is modified from Agam and Wilson (2018, and see supplementary tables therein).

4.1. The Rationale Behind The Blind Test

In recent years, petrographic and geochemical methods have become an integral part of lithic raw material studies (e.g., Andreeva et al., 2014; Ekshtain et al., 2014; Gurova et al., 2016; Navazo et al., 2008). Nevertheless, two main factors limit the extent to which these methods can be used. First, when performed on a large scale, these methods are expensive, making the number of samples analyzed a direct function of the researcher's available budget. Second, due to the high costs of these methods, the pieces to be analyzed should be wisely selected, and this must be based mainly, if not solely, on an initial macroscopic evaluation, even if that method is considered to be insufficient (Milne et al., 2009; Moreau et al., 2016). Clearly, this is a circular argument. Therefore, since macroscopic classification is an essential instrument in many geoarchaeological lithic studies, a process for evaluating its reliability and accuracy is needed.

Blind testing is an important method in archaeology, especially when dealing with techniques which might be affected by human biases and subjectivity, allowing the identification of weaknesses within the examined technique (Evans, 2014). Rots et al. (2006: 935) define blind tests as "an objective means to evaluate the accuracy of information retrieved by a specific method." Indeed, blind tests are commonly used in micro-wear and macro-wear studies (e.g., Bamforth, 1988; Bamforth et al., 1990; Newcomer et al., 1986; Rots et al., 2006), residue analysis (e.g., Hayes et al., 2017; Lombard and Wadley, 2007; Rots et al., 2016; Wadley and Lombard, 2007; Wadley et al., 2004), archaeozoological studies (e.g., Blumenschine et al., 1996; Giovas et al., 2017; Gobalet, 2001; Lloveras et al., 2014; Morin et al., 2017), and radiocarbon dating (e.g., Kim et al., 2016; Olsen et al., 2008). However, so far, no such tests have been applied to macroscopic raw material sorting (but see Ferguson and Warren, 1992; and Price et al., 2012). Here I present the results of a blind test based on archaeological material from QC, aimed at examining the consistency and replicability of the flint type classification described above. This blind test is also used to improve inconsistencies which were identified within the classification scheme, and fine-tune any problems of clarity detected in our original definitions. Finally, the results are used to suggest several factors that should be considered in a standard procedure of flint type analyses, and which, in our view, would improve the accuracy and reliability of such classifications.

It should be stressed that this study is the first step in a series of planned studies aimed at the evaluation of the reliability of macroscopic raw material analysis. As the first stage of our raw materials analysis is the macroscopic classification of flint items into flint types and groups of flint types, the current blind test focuses on inter-observer error, meaning that we tried to identify consistencies and weaknesses within our own classification scheme, rather than correctly assign flint pieces to their geologic origins. Future work will examine the reliability of the identification of geologic specimens obtained from primary sources in order to assess the accuracy of visual type classification.

4.2. The Blind Test – Materials and Methods

4.2.1. The Participants

Twelve students participated in this blind test. Two of the students had several years of experience in typo-technological analysis of archaeological flint assemblages from QC, under the instruction of Prof. Avi Gopher and Prof. Ran Barkai; these students' results are labeled EQ1 and EQ2 (EQ stands for Experienced Qesem). Two others had participated in one season of excavations at QC and had performed lithic typo-technological studies of assemblages from other archaeological sites (GE1 and GE2; GE stands for German Expedition). Two others had participated in one season of excavations at QC, but had no experience in analyzing archaeological lithic finds before (FY1 and FY2; FY stands for First Year). The remaining six were Canadian students who had taken introductory geology and geoarchaeology courses, including sections on mineral and rock identification, but had never examined a wide variety of pieces of flint (SJ1 through SJ6; SJ stands for Saint John). In addition, Prof. Lucy Wilson (labeled LW), who regularly sorts flint assemblages into flint types from QC, as well as from other sites, and myself (labeled AA), who has studied raw materials since 2013 under the instruction of Prof. Wilson, also performed the test as described below. SJ1 through SJ6 took the test in Saint John, New Brunswick, Canada, in May 2016, and all other participants took it in the summer of 2016, in Israel.

4.2.2. The Tutorial Process

Before taking the test, all participants were given a tutorial session about the principles of raw material sorting, focusing specifically on the raw materials analysis performed thus far for the QC lithic assemblages. The characteristics of each flint type detected within the QC assemblages were stressed and demonstrated, to show how specific types should be identified. I had previously put together a random sample of 50 artefacts from a QC assemblage for which the raw materials and typo-technological analyses have not yet been completed. In order to form this sample of 50 pieces, the lithic artefacts from several excavation units from one of the unanalyzed assemblages of QC were taken, organized in rows and numbered. Pieces were then randomly selected using an internet random number generator (www.randomizer.org). An unanalyzed assemblage was used in order to reduce the chances of bias in the composition of the selected sample, or in the classification process, caused by typo-technological considerations. The test participants were given this, in groups (in Saint John and in Israel), to practice on. At this stage the group members were able to consult with each other and with LW and AA, so that they could learn about the process of classification, as well as create as unified an analytic approach as possible.

4.2.3. The Test

Blind tests reported in the literature vary in sample size, although this usually does not exceed 40 items. Newcomer et al. (1986), for example, analyzed 30 tools, divided into groups of 10, to evaluate the identification of microwear polishes by blind testing. In order to achieve an error level of 5% or less in a blind test examining the identification of cut marks, percussion marks, and carnivore tooth marks on bone surfaces, Blumenschine et al. (1996) used a sample size of between 20 and 40 specimens for each blind test. Three blind tests performed by Rots et al. (2006), aimed at evaluating prehension and hafting marks, included 8, 10 and 6 tools. Wadley et al. (2004) used 17 and 10 artifacts, respectively, for their two blind tests of residue identification. Lemorini et al. (2014) used 10 quartzite flakes for their use-wear blind test during the study of an Oldowan quartz and quartzite assemblage from Kanjera South (Kenya). As described below, we therefore felt it would be sufficient to perform the blind test on 100 items, in order to include a significant proportion of the flint types detected so far in the assemblages of QC.

Thus, using the technique described above for the tutorial process, a sample of 100 pieces was randomly selected from another as-yet unstudied lithic assemblage from QC. Once again, the decision to use an un-sorted assemblage was aimed at reducing the chance of biases in the flint types represented. The 100 pieces selected were labeled in sequential order, from 1 to 100, and placed on trays in ascending order. The samples of the flint types which were selected by Prof. Wilson during our raw material study (Wilson et al., 2016), to serve as examples of the types, were also arranged on trays, in alphabetical order. These were available to the participants during the entire test, in addition to the full description of each type as formulated during our on-going raw material analysis (see supplementary material in Agam and Wilson, 2018).

Each of the fourteen test participants then classified the sample of 100 pieces, on their own, within seven days of the tutorial session. Each piece had to be classified as one of the types on the QC types list, if the participant found one that they thought matched the test piece. If the participant considered that no flint type fitted the piece, that piece could be classified as either a "new type", or “unidentified”. The latter attribution was to be used for pieces which the participant viewed as too worn or burned to be identified and assigned to a flint type. The results were recorded by each participant during the analysis in a simple Excel table of two columns: piece number (1-100), and corresponding flint type. Only after all 14 participants had completed the test were the 14 separate Excel tables integrated into one file. No typo-technological analysis was performed or taken into consideration during the test.

4.2.4. Data Analysis

The raw results thus consisted of 14 sets of attributions of 100 pieces by flint type. I then further assigned each flint type to a group of types, based on the grouping process conducted for the general QC sample (supplementary material in Agam and Wilson, 2018). This allowed us to identify when the participants had noticed broad similarities between types, even if they had then opted for different individual types within those broad groups. The analysis of the results was performed on both the types and the group-of-types levels (for the full database see supplementary material in Agam and Wilson, 2018). The results of Prof. Wilson, the most experienced participant, were used as an anchor: the “right” answers to which all other results were compared. This was necessary because we had to have some benchmark to which we could compare all of the results. In our planned future study of variability in attributing samples to raw material sources, we will know which sources the samples actually came from, but in this case we did not test participants’ ability to identify sources of rock types, but, rather, explored their consistency in “seeing” the similarity of flint pieces to other flint pieces. We also started with the assumption that Prof. Wilson, with decades of experience in studying both geologic and archaeological flint samples, is the most likely to be able to focus on the criteria that are more significant in terms of determining flint origin, and less likely to be distracted by unimportant variations, such as slight reddening due to heating, to which less experienced participants might attribute unjustified significance. Correlations between the results of Prof. Wilson and those of other participants were then evaluated, and patterns of inconsistencies were searched for. Inconsistencies were analyzed, and the causes for each inconsistency were defined and described, if possible.

4.3. Blind Test Results

4.3.1. Results by Flint Types

The highest number of matches to LW's results is that achieved by AA, with 36 on the flint-type level (and 49 matches on the group-of-types level) (Tables 8 and 9; Figs. 6 and 7), followed by EQ2 (n=34 as types; 42 matches on the group-of-types level), GE1 (n=28 as types; 41 matches on the group-of-types level), and EQ1 (n=27 as types; 38 on the group-of-types level). The most inexperienced participants, for whom this was the first serious encounter with archaeological material (SJ1 to SJ6), achieved the lowest numbers of matches with LW, ranging between 15 and 23 as types (median: 19), and between 26 and 29 matches on the group-of-types level (median: 28). The general average of matches is 22.6 on the types level, while the median is 20.

Table 8: Number of matches by participant, individual types, and group of flint types.

Participant	Number of matches with LW by groups of flint types	Number of matches with LW by individual flint type
AA	49	36
EQ1	38	27
EQ2	42	34
GE1	41	28
GE2	29	17
FY1	27	16
FY2	36	25
SJ1	28	18
SJ2	28	20
SJ3	29	23
SJ4	29	20
SJ5	28	15
SJ6	26	15

Abbreviations: LW: Lucy Wilson; AA: Aviad Agam; EQ: Experienced Qesem; GE: German Expedition; FY: First Year; SJ: Saint John.

Table 9: Blind test results by groups of participants.

	By group of flint types		By individual flint types	
Group of participants	Range of Matches	Median	Range of Matches	Median
AA	49	49	36	36
EQ	38-42	40	27-34	31
GE	29-41	35	17-28	23
FY	27-36	32	16-25	21
SJ	26-28	28	15-23	19

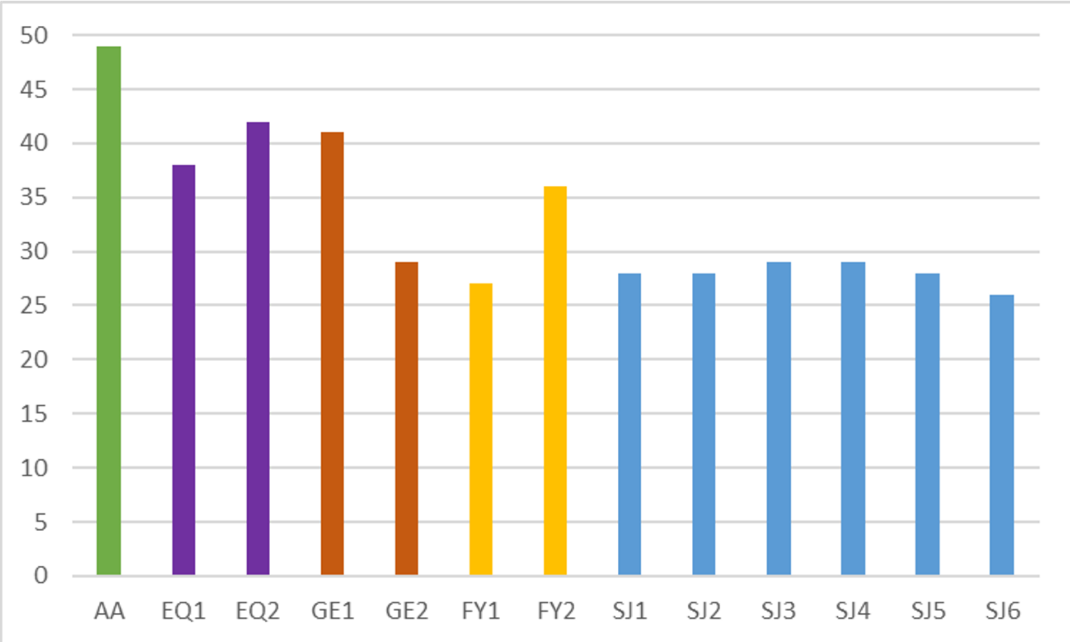

Fig. 6. Number of matches between LW and the rest of the participants on a groups of flint-type level.

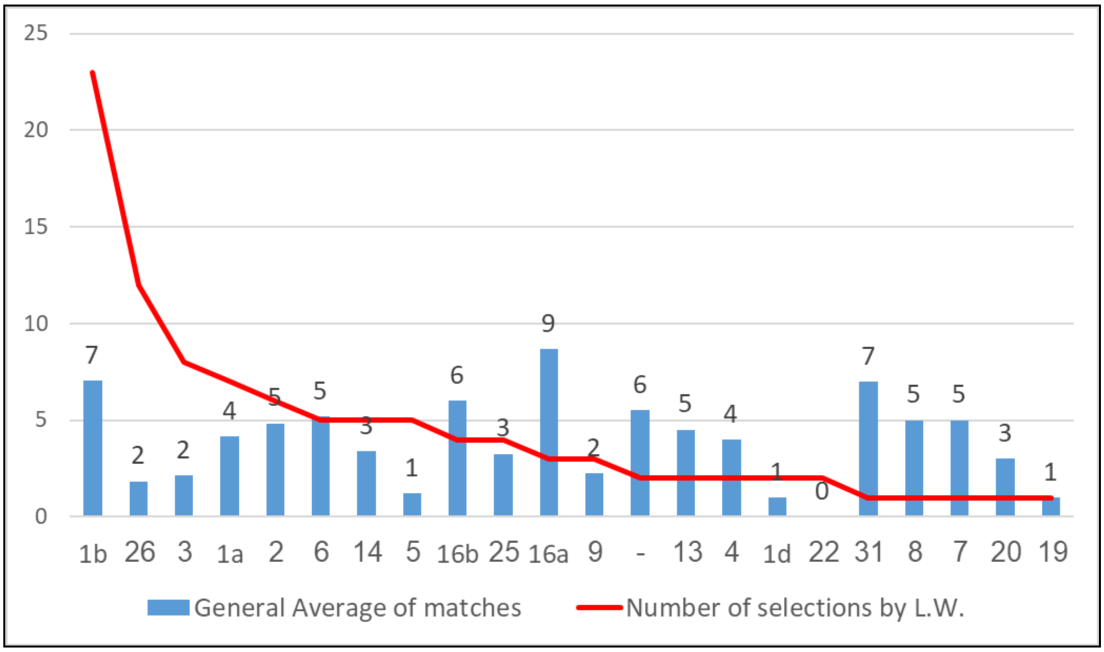

Fig. 7. Number of matches between LW and the rest of the participants on a group-of-flint-types level.

Each individual piece was examined by LW and 13 others, and therefore could potentially be assigned to between 1 and 14 different types. In fact, the pieces were assigned on average to 4.3 different types, with results ranging from 2 to 11. When examining the data on a group-of-participants level (AA being a group of his own), interesting results emerge. The highest median of matches with LW is that of AA (n=36), followed by the EQ group (median=30.5), GE (median=22.5), FY (median=20.5), and then the SJ group (median=18.5). This is also the order of the degree of experience of the groups with the QC material – from the most experienced (AA), through the second most experienced (EQ), the third (~~EG~~GE), the fourth (FY), and down to the fifth, least experienced group (SJ). Although these results are not statistically significant, as the sample is too small, and while this is only an inter-observer evaluation with no truly objective “right” answers to which the results can be compared, the pattern suggests that experience affects the ability of a participant to classify lithic materials in a consistent manner.

4.3.2. Results by Groups of Flint Types

Within the sample of 100 pieces, LW identified 21 different groups of flint types (Table 10). Group 1b, a group of striped homogenous local flint types of Turonian origin, was most common, with LW identifying it 23 times. The average number of matches for the rest of the participants with LW for each appearance of this group is 7.0 (out of 13 possible matches; median: 7). In 17 out of the 23 cases, AA selected group 1b as well (73.9%). The second most common group is group 26, constituted of types S and CC, a Cenomanian (Upper Cretaceous) pinkish café-au-lait flint type, with irregular darker sub-cortical stripes and white cortex (selected by LW 12 times). The average number of matches in these 12 cases is much lower than in group 1b, with 1.8 matches per case (median: 1), including four cases in which no matches were found. AA selected group 26 in 5 out of these 12 cases (41.7%). These two examples suggest that some flint types and groups of types are easier to detect, possibly due to their more distinctive traits, such as stripes.

Table 10: Blind test results by group of flint types, and percentage of success in identification for each group of participants.

Flint type group	**Number of selections by LW**	**Average of Matches**	**AA**	**EQ**	**GE**	**FY**	**SJ**	**total**
1b	23	7.0	73.9%	65.2%	69.6%	52.2%	42.8%	52.5%
26	12	1.8	41.7%	16.7%	25.0%	8.3%	6.9%	11.8%
3	8	2.1	0.0%	25.0%	25.0%	25.0%	10.4%	17.7%
1a	7	4.1	57.1%	50.0%	7.1%	21.4%	33.3%	29.8%
2	6	4.8	66.7%	8.3%	25.0%	41.7%	44.4%	34.7%
6	5	5.2	40.0%	40.0%	50.0%	50.0%	33.3%	40.0%
14	5	3.4	40.0%	40.0%	20.0%	20.0%	23.3%	25.0%
5	5	1.2	40.0%	30.0%	0.0%	0.0%	3.3%	6.7%
16b	4	6.0	100.0%	50.0%	75.0%	37.5%	29.2%	41.7%
25	4	3.3	25.0%	50.0%	37.5%	25.0%	12.5%	25.0%
16a	3	8.7	66.7%	66.7%	33.3%	66.7%	77.8%	66.7%
9	3	2.3	0.0%	16.7%	16.7%	16.7%	27.8%	22.2%
unidentified	2	5.5	50.0%	50.0%	25.0%	50.0%	41.7%	41.7%
13	2	4.5	50.0%	25.0%	0.0%	25.0%	50.0%	33.3%
4	2	4.0	100.0%	50.0%	25.0%	50.0%	8.3%	25.0%
1d	2	1.0	0.0%	0.0%	0.0%	25.0%	8.3%	8.3%
22	2	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
31	1	7.0	100.0%	100.0%	50.0%	50.0%	33.3%	50.0%
8	1	5.0	0.0%	50.0%	0.0%	50.0%	50.0%	41.7%
7	1	5.0	100.0%	50.0%	50.0%	0.0%	33.3%	33.3%
20	1	3.0	0.0%	0.0%	50.0%	0.0%	33.3%	25.0%
19	1	1.0	0.0%	50.0%	0.0%	0.0%	0.0%	8.3%
Total	**100**	**3.8**	**49.0%**	**40.0%**	**35.0%**	**31.5%**	**28.0%**	**31.8%**

In 12 out of the 21 groups of flint types (57.1%), AA achieved the highest classification score, including four out of the five most common groups (1b, 26, 1a and 2). In 10 out of the 21 type-groups, participant-group EQ achieved the highest or the second-highest results (47.6%). Again, these results indicate that participants with more experience are more likely to identify the different flint groups correctly. The number of consistencies between the classifications of LW and AA further supports this notion, because we worked together to define the types in the first place, starting in 2013, and thus know which characteristics we believe are more important in assigning types.

The group of types with the highest average of matches between LW and the rest of the participants is group 16a, which includes only type AF, a semi-translucent dark-brown homogenous flint, originating from the Campanian Mishash formation. This group was selected by LW in three cases, and the average of matches for these three cases is 8.7 out of 13 potential matches for each case. Next are groups 1b (selected by LW 23 times) and 31 (constituted of type BJ, a semi-translucent light brown flint, selected by LW once), with an average of 7.0 matches each. Interestingly, there is no clear correlation between the number of matches and the number of times LW picked a certain group, indicating that the most common groups are not necessarily easier to detect.

4.3.3. Selected Case Studies

In this section I provide several examples from the blind test, in order to demonstrate the importance and influence of experience in flint type classification, and to show some of what can go wrong during classification. These cases are further used below to draw conclusions and suggest ways to improve future classifications.

4.3.3.1. Type AF

Type AF (of group 16a) was identified by LW three times (pieces numbered 37, 43, and 48; Fig. 8). AA matched these classifications in two out of three cases (37 and 43). In the third case (piece number 48), a total of six participants classified the piece as type AF, while in the other two cases, respectively 11 and 10 participants selected type AF. The piece with the most varied answers was thinner, and therefore lighter in colour, than the other two specimens. This difference in colour may have accounted for some of the misclassifications. The type which was consistently selected instead of type AF was type BG (in two, three and six cases, respectively), which is similar in colour – it is also brown, but is more granular in texture. This suggests that some of the participants missed the significance of granulometry in classification.

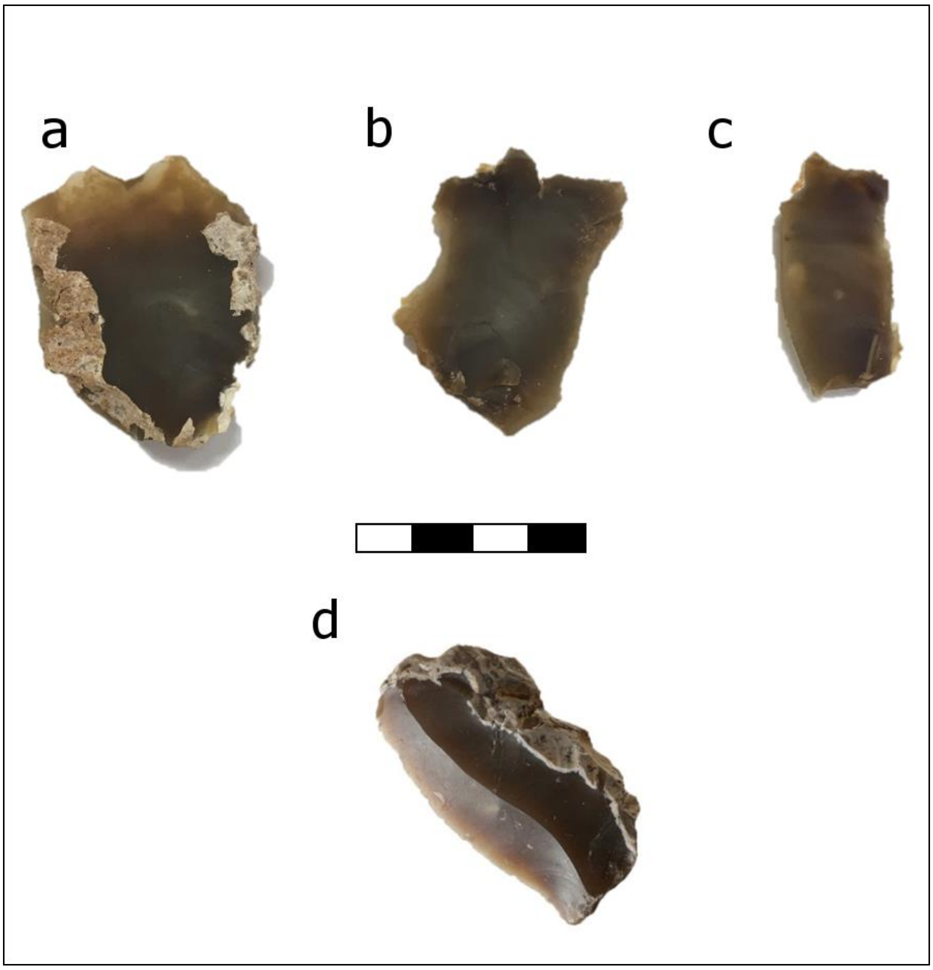

Fig. 8. Type AF: a) test piece 37; b) test piece 43; c) test piece 48; d) type specimen of AF, taken from the collection of flint types of QC.

4.3.3.2. Type AQ

Type AQ (Fig. 9) is a very distinctive brecciated flint type, corresponding to group 16b. LW assigned four pieces to this type. In one case (piece number 15) the brecciated texture was noticed by all participants except for SJ6. In the three other cases (23, 41 and 76), AA also assigned them to this type, and EQ2 assigned two of the three to type AQ. On the other hand, in cases where the brecciated texture was less obvious, perhaps because mainly big clasts were visible, the results tended to be extremely varied, resulting in the selection of ten (piece number 23), six (piece 41) and ten (piece 76) different types by the participants. This case further demonstrates the importance of experience in flint type classification.

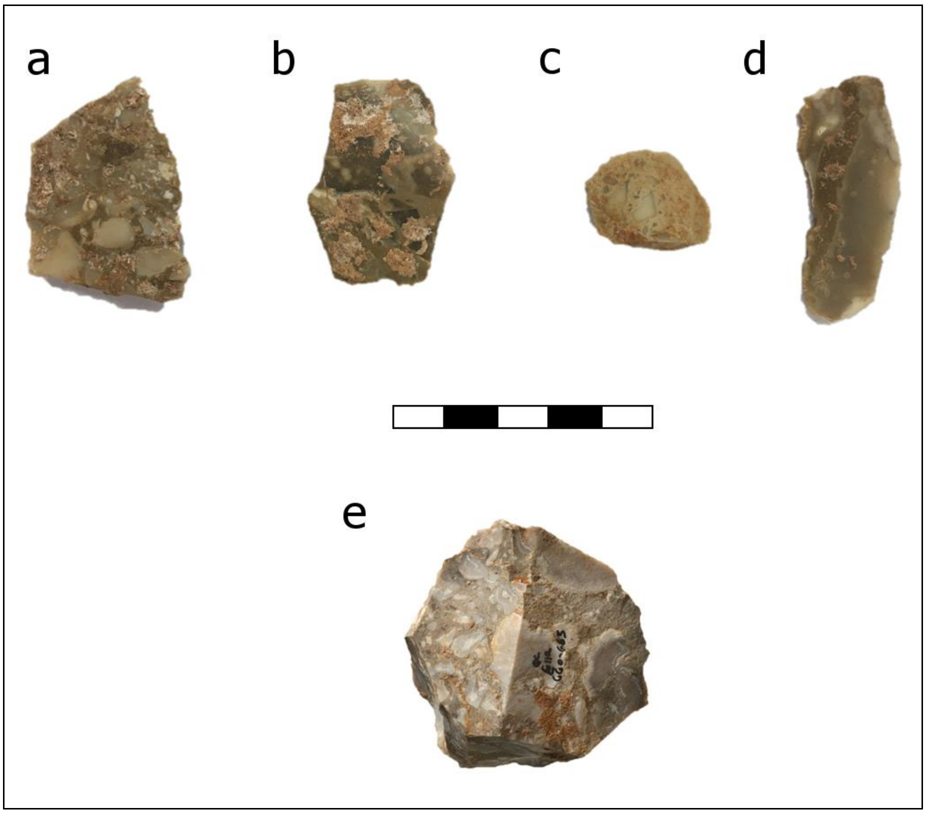

Fig. 9. Type AQ: a) test piece number 15; b) test piece number 23; c) test piece number 41; d) test piece number 75; e) type specimen of AQ, taken from the collection of flint types of Qesem Cave.

4.3.3.3. Test Piece 17

LW and AA both classified piece 17 (Fig. 10) as type N, but none of the other participants did so. Type N has a greyish to brownish opaque colour, with spots and a thin red external surface. The most common choice for piece 17 among the test participants was type AK, which is also brownish to grayish in colour, with spots. It is, however, slightly translucent, and has a thick cortex, with a thin gray sub-cortical line, and a dark red exterior. In this case, then, it may be that only LW and AA had sufficient experience with the material to focus on these subtle differences and choose the same type assignment as each other. However, since there are cases in which LW selected different flint types than those selected by AA, and in which other participants matched LW (e.g., pieces 27, 64 and 67), this conclusion should be treated cautiously.

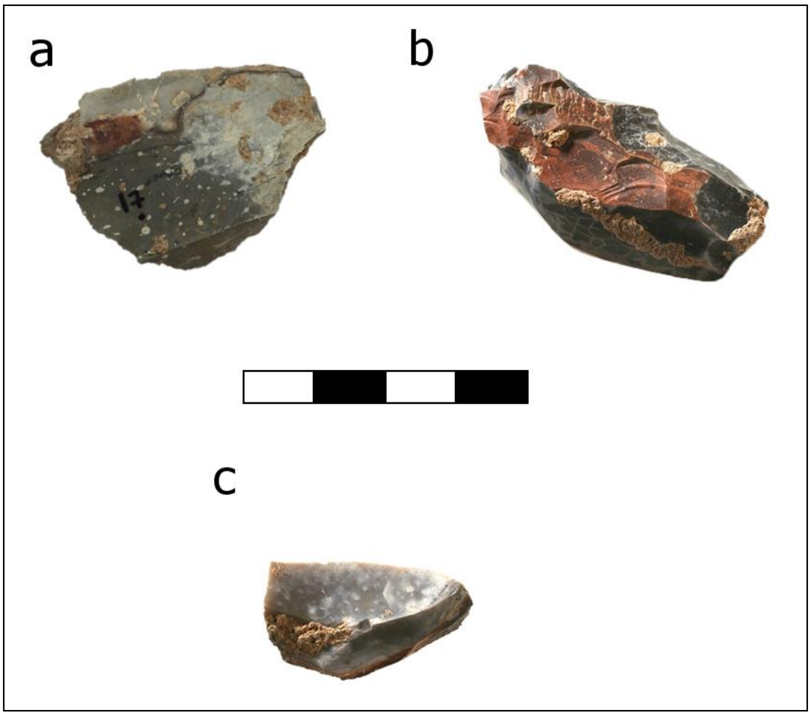

Fig. 10. a) test piece number 17; b) type specimen of N, taken from the collection of flint types of QC; c) type specimen of AK, taken from the collection of flint types of QC.

4.3.3.4. Test Piece 3

While LW classified piece number 3 (Fig. 11) as type J, most other participants classified it as type AO, and no other participant, including AA, picked type J. Piece 3 is burnt, black, with red cortex and several sub-cortical layers. Type J is of Turonian origin, and, like piece 3, it is also burnt, has similar sub-cortical layers, and a red cortex. Type AO, a Campanian Mishash flint, is not burnt, but simply black. Most classifiers, including AA, focused on the colour rather than on the fact that it is a burnt piece, and that the black colour of the analyzed piece is the result of that burning, and did not pay attention to the sub-cortical layers. These results suggest that while colour can be highly important, it is a limited indicator and should not override other characteristics.

Fig. 11. a) test piece number 3; b) type specimen of J, taken from the collection of flint types of Qesem Cave; c) type specimen of AO, taken from the collection of flint types of Qesem Cave.

4.3.3.5. Groups with a Low Median Number of Matches

Some of the groups of flint types presented an especially low median number of matches between LW and the other participants. Group 26, for example, was selected by LW 12 times, but the median number of matches with the other participants was only 1.8 matches per case, out of 13 potential matches. Group 26 is a group of light brown fine-textured homogenous flint pieces. AA selected this group in

41.7% of the cases in which LW selected it, but other participants tended to select group 1b, which is a group of striped homogenous flint types, or group 14, which is a group of light grey to green homogenous flint types. It is possible that variations in the degree of homogeneity and in texture caused these different selections. Group 14 was selected by LW five times, while the average of matches for this group is 3.8 out of 13 potential matches, often mixed with group 1b, further demonstrating the difficulty in consistently differentiating between these two groups.

In the case of group 22, a breccia of pink (burned) to brown fine-grained flint pieces with matrix sandwiched between them (including only flint type AT), the difficulty in identifying the group was even more marked. LW selected it twice (test pieces 8 and 44), while no other participant selected it in these cases. AA selected flint types corresponding to groups 14 and 16b, respectively. EQ2 selected type AQ, of group 16b, twice. The selection of type AQ, a brecciated flint type, by both AA and EQ2, suggests that part of the confusion lies in the fact that both groups consist of brecciated types. For piece 44, six of the participants selected flint types corresponding to group 1b, mainly flint type G. It seems that the brecciated nature of group 22 is not as obvious as in the case of group 16b. Rather, the faint pattern of stripes may cause this group to be confused with group 1b.

4.4. The Significance of the Blind Test

These results demonstrate the importance of experience in flint type classification. The most experienced participant other than LW, AA, had the highest number of matches with the classification of LW. The two EQ participants had the second highest average number of matches with LW. These results indicate that the more familiar you are with the process of classification, and, more importantly, with the material classified, the more likely you are to produce consistent and reproducible results, further supporting the value of experience in the classification process. The lowest average number of matches was achieved by the six Saint John students, who had never before encountered the QC material (group SJ). Hence, it seems that the ability to repetitively identify certain patterns, colours, textures and fossils in flint is acquired through time and improves through practice. For this current study these results mean that the three years of practice under the supervision of LW should have significantly improved my ability to consistently classify the QC material into flint types.

It is noteworthy that in some cases the less experienced participants matched the selections of LW better than the more experienced participants (e.g., test pieces 27, 61 and 64). However, when examining the assemblage as a whole, the effect of experience on the results is clear. The cases of mismatch between the more experienced participants were used in order to evaluate the reasons for these mismatches, and to establish ways to avoid such cases in the future.

While it is difficult to estimate what should be considered as a good result, the best results, 49% of successful matches on the group of flint types level, and 36% on the flint type level, are definitely less than we would have expected. However, as the blind test brought to light some shortcomings of our definitions, it allowed us to correct them and fine-tune our descriptions, and to create a more reliable and accurate database. Therefore, it seems that the knowledge gathered during the blind test, the additional experience gathered through time, and additional blind tests in the future will all further improve the degree of consistency and accuracy achieved. At this stage the blind test allowed the fine-tuning of our flint type descriptions, as demonstrated below. This, of course, was also adjusted in the light of our geologic work, since the ultimate goal is accurate attribution to the sources of the rocks, not just to arbitrary types.

Some pieces were allotted to a wide variety of flint groups by the participants, indicating that there may be too much superficial resemblance between types, or perhaps some degree of "mix-up" between different types, and certainly that there is a lack of clarity in some descriptions and definitions of the types. On the other hand, other pieces were consistently classified by most participants, indicating that at least some flint types are fairly easy to spot, due to distinctive characteristics such as specific colours, textures or fossils, and/or a more precise description. Thus, blind tests can be used to reveal inconsistencies between different classifiers, and problems with some type descriptions.

In the case of the QC raw material analysis, the blind test brought to light several inconsistencies in the way we classify certain types. While no flint types or groups of flint types were eliminated during the fine-tuning process, we reviewed the definitions we use, and stressed certain significant traits of certain flint types and groups. For example, as a result of the repetitive "mix-up" we have between types D and S which appeared in our results, we have fine-tuned the description of each (the importance of the stripes of type D, for instance). The 100 pieces of the blind test were kept spread out on trays and available for use after the blind test, and I have been using them in practice, along with the results of LW, as a comparison collection for cases in which dilemmas in classification occurred.

Differences between LW's and AA's results and those of the rest of the participants were examined separately in order to detect more shortcomings of our descriptions. In most cases these differences were due to the other participants overlooking important features of certain types. In other cases, we clarified the definitions of types which had been mismatched.

In order to improve the future work of ourselves and others, and as part of a more general interpretation of our results, we make the following suggestions. First, when creating a collection of flint types, more than one piece of each flint/rock type should be kept, in order to better reflect its possible variability. Second, blind tests should be used as a regular instrument to check the results of flint type classification, evaluating weaknesses within the classification scheme, making adjustments and any required corrections within the classification scheme, and updating the database accordingly (re-analyzing it, if necessary). This will allow the improvement of the accuracy of the analysis.

Finally, it seems likely that we caused some difficulties for ourselves in the design of this blind test. We asked the participants to choose only one answer for each analyzed piece, rather than allowing them to give what they thought were the 2 or 3 best matches. In future blind tests, each participant will be allowed to choose up to 3 best matches, in order to better reflect the variability of each flint type, its distinctiveness, and the real degree of consistency in its identification.

4.5. Conclusions and Implication Of The Blind Test

Clearly, macroscopic classification has some weaknesses. The human eye is a limited and subjective tool, and what one person would call "red", for example, someone else might call "orange" or "brown". The colour problem can be reduced by using objective colour criteria such as the Munsell Code, but other descriptors, such as “spots” and “stripes”, do not necessarily have ready-made criteria, and each analyst needs to clearly define them. However, while some argue that the macroscopic visual traits of flint are commonly used only "because they are easily accessible, and they require the least amount of time and equipment with which to gather data" (Milne et al., 2009: 434), it is also clear that in many cases this macroscopic evaluation does detect real differences between flints of different geologic ages and origins. Thus, the macroscopic evaluation of raw materials currently plays an essential role in lithic raw material studies, as it is the most economical way, in terms of both cost and time, of handling large numbers of artefacts. Furthermore, if the process of classification is done systematically, with enough practice, and while using a detailed and clear set of descriptions of rock types, consistency should be achieved, even when the study is performed by more than one person. When the classification is performed by a single person, chances of any inconsistencies are reduced, due to repetition in the way this person views the material.

In order to create reproducible results, the description of each type has to be as accurate and detailed as possible, mentioning all elements that make this type a separate type (Crandell, 2006). Furthermore, the description must be accompanied by rock samples which reflect, as much as possible, the variability within this type (e.g., variation in colour or texture, patination, etc.). Clearly, different people will put an emphasis on different criteria. Therefore, flint type classification should include the use of standardized criteria of descriptive points and terminology concerning appearance, colour, patterns and cortex (Crandell, 2006).

Another major aspect is the importance of experience and practice in flint type classification. Macroscopic flint type analyses are greatly affected by experience, demonstrating that it is an acquired skill. Constructed processes of training, using both verbal and visual explanations, as well as "learning-by-imitating" stages, are crucial for such studies (Offerman and Sonnemans, 1998). A sufficient body of knowledge cannot be gained in short periods of time. Rather, such knowledge can be accumulated only with time and meticulous practice. Even though LW and AA have worked together on identifying QC flint for more than three years, and were jointly responsible for initially describing most of the types on the list, we still achieved only a 49% match rate on the blind test at the groups-of-types level (and a lower match on the type level).

Within this framework, blind tests are of the foremost importance. Blind tests should be regularly used to check the reproducibility of results, to evaluate weaknesses within the classification scheme, and to correct the classification, if needed. ~~Blind tests will help to assess the definitions set by the analyst, and will allow fine-tuning and calibration of the classification process.~~ The application of blind tests in lithic raw material studies will improve the results, and, furthermore, allow the formation of comparative databases in the future. Finally, and as emphasized by the relatively low number of matches between LW and AA, it must be stressed that ideally, every macroscopic raw material analysis should be used only as the basis for further higher-resolution analysis (e.g., petrographic analysis, geochemical analysis, or both), which will cross-check the macroscopic classification, thus reducing chances for biases created by the subjective human eye. ~~It should be stressed that in this study the blind test was used mainly as a methodological instrument, while no re-classification process was carried out afterwards. However, t~~The macroscopic classification used here was followed by both petrographic and geochemical analyses, as elaborated below.

Chapter 4: Data Analysis

5. Results

In the following pages I present the results of this study. I start with the potential flint sources identified during our geologic field surveys. This is followed by a presentation of the flint types and groups of flint types classified based on the analysis of the QC sample. I then present the results of the petrographic analysis conducted for 102 thin sections of both archaeological and geologic samples. After this, I present and discuss the results of a geochemical analysis performed for 47 samples, taken from both geologic sources and archaeological samples. Finally, I present the assignment of the different QC flint types to potential sources, based on these three sets of data.

5.1. The potential flint sources

We spent over four accumulated weeks in the field, exploring the areas surrounding the cave, in order to identify, document and sample any potential geologic flint sources. Each identified potential source was recorded using the methods described in Wilson (2007a) and Browne and Wilson (2011), and sampled, with as many representative pieces as needed to reflect the variety of flint at that source, and in accordance to the number of available pieces at the source. In total, 42 potential flint sources were identified (see Table 11 and Fig. 1; for the full list see supplementary material volume – Table 3). Flints from the identified sources were first macroscopically described, and then selected samples were thin-sectioned and analyzed petrographically (see the petrography section below). Finally, a few of the sources were geochemically analyzed (see the geochemistry section below).

Flint sources are divided to primary sources and secondary sources. While primary sources provide secure information concerning the geologic origin of the flint in them, secondary sources should be treated more carefully, as their geologic origin is uncertain. ~~Moreover, secondary sources may reflect human activity, as people may have carried flint pieces, knapped or unmodified, from other places.~~

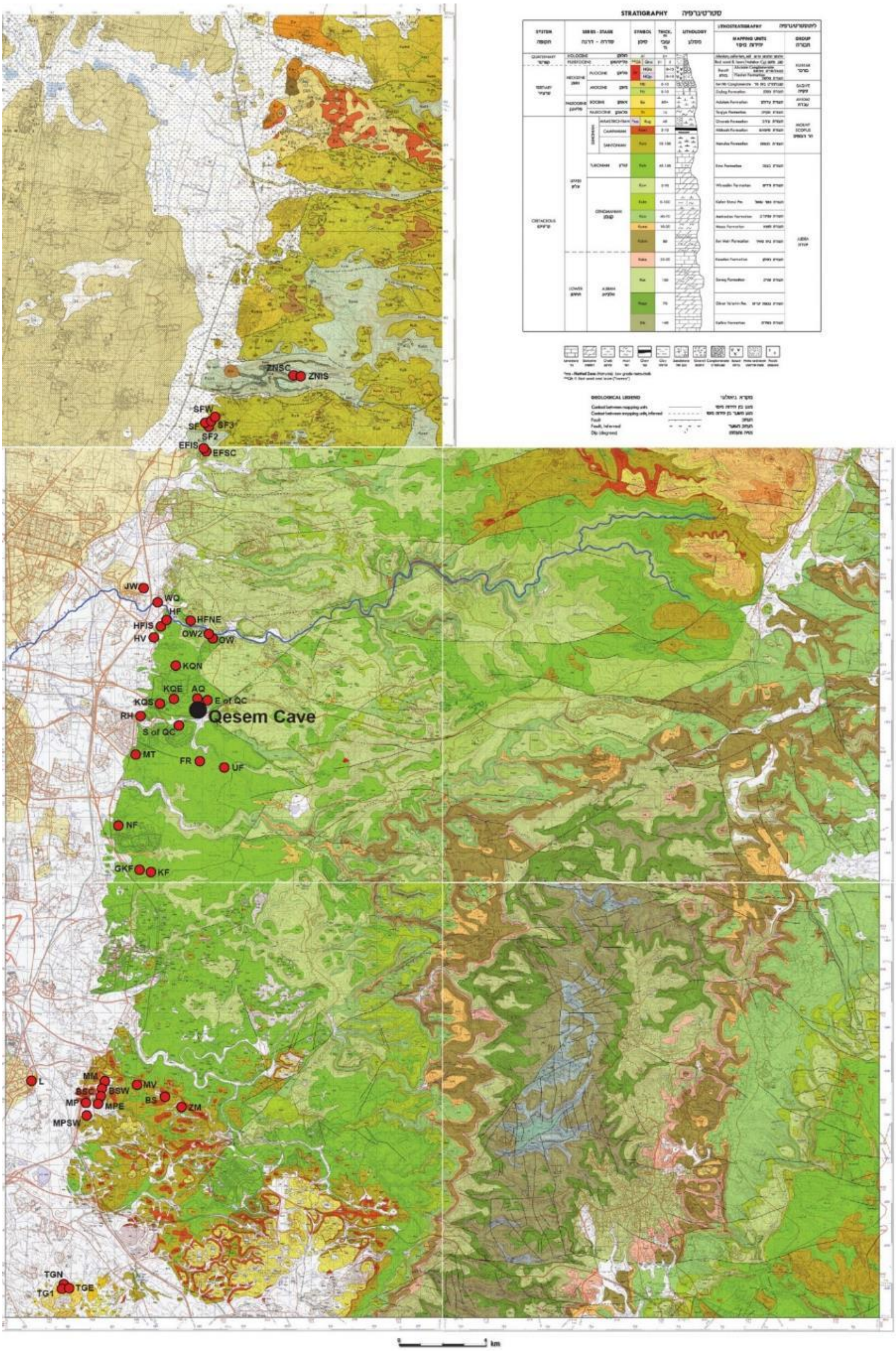

Fig. 12. Geologic map of the area, presenting all of the 42 identified flint sources.

Table 11: The identified potential sources.

	Name	ID	Coordinates	Age	Formation	Distance from QC (in km)	Primary / secondary
1	Above Qesem	AQ	32° 6'7.97"N, 34°59'11.73"E	Turonian	B'ina	0.02	secondary
2	Kafr Qasim East	KQE	32° 6'8.50"N, 34°59'12.34"E	Turonian	B'ina	0.03	primary
3	Kafr Qasim South	KQS	32° 6'10.08"N, 34°58'22.57"E	Turonian	B'ina	0.6	primary
4	East of Qesem Cave	E of QC	32° 6'29.12"N, 34°59'29.53"E	Turonian	B'ina	0.79	secondary
5	South of Qesem Cave	S of QC	32° 6'1.31"N, 34°58'30.70"E	Turonian	B'ina	1.1	secondary
6	Firing Range	FR	32° 5'1.90"N, 34°59'14.14"E	Turonian	B'ina	2.06	secondary
7	Kafr Qasim North	KQN	32° 7'20.23"N, 34°58'49.65"E	Turonian	B'ina	2.32	primary
8	Rosh HaAyin	RH	32° 6'15.37"N, 34°57'41.47"E	Turonian	B'ina	2.39	secondary
9	Under the Fort	UF	32° 4'52.98"N, 34°59'55.23"E	Turonian	B'ina	2.59	secondary
10	Migdal Tsedek	MT	32° 5'4.16"N, 34°57'35.23"E	Turonian	B'ina	3.21	primary
11	Oranit West	OW	32° 7'59.81"N, 34°59'8.82"E	Turonian	B'ina	3.45	secondary
12	Oranit West #2	OW2	32° 8'4.31"N, 34°59'6.64"E	Turonian	B'ina	3.62	primary
13	Horashim Village	HV	32° 8'14.56"N, 34°58'7.00"E	Turonian	B'ina	4.29	primary
14	Horashim Forest North-East	HFNE	32° 8'31.91"N, 34°59'9.86"E	Turonian	B'ina	4.38	primary
15	Horashim Forest	HF	32° 8'30.27"N, 34°58'23.54"E	Turonian	B'ina	4.52	secondary
16	Horashim Forest In situ	HFIS	32° 8'28.58"N, 34°58'18.38"E	Turonian	Bi'na	4.57	primary
17	Wadi Qana	WQ	32° 8'52.49"N, 34°58'4.78"E	Turonian	Bi'na	5.38	secondary
18	Jaljulia Wadi	JW	32° 8'58.96"N, 34°57'42.79"E	Turonian	Bi'na	5.78	secondary

19	Nahshonim Forest	NF	32° 3'15.66"N, 34°56'51.83"E	Turonian	Bi'na	6.43	secondary
20	Givat Koah Forest	GKF	32° 2'18.15"N, 34°57'15.11"E	Turonian	Bi'na	7.69	secondary
21	Kula Forest	KF	32° 2'6.71"N, 34°57'28.81"E	Turonian	B'ina	7.88	secondary
22	Eyal Forest In Situ	EFIS	32°12'41.57"N, 34°59'1.80"E	Upper Cenomanian - Turonian	Eyal	12.15	primary
23	Eyal Forest Surface Collection	EFSC	32°12'41.57"N, 34°59'1.80"E	Upper Cenomanian - Turonian	Eyal	12.15	secondary
24	Sapir Forest	SF	32°13'12.18"N, 34°59'6.59"E	Cenomanian or Turonian	Sakhnin / Bi'na	12.85	primary
25	Sapir Forest 2	SF2	32°13'11.98"N, 34°59'9.19"E	Cenomanian or Turonian	Sakhnin / Bi'na	13.09	primary
26	Sapir Forest Wadi	SFW	32°13'13.78"N, 34°59'10.20"E	Cenomanian or Turonian	Sakhnin / Bi'na	13.13	secondary
27	Sapir Forest 3	SF3	32°13'14.37"N, 34°59'9.54"E	Cenomanian or Turonian	Sakhnin / Bi'na	13.16	primary
28	Zur Natan In Situ	ZNIS	32°14'24.34"N, 35° 0'42.64"E	Cenomanian or Turonian	Sakhnin	15.51	primary
29	Zur Natan Surface Collection	ZNSC	32°14'25.27"N, 35° 0'43.11"E	Cenomanian or Turonian	Sakhnin	15.52	secondary
30	Modiin Viewpoint – Mitzpe Modiin	MV	31°56'57.52"N, 34°57'24.09"E	Campanian	Mishash	17.17	secondary
31	Mexican Monument	MM	31°57'6.57"N, 34°56'26.50"E	Campanian	Mishash	17.21	secondary
32	Ben Shemen	BS	31°56'42.06"N, 34°58'9.07"E	Campanian	Mishash	17.63	secondary
33	Ben-Shemen West	BSW	31°56'48.19"N, 34°56'17.15"E	Campanian	Mishash	17.82	primary
34	Ben-Shemen Center	BSC	31°56'43.39"N, 34°56'16.67"E	Campanian	Mishash	17.97	primary + secondary
35	Lod	L	31°57'13.94"N, 34°54'19.73"E	Eocene	Adulam	18.13	secondary
36	The Monkeys Park	MP	31°56'38.31"N, 34°55'59.94"E	Campanian	Mishash	18.23	secondary
37	Monkeys Park East	MPE	31°56'35.70"N, 34°56'8.76"E	Campanian	Mishash	18.25	primary + secondary

38	Zaglembie Martyrs (Memorial)	ZM	31°56'14.53"N, 34°59'1.06"E	Campanian	Mishash and/or Menuha Formation	18.34	secondary
39	Monkeys Park South-West	MPSW	31°56'25.59"N, 34°55'48.15"E	Campanian	Mishash	18.7	secondary
40	Tel Gezer North	TGN	31°51'35.71"N, 34°55'10.67"E	Eocene	Adulam	27.58	primary
41	Tel Gezer East	TGE	31°51'35.66"N, 34°55'10.77"E	Eocene	Adulam	27.58	primary + secondary
42	Tel Gezer 1	TG1	31°51'35.60"N, 34°55'10.68"E	Eocene	Adulam	27.59	secondary

QC is located within rich flint-bearing limestone outcrops of the Bi'na Formation, of the Upper Cretaceous Turonian (Hildebrand-Mittlefehldt, 2011). In this area, 21 potential geologic flint sources of the Bi'na formation were detected, within a radius of up to 8 km from the site (Fig. 1).

Seven of the Turonian sources are primary, containing flint as nodules embedded into the limestone (KQE, MT, HFNE, HV and OW2), or as layers (KQS and HFIS). The nodules are either slab-like, or irregular in shape, with colours varying between grey and brown (Fig. 13), nodule size ranging between less than 5 cm and up to 25 cm across, and with their extent ranging between a few meters and a few tens of meters.

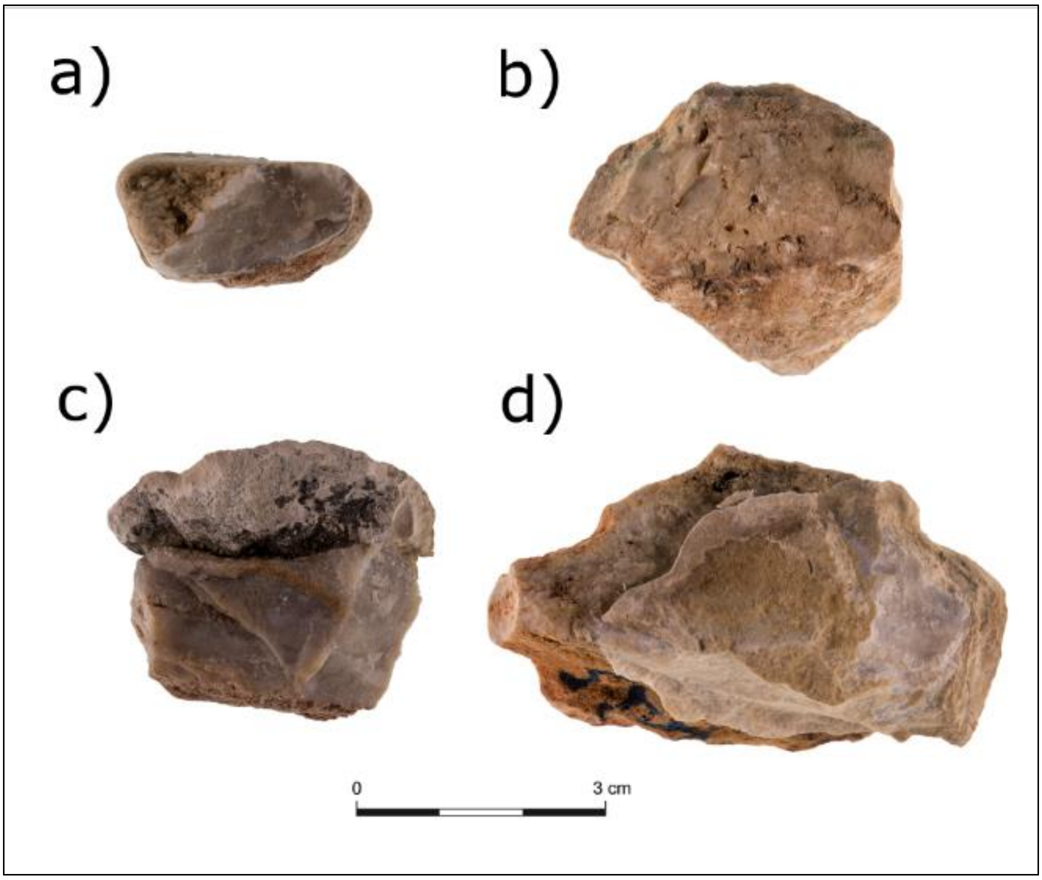

Fig. 13. Examples of flint samples from primary Turonian sources: a-b) KQE; c-d) KQS.

The remaining ten Turonian sources are secondary deposits, colluvium and alluvium, with flint nodules derived most likely from the Turonian (AQ, KQN, E of QC, S of QC, FR, RH, UF, OW, and HF). These secondary sources contain flint which appears in the form of slabs, rounded cobbles and irregular nodules. Their colours vary between light grey and dark brown (Fig. 14), with their size ranging between less than 5 cm and up to 25 cm across. Their extent ranges between a few meters across (AQ) to over 100 m across (S of QC).

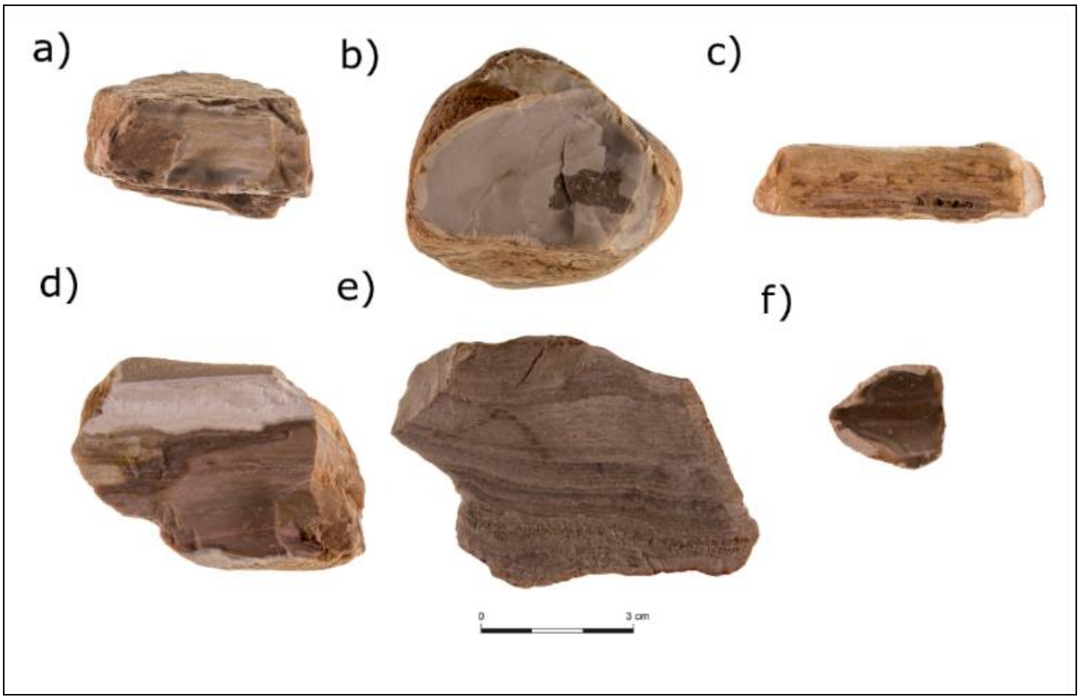

Fig. 14. Examples of flint samples from secondary Turonian sources: a) S of QC; b) E of QC; c-e) UF; f) FR.

The QC flint types were attributed, based on their characteristics, to one of the following six sub-groups of sources, based on their location in relation to QC and on how distinctive their characteristics were: south of QC, north of QC, center area, center or north of QC, center or south of QC, and anywhere in the area of QC. While no flint of any other geologic age was conclusively detected in the area, it seems that there is some variation within the Turonian Bi'na Formation, with the flint coming from the center and south sources having a tendency to appear as flat slabs of opaque, striped flint, while flints from the northern sources mainly appear as more translucent, zoned, or homogenous, rather than striped, in addition to showing a higher frequency of rounded nodules (Wilson et al., 2016). Slab-like nodules were found in three of these sources, one of which is located just north of QC (KQS), while two are located just south of QC (S of QC, and UF). Striped flint was found in several Turonian sources, and is especially abundant in UF, south of QC (Fig. 2).

As not all flint types found at QC are consistent with Turonian flint (Wilson et al., 2016), we explored further away, within other geologic formations. Flint-rich Upper Cretaceous sources of the Mishash Formation were found in the area of the Ben-Shemen forest, ~15 km or more south of QC (Yechieli, 2008). Nine sources were found in this area. Three of the nine sources are primary (BSW, BSC and MPE), while the remaining six are secondary (MV, MM, BS, MP, ZM, and MPSW). Flint from these sources tends to appear in rounded, angular or amorphic nodules, in brown shades which vary from beige to dark brown (Fig. 15). Nodule size ranges between less than 10 cm and up to 1 m across (in MPE, for example), while the sources' extent ranges between 1-2 meters across (MP), and up to several tens of meters across (MM, BSC and MPE). The presence of brecciated nodules is also of note. Other, more distant sources of the Mishash formation are known to exist 25 km and more east of QC (Sneh and Shaliv, 2012).

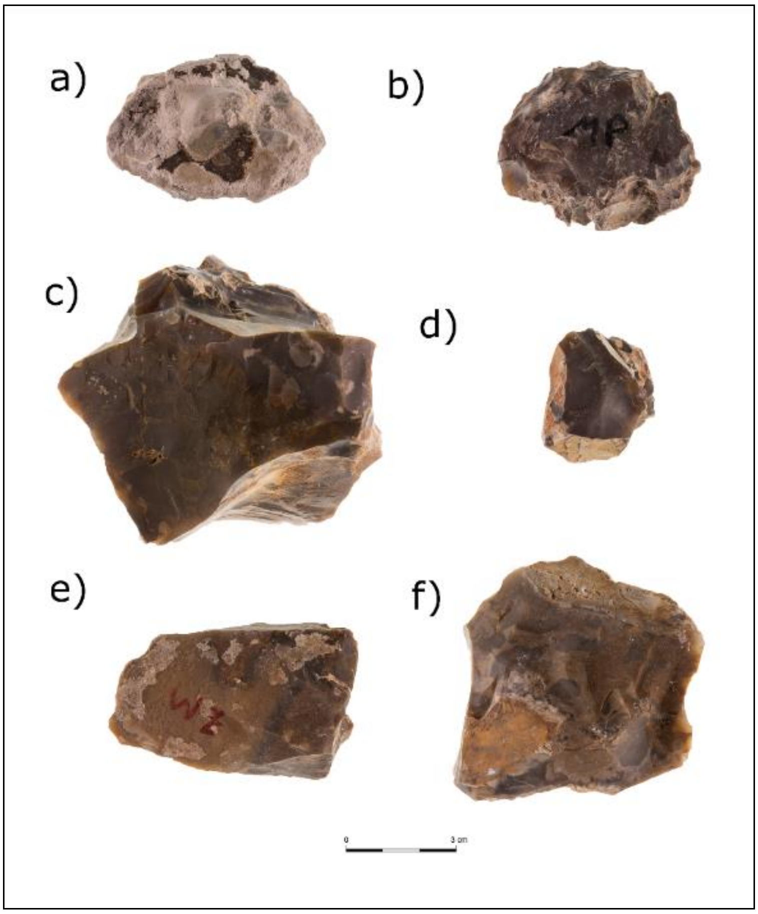

Fig. 15. Examples of flint samples from Campanian sources: a) BSW; b) MP; c) BSC; d-f) ZM.

Upper Cenomanian-Turonian flint sources of the Eyal Formation were found some 12 km north of QC, in Eyal Forest (Ilani, 1985). Two sources were identified in this forest: EFIS, which is a primary source containing brown to black small nodules of mostly brecciated flint in small knobs and lines through the bedrock; and EFSC, which is a secondary source containing loose pieces of flint scattered on the ground (Fig. 16). Both sources extend over several tens of meter across. Additional Cenomanian sources of the Eyal Formation are known to exist 12-13 east of QC (Hildebrand-Mittlefehldt, 2011).

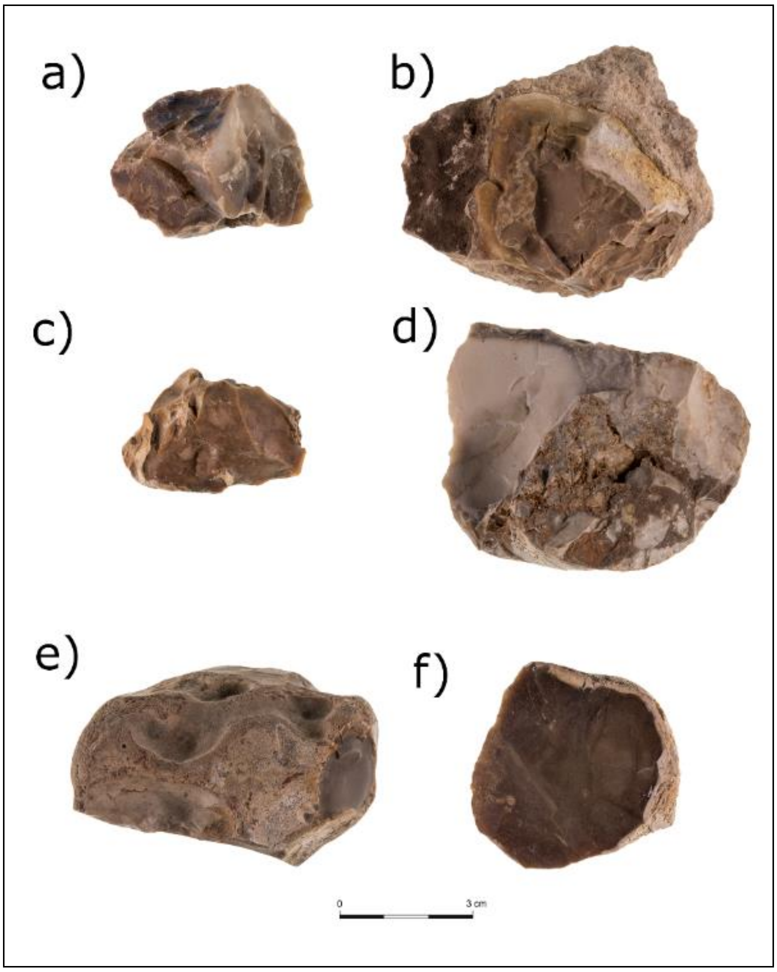

Fig. 16. Examples of flint samples from Upper Cenomanian - Turonian sources: a-c) EFIS; d-f) EFSC.

Six sources were identified within terrain which is located on the border between Cenomanian (Sakhnin Formation) and Turonian (Bi'na Formation) territories, 13-15 north of QC. These sources are registered here as Cenomanian or Turonian. Four of these sources were found in Sapir Forest (SF, SF2, SFW and SF3), about 13 km north of QC, all ranging between 20-30 meters across and up to over 100 meters across. Three of these sources are primary (SF, SF2 and SF3), and contain light brown to medium brown flint, in the form of round and flat nodules, embedded within the limestone (Fig. 17). The fourth source found in Sapir Forest (SFW) is a wadi with a variety of flint nodules, ranging in size from small (less than 5 cm in diameter) to large (up to 20-30 cm in diameter). The two other sources were found on a slope located south of Zur Nathan (ZNIS and ZNSC), about 15.5 km north of QC. ZNIS is a primary source, with small (less than 5 cm in diameter) yellow and white amorphic nodules, embedded within the limestone. ZNSC is a colluvium of brown, grey and yellow small (less than 5 cm in diameter) flint nodules. Both sources extend over 20-30 meters across. Other Cenomanian flint sources, of the Beit Meir Formation, are known to exist in outcrops located 25 km or more east of QC (Sneh and Shaliv, 2012).

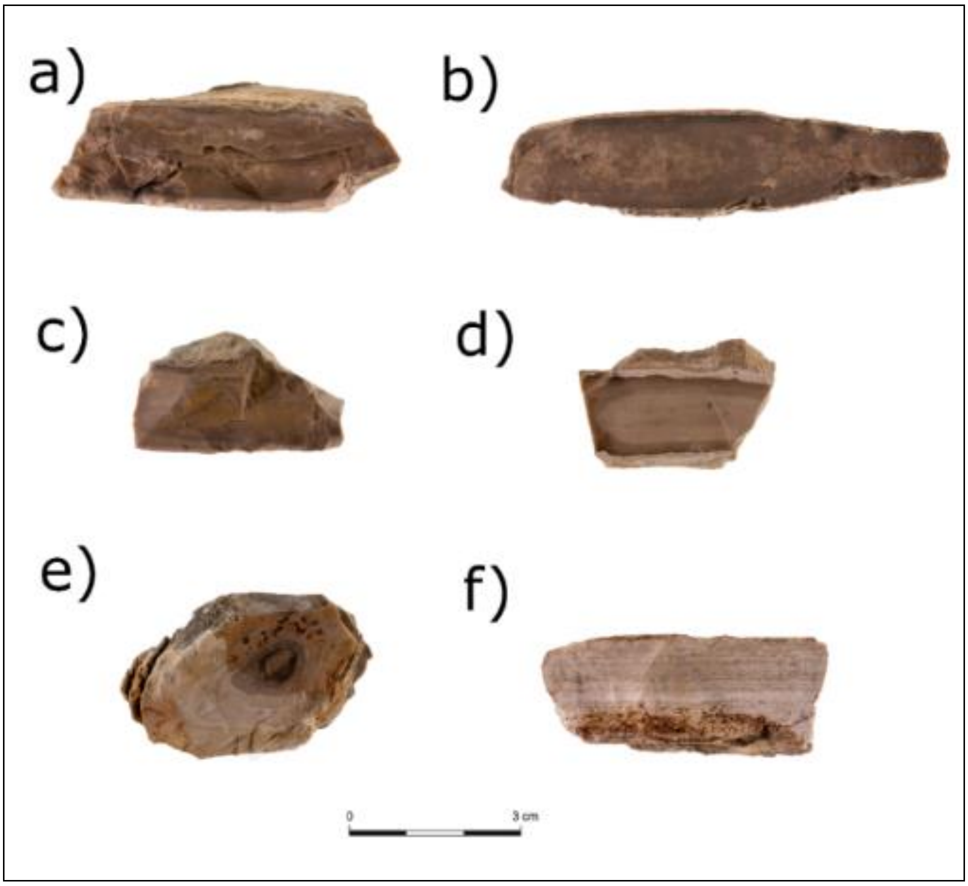

Fig. 17. Examples of flint samples from Upper Cenomanian - Turonian sources: a-b) SF; c) SF2; d) SF3; e) ZNIS; f) ZNSC.

Four Eocene flint sources were surveyed. One colluvial secondary Eocene source of the Adulam Formation (Yechieli, 2008) was found near the city of Lod, next to Ginaton Junction, in a plowed olive grove, 18.3 km south of QC. It extends over

~20 meters across, and currently contains very low quantitites of loose weathered round flint nodules, white and brown in colour, up to 10 cm in diameter (Fig. 18). At this point it is impossible to say whether flint would have been available there during prehistoric times. Other low-density Eocene sources were sampled at Tel-Gezer, almost 30 km south of QC. TG1 is a secondary accumulation of cobbles of siliceous breccia in olive grove north of Tel Gezer, extending over several tens of meters across. TGN is a very poor primary source, represented by one single grey *in situ* irregular nodule, which is about 3-4 cm across, with a granular texture. TGE, which extends over several tens of meters across, includes one white *in situ* nodule, in addition to other brown flint nodules scattered on the ground. The flint in that source appears as flat nodules, up to 10 cm across. More Eocene flint sources, of the Timrat formation, exist ~25 km east of the cave (Sneh and Shaliv, 2012).

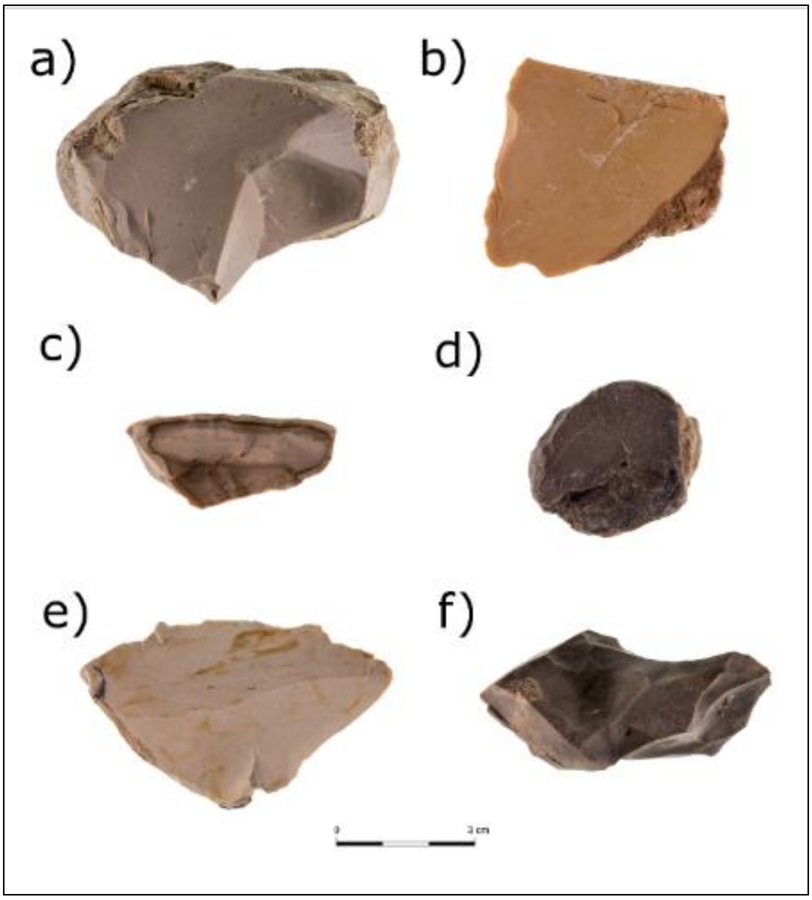

Fig. 18. Examples of flint samples from Eocene sources: a-b) Lod; c) TG1; d) TGN; e-f) TGE.

As mentioned in the introduction, none of the non-Turonian potential flint sources located to the east of QC have been surveyed during this study, due to logistics and security issues. Therefore, the abundance of these sources, as well as their extent, nature and the variety within them, are currently unknown. They are, however, located along the current course of Wadi Qana (Fig. 19), which passes some 3 km north of QC at its closest point. Therefore, the wadi could, potentially, have carried flint nodules from their geologic sources closer to the cave, and made them more likely to be exploited by the QC hominins.

Recent surveys conducted in the segment of Wadi Qana closest to QC, in Horashim Forest (3-5 km north of the cave) found no conclusively non-Turonian flint. However, the lately-discovered Acheulian site of Jaljulia provides significant data in this respect. Jaljulia is located approximately 6 km north of QC, and 100 m north of the closest point to Wadi Qana. In Area A, at the south-eastern part of the site, an ancient stream was revealed, which is probably related to Wadi Qana, possibly representing an old stream channel. Preliminary surveying of this ancient stream revealed a larger variety of flint than in the current wadi, including the possible presence of Campanian and Cenomanian flints. This suggests that the ancient course of Wadi Qana might have transported flint from the eastern sources. In this case, these relatively distant flint types would become more likely to be used by the QC hominins.

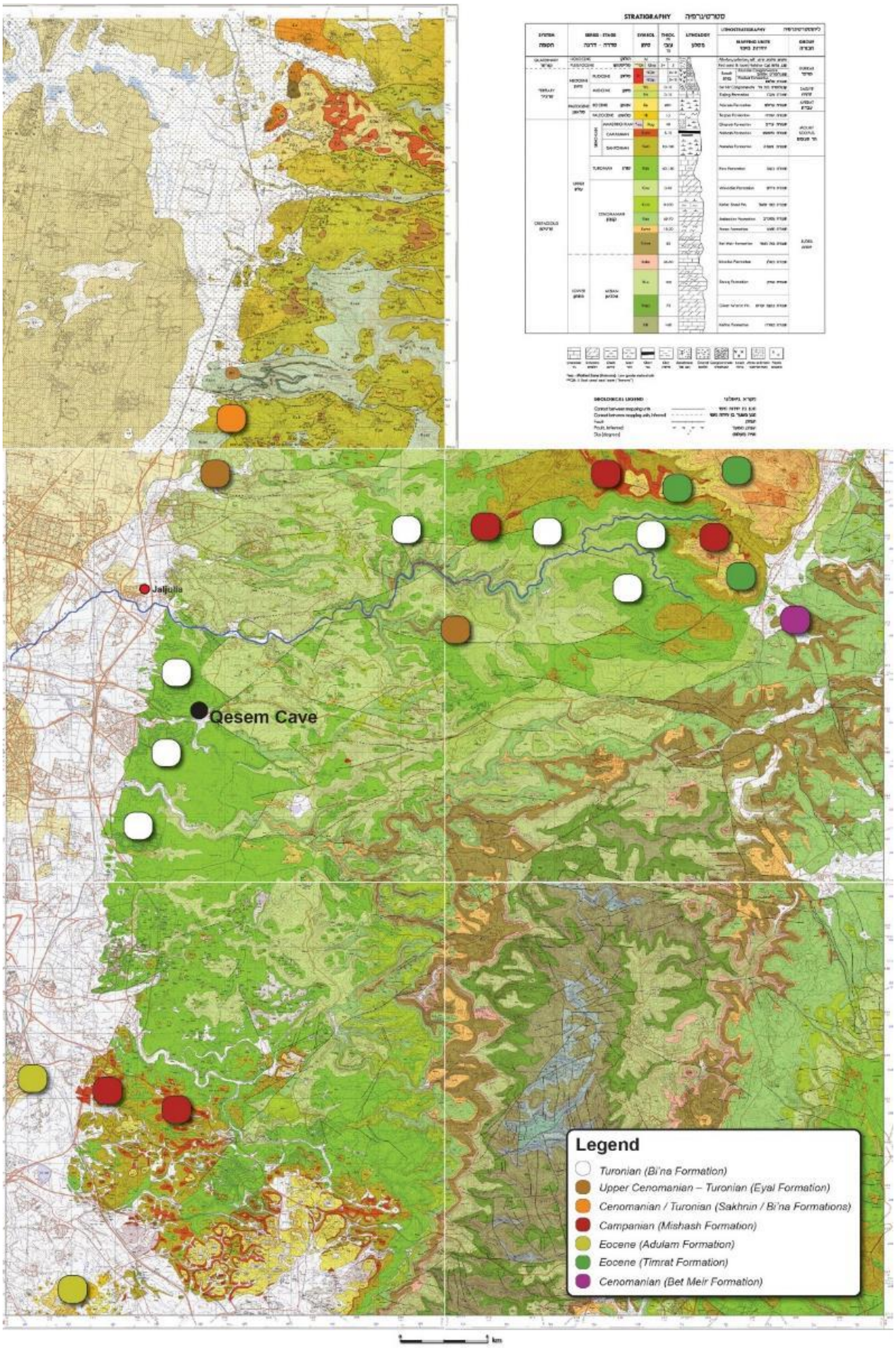

Fig. 19. A general view of the area of Qesem Cave and the potential flint bearing areas, based on geologic age and distance. Note Wadi Qana (marked by a blue line) which passes 3 km north of QC, as well as the potential flint sources east of QC, which were not surveyed during this study.

5.2. The QC Flint Types and Groups of Flint Types

In this study, flint artifacts were classified to flint types based on macroscopic traits, including colour, texture, size and shape, degree of homogeneity, degree of translucency, traits of cortex, sub-cortical layers, any detectable unique patterns, and any macroscopically visible fossils (see more details in the Methodology chapter). In total, 96 different flint types were classified during this study. They were labeled alphabetically, from A to CS, based on order of identification (Supplementary material volume - Table 1). Missing values are due to flint types which got canceled after their initial classification, as they were integrated into other flint types during the analysis process.

It should be stated immediately that indeed, 96 is a high number of different flint types. Past studies present significantly lower numbers of identified lithic types (note that as no similar raw materials studies were performed concerning Levantine Lower Paleolithic sites, I provide examples from sites which differ from QC in both geographic location and chronology). Ekshtain et al. (2014), for example, defined 17 types out of the lithic assemblages of the Middle Paleolithic site ’Ein Qashish (Israel), based on colour and texture, using a sample of 2,810 artifacts. Bustillo et al. (2009) classified seven types of raw materials out of material taken from the lithic assemblage of 5,043 artifacts from the Early Neolithic mining complex Casa Montero (Spain). Vukosavljević and Perhoč (2017) classified five different rock types out of a sample of 8,092 artifacts taken from the Epigravettian site Kopačina Cave (Dalmatia, Croatia). Nonetheless, here I use this level of division because differences which may appear between closely-related flint types may provide useful information concerning certain patterns of procurement and exploitation of flint types with specific characteristics. Moreover, as this current study includes a significantly higher number of artifacts (n=21,102), it is likely to result in a higher quantity of identified flint types. Additionally, it should be stressed that we grouped the flint types into 41 groups of flint types, based on common traits, so that we do not lose data due to over-division. Finally, and most importantly, it should be stressed that the main division used here for the data analysis is that of geologic origins (i.e., Turonian, Cenomanian / Turonian, Upper Cenomanian - Turonian, Campanian, Eocene, and undetermined).

The 96 flint types and 41 groups of flint types are fully described in the supplementary material volume (Tables 1 and 2). The following section presents some of the main traits characterizing the identified flint types and groups. As demonstrated above in the blind test section, macroscopic classifications may be used, to a certain extent, as a reliable source of information, but should be treated cautiously, and should be combined, whenever possible, with other, more accurate classification methods (and see Agam and Wilson, 2018). Therefore, macroscopic traits are used here to classify flint types into sources of origin only as supporting data for petrographic data, and are used to tentatively assign flint types to potential sources only in cases in which the petrographic information was lacking.

5.2.1. The QC Flint Types

Flint artifacts were classified into flint types based on the following visual traits: colour, texture, size and shape of the nodule, degree of homogeneity, degree of translucency, traits of cortex, sub-cortical layers, any unique visual patterns, and any visible fossils (for a detailed description of each trait, see the Methodology chapter). Figs. 20, 23 and 26 present the breakdown of the QC flint types based on degree of homogeneity, by texture and by degree of translucency, respectively. Figs. 21, 22, 24, 25, 27 and 28 provide examples of the different classifications within these three categories.

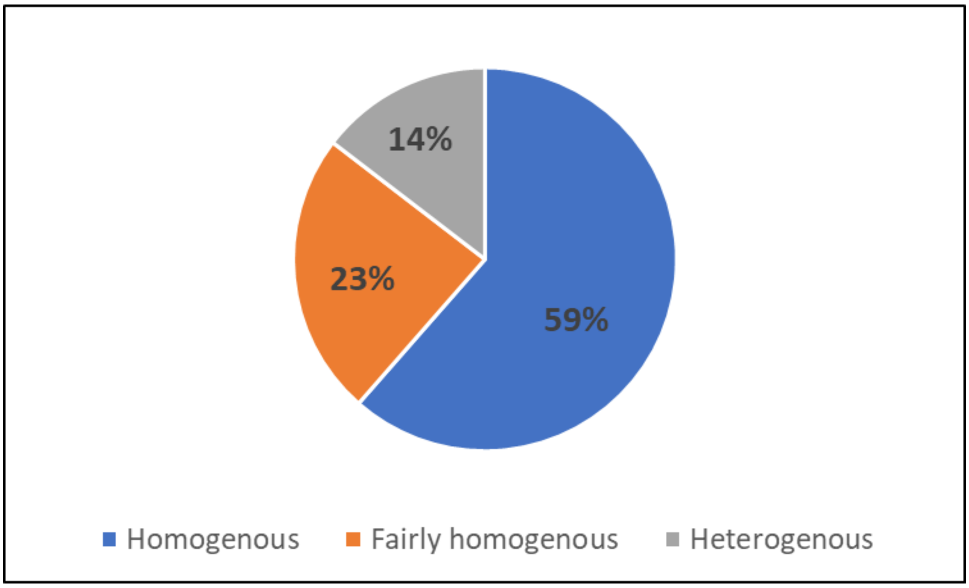

Fig. 20. Flint types by degree of homogeneity.

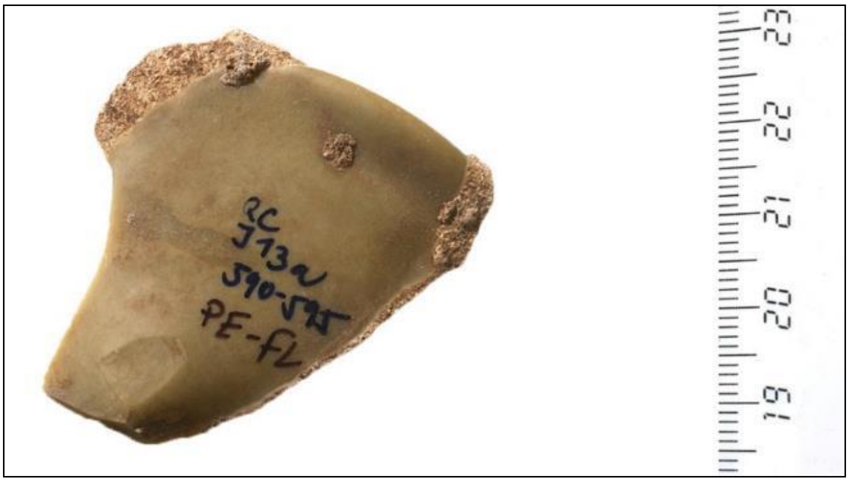

Fig. 21. QC-AW – an example of a homogenous flint type.

Fig. 22. QC-BT – an example of a heterogenous flint type.

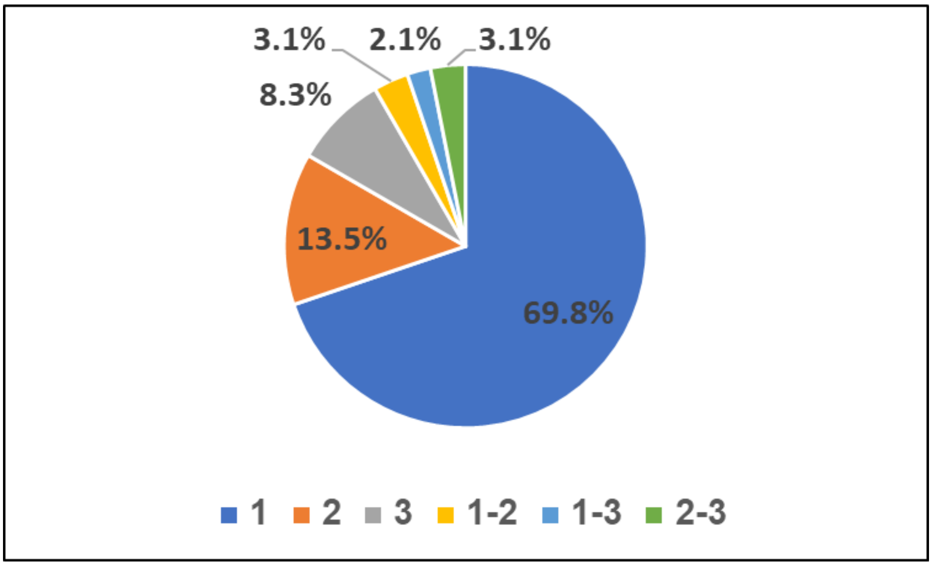

Fig. 23. Flint types by texture. 1: Fine-textured; 2: Medium-textured; 3: Coarse-textured. 1-2: Vary between fine-textured and medium-textured; 2-3: Vary between medium-textured and coarse-textured.

Fig. 24. QC-C – an example of a fine-textured flint type.

Fig. 25. QC-BD – an example of a coarse-textured flint type.

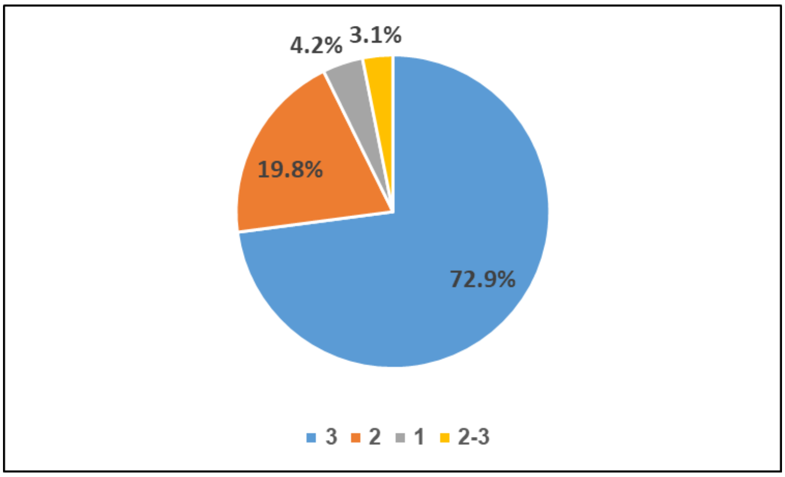

Fig. 26. Flint types by degree of translucency. 1: Translucent; 2: Slightly translucent; 3: Opaque; 2-3: Vary between slightly translucent and opaque.

Fig. 27. QC-K – an example of a slightly translucent flint type.

Fig. 28. QC-AH – an example of a translucent flint type.

Out of the 96 flint types, 38 flint types (39.6%) are striped (Fig. 29), varying from faintly striped (for example, types G, R and AU) to densely and distinctively striped (for example, types M, AY and BX). Most of these striped flint types (n=26; 68.4%) are of Turonian origin. In our previous publication we showed that striped flint tends to be found in sources in the immediate vicinity of the cave (within a radius of up to 2 km away from the cave) and south of the cave (Wilson et al., 2016).

Fig. 29. QC-M – an example of a striped flint type.

Spots were observed in 25 flint types, varying between faintly spotted (Type AO, for example) and densely spotted (Type BC, for example; Fig. 30). Interestingly, 14 out of these 25 flint types (56.0%) are from unknown sources.

Fig. 30. QC-BC – an example of a densely spotted flint type.

Nine flint types contain inclusions which might be fossils, while in 17 other flint types macroscopically-visible fossils were clearly seen. Type T, for instance, contains sponge spicules, as do Types Z, BL, CK, CN and CQ; in Type Q a shell fragment was identified. Special fossils were detected in some of the flint types. Type BO, for example, was found to contain shell fragments, short spike-like fossils, and large (several mm) net-like, cross-hatched shapes (Fig. 31). Type CJ contains bivalve shell fragments. Type CO contains foraminifera, mollusks, ostracods, shell fragments, and possible sponge spicules.

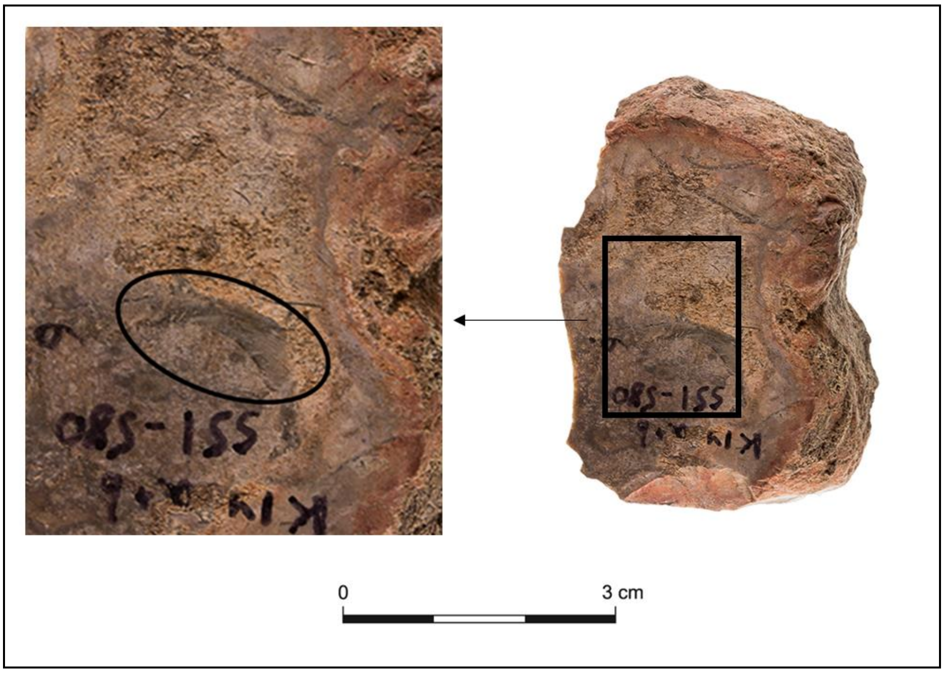

Fig. 31. QC-BO – a close-up view of the net-like, cross-hatched shapes.

Eleven out of the 18 flint types with macroscopically-visible fossils are from unknown sources (61.1%). Five types (27.8%) were found to contain nummulites (Fig. 32): Types BB, BY, CE, CK, and Type CN, indicating that these flint types are of Eocene origin (Racey, 2001). The remaining two macroscopically-fossiliferous flint types (Types Q and Z; 11.1%) were assigned to Turonian origin. In Type Q a shell fragment was observed, and it was tentatively assigned to Turonian origin based on macroscopic similarities to samples from UF, FR and HV; in Type Z sponge spicules and possible foraminifera were observed, and it was tentatively assigned to Turonian origin based on macroscopic similarities to samples from UF and OW, and petrographic similarities to a sample from HFNE.

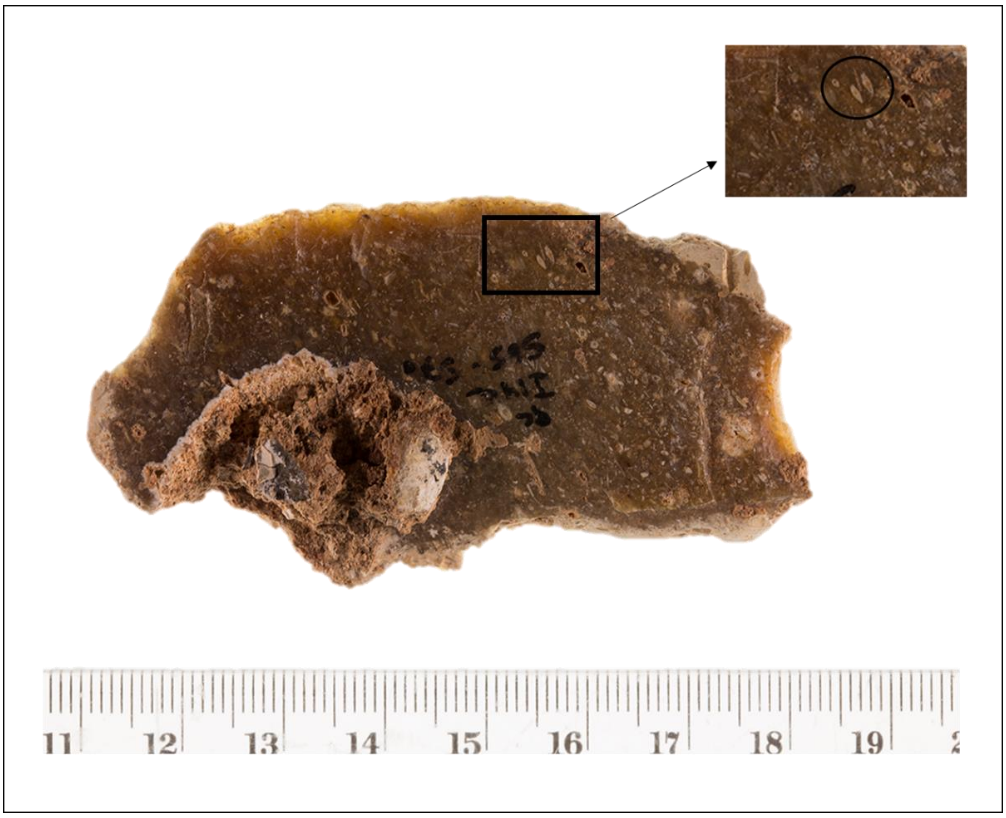

Fig. 32. QC-BB – close-up view of macroscopically visible nummulites.

5.2.2. The Groups of Flint Types

After the initial classification, each flint type was assigned to a group of types, based on their shared characteristics. The 96 flint types were grouped into 41 different groups of types (Supplementary Material volume - Table 2). The grouping of the different flint types allowed us to explore the data on a macro-level, without losing the information concerning fine differences between different flint types.

Within the characteristics used for the grouping of certain flint types, I can mention the presence of distinct patterns (e.g., Group 1b [striped homogenous flint types], and Group 18 [brown to pink slightly translucent flint types, with a concentric pattern]), the presence of macroscopically-visible fossils (e.g., Groups 29 [flint types with nummulites] and 30 [flint types with foraminifera and possibly other fossils]), and the presence of breccia (Groups 16b and 22; Fig. 33). Some common combinations of traits were also used for these groupings: colour and texture (e.g., Groups 26 and 31), colour and degree of translucency (e.g., Groups 12, 16a and 17), and colour and degree of homogeneity (e.g., Groups 13 and 19).

Fig. 33. QC-AQ – a brecciated flint type.

Some of the flint types do not present any traits which allow their inclusion in other groups, leading to their definition as a group of their own. Group 3, for example, includes only Flint Type K, a light grey-brown slightly translucent flint type. Another example worth mentioning is that of Type AL, a highly burnt flint, black and grey with red stain on some surfaces, with possible fossils (and see the petrography section for additional information concerning Type AL).

The group which includes the most flint types is Group 1b, with 14 different flint types (Types C, D, E, F, G, J, L, M, Y, AY, BE, BF, BX, and CI). These flint types are all striped, homogenous, and derived from flat, slab-like nodules. They are all of Turonian origin.

Group 6 includes eight different flint types (Types T, AX, BA, BV, BW, CD, CJ, CS). It is a group of dark-brown to light brown heterogeneous flint types. Most of them are of Turonian origin, excluding Types T and BV, which are from one or more yet undetermined sources. While flint types were grouped based on visual common traits, we did not find matching geologic samples to all of them, therefore leaving some of the flint types as of an unknown source, while being attributed to groups of flint types including flint types of known sources.

Finally, Group 29 also deserves special attention, including Types BB, BY, CE, CK, and CN. These flint types all have macroscopically visible Nummulites. This allows their immediate assignment to Eocene origins (Racey, 2001).

5.3. Petrographic Data

Petrographic thin sections were used in this study to identify indicative micro-fossils and minerals, as well as to identify any diagenetic processes which might allow the assignment of flint types to geologic ages and potential geologic origin(s) (Wilson, 2007a). In total, 104 thin sections were analyzed, 64 of them representing 62 of the QC flint types, and 40 taken from potential primary and secondary geologic sources. Figures of thin sections appear in both plane polarized light (marked as "PP"), and in cross-polarized light (marked as "XP").

While primary sources provide more reliable information concerning their geologic origin (Luedtke, 1978), the secondary sources examined here are also of interest as they present some visual matches with the QC flint types, suggesting they might have been exploited by the QC hominins. However, since secondary sources may represent accumulations from several different geologic ages and formations, petrographic similarities between geologic samples from secondary sources and archaeological samples cannot conclusively prove these were the sources of these flint types.

This chapter presents the major indicative components identified in the analyzed thin sections, from both the archaeological material and the geologic sources. It then presents the petrographic characteristics of the QC flint types and the geologic sources, and discusses the matches between the QC flint types and the potential geologic sources. The full analysis of all thin sections is available in the supplementary material volume.

5.3.1. A Review of the Major Components

In this sub-section, I present the major components which were identified in the analyzed thin sections, of both the archaeological material and the geologic sources. I start with the micro-fossils, and continue with the minerals and textures.

5.3.1.1. The Micro-Fossils

This section discusses the following groups: foraminifera, including nummulitic, miliolid, globigerinid, buliminid, nodosarid, and other foraminifera (uniserial, biserial, coiled, lens-shaped), which could not be identified to a more precise taxonomic level; sponge spicules; ostracods; mollusks, focusing on gastropods and cephalopods, but also including bivalves; radiolaria; bryozoans; and charophytes.

Foraminifera are a sub-phylum of the phylum Protozoa, which are unicellular animals. They are very common, found in limestone from the Paleozoic to Recent age, and are distributed worldwide in all marine environments (Horowitz and Potter, 1971: 47). They are very diverse in size, morphology and distribution (Gooday, 1994). As a general description, these are one-celled animals with calcareous shells, which are, in most cases, multi-chambered (Horowitz and Potter, 1971: 43). Typical known forms of foraminifera are uniserial (arranged in a single row), biserial (arranged in two rows), coiled (arranged in a series of circles, one above or inside the other), oval (with an ellipse-shape), lens-shaped and concentric (arranged in circles within circles) (Horowitz and Potter, 1971). Foraminifera are often used for environmental interpretations as well as for chronological correlations (Horowitz and Potter, 1971: 47). The frequency, size and structure of foraminifera in thin sections may be used to indicate the attribution of a sample to a potential source(s).

Nummulites (Fig. 34) are a Tertiary genus of benthic foraminifera, especially common in the Tethyan region (Racey, 2001). They are characterized by their large, generally lenticular shape, which consists of a single planispirally-coiled layer subdivided into numerous separate chambers. In thin sections they tend to appear in a clear lens shape, or as rectangular fragments. Nummulites are stratigraphically restricted to the uppermost Lower to Middle Eocene (Racey, 2001), making them excellent chronologic indicators.

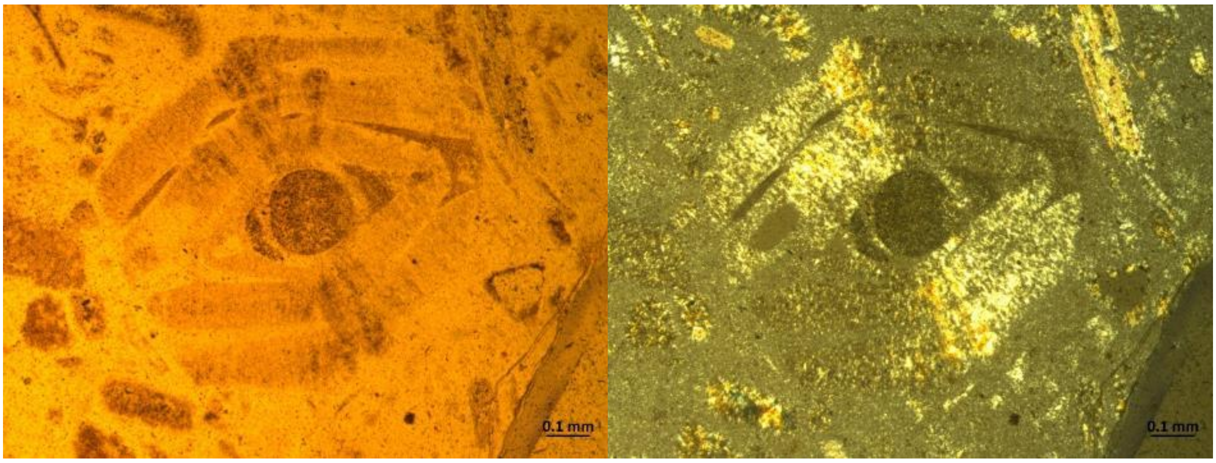

Fig. 34. A nummulite, in PP and in XP, in QC-BB (thin section number 67).

The Miliolida (Fig. 35) are an order of foraminifera with calcareous tests that are imperforate, commonly with a lining (Loeblich Jr., 1964; Pawlowski et al., 2001). Their tests are multi-chambered, and composed of calcite (Horowitz and Potter, 1971: 104). Miliolids are benthic Foraminifera which are commonly found in shallow waters, though some forms may appear in deep-water oceans. They are known from the Carboniferous to Recent (Omaña et al., 2016).

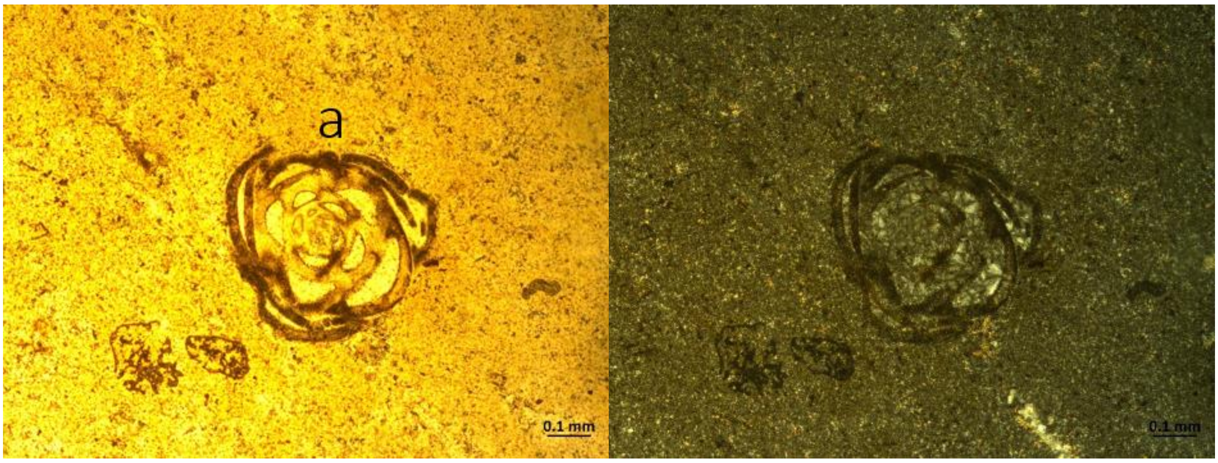

Fig. 35. a miliolid foraminifer (a), in PP and in XP, in MT (thin section number 19).

Globigerina (Fig. 36) is a genus of planktonic Foraminifera that have populated the world's oceans since the Middle Jurassic and until Recent times. They appear in globular forms, with tests composed of spherical to ovate elongate chambers (Bü, 1967). The shell wall is calcareous and perforate. They can be found worldwide, in deep-sea environments (Peeters et al., 2002).

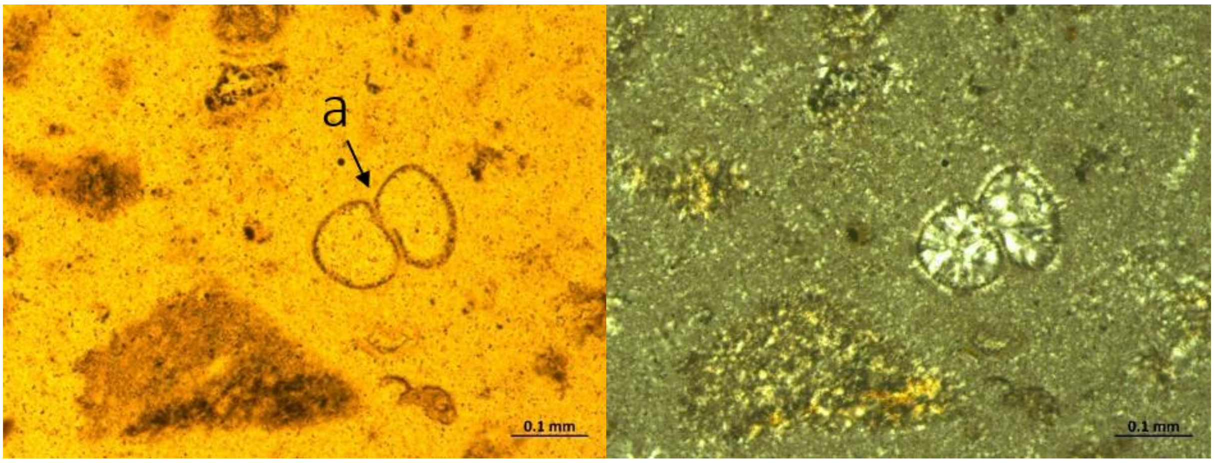

Fig. 36. a globigerinid foraminifer (a), in PP and in XP, in QC-BB (thin section number 67).

Buliminida (Fig. 37) is an order of mostly benthic foraminifera with walls which are usually of perforate, radially laminated calcite, and with chambers arranged bi-serially or tri-serially (Loeblich Jr., 1964; see an example in Fig. 5). It is known from Jurassic to Recent age, and is common in the Cretaceous upwelling belt

(Almogi-Labin et al., 2012). Buliminid foraminifera are mostly known from deep-water sediments, while shallow-water buliminids are often overlooked in biofacies studies due to their low abundance and small size (Haig, 1993). Buliminids are considered a foraminifer typical to the Late Cretaceous Mishash formation (Almogi-Labin et al., 2012).

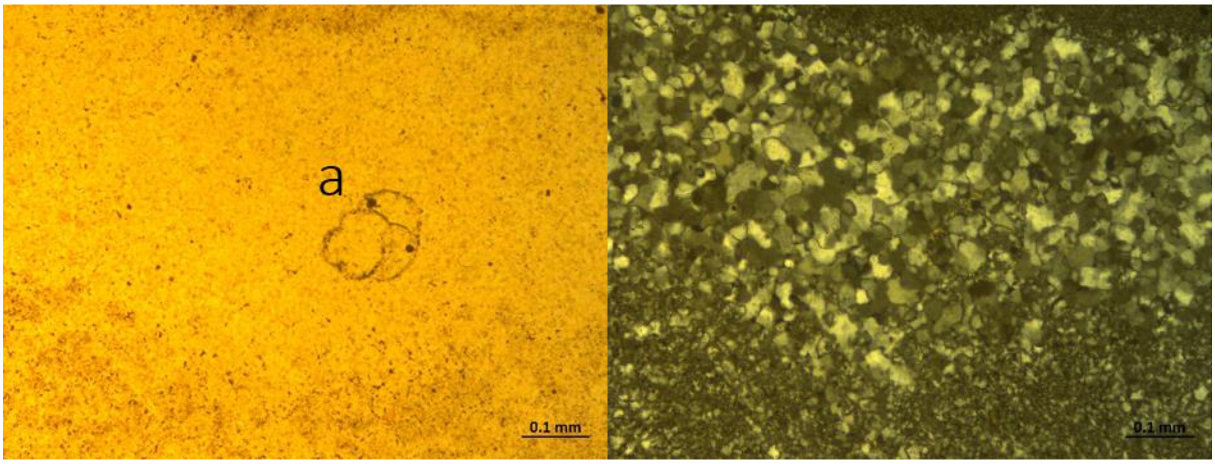

Fig. 37. A bulimina foraminifera (a), in PP and in XP, in a sample from the Campanian source BS2.

Nodosaria (Fig. 38) is a genus of uniserial multi-chambered foraminifers with a shell composed of chambers arranged in a straight or gently curved line (Loeblich Jr. and Tappan, 2015: 697). Some nodosaria are asymmetrically curved (Boltovskoy and Wright, 2013: 219). Nodosarids are commonly associated with an Eocene origin (Coryell and Embich, 1937; Golden, 1989).

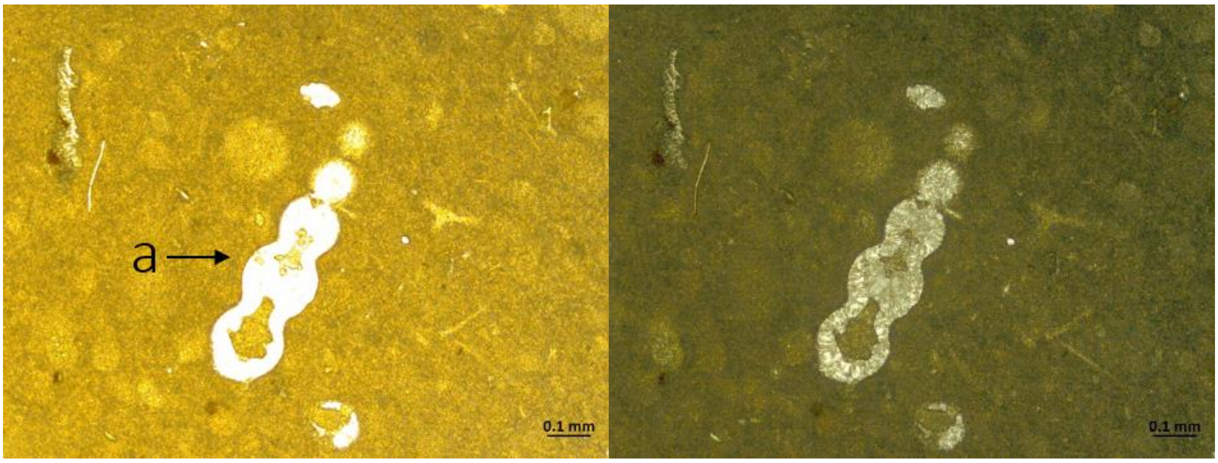

Fig. 38. A nodosarid (a), in PP and in XP, in a sample from the secondary source Lod.

Sponges are known from Cambrian to Recent-aged rocks, and take various shapes, with whole sponges most often consisting of a globular, vase or cup-shaped fleshy body, stiffened by mineralized needle- or rod-like structures called spicules (Horowitz and Potter, 1971: 48; Fig. 39). They are mostly found in silica-rich environments such as deep bottoms and upwelling zones (Uriz et al., 2003). In addition, sponges are contributors to the formation of coral reefs (e.g., Land, 1976; Maldonado et al., 1999; Rützler and Macintyre, 1978). In siliceous sponges, spicules occur in a wide morphological variety (Sethmann and Wörheide, 2008). Sponge spicules range in size from less than 1 mm long up to few centimeters, while transverse sections are usually less than 1 mm in diameter (Horowitz and Potter, 1971: 48). Opaline silica, from which siliceous sponges are often formed, is relatively unstable, and therefore it is not rare for sponge spicules to be replaced by calcite (Horowitz and Potter, 1971: 48). However, in flint they are usually siliceous.

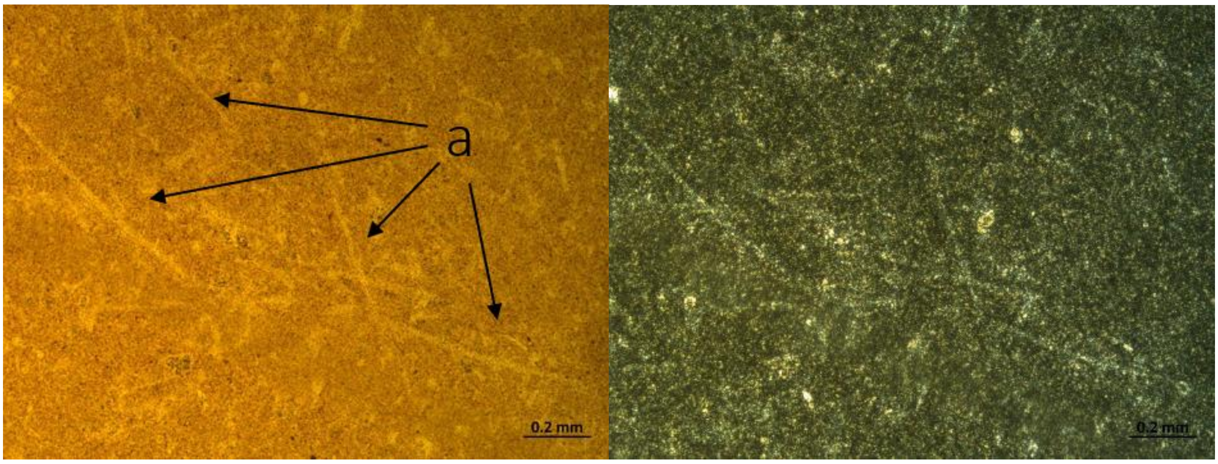

Fig. 39. Sponge spicules (a), in PP and in XP, in QC-E (thin section number 27).

Ostracods (Fig. 40) are members of a class belonging to the phylum Arthropoda, and are characterized by an outer skeleton which is usually not calcified, with numerous jointed appendages (Horowitz and Potter, 1971: 68). They are composed of two valves, either smooth or ornamented, joined along a hinge, with an overlap (Horowitz and Potter, 1971: 69). The overlap provides the ostracod with an asymmetrical appearance. Most documented ostracods are less than 1 mm in diameter, but forms up to 3 cm are also known (Horowitz and Potter, 1971: 69). Ostracods are distributed worldwide in most aquatic environments, both marine and fresh water, starting from the late Paleozoic onwards (Horowitz and Potter, 1971: 70). While many ostracod valves appear as smooth curves in thin sections, others may be highly ornamented and spinose (Horowitz and Potter, 1971: 70). Levinson (1961) suggested that the shell structures of ostracods vary and therefore may be useful in taxonomic and chronologic studies. Henningsmoen (1965), for example, has documented cross sections of Paleozoic ornamented ostracods. Most ostracods are difficult to determine beyond the class level, however, and none of the ostracods observed during this study were identified beyond that level. No clearly ornamented ostracods were observed in the analyzed thin sections.

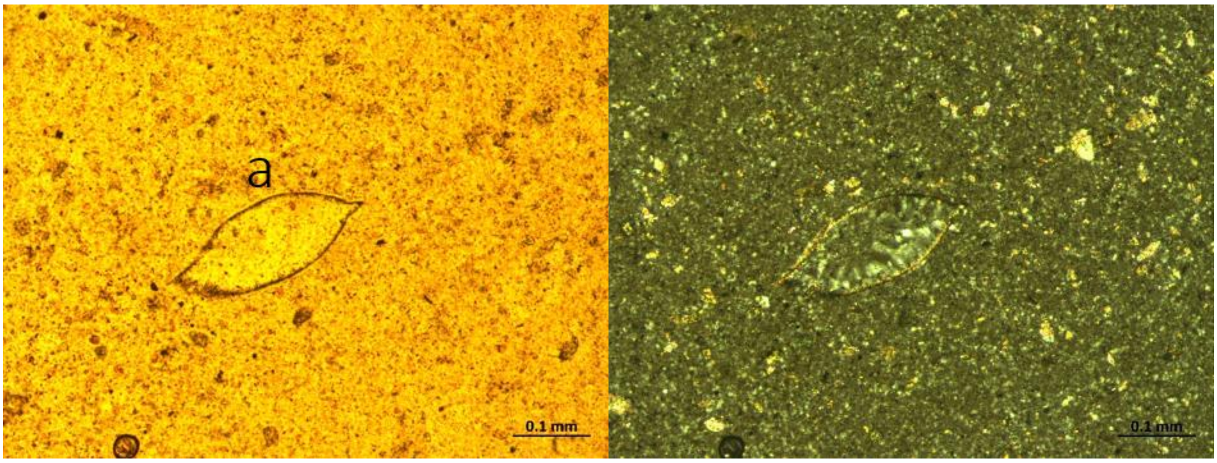

Fig. 40. an ostracod (a), in PP and in XP, in QC-S (thin section number 37).

Mollusks (Fig. 41) are another large and diversified phylum, distinguished by the presence of a mantle cavity, which is the hollow between the covering and the body of mollusks in which the respiratory organs lie, and which is often associated with breathing, excretion, the collecting and sorting of food, reproduction and incubation (Purchon, 2013: 2-3). Mollusks exhibit a wide range of shell shapes (Horowitz and Potter, 1971: 62). Examples from three major molluscan groups – bivalves, gastropods and cephalopods – were identified in the thin sections studied for this research.

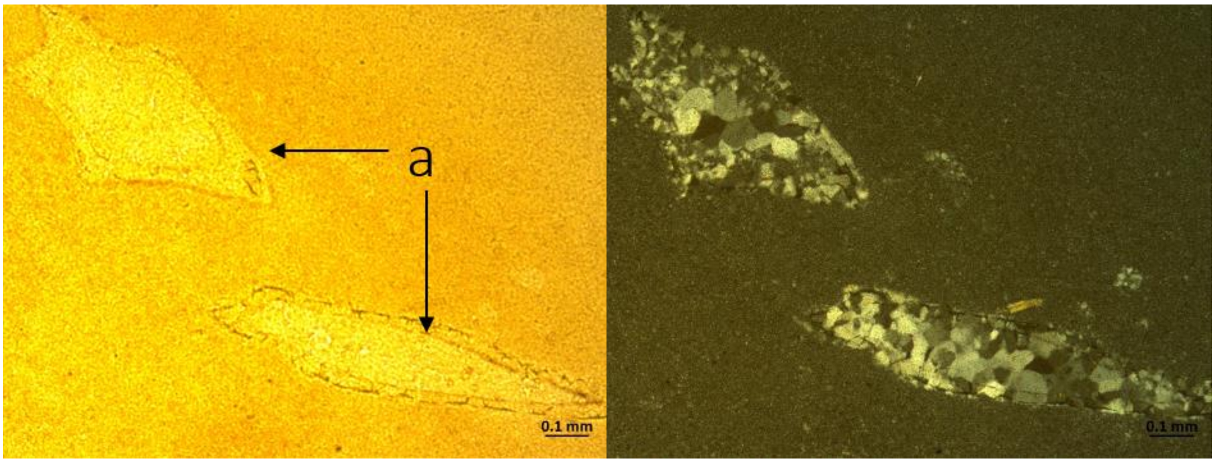

Fig. 41. two large fragments of crushed mollusks (a), in QC-AD, in PP and in XP.

Bivalvia is a class of mollusks comprising animals enclosed in two shell valves, such as mussels, oysters, scallops and clams (Gosling, 2008: ix). It is a highly successful class, known from the Cambrian to Recent time, which can be found in marine and freshwater habitats throughout the world. The shells of bivalves have several functions: they act as a skeleton to which the muscles are attached, they protect against predators, and they keep mud and sand away from the mantle cavity (Gosling, 2008: 7). They are composed mainly of calcium carbonate (Gosling, 2008: 7).

Gastropod shells are usually coiled tubes of various shapes (Horowitz and Potter, 1971: 66; Fig. 42). These coiled tubes are logarithmic spirals (Raup, 1966). Cross sectional views of gastropods vary significantly, depending on whether they are parallel, perpendicular, or at some other angle to the axis of coiling (Horowitz and

Potter, 1971: 66). Unlike foraminifera, gastropods are not chambered and usually present an infilled walled microstructure (Horowitz and Potter, 1971: 47). The gastropods are a very successful group, and have adapted to fresh water, marine, and terrestrial environments. They are distributed worldwide, and are known from the Cambrian up to Recent times (Horowitz and Potter, 1971: 67). The earliest known fresh-water gastropods are most likely Carboniferous, and the earliest conclusively identified land snails are Cretaceous (Knight et al., 1960).

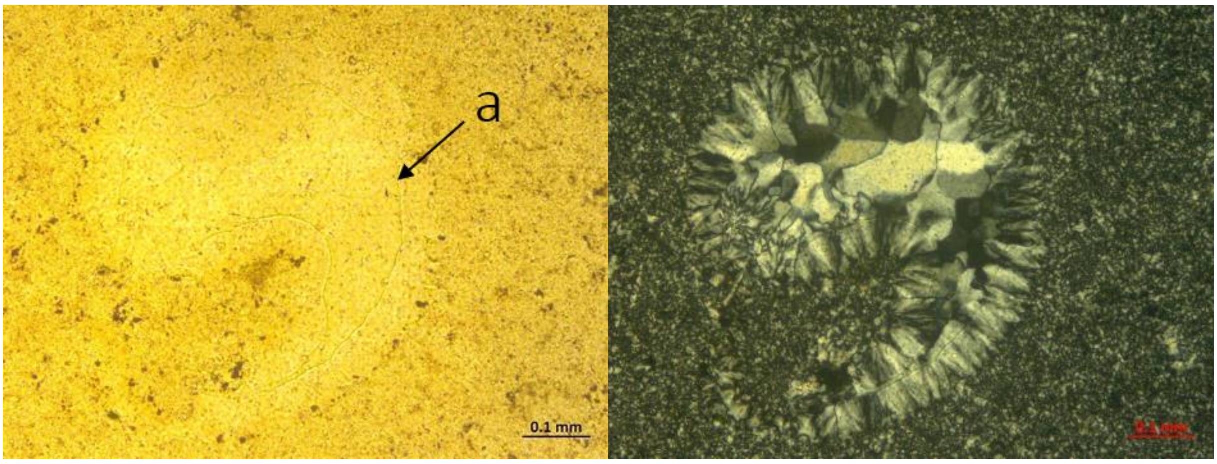

Fig. 42. A gastropod (a), in PP and in XP, in QC-AB (thin section number 46).

Cephalopods (Fig. 43) have coiled or straight shells divided into chambers, which appear round or ovate to sub-rectangular in cross-section (Horowitz and Potter, 1971: 67). They often have involute coiling, which means that the last spiral covers the previous ones. They range in size from a few millimeters to 10 meters, though most of them range between 2 and 10 cm (Horowitz and Potter, 1971: 67). Sections of cephalopods may demonstrate an initial chamber and partitions, which are responsible for the production of the multi-chambered shell (Horowitz and Potter, 1971: 67). They are usually larger than foraminifers, with much larger chambers, and their walls (initially made of aragonite) are often recrystallized to calcite (Horowitz and Potter, 1971: 47). They can be found in marine environments worldwide, starting from the

Ordovician and up to Recent times. However, they are most abundant in Paleozoic and Mesozoic rocks (Horowitz and Potter, 1971: 43).

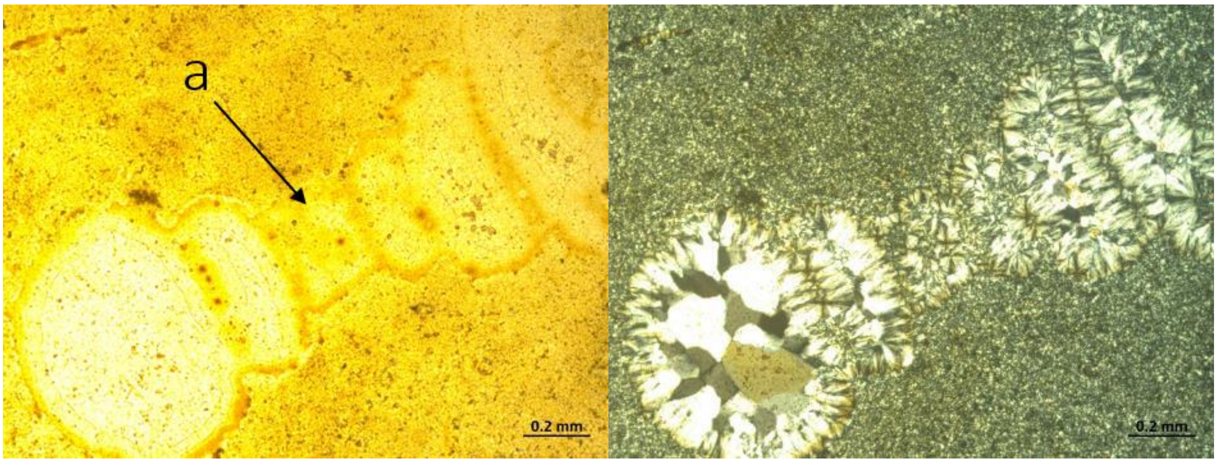

Fig. 43. A cephalopod (a), in PP and in XP, in QC-AB (thin section number 46).

Radiolaria (Fig. 44) are one-celled organisms which usually range in size between 0.1 and 0.2 mm in diameter (Horowitz and Potter, 1971: 43). Their siliceous shell is usually in the shape of a hollow perforate sphere or a vase, but it may vary. Occasionally spines extend beyond the wall of the shell. Radiolaria are found worldwide, exclusively in marine environments, starting from Ordovician to Recent times (Horowitz and Potter, 1971: 43). High concentrations of radiolaria in flint and silica beds have been interpreted in the past as evidence of volcanic activity, which provided the radiolaria with abundant silica for their initial blooming (Horowitz and Potter, 1971: 43).

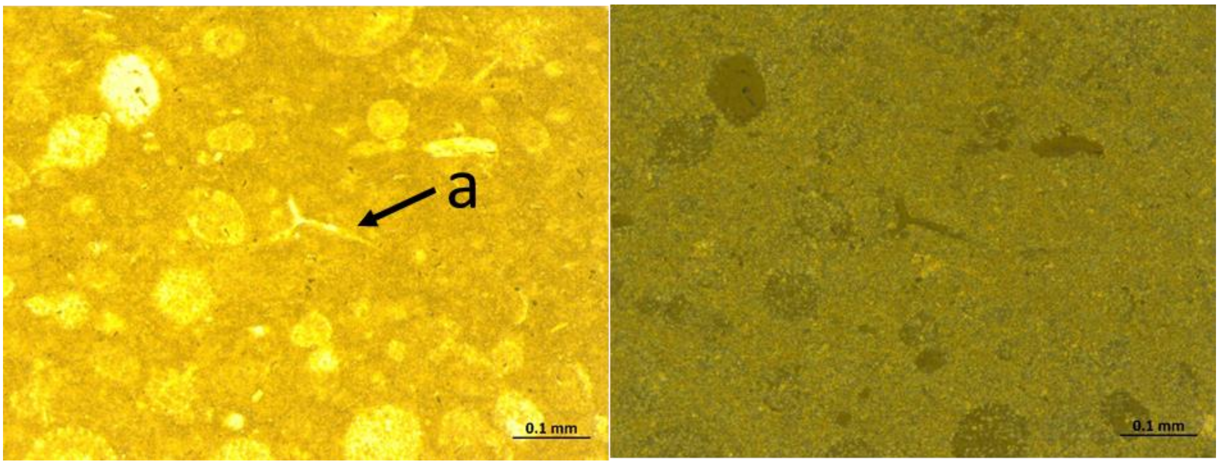

Fig. 44. A radiolarian (a), in PP and in XP, in Lod (thin section number 18).

Bryozoa are a phylum of colonial animals, whose calcareous skeleton may appear in various shapes, the most common ones being encrusting, branching and fenestrate (Horowitz and Potter, 1971: 54) (Fig. 45). The size of bryozoan colonies ranges from a few millimeters to half a meter, while the common range is between 1 and 10 cm (Horowitz and Potter, 1971: 54). They are marine dwellers, and can be found at all depths and latitudes, although they are most commonly found in shallow continental seas (Schopf, 1969). Their distribution is worldwide, starting from the Ordovician and until Recent times (Horowitz and Potter, 1971: 57). As they do not change much throughout time, and since they are found in a wide range of marine environments, they are not of much use as either chronological or environmental indicators.

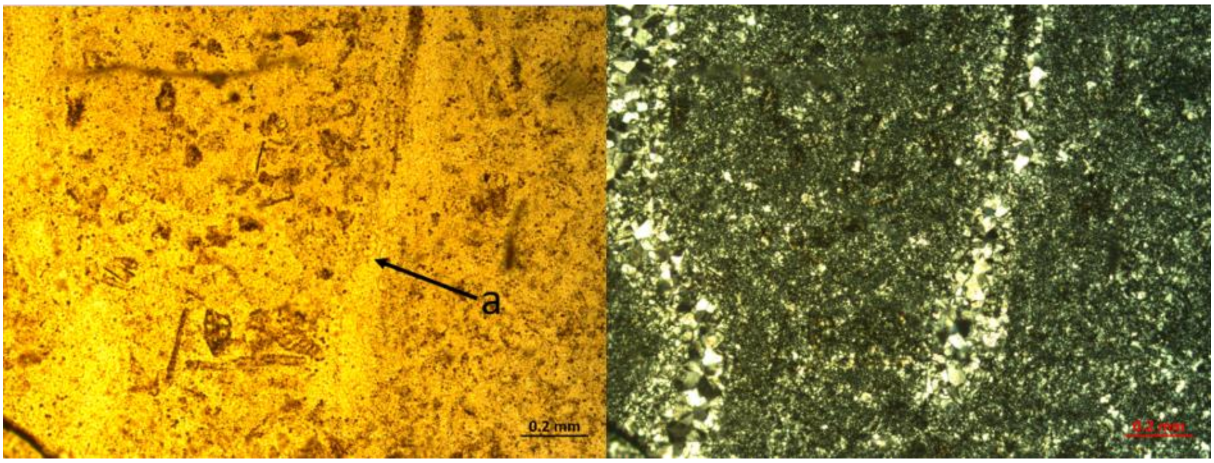

Fig. 45. A bryozoan (a), in PP and in XP, in TG1 (thin section number 96).

The phylum Charophytes (Fig. 46) includes extant and fossil members of the order Charales, as well as the members of the extinct orders Sycidiales and Moellerinales (Feist et al., 2005; Schneider et al., 2015). Charophytes are algae with a complex morphology, consisting of a central axis made of long unicellular cells, and short multicellular nodes, where whorls of branchlets are formed at relatively regular intervals (Schneider et al., 2015). They can be found worldwide (excluding Antarctica), starting from the Early Paleozoic and until Recent age, in fresh to hyper-saline waters (Schneider et al., 2015). They have not been not documented in fully marine environments (Schneider et al., 2015).

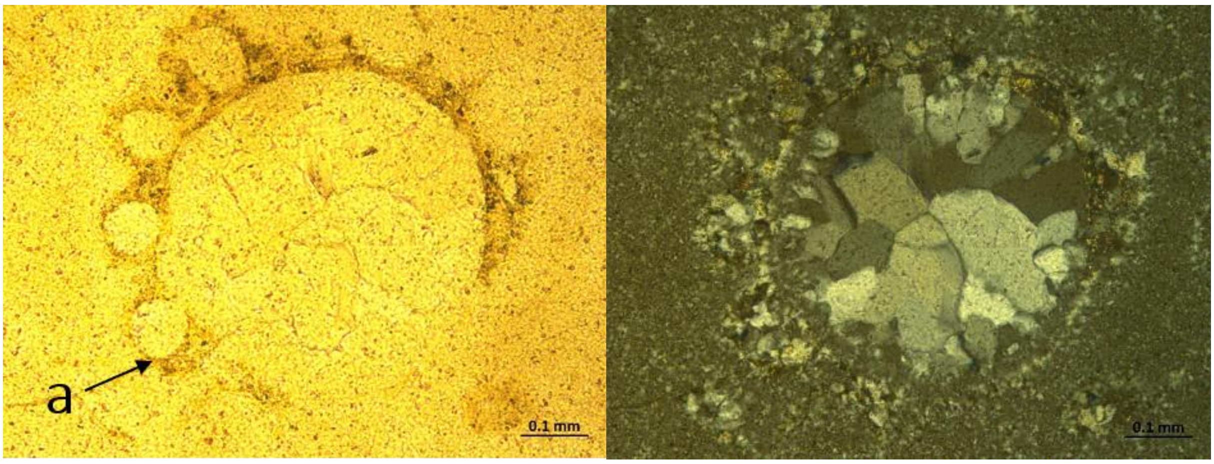

Fig. 46. a charophyte (a), in PP and in XP, found in flint type QC-AL.

5.3.1.2. *The Main Minerals and Textures*

This section will discuss the following minerals and textures: dolomite and calcite; and stripes, pellets, breccia, and spherulites. Depositional conditions change from one sedimentary sequence to another, and as a result mineral composition, stratification and other textural characteristics will also vary. Such variations can indicate different environments of formation (Williams et al., 1982: 312).

Rhombs of dolomite (Fig. 47) are common in flints, and may also provide information concerning the formation and diagenetic history of the rock (Knauth, 1979; Williams et al., 1982: 406-407). For instance, if scattered rhombs of dolomite were present in a limestone, later replacement of calcite by flint might have left crystals of dolomite "floating" in the flint. Alternatively, flint and dolomite could have formed contemporaneously, or flint could have been replaced by dolomite (Williams et al., 1982: 407). Generally, flint and well-formed crystals of dolomite are often found in association in limestone, implying a possible genetic relation between the two (Williams et al., 1982: 407). This may be related to a similar favorable diagenetic environment for the formation of both dolomite and flint, resulting in an overlapping of silicification and dolomitization (Knauth, 1979).

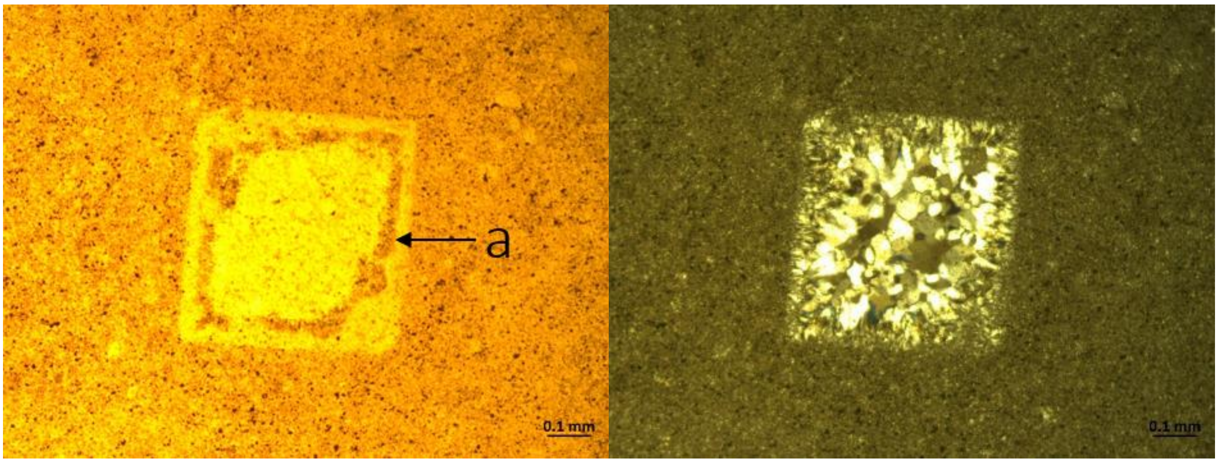

Fig. 47. A rhomb of dolomite (a), in PP and in XP, in QC-C (thin section number 25).

Calcite (Fig. 48) may be recognized in thin sections as a rhombohedral carbonate with perfect cleavage, and by its extremely high birefringence (Deer et al., 1992: 629). Calcite is a very common mineral, and has an important role in the formation of rocks in sedimentary environments (Deer et al., 1992: 630). In sedimentary rocks it is the main constituent of most limestones, appearing as independent crystals (spar, or sparry calcite), as a microcrystalline lime “mud” called micrite, as a replacement for other pre-existing minerals or fossils, and in the form of fossil shells (Deer et al., 1992: 630). Rocks which are fully composed of microcrystalline calcite are also called micrite (Williams et al., 1982: 369). In thin sections these tend to be sub-translucent and dark, usually in brown hues (Williams et al., 1982: 378). In the case of flint, as it forms in limestone, it is common to find remnant crystals or zones of calcite in it.

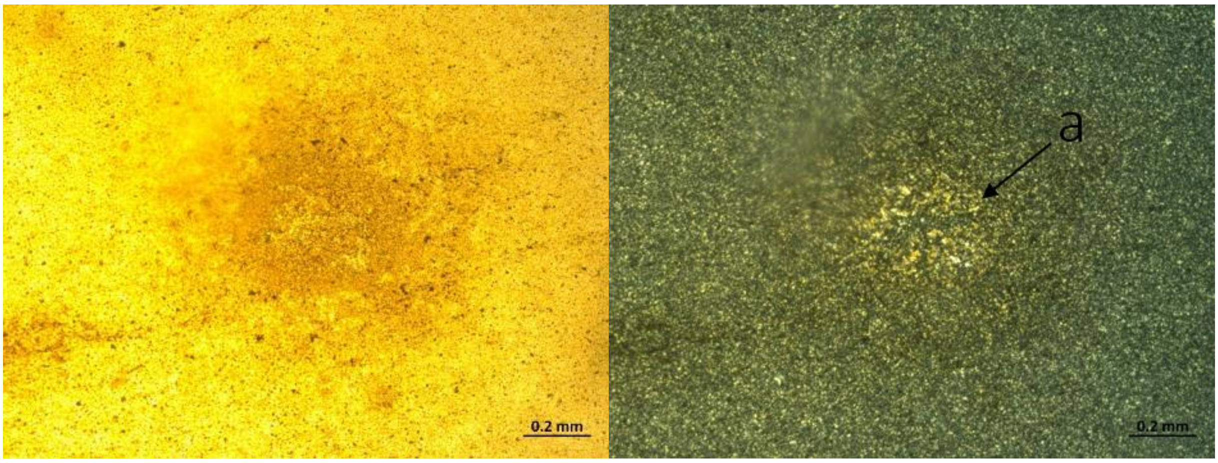

Fig. 48. A concentration of sparry calcite (a), in PP and in XP, in QC-D (thin section number 26).

In the following paragraph I discuss the main textures observed during this study. I start with stripes, and then move on to pellets, breccia, and spherulites. The thinnest layers or strata within a rock, called laminae, are less than a few millimeters thick, and therefore can be viewed in thin sections, often giving a slide a striped appearance (Fig. 49). Parallel laminae may be distinguished by differences in grain size and mineral composition. Usually, the coarser grains tend to accumulate at the bottom of the sequence (Williams et al., 1982: 313). Most sedimentary deposits of sand size and less tend to be deposited with lamination. However, after the deposition, the lamination is often disrupted by the activity of organisms, especially in marine environments, due to burrowing and scavenging activities. This process is termed bioturbation (Williams et al., 1982: 313). It may also occur in non-marine settings, due to the activity of roots, worms, and burrowing animals and insects. Therefore, clear laminae in a thin section may indicate a less disturbed environment of formation. However, this pattern may also be complicated by the fact that flint forms by secondary precipitation within a rock or sedimentary deposit, so the lamination may be a relict of the previous deposit, or a product of the flint's own formation process. For instance, crystallization of silica may occur along planes of suitable chemical conditions, pushing "impurities" away to form lineation.

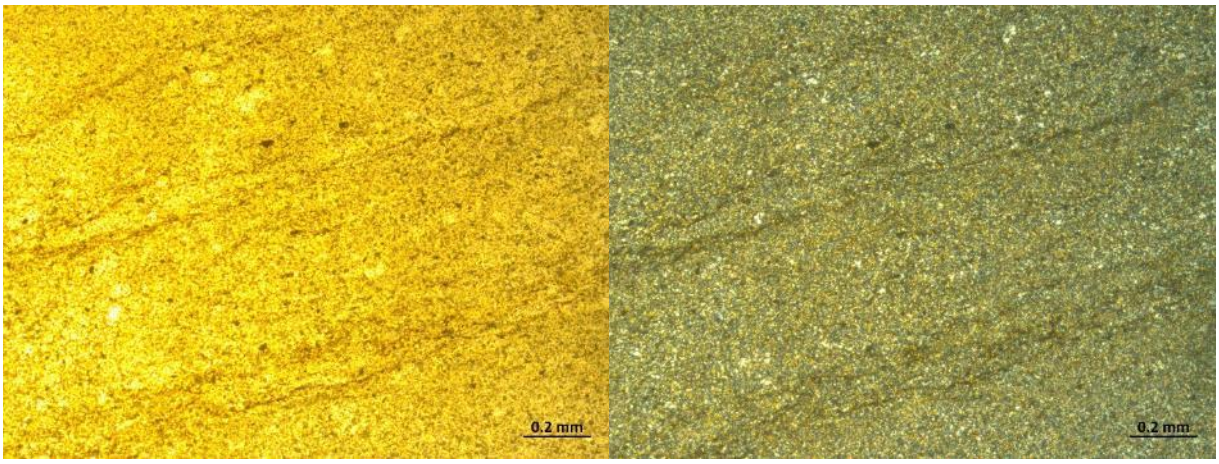

Fig. 49. A pattern of slightly irregular but continuous stripes, in PP and in XP, in QC-B.

The presence of pellets (Fig. 50) may also provide evidence of certain environmental and formational processes. Pellets are generally silt- to sand-sized grains composed of micrite, commonly oval, and without internal laminations, most likely of a faecal origin (Horowitz and Potter, 1971: 34).

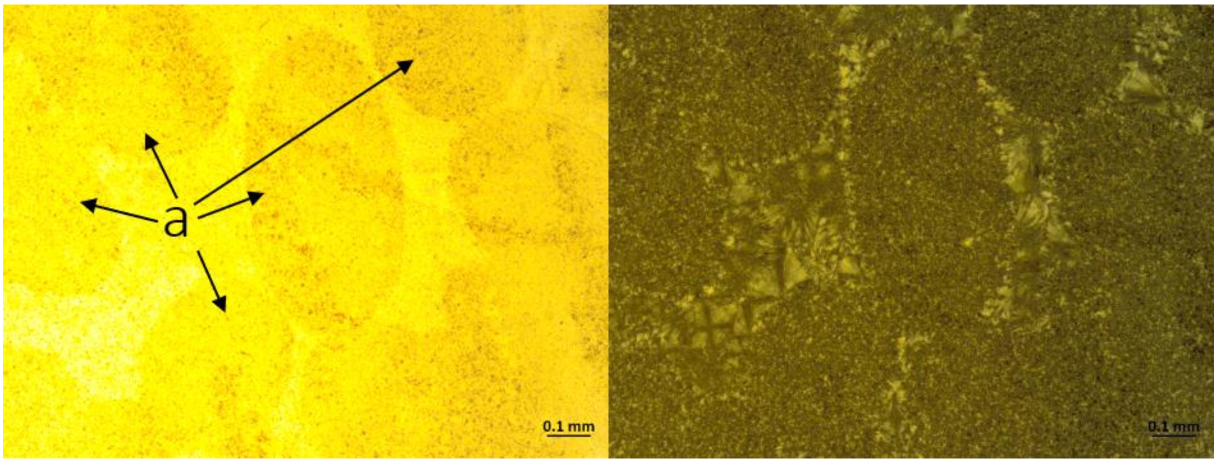

Fig. 50. Former pellets (a), in PP and in XP, in QC-BM (thin section number 75).

Breccia (Fig. 51) is defined by Williams et al. (1982: 306) as a coarse-grained clastic rock composed of angular grains (clasts), held together by either a crystalline cement or a matrix of finer grains (typically either clays and silt, or calcite). A similar rock composed of abraded rounded grains is a conglomerate. In archaeological flint, both the clasts and the matrix must be siliceous and they must be well cemented; if not, the rock will be entirely useless for stone tools.

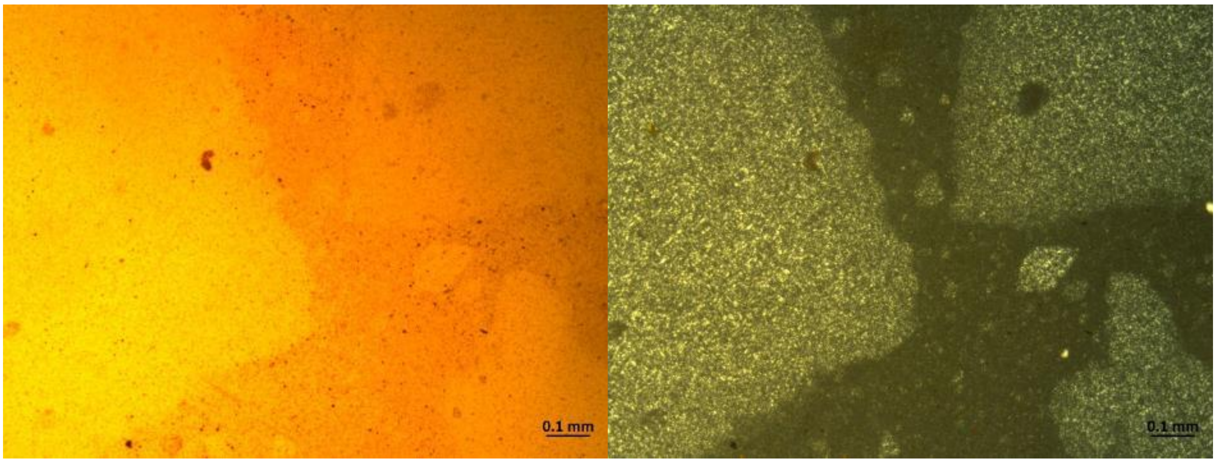

Fig. 51. A brecciated texture, in PP and in XP, in QC-AF (thin section number 50).

Spherulites (Fig. 52) are clusters of confocally radiating fibrous crystals, which commonly occur in silica-rich rocks (Lofgren, 1971). Each fiber is a single crystal slightly diverging from its neighboring fibers, forming a generally spherical composition (Lofgren, 1971). In the case of flint, the crystallization of spherulites occurs outwards from crystal nuclei, and in many cases must have occurred simultaneously from neighboring nuclei within an "empty" or liquid-filled space, resulting in spherulites blocking each other's growth and creating the interrupted-spheres appearance shown in Fig. 17.

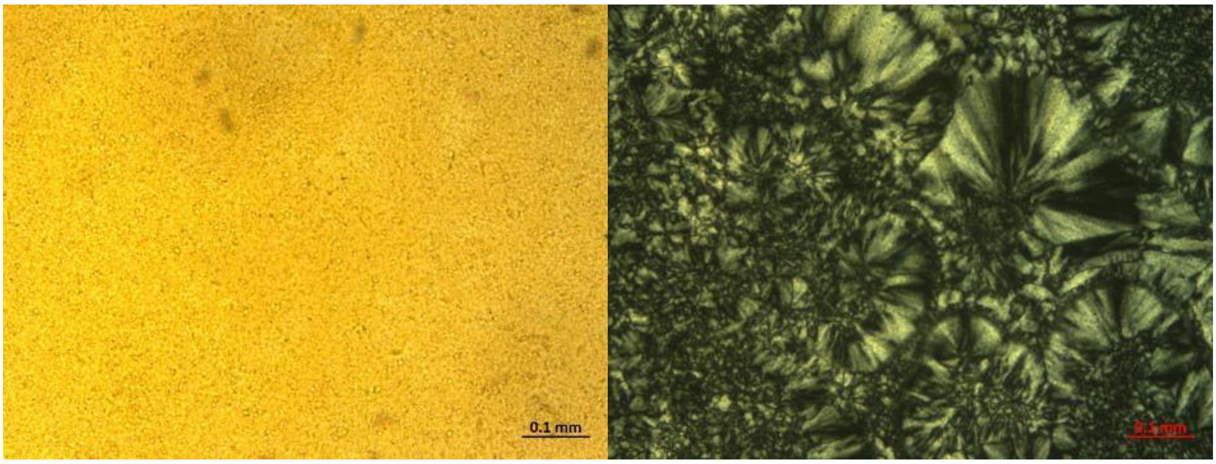

Fig. 52. A spherulitic texture, in PP and in XP, in QC-AG (thin section number 51).

5.3.2. Petrographic Analysis Results

In this section I present the analysis of the thin sections made of the geologic samples, trying to identify traits characterizing each source. I then cross these traits with the archaeological thin sections, in order to identify potential sources from which these flint types could have originated. For the full description of all thin sections, including figures, see the supplementary material volume.

5.3.2.1. The Geologic Sources

Table 3 in the supplementary material in the attached excel file presents identified types of foraminifera observed in the thin sections of the geologic samples. Table 4 in the petrography supplementary material excel file presents foraminifera which could be identified to a species level observed in the thin sections of the geologic samples. Table 5 in the petrography supplementary material Excel file presents other fossils observed in the thin sections of the geologic samples; Table 6 in the petrography supplementary material Excel file presents the minerals and textures observed in them. This section summarizes some of the significant results that emerge from the data gathered.

Iron is a very abundant element in the earth's crust, and can be found in many minerals (Luedtke, 1992: 41). Therefore, while it was identified in many thin sections, of both geologic and archaeological samples, iron cannot be considered as indicative of origin. Calcite is also a very common mineral, involved in the formation of many sedimentary rocks (Deer et al., 1992: 630), and in particular is the main mineral in the limestones in which flint typically forms. It therefore also cannot be used for the attribution of flint to specific sources. These two components are thus not discussed below.

For the primary Turonian sources three thin sections were made: MT (thin section number 19), OW2 (22) and HFNE (12). No overlaps in types of foraminifera were observed among the three thin sections, other than the presence of concentric foraminifera in both MT and OW2. As for other micro-fossils, ostracods were definitely observed in HFNE, and they were possibly present in the other two slides. Shell fragments were observed in MT and OW2, and were possibly observed in HFNE as well. Bivalves were definitely observed in MT, while possibly observed in the other two thin sections. No unified texture or minerals were observed, other than the absence of brecciated texture. The common traits which seem to characterize Turonian flint from primary sources are summarized in Table 12.

Table 12: Summary of the common traits of Turonian flint from primary sources.

Name	Age	Thin sections	Concentric Foram.	Ostracods	Shell fragments	Bivalve	Breccia
Migdal Tsedek	Turonian	MT (19)	+	?	+	+	-
Oranit West #2	Turonian	OW2 (22)	+	?	+	?	-
Horashim Forest North-East	Turonian	HFNE (12)	-	+	?	?	-

Secondary sources should be treated more cautiously, as they may represent accumulations from several different geologic ages and formations (Luedtke, 1978). Therefore, resemblances between different secondary sources located in Turonian terrain, for example, may suggest a similar origin, but they cannot do so conclusively, nor do they necessarily imply a certain geologic age and formation. The same is true for archaeological flint types which present petrographic similarities to any of these secondary sources- these cannot be securely assigned to these sources.

Foraminifera were observed and identified to type level in a few of the thin sections taken from secondary sources located within the Turonian terrain around QC, but with no clear overlaps (Table 3 in the petrography supplementary Excel file). The absence of indicative foraminifera, such as bulimina, a foraminifer typical of Campanian flint (C. Benjamini, personal communication), and nummulites, which are indicative of Eocene flint (Racey, 2001), is of note, reducing the likelihood of the presence of secondary deposits of these ages in the area. The presence of a partially-preserved nodosarid foraminifer, on the other hand, in a thin section from Wadi Qana (WQ3, thin section number 102; Fig. 53), in addition to the presence of bulimina foraminifera, is of special interest. While nodosarid fossils are occasionally associated with an Eocene origin (e.g., Golden, 1989), the background of the thin section rules out the option of an Eocene origin, as it also contains Cretaceous planktonic foraminifera (C. Benjamini, personal communication). Bulimina foraminifera, on the other hand, are typical of the Mishash Formation (C. Benjamini, personal communication), implying a Campanian origin. This suggests that Wadi Qana carried Campanian flint from sources located east of QC, making them more likely to be exploited by the QC hominins. Globigerinid foraminifera were observed in samples from two secondary sources located within the Turonian terrain around QC: FR (8) and NF (20). As these two sample also contain uniserial and coiled foraminifera, a possible shared origin may be suggested for them. However, as these are two secondary sources, and as NF is a very scarce source, this relationship should be treated cautiously.

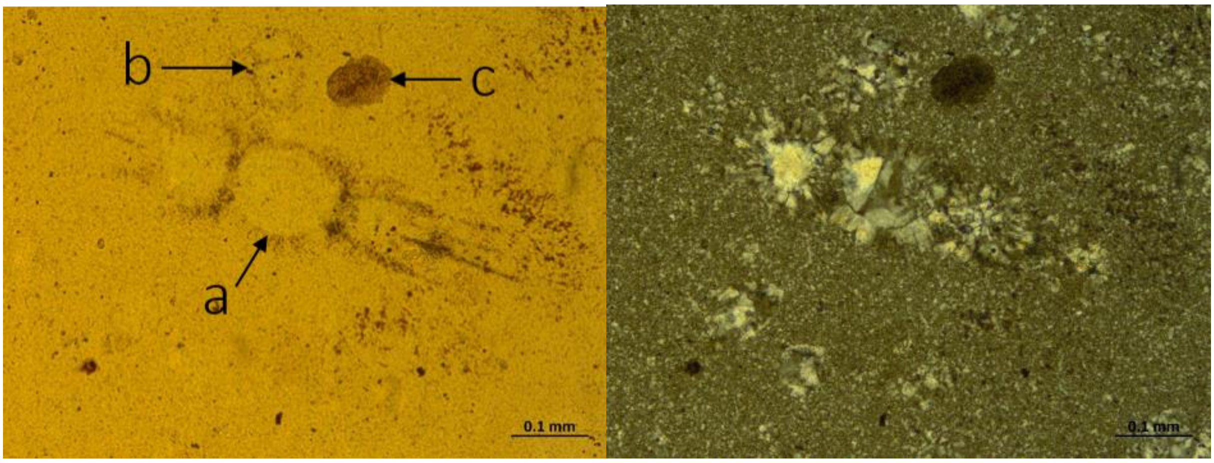

Fig. 53. WQ3 – cross-section of a partially-preserved nodosarid foraminifer (a), a bulimina foraminifer (b), and a possible spore or pollen grain (c), in PP and in XP.

Foraminifera which were not identified to a type level were observed in several thin sections. Uniserial foraminifera were observed in four secondary sources located within Turonian terrain: FR (thin section number 8), KQN (17), and in two thin sections from Horashim Forest - HF2 (10) and HF3 (11). Coiled foraminifera were observed in five secondary Turonian thin sections: E of QC2 (3), E of QC3 (4), FR (8), FF2 (10), and abundantly in WQ3 (102).

Stripes were observed in six thin sections of samples from secondary sources located within Turonian terrain (S of QC [87], UF1 [98], UF2 [99], HF [9], WQ1

[100], JW1 [14]), implying a relatively undisturbed environment during the deposition of these flint pieces, with low bioturbation activity (Williams et al., 1982: 313). The two thin sections from UF (98 and 99) also contain rhombs of dolomite.

The three samples from the Jaljulia Wadi (labeled JW1, JW2 and JW3; thin sections 14, 15 and 16, respectively) present a brecciated texture (Fig. 54, which also shows samples known to come from the Mishash formation). A brecciated texture was also identified in thin sections from the wadi at Horashim Forest (HF2, thin section number 10) and from Wadi Qana (WQ1, thin section number 100). As Horashim Forest and Wadi Qana are different parts of the same wadi, and as Jaljulia Wadi represents, most likely, an old course of Wadi Qana, similarities between the three sources are to be expected. As brecciated texture is considered a trait of the Mishash Formation (Kolodny, 1969), a Campanian origin of these samples is possible. Indeed, Campanian exposures exist further to the east along the course of Wadi Qana (Sneh and Shaliv, 2012, and for a comparison between the traits of the brecciated textures from the different sources see below). Further supporting a common origin of these sources is the presence of spherulites in four of these samples: JW1, JW2, WQ2 and WQ3.

Some overlaps between these three sources (HF, WQ and JW) also occur in terms of micro-fossils. Shell fragments appear in HF (9), HF3 (11), WQ1 (100), WQ3 (102) and JW1 (14); sponge spicules appear in two of them: HF3 (11) and WQ4 (103); gastropods appear in three of them: HF2 (10), WQ3 (102) and JW1 (14); bivalves appear in two of them: HF3 (11) and JW1 (14). These overlaps further support a common origin for these three sources. Table 13 summarizes the repeated traits in the thin sections from these three sources.

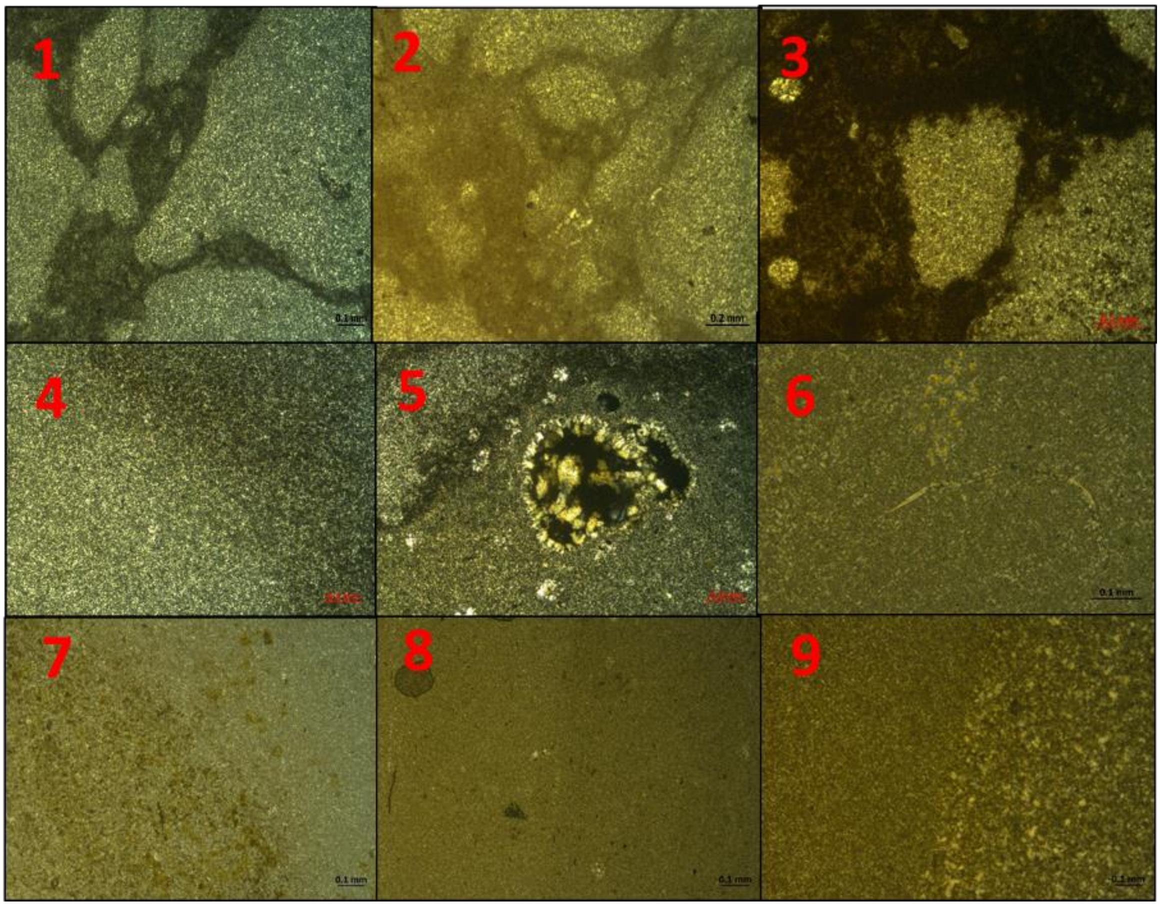

Fig. 54. The brecciated textures in the Campanian and Turonian thin sections: 1) BS1; 2) BS2; 3) ZM; 4) E of QC 2; 5) HF2; 6) WQ1; 7) JW1; 8) JW2; 9) JW3.

Table 13: Traits appearing at least twice in the thin sections from the sources Horashim Forest, Wadi Qana and Jaljulia Wadi.

Name	Distance (km) from QC	Thin sections	Sponge spicules	Shell fragments	Gastropods	Bivalve	Uniserial foram.	Coiled foram.	Stripes	Breccia	Spherulites
Horashim Forest	4.52	HF (9)		+					+		
		HF2 (10)			+		+	+		+	
		HF3 (11)	+	+		+	+				
Wadi Qana	5.38	WQ1 (100)		+					+	+	
		WQ2 (101)									+
		WQ3 (102)		+	+			++			+
		WQ4 (103)	+								
Jaljulia Wadi	5.78	JW1 (14)		+	+	+			+	+	+
		JW2 (15)								+	+
		JW3 (16)								+	

Cenomanian / Turonian sources, located 12-13 km north of QC, are also divided into primary sources and secondary sources. The primary sources include Sapir Forest (SF), Sapir Forest 2 (SF2) and Sapir Forest 3 (SF3). These sources are similar in terms of both macroscopic traits and shape of nodules (either flat slabs or roundish, appearing as layers embedded into the limestone) and petrographic traits (Fig. 55.; Table 14), suggesting that they represent the same geologic age and formation.

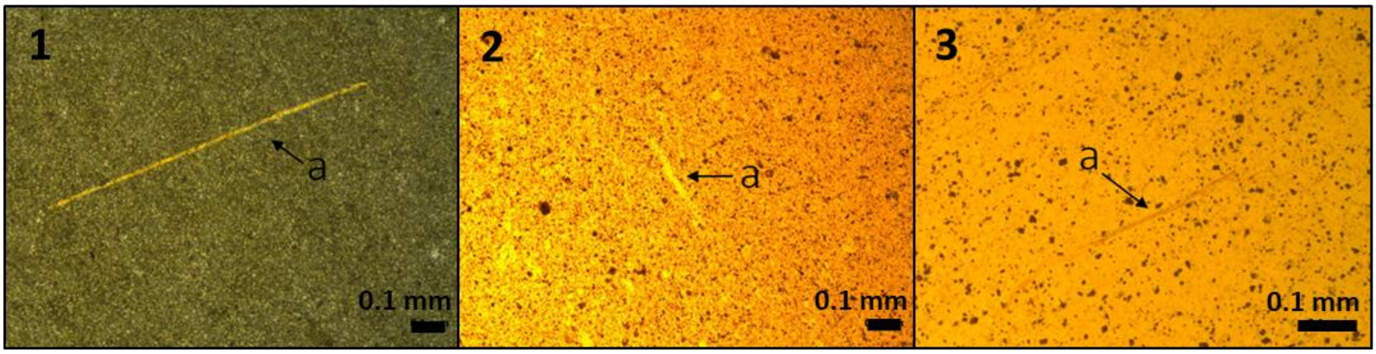

Fig. 55. Sponge spicules (marked by the letter "a") in thin sections from Sapir Forest. 1) SF (88), in XP; 2) SF2 (89), in PP; 3) SF2-1 (91), in PP.

Table 14: Traits which appear at least twice in primary Cenomanian / Turonian thin sections.

Source	Thin sections	Sponge spicules	Ostracods	Dolomite
Sapir Forest	SF (88)	+	?	-
Sapir Forest	SF2 (89)	+	?	+
Sapir Forest	SF-3 (90)	-	-	+
Sapir Forest 2	SF2-1 (91)	+	?	-

One secondary source was sampled in Cenomanian / Turonian terrain – Sapir Forest Wadi (SFW). Four thin sections were produced from samples from this source: SFW-1 (92), SFW-2 (93), SFW-3 (94) and SFW-4 (95). The petrographic similarities between these thin sections are summarized in Table 15. The stripes observed in two of these thin sections imply a low degree of bioturbation at the time of their formation, but do not necessarily imply the same origin. Given the low number of similarities between the four thin sections, it might be suggested that the wadi represents an accumulation of rocks from different geologic origins, though the data collected from these thin sections are not indicative enough to suggest any geologic origin.

Table 15: Traits which appear at least twice in secondary Cenomanian / Turonian thin sections.

Name	Thin sections	Biserial foram.	Stripes
Sapir Forest Wadi	SFW-1 (92)	-	+
Sapir Forest Wadi	SFW-2 (93)	-	-
Sapir Forest Wadi	SFW-3 (94)	+	-
Sapir Forest Wadi	SFW-4 (95)	+	+

Upper Cenomanian – Turonian sources, located in Eyal Forest, about 12 km north of QC, include EFIS, which is primary, and EFSC, which is secondary. Thin sections were made from two samples from EFIS (5-6) and one from EFSC (7). No common components were detected in these thin sections. However, each one individually shows some markers which might serve to indicate relationships to other samples in the future. EFIS (5) is characterized by the presence of a brecciated texture, with diffused boundaries, and of dolomite. EFIS-2 (6) contains calcite, sponge spicules, possibly ostracods, and shell fragments. EFSC (7) presents in one zone a weathered rock fragment of an igneous or metamorphic rock, which most likely got trapped within the flint during its formation process.

Campanian sources, located approximately 15 km or more south of the cave, include six secondary sources (MV, MM, BS, MP, ZM, and MPSW), and three primary sources (BSW, BSC and MPE). Thin sections were made from two samples taken from BS (1-2), and one from ZM (104). All three Campanian thin sections are characterized by a brecciated texture (Fig. 17). Brecciated textures are a known component of Mishash flints (Kolodny, 1969). In addition, buliminid foraminifera, typical of the Mishash formation (C. Benjamini, personal communication), were observed in one of the three Campanian slides, BS2 (Fig. 56). The identification of buliminid foraminifera in archaeological flint types can be used as an indicator of a Campanian origin of such types.

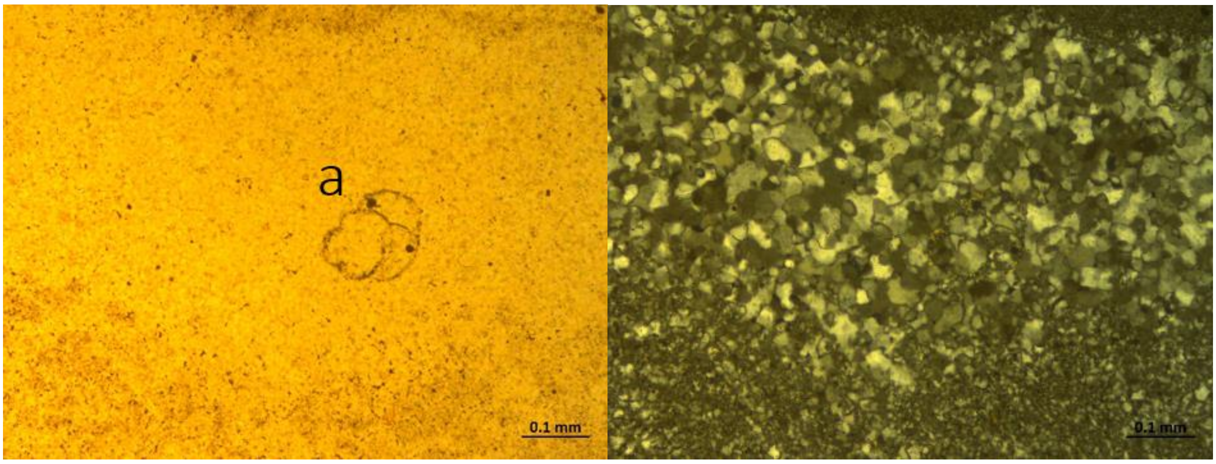

Fig. 56. A bulimina foraminifera (a), in BS2 – in PP and in XP.

As brecciated texture was also observed in thin sections of samples from Turonian sources (E of QC 2, HF2, JW1, JW2, JW3, and WQ1), the differences between the brecciated textures from each origin should be addressed here. Table 16 and Fig. 54 present the main characteristics of the brecciated textures observed in the Campanian and Turonian sources. The main difference between the Campanian breccia and the breccia observed in Turonian samples is the fact that boundaries between the clasts and the matrices tend to be distinct in the Campanian samples, while being more diffuse in the case of Turonian samples. The diffuse breccia resembles, to some extent, the diffuse breccia observed in EFIS (5), implying a relationship between the secondary Turonian breccia and the primary Upper Cenomanian – Turonian sources. Still, as these Turonian sources are secondary, a Campanian origin cannot be ruled out. As for the fossils observed in those samples, it is of note that uniserial and biserial foraminifera were found in the ZM sample, while biserial foraminifera were observed in E of QC 2, and uniserial foraminifera were observed in HF2. This might imply a relationship between these samples. However, as the boundaries between the clasts and the matrices in ZM are different than those observed in the two E of QC 2 and HF2 samples, this relationship cannot be considered conclusive. The presence of bulimina foraminifera in BS2 supports its assignment to a Campanian origin. Buliminids were also found in samples from WQ3 (see above) and Lod (see further below).

Table 16: The brecciated textures observed in Campanian and Turonian samples.

Sample	Origin	General description	Boundaries	Fossils	Iron	Comments
BS1	Campanian	A flint with a brecciated texture, with very fine-grained clasts	Distinct	Sponge spicules	+	with small roughly oval zones of a “bobbly” texture and opaque materials
BS2	Campanian	Brecciated flint, with some iron staining. Very similar to BS1	Distinct	bulimina foraminifera	+	
ZM	Campanian	A distinctively brecciated texture, similar to BS1 and BS2. Clasts are very pure, very fine silica with occasional coarser zones	Distinct	Uniserial foraminifera, biserial foraminifera, concentric foraminifera, possibly sponge spicules,	+	
E of QC 2	Turonian	A brecciated groundmass containing two matrices, both of which are extremely fine-grained.	Diffuse	Biserial foraminifera, coiled foraminifera	-	
HF2	Turonian	A breccia formed of extremely fine-grained and coarser-grained clasts.	Distinct	Uniserial foraminifera, coiled foraminifera, gastropods	-	
JW1	Turonian	A brecciated flint, with zones of fine-grained light-coloured fossiliferous groundmass.	Diffuse	Possibly ostracods, shell fragments, gastropods, bivalves	+	with a vaguely lineated structure.
JW2	Turonian	A brecciated medium to fine-grained flint, with zones which are fine-grained and light in colour and zones which are coarser-grained and darker.	Diffuse	-	+	
JW3	Turonian	A medium-textured breccia	Diffuse	-	+	
WQ1	Turonian	A medium to fine-grained breccia, with fine-grained clasts and coarse-grained matrix, with tiny holes, and some shell fragments	Diffuse	Shell fragments	-	

Finally, the Eocene sources included in this study are Lod, located on the outskirts of the city of Lod, ~18 km south of QC, and TGN, TGE and TG1, located at Tel Gezer, about 30 km south of QC. Samples collected at TGE came from both primary and secondary origins, while the other three sources are secondary. Thin sections were made from three Eocene samples, a primary-sources sample from TGE (97) and surface collection samples from Lod (18), and TG1 (96). While TGN, TGE and TG1 are located very close to one another, Lod is located about 10.5 km north of the other three sources, and might include material from a different formation of Eocene age. Still, some similarities between the thin section from Lod and those from Tel Gezer can be pointed out (Table 17). First, both Lod and TGE contain nodosarids (Figs. 57-58) and subbotina foraminifera (Fig. 56). Both nodosarids (Coryell and Embich, 1937; Golden, 1989) and subbotina foraminifera (C. Benjamini, personal communication) are associated with an Eocene origin. While the sample from Lod also contains bulimina foraminifera, which is typical of Campanian flint, it was identified as an Eocene flint, given the other components observed in it (C. Benjamini, personal communication). Interestingly, nummulites, which are well-known from Eocene flint (Racey, 2001), were not clearly observed in any of these flints, and only possibly observed in the Lod and TG1 samples, while they were not observed at all in the TGE sample.

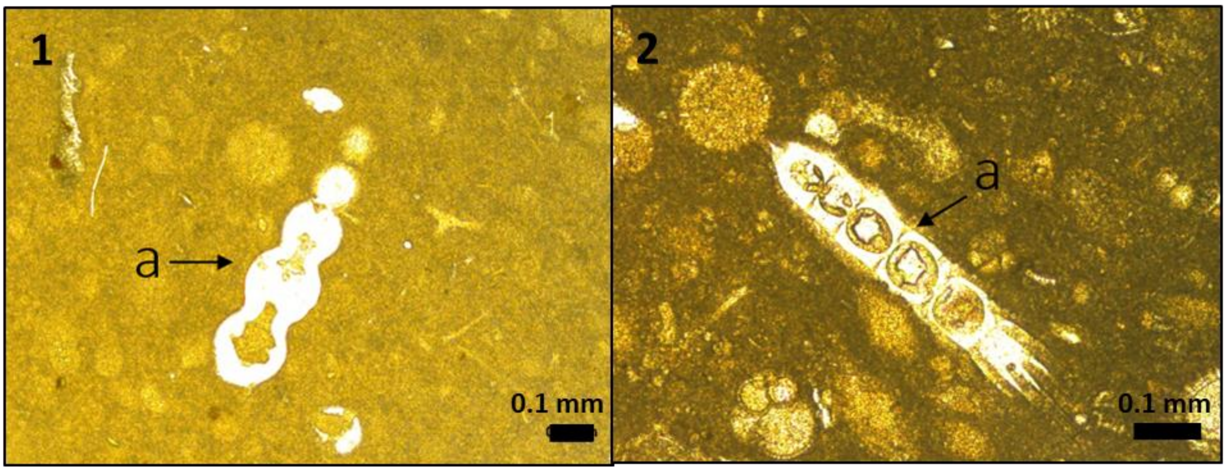

Fig. 57. Nodosarid foraminifera (a) in: 1) Lod (18), in PP, and 2) in TGE (97), in PP.

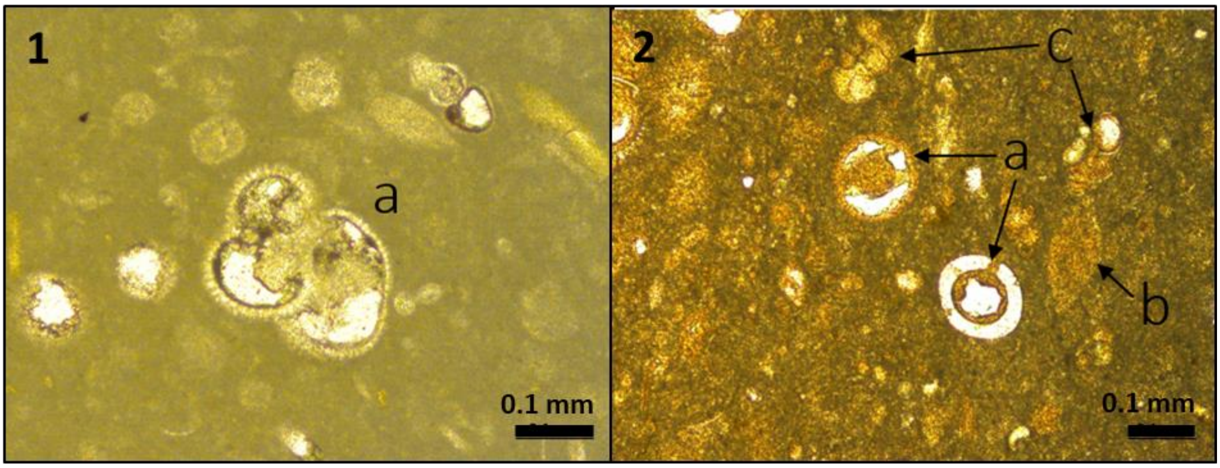

Fig. 58. 1) A subbotina foraminifer in the thin section of Lod (18), in PP; 2) Two nodosarid foraminifera, both in cross-section (a), a lens-shaped ostracod (b), and a subbotina foraminifer (c) in TGE (97), in PP.

Table 17: Petrographic traits appearing at least twice in the Eocene thin sections.

Name	Thin sections	Nodosaria	Nummulites	Subbotina foram.	Globigerinid foraminifera	Sponge spicules	Ostracods	Shell fragments
Lod	Lod (18)	+	?	+	+	+	+	+
Tel Gezer East	TGE (97)	+		+	+		+	
Tel Gezer 1	TG1 (96)		?			+	+	+

5.3.2.2. The Archaeological Samples

This sub-section presents some of the matches between the geologic thin sections and the archaeological thin sections. The full assignment of each flint type to its potential sources can be found in the supplementary material volume.

Eight of the flint types were assigned to Turonian sources based on the presence of stripes which are visible both macroscopically and microscopically. Flint types QC-B, QC-C, QC-D, QC-H, and QC-M, for example, all showed stripes which were observed both macroscopically and by using optical microscopy. Striped patterns were also seen, macroscopically and microscopically, in geologic samples taken from several Turonian sources [S of QC (thin section number 87), UF1 (98),

UF2 (99), HFNE (12), HF (9), WQ1 (100), and JW1 (14)]. These results, combined with the macroscopic similarities identified in terms of shape, colour and texture (see the full assignment of flint types to sources in the supplementary material volume), suggest the assignment of these flint types to these sources (see an example in Fig. 59).

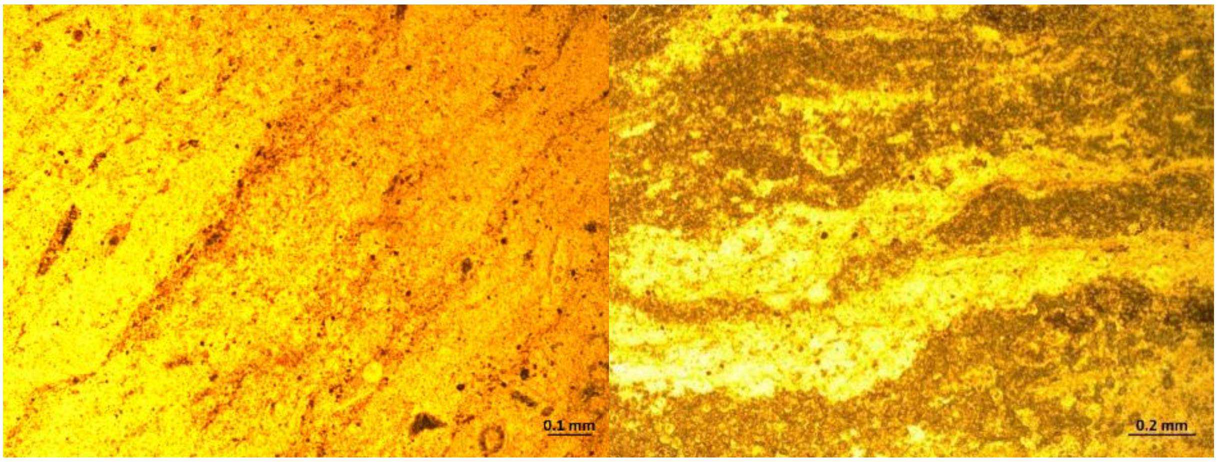

Fig. 59. Stripes in QC-M (left) and in UF2 (right), both in PP.

Slab-shaped nodules were common in some of the Turonian sources, while also being observed in some of the archaeological samples of these flint types (such as type QC-CI). It should be noted that the knapping process blurs the original shape of a nodule, therefore reducing the chances of identifying the original slab shape of the knapped nodule.

Globigerinid foraminifera were observed in thin sections of several flint types. The thin section of flint type QC-A, for example, presented globigerinid foraminifera (Fig. 60), as did the thin sections from the Turonian sources FR, which located 2.06 km south QC, and NF, which is located 6.43 km south of the cave. Combined with its macroscopic similarities to three Turonian sources - E of QC (0.79 km east of QC), S of QC (1.1 km south of QC), and UF (2.9 km south of QC), type QC-A was assigned to the Turonian, but with no clear assignment to a specific group of sources. It should be stressed, though, that as these sources are secondary, their affiliation to a Turonian origin is not conclusive.

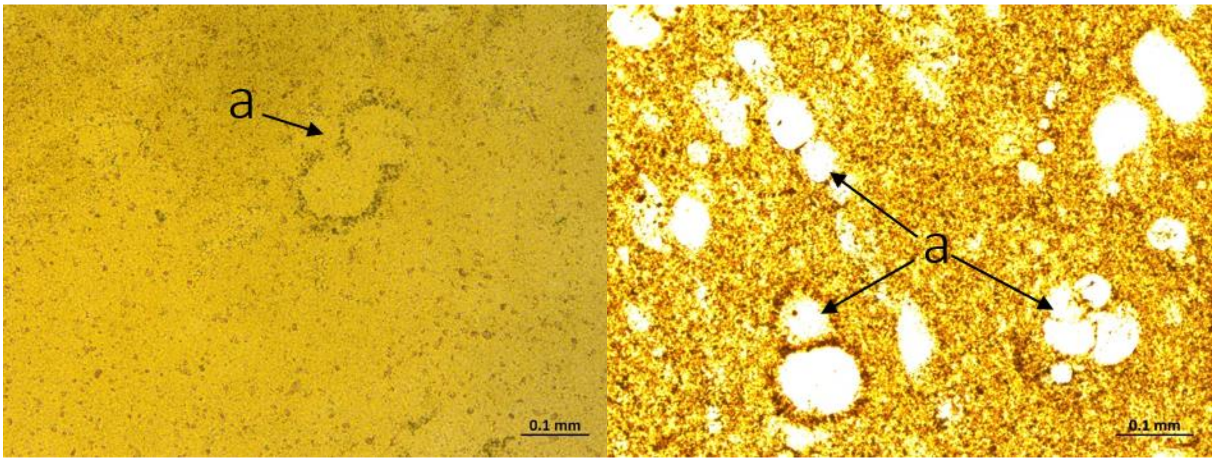

Fig. 60. Globigerinid Foraminifera in QC-A (left) and NF (right), both in PP.

The attribution of flint types to an Eocene age was mainly based on the presence of nummulitic foraminifera, which were observed either macroscopically, petrographically, or both. The presence of nummulites securely indicates an Eocene origin (Horowitz and Potter, 1971: 106) (Fig. 61-62). We could not securely attribute any Eocene flint type to a specific Eocene source, but given the distribution of the known Eocene sources, they must originate from sources which are not located in the immediate vicinity of the cave.

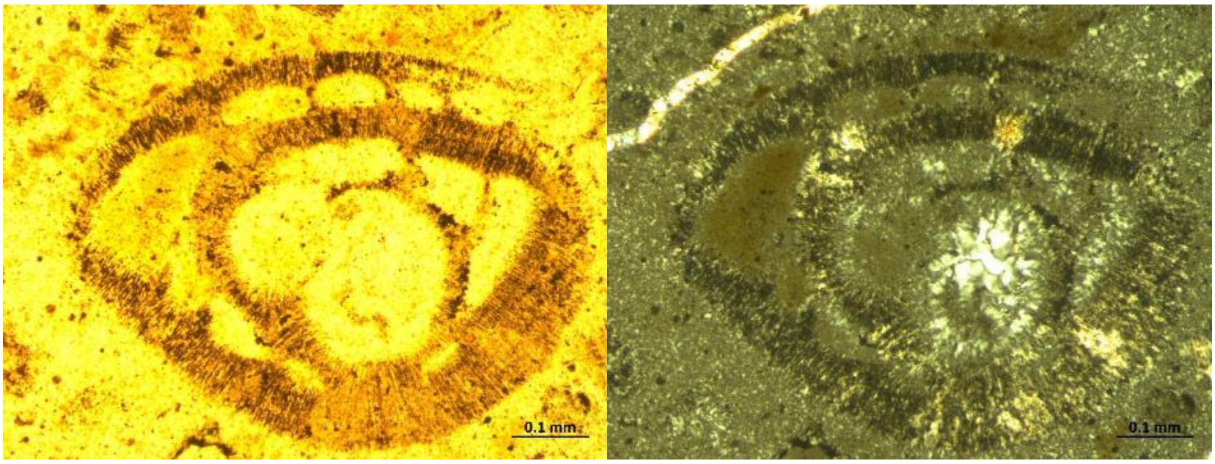

Fig. 61. QC-BB – a nummulite, in PP and in XP.

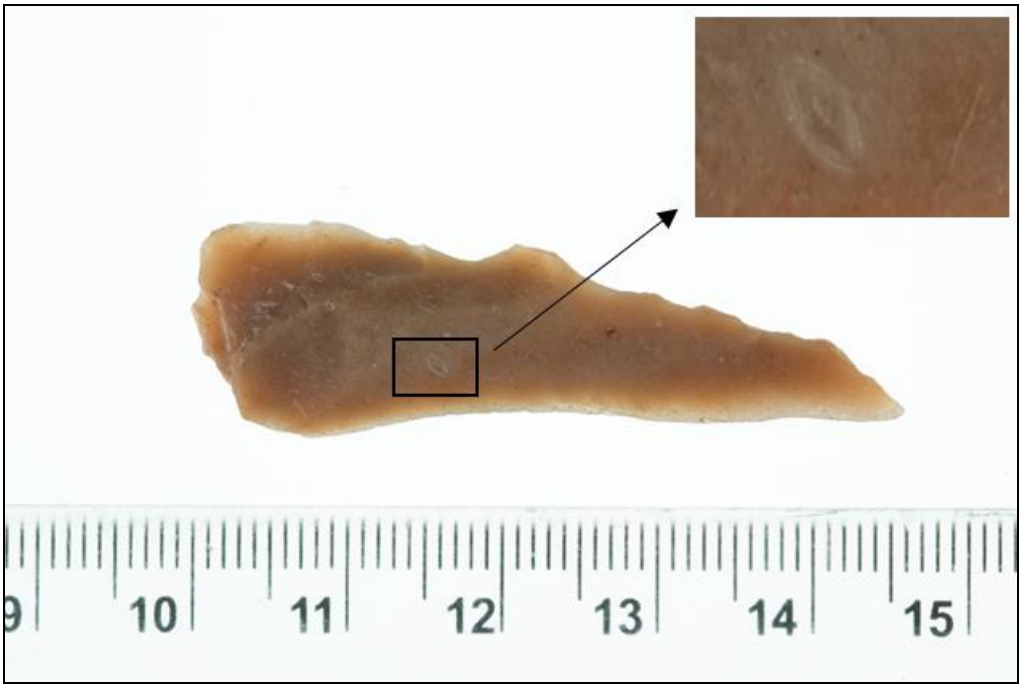

Fig. 62. A macroscopically visible nummulite in QC-CE.

The presence of charophytes in flint types QC-AL and QC-BB is of special note (Fig. 63). Charophytes imply brackish shallow lake environments with water depth of less than 10 m (Sim et al., 2006), an uncommon setting in the Southern Levant (C. Benjamini, personal communication). As charophytes are occasionally associated with Eocene rocks in the Levant (Wanas et al., 2015), and as type QC-BB contains nummulites, both macroscopically and microscopically visible, we assume at this point that type QC-AL, which does not contain nummulites, is also of an Eocene origin. This affiliation, however, is yet inconclusive.

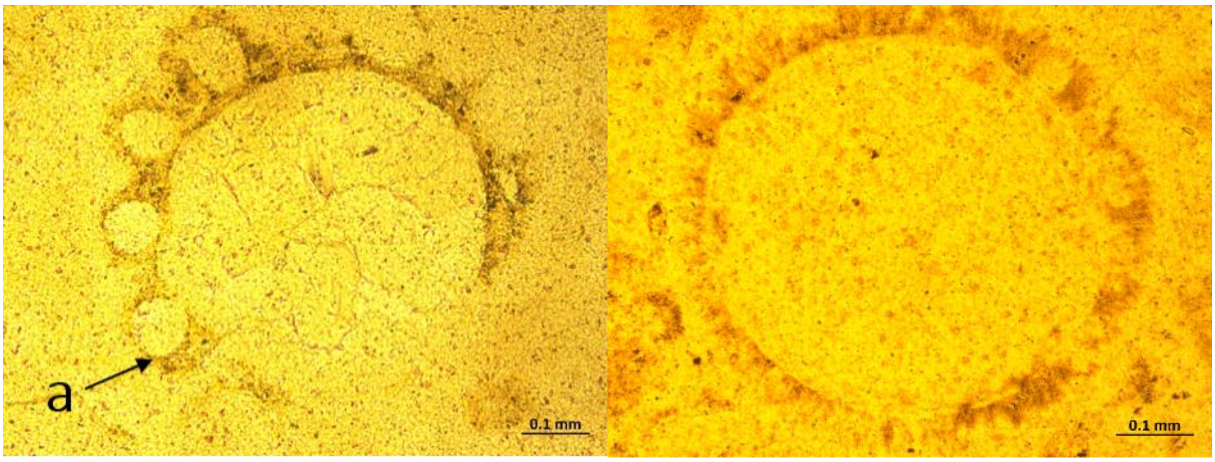

Fig. 63. Charophytes in QC-AL (left) and in QC-BB (right), both in PP.

The Campanian flint analyzed here (BS1, BS2, ZM) is characterized by a brecciated texture, in addition to the presence of bulimina foraminifera. Five of the QC flint types (QC-AF, QC-AO; QC-AQ; QC-AR; QC-BN) were assigned to a Campanian origin. The thin sections of flint types QC-AF and QC-BN, for example, both present a brecciated texture and bulimina foraminifera, similar to thin sections of the Campanian geologic samples BS1 (1) and BS2 (2) (see Figs. 64 and 65).

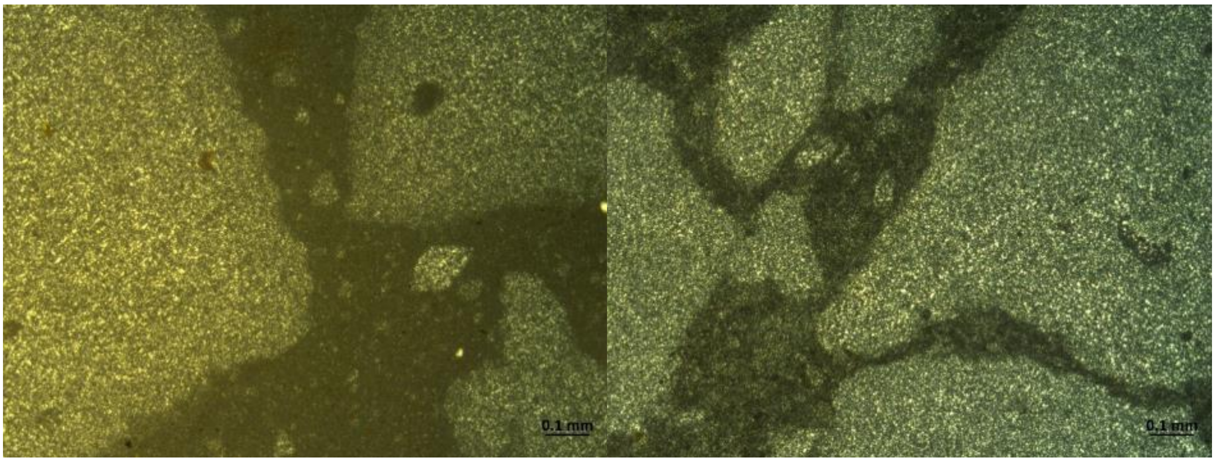

Fig. 64. A brecciated texture in QC-AF (left) and in BS1 (right), both in XP.

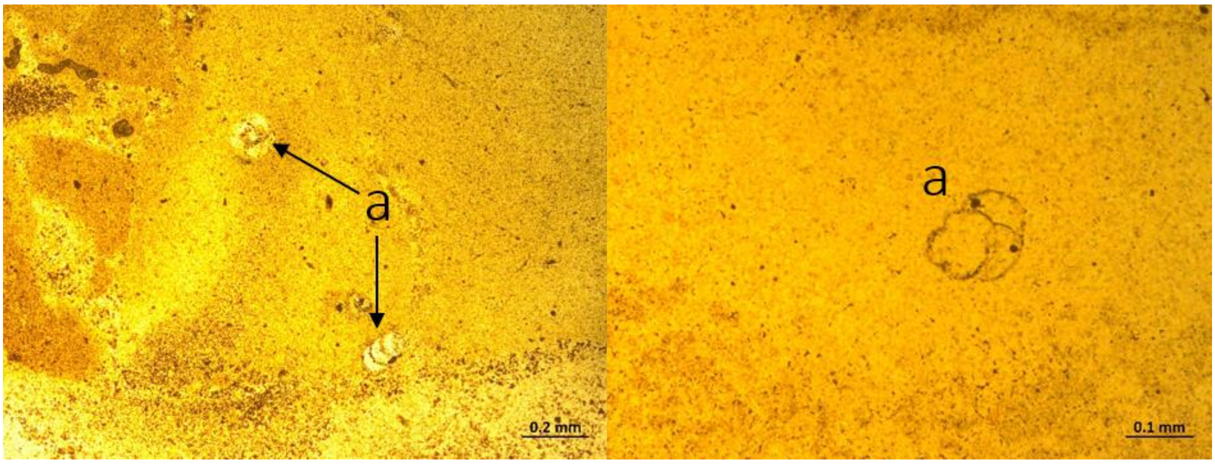

Fig. 65. Bulimina foraminifera (a) in QC-BN (left) and in BS2 (right), both in PP.

Flint types QC-S, QC-AW and QC-CC were assigned to sources located in Sapir Forest (SF, SF2, SFW, SF3), some 12-13 km north of QC, which represent either a Cenomanian or Turonian origin. The thin sections of samples taken from this area contain sponge spicules, possibly ostracods, and rhombs of dolomite. The thin section of type QC-S also contains sponge spicules and ostracods (Fig. 66). In addition, type QC-S shows macroscopic similarities to samples taken from Sapir Forest. Flint type QC-AW shows petrographic similarities to SF2 (89), with a similar texture, dolomite, sponge spicules, and possible ostracods. Flint type QC-CC was not examined microscopically. Therefore, based only on the traits it has in common with flint type QC-S, it was tentatively assigned to this group of sources.

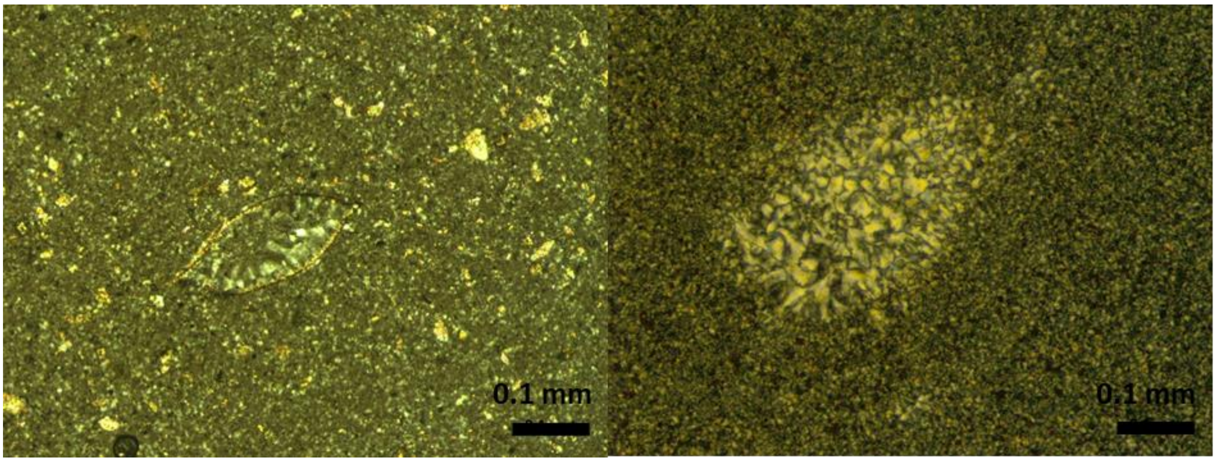

Fig. 66. An ostracod in QC-S (left) and a possible ostracod in SF (right), both in XP.

Flint type QC-U was tentatively assigned to Upper Cenomanian – Turonian sources located in Eyal Forest, some 12 km north of QC (EFIS and EFSC). The thin section of EFIS-2 (6) presents a very fine-grained texture, with calcite, ostracods, sponge spicules and shell fragments, similar to the thin section of flint type QC-U (Fig. 67).

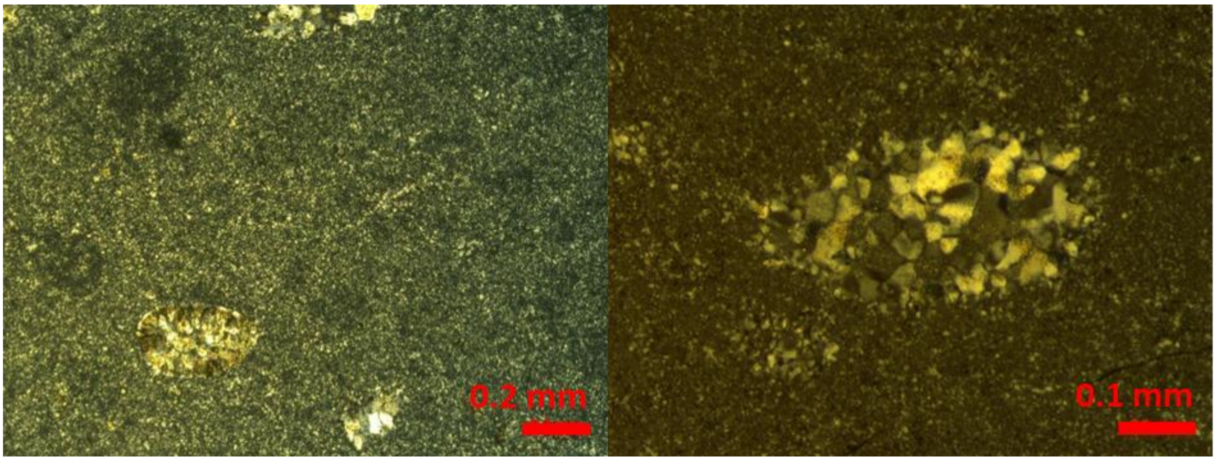

Fig. 67. Ostracods in QC-U (left) and in EFIS-2 (right), both in XP.

A brecciated texture was seen in eight of the QC flint types: QC-O, QC-AF, QC-AP, QC-AQ, QC-AT, QC-BN and QC-BZ. Types O, AQ, AT and BZ present a breccia with soft, diffuse boundaries, which matches the breccia observed in the *in-situ* sample EFIS (5) and in secondary Turonian more than that of the Campanian samples, while the breccia in Types AF, AP and BN is more distinct, matching the Campanian samples. However, as macroscopic observations point to visual resemblances between Type AP and Turonian sources, and Type AQ and Campanian sources, the division between diffuse breccia and distinct breccia should be treated cautiously.

Nummulites were identified in thin sections of two of the QC flint types (QC-BB and QC-CK; Fig. 2), as well as macroscopically in QC-BB, QC-BY, QC-CE, QC-CK, and QC-CN. They were not, however, conclusively identified in any of the geologic Eocene thin sections (Lod, TGE and TG1), therefore implying that these flint types did not originate from any of these Eocene sources. The fact that none of these flint types macroscopically matches geologic samples from any of these sources further supports this observation.

5.3.3. Summary of the Petrography Results

The petrographic results presented above, combined with macroscopic similarities, allowed the assignment of flint types to sources on three levels of certainty: certain, likely and tentative. Flint types of Eocene origin, for example, were securely assigned to their geologic age based on the presence of nummulites. The attribution of flint types to a Campanian origin is certain, given their brecciated texture and the presence of bulimina foraminifera; this is supported by strong macroscopic similarities. Overall, of 96 QC types, 8 can be assigned with certainty to their geologic source, source area or age, while 13 have been assigned a likely source, 59 a tentative source, and 16 still have no known source. The 16 flint types for which the source is yet unknown indicate that at least some of the flint sources used by the QC hominins were not identified during this study. The results might also be influenced, ar least partially, by the fact that I did not sample the potential flint sources located far to the east of QC (25-30 km from it). For a summary of the final assignment of all flint types to their potential sources, using both macroscopic, petrographic and geochemical data, see Table 22 further below.

5.4. Geochemical Analysis

ICP-MS (Inductively coupled plasma mass spectrometry) and ICP-AES (Inductively coupled plasma atomic emission spectroscopy) geochemical analyses were used in this study to analyze 38 different elements in 47 samples, taken from both geologic sources and archaeological samples. This part of the study is aimed at testing whether geochemical differences can be detected between the flint sources surrounding QC, focusing mainly on the local Turonian sources, in order to improve our understanding of the origin of some of the QC flint types. This analysis also tests the assumption that each source is relatively homogenous, and that we should be able to differentiate between different sources based on their elemental compositions (Luedtke, 1978).

In order to do so, I selected 30 flint samples from six different potential geologic sources around the cave (five samples from each source), two of which are primary and four are secondary: East of QC ("E of QC", 0.79 km east of QC, a secondary source, located within Turonian terrain), South of QC ("S of QC", 1.1 km south of QC; a secondary source, located within Turonian terrain), Under the Fort ("UF", 2.59 km south of QC; a secondary source, located within Turonian terrain), Horashim Forest ("HF", 4.29 km north of QC; a primary source, Turonian, Bi'na Formation), Eyal Forest In-Situ ("EFIS", 12.15 km north of QC, a primary source, Upper Cenomanian - Turonian, Eyal Formation), and Ben-Shemen Forest ("BS", 17.63 km south of QC, a secondary source, located within Campanian terrain).

Clearly, it would be best to identify and study as many potential outcrops as possible (Meyers, 1970). It is also preferable to sample, if possible, primary sources rather than secondary ones (Luedtke, 1978). In this study, however, I examined four secondary sources, and two primary sources (out of 21 Turonian sources identified during our survey). These secondary sources are of interest as they present some macroscopic matches with the QC flint types, implying they might have been used by the QC hominins. However, since secondary sources can represent accumulations from several different geologic ages and formations, cases of a significant degree of geochemical resemblance between geologic samples from these sources and archaeological samples might suggest use by the QC hominins, but cannot conclusively demonstrate this. As this is only a preliminary evaluation of the geochemical data which can be yieleded from the potential sources around the cave, these six sources were considered sufficient to preliminarily evaluate the geochemical composition of flint from both primary and secondary sources. Future work will expand this sample.

In addition to these six sources, 17 archaeological flint samples from QC were also analyzed, representing 13 different flint types. Nine of the 13 flint types were preliminarily associated with Turonian sources (Types A, K, M [three samples], O, W, AA and AD), based on macroscopic traits; three were associated with Campanian sources (Type AF [three samples]), one with Upper Cenomanian-Turonian sources (Type S), and four were considered to come from unknown sources (Types T, BJ, BP and BT).

This section focuses on the results for elements which have provided indicative data, while all of the results are available in the geochemistry supplementary Excel file. I present here the results for lithium (Li), sodium (Na), potassium (K), magnesium (Mg), calcium (Ca), aluminum (Al), rubidium (Rb), strontium (Sr), barium (Ba), vanadium (V), chromium (Cr), manganese (Mn), iron (Fe), nickel (Ni), cobalt (Co), copper (Cu), lead (Pb), zinc (Zn), yttrium (Y), neodymium (Nd), and uranium (U) within the samples. The results are presented in ppm (parts per million).

Table 18 presents a summary of the results. The "+" sign indicates that an element was found in relatively high proportions within a sample, while a "-" sign indicates that an element appears in relatively low proportions within a sample. A value is considered here as high if it is at least one standard deviation higher than the mean of all results of a certain element, while a value is considered as low if it is at least one standard deviation lower than the mean of all results of a certain element. In most cases the values of the different elements are very low, so this study compares subtle variations in the proportions of the elements. The elements are organized within the table based on their natural co-occurrence (see Table 4.2 in Luedtke, 1992: 40, and discussion in the following sub-section).

Table 18. Summary of the geochemical analysis highlights.*

Sample	Origin	Li	Na	K	Al	Mg	Ca	Rb	Sr	Ba	V	Cr	Mn	Fe	Co	Ni	Cu	Pb	Zn	Y	Nd	U
E OF QC 1	Turonian				-										-	-				+	+	
E OF QC 2	Turonian		-	-	-																+	
E OF QC 3	Turonian												+		-	-						
E OF QC 4	Turonian																			+	+	
E OF QC 5	Turonian		-												-	-						
S OF QC 1	Turonian														-							
S OF QC 2	Turonian																		+			
S OF QC 3	Turonian	+																				
S OF QC 4	Turonian																					
S OF QC 5	Turonian																					
UF 1	Turonian						+		+						+							
UF 2	Turonian	+															+	+				
UF 3	Turonian			+	+		+	+	+		+											
UF 4	Turonian																					
UF 5	Turonian	+													+	+						
HF 1	Turonian					+					-				-	-						
HF 2	Turonian	+																				
HF 3	Turonian	+					+															
HF 4	Turonian		+	+	+			+														
HF 5	Turonian	-			-																	
EFIS 1	Cenomanian - Turonian		+	+	+			+		+	+	+	+	+		+			+	+	+	
EFIS 2	Cenomanian - Turonian		+	+	+	+		+			+	+	+	+		+		+		+		
EFIS 3	Cenomanian - Turonian		+	+	+		+	+	+	+	+	+	+	+		+			+	+	+	
EFIS 4	Cenomanian - Turonian	-																				
EFIS 5	Cenomanian - Turonian		+	+	+			+			+	+	+	+		+			+	+	+	
BS 1	Campanian									+												+
BS 2	Campanian	-													-	-						
BS 3	Campanian	-																				
BS 4	Campanian																					+

BS 5	Campanian	-													-							+
QC A		+													+	+						
QC K		-																				
QC M1																						
QC M2																						
QC M3											+											
QC O		-																				
QC S			+	+	+			+														
QC T															-	-						
QC W			+												+							
QC AA 1													+							+	+	
QC AD		+																				-
QC AF 1		-													+							
QC AF 2		-																				+
QC AF 3																			+			
QC BJ						+	+		+				+									
QC BP			+	+	+						+	+		+		+			+	+	+	
QC BT															+							

* The "+" sign indicates that ppm values for an element are more than one standard deviation greater than the average for the assemblage as a whole; the"-" sign indicates that ppm values for an element are more than one standard deviation lower than the average for the assemblage as a whole.

As this is a preliminary geochemical analysis, it includes only five samples from each geologic source. Other studies vary greatly in the number of samples taken from each source. Ekshtain (2014), for example, in her PhD thesis, used between 1 and 25 samples from each geologic source for her geochemical analysis; Ekshtain et al. (2017) used between 3 and 15 samples from each source for their study of Amud Cave (Israel); Speer (2014), in his experimental sourcing in the Edwards Plateau (Texas), used between 9 and 224 samples from each sampled region for his LA-ICP-MS analysis; Finkel et al. (2017) used 10 samples from each analyzed tailings pile for geochemical analysis in their study of prehistoric flint extraction and reduction sites in the Galilee (Israel). Obviously, higher numbers of samples from each source could provide us with a broader picture of the geochemical variations within formations and between formations, and therefore, potentially, with a deeper understanding of the geochemical data of the examined sources and flint types.

5.4.1. Relations Between Elements

Almost all flints contain clays, as these are ubiquitous in sedimentary environments (Luedtke, 1992: 41). Therefore, as clays tend to adsorb other ions, flints that have a high content of clays will usually have relatively high proportions of many other elements, too, including Li, Na, K, Al, Cr, Y and U (Luedtke, 1992: 41). All clays contain Al (Luedtke, 1992: 41). V and Rb are often associated with calcite and with clays.

Iron is the fourth most abundant element in the earth's crust and it is found in many minerals. Manganese, while far less abundant, tends to behave in the same way, and is often found in association with iron (Luedtke, 1992: 41). Similarly to clays, iron and manganese oxides tend to adsorb other ions, especially Co, Ni and Cu. In flint, there is in many cases a close correlation between clays and metals both between and within different formations (Cressman, 1962). Mn, Fe, Co, Ni, Cr and Zn are associated with iron minerals, and are considered siderophile elements. Cu and Pb are also associated with iron minerals, and are considered chalcophile elements (Luedtke, 1992: 41-42). It should be noted that iron contaminations may also be caused by the use of hammers during the retrieving of samples from the geologic outcrops (Luedtke, 1978). In this study, in order to reduce chances of outer contamination, after crushing the samples in the Retsch Jaw Crusher BB 100, I chose only fragments from the inner parts of the samples for the finer processing, avoiding the use of outer surfaces. Outer surfaces were identified by the presence of cortex or patinated surfaces.

Carbonate minerals are common contaminants in flint, as many flints are formed by the replacement of carbonates, such as chalk, limestone and dolomite (Luedtke, 1992: 42). Therefore, we often see remnants of such minerals within flint, such as unreplaced rhombs of dolomite (Luedtke, 1992: 42). Ca can be found in most of the carbonate minerals, while Mg is a necessary component of dolomite. Mg, Mn, Fe and Sr often substitute for Ca in the carbonate minerals included in flint, as do Na, Ba, and the rare earth elements. Generally, Ca, Mg and Sr are considered the best indicators for carbonate content in flints (Luedtke, 1992: 42).

As flint often forms in close association with biologic organisms, organic materials may also be found as impurities within flint (Luedtke, 1992: 42). Ba, for example, is associated mainly with organic matter, while it may also be associated with clays and iron minerals. U occasionally co-occurs with organic carbon in some sedimentary rocks (Mason and Moore, 1985: 177).

Elements that are commonly associated with limestone are expected to vary greatly in flint, and cannot be considered as indicative of any particular source. Elements which are associated with clays also vary greatly within flint, and cannot in most cases be used to attribute flint to specific sources, as it is likely for a sample to have included a small spot of calcite, for example, and/or a few clay minerals. On the other hand, it is also easy for a sample to *not* include calcite and clays, giving a very different result which also should not be taken as significant. Luedtke (1978) suggests that a single nodule cannot be used as a representative of an entire source from which it originates, even in cases of visual homogeneity. Moreover, as the colour of flint is determined by compounds, and not by elemental content, flint colour is not directly correlated with elemental composition (Luedtke, 1978). Nonetheless, patterns of geochemical variation between sources and formations have been documented in the past (e.g., Ekshtain, 2014; Ekshtain et al., 2017; Finkel et al., 2018b; Luedtke, 1978), so it is also possible that some valid data might be obtained from such a study.

5.4.2. Geochemical Analysis Results

The four sources which are located within Turonian territory (UF, E of QC, S of QC – which are secondary, and HF, which is primary), show no clear unifying pattern. There are no elements which appear in especially high or low proportions within the Turonian samples, compared to the Upper Cenomanian-Turonian source (EFIS), or the Campanian source (BS) included in this study. This is not surprising, since flints from the same formation have been shown in the past to vary in their elemental compositions (Luedtke, 1978). As three of these four sources are secondary, and therefore might reflect a mixture of several different geologic origins, the likelihood of a lack of a clear pattern increases. It remains possible, however, that with a larger sample size, some clearer patterns might have been observed.

The results for the primary source EFIS did reveal some distinctive patterns. While samples EFIS 1, 2, 3 and 5 have relatively high values of K, Rb, V, Cr, Mn, Fe, Ni, Y and Nd, sample 4 has significantly lower values of these elements, showing it to be much purer than the other four samples from that source. The higher-than-mean values of these elements in the four samples (EFIS 1, 2, 3 and 5), as demonstrated below, and the lower values of EFIS4, imply that flint from EFIS varies in purity: there is in fact as much variation within this outcrop as there is across all of the sources tested here. The question remains whether EFIS provides flint which is either pure or particularly impure, or whether it can also provide flint with intermediate values for these elements.

The relatively high values of Rb (between 1.35 and 1.62 ppm, compared to a general mean of 0.45 ppm), and V (between 11.62 and 13.63 ppm; general mean: 5.67

ppm) in four out of the five EFIS samples are probably due to the presence of spots of calcite in the samples. The higher-than-average values of the siderophile elements Cr (between 25.71 and 40.56 ppm; general mean: 6.48 ppm), Mn (between 7.4 and 10.46 ppm; general mean: 3.24 ppm), Fe (between 1190.59 and 1609.05 ppm; general mean: 343.1 ppm) and Ni (between 10.14 and 12.7 ppm; general mean: 5.44 ppm) (Fig. 68) may imply the presence of clays or very minor metallic impurities. The chalcophile elements Cu (between 8.29 and 10.5 ppm; general mean: 3.63 ppm) and Pb (between 0.65 and 1.14 ppm; general mean: 0.4 ppm) are also slightly higher than the general mean, which may also imply the presence of clays or very minor metallic impurities.

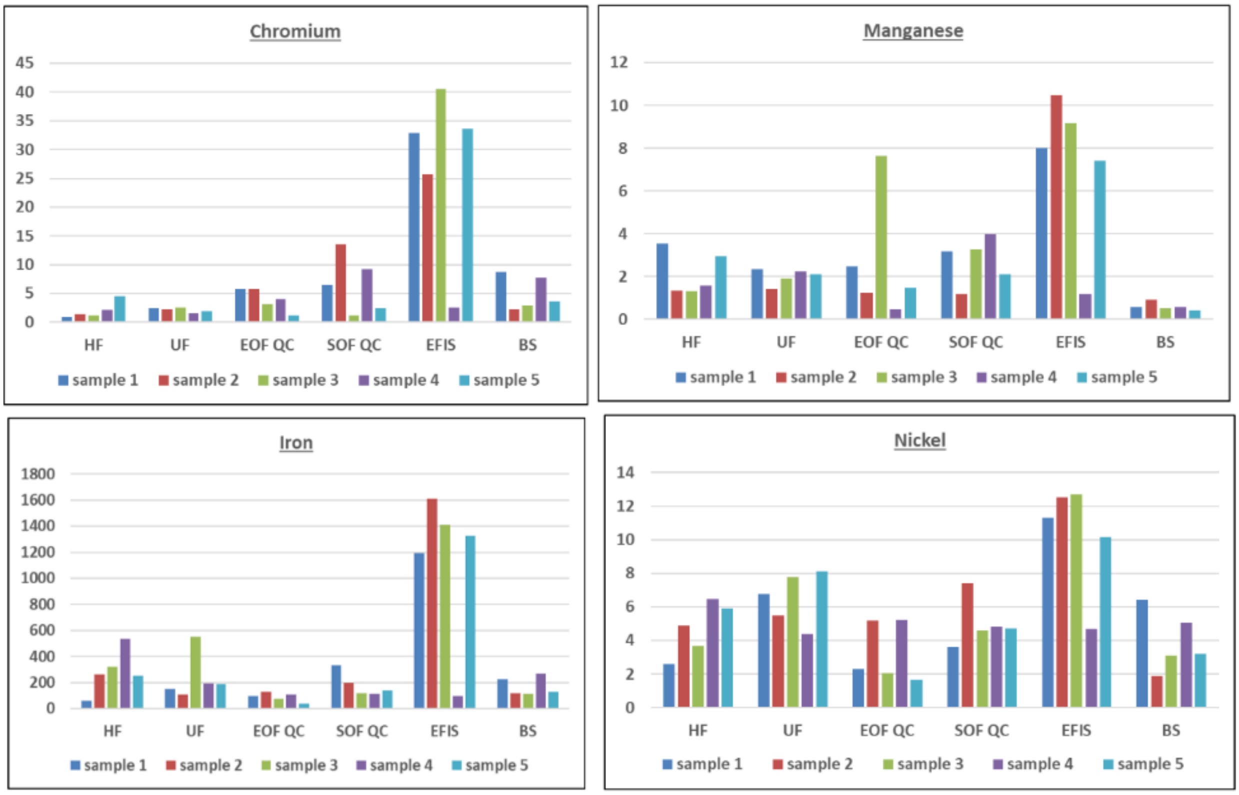

Fig. 68. Quantities of selected siderophile elements in samples from the geologic sources (in ppm).

Two archaeological flint types, S and BP, present a resemblance to the chemical compositions of the EFIS samples. The relatively high values of Na (Type S: 438.68 ppm; Type BP: 458.70 ppm; EFIS 1, 2, 3 and 5: range between 450.25 and

520.22 ppm; general mean: 204.06 ppm; Table 19) and K (Type S: 479.64 ppm; Type BP: 407.89 ppm; EFIS 1, 2, 3 and 5: range between 643.96 and 681.90 ppm; general mean: 219.49 ppm; Table 20) may be associated with clay, however, and cannot be considered a reliable indicator of their origin. The same is true for the relatively high values of Rb (Type S: 1.16 ppm; Type BP: 0.76 ppm; EFIS 1, 2, 3 and 5: range between 1.35 and 1.62 ppm; general mean: 0.45 ppm), an element associated with calcite, in these two flint types.

Table 19: Na values for all samples of the geochemistry analysis*.

	Sample 1	**Sample 2**	**Sample 3**	**Sample 4**	**Sample 5**
HF	89.28	146.07	182.40	383.48	83.87
UF	108.34	134.40	280.34	80.06	156.41
EOF QC	81.07	50.05	76.35	116.95	51.97
SOF QC	106.38	128.26	89.19	100.94	98.02
EFIS	536.63	450.25	494.74	108.89	520.23
BS	246.16	187.21	166.53	243.59	163.68
QC A	206.21				
QC K	110.81				
QC M	205.34	307.77	196.76		
QC O	166.47				
QC S	438.68				
QC T	193.67				
QC W	342.40				
QC AA	123.36				
QC AD	202.56				
QC AF	204.58	242.86	146.86		
QC BJ	182.37				
QC BP	458.71				
QC BT	199.79				

* coloured spaces represent values one standard deviation higher than the assemblage mean value; bolded fields represent values one standard deviation lower than the mean value (204.06 ppm).

Table 20: K values for all samples of the geochemistry analysis*.

Group	sample 1	sample 2	sample 3	sample 4	sample 5
HF	127.61	215.66	293.72	498.04	63.53
UF	105.70	188.16	433.53	97.66	234.32
EOF QC	61.33	48.11	62.89	128.53	69.36
SOF QC	133.85	122.04	123.84	129.78	165.49
EFIS	652.48	681.91	643.96	90.07	658.51
BS	201.10	123.50	113.31	180.04	121.41
QC S	479.64				
QC W	283.49				
QC K	62.34				
QC O	109.48				
QC T	192.04				
QC AF	129.66	154.3624	125.9506		
QC AA	140.50				
QC M	227.80	229.5455	202.4263		
QC BP	407.89				
QC BT	190.41				
QC BJ	108.54				
QC AD	239.68				
QC A	262.70				

* coloured spaces represent values one standard deviation higher than the assemblage mean value; bolded fields represent values one standard deviation lower than the mean value (219.49 ppm).

The levels of U within the Campanian Mishash Formation BS samples are relatively higher than those found in the samples from the other sources, ranging between 2.4 and 5.47 ppm (general mean: 1.55 ppm; Table 21; Fig. 69). QC-AF2 has the highest U values (7.01 ppm), followed by BS4 (5.47 ppm), BS1 (4.83 ppm), and BS5 (3.71 ppm). The two other AF samples (AF1 and AF3), on the other hand, have relatively low U values (AF1: 1.9 ppm; AF3: 1.37 ppm). Therefore, while a relationship between Type AF and the source BS from the Campanian Mishash Formation area was implied by the macroscopic and petrographic data, and while some resemblance between the U levels of the BS samples and one of the type AF samples might be suggested, the geochemical information remains inconclusive.

Table 21: U values for all samples of the geochemistry analysis*.

Group	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
HF	0.33	0.42	0.26	0.22	0.37
UF	2.53	0.43	1.76	2.15	0.64
EOF QC	0.82	0.47	2.52	0.45	0.54
SOF QC	1.37	2.04	0.26	0.58	0.77
EFIS	1.20	1.59	1.11	1.26	1.15
BS	4.83	2.61	2.40	5.47	3.71
QC S	0.85				
QC W	0.51				
QC K	0.85				
QC O	0.97				
QC T	1.92				
QC AF	1.90	7.01	1.37		
QC AA	0.89				
QC M	2.86	1.09	2.35		
QC BP	1.79				
QC BT	2.00				
QC BJ	1.39				
QC AD	0.12				
QC A	0.55				

* coloured spaces represent values one standard deviation higher than the assemblage mean value; bolded fields represent values one standard deviation lower than the mean value (1.55 ppm).

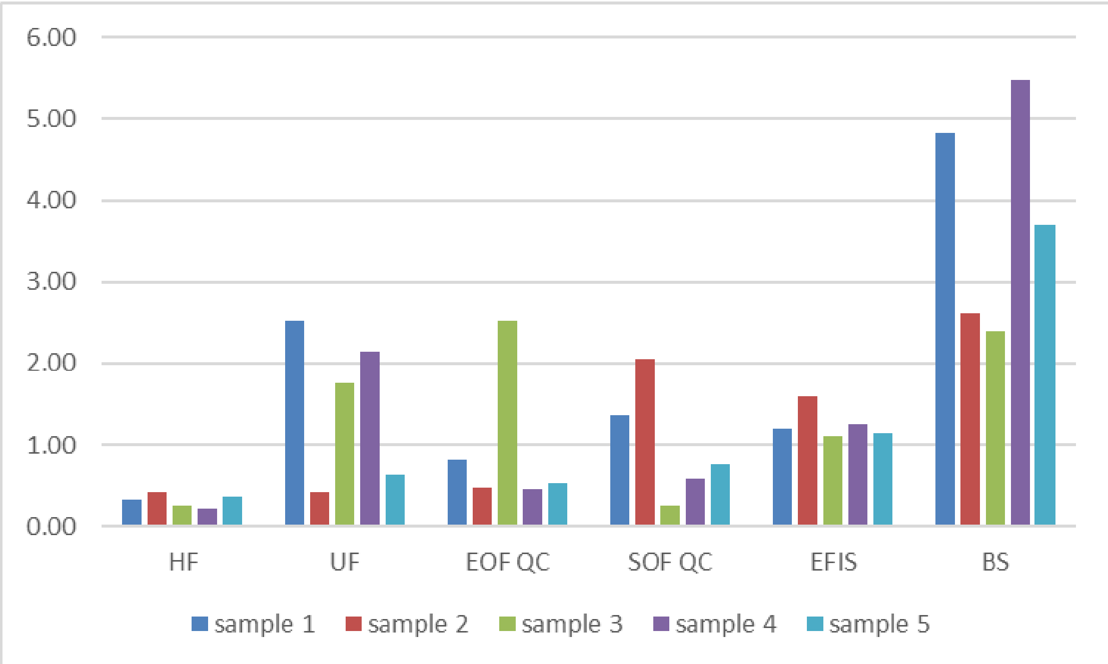

Fig. 69. Uranium values for samples from the geologic source (in ppm).

Certain flint types have relatively high values of specific elements. Type AA, for example, has relatively high values of Mn (16.72 ppm), higher than any of the geologic samples (general mean: 3.24 ppm). Type A has a high Co value (350.14 ppm), much higher than any other sample (general mean: 137.88 ppm). Type AD has a higher value for of Li (49.06 ppm), out of the range of all other samples (general mean: 13.18 ppm).

Type BJ has relatively high values for several elements. For example, it has high Mn values (9.62 ppm; general mean: 3.24 ppm), higher than any source except for the EFIS samples. It also has high values of Sr (52.00 ppm; general mean: 10.18 ppm). This value is higher than all the other samples, except for UF3 (56.43 ppm) and EFIS3 (89.32 ppm). Type BJ is also relatively high in Mg values (969 ppm; general mean: 200.39 ppm), higher than all other samples, except HF1 (2604.21 ppm) and EFIS2 (1202.51 ppm). Mg occurs in dolomite, and crystals of dolomite were identified in a petrographic thin section of a sample from EFIS (thin section number 5), but not in the petrographic thin section of Type BJ (thin section number 73), nor in any of the three thin sections taken from HF. The two thin sections from UF, on the other hand, do contain crystals of dolomite, while having low values of Mg. This variation might be due to randomness of sampling: if a sample happened to include crystals of dolomite, it would have relatively high values of Ca and Mg. It is, therefore, impossible at this point to suggest an origin attribution of type BJ based on the geochemical results.

5.4.3. Discussion of the Geochemistry Results

The results presented above show that, at least in some cases, flint-bearing formations cannot be considered to be geochemically homogenous (Luedtke, 1978). Rather, variations between samples from the same source were demonstrated.

Four of the five samples taken from EFIS present relatively high values of certain elements, demonstrating that they are fairly impure. The fifth EFIS sample (EFIS4), however, does not reflect the same patterns, implying that the flint from EFIS varies in its degree of purity. We have not determined whether the EFIS flint is characterized by flint which is either highly impure or pure, or whether flint with intermediate levels of these elements could also be found in it.

Three of the five Campanian samples are characterized by high values of U, ranging between 3.71 and 5.47 ppm (general mean: 1.55 ppm). The other two are not as high, but are still higher than the general average (BS2: 2.61 ppm; BS3: 2.4 ppm). These results might imply that flint from BS is characterized by a relatively high content of U, but more research is required in order to further demonstrate this. Sample AF2 also presents a high value of U (7.01 ppm), while samples AF1 and AF3 present values which are closer to the average value (AF1: 1.9 ppm; AF3: 1.37 ppm). Therefore, a definitive geochemical association between the BS samples and the type AF samples cannot be asserted at this point.

The geochemical analysis presented above, therefore, does not provide us with any conclusive attributions of flint types to their potential sources of origin. It does, however, provide some clues concerning potential paths for future investigations. The U values of samples from BS, for example, may justify further studies; the variation in the values of certain elements within the EFIS samples may also serve as a dataset for future analysis.

5.5. The Assignment of the QC Flint Types to Potential Geologic Origins

Table 22 presents a summary of the suggested geologic affiliation of the QC flint types. Most of the assignments of flint types to potential sources were based on microscopic similarities between flint types and geologic samples, as demonstrated above. Macroscopic similarities were used as supporting data, while being used as a determination instrument only in cases of a lack of any conclusive petrographic data. No conclusive affiliations were based on the geochemical data. The full account concerning each assignment is available in the supplementary material volume.

Table 22: Assignment of flint types to their geologic origin, type of origin, degree of certainty, and the petrographic indicative traits used for their assignment.

Origin	Primary / Secondary	Certainty	Flint types	Petrographic indicative traits
Turonian (primary)	primary	likely	AI, AV, BE	Stripes, dolomite, ostracods, sponge spicules, shell fragments, gastropods
		tentative	H, I*, W*, X, Z, AA, AC*, AD, AE, AK*, AS*	Stripes, sponge spicules, shell fragments, ostracods, possible bivalves
Turonian (secondary)	secondary	likely	A, B, C, D, F*, M, AP	Stripes, sponge spicules, dolomite, breccia, coiled and biserial foraminifera
		tentative	E, G, J*, K*, L*, N*, O, P, Q*, R, V, Y*, AB*, AG, AH*, AJ*, AM*, AN*, AO, AT, AX, AY*, BA, BD*, BF*, BG, BH, BI*, BK*, BO, BP, BR*, BS*, BU, BW, BX*, CD*, CF*, CI*, CJ*, CS*	Sponge spicules, ostracods, diffuse breccia, dolomite, spherulites, shell fragments, coiled foraminifera, uniserial foraminifera, globigerinid foraminifera
Campanian	secondary	certain	AF, AQ, BN	Breccia, dolomite, bulimina foraminifera
Cenomanian / Turonian	primary	likely	S	Sponge spicules, possibly ostracods
		tentative	AW, CC*	Dolomite, sponge spicules, possible ostracods
Upper Cenomanian - Turonian	primary	tentative	U	Sponge spicules, possibly ostracods, shell fragments
Eocene	secondary	certain	BB, BY*, CE*, CK, CN*	Nummulites, globigerinid foraminifera
		likely	BJ, CB	sponge spicules, lens-shaped foraminifera, ostracods, shell fragments, gastropods, alga, bryozoans, nodosaria
		tentative	AL, BC*, CA*, CH*	charophytes
Undetermined	-	-	T, AR, AU, AZ, BL, BM, BQ, BT, BV, BZ, CG, CL, CO, CP, CQ, CR	-

* The assignment of these flint types to potential sources was not based on petrographic data, but, rather, on macroscopic information.

In many cases the assignment of flint types to origins is uncertain ("certain": 8 flint types; "likely": 13 flint types; "tentative": 59 flint types; "undetermined": 16 flint types). Given the partial data we have concerning the distribution of sources around the cave during prehistoric times (for more on this see section 3.2), caution is required in classifying flint sources to potential sources. Moreover, as many of the sources are secondary, they may in fact represent accumulations of flint types from several different geologic origins, further stressing the need for discretion during classification. Finally, as the macroscopic classification cannot be used as a sole method of analysis (and for more on this see Agam and Wilson, 2018), flint types without sufficient petrographic data could have not been securely assigned to a geologic origin (excluding the case of Eocene flint types in which nummulites were macroscopically observed).

5.6. Data Analysis

In this section I present the results of the flint type analysis performed for the general sample selected from the QC assemblages. First, I present the analysis of the entire sample (all 12 assemblages combined) as a whole, and each assemblage by itself. I then present diachronic and synchronic analyses and a comparison of the Amudian and Yabrudian industries. Finally, I zoom-in into groups of specific assemblages. All of the information presented in this chapter was tested using a Chi Square Test. In order to do so, I computed the expected ~~excepected~~ values for each set of compared groups (e.g., specific categories and the general sample; selected assemblages, etc.). This calculation was performed by multiplying the grand total of each column with the grand total of each row, divided by the general grand total. I then contrasted the expected values with the observed results, using the "chitest" function of the Excel program, to get a probability level. In cases in which the results were found to be significant ($p < 0.05$), this is mentioned. When statistical significance was not observed, no comment was made. However, this test was performed for all of the results presented here.

Full descriptions of the flint types and flint groups mentioned throughout this chapter are found in the Supplementary material volume. This general section is followed by sections which focus on blades, Quina and demi-Quina scrapers, and bifaces from QC. All assemblage tables throughout this chapter are arranged, from top to bottom, from the youngest assemblage to the oldest.

Note that when data are analyzed as a combined sample (n=21,102), numbers are weighted based on the proportion of each assemblage within the general sample, in order to eliminate biases towards larger samples. This process was derived from statistical weighting models (Boonstra, 2004; Börsch-Supan et al., 2004; Kalton and Flores-Cervantes, 2003; Schonlau et al., 2004; for an explanation see the methodology chapter).

5.6.1. Results - The General Sample

According to the weighted results, 73.6% of the general sample were assigned to local Turonian flint sources of the Bi'na Formation (Fig. 70; Table 23). The dominance of local lithic materials is not surprising, as this is the case at many Paleolithic sites (e.g., Ekshtain et al., 2017; Frahm et al., 2016; Turq et al., 2017; Vukosavljević and Perhoč, 2017).

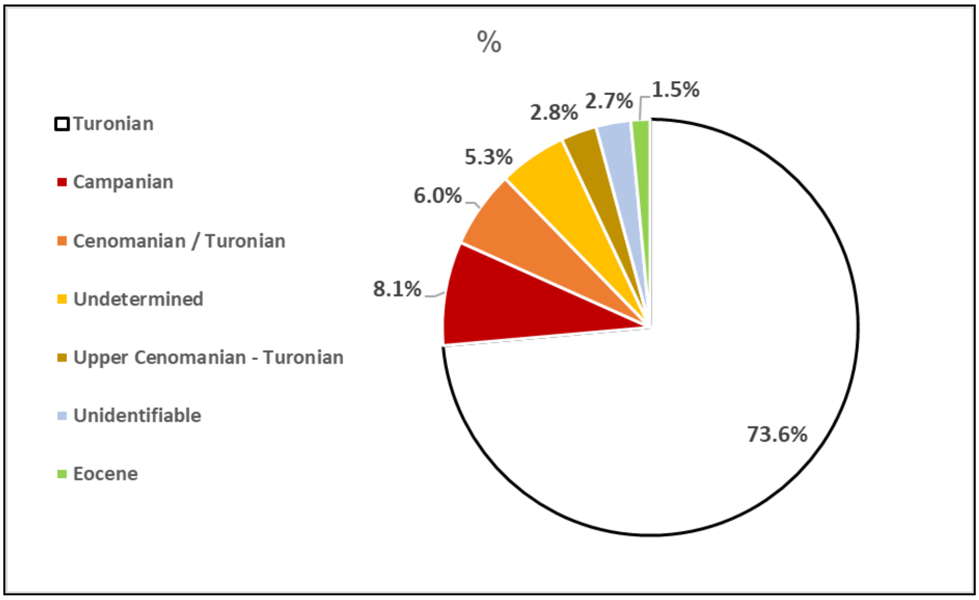

Fig. 70. Breakdown of the general sample by geologic sources of origin.

Table 23: Numbers and frequencies of geologic sources among the 12 assemblages.

Assemblage	Turonian	Campanian	Cenomanian / Turonian	Undetermined	Upper Cenomanian – Turonian	Unidentifiable	Eocene	Total
Top Level Amudian	1,889	239	224	172	34	51	45	2,654
Top Level Yabrudian	313	36	31	44	12	8	11	455
K-10	700	99	61	44	19	28	14	965
Hearth	1,667	62	85	130	79	37	32	2,092
South of hearth	1,918	295	120	159	75	55	26	2,648
G-19/20	1,148	158	108	87	14	13	30	1,558
South-Western Yabrudian	936	88	82	39	64	80	17	1,306
The Southern Area	1,598	172	135	114	34	22	19	2,094
Yabrudian Below the Shelf	1,503	112	87	70	106	87	6	1,971
Amudian Below the Shelf	1,593	78	117	40	124	32	7	1,991
Amudian (Shelf)	412	52	18	39	2	35	20	578
Deep Shelf – Unit I	1,945	332	255	131	41	52	34	2,790
Total	**15,622**	**1,723**	**1,323**	**1,069**	**604**	**500**	**261**	**21,102**
Top Level Amudian	71.2%	9.0%	8.4%	6.5%	1.3%	1.9%	1.7%	100.0%
Top Level Yabrudian	68.8%	7.9%	6.8%	9.7%	2.6%	1.8%	2.4%	100.0%
K-10	72.5%	10.3%	6.3%	4.6%	2.0%	2.9%	1.5%	100.0%
Hearth	79.7%	3.0%	4.1%	6.2%	3.8%	1.8%	1.5%	100.0%
South of hearth	72.4%	11.1%	4.5%	6.0%	2.8%	2.1%	1.0%	100.0%
G-19/20	73.7%	10.1%	6.9%	5.6%	0.9%	0.8%	1.9%	100.0%
South-Western Yabrudian	71.7%	6.7%	6.3%	3.0%	4.9%	6.1%	1.3%	100.0%
The Southern Area	76.3%	8.2%	6.4%	5.4%	1.6%	1.1%	0.9%	100.0%
Yabrudian Below the Shelf	76.3%	5.7%	4.4%	3.6%	5.4%	4.4%	0.3%	100.0%
Amudian Below the Shelf	80.0%	3.9%	5.9%	2.0%	6.2%	1.6%	0.4%	100.0%
Amudian (Shelf)	71.3%	9.0%	3.1%	6.7%	0.3%	6.1%	3.5%	100.0%
Deep Shelf – Unit I	69.7%	11.9%	9.1%	4.7%	1.5%	1.9%	1.2%	100.0%

The total weight of the analyzed samples is 216.73 kg. (Table 24). The weight of samples by geologic origin generally reflects the same pattern as the proportions of pieces from each origin. The average weights per piece from each source are close to each other, with the highest average being for pieces from undetermined sources (12.83 grams per piece), and the lowest for pieces from Cenomanian / Turonian sources (9.49 grams per piece). Unidentified pieces weigh an average of 3.38 grams, reflecting the fact that their small size was one of the factors preventing their assignment to any specific flint type.

Table 24: The total weight of samples of each geologic origin among the 12 assemblages (in kg).

Assemblage	**Turonian**	**Campanian**	**Cenomanian / Turonian**	**Undetermined**	**Upper Cenomanian – Turonian**	**Unidentifiable**	**Eocene**	**Total**
Top Level Amudian	16.32	2.24	1.57	1.77	0.36	0.16	0.40	22.81
Top Level Yabrudian	3.26	0.36	0.36	0.74	0.27	0.03	0.14	5.16
K-10	4.91	0.87	0.41	0.39	0.23	0.07	0.11	7.00
Hearth	20.47	0.81	0.85	1.44	1.34	0.17	0.73	25.82
South of hearth	14.74	2.94	0.85	2.36	0.57	0.15	0.39	22.00
G-19/20	11.15	1.76	1.03	0.90	0.19	0.04	0.29	15.37
South-Western Yabrudian	6.76	0.91	0.92	0.89	0.72	0.17	0.21	10.58
The Southern Area	16.10	2.35	1.42	1.65	0.57	0.05	0.20	22.34
Yabrudian Below the Shelf	19.32	2.31	0.90	1.28	1.36	0.44	0.12	25.72
Amudian Below the Shelf	18.27	0.78	1.41	0.50	1.37	0.11	0.07	22.50
Amudian (Shelf)	3.55	0.45	0.21	0.52	0.03	0.13	0.19	5.07
Deep Shelf – Unit I	21.62	4.90	2.67	2.05	0.55	0.17	0.39	32.36
Total	**156.47**	**20.68**	**12.59**	**14.48**	**7.56**	**1.69**	**3.24**	**216.73**
Top Level Amudian	71.6%	9.8%	6.9%	7.7%	1.6%	0.7%	1.7%	100.0%
Top Level Yabrudian	63.1%	6.9%	7.0%	14.4%	5.2%	0.6%	2.8%	100.0%
K-10	70.2%	12.5%	5.9%	5.5%	3.3%	1.0%	1.6%	100.0%
Hearth	79.3%	3.1%	3.3%	5.6%	5.2%	0.7%	2.8%	100.0%
South of Hearth	67.0%	13.4%	3.9%	10.7%	2.6%	0.7%	1.8%	100.0%
G-19/20	72.5%	11.5%	6.7%	5.8%	1.3%	0.3%	1.9%	100.0%
South-Western Yabrudian	63.8%	8.6%	8.7%	8.4%	6.8%	1.6%	2.0%	100.0%
The Southern Area	72.1%	10.5%	6.4%	7.4%	2.6%	0.2%	0.9%	100.0%
Yabrudian Below the Shelf	75.1%	9.0%	3.5%	5.0%	5.3%	1.7%	0.5%	100.0%

Amudian Below the Shelf	81.2%	3.5%	6.3%	2.2%	6.1%	0.5%	0.3%	100.0%
Amudian (Shelf)	70.0%	8.9%	4.1%	10.2%	0.5%	2.5%	3.8%	100.0%
Deep Shelf – Unit I	66.8%	15.2%	8.2%	6.3%	1.7%	0.5%	1.2%	100.0%
Total	**72.2%**	**9.5%**	**5.8%**	**6.7%**	**3.5%**	**0.8%**	**1.5%**	**100.0%**

In terms of number of pieces (of the weighted results), all typo-technological categories are strongly dominated by local Turonian flints (Table 25). The proportions of Campanian flints are the highest among the tools, and lowest among the Naturally Backed Knives. Upper Cenomanian – Turonian flint types appear in low proportions in all categories, as do Eocene flint types.

Table 25: Geologic origins of typo-technological categories.

Category	**Turonian**	**Campanian**	**Cenomanian / Turonian**	**Undetermined**	**Upper Cenomanian – Turonian**	**Unidentifiable**	**Eocene**	**Total**
Flakes	73.7%	8.6%	4.5%	5.3%	2.3%	4.2%	1.4%	100.0%
Tools	68.0%	11.0%	6.2%	7.0%	3.4%	2.4%	2.0%	100.0%
Cortical flakes	75.0%	6.3%	7.6%	5.8%	2.2%	2.0%	1.1%	100.0%
Naturally backed knives	79.7%	3.6%	8.2%	3.5%	3.7%	0.7%	0.5%	100.0%
Core trimming elements	74.4%	8.0%	7.2%	4.7%	3.4%	1.2%	1.1%	100.0%
Blades	71.9%	9.3%	6.4%	6.4%	1.8%	0.9%	3.4%	100.0%
Products of Cores on flakes	71.3%	10.4%	3.9%	5.1%	4.1%	4.7%	0.6%	100.0%
Cortical blades	81.2%	5.4%	7.4%	1.5%	2.7%	0.9%	0.9%	100.0%
Cores	72.1%	9.4%	7.3%	6.1%	3.5%	0.0%	1.6%	100.0%
Special spalls	75.8%	6.5%	3.6%	4.0%	3.5%	6.0%	0.6%	100.0%
Bladelets	74.3%	4.7%	7.2%	4.0%	1.4%	4.1%	4.3%	100.0%
Cores-on-Flakes	73.9%	6.7%	6.8%	6.0%	3.8%	1.2%	1.6%	100.0%
Total	**73.6%**	**8.1%**	**6.0%**	**5.3%**	**2.8%**	**2.7%**	**1.5%**	**100.0%**

Cortical flakes appear in notable proportions among items from all geologic origins (Table 26). This suggests that a significant portion of the initial processing of lithic materials of all geologic origins occurred on-site, rather than next to their sources of origin/procurement.

Table 26: Typo-technological categories in pieces from each geologic origin.

Category	Flakes	Tools	Cortical flakes	Naturally backed knives	Core trimming elements	Blades	Products of Cores on flakes	Cortical blades	Cores	Special spalls	Bladelets	Cores-on-Flakes	Total
Turonian	32.8%	15.0%	14.2%	9.2%	6.6%	5.2%	4.2%	4.7%	2.8%	2.0%	1.8%	1.5%	100%
Campanian	35.0%	22.2%	10.9%	3.8%	6.5%	6.1%	5.6%	2.8%	3.4%	1.5%	1.0%	1.3%	100%
Cenomanian / Turonian	24.3%	16.7%	17.6%	11.7%	7.8%	5.6%	2.8%	5.2%	3.5%	1.1%	2.1%	1.7%	100%
Undetermined	32.5%	21.5%	15.2%	5.7%	5.8%	6.3%	4.1%	1.2%	3.3%	1.4%	1.3%	1.7%	100%
Upper Cenomanian – Turonian	26.6%	19.8%	11.2%	11.5%	8.1%	3.4%	6.4%	4.1%	3.6%	2.4%	0.9%	2.1%	100%
Unidentifiable	51.3%	14.4%	10.6%	2.3%	3.0%	1.8%	7.6%	1.4%	0.0%	4.2%	2.7%	0.7%	100%
Eocene	31.5%	22.8%	10.3%	3.1%	5.0%	12.3%	1.6%	2.6%	3.1%	0.8%	5.2%	1.7%	100%
Total	**32.80%**	**16.30%**	**14.00%**	**8.50%**	**6.60%**	**5.30%**	**4.30%**	**4.20%**	**2.90%**	**1.90%**	**1.80%**	**1.50%**	**100.00%**

Turonian flint types were divided into groups based on their proximity to QC, according to the Turonian sources from which matching geologic samples were obtained: center (up to 2 km away from the cave in any direction), south of the cave (more than 2 km south of the cave), north of the cave (more than 2 km north of the cave), center or north of the cave (up to 8 km north of the cave), center or south of the cave (up to 8 km south of the cave), or in any direction within the Turonian terrain around the cave (up to 8 km in any direction). Almost half of Turonian flints could originate from anywhere in the area of the cave, meaning that they have been observed in potential flint sources both in the central area, south of the cave, and north of the cave (Fig. 71).

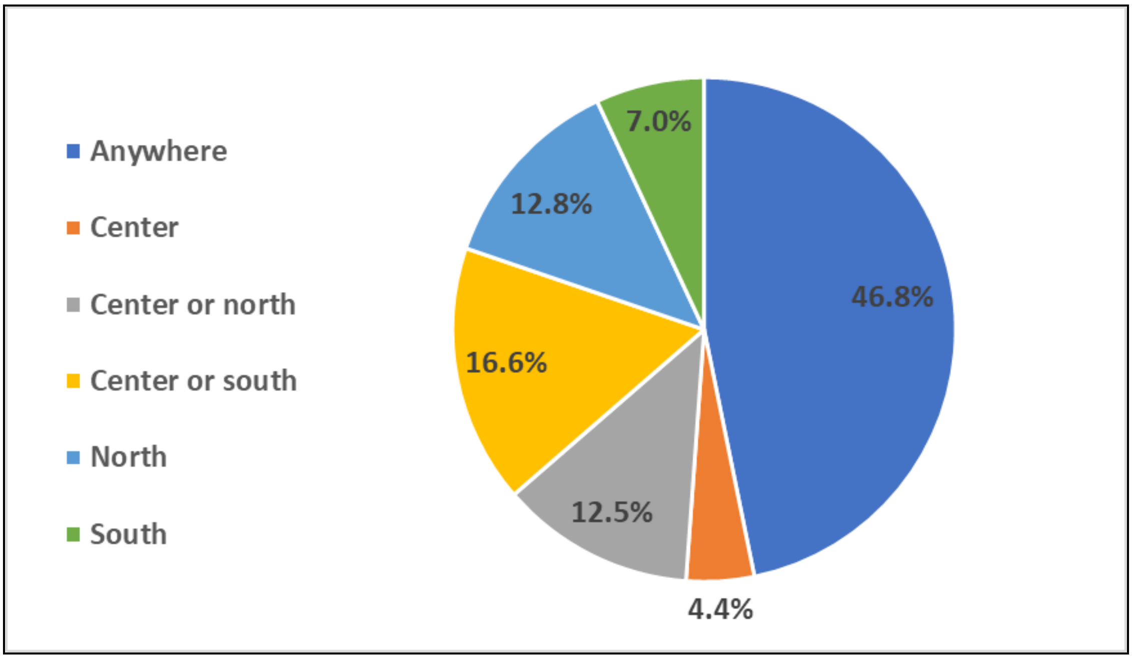

Fig. 71. Breakdown of the Turonian flint types by their direction of origin in relation to QC.

Table 27 presents the ten most represented flint types. Note that while the most represented flint type is type AF, which is of the Campanian Mishash Formation (Fig. 72-a; Table 27), eight of the 10 most represented flint types found in the general sample are of Turonian origin, constituting together more than a third of the general sample.

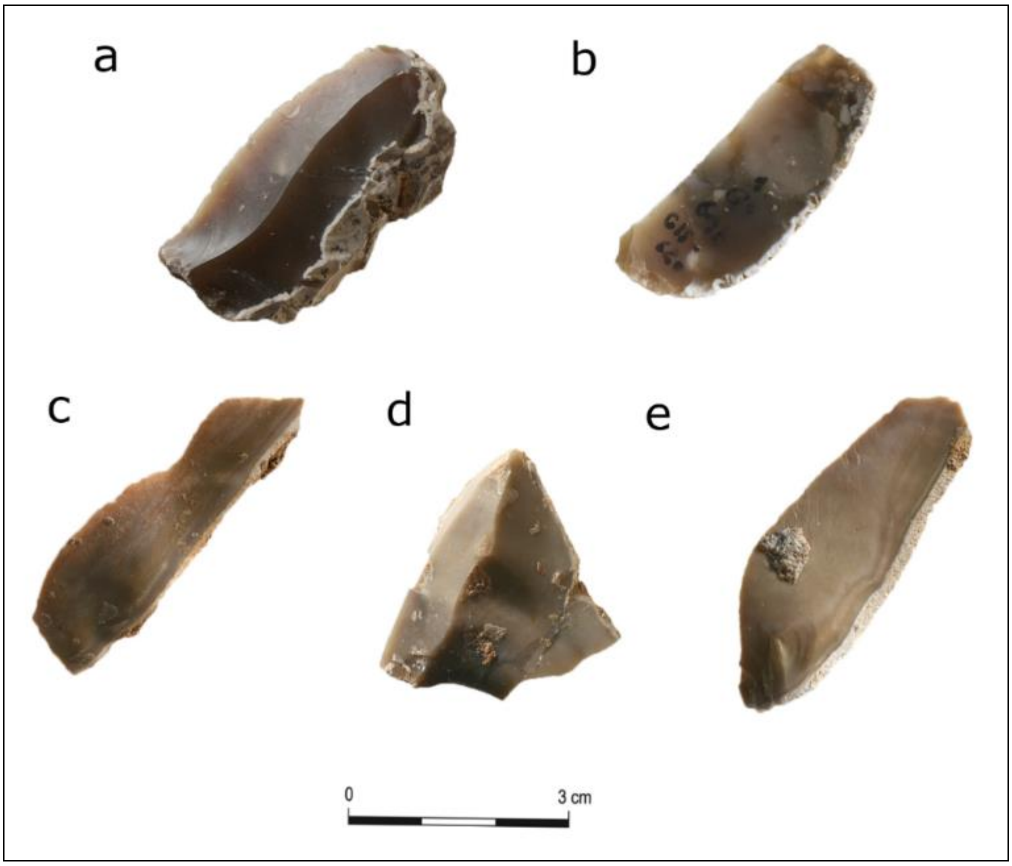

Fig. 72. The most represented flint types at QC: a) Type QC-AF (Campanian); b) Type QC-O (Turonian); c) Type QC-D (Turonian); d) Type QC-AD (Turonian); e) Type QC-S (Cenomanian / Turonian).

Table 27: The 10 most represented flint types in the general sample (weighted results).

Type	%	Origin	Description
AF	6.7%	Campanian	Slightly-translucent fairly homogenous fine-textured dark brown homogenous flint with a thin (1-2 mm) rough orange cortex.
O	6.6%	Turonian	Zoned and spotted browns semi-translucent fine-textured heterogenous flint with smooth (worn) beige cortex 1-2 mm thick.
D	5.9%	Turonian	Finely striped homogenous opaque fine-textured brown to grey-brown flint with rough beige to slightly orange thin (<1-2 mm) cortex.
AD	5.2%	Turonian	Slightly greenish-brown fairly homogenous fine-textured slightly translucent flint with some darker irregular lines; cortex beige to orange but very worn (secondary source).
S	4.8%	Cenomanian / Turonian	Pinkish (sometimes) café-au-lait homogenous fine-textured opaque flint, with irregular darker sub-cortical stripes (thin, <1 mm) and white cortex (2-15 mm thick), beige on the surface.
C	4.6%	Turonian	Finely striped homogenous opaque fine-textured grey + grey-brown flint with rough beige to slightly orange thin (1-2 mm) cortex.
M	4.3%	Turonian	Distinctly striped beige, grey and pink homogenous fine-textured opaque flint, stripes 1-2 mm thick, with rough beige-pink thin cortex (1-2 mm thick).
AC	3.5%	Turonian	Medium brown with paler brown areas, homogenous fine-textured opaque flint with traces of orange patina on one surface.
A	3.2%	Turonian	Reddish brown, lightly striped homogenous opaue fine-textured flint, with light pink inner cortex (2-3 mm thick), thin white layer and thin light orange layer outer cortex (less than 1 mm thick together).
K	2.8%	Turonian	Light grey-brown homogenous slightly translucent fine-textured flint with rough beige cortex (1-3 mm thick), orange on the surface.

The QC flint types were grouped into groups of flint types based on shared visual traits. In total, the 96 QC flint types were grouped into 41 groups (supplementary material volume - Table 2). Table 28 presents the ten most represented groups of flint types. The most commonly represented group of flint types is group 1b, which includes striped homogenous flint types, in the form of flat, slab-like nodules (Fig. 73). All flint types included in this group were assigned to Turonian sources.

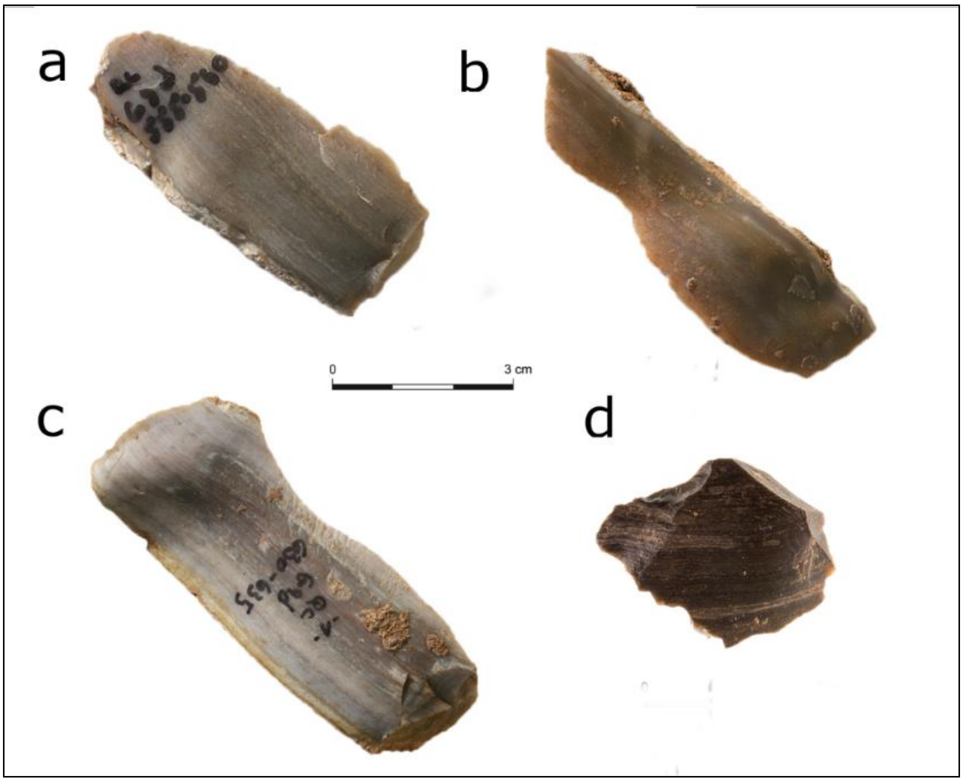

Fig. 73. Four flint types of Group 1b, the most represented group of flint types at QC: a) Type QC-C; b) Type QC-D; c) Type QC-M; d) Type QC-BE.

Table 28: The 10 most represented groups of flint types in the general sample (weighted results).

Type group	%	Description	Included flint types	Origin
1b	24.8%	Striped homogenous flint types, preferably visibly derived from flat, slab-like nodules	C, D, E, F, G, J, L, M, Y, AY, BE, BF, BX, CI	Turonian
16a	6.7%	Semi-translucent dark brown homogenous flint types	AF	Campanian
5	6.6%	A zoned semi-translucent brown flint type.	O	Turonian
14	5.3%	Light grey to green homogenous flint types	AD, BS	Turonian
26	5.0%	Light brown fine-textured homogenous flint types	S, CC	Cenomanian / Turonian
1a	4.9%	Red to brown homogenous flint types, with pink to red cortex, preferably visibly derived from flat, slab-like nodules	A, B, CF	Turonian
2	4.5%	Green to yellow homogenous flint types	I, P, AW	Cenomanian / Turonian
13	4.2%	Brown homogenous fine-textured flint types	AC, BP, BR	Turonian
6	3.7%	Dark brown to light brown heterogeneous flint types	T, AX, BA, BV, BW, CD, CJ, CS	undetermined / Turonian
9	3.0%	Mottled brown fine-textured flints, with pockets of disturbances	W, AP	Turonian

A little more than half of the items in the general sample are made of homogenous flint types (Fig. 74). Another third is made of fairly homogenous flint types.

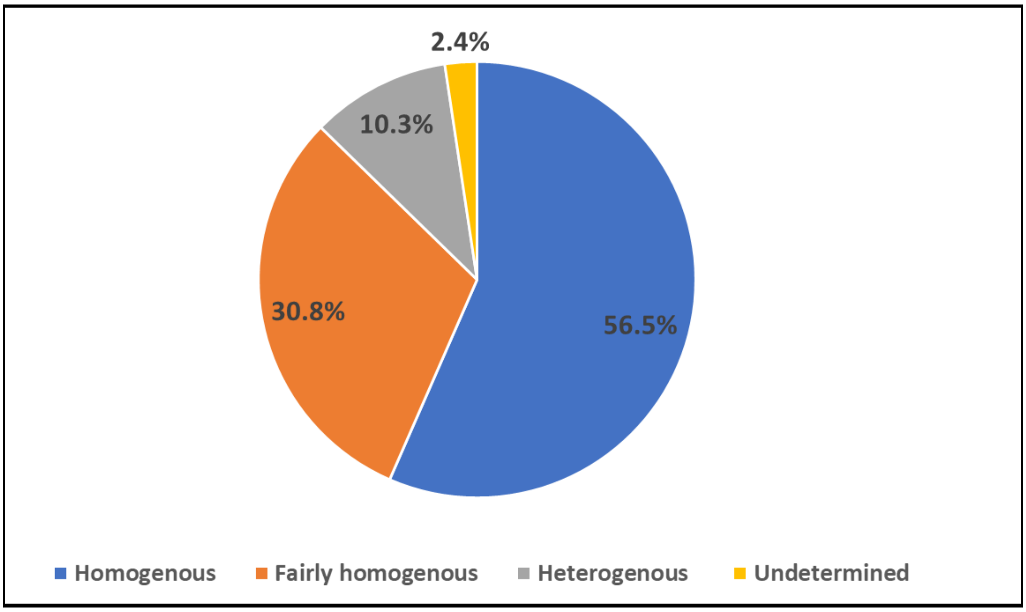

Fig. 74. The general sample by degree of homogeneity.

Most of the analyzed items are made of fine-textured flint types (Fig. 75). This strong dominance of fine-textured materials most likely reflects the presence of fine-textured flints in the exploited sources and a preference towards the procurement and use of fine-textured flint types.

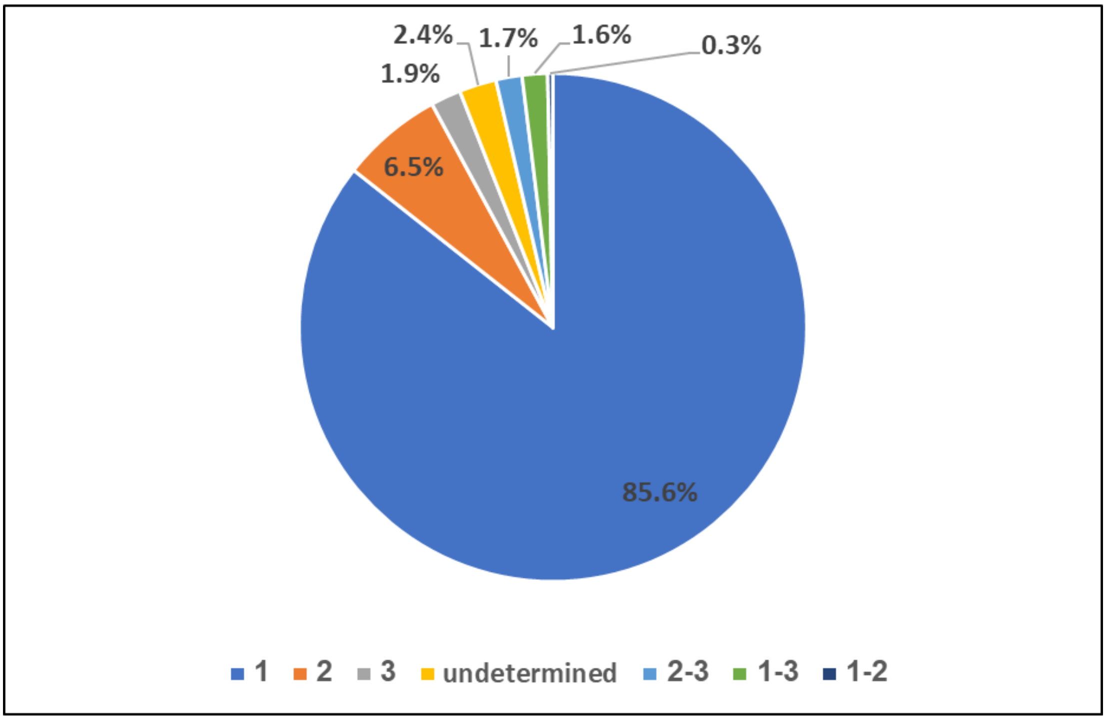

Fig. 75. The general sample by texture. 1: Fine-textured; 2: Medium-textured; 3: Coarse-textured.

Pieces made of Turonian flint types are mostly fine-textured (93.0%, n=14,169). Pieces made of Campanian flint are also mostly fine-textured (83.2%, n=2152). Among the pieces made of Cenomanian / Turonian material this pattern is even more pronounced, as 100% of them are fine-textured (n=1,036). The case is different for the Eocene material, and for the pieces from undetermined sources. Pieces made of Eocene flint are mainly medium-textured (90.0%, n=217), while an additional 9.5% (n=23) are coarse-textured. Pieces from undetermined sources include a notable component of medium to coarse-grained materials (50.4%, n=758).

Most of the analyzed items are opaque (Fig. 76). Another quarter are slightly translucent, and only few items are translucent.

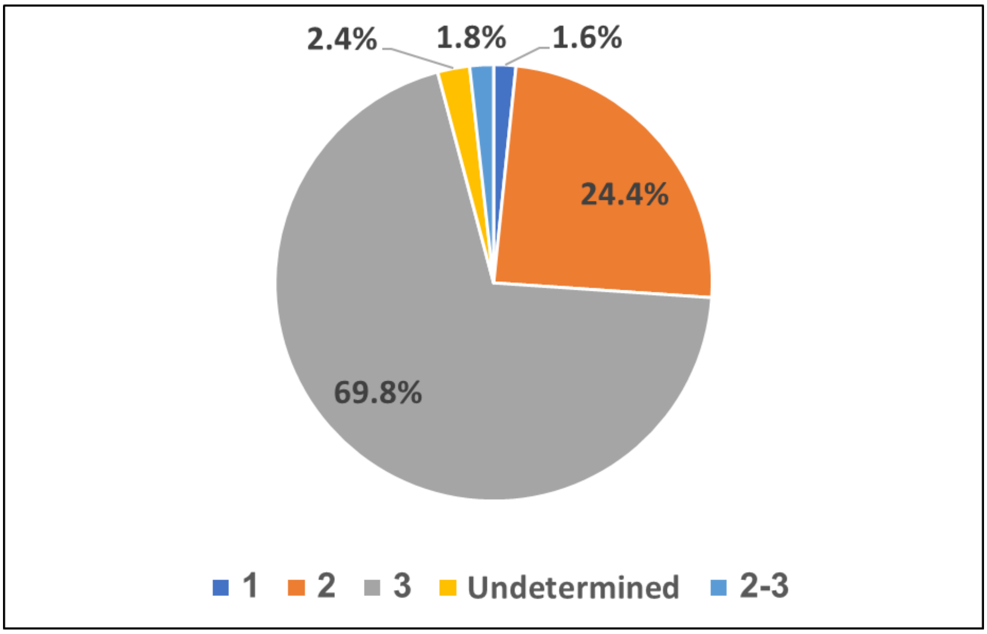

Fig. 76. The general sample by degree of translucency. 1: Translucent; 2: Slightly translucent; 3: Opaque.

The most common combination of traits represented is that of homogenous, fine-textured, opaque flints (Fig. 77). Far behind are fairly homogenous, fine-textured slightly translucent flints, followed by heterogeneous, fine-textured, slightly translucent flints. This dominance of homogenous, fine-textured opaque flint types may imply that it was a preferable combination when choosing lithic materials, possibly reflecting a technological/functional advantage. Alternatively, and more likely, this could be the reflection of availability of such flint types within the exploited sources. Indeed, the geologic samples collected from Turonian sources during our survey are also dominated by homogenous, fine-textured opaque flint types. While this pattern could have been influenced by our own selectivity during sample collection, it seems likely that such combinations were common in these sources during prehistoric times as well.

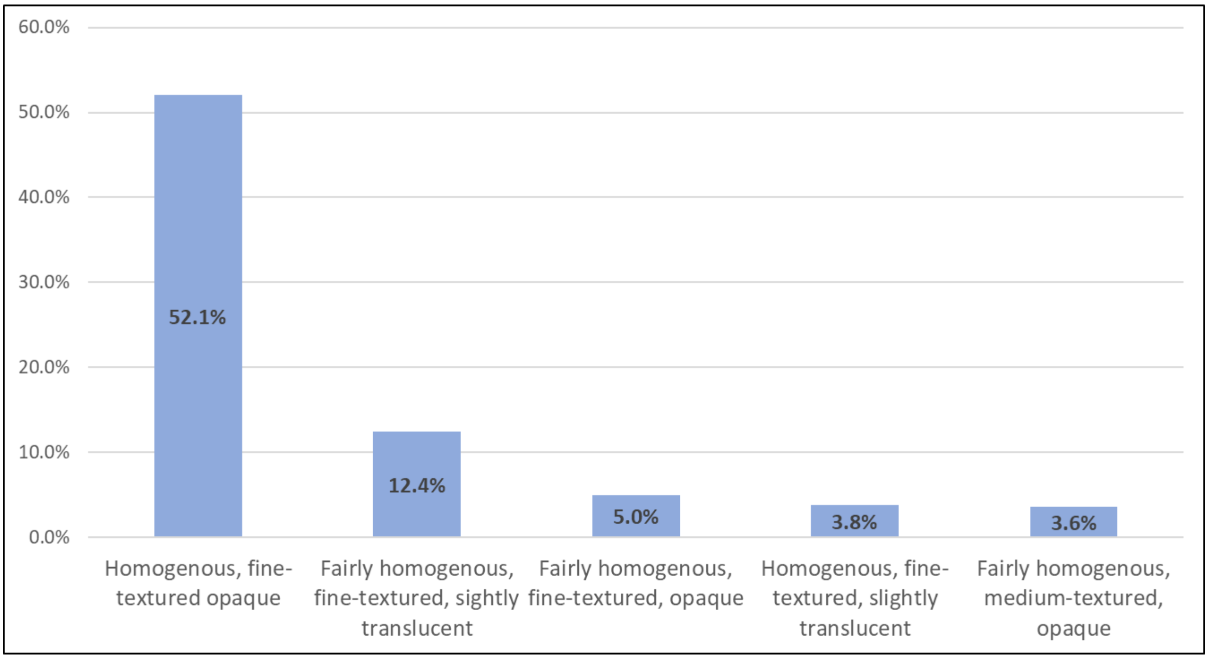

Fig. 77. The five most represented combinations of traits in the general sample (weighted results).

Availability and accessibility have often been suggested to play a major role in shaping the composition of prehistoric lithic assemblages (e.g., Asryan et al., 2014; Fiers et al., 2019; Groucutt et al., 2017). Yet, even so, preference and selectivity could have also played a role in influencing the composition of the lithic assemblages. Indeed, selectivity in the exploitation of lithic materials has already been demonstrated within the QC assemblages in the past (Wilson et al., 2016), as well as in other Paleolithic sites in the Levant (e.g., Bar-Yosef and Goren-Inbar, 1993; Belfer-Cohen and Goren-Inbar, 1994; Ekshtain et al., 2014; Zaidner, 2014) and beyond (e.g., Caruana and Mtshali, 2018; Pargeter and Hampson, 2019; Wilkins, 2017). Moreover, availability of resources could have played a role in the decision as to where to locate the habitation site (Barkai et al., 2018). On the other hand, early humans could have, and probably must have in many cases, adapted to the lithic materials available to them, modifying their technological trajectories to suite the flint types available in their immediate surroundings (Turq et al., 2017). Still, it has been shown that in many cases early humans were able to manipulate different rock types according to their technological conceptions (e.g., Sharon, 2008).

To conclude, the general sample is strongly dominated by local Turonian flint types. The most represented group of flint types is group 1b, which is a group of striped homogenous flint types, visibly derived from flat, slab-like nodules, of a Turonian origin. Most of the used flints are homogenous, fine-textured and opaque. However, many other flint types have also been found at the cave, reflecting the familiarity of its inhabitants with the different primary and secondary lithic sources in the area.

5.6.1.1. Diachronic Patterns of Flint Exploitation at QC

This sub-section presents the results of a diachronic analysis of the data, comparing the assemblages in chronological-stratigraphic order, from the oldest assemblage (the Deep Shelf – Unit I assemblage) to the youngest (the Top Level Amudian assemblage). It is aimed at identifying changes or consistencies in the way flint was exploited through time by the cave's inhabitants. Table 29 presents the number assigned to each assemblage in this section by age, "1" being the oldest assemblage and "12" – the youngest. This is true for all charts that appear in this section.

Table 29: The number assigned to each assemblage in this study.

#	Assemblage
12	Top Level Amudian
11	Top Level Yabrudian
10	K-10
9	Hearth
8	South of hearth
7	G-19/20
6	South-Western Yabrudian
5	The Southern Area
4	Yabrudian Below the Shelf
3	Amudian Below the Shelf
2	Amudian (Shelf)
1	Deep Shelf – Unit I

While Turonian flint dominates all assemblages, its proportions are especially high in the Amudian Below the Shelf (80.0%) and the Hearth assemblage (79.7%), which is also Amudian (Fig. 78). Turonian flint appears in relatively lower proportions, on the other hand, in the Top Level Yabrudian (68.8%) and the Deep Shelf – Unit I (69.7%) assemblages, both of which are Yabrudian. The 12 assemblages present a wide variability of proportions of other geologic origin as well (Fig. 79).

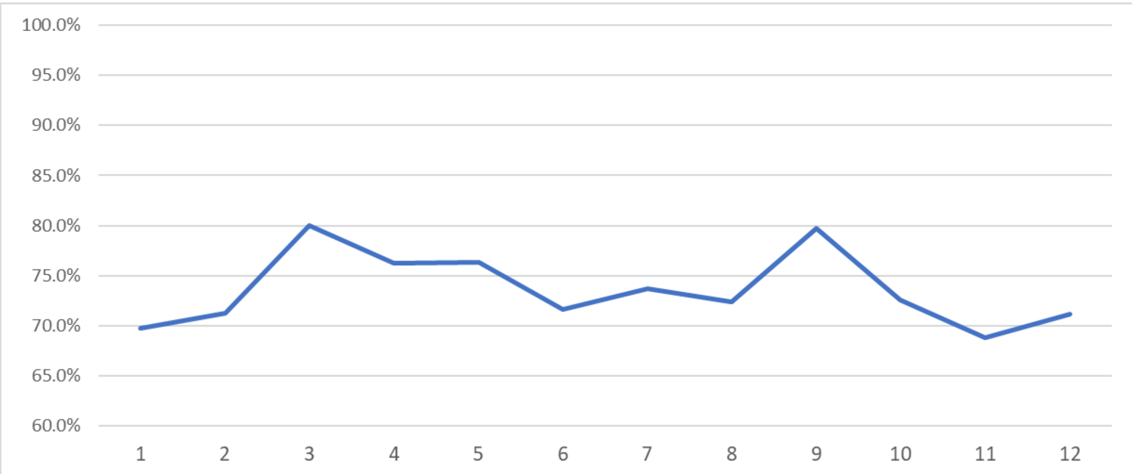

Fig. 78. Proportions of Turonian flint in the assemblages, in chronologic order.

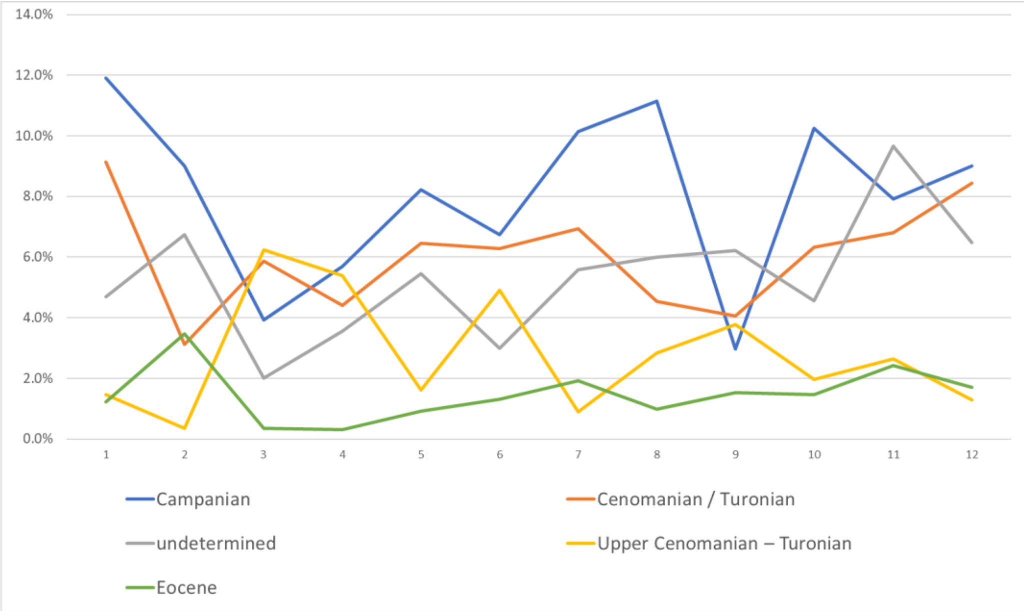

Fig. 79. Proportions of other flint in the assemblages, in chronologic order. Unidentifiable pieces are not included in this graph.

The Deep Shelf – Unit I assemblage, which is the oldest assemblage found at QC to date, stands out as different in the proportions of some of the geologic origins. While the proportions of Turonian flint are relatively low in the Deep Shelf – Unit I assemblage, the proportions of Campanian flint are the highest in this assemblage. Cenomanian / Turonian flint are at their highest proportions in it, while Upper Cenomanian – Turonian flint is at its lowest in it. The proportions of Campanian flint are also relatively pronounced in the South of Hearth and G-19/20 assemblages.

As the proportions of the different geologic origins vary between assemblages, it seems that the pattern of flint procurement and exploitation at the site was not repetitive. This suggests that lithic preferences and choices at the cave changed through time, but in no consistent way. The dominance of homogenous flint types does seem to be consistent through time, ranging between 54.3% and 70.6% (Fig. 80). As 61.7% of the Turonian flint types are homogenous (n=29), it is indeed likely that homogenous flint types would dominate all assemblages. The Amudian Below the Shelf assemblage stands out with the highest proportions of homogenous flints

(70.6%), suggesting a higher degree of selectivity towards more homogenous flint types during the accumulation of this assemblage. This suggestion is further supported by the fact that the proportion of homogenous Turonian flint types is the highest in this assemblage (72.8%, compared to 67.4% among all assemblages combined).

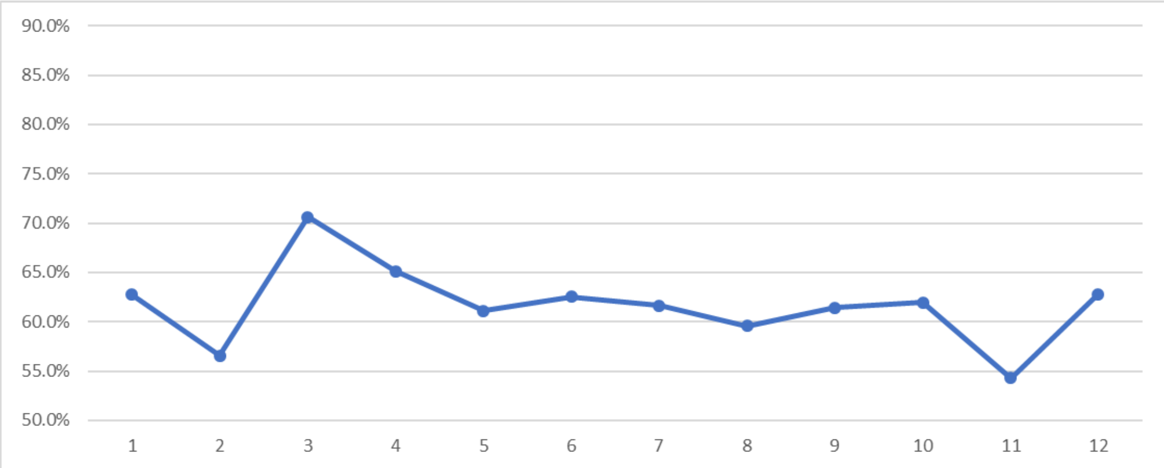

Fig. 80. The proportions of homogenous flint types through time, from the oldest assemblage to the youngest.

The high proportion of fine-textured flint types also demonstrates consistency through time (Fig. 81). As 72.3% of the Turonian flint types are fine-textured, this suggests selectivity towards fine-textured flint types in all analyzed assemblages.

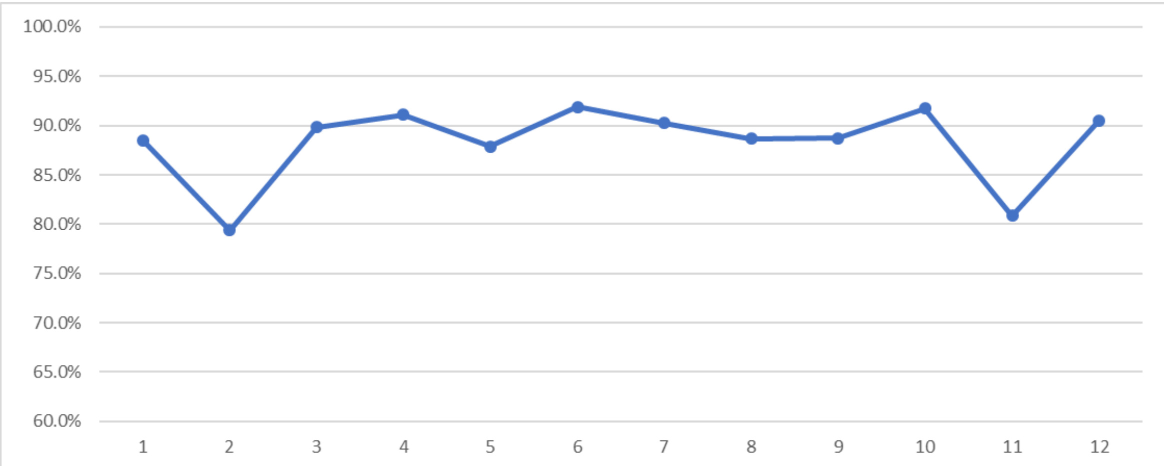

Fig. 81. The proportions of fine-textured flint types through time, from the oldest assemblage to the youngest.

As for the groups of flint types, there is a slight decline in the proportions of the striped Turonian Group 1b flints through time (Fig. 82), and an increase in the proportions of Group 5, a group of zoned semi-translucent brown flints. Group 16a, a group of semi-translucent dark brown homogenous flint types of Campanian origin, appears in its highest proportions in the Deep Shelf – Unit I assemblage (10.1%). Group 5 appears in its highest proportions in the Top Level Yabrudian assemblage (11.2%). The proportions of Group 14, a group of light grey to green homogenous flint types of Turonian origin, appears in especially high proportions in the Southern Area assemblage (9.0%), and in especially low proportions in the South-Western Yabrudian assemblage (1.7%).

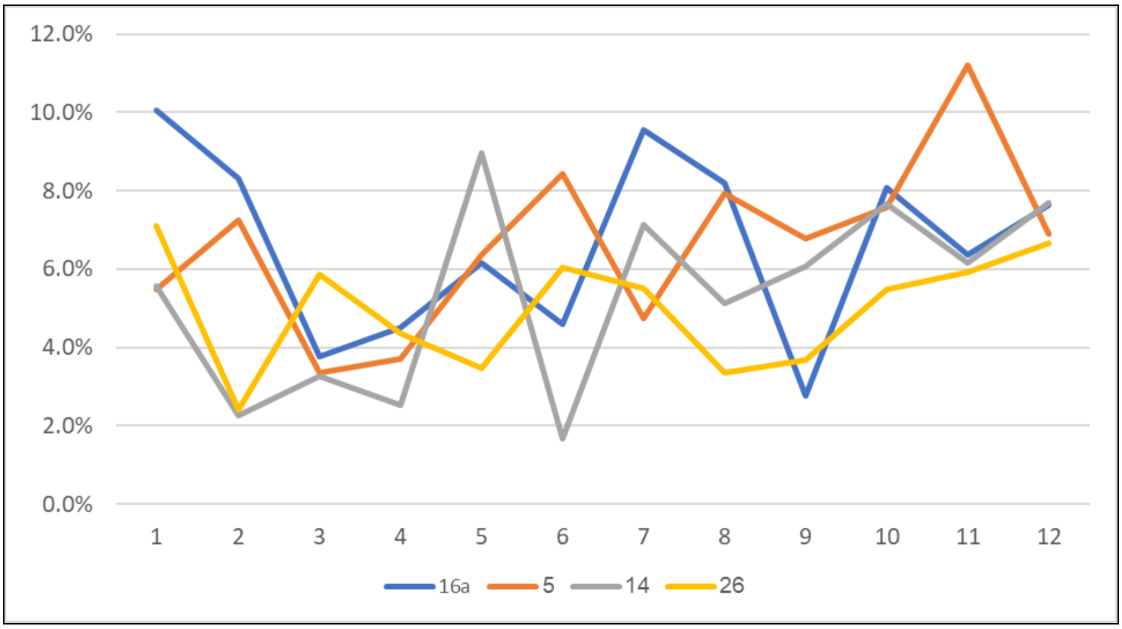

Fig. 82. The four most represented groups of flint types through time.

To conclude, the results demonstrate that while there was a general tendency to procure and exploit fine-textured homogenous flint types throughout time, there was also a wide variability between the 12 assemblages analyzed here. This variability may reflect changes in human activities and lithic preferences through time. The Deep Shelf – Unit I assemblage stands out in several of the above-mentioned parameters, suggesting that this assemblage reflects a different set of choices concerning the exploited flint types. Also of note is the consistency demonstrated concerning the degree of homogeneity and texture, possibly reflecting a repetitive preference of the QC hominins towards homogenous fine-textured flint types.

5.6.1.2. Results by Industries

In this sub-section I compare the two major lithic industries found at QC: the blade-dominated Amudian and the Quina-dominated Yabrudian. The comparison includes an analysis of the potential flint sources represented in each industry, the degree of homogeneity and texture of the flint types used, and the proportions of flint types and groups of flint types used in each of the two industries. It should be stressed again that the differences between the two industries are, in our view, mostly quantitative rather than qualitative (Assaf et al., 2015; Parush et al., 2016).

As shown in Table 30 and Fig. 83, the Amudian and Yabrudian industries at QC present similar proportions of the different geologic origins. These similarities, again, demonstrate the view that the two industries represent two facies of the same techno-cultural world.

Table 30: The proportions of each geologic origin in each industry.

Origin	**Amudian assemblages**	**Yabrudian assemblages**	**total**	**Amudian assemblages**	**Yabrudian assemblages**	**Total**
Turonian	10,925	4,697	15,622	74.9%	72.0%	74.0%
Campanian	1,155	568	1,723	7.9%	8.7%	8.2%
Cenomanian / Turonian	868	455	1,323	6.0%	7.0%	6.3%
undetermined	785	284	1,069	5.4%	4.4%	5.1%
Upper Cenomanian – Turonian	381	223	604	2.6%	3.4%	2.9%
unidentifiable	273	227	500	1.9%	3.5%	2.4%
Eocene	193	68	261	1.3%	1.0%	1.2%
Total	**14,580**	**6,522**	**21102**	**100.0%**	**100.0%**	**100.0%**

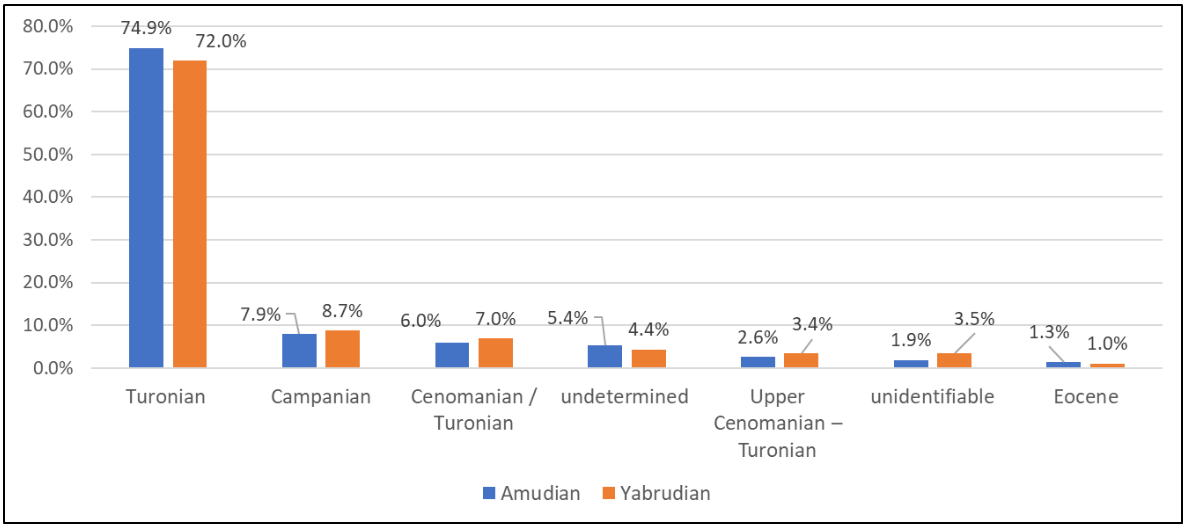

Fig. 83. A breakdown of the Amudian and Yabrudian industries at QC by flint origin.

Resemblances also appear in other parameters. The proportions of homogenous flint types are almost exactly the same (62.4% of the Amudian assemblage, 62.8% of the Yabrudian assemblages). Similar values can also be found in the proportions of fine-textured flint (86.0% of the Amudian assemblages [n=12,537], compared to 84.8% of the Yabrudian assemblages [n=5,531]), and the proportions of opaque items (69.3% in the Amudian assemblages [n=10,109], compared to 70.8% of the Yabrudian assemblages [n=4,620]).

The groups of flint types used for the manufacture of these two industries are also almost the same. Group 1b is the most represented within the two industries (24.5% within the Amudian; 27.9% within the Yabrudian). The second most represented group in both industries is Group 16a (6.6% in the Amudian; 7.0% in the Yabrudian).

Laminar items, the hallmark of the Amudian, were produced mainly of flint types of Group 1b in both industries, and in close proportions (32.1% in the Amudian, n=1,240; 35.9% in the Yabrudian, n=617). The proportions of the second most represented group in the laminar items of both industries, Group 26, are also close to each other (6.4% in the Amudian, n=248; 7.0% in the Yabrudian, n=120). For more on the blade analysis, see the blades sub-section below.

As for the groups of flint types used for the production of cores, although here again Group 1b is the most represented in both groups, and in similar proportions (20.7% in the Amudian, n=106; 22.0% in the Yabrudian, n=35), Group 14 stands out in the cores of the Amudian (11.5%, n=59; versus 5.0%, n=8, in the Yabrudian), while Group 16a stands out in the cores of the Yabrudian (10.1%, n=16; versus 6.3%, n=32, in the Amudian).

Interestingly, this pattern does not repeat itself in the Core Trimming Elements (CTEs) category. The proportions of Group 14 are almost the same (5.9% in the Amudian, n=62; 5.4% in the Yabrudian, n=16), while the proportions of Group 1b are slightly higher in the Yabrudian assemblages (35.0%, n=103) than in the Amudian assemblages (28.9%, n=306), suggesting that cores of this group of flint types were maintained more often in Yabrudian assemblages than in Amudian assemblages. It seems, then, that cores of Group 14 were not maintained and rejuvenated in the Amudian as often as cores from other groups. Among the Yabrudian, on the other hand, cores from Group 14 were maintained in accordance to their proportion among the cores.

Finally, similarities occur also among the scrapers analyzed. Turonian flint was used for 76.5% of the scrapers found in the Amudian assemblages (n=62), compared to 70.5% in the Yabrudian (n=248). Cenomanian / Turonian flint is slightly more common in the Yabrudian (6.0%, n=21), than in the Amudian industry (2.5%, n=2). Still, it seems that there is a similar pattern in the decision about which flint types to use for the production of scrapers, regardless of the industry in which they were found. For more information concerning the scrapers, see the scrapers section below.

The results presented above suggest that there are some clear consistencies and similarities in the patterns of flint exploitation observed in the Amudian and the Yabrudian industries, implying that at least some similar lithic choices and preferences were practiced by the makers of both industries. These results further support the view that the Amudian and Yabrudian industries are part of a single technological repertoire, representing activity-related emphasis in the different contexts of the cave (Assaf et al., 2015; Parush et al., 2016).

5.6.1.3. Patterns of Exploitation in Specific Assemblages from Selected Contexts

The following sub-sections compare assemblages which can be associated with each other, either chronologically, spatially, or technologically, as explained below for each case study, in search of patterns of resemblances or differences. Many combinations could be made of the twelve assemblages analyzed here. However, I selected groups of assemblages which may provide data concerning spatial, chronological and technological issues, in the hope of identifying patterns of procurement and exploitation of flint following these criteria.

5.6.1.3.1. The Hearth, South of Hearth, and the South-Western Yabrudian assemblages

The Hearth and the South of Hearth assemblages are characterized as Amudian, while the South-Western Yabrudian is Yabrudian. These three assemblages come from the top part of the lower stratigraphic sequence of the cave, are generally contemporaneous (based on observed field relations), and are dated to around 300 kya

(Falguères et al., 2016; Gopher et al., 2016). The faunal assemblages of the Hearth and South of Hearth assemblages were previously compared and published (Blasco et al., 2016a).

All three assemblages are strongly dominated by Turonian flint (Fig. 84). Also, Cenomanian / Turonian flints and Eocene flint types are present in similar proportions within the three assemblages.

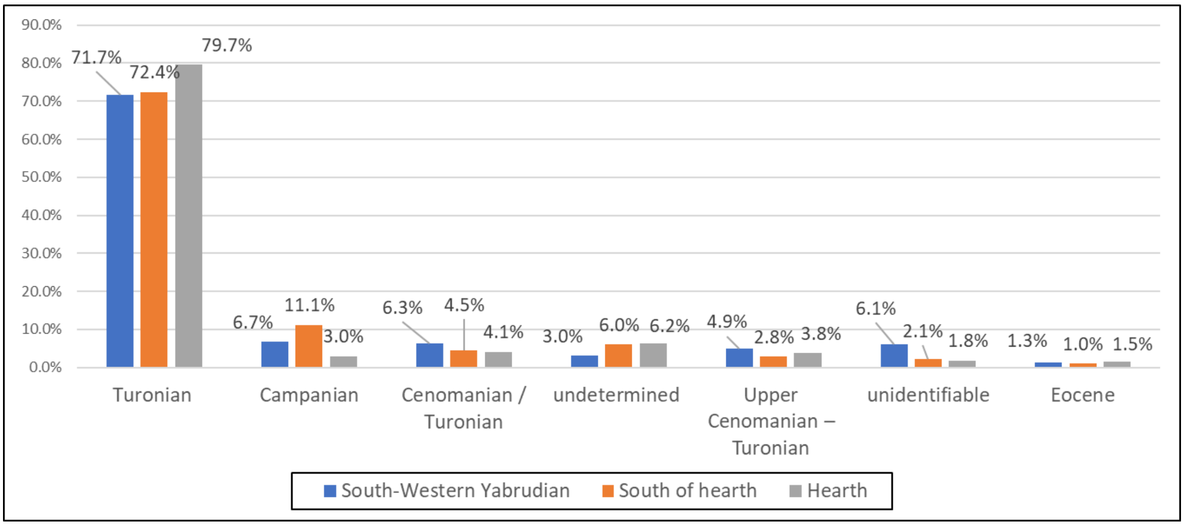

Fig. 84. Proportions of each geologic origin in three assemblages: The South-Western Yabrudian, South of Hearth, and Hearth.

However, some differences are worth noting. Flint types originating from Campanian sources, for example, are more common in the South of Hearth assemblage than they are in the Hearth and South-Western Yabrudian assemblages.

The South-Western Yabrudian assemblage includes 47 scrapers, 66.0% (n=31) of which are made of Turonian flints. Scrapers obviously appear in much smaller proportions in the two Amudian assemblages (Hearth assemblage: 9; South of Hearth assemblage: 4), and therefore it is hard to make any profound statement on the matter. However, Turonian flint types are also common in those two cases (8 out of the 9 [88.9%] and 2 out of the 4 [50.0%]) .

Another component worth noting is the laminar NBKs (Naturally Backed Knives). Flint types D and C, striped flint types of Turonian origin, are the most represented flint types among the laminar NBKs of the South-Western Yabrudian assemblage (23.9% and 15.2%, respectively) and of the Hearth assemblage (13.2% and 8.5%, respectively). Within the South of Hearth assemblage, however, type M, another striped flint type of Turonian origin, is the most represented flint type (19.4%), followed by type D (16.1%). Types C, D and M all belong to the striped group of flint types (1b), which was found to be dominant among the blades of QC (Wilson et al., 2016).

On a group-of-types level, group 1b is the most frequently used among the laminar NBKs of all three assemblages, but it is by far more common in the South-Western Yabrudian (63.0%, compared to 49.6% in the Hearth assemblage, and 48.4% in the South of Hearth assemblage). Group 14, a group of light grey to green homogenous flint types of Turonian origin, most likely from the center or north of the Turonian terrain, appears among the laminar NBKs only in the Hearth assemblage (7.8%, n=10, ranked third among the laminar NBKs of this assemblage), while being completely absent in the two other assemblages.

Among the cores, type AD, a Turonian flint type, is the most dominant flint type in the two Amudian assemblages (Hearth: 19.3% of the cores, n=16; South of Hearth: 7.6% of the cores, n=6), but it is completely absent from the Yabrudian assemblage's cores. On the other hand, Type S, a Cenomanian / Turonian flint type, appears in high proportions in the Yabrudian assemblage (18.4%, n=7), but it is very minor in the two Amudian assemblages (Hearth: 1.2%, n=1; South of Hearth: 1.3%, n=1).

This pattern is partially supported by the Core Trimming Elements (CTEs), a category in which Type S is better represented in the Yabrudian assemblage (12.7%, n=7) than in the Amudian assemblages (Hearth: 4.6%, n=3; South of Hearth: 5.4%, n=6). The proportions of Type AD, however, are the lowest in the South of Hearth assemblage (1.8%; 6.2% in the Hearth assemblage, 3.6% in the South-western Yabrudian).

It is also of note that type T, a flint type from an unknown source, can be found in the South of Hearth assemblage in both cores and CTEs (7.6% and 9.9%, respectively), while being completely absent from both categories in the Hearth assemblage, indicating the existence of intra-Amudian differences.

When looking at the summary of this comparison (Table 31), we can see a dominance of Turonian flint in all three assemblages, in addition to low proportions of Eocene flint. Beyond this, the South-Western Yabrudian assemblage seems to stand out, presenting choices which are different than the two Amudian assemblages in both the general proportions of the different geologic origins and in the use of flint types for specific categories, such as the cores. These differences might represent different technological needs between the Amudian and Yabrudian industries. On the other hand, as spatial differences were identified at the cave within and between industries, as well as different activity areas (Gopher et al., 2016), variability in patterns of flint exploitation may be expected.

Table 31: A summary of the parameters presented above concerning the Hearth, South of Hearth and South-Western Yabrudian assemblages*.

Parameter	Hearth	South of Hearth	South-Western Yabrudian
Turonian flint	79.90%	72.40%	71.70%
Campanian flint	3.00%	11.10%	6.70%
Cenomanian / Turonian flint	4.10%	4.50%	6.30%
Upper Cenomanian / Turonian	3.80%	2.80%	4.90%
Flints of undetermined sources	6.20%	6.00%	3.00%
Unidentified	1.80%	2.10%	6.10%
Center or the near south (Turonian)	17.30%	15.70%	21.70%
Scrapers (Turonian)	77.80%	50.00%	70.20%
Laminar NBKs (Type D)	13.20%	16.10%	23.90%
Laminar NBKs (Type C)	8.50%	6.50%	15.20%
Laminar NBKs (Type M)	6.20%	19.40%	0.00%
Laminar NBKs (Group 1b)	49.60%	48.40%	63.00%
Laminar NBKs (Group 14)	7.80%	0.00%	0.00%
Cores (Type AD)	19.30%	7.60%	0.00%
Cores (Type S)	1.20%	1.30%	18.40%
Cores (Type T)	0.00%	7.60%	5.30%
CTEs (Type S)	4.60%	5.40%	12.70%
CTEs (Type T)	0.00%	9.90%	1.80%

* Green background marks fields with values notably higher than the two other assemblages; red background marks fields with values notably lower than the two other assemblages. None of these results were statistically significant.

However, several differences between the two Amudian assemblages were also observed, in terms of both general preferences (such as the higher representation of Campanian flint in the South of Hearth assemblage), and in specific typo-technological categories (such as the complete absence of type T among the cores and CTEs of the Hearth assemblage).

5.6.1.3.2. The Top Level Amudian, Top Level Yabrudian and Deep Shelf – Unit I Assemblages

Here I present the two youngest assemblages found at QC - The Top Level Amudian and the Top Level Yabrudian, compared to the oldest assemblage found at the site to date – the Deep Shelf – Unit I Assemblage. The latter assemblage is considered Yabrudian. The proportions of Turonian flints are similar in all three assemblages, (Table 32), as are the proportions from other geologic origins.

Table 32: A breakdown of the Top Level Amudian, Top Level Yabrudian and Deep Shelf – Unit I Assemblages by origin.

origin	Top Level Amudian	Top Level Yabrudian	Deep Shelf – Unit I	Top Level Amudian	Top Level Yabrudian	Deep Shelf – Unit I
Turonian	1890	313	1945	71.2%	68.8%	69.7%
Campanian	239	36	332	9.0%	7.9%	11.9%
Cenomanian / Turonian	224	31	255	8.4%	6.8%	9.1%
undetermined	172	44	131	6.5%	9.7%	4.7%
Upper Cenomanian – Turonian	34	12	41	1.3%	2.6%	1.5%
unidentifiable	51	8	53	1.9%	1.8%	1.9%
Eocene	45	11	34	1.7%	2.4%	1.2%
Total	**2655**	**455**	**2791**	**100.0%**	**100.0%**	**100.0%**

Type AF, of Campanian origin, is the most represented flint type in the Deep Shelf – Unit I assemblage, and is more common than in the Top Level Amudian and in the Top Level Yabrudian. Type M, a striped flint type of Turonian origin, is ranked second in the Deep Shelf – Unit I assemblage, but is less common in the two Top Level assemblages (Table 33). The most represented flint type in the Top Level Yabrudian is type O, which appears in lower proportions in the Top Level Amudian and the Deep Shelf – Unit I assemblage. It is of note that type T, of unknown source, appears in a relatively high proportion in the Top Level Yabrudian, compared to the Top Level Amudian and the Deep Shelf – Unit I assemblage.

Table 33: The most represented flint types* in the Top Level Amudian, Top Level Yabrudian and Deep Shelf – Unit I assemblages.

origin	Top Level Amudian	Top Level Yabrudian	Deep Shelf – Unit I
Type AF (Campanian)	7.6% (1st)	6.4% (2nd)	10.1% (1st)
Type M (Turonian)	4.6% (6th)	1.5% (20th)	9.5% (2nd)
Type O (Turonian)	6.9% (3rd)	11.2% (1st)	5.5% (5th)
Type T (undetermined)	0.3% (49th)	6.4% (2nd)	0.9% (26th)

* numbers in parentheses represent the rank of each flint type among all flint types in each assemblage.

Group 1b is the most represented in all three assemblages (Table 34). Group 16a appears in higher proportions in the Deep Shelf assemblage, compared to the Top Level Amudian and the Top Level Yabrudian. The high proportions of Groups 5 and 6 in the Top Level Yabrudian are also of note.

Table 34: Groups of flint types* of interest in the Top Level Amudian, Top Level Yabrudian and Deep Shelf – Unit I.

type group	Top Level Amudian	Top Level Yabrudian	Deep Shelf – Unit I
1b	20.6% (1st)	16.0% (1st)	23.4% (1st)
16a	7.6% (3rd)	6.4% (4th)	10.1% (2nd)
5	6.9% (3rd)	11.2% (2nd)	5.5% (6th)
6	2.9% (11th)	11.2% (2nd)	3.2% (9th)

* numbers in parentheses represent the rank of each flint type among all flint types in each assemblage.

While fine-textured flint types are the most common in all three assemblages, their proportions are slightly lower in the Top Level Yabrudian (74.3%, compared to 87.8% in the Top Level Amudian and 85.7% in the Deep Shelf – Unit I assemblage). Medium to coarse-textured flints, on the other hand, are more common in the Top Level Yabrudian (20.9%, n=95) than they are in the Top Level Amudian (8.3%, n=221) and in the Deep Shelf – Unit I assemblage (10.1%, n=283), a difference which was found to be statistically significant (X^2 = 65.53; df = 3; $p < 0.05$). Heterogenous flint types are also more common within the Top Level Yabrudian (21.3%, n=97) than within the Top Level Amudian (10.3%, n=274) and the Deep Shelf – Unit 1 assemblage (9.2%, n=256). This difference was also found to be statistically significant (X^2 = 109.67; df = 3; $p < 0.05$).

Before discussing the patterns of specific typo-technological categories, it should be stressed that the Top Level Yabrudian sample is significantly smaller than that of the two other assemblages. Therefore, any pattern observed should be referred to cautiously. Having said that, some patterns do deserve special attention.

Among the cores, for example, Campanian flints are completely absent from the Top Level Yabrudian, but especially notable in the Deep Shelf – Unit I assemblage (14.5%, n=10), while also appearing in the Top Level Amudian (4.9%, n=6). Interestingly, Campanian flints are also completely absent from the CTEs of the Top Level Yabrudian (compared to the Top level Amudian: 11.7%, n=18, and the Deep Shelf – unit I: 5.5%, n=3).

Differences between the Top Level Yabrudian and the two other assemblages also occur among the NBKs. While Campanian flint appears in the Top Level Amudian (4.7%, n=7, out of 148 NBKs) and the Deep Shelf – Unit I assemblage (7.3%, n=11), it is, again, completely absent in the Top Level Yabrudian (0.0%, out of 14 NBKs).

As for the scrapers, the proportions of Campanian flint are lower in the Top Level Yabrudian, compared to the Deep Shelf – Unit I assemblage and the Top Level Amudian (Table 35). Cenomanian / Turonian flints, on the other hand, are completely absent from the Top Level Amudian assemblage, while being present in notable proportions in the two Yabrudian assemblages. Eocene flint types are also completely absent from the Top Level Amudian assemblage, while appearing (in low numbers) in both Yabrudian assemblages.

Table 35: Breakdown of the scrapers of the Top Level Amudian, Top Level Yabrudian and the Deep Shelf – Unit I by geologic origin.

origin	Top Level Amudian	Top Level Yabrudian	Deep Shelf – Unit I	Top Level Amudian	Top Level Yabrudian	Deep Shelf – Unit I
Turonian	9	15	53	69.2%	50.0%	58.2%
Campanian	2	2	17	15.4%	6.7%	18.7%
Cenomanian / Turonian		3	8	0.0%	10.0%	8.8%
undetermined	2	6	9	15.4%	20.0%	9.9%
Upper Cenomanian – Turonian		2	2	0.0%	6.7%	2.2%
Eocene		2	2	0.0%	6.7%	2.2%
Total	**13**	**30**	**91**	**100.0%**	**100.0%**	**100.0%**

To conclude, in all three assemblages Turonian flint is strongly dominant. No statistically significant differences were observed between the three assemblages concerning other geologic origins, with the same flint types and groups of flint types appearing as dominant. However, as can be seen in Table 36, the Top Level Yabrudian stands out as different in several parameters, compared to the two other assemblages. The Top Level Amudian and the Deep Shelf – Unit I Yabrudian assemblages, on the other hand, present similar proportions in most parameters.

Table 36: A summary of the parameters presented above concerning the Deep Shelf – Unit I, the Top Level Amudian and the Top Level Yabrudian assemblages*.

Parameter	**Top Level Amudian**	**Top Level Yabrudian**	**Deep Shelf – Unit I Yabrudian**
Turonian flint	71.2%	68.8%	69.7%
Campanian flint	9.0%	7.9%	11.9%
Flints of undetermined sources	6.5%	9.7%	4.7%
Type AF (Campanian)	7.6%	6.4%	10.1%
Type M (Turonian)	4.6%	1.5%	9.5%
Type O (Turonian)	6.9%	11.2%	5.5%
Type T (undetermined)	0.3%	6.4%	0.9%
Group 1b	20.6%	16.0%	23.4%
Group 16a	7.6%	6.4%	10.1%
Group 5	6.9%	11.2%	5.5%
Group 6	2.9%	11.2%	3.2%
Medium to coarse-textured flints	8.3%	**20.9%**	10.1%
Heterogenous flint types	10.3%	**21.3%**	9.2%
Cores (Campanian)	14.5%	0.0%	4.9%
CTEs (Campanian)	11.7%	0.0%	5.5%
NBKs (Campanian)	4.7%	0.0%	7.3%
scrapers (Turonian)	69.2%	50.0%	58.3%
scrapers (Campanian)	15.4%	6.7%	18.7%
Scrapers (Cenomanian / Turonian)	0.0%	10.0%	8.8%
Scrapers (Eocene)	0.0%	6.7%	2.2%

* Green background marks fields with values which are notably higher than the two other assemblages; red background marks fields with values which are notably lower than the two other assemblages. Differences which are statistically significant (at $p<0.05$) are bolded.

The Top Level Amudian and the Top Level Yabrudian assemblages originate from the same strata and are most probably contemporaneous. Moreover, as mentioned above, and as supported by the comparison between the two industries (section 5.6.1.2), the Amudian and Yabrudian industries represent two facies of the same techno-cultural system (Assaf et al., 2015; Parush et al., 2016). Nonetheless, some differences between the two assemblages were observed, such as the groups of flint types exploited in each of the assemblages, as well as the flints which were exploited for the production of cores, CTEs and NBKs in each assemblage. Of special note is the pattern observed within the scrapers, suggesting clear differences between the Amudian and Yabrudian assemblages. The small sample size of the Top Level Yabrudian assemblage does, however, mean that we should use caution in interpreting these results.

The two Yabrudian assemblages (the Top Level Yabrudian and the Deep Shelf – Unit I) are different from each other as well. The only parameters in which a resemblance between them was found are the general proportions of the Turonian flint, and, most strikingly, the geologic origins used for the production of scrapers. It therefore seems that specific flint types were chosen for the production of scrapers in Yabrudian assemblages throughout the human occupation of the cave. This pattern is further stressed in the section discussing the scrapers, below.

5.6.1.3.3. The Deep Shelf – Unit I, Amudian (Shelf), Amudian Below the Shelf, and the Yabrudian Below the Shelf Assemblages

The four assemblages discussed in this section are located below the rock shelf, and are older than 300,000 BP, with the Deep Shelf – Unit I assemblage being the oldest, followed by the Amudian (Shelf), the Amudian Below the Shelf, and the Yabrudian Below the Shelf Assemblages. The two middle assemblages are Amudian, while the lowest and uppermost ones are Yabrudian. The Amudian Below the Shelf and Yabrudian Below the Shelf were included in the preliminary study of Wilson et al. (2016).

Here, again, Turonian flints are dominant in all four assemblages (Table 37). Turonian flints are, however, a little less common in the Amudian (Shelf) and the Deep Shelf – Unit I than they are in the Amudian Below the Shelf and the Yabrudian

Below the Shelf assemblages. The proportions of Campanian flints, on the other hand, are higher in the Amudian (Shelf) assemblage and the Deep Shelf – Unit I assemblage than in the Amudian Below the Shelf and the Yabrudian Below the Shelf. Flint types of undetermined sources are also more common in the Amudian (Shelf) and in the Deep Shelf – Unit I than they are in the Amudian Below the Shelf and in the Yabrudian Below the Shelf. Finally, Eocene flint appears in the Amudian (Shelf) in noteworthy proportions, while appearing in low proportions in the Deep Shelf – Unit I, in the Amudian Below the Shelf and in the Yabrudian Below the Shelf.

Table 37: Proportions of each geologic origin within the Deep Shelf – Unit I, the Amudian (Shelf), the Amudian Below the Shelf, and the Yabrudian Below the Shelf assemblages.

origin	Deep Shelf – Unit I	Amudian (Shelf)	Amudian Below the Shelf	Yabrudian Below the Shelf	Deep Shelf – Unit I	Amudian (Shelf)	Amudian Below the Shelf	Yabrudian Below the Shelf
Turonian	1,945	412	1,594	1,504	69.7%	71.2%	80.0%	76.2%
Campanian	332	53	78	112	11.9%	9.2%	3.9%	5.7%
Cenomanian / Turonian	255	18	117	87	9.1%	3.1%	5.9%	4.4%
undetermined	131	39	40	70	4.7%	6.7%	2.0%	3.5%
Upper Cenomanian – Turonian	41	2	124	107	1.5%	0.3%	6.2%	5.4%
unidentifiable	53	35	32	87	1.9%	6.0%	1.6%	4.4%
Eocene	34	20	7	6	1.2%	3.5%	0.4%	0.3%
Total	2,791	579	1,992	1,973	100.0%	100.0%	100.0%	100.0%

As for the degree of homogeneity, while all four assemblages are dominated by homogenous materials, their proportions are lower in the Amudian (Shelf) and in the Deep Shelf – Unit I than in the Amudian Below the Shelf and in the Yabrudian Below the Shelf (Table 38).

Table 38: Degree of homogeneity between the Deep Shelf – Unit I, Amudian (Shelf), Amudian Below the Shelf, and the Yabrudian Below the Shelf Assemblages.

homogeneity	Deep Shelf – Unit I	Amudian (Shelf)	Amudian Below the Shelf	Yabrudian Below the Shelf	Deep Shelf – Unit I	Amudian (Shelf)	Amudian Below the Shelf	Yabrudian Below the Shelf
1	1751	327	1407	1286	62.8%	56.5%	70.6%	65.2%
2	731	126	397	445	26.2%	21.8%	19.9%	22.6%
3	256	91	156	155	9.2%	15.7%	7.8%	7.9%
-	52	35	32	87	1.9%	6.0%	1.6%	4.4%
Total	2790	579	1992	1973	100.0%	100.0%	100.0%	100.0%

In terms of texture, the Amudian (Shelf) stands out as different (Table ~~9~~39). While all four assemblages are dominated by fine-textured flints, their proportions are lower in the Amudian (Shelf) assemblage, compared to the Deep Shelf – Unit I, the Amudian Below the Shelf and the Yabrudian Below the Shelf. The proportions of medium to coarse-grained flints are, obviously, higher in the Amudian (Shelf) than in the Deep Shelf – Unit I, the Amudian Below the Shelf and the Yabrudian Below the Shelf. These results may reflect a different pattern of movement applied by the QC inhabitants during the formation of the Amudian (Shelf), compared to that applied during the formation of the three other assemblages~~, meaning that they possibly moved more often in other directions, compared to during the accumulation of the other three assemblages~~.

Table 39: Texture of the flints analyzed from the Deep Shelf – Unit I, Amudian (Shelf), Amudian Below the Shelf, and the Yabrudian Below the Shelf Assemblages.

Texture*	Deep Shelf – Unit I	Amudian (Shelf)	Amudian Below the Shelf	Yabrudian Below the Shelf	Deep Shelf – Unit I	Amudian (Shelf)	Amudian Below the Shelf	Yabrudian Below the Shelf
1	2393	420	1761	1708	85.8%	72.5%	88.4%	86.6%
2	157	71	143	116	5.6%	12.3%	7.2%	5.9%
3	91	14	6	11	3.3%	2.4%	0.3%	0.6%
-	52	35	32	87	1.9%	6.0%	1.6%	4.4%
1-2	10	1			0.4%	0.2%	0.0%	0.0%
1-3	52	6	16	30	1.9%	1.0%	0.8%	1.5%
2-3	35	32	34	21	1.3%	5.5%	1.7%	1.1%
Total	2790	579	1992	1973	100.0%	100.0%	100.0%	100.0%

* 1: fine-textured; 2: medium texture; 3: coarse texture; 1-2: samples vary between fine texture and medium texture; 1-3: samples vary between fine texture and coarse texture; 2-3: samples vary between medium texture and coarse texture.

As for groups of flint types, Group 1b, which is the most represented group in all four assemblages, appear in lower proportions in the Amudian (Shelf) and in the Deep Shelf – Unit I, than in the Amudian Below the Shelf and in the Yabrudian Below the Shelf (Table 40). Group 7, a group of purplish-grey flints of Upper Cenomanian – Turonian origin, which was found in the Amudian Below the Shelf and in the Yabrudian Below the Shelf, is almost absent in the Amudian (Shelf), and was found in low proportions in the Deep Shelf – Unit I assemblage. Group 16a, on the other hand, a group of semi-translucent dark brown homogenous flints, is more common in the Deep Shelf – Unit I and the Amudian (Shelf) assemblages, while appearing in lower proportions in the Amudian Below the Shelf and Yabrudian Below the Shelf. Group 17, a group of greyish slightly translucent homogenous flint types of Turonian origin, appears in notable proportions in the Amudian (Shelf) assemblage, but in lower proportions in the other three assemblages.

Table 40: The most represented groups of flint types in the Deep Shelf – Unit I, Amudian (Shelf), Amudian Below the Shelf, and the Yabrudian Below the Shelf Assemblages.

Type Group	Deep Shelf – Unit I	Amudian (Shelf)	Amudian Below the Shelf	Yabrudian Below the Shelf	Deep Shelf – Unit I	Amudian (Shelf)	Amudian Below the Shelf	Yabrudian Below the Shelf
1b	653	107	776	666	23.4%	18.5%	39.0%	33.8%
7	41	2	124	107	1.5%	0.3%	6.2%	5.4%
2	133	21	90	111	4.8%	3.6%	4.5%	5.6%
4	71	13	120	88	2.5%	2.2%	6.0%	4.5%
26	198	14	117	86	7.1%	2.4%	5.9%	4.4%
16a	281	49	75	89	10.1%	8.5%	3.8%	4.5%
5	153	42	67	73	5.5%	7.3%	3.4%	3.7%
1d	20	17	81	66	0.7%	2.9%	4.1%	3.3%
9	47	5	56	94	1.7%	0.9%	2.8%	4.8%
unidentifiable	52	35	32	87	1.9%	6.0%	1.6%	4.4%

Among the CTEs, Turonian flint types dominate all four assemblages (Table 41). However, flint types of Cenomanian / Turonian origin appear in higher proportions in the CTEs of the Deep Shelf – Unit I and the Amudian (Shelf) than in the CTEs of the Amudian Below the Shelf assemblage, and those of the Yabrudian Below the Shelf.

Table 41: CTEs and their geologic origin in the Deep Shelf – Unit I, Amudian (Shelf), Amudian Below the Shelf, and the Yabrudian Below the Shelf Assemblages.

origin	Deep Shelf – Unit I	Amudian (Shelf)	Amudian Below the Shelf	Yabrudian Below the Shelf	Deep Shelf – Unit I	Amudian (Shelf)	Amudian Below the Shelf	Yabrudian Below the Shelf
Turonian	42	30	209	126	76.4%	73.2%	83.6%	79.2%
Campanian	3	2	8	11	5.5%	4.9%	3.2%	6.9%
Cenomanian / Turonian	5	4	13	5	9.1%	9.8%	5.2%	3.1%
undetermined	2	4	2	2	3.6%	9.8%	0.8%	1.3%
Upper Cenomanian – Turonian	1		17	13	1.8%	0.0%	6.8%	8.2%
Unidentifiable	2	1		2	3.6%	2.4%	0.0%	1.3%
Eocene			1		0.0%	0.0%	0.4%	0.0%
Total	55	41	250	159	100.0%	100.0%	100.0%	100.0%

Within the scrapers, while there are only 11 scrapers in the Amudian (Shelf) assemblage, two of them are of Eocene origin, compared to two of the 91 scrapers of the Deep Shelf – Unit I assemblage, none in the Amudian Below the Shelf and one in the Yabrudian Below the Shelf (Table 42). The proportions of Turonian flint are lower in the Deep Shelf – Unit I assemblage and the Amudian (Shelf) than in the Amudian Below the Shelf and the Yabrudian Below the Shelf. Upper Cenomanian – Turonian flint types are completely absent from the Amudian (Shelf) scrapers, and appear in low proportions in the scrapers of the Deep Shelf – Unit I, while they are present in higher proportions in the scrapers of the Amudian Below the Shelf and the Yabrudian Below the Shelf.

Table 42: Scrapers and their geologic origin in the Deep Shelf – Unit I, Amudian (Shelf), Amudian Below the Shelf, and the Yabrudian Below the Shelf Assemblages.

origin	Deep Shelf - Unit I	Amudian (Shelf)	Amudian Below the Shelf	Yabrudian Below the Shelf	Deep Shelf - Unit I	Amudian (Shelf)	Amudian Below the Shelf	Yabrudian Below the Shelf
Turonian	53	7	29	149	58.2%	63.6%	82.9%	81.0%
Campanian	17	1	1	9	18.7%	9.1%	2.9%	4.9%
Cenomanian / Turonian	8		1	5	8.8%	0.0%	2.9%	2.7%
Undetermined	9	1	1	10	9.9%	9.1%	2.9%	5.4%
Upper Cenomanian – Turonian	2		3	9	2.2%	0.0%	8.6%	4.9%
Unidentifiable				1	0.0%	0.0%	0.0%	0.5%
Eocene	2	2		1	2.2%	18.2%	0.0%	0.5%
Total	91	11	35	184	100.0%	100.0%	100.0%	100.0%

To conclude, as can be seen in Table 43, the Deep Shelf – Unit I and the Amudian (Shelf) assemblages present a different pattern than the other two later assemblages in almost all presented parameters. Therefore, these results might reflect a shift in patterns of procurement and exploitation of flint throughout time, regardless of the industry characterizing each assemblage. It should be stressed again that the differences between the Amudian and Yabrudian industries do not reflect, in our view, separate worlds, but, rather, two elements within the same techno-cultural system (Assaf et al., 2015; Parush et al., 2016). The similarities between the two older assemblages, and the similarities between the two younger assemblages, further support this observation.

Table 43: A summary of the parameters presented above concerning the Deep Shelf – Unit I Yabrudian, Amudian (Shelf), the Amudian Below the Shelf, and the Yabrudian Below the Shelf assemblages*.

Parameter	Deep Shelf - Unit I	Amudian (Shelf)	Amudian Below the Shelf	Yabrudian Below the Shelf
Turonian flint	69.7%	71.2%	80.0%	76.2%
Campanian flint	11.9%	9.2%	3.9%	5.7%
Flints of undetermined sources	4.7%	6.7%	2.0%	3.5%
Eocene flint	1.2%	3.5%	0.4%	0.3%
Homogenous flint	62.8%	56.5%	70.6%	65.2%
Medium to coarse-textured flints	10.1%	20.2%	9.2%	7.5%
Group 1b	23.4%	18.5%	39.0%	33.9%
Group 7	1.5%	0.3%	6.2%	5.4%
Group 16a	10.1%	8.5%	3.8%	4.5%
Group 17	1.7%	10.4%	0.9%	0.5%
CTEs (Turonian)	76.4%	73.2%	83.6%	79.2%
CTEs (Cenomanian / Turonian)	9.1%	9.8%	5.2%	3.1%
Products of COFs (Turonian)	X	68.6%	73.3%	67.6%
Products of COFs (Campanian)	X	20.0%	6.2%	9.9%
Scrapers (Eocene)	2.2%	18.2%	0.0%	0.5%
scrapers (Upper Cenomanian – Turonian)	2.2%	0.0%	8.6%	4.9%

* Green background marks fields with value which are notably higher than the other assemblages; red background marks field with values which are notably lower than the other assemblages. Note that none of the presented results was found to be statistically significant.

5.6.2. Blades, Scrapers and Bifaces Analysis

In the following sections I present the results of the analysis of blades, Quina and demi-Quina scrapers, and bifaces. These results are compared to the results of the general sample presented above.

5.6.2.1. Blades Analysis

The systematic production of blades is one of the major innovations of the AYCC, appearing in significant proportions within Amudian assemblages (Barkai et al., 2018; Bar-Yosef and Kuhn, 1999; Copeland, 2000) and in lesser numbers (although by similar production technologies) in Yabrudian ones at Qesem Cave (Shimelmitz et al., 2011). This section presents the results of the flint type analysis performed for a sample of 4,145 laminar artifacts (which are all a part of the general sample of 21,102 artifacts).

5.6.2.1.1. The Blades Analysis - Results

This section presents the analysis of artifacts characteristic of the blade industry. In total, 4,145 laminar artifacts are analyzed here. Those items are divided into four sub-categories (Table 44): blade tools, cortical blades, blades, and naturally backed knives.

Table 44: A breakdown of the laminar items sample.

category	Total
Blade tools	1,138
Blades	1,048
Cortical blades	985
Naturally Backed Knives	974
Total	**4,145**

Most laminar items were produced of Turonian flint types (Fig. 85). These results are in accordance with the pattern observed in the general sample. Other geologic origins appear in much lower proportions.

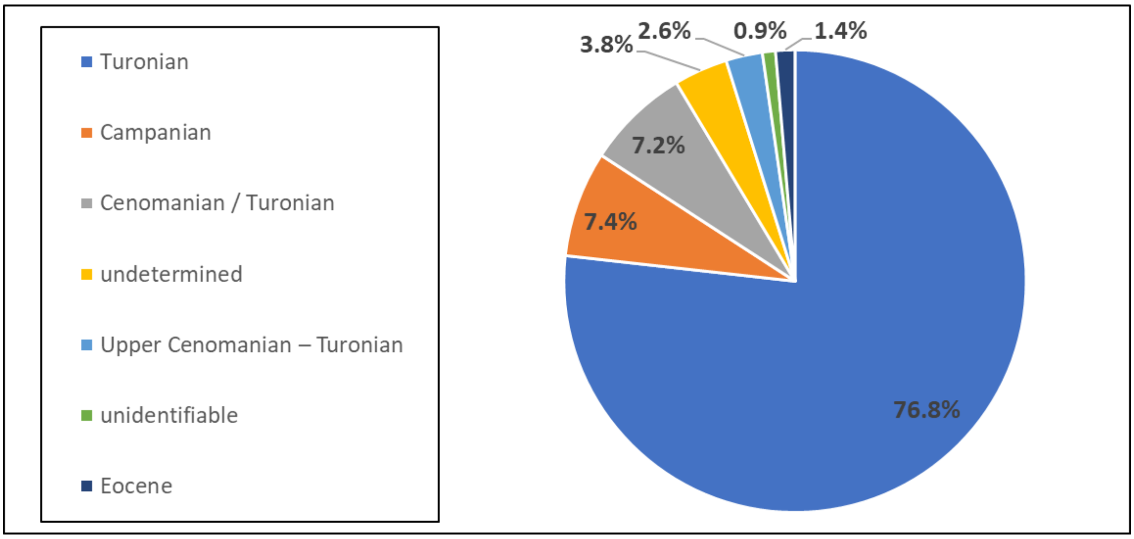

Fig. 85. Proportions of each geologic origin in the laminar items.

As in the general sample, about a half of the Turonian flints found among the laminar items could come from anywhere within the Turonian territory (Table 45). The proportions of flint types which have been observed from central or southern Turonian sources, on the other hand, are slightly higher among the laminar items than in the general sample. The proportions of flint types which have been observed from northern Turonian sources or central or northern Turonian sources are a little lower than those in the general sample.

Table 45: Frequencies of Turonian groups of sources among the laminar items and in the general sample.

source	Laminar Items	General Sample
anywhere	53.6%	46.8%
center or south	18.6%	16.6%
center or north	9.1%	12.5%
north	8.2%	12.8%
south	7.2%	7.0%
center	3.3%	4.4%
Total	**100.0%**	**100.0%**

When examining each blade category separately (Table 46), the general pattern remains: Turonian flint types are still by far the most common in each of the groups. The proportions of Campanian flint types are highest among the blade tools. Cenomanian / Turonian flints are slightly more common among the Naturally Backed Knives than among any of the other laminar categories. Interestingly, both cortical blades and Naturally Backed Knives have the highest proportions of the closest, most easily accessible local materials. The presence of cortex on these items implies that a major portion of the production of blades took place on-site, rather than at the locality of procurement.

Table 46: A breakdown of each laminar category based on the proportions of each geologic origin.

origin	Blade tools	Blades	Cortical blades	Naturally Backed Knives	Total
Turonian	811	775	795	801	3182
Campanian	123	94	59	31	307
Cenomanian / Turonian	71	71	77	81	300
undetermined	62	52	17	25	156
Upper Cenomanian – Turonian	31	22	23	30	106
unidentifiable	23	7	5	3	38
Eocene	17	27	9	3	56
Total	**1138**	**1048**	**985**	**974**	**4145**
Turonian	71.3%	74.0%	80.7%	82.2%	76.8%
Campanian	10.8%	9.0%	6.0%	3.2%	7.4%
Cenomanian / Turonian	6.2%	6.8%	7.8%	8.3%	7.2%
undetermined	5.4%	5.0%	1.7%	2.6%	3.8%
Upper Cenomanian – Turonian	2.7%	2.1%	2.3%	3.1%	2.6%
unidentifiable	2.0%	0.7%	0.5%	0.3%	0.9%
Eocene	1.5%	2.6%	0.9%	0.3%	1.4%
Total	**100%**	**100%**	**100%**	**100%**	**100%**

As for the groups of flint types, the most represented group of types used for the manufacture of laminar items is Group 1b, which is a group of striped homogenous flint types, most likely derived from flat, slab-like nodules, all of Turonian origin (Fig. 86; Table 47). The slab-like morphology of these nodules makes them suitable for the systematic production of blades (Barkai et al., 2009, Shimelmitz et al., 2011). While it is also the most represented group of flint types in the general sample, the proportions of Group 1b in the general sample are a little lower than those observed among the laminar items. This suggest that there was a slight preference for the exploitation of these flint types in the production of blades. Such slab-like nodules were found in abundance in UF, a secondary flint source located 2.59 km south of QC (Wilson et al., 2016). This observation is in accordance with the relatively high frequency of southern Turonian sources among the laminar items, compared to the general sample, which was demonstrated above.

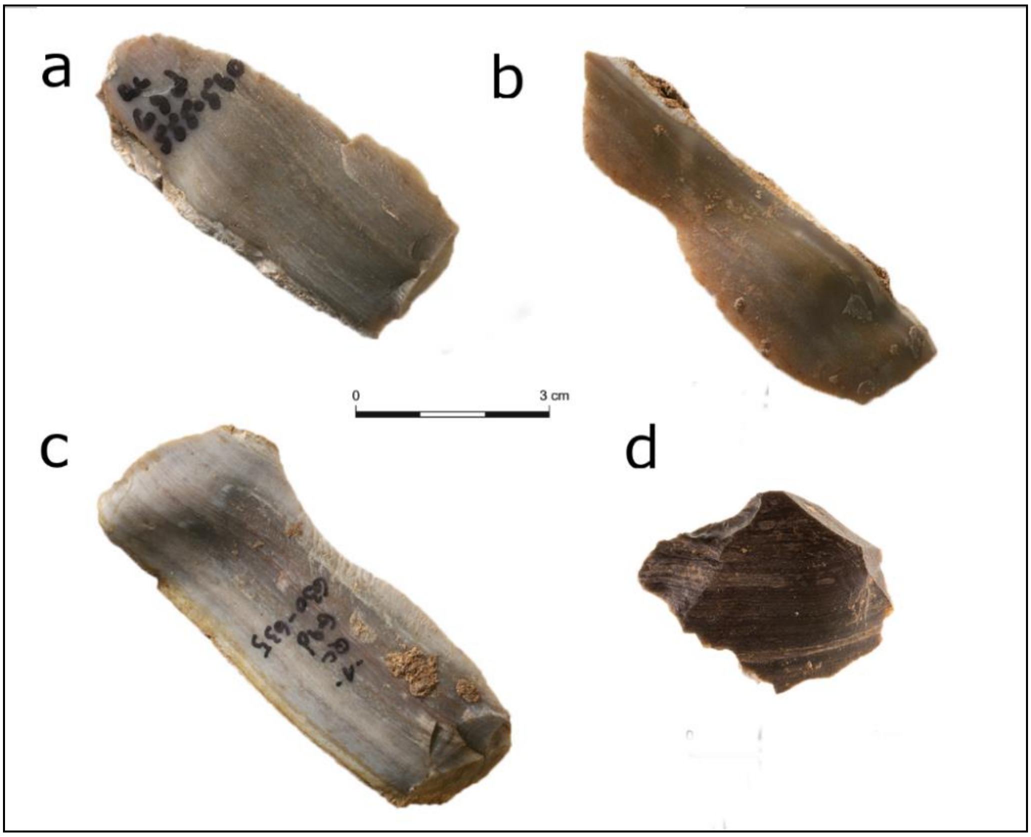

Fig. 86. Four flint types of Group 1b, the most common group of flint types among the laminar items: a) Type C; b) Type D; c) Type M; d) Type BE.

Table 47: The top ten most represented groups of flint types among the laminar items.

type group	Total	%
1b	1857	33.3%
16a	368	6.6%
26	333	6.0%
1a	292	5.2%
2	283	5.1%
5	264	4.7%
14	222	4.0%
13	199	3.6%
3	174	3.1%
9	167	3.0%

Most of the laminar items are made of homogenous flint types (69.5%; n=2,881). These proportions are a little higher than those observed within the general sample (62.6%; n=13,200). Similarities also occur in the proportions of fine-textured flint types among the laminar items sample (90.0%; n=3,730) and the general sample (85.6%; n=18,068), and of opaque flint types among the laminar items (74.8%; n=3,101) and in the general sample (69.8%; n=14,729). These results suggest that homogenous, fine-textured, opaque flint types were preferred at QC in general, both in the general sample and among the blades, or, again, were simply more available in the vicinity of the site, as implied by our geologic survey.

Interestingly, the general proportions repeat themselves even when comparing the laminar items from Amudian assemblages and the laminar items from Yabrudian assemblages (Fig. 87). All flint types appear in similar proportions in both groups. This pattern indicates that while the two industries vary in composition and mainly in the proportions of the two major AYCC markers, the blades and the Quina scrapers, the selection of which flint types to use for the production of blades remained consistent. This observation further supports the suggestion that these two industries should viewed as two parts of the same system of production (Assaf et al., 2016; Parush et al., 2016).

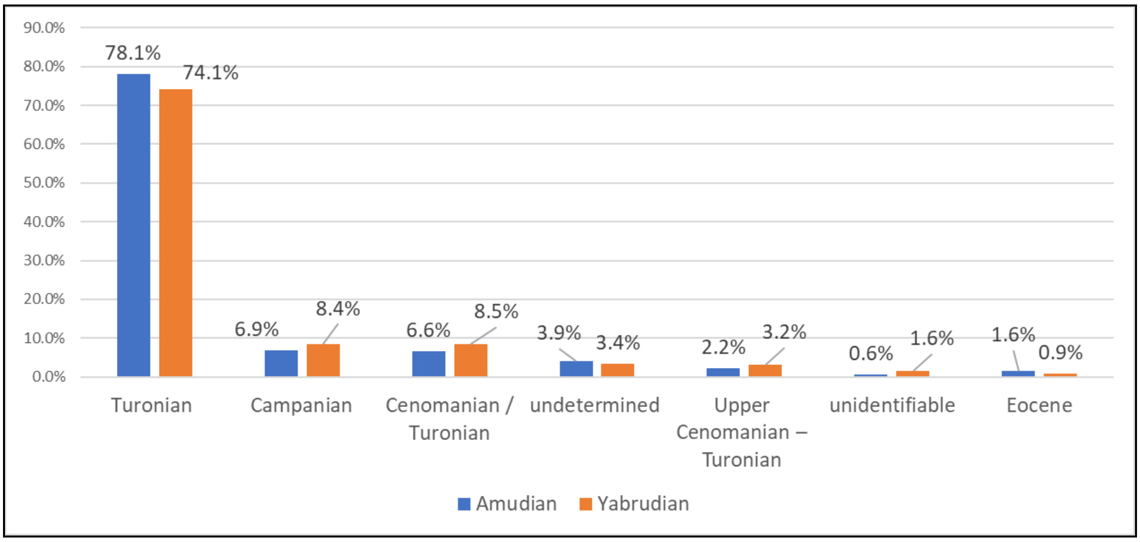

Fig. 87. Laminar items in Amudian and Yabrudian assemblages, by geologic origin.

The repeated exploitation of Group 1b for the production of laminar items is also fairly consistent when looking at the data on an industry level (32.1% in the Amudian assemblages; 35.9% in the Yabrudian assemblages; Table 48). Group 16a maintains its second position in both groups (6.4% in the Amudian assemblages; 7.0% in the Yabrudian assemblages).

Table 48: The ten most common groups of flint types in the laminar items, and their proportions in each of the two industries.

type group	Amudian assemblages	Yabrudian assemblages	Total	Amudian %	Yabrudian %	Total
1b	1240	617	1857	32.1%	35.9%	33.3%
16a	248	120	368	6.4%	7.0%	6.6%
26	215	118	333	5.6%	6.9%	6.0%
1a	198	94	292	5.1%	5.5%	5.2%
2	184	99	283	4.8%	5.8%	5.1%
5	209	55	264	5.4%	3.2%	4.7%
14	176	46	222	4.6%	2.7%	4.0%
13	156	43	199	4.0%	2.5%	3.6%
3	123	51	174	3.2%	3.0%	3.1%
9	118	49	167	3.1%	2.9%	3.0%

5.6.2.1.2. Laminar Items Analysis by Assemblages

When comparing the laminar items between assemblages, some results are noteworthy (Table 49). Turonian flint types dominate the laminar items in all assemblages. The proportions of Turonian flint are the highest in the Hearth and the Amudian Below the Shelf assemblages, two Amudian assemblages with about the same chronology (Gopher et al., 2016). The blades of the Deep Shelf – Unit I assemblage, a Yabrudian assemblage which is the oldest assemblage found to date at QC, present the highest proportions of Campanian flint, while the Hearth assemblage presents the lowest proportions of Campanian flint. As for Cenomanian / Turonian flint, again, the Deep Shelf – Unit I assemblage presents the highest proportions. This suggests that during the accumulation of the Deep Shelf – unit I assemblage the blade production was less restricted to local Turonian flint types. The relatively high proportion of Eocene flint among the blades of the Amudian (Shelf) assemblage is also of note.

Table 49: Laminar items by assemblage and geologic origin.

Assemblage final	Turonian	Campanian	Cenomanian / Turonian	undetermined	Upper Cenomanian – Turonian	unidentifiable	Eocene	Total
Top Level Amudian	280	30	32	17	2	2	5	368
Top Level Yabrudian	32	3	4	5	2		1	47
K-10	155	23	13	10	1	5	5	212
Hearth	314	6	17	13	9		7	366
South of Hearth	162	19	11	10	8	3	3	216
G-19/20	557	71	57	34	6	3	15	743
South-Western Yabrudian	135	18	8	4	11	1	2	179
The Southern Area	113	12	9	5	4		2	145
Yabrudian Below the Shelf	360	18	37	16	19	20	1	471
Amudian Below the Shelf	439	15	33	8	30	1		526
Amudian (Shelf)	118	13	8	11	1	2	7	160
Deep Shelf – Unit I	517	79	71	23	13	1	8	712
Total	**3182**	**307**	**300**	**156**	**106**	**38**	**56**	**4145**
Top Level Amudian	76.1%	8.2%	8.7%	4.6%	0.5%	0.5%	1.4%	100%
Top Level Yabrudian	68.1%	6.4%	8.5%	10.6%	4.3%	0.0%	2.1%	100%
K-10	73.1%	10.8%	6.1%	4.7%	0.5%	2.4%	2.4%	100%
Hearth	85.8%	1.6%	4.6%	3.6%	2.5%	0.0%	1.9%	100%
South of Hearth	75.0%	8.8%	5.1%	4.6%	3.7%	1.4%	1.4%	100%
G-19/20	75.0%	9.6%	7.7%	4.6%	0.8%	0.4%	2.0%	100%
South-Western Yabrudian	75.4%	10.1%	4.5%	2.2%	6.1%	0.6%	1.1%	100%
The Southern Area	77.9%	8.3%	6.2%	3.4%	2.8%	0.0%	1.4%	100%
Yabrudian Below the Shelf	76.4%	3.8%	7.9%	3.4%	4.0%	4.2%	0.2%	100%
Amudian Below the Self	83.5%	2.9%	6.3%	1.5%	5.7%	0.2%	0.0%	100%
Amudian (Shelf)	73.8%	8.1%	5.0%	6.9%	0.6%	1.3%	4.4%	100%
Deep Shelf – Unit I	72.6%	11.1%	10.0%	3.2%	1.8%	0.1%	1.1%	100%
Total	**76.8%**	**7.4%**	**7.2%**	**3.8%**	**2.6%**	**0.9%**	**1.4%**	**100%**

The proportions of Cenomanian / Turonian flint types are relatively high in the Deep Shelf – Unit I assemblage (9.7%; n=76), compared to their proportions in the laminar items of all assemblages combined (6.9%; n=383). The proportions of Cenomanian / Turonian flint types are especially low, on the other hand, in the Hearth assemblage (4.1%; n=17).

The Amudian Below the Shelf assemblage stands out as having the lowest proportions of flint types of Campanian origin (2.8%, versus 7.3% in all assemblages combined), of an undetermined origin (1.1%; 3.6% in all assemblages combined), and of Eocene origin (0.0%; 1.2% in all assemblages combined). The proportions of Turonian flints, on the other hand, are the second highest in this assemblage (82.6%; 76.5% in all assemblages combined), second only to the Hearth assemblage (84.7%).

Finally, the proportions of Group 1b among the laminar items in the different assemblages should be addressed here (Fig. 17). While Group 1b is the most common in all assemblages, its proportions vary greatly. Its highest proportion is in the Amudian Below the Shelf assemblage, and its lowest in the Amudian (Shelf) assemblage. It should be noted, however, that in the Amudian (Shelf) assemblage Group 1b is followed by Group 1a, a group of red to brown homogenous flint types, which are also derived from flat, slab-like nodules, and which are all also of Turonian origin, but which could have come from anywhere in the Turonian area.

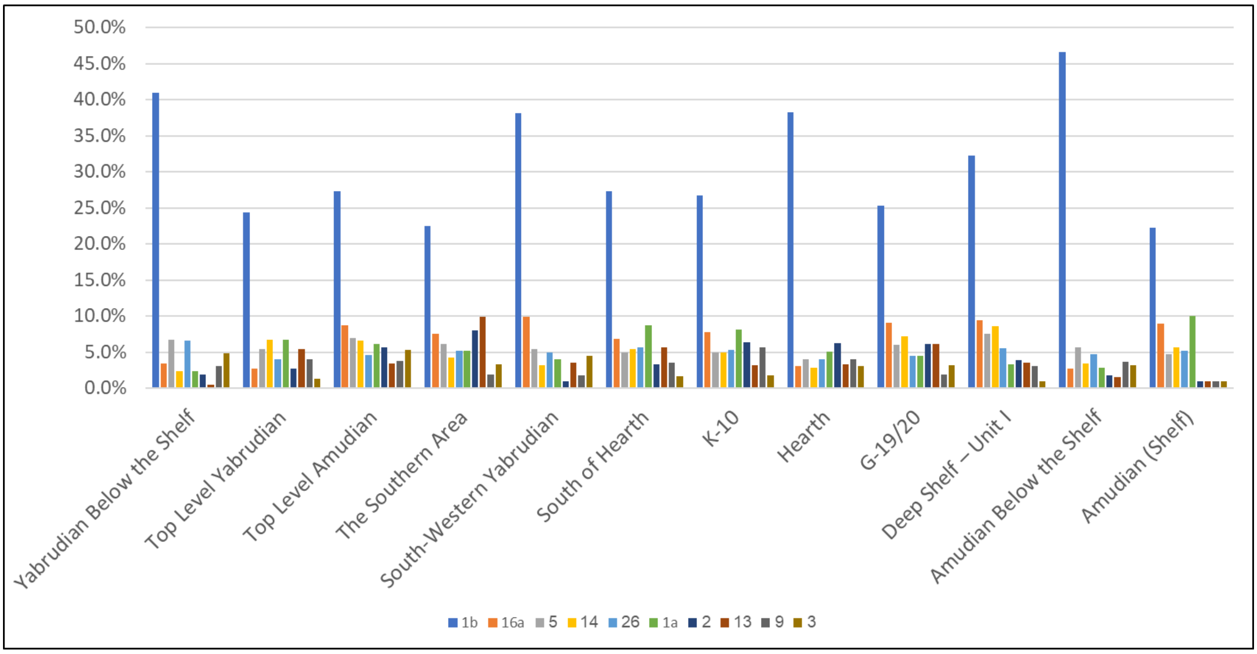

Fig. 88. The proportions of the ten most common groups of flint types among the laminar items in the different assemblages.

5.6.2.1.3. Discussion of the Laminar Items Results

Generally, the results presented above concerning the laminar items reflect a pattern similar to that observed within the general sample: About three-quarters of the analyzed lithic material is of Turonian origin. It is therefore possible that the suitability of the flint types available around the cave, both for blade production and for other technological trajectories practiced at the site, played an important role in the decision to locate the occupation where it is. Alternatively, it is possible that due to the intensity of blade production at the cave, these flint types, which were highly suitable for the manufacture of blades, became the most common at QC.

According to Shimelmitz et al. (2011), for the production of blades the QC flint knappers usually preferred flat flint slabs. Indeed, some of the available flint in the immediate vicinity of the site tends to be found in flat nodules, suitable for the production of blades by the technology practiced on site. This is especially true for the UF source, located 2.59 km south of QC. The relatively high proportions of flint types of Group 1b, compared to the general sample, support this notion, as they demonstrate such traits. These nodules are angular and therefore most likely required only minor preparations to no preparation at all, taking advantage of the natural shape of the nodule (Barkai et al., 2009; Shimelmitz et al., 2011). This reduced the need for a preliminary shaping stage, and therefore enabled the transformation of larger masses of material into laminar items, without much effort, and with few by-products (Shimelmitz et al., 2011). In most cases cortex was not removed prior to blade production (Barkai et al., 2009).

Still, while thin flat Turonian nodules were often used for the production of blades at QC, other flint types, of other origins and of other shapes, were also used for this propose, including rounded or amorphous nodules (Shimelmitz et al., 2011). The exploitation of such nodules required more preparation work before blade production, often accompanied by the by-production of flakes (Shimelmitz et al., 2011). Group 16a (flints of Campanian origin), the second most common group among the laminar items, is characterized by rounded or amorphous nodules, as is Group 26 (flints of Cenomanian / Turonian origin), the third most common group. While the exploitation of these two types of nodules (flat nodules and rounded/amorphous nodules) reflects the existence of two separate technological trajectories, no major differences have been observed between the laminar items produced from these two types of nodules (Shimelmitz et al., 2011). Furthermore, experimental knapping has demonstrated that the trajectory exploiting rounded/amorphous nodules is efficient as well, regardless of the by-products production involved in its application (Shimelmitz et al., 2011). It seems, then, that the QC knappers were flexible in their choice of flint types for blade production, and were capable of adapting their technological procedures based on the flint type selected at a specific moment. Boaretto et al. (2009) demonstrated that some blades contain low levels of ^{10}Be, while others have high levels of ^{10}Be, suggesting that flint for blade production was obtained both through surface collection and through the exploitation of primary geologic sources. These results further demonstrate the flexibility in flint procurement for blade production.

Curiously, later blade-producing industries mainly used rounded or amorphous nodules for the production of blades (e.g., Anikovich et al., 2007; Eren et al., 2008; Kuhn et al., 1999), usually involving stages of pre-shaping, which are wasteful in terms of lithic material, time and effort (Shimelmitz et al., 2011). The QC knappers, on the other hand, were more selective in the choice of nodules for the production of blades, in order to keep the preparation stages to a minimum. Also, the flakes produced during core preparation and maintenance could have been utilized as well, and were defined in previous studies at QC as flake NBKs (Shimelmitz et al., 2011).

Use-wear analysis suggests that the QC blades were mainly used for cutting activities, mostly of soft material, probably fleshy tissues (Lemorini et al., 2006). Interestingly, the use-wear results suggest that the examined blades were used only for short periods of time, without a resharpening stage, after which they were discarded. The high availability of the flint types used for the manufacture of blades, as well as their suitability for blade production in a relatively straight-forward manufacture procedure, may provide a possible explanation for these short usages, implying that there was no justification to make the effort of rejuvenating these blades. Alternatively, it is possible that the mechanical traits of these flint types caused the artifacts to quickly go dull, leading to their abandonment after short periods of usage. This idea has not yet been tested.

To conclude, the QC knappers understood the high suitability of specific, slab-like cortical flint nodules (specifically those of Groups 1b and 1a) for the systematic and serial production of blades, involving minor preparation, or no preparation at all, which allowed for the regular manufacture of Naturally Backed Knives. Round nodules were also used for the production of blades, but to a lesser extent. While some scholars have argued that the lack of preparation in blade production during the AYCC reflects the lack of planning (e.g., Copeland, 2000; Monigal, 2002), Shimelmitz et al. (2011) have suggested that that AYCC blade production reflects "*an innovative and well thought-out and planned technology [which] was practiced… [and] maintained a systematic and serial production of predetermined blanks*" (Shimelmitz et al., 2011: 477). Indeed, based on the flint types results presented above, it seems more likely that the choice to use locally available flat flint nodules which require minor stages of pre-shaping reflects the ability to plan in advance, aiming at saving the hard work involved in core preparation, as well as the time and waste of lithic materials.

5.6.2.2. The Quina and demi-Quina Scrapers Analysis

This section presents the results of the flint type analysis of a sample of 75 Quina scrapers and 133 demi-Quina scrapers, and compares them to the results of the general sample. In this section I use the results of a detailed use-wear analysis performed for the Quina and demi-Quina scrapers by A. Zupancich (see Zupancich et al., 2016a, 2016b for methodology, and for more details). I use indications concerning the activities performed with these tools, as well as data concerning the worked materials. I first analyze the two groups in full, and then focus on two specific assemblages: the "Deep Shelf – Unit I" assemblage, and the "Yabrudian Below the Shelf" assemblage, as these assemblages provide large scraper samples.

5.6.2.2.1. Quina and demi-Quina Scrapers – General Results

While local Turonian flint types of the Bi'na Formation strongly dominate the general sample (74.0% of the analyzed pieces), the proportion of Turonian materials is notably lower among the Quina (44.0% of the sample, n=33) and demi-Quina scrapers (58.6%, n=78) (Figs. 89-90). Campanian flints of the Mishash Formation, on the other hand, are more common among the scrapers than within the general sample (20.0% of the Quina scrapers, n=15; 13.5% of the demi-Quina scrapers, n=18; 8.2% of the general sample; n=1,723). Cenomanian / Turonian flints of the Eyal Forest are more common among the demi-Quina scrapers (14.3%, n=19) and the Quina scrapers (12.0%, n=9), than within the general sample (6.3%; n=1,323). In both cases the results were found to be statistically significant (Quina scrapers: X^2 = 116.19, df = 6, p < 0.05; demi-Quina scrapers; X^2= 43.94, df = 6, p < 0.05).

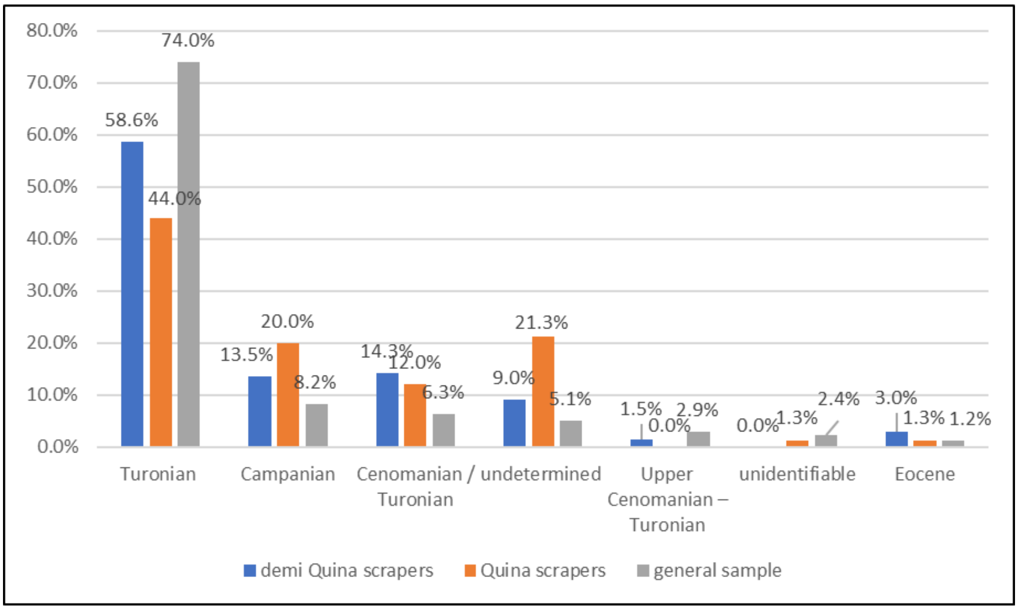

Fig. 89. All analyzed Quina and demi-Quina scrapers by sources of origin, compared to the general sample.

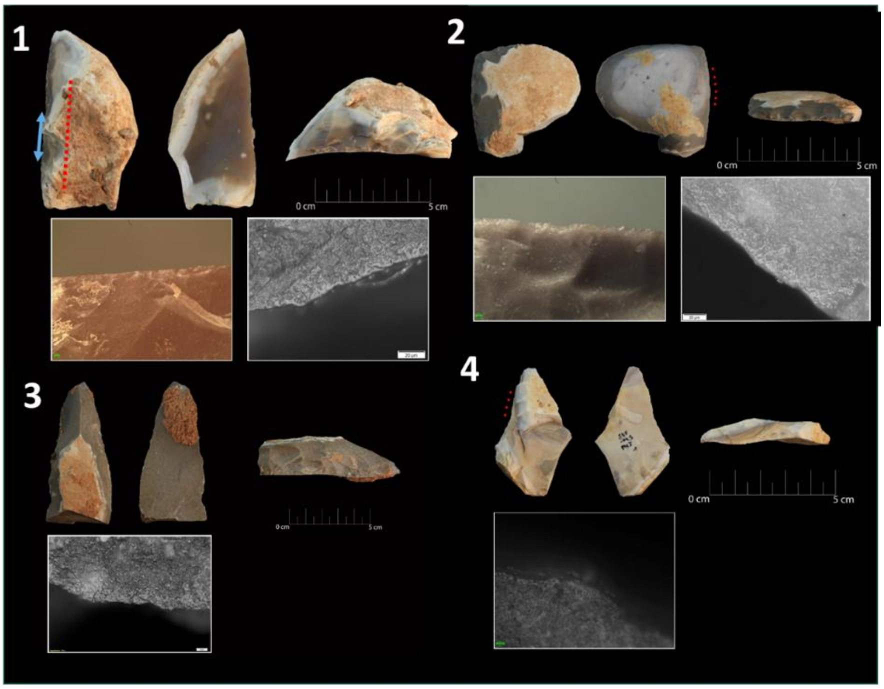

Fig. 90. Examples of Quina and demi-Quina scrapers, their geologic origin, and the results of their functional analysis: 1) A Quina scraper made of Turonian flint, with use-wear indicating the cutting of bones. 2) A demi-Quina scraper made of Campanian flint, with use-wear indicating the cutting of fresh hide and animal tissues. 3) A Quina scraper made of Eocene flint, which was used for scraping of bone and animal tissues. 4) A demi-Quina scraper made of Cenomanian / Turonian flint, used for cutting dry hide (picture by A. Zupancich).

At the flint type level, some more interesting patterns emerge (Figs. 91-92). Type AF, a semi-translucent dark-brown homogenous flint type of the Campanian Mishash formation, is the most prominent flint type among Quina scrapers (n=15, 20.0%). Among the demi-Quina scrapers it is the second most frequent flint type (n=16, 12.0%). Within the general sample, its proportions (6.7%) are notably lower than among the two groups of scrapers. The second most common flint type among the Quina scrapers is type AU (n=11; 14.7%), a chocolate brown homogenous flint type of undetermined origin. Type AU is ranked sixth among the demi-Quina scrapers (n=7, 5.3%), and ranked 17th within the general sample (2.3%; n=478).

Fig. 91. The flint types mentioned in this section: 1) Type AF (Campanian flint); 2) Type AU (of undetermined origin); and 3) Type S (Cenomanian).

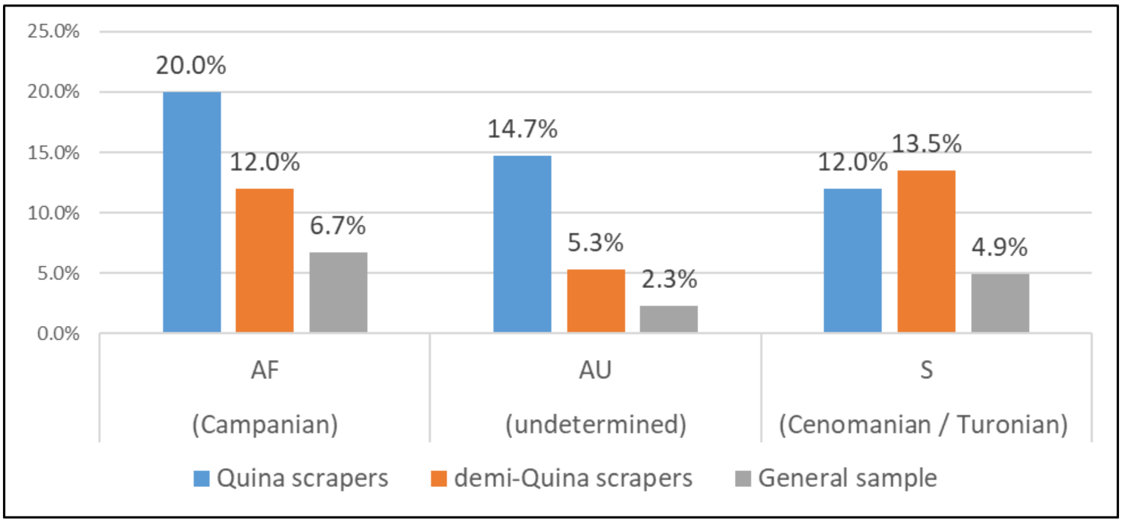

Fig. 92. The frequencies of flint types AF, AU and S among the Quina and demi-Quina scrapers and in the general sample.

The most common flint type among the demi-Quina scrapers is type S, a Cenomanian / Turonian pinkish to light brown fine-textured opaque flint. Among the Quina scrapers, its presence is also notable (ranked third), although in lower proportions. Type S is less frequent within the general sample, but is ranked fifth. The other scrapers, of both types, are made of 35 different flint types, each appearing in low frequencies (n<8).

It is interesting to note that the most common flint type among the Quina scrapers, type AF, is of Campanian origin, while the most common flint type among the demi-Quina scrapers, type S, is of Cenomanian / Turonian origin. While it is as yet unknown which exact sources were exploited for the procurement of these flint types, this pattern may suggest that the QC hominins moved in two different directions when collecting flint for the production of Quina scrapers and when collecting flint for the production of demi-Quina scrapers, or, alternatively, that Type AF was somehow more suitable for the production of Quina scrapers, while Type S was more suitable for the production of demi-Quina scrapers.

Out of the 75 analyzed Quina scrapers, 38 yielded indicative data concerning the activity for which they were used (Fig. 93). Quina scrapers were mostly used for scraping, regardless of their geologic origin. The analysis of the worked materials (Fig. 94) accords well with this fact, as most Quina scrapers were used for the processing of both fresh and dry hide, again, regardless of the geologic origin of the flint types of which they were produced.

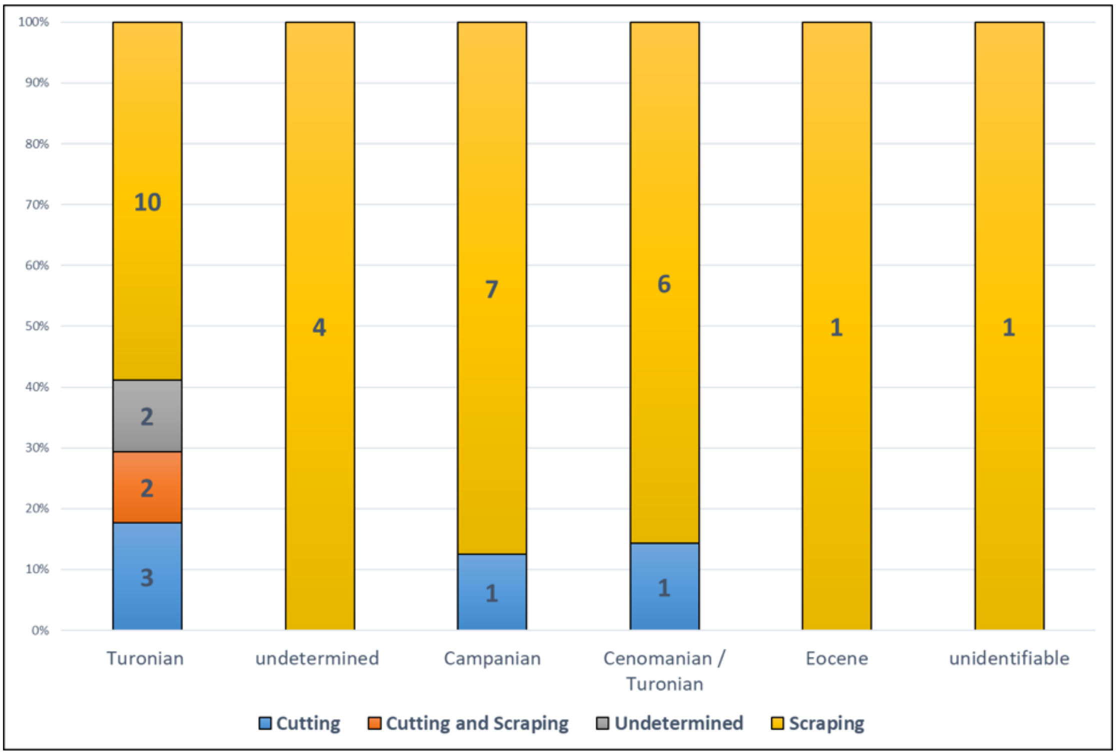

Fig. 93. Correlation between activity and origin among the Quina scrapers.

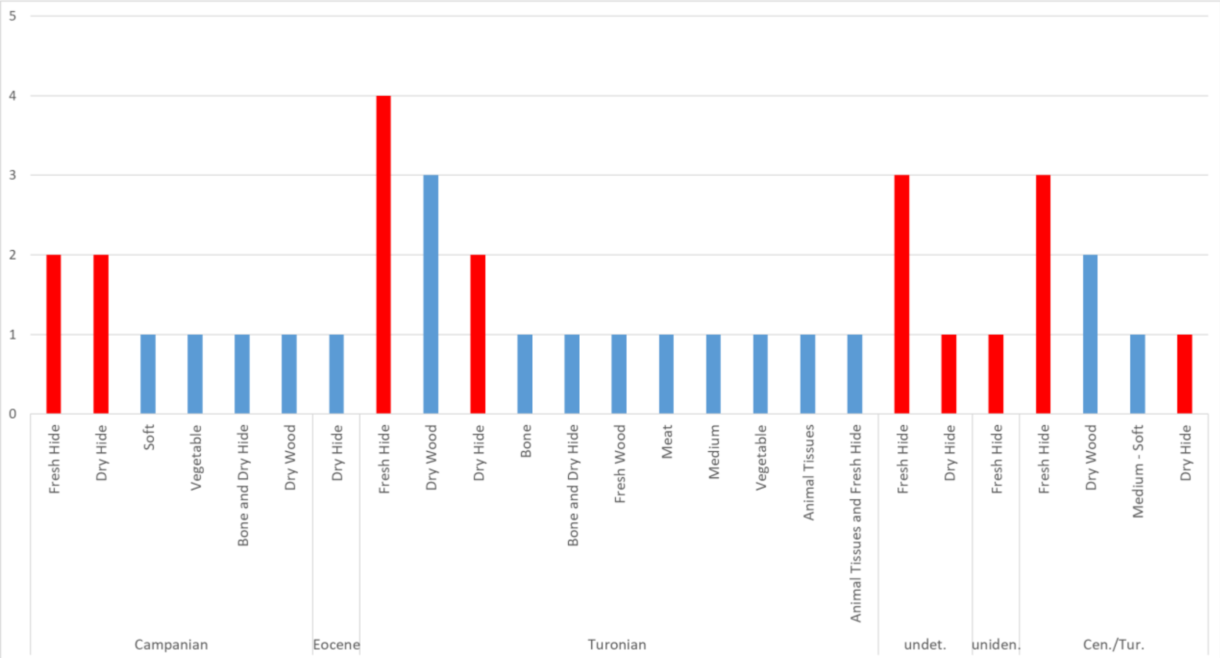

Fig. 94. Worked materials by origin of the Quina scrapers. Fresh and dry hide are represented by the red columns. "Undet." stands for flints of undetermined sources; "uniden." stands for "unidentified"; "Cen./Tur." stands for flint types of Cenomanian / Turonian origin.

Demi-Quina scrapers, on the other hand, were much more versatile, and were used for various functions, regardless of their geologic origin. Fig. 95 demonstrates that in addition to scraping activities, which were observed on scrapers of all geologic origins, demi-Quina scrapers were also often used for cutting. These results are also reflected by the worked materials (Fig. 96), demonstrating that demi-Quina scrapers were used for the processing of a wide variety of materials, including fresh and dry hide, but also fresh and dry wood, vegetal materials, animal tissues, and bones. These results imply that the decision which flint type to use for the production of these scrapers was not related to the material which was going to be processed with this tool. Rather, it is possible that these flint types were selected due to their suitability for the production procedure at hand, as well as their suitability for the processing of a wide variety of materials.

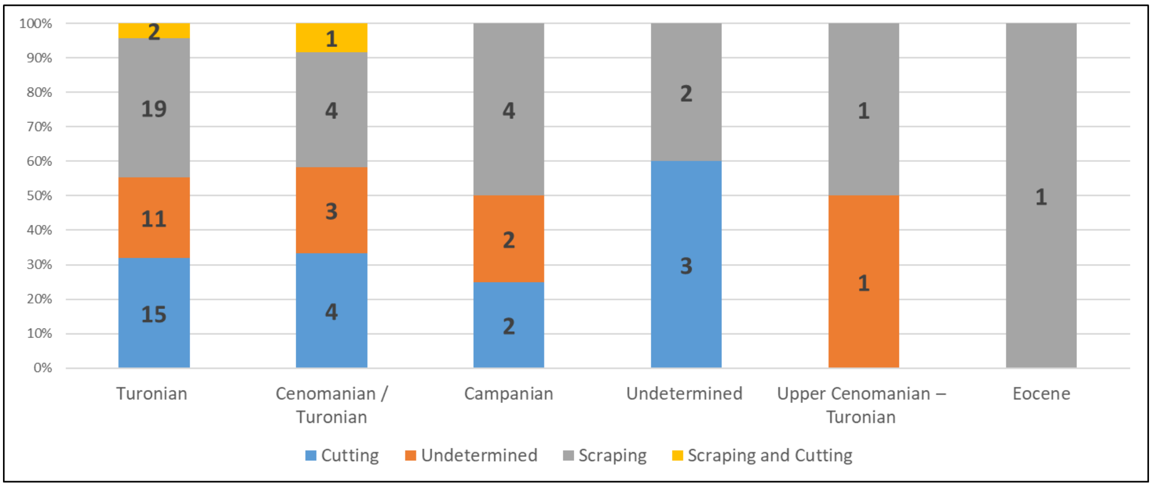

Fig. 95. Correlation between activity and origin among the demi-Quina scrapers

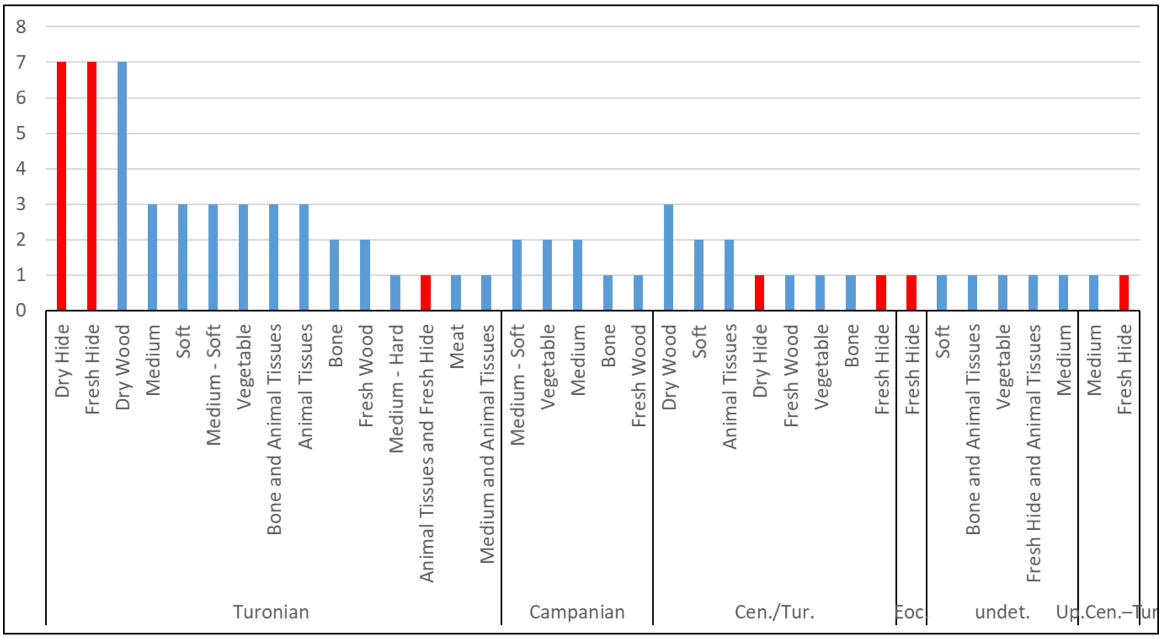

Fig. 96. Worked materials by origin of the demi-Quina scrapers. Fresh and dry hide are represented by the red columns. "Undet." stands for flints of undetermined sources; "uniden." stands for "unidentified"; "Cen./Tur." stands for flint types of Cenomanian / Turonian origin; "Up.Cen.-Tur." stands for Upper Cenomanian – Turonian.

The degree of homogeneity seems to play a role in the decision as to which flint types to use for the manufacture of Quina and demi-Quina scrapers. While 62.6% of the flints within the general sample are homogenous, the proportions of homogenous flints are higher among the Quina (80.0%; n=60) and demi-Quina scrapers (69.9%; n=93). These results imply an emphasis towards homogenous flint types in the manufacture of both Quina and demi-Quina scrapers.

Fine-textured flint types are more common among the Quina scrapers (74.7%; n=56) than among the demi-Quina scrapers (61.7%; n=82). Within the general sample, however, fine-textured flint types are even more common (85.6%; n=18,068). The proportions of opaque flints are also higher in the general sample (69.8%; n=14,729) than among the Quina scrapers (58.7%; n=44) and demi-Quina scrapers (53.4%; n=71). These patterns may imply that a fine texture and opacity were common characteristics in the flint types which were available around QC, or, alternatively, that such flint types were preferred during the flint procurement process.

Nine Quina scrapers (12.0%: three from unknown sources, two Turonian, two Campanian, one Eocene, and one Cenomanian / Turonian), and 21 demi-Quina scrapers (15.8%; 10 Turonian, three Cenomanian / Turonian, three Eocene, two Campanian, two of undetermined origin, and one Upper Cenomanian - Turonian), presented patina differences, indicating they were collected as old previously produced blanks. These proportions of patinated blanks used for the manufacture of both types of scrapers suggest that this was one of the technological trajectories of lithic procurement used for the acquisition of flint for the production of Quina and demi-Quina scrapers.

5.6.2.2.2. Analysis of the Quina and demi-Quina Scrapers from Two Yabrudian Assemblages

For this study, a sample of 22 Quina scrapers and 50 demi-Quina scrapers (a total of 72 scrapers) was taken from the "Deep Shelf – Unit I" assemblage, a Yabrudian assemblage which is the oldest assemblage excavated to date at QC. In this sample, among the Quina scrapers 22.7% (n=5) are of Campanian origin, while

12.0% (n=6) of the demi-Quina are of Campanian origin – both higher than the general sample (8.2%, n=1,723; Fig. 97). Cenomanian / Turonian flints, on the other hand, constitute 14.0% of the demi-Quina scrapers (n=7) while being completely absent from the Quina scrapers of the Deep Shelf – Unit I assemblage (6.3% in the general sample; n=1,323). The results for the Quina scrapers, compared to the general sample, are statistically significant (X^2 = 23.11, df = 6, p < 0.05).

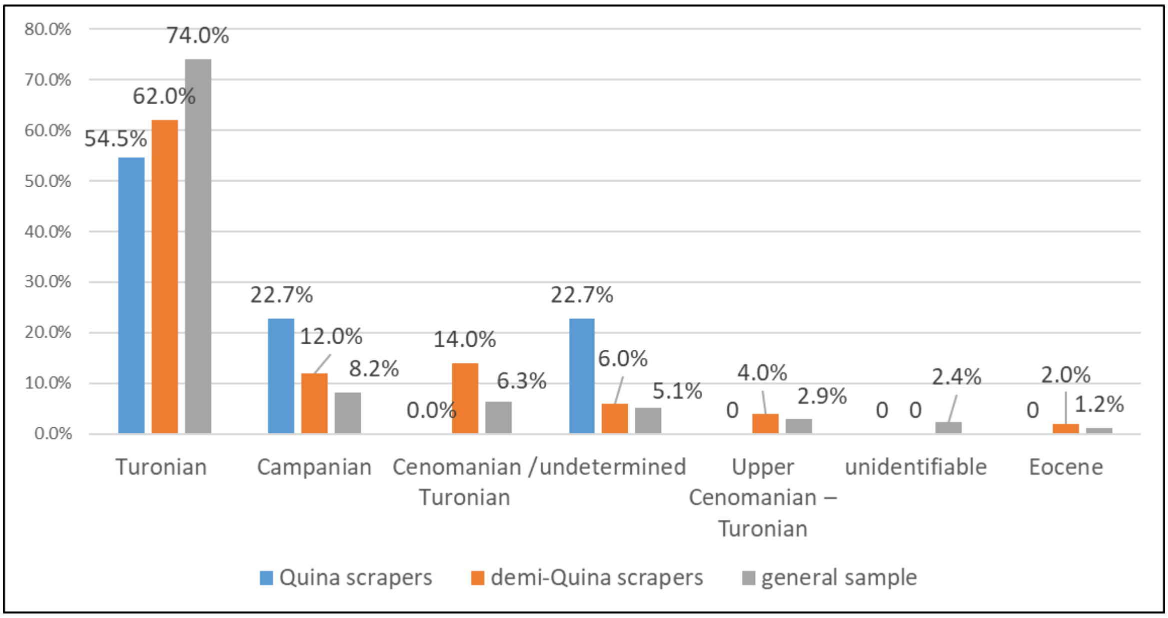

Fig. 97. Quina and demi-Quina scrapers from the Deep Shelf – unit I assemblage by sources of origin, compared to the general sample.

The "Yabrudian Below the Shelf" assemblage is younger than the "Deep Shelf" assemblage, and is stratigraphically located several meters above it. A sample of 15 Quina scrapers and 18 demi-Quina scrapers was taken for this study, out of several dozen scrapers excavated from this assemblage. While the pattern observed among the Quina and demi-Quina scrapers in general is preserved here (i.e., a relatively low proportion of Turonian flints, and a higher proportion of Campanian and Cenomanian / Turonian flints), some differences are worth noting (Fig. 98). Within the Quina scrapers, two of the 15 scrapers (13.3%), and three of the 18 demi-Quina scrapers (16.7%) are of Campanian origin – a slight difference compared to the

"Deep Shelf" assemblage. Cenomanian / Turonian flints are more conspicuous in this assemblage among both Quina scrapers (n=5; 33.3%) and the demi-Quina scrapers (n=4; 22.2%), compared to the general sample (6.3%; n=1,323). Here, as well, the difference between the results for the Quina scrapers and those for the general sample, were found to be statistically significant (X^2 = 20.51, df = 6, p < 0.05).

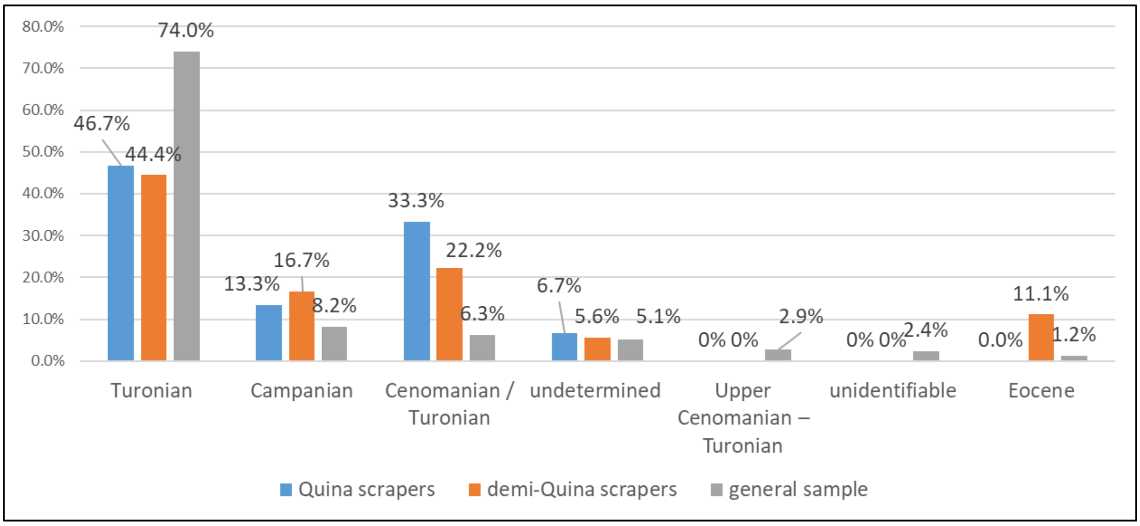

Fig. 98. Quina and demi-Quina scrapers from the Yabrudian of the Shelf assemblage by sources of origin, compared to the general sample.

It seems, then, that while there are some minor differences between the two assemblages, these are mainly related to the exact proportions of Campanian and Cenomanian / Turonian flints within the two types of scrapers, rather than reflecting two different patterns of behaviours. The general pattern observed among the Quina and demi-Quina scrapers, of a relatively low proportion of Turonian flint compared to the general sample, and higher proportions of Campanian and Cenomanian / Turonian flint types, remains.

5.6.2.2.3. The Significance of the Quina and demi-Quina Results

The results presented above concerning the entire sample of Quina and demi-Quina scrapers show that Turonian flint, which is abundantly available in the immediate vicinity of QC, was often used for the production of Quina and demi-Quina scrapers, but that Campanian and Cenomanian / Turonian flints were also used in notable proportions, a pattern different than that observed in the general sample.

The closest known Campanian sources are located ~15 km south of QC; the closest Cenomanian / Turonian sources are about 12 km north of QC. However, as explained above, it is also possible that flints from these geologic origins were available in closer sources – either in primary sources which were eventually fully exploited, becoming presently invisible, or as materials carried closer to the site by streams. These secondary sources would then become a new source for these originally distant flint types, most often containing a mix of flints from several different geologic origins. In either of these scenarios, given the repeated exploitation of these flint types for the manufacture of Quina and demi-Quina scrapers through time, it is plausible that the observed pattern reflects a high degree of familiarity with the locations of the various sources from which these specific desired flint types could have been acquired regularly (Barkai et al., 2009). This idea is also supported by the exploitation of flint from primary geologic sources for the production of Quina and demi-Quina scrapers at QC, as demonstrated by Boaretto et al. (2009).

Both the Quina and demi-Quina scrapers of QC, and especially the Quina scrapers, tend to be made on flint types which are more homogenous than the artefacts in the general sample, implying a probable technological/functional advantage for these flint types. However, as homogenous flint types are available within local

Turonian sources, the relatively high proportions of non-Turonian flint among the Quina and demi-Quina scrapers might stem from other motivations. These possible motivations are discussed further below.

The recycling of old patinated blanks, which were probably collected from outside the cave, for the production of Quina and demi-Quina scrapers, should also be discussed here. While it is certainly only a secondary trajectory of blank procurement, it was still observed, mainly among the Quina scrapers (6.7%). Some scholars suggest that lithic recycling is strongly related to the availability of flint in the area (e.g., Dibble and Rolland, 1992; Hiscock, 2009; Vaquero et al., 2015). 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 accumulation of Levantine Paleolithic assemblages. In the case of QC, the site is located within an environment in which flint is abundantly available, therefore ruling out scenarios of exploitation of old used blanks due to flint constraints. It seems, then, that other considerations, either technological, social, visual, or any combination of them, influenced the decision to recycle these blanks for the production of Quina and demi-Quina scrapers.The habit of collecting old, previously knapped, patinated blanks from outside the cave has been demonstrated concerning several other technological trajectories at QC, such as handaxes (Parush et al., 2015), spheroids (Barkai and Gopher, 2016), and flakes (Assaf et al., 2015; Parush et al., 2015), suggesting that it was a repeated pattern of behaviour at the cave.

The emergence of the Quina method at the beginning of the AYCC, alongside the emergence of the new blade production technology, suggests a shift in human behaviour and subsistence. The need to learn how to produce these new tools required new strict knowledge-transmission mechanisms (Barkai et al., 2017). These procedures of knowledge transmission included the understanding of which flint types to use for this technological trajectory, and where to get them from. The specific patterns of flint acquisition and exploitation for the manufacture of these tools, starting in the earliest stages of the Acheulo-Yabrudian of QC, imply that they had a special role among the people who manufactured them. As demonstrated by the ethnographic record, animal hides could be used for the production of a wide variety of artefacts and implements, including the manufacture of various types of clothing (e.g., Binford, 1967; Ingold, 2000: 124; Keeley, 1988; Potapov, 1999), disguises for hunting (e.g., Thackeray, 1983, 2005), containers (e.g., Manhire et al., 1986; O'Connell, 1980), and musical instruments (e.g., Potapov, 1999). It is yet unknown what hides were used for at QC, but Quina and demi-Quina scrapers used for the repeated processing of this material must have had some functional and perhaps cultural significance in the lives of the QC hominins. While scrapers are known from Oldowan and Acheulian sites (e.g., Agam and Barkai, 2018a; Goren-Inbar, 1985; Lemorini et al., 2014; Solodenko et al., 2015), and while scraping activities were performed as early as the Oldowan (e.g., Lemorini et al., 2014), Quina scrapers represent an innovative technological behaviour within the AYCC in terms of both the scope of the phenomenon, and the technological procedure used for their production.

5.6.2.3. Bifaces Analysis

In this study the term *bifaces* relates to all artifacts which show bifacial knapping; the term roughout refer to artifacts which bear only preliminary bifacial knapping; the term handaxe refer to items which were fully (or almost fully) bifacially knapped, and which are considered as complete products. This study includes an assemblage of 16 bifaces and one bifacial spall, found in a variety of stratigraphic contexts at QC. The small size of this assemblage stands in strong contrast to the abundance of blades and Quina and demi-Quina scrapers at the cave.

5.6.2.3.1. The Bifaces - Results

This section presents the results of the bifaces analysis in terms of flint types and potential geologic sources. This section is followed by sections focusing on each of the biface sub-types. Table 50 summarizes the metric attributes of the bifaces.

Table 50: Metrics of the bifaces.

number	Type	weight (g)	length (cm)	width (cm)	thickness (cm)
1	handaxe	680	15.1	9.5	5.2
2	handaxe	401	12.7	8.5	3.7
3	handaxe	344	11.1	8	4.2
4	handaxe	343	11.1	7.4	4.2
5	handaxe	305	11.5	7.2	3.6
6	handaxe	259	10.9	7	3.5
7	handaxe	239	10.2	6.3	4.9
8	handaxe	207	8.1	6.4	3.6
9	handaxe	165	8.6	5.9	2.9
10	handaxe	129	8.7	5.7	2.5
11	handaxe	119	9.1	5.2	2.6
12	handaxe	114	10	6.4	2
13	roughout	3285	22	15	10
14	roughout	1680	17	14	7.5
15	roughout	1555	13.9	10.9	7.5
16	trihedral	103	8.3	4.7	3.4
17	bifacial spall	95	9.3	5.3	1.9

As described above, QC is located in a terrain of Turonian limestone which is rich in flint. Therefore, it is not surprising that Turonian flint was often exploited by the cave's inhabitants, and it strongly dominates the site's lithic assemblages (74.0% of the general sample; n=15,622, out of 21,102 items; Table 51). The biface assemblage, on the other hand, reflects a different pattern. Out of the 17 bifacial artifacts, 13 are made of non-Turonian flint types (76.5%; non-Turonian flints within the general sample: 26.0%). Six items (35.3%) are made of Campanian flint (Campanian flint in the general sample: 8.2%; n=1,723); six more (35.3%) are of undetermined origin (flint of undetermined sources in the general sample: 5.1%; n=1,069); four (23.5%) are made of Turonian flint (Turonian flint in the general sample: 74.0%), and one (5.9%) is made of Eocene flint (Eocene flint in the general sample: 1.2%; n=261). No Upper Cenomanian – Turonian or Cenomanian / Turonian flints have been observed among the bifaces. The differences presented above are statistically significant (X^2 = 56.53, df = 6, $p < 0.05$).

Table 51: Comparison of the frequency of different geologic origins in the general sample and in the biface assemblage.

origin	General sample	Biface assemblage
Turonian	74.0%	23.5%
Campanian	8.2%	35.3%
Cenomanian / Turonian	6.3%	-
undetermined	5.1%	35.3%
Upper Cenomanian – Turonian	2.9%	-
unidentifiable	2.4%	-
Eocene	1.2%	5.9%
Total	**100.0%**	**100.0%**

The six artifacts which are of Campanian origin are made of Type AQ (items number 1,5, 7, 13, 14 and 17; Fig. 99). This is a brecciated flint type, composed of clasts of light brown fine-textured opaque flint in a light brown matrix. Brecciated textures are a known component of Mishash flints (Kolodny, 1969). This flint type constitutes only 1.4% of the general sample (n=297), and reaches a maximum of 2.5% in the other typo-technological categories (the highest proportion being within the cores).

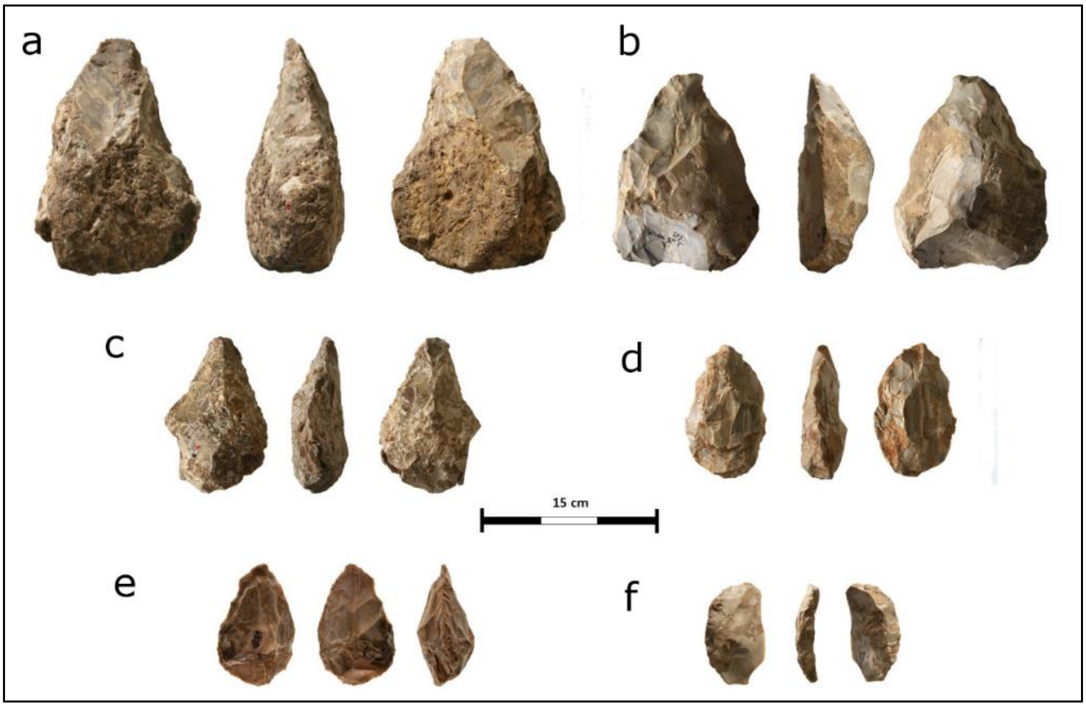

Fig. 99. The bifaces made of Type AQ: a-b) roughouts (item numbers 13 and 14); c-e) handaxes (item numbers 1, 5 and 7); f) bifacial spall (a tranchet spall; item number 17).

The six artifacts made of Type AQ include three handaxes, two roughouts, and one bifacial spall. The average weight of these six artifacts is 1,047.3 grams. This result is, however, strongly influenced by the presence of the two roughouts. The median weight is 343.5 grams. In the general sample (which does not include bifaces), the average weight of pieces made of Type AQ is 20.4 grams (median: 10 grams), while the average weight of all pieces in the entire general assemblage is 10.3 grams (median: 6 grams), implying that Type AQ was often used for the production of relatively large blanks. Our survey of the sources has shown that Type AQ tends to be found in large nodules and beds, or remnant bed fragments. This large size of nodules may have played a role in the decision to use this flint type for the production of bifaces. Indeed, it has already been suggested that size and shape of the naturally available raw materials played an important part in determining which blank would be selected for biface production (Sharon, 2008). However, it should also be noted that large nodules of flint have also been observed in Turonian sources (such as Horashim Forest, located five km north of QC), and that handaxes were in fact also manufactured of Turonian flint, as demonstrated below. Moreover, the existence of relatively small handaxes in many sites implies that size and shape were not necessarily significant factors in the decision as to what lithic materials to use for the production of bifaces (Sharon, 2008).

Five of the six bifaces from an undetermined source (29.4% of the bifaces) are made of Type T (item numbers 2, 3, 4, 10 and 15), which is a dark grey-brown and light brown roughly zoned heterogenous medium- to coarse-textured opaque flint type, with macroscopically visible sponge spicules (Fig. 100). Type T constitutes 1.5% of the general sample (n=320), and reaches a maximum proportion of 2.2% of the cores and of the CTEs. The average weight of these five pieces is 554.4 grams (median: 305 grams), again influenced by a bifacial roughout, which weighs 1,555 grams. The average weight of Type T within the general sample is only 8.9 grams (median: 3 grams).

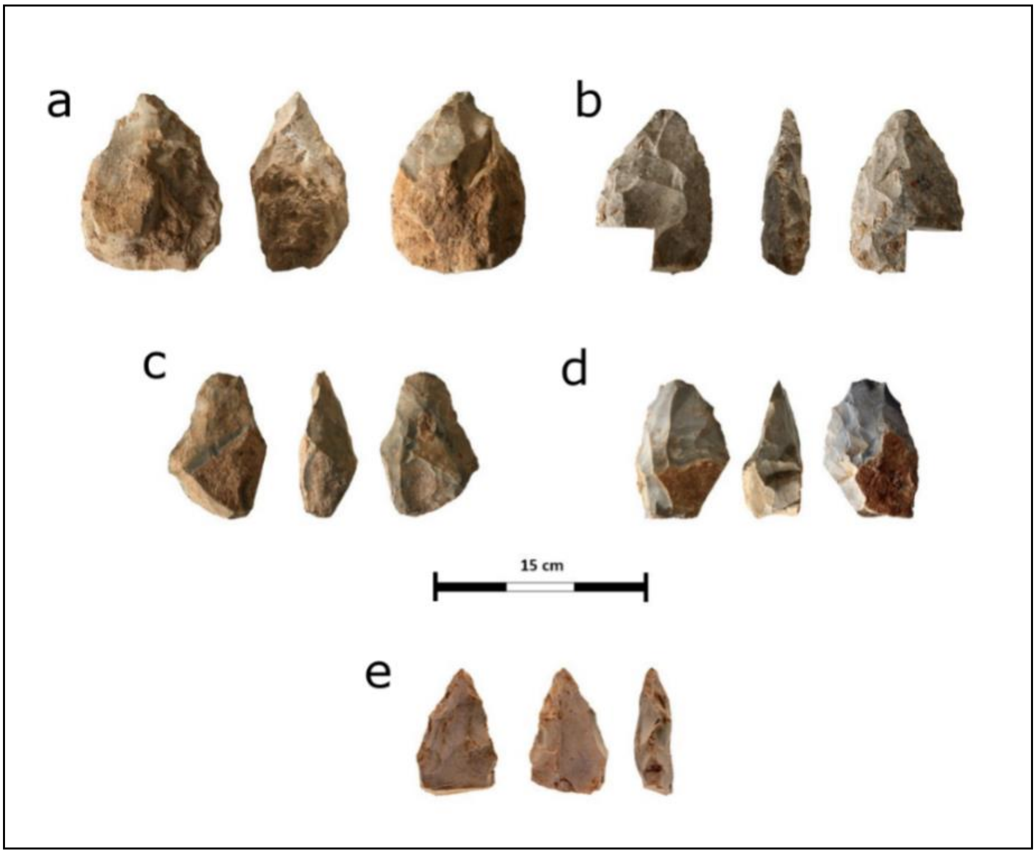

Fig. 100. The bifaces made of Type T: a) a roughout (item number 15); b-e) handaxes (item numbers 2, 3, 4 and 10, respectively).

Item number 6 is made of Type AU (5.9%), also from an unknown source (Fig. 101-e). It is a rich chocolate brown homogenous fine-textured opaque flint, with a faintly striped appearance. This handaxe weighs 259 grams. Type AU constitutes 2.3% of the general sample (n=478), with an average weight of 10.5 grams per piece (median: 6 grams). Its highest proportion within the other categories is 3.3% of the tools and of the special spalls.

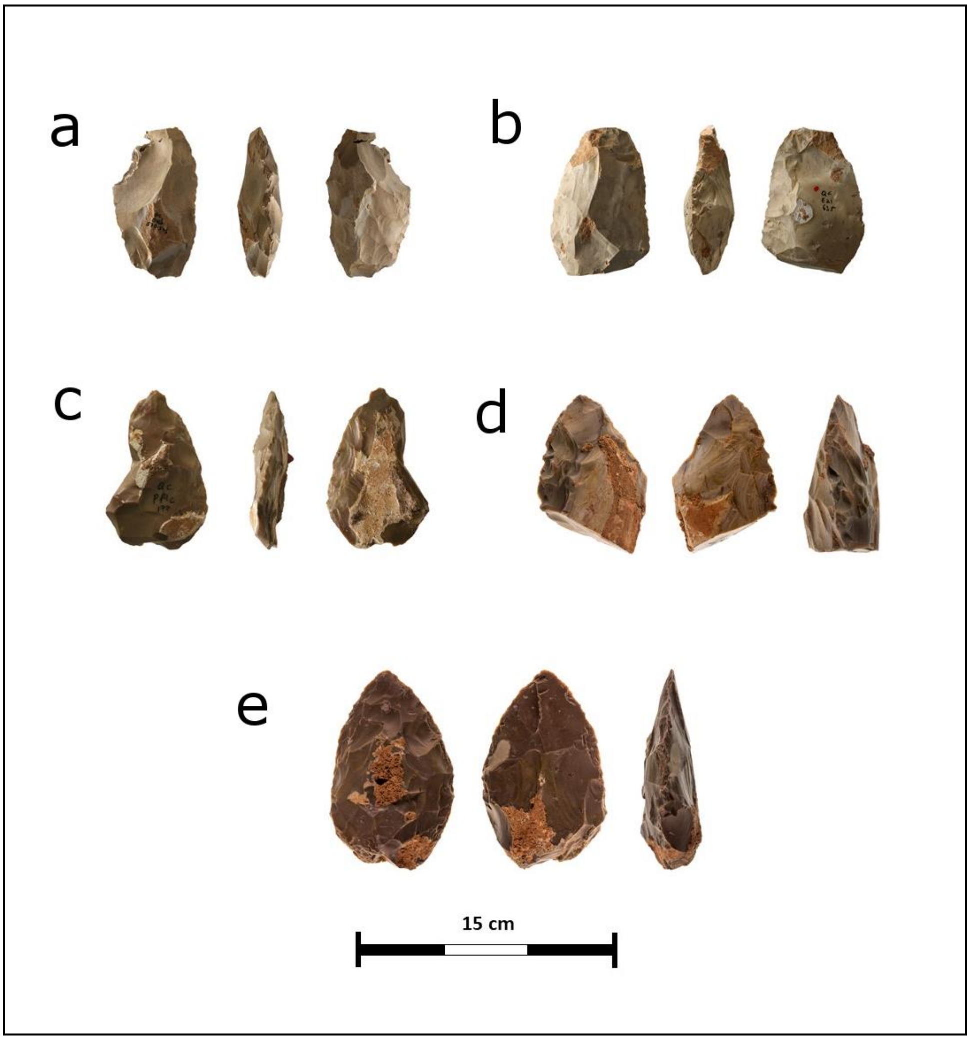

Fig. 101. Group 1: the homogenous fine-textured handaxes, four of which made of Turonian flint (a-d), and one of flint from an undetermined source (e). a) item number 11; b) item number 9; c) item number 12; d) item number 8; e) item number 6.

Four artifacts are made of Turonian flint types. Two handaxes (11.8% of the biface assemblage) are made of Type W (item numbers 9 and 11; versus 2.8% of the general sample; n=585), a fine-textured brown roughly striped flint type. The average weight of the two handaxes is 142 grams. The average weight of pieces made of Type W in the general sample is 10.0 grams (median: 5 grams). Its highest proportion in any other technological category is 5.1%, in the special spalls.

One handaxe (5.9%) is made of Type M (item number 8), a Turonian flint type which is distinctly striped, in beige, grey and pink (4.8% of the general sample;

n=1,003). It weighs 207 grams, while the average weight of pieces of Type M in the general sample is 16.0 grams (median: 10 grams), higher than the average weight of the entire general sample. Type M is a common flint type within the general sample, and its proportions within the other categories range between 1.9% (of the bladelets) and 9.9% (of the naturally backed knives).

The last biface made of Turonian flint is a handaxe made of Type AI (item number 12; 5.9%; versus 1.7% of the general sample, n=355). It is a greenish-brown fine-textured flint. This handaxe weighs 114 grams, while the average weight of artifacts made of Type AI in the general sample is 14.4 grams per piece (median: 9 grams). The highest proportion of Type AI in any of the other technological categories is 3.5% (of the recycled artifacts).

One artifact – the trihedral pick – is made of Type BJ, a coarse-textured Eocene flint. It is presented in detail and discussed further below.

5.6.2.3.1.1. The Roughouts

Two of the three bifacial roughouts found at QC (item numbers 13 and 14) are made of Type AQ (of Campanian origin) and one (item number 15; Fig. 5-a) of Type T (from an unknown source). The heaviest roughout (item number 13) is significantly heavier than the two other roughouts (Table 50). The heaviest roughout is also the longest, the widest and the thickest (and for more details on this item see Barkai et al., 2013).

Items number 13 and 15 were produced from large nodules, and still have a significant proportion of cortex on both faces. Item number 14, on the other hand, was produced on a large flake, with its ventral face and bulb of percussion still clearly preserved. Most of its dorsal face is still covered in cortex. It has several surfaces bearing patina, and some post-patina flaking, mainly on its ventral face, indicating that it was recycled, either for the production of flakes, or for the further processing into a biface. Item numbers 14 and 15 (as well as item number 1) were analyzed for ^{10}Be (Beryllium-10) content (Boaretto et al., 2009), and presented low levels of ^{10}Be, suggesting that they were procured from primary geologic sources, possibly involving quarrying (for more details see Boaretto et al., 2009; Verri et al., 2004, 2005).

5.6.2.3.1.2. The Handaxes

In total, 12 handaxes were found at the cave. The weight of these handaxes ranges between 114 and 680 grams, while their length ranges between 8.2 and 15.1 cm. Their width ranges between 5.2 and 9.5 cm, and their thickness between 2.0 and 5.2 cm.

Six of the handaxes (50%; item numbers 3, 4, 6, 8, 11 and 12) were produced on nodules, identified by the presence of cortex on both faces of these artifacts. Three handaxes were produced on flakes (25%; item numbers 5, 9 and 10), identified by the existence of clear ventral faces. For the remaining three handaxes (25%; item numbers 1, 2 and 7) the blank could not be determined. Four of the handaxes (item numbers 1, 2, 3 and 11) are clearly covered in patina, while one of them (item number 11) bears clear post-patina removals, indicating it was recycled for the production of flakes after being shaped into a handaxe, with a time gap between the two stages.

Three handaxes (item numbers 5, 10 and 11) bear removals of large flakes from their circumference, removals which were most likely not related to their bifacial shaping. These removals probably reflect the recycling of these handaxes into cores, taking advantage of the handaxe convexities. The phenomenon of handaxes with preferential flake scars has been suggested by some scholars to reflect a possible link between Acheulian handaxes and the emergence of ~~the~~ proto-Levallois ~~method~~

production (see DeBono and Goren-Inbar, 2001; Shimelmitz, 2015; White et al., 2011).

Seven of the 12 handaxes (58.3%; item numbers 1, 2, 3, 4, 5, 7 and 10) are made of heterogenous flint types – three of Type AQ and four of Type T. Five others (41.7%; item numbers 6, 8, 9, 11 and 12) are made of homogenous flint types – two of Type W, one of Type AU, one of Type M, and one of Type AI. This pattern implies that the degree of homogeneity did not play a role in the decision about what flint types to use for the production of these handaxes.

There is however a clear correlation between the degree of homogeneity, the texture and the size of the handaxes. First, the five homogenous handaxes are also fine-textured, while the seven heterogenous flint types are coarse-textured. Second, the average weight of the homogenous fine-textured handaxes is 172.8 grams (median: 165 grams), while the average weight of the heterogenous coarse-textured handaxes is 348.7 grams (median: 343 grams). These results suggest that the handaxes can be divided into two groups: One (henceforth Group 1, Fig. 101) consists of handaxes made of homogenous, fine-textured flint types, which tend to be smaller, and the second (henceforth Group 2), consists of handaxes made of heterogenous, coarse-textured flint types, which tend to be larger. Four of the five handaxes of Group 1 were produced on nodules, while only two handaxes of Group 2 (28.6%) were clearly produced on nodules, while two others were produced on a flake (28.6%), and for the remaining three the blank could not be determined (42.9%). Moreover, three handaxes of Group 2 are covered in patina (42.9%), while only one handaxe of Group 1 is covered in patina (20%). Finally, four of the five handaxes of Group 1 (80.0%) are made of Turonian flint types (with the fifth being from an undetermined source), while three of the seven handaxes of Group 2 are made of

Campanian flint, and four of flints of unknown origin. These differences (summarized in Table 52) suggest that there may have been two separate procedures for acquiring flint for each of these two groups.

Table 52: Summary of differences between the two groups of handaxes

	Group 1	Group 2
Blanks	nodules (80%)	undetermined (60%)
Patina	20%	60%
Homogeneity	homogenous (100%)	heterogenous (100%)
Texture	fine	coarse
Average weight	172.8 g	393.8 g
Average length	9.34 cm	12.12 cm
Average width	6.18 cm	7.9 cm
Average thickness	2.92 cm	4.32 cm
Origin	Turonian (80%)	non-Turonian (100%)

One handaxe is not included in this study because its whereabouts are, unfortunately, currently unknown, but it does deserve some special attention here (Fig. 102). This is a patinated handaxe, produced on a homogenous flint type (R. Barkai, personal communication), which bears several post-patina blade removals, indicating that it was recycled into a blade core (Parush et al., 2015; Shimelmitz, 2009). We can therefore see the Acheulian hallmark, the handaxe, and one of the main Acheulo-Yabrudian hallmarks, the systematic production of blades, on one artifact, with a clear time gap between these two stages.

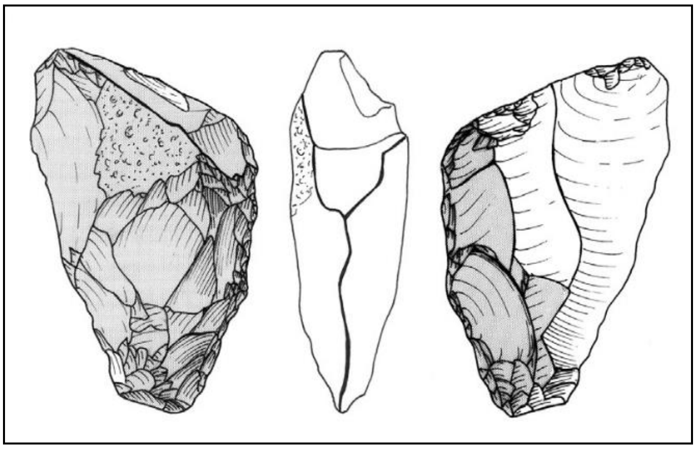

Fig. 102. A handaxe recycled into a blade core.

5.6.2.3.1.3. The Bifacial Spall

One bifacial spall has been found in the QC assemblages (item number 17). As mentioned above, a few other potential bifacial spalls were also found at the site, but they were not conclusively associated with the bifacial knapping procedure, so they are not included in this study. The large bifacial spall was found in the same sub-square (1/4 M^2) as the largest roughout (item number 13), and it is made of the same flint type as the large roughout – Type AQ, which is of Campanian origin. However, it is not directly related to the roughout, and was not flaked from it. It weighs 95 grams, and measured 9.3 cm long, 5.3 cm wide, and 1.9 cm thick.

This artifact is a product of a transversal blow, using the Tranchet blow technique (Inizan et al., 1992: 72). Such spalls are known from several Lower Paleolithic sites (e.g., Bergman and Roberts, 1988; Roberts and Parfitt, 1999; Rollefson, 2016; Sharon, 2010; and for more information see Barkai, 2005). These blows were aimed at shaping the active edge of handaxes, and at creating a very sharp edge. It has two ventral faces, indicating that the original biface was most likely produced on a large flake. The spall could not be directly associated with any of the bifaces found at the cave. Moreover, no biface from QC bears scars of the Tranchet blow technique. Its presence does, however, imply that at least one additional biface from which this artifact was flaked exists or formerly existed at the cave, or, alternatively, that this artifact was brought from outside the cave in its current state.

A few other isolated artifacts which might also represent biface *débitage* related to the procedure of bifacial knapping were also observed within the cave's assemblages (i.e., possible thinning flakes, possible maintenance spalls). These, however, are very few (n<10), and were not indicative enough to be conclusively associated with the bifacial knapping procedure. Therefore, they were not included in this study.

5.6.2.3.1.4. The Trihedral Pick

The trihedral pick is made of Type BJ, which is a semi-translucent grainy light brown flint with abundant small macroscopically visible white fossils (Fig. 103). Its thin-section revealed some nummulitic debris (Fig. 8), conclusively assigning it to the uppermost Lower to Middle Eocene (Racey, 2001). Additionally, an echinoid spine similar to ones found in other Eocene samples was also observed (Fig. 104). Type BJ was found in low proportions in the general sample (0.3%; n=63). The trihedral pick bears some patinated surfaces. It weighs 103 grams, while the average weight of the 63 pieces made of Type BJ in the general sample is 10.1 grams (median: 4 grams).

Fig. 103. The trihedral pick, made of Type BJ, of Eocene origin.

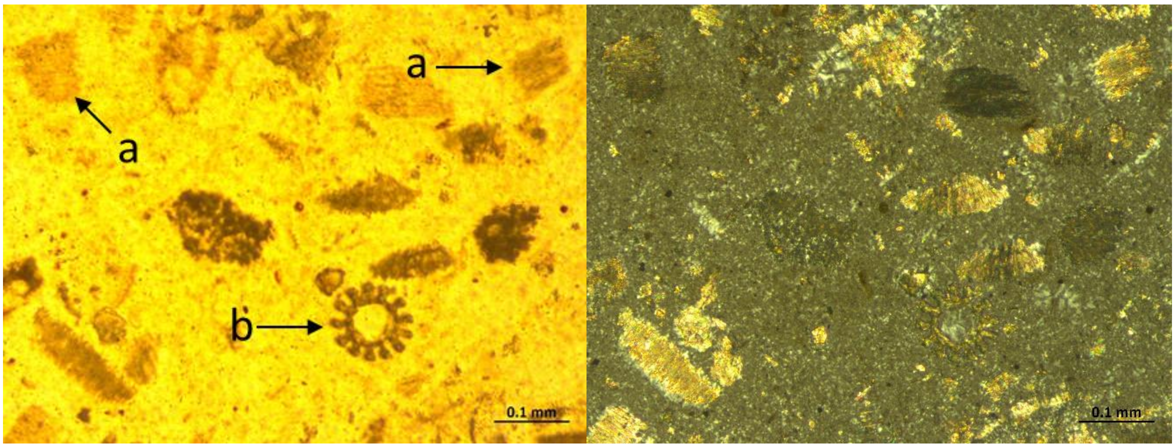

Fig. 104. Type BJ –nummulitic debris (a), and an echinoid spine (b), in plane- and cross-polarized light.

Trihedral picks are well-known from several Levantine Acheulian sites (Gilead, 1970; Shea and Bar-Yosef, 1999; Tchernov et al., 1994), including Eyal 23, an Acheulian site located ~12 km north of QC (Ronen and Winter, 1997). These tools are, however, usually absent from Acheulo-Yabrudian contexts. There are two Acheulian sites known, at the moment, to exist in the vicinity of QC: Jaljulia (Shemer et al., 2018), which is located 5-6 km north of the cave, and Eyal 23 (Ronen and Winter, 1997), located approximately 12 km north of the cave. Other Acheulian contexts could have also existed in the area of QC. It is, therefore, possible that this trihedral pick was collected from outside the cave, possibly from an old Acheulian site located somewhere in the vicinity of QC, rather than being produced in it.

5.6.2.3.2. A Comparison to the Jaljulia Handaxes

In this sub-section I briefly present the analysis of a sample of 60 handaxes from the Late Acheulian site Jaljulia, and compare it to the QC bifaces analysis presented above. These handaxes were taken from the assemblages of Areas B and D in Jaljulia, and were randomly selected, following the procedure explained in the methodology chapter above, out of hundreds of handaxes found at Jaljulia. The full analysis of the Jaljulia and Revadim material is presented separately further below.

The most common group of flint types among the Jaljulia handaxes is Group 3 (37 out of 60 bifaces; 60.0%), which is a group of brecciated flint types. These flint types resemble Type AQ, which is the most common flint type among the QC bifaces (Fig. 105). Other groups of flint types appear within the Jaljulia handaxes in notably lower numbers. The next most common group is Group 8, a group of striped fine-grained homogenous opaque flint types, with 6 bifaces (10.0%). It is followed by Groups 4 and 13, with four bifaces each (6.7%). Group 3 is also the most common group in the entire Jaljulia sample (37.0%, n=173, out of a sample of 467 items). In the case of QC, on the other hand, as mentioned above, Type AQ is not as common in the general sample as it is among the bifaces (1.4%; n=297).

Fig. 105. A handaxe from Jaljulia, made of a brecciated flint from Group 3.

It is premature to suggest a direct relationship between the bifaces from QC and those from Jaljulia. Additional petrographic thin sections and geologic surveys are needed in order to corroborate or disprove such a relationship. The resemblance is nonetheless striking. Furthermore, as Wadi Qana could have served as a source for flint for the QC inhabitants, being located about 3 km north of QC at its closest part, it is plausible that the QC hominins explored this area, and were familiar with features throughout it, including older sites reflecting older human occupations. It is of note that brecciated flint types also dominate the handaxes from Revadim (see below), suggesting a general preference for brecciated flint types in the production of Lower Paleolithic bifaces.

5.6.2.3.3. The Role of Handaxes in Lower Paleolithic Lifeways

In order to better understand the place of handaxes and bifaces at QC, we first need to discuss the role and function of handaxes in general. While many studies have tried to understand the functionality of handaxes, the nature of their use is still considered enigmatic, and is still strongly debated. Past studies have proposed that handaxes were used during the Lower Paleolithic for the processing of vegetal materials (e.g., Binneman and Beaumont, 1992), the processing of wood (e.g., Domínguez-Rodrigo et al., 2001), in butchering activities (e.g., Keeley, 1977, 1980; Machin et al., 2007; Mitchell, 1996; Solodenko et al., 2015), and even as hunting hurled/thrown weapons (e.g., Calvin, 1993; O'Brien, 1981, but see Whittaker and McCall, 2001). Handaxes are also often referred to as general-purpose tools (e.g., Keeley, 1980). Other, less common, proposals have suggested that handaxes should be viewed as cores, intended for the efficient production of flakes (e.g., Jelinek, 1977).

In addition to their practical function, other, non-utilitarian, potential roles of handaxes are also often discussed. Gamble (1998), for example, suggests an association between the manufacture of handaxes and the manifestation of personal or group identities. Kohn and Mithen (1999) propose a model according to which handaxes were products of processes of sexual selection. According to this model, those individuals that manufactured symmetric, aesthetic, finely knapped handaxes, were preferred in the process of sexual selection, as their handaxes reflected knowledge of resource distribution, the ability to execute plans, good health, and, most importantly – good genes. Wynn and Gowlett (2018) suggest that the production of the more meticulous handaxes was motivated by aesthetic considerations, as their symmetry might have created a sensory response of pleasure, emphasizing the visual value of handaxes.

Most recent studies suggest, based on use-wear analyses, zooarchaeological data, and experimental works, a relationship between handaxes and the processing of meat, including the skinning, cutting, defleshing, and dismembering of animal carcasses (e.g., Claud, 2008; Machin et al., 2007, 2016; Solodenko et al. 2015). Of special note is the relationship between the presence of handaxes and the presence of the remains of very large game, mainly proboscideans, during the Lower Paleolithic (Finkel and Barkai, 2018). Indeed, several Acheulian sites have yielded elephant remains bearing cut marks (e.g., Blasco et al., 2013b; Solodenko et al. 2015), as well as elephant bones which were found in direct association with bifacial tools (e.g., Goren-Inbar et al. 1994; Zutovski and Barkai 2016, and see additional references therein). The important role of elephants in the diet and adaptation of Acheulian populations has already been suggested in the past (Agam and Barkai, 2016, 2018b; Ben-Dor et al., 2011), and is further supported by many Acheulian sites containing elephant remains (e.g., Anzidei et al., 2011; Goren-Inbar et al. 1994; Rabinovich et al., 2012).

Finkel and Barkai (2018) propose that handaxes were a useful tool in the processing of elephant carcasses, allowing the removal of meat and fat, as well as the disarticulation of elephant body parts in order to enable their transportation to habitation sites. Handaxes are highly suitable for massive and continuous butchering activities, enabling the application of force and leverage required in cutting and dismembering activities. Evidence of transportation of selected proboscidean body parts is provided by Paleolithic cave sites containing elephant remains, and especially elephant heads (Agam and Barkai, 2016 and see references therein). Thus, Finkel and Barkai suggest that handaxes were an essential tool in large game processing during the Acheulian. The appearance of bifacial tools made of elephant bones further implies that elephants had major nutritional and social roles in the lives of these hominin groups (Zutovski and Barkai, 2016). Additional support for the connection between handaxes and elephants is provided by the geographical and chronological synchronization between these two elements (Finkel and Barkai, 2018). This set of evidences is used by Finkel and Barkai (2018) to propose that when elephants ceased to be a part of early human diet, the manufacture and use of handaxes stopped as well.

For our case, the proposed scenario implies that with the disappearance of elephants from the Levant at the end of the Acheulian, and with the emergence of the Acheulo-Yabrudian, handaxes lose their role as essential functional and social tools. Therefore, a non-functional explanation could contribute to the presence of these few bifaces within the cave's assemblages.

5.6.2.3.4. Explaining the Presence of Bifaces at QC

While Turonian flint dominates the QC assemblages, non-Turonian flint types are prominent in the QC biface assemblage. The presence of three roughouts and 12 complete handaxes, alongside the absence of bifacial knapping by-products, as well as the absence of a clear spatial pattern of distribution of the bifaces throughout the site's sequence, stresses the fragmentation of the bifacial *chaîne opératoire*, and suggest that the bifaces were not produced at the site, but, rather, were brought to the cave in their current state.

Some of the other Acheulo-Yabrudian sites present similar patterns. In Tabun Cave Layer E, for example, by-products of biface production are also rare (Shimelmitz et al., 2017), leading the authors to suggest 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.

The two different groups identified within the QC handaxes (Groups 1 and 2) may reflect two different types of life histories. The different circumstances behind the formation of each group are, however, yet unclear. No spatial pattern was observed between the two groups. Similarly to Group 1, homogenous flint types strongly dominate the general sample (62.6%; n=13,200), suggesting that Group 1 might be more closely related to the general pattern observed at QC than Group 2.

In any case, the extremely low quantity of bifaces at QC, compared to the rich lithic assemblages, suggests that handaxes did not play a major functional role in the QC hominins' everyday lives. It is therefore possible that the QC bifaces originated from older contexts, most likely Acheulian sites, which might have existed in the vicinity of the cave. The existence of at least two Acheulian sites in the area of QC (Jaljulia and Eyal 23) is noteworthy in that respect (Ronen and Winter, 1997; Shemer et al., 2018). Both sites have yielded bifaces, and Eyal 23 has also yielded trihedral picks (while the lithic analysis of the Jaljulia material is still ongoing). The existence of such sites near QC may provide a potential origin for these artifacts.

The habit of prehistoric people to collect old knapped artifacts is well-documented in many archaeological sites (e.g., Agam and Barkai, 2018a; Hiscock, 2015; Vaquero et al., 2015; Whyte, 2014). Similar patterns of behaviour have also been observed among recent hunter-gatherers. The Aborigines of the Western Desert in Australia, for example, were documented to collect and re-fashion prehistoric tools, while being fully aware of their old lives as tools produced by past societies (Gould, 1980:134).

As for QC, the inhabitants of the cave often collected old artifacts covered by heavy patina and brought these previously knapped items to the cave (Barkai and Gopher, 2016). Efrati et al. (2018) argued that 12% of all analyzed assemblages at QC in general is made on patinated previously knapped artifacts, which were most likely collected as knapped artifacts from outside the cave, as indicated by the presence of patina and of post-patina removals.

Caricola et al. (2018) analyzed spheroids from QC, using both technological analysis and use-wear and residue analyses, and showed that at least some of these spheroids are covered in patina, suggesting that they were collected from outside the cave as knapped objects. Also, some side scrapers from QC were produced from old patinated flakes, with a scalar retouch which was performed after the flake got patinated, reflecting the existence of a time gap between the two stages of manufacture (Parush et al., 2015). The production of small blanks by means of lithic recycling from parent flakes or blades also included in some cases the use of patinated blanks, with removals of later flakes after the patina was formed (for more details see Parush et al., 2015). The patinated blanks were suggested to be collected from outside the cave, rather than being originally produced in it.

Finally, some of the handaxes found at QC also show evidence of a second use cycle. As mentioned above, one heavily patinated handaxe was recycled into a blade core after being covered in patina (Parush et al., 2015; Shimelmitz, 2009). Other bifaces were used for the production of flakes after their original manufacture.

Given the data presented above, I suggest that the collecting of old knapped artifacts from outside the cave was a repetitive pattern of behaviour at QC. The QC hominins were most likely highly familiar with the surroundings of the cave. They probably often roamed the land in search of various resources, such as food, rocks for tool production, and wood for fire, and were well aware of the different features and localities around them. These included, most likely, old, yet-uncovered hominin sites. The knapped lithic artifacts spread on the ground, as well as the likely presence of fragmented animal bones, could have led the QC hominins to realize there had been a past human presence at the locality. Early humans had an intimate relationship with the lithic materials surrounding them, and stone tools played an important role in these early humans' lives (Berleant, 2007). Moreover, the fact that the lithic artifacts spread on the ground had a meaning to earlier human groups could have enhanced the sensory effect they had over the later human groups seeing them (Berleant, 2007). Therefore, and given the tendency of the QC hominins to collect old knapped artifacts (Parush et al., 2015), as demonstrated above, these encounters might have inspired them to collect some of the old artifacts which captured their eyes (Berleant, 2007). Within this context, bifaces were more likely than other artifacts to raise their interest, given their large size, high visibility, and high aesthetic value (Hodgson, 2015; Mithen, 2003; and see Wynn and Gowlett, 2018 for additional details). It has already been suggested that the QC hominins brought artifacts to the cave due to their aesthetic characteristics (Assaf, 2019), and the possible collection of bifaces due to their high aesthetic value may be another example of this.

5.7. The Jaljulia and Revadim analysis

This sub-section presents preliminary results of a raw material analysis performed on samples taken from the Late Acheulian sites Jaljulia and Revadim. For this analysis I use the same classification methods as were applied to the QC sample. It should be stressed that this study does not include a petrographic analysis of samples, nor does it include a survey concerning the potential geologic sources from which flint could have been brought to the sites. Therefore, these two case studies serve here only as a pilot, aimed at preliminarily evaluating behaviours related to lithic materials throughout time in the final stages of the Levantine Lower Paleolithic.

The two assemblages from Jaljulia, taken from Areas B and D, are analyzed here as one unit (n=467; Table 5). The analysis of both samples is performed here on two levels: flint types and groups of flint types. Since some of the typo-technological categories are represented by low numbers of artifacts, the results should be treated cautiously.

5.7.1. The Jaljulia sample analysis

In total, 35 different flint types were classified for the Jaljulia sample (supplementary material volume – Table 4). Table 53 presents the ten most common flint types in the Jaljulia sample, along with their descriptions. Fig. 106 presents the four most common flint types. The Jaljulia flint types were grouped into 14 groups of flint types, based on common visual traits (Table 54). About half of the sample consists of heterogenous flint (Fig. 107), while most of the analyzed pieces are fine-textured (Fig. 108).

Table 53: The ten most represented Jaljulia flint types, and their description.

Flint type	Description	#	%
C	Grey-green to orange-patinated heterogenous, mostly opaque breccia, with thin red-orange veins, and thicker veins of a light to medium brown opaque matrix. No cortex on specimen.	92	19.7%
U	Dark brown fine-textured translucent brecciated flint, with occasional spots and thin veins of white opaque matrix, with a rough thin (< 1 mm) worn beige to dark brown cortex. * possibly related to type QC-AF.	47	10.1%
Q	Dark brown to orange to light orange, mainly translucent, fine-grained breccia, with veins of dark brown and white matrix, and a thin (< 1 mm) dark brown worn cortex.	47	10.1%
G	Light brown to orange semi-translucent fine-grained flint, with occasional grey-yellow small to medium opaque spots, and occasional pockets of quartz, with a rough white, ~1 mm thick cortex, and a diffused dark brown thin translucent sub-cortical layer. * possibly related to type AR at QC.	47	10.1%
A	Grey to yellow slightly translucent fine-grained slightly striped homogenous flint, with an orange 1 mm thick sub-cortical layer, and a white worn thin cortex.	23	4.9%
N	Dark brown to orange to light orange, broadly layered heterogenous flint, slightly translucent, with layers varying between very thin and thick, and between fine- and medium-sized grains, with white to grey thin (< 1 mm) cortex. Possibly a breccia.	20	4.3%
O	Light orange to orange to white fine-grained homogenous opaque banded flint, with thin (< 1 mm) rough white cortex. Possibly a breccia. *possibly related to type QC-AR.	16	3.4%
D	Grey-brown semi-translucent fine-textured homogenous flint, with a heavy green-yellow patina, and a thin (< 1 mm) orange worn smooth cortex. Of a secondary source.	16	3.4%
J	Green-brown to patinated orange to red fine-grained slightly translucent homogenous flint, with red patinated surfaces. No cortex on specimen.	15	3.2%
B	Yellow to orange opaque coarse-grained porous homogenous flint, with a beige rough 1-2 mm thick cortex.	15	3.2%

Table 54: The Jaljulia groups of flint types.

Groups of Flint Types	Flint Types Included	Description	Quantity	%
3	C, N, M, Q, R	Brecciated flint types	173	37.0%
4	D, E, G, H, J, AA, AD	Fine-textured grey to orange homogenous flint types	98	21.0%
6	K, U, AC	Slightly translucent brown fine-textured flint types	59	12.6%
1	A, V, Y, Z	Brown to light brown opaque flint types, with brown to orange sub-cortical layers	43	9.2%
8	O, S	Light brown to orange striped flint types	30	6.4%
2	B, F, X	Light brown spotted opaque flint types	28	6.0%
7	L, AE	Dark brown to orange opaque flint types	17	3.6%
9	P, AF	Brown to orange opaque flint types with white objects, possibly fossils	4	0.9%
13	AG, AH	Light brown to orange flint types with nummulites	4	0.9%
5	I	Dark red-patinated opaque heterogenous medium-grained flint.	3	0.6%
Unidentified			3	0.6%
12	AB	Dark brown opaque fairly homogenous fine-textured flint, with some pinkish veins, sporadically spotted in white	2	0.4%
10	T	Light cream opaque flint, densely spotted with tiny black to brown spots.	1	0.2%
14	AI	Weathered orange coarse-textured opaque heterogenous flint, with abundant pores and objects which might be fossils.	1	0.2%
15	AJ	Orange-green to dark grey fine-textured opaque homogenous flint, with a very large coiled foraminifer, in addition to a possible shell fragment.	1	0.2%
Total			**467**	**100.0%**

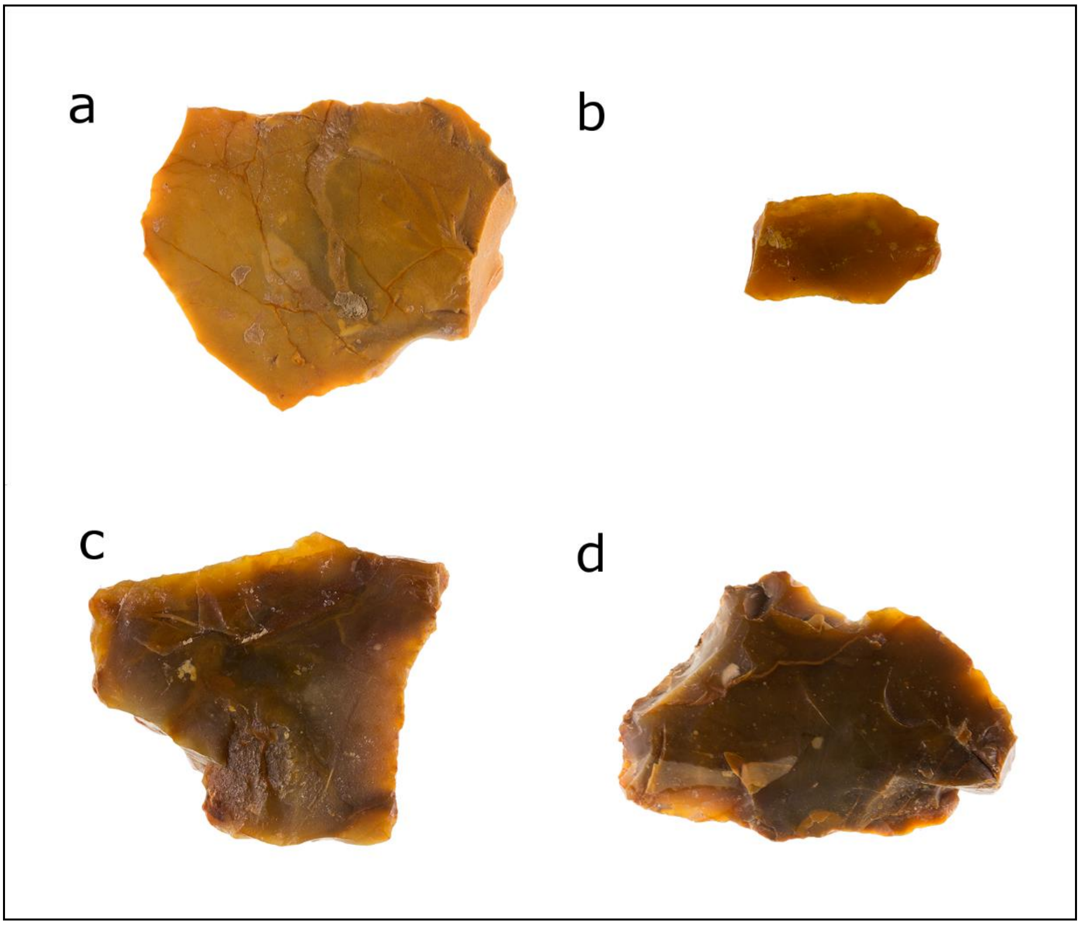

Fig. 106. The four most common Jaljulia flint types: a) Type C; b) Type G; c) Type Q; d) Type U.

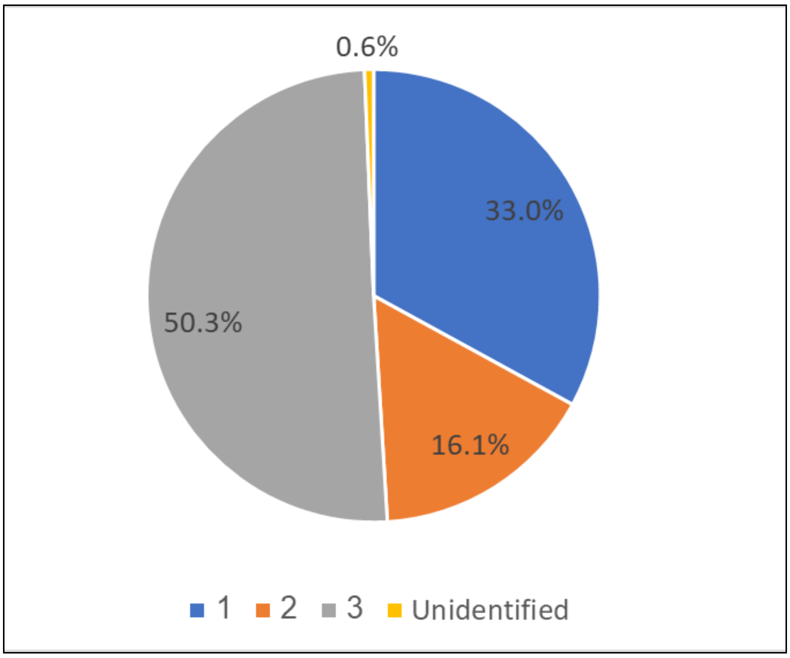

Fig. 107. Degree of homogeneity in the Jaljulia sample. 1: homogenous; 2: fairly homogenous; 3: heterogenous.

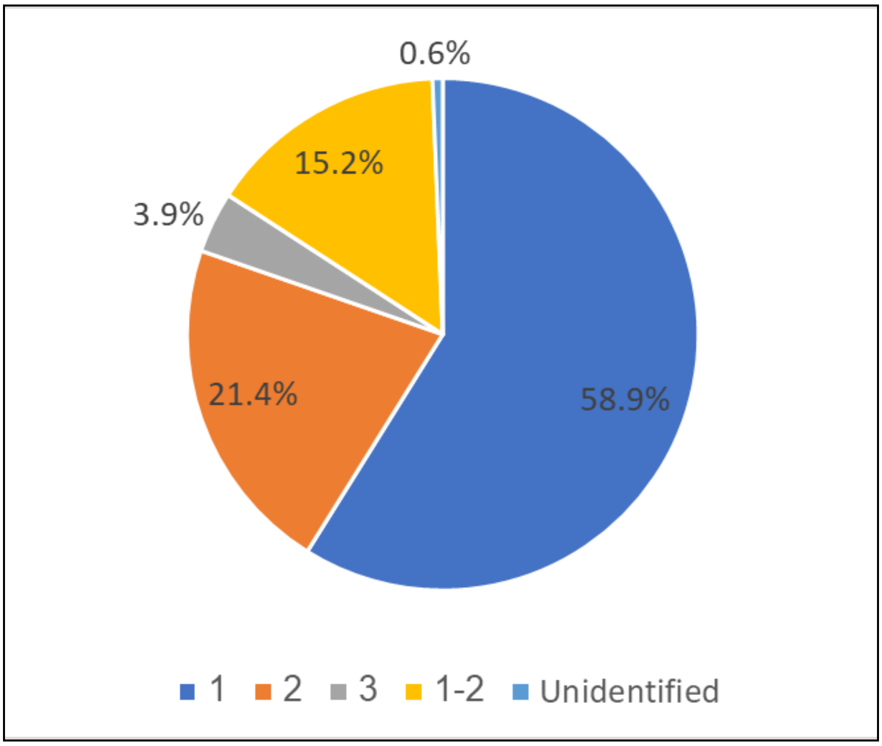

Fig. 108. The texture of artifacts in the Jaljulia sample. 1: fine-textured; 2: medium texture; 3: coarse texture; 1-2: samples vary between fine texture and medium texture.

Some categories stand out concerning the groups of flint types (Table 55). For example, the dominance of Group 3, brecciated flint types, among the Jaljulia bifaces, is of special note (and for a discussion on this, see the QC bifaces section above). Group 4, on the other hand, appears in relatively low proportions among the Jaljulia bifaces. As other categories were sampled in low numbers, the other patterns mentioned in Table 55 should be treated cautiously.

Table 55: Note-worthy results among the Jaljulia groups of flint types.

category	Groups of flint types	N=	% of this flint group out of the examined category*	General % Jaljulia sample
Bifaces	3	36	**60.0%**	37.0%
	4	4	**6.7%**	21.0%
Cores	7	5	**9.1%**	3.6%
	2	1	**1.8%**	6.0%
Cortical flakes	1	9	**19.1%**	9.20%
COFs	6	5	**27.8%**	12.60%
	8	0	**0.0%**	6.40%

* Green colour marks fields with values notably higher than the general Jaljulia sample; red colour marks fields with values notably lower than the general Jaljulia sample. None of these differences were statistically significant.

It is interesting to note that while most flint pieces analyzed from Jaljulia are fine-textured (58.9%), the proportion of fine-textured flint types among the COFs is greater still (72.2%; n=13). This might imply that fine-textured flint types were preferred for the production of small flakes, possibly due to the sharp edges they form. On the other hand, products produced from COFs present lower proportions of fine-textured flint types (54.5%; n=6), suggesting that the small flakes produced from COFs were moved to other locations, either within the site, or, alternatively, out of it.

Generally, the presence of an old stream in the south-eastern part of the site, as well as the water activity indicated throughout the geological sections (Shemer et al., 2018), suggest a landscape favorable for human occupation, as it was most probably rich in water, prey animals (which were attracted to the water), and rocks suitable for the production of stone tools (in the stream deposits). This, in turn, led Acheulian populations to repeatedly occupy the site, as indicated by the wide-spread archaeological localities, which are assumed to be the result of repeated occupations (Shemer et al., 2018).

Interestingly, although the site sits just next to a rich flint source, which was most likely frequently exploited for the procurement of flint, the results presented above demonstrate a certain selectivity in the patterns of flint exploitation. Future work will expand the sample taken from Jaljulia, and compare it to geologic samples from the potential flint sources around the site.

5.7.2. The Revadim Sample Analysis

The Revadim sample includes 621 artifacts. In total, 63 flint types were classified for this sample (Table 56; Fig. 109; for the full list see supplementary material – Table 5), grouped into 14 flint groups based on visual similarities, while geologic sources are yet unknown (Table 57). About a half of the Revadim sample is homogenous (Fig. 110), while one-third of it is fine-textured, and another third is medium textured (Fig. 111).

Table 56: The ten most represented flint types at Revadim

flint type	Description	Quantity	%
AX	Red-brown to dark grey semi-translucent homogenous flint, slightly spotted, with a white to light brown thin (< 1 mm) cortex.	71	11.4%
Y	Red-brown to grey semi-translucent homogenous flint, with a white to light brown thin (< 1 mm) cortex.	49	7.9%
A	Grey to yellow-orange heterogeneous slightly translucent breccia, with "pockets" of grey to brown substance, rough white to orange thin cortex (1-2 mm), and a brown to yellow sub-cortical layer (1-4 mm).	47	7.6%
AG	Brown to orange slightly translucent homogenous flint with "pockets" of white circular disturbances, and a rough white to orange cortex (1-3 mm thick).	43	6.9%
C	Grey to orange opaque slightly spotted, homogenous flint, with beige to brown thin cortex (< 1 mm), and a thin brown sub-cortical layer.	43	6.9%
BE	Brown to orange translucent flint, mixed with small chunks of white substance, and a beige rough thin (< 1 mm) cortex.	41	6.6%
D	Grey to orange opaque breccia, with veins in varieties of white and brown, and with a white thin cortex (< 1 mm) and a deep brown thin sub-cortical layer (up to 1 mm).	38	6.1%
Q	Brown translucent fine-grained homogenous flint, with thin (< 1 mm) beige to white cortex.	21	3.4%
P	Grey to brown fine-grained homogenous semi translucent flint, with white rough thin (< 1 mm) cortex, and a yellow slightly translucent sub-cortical layer (1-4 mm thick).	18	2.9%
E	Grey to deep orange opaque heterogeneous flint, with brown disturbances, outlined by thin white lines, a beige cortex and a very thin distinctive brownish slightly translucent sub-cortical layer.	17	2.7%

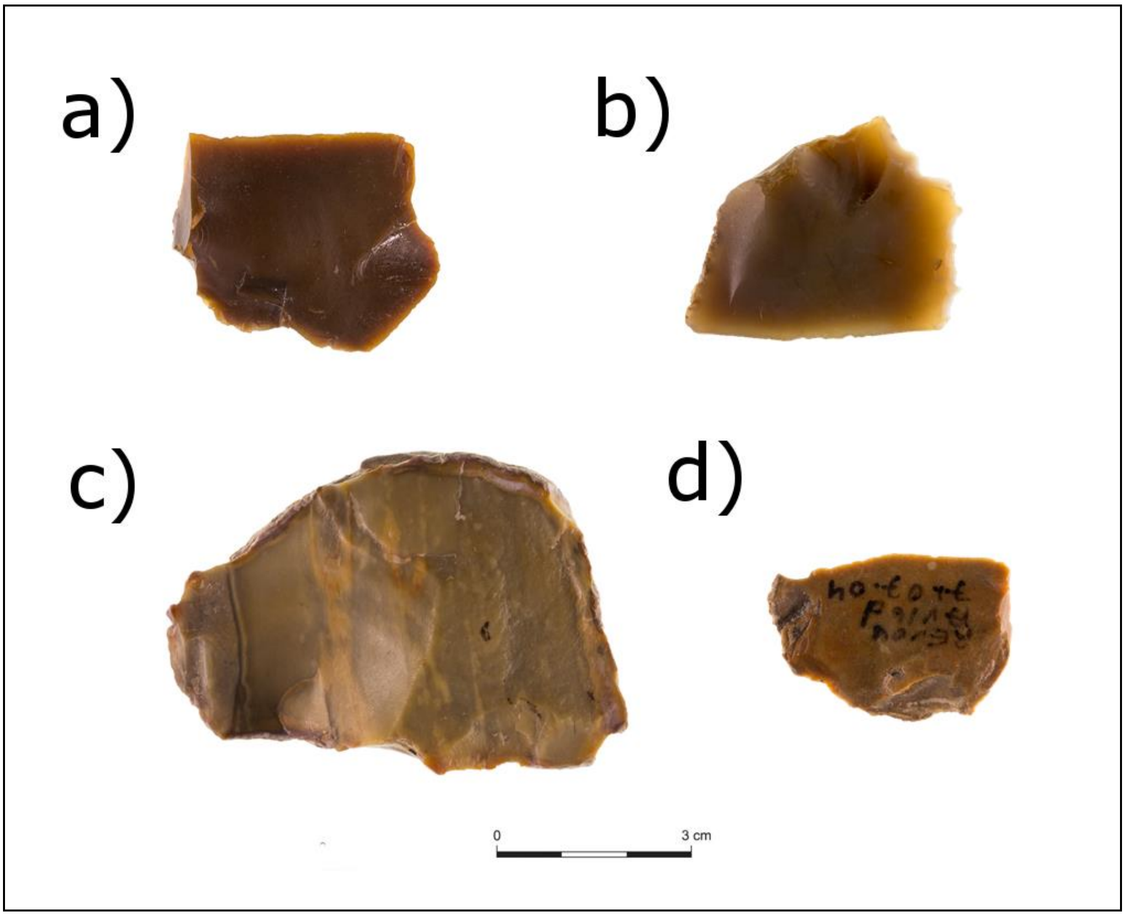

Fig. 109. The four most represented flint types in the Revadim sample: a) Type AX; b) Type Y; c) Type A; d) Type AG.

Table 57: The Revadim groups of flint types, with their frequency and percentage.

Group	Flint types Included	Description	Quantity	%
6	P, Y, AJ, AX, BD	Grey to brown fine-textured homogenous semi translucent flint types	140	24.0%
3	E, K, AG, AH, AQ, BE, BI, BS	Grey to orange to brown heterogeneous flint types	130	23.7%
1	A, B, D, F, S, T, X, AA, AE, AO	Grey to yellow-orange heterogeneous brecciated flint types.	115	19.7%
2	C, AC, AS, CJ	Grey to orange opaque slightly spotted, homogenous flint type	51	8.7%
7	Q, Z, AB, AP, AT, CF	Brown translucent fine-textured homogenous flint types, occasionally with spots	48	8.2%
8	V, W, AW, CA, CI, CH	Light yellow to grey chalky heterogenous flint types	25	4.3%
4	G, L, R, CC, CK	Brown coarse-textured opaque spotted flint type	17	2.9%
10	AR, AV, BR	Grey to orange to brown semi-finely striped flint types	12	2.1%
9	AF, AI, AM, CB, CD	Yellow-brown opaque flint types with a concentric white-yellow-brown pattern	10	1.7%
13	BN, BU, CE	Thinly striped flint types	9	1.5%
11	AU, BJ, BH, BP	Light grey to yellow broadly striped flint types.	7	1.2%
unidentified	-	-	6	1.0%
5	O, CG	Brown-bluish flint with a dark brown opaque disturbances	4	0.6%
15	BW	Grey-yellow-orange coarse-grained material, with visible grains of quartz	3	0.5%
12	AZ, BO	Mottled flint types, in various shades of brown, with a rough white and brown cortex, and chocolate brown sub-cortical layers	2	0.3%
		Total	**621**	**100.0%**

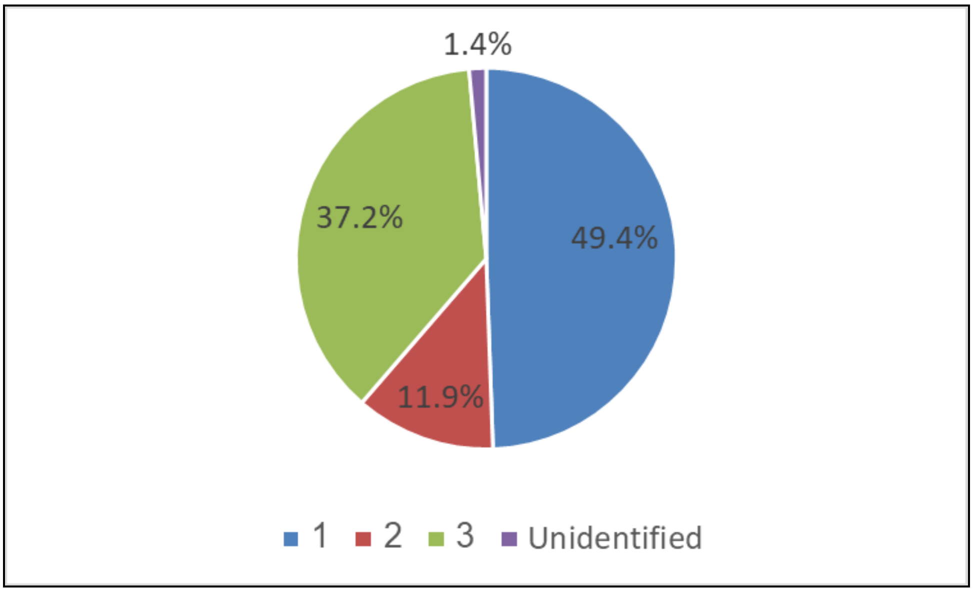

Fig. 110. Degree of homogeneity within the Revadim sample. 1: homogenous; 2: fairly homogenous; 3: heterogenous.

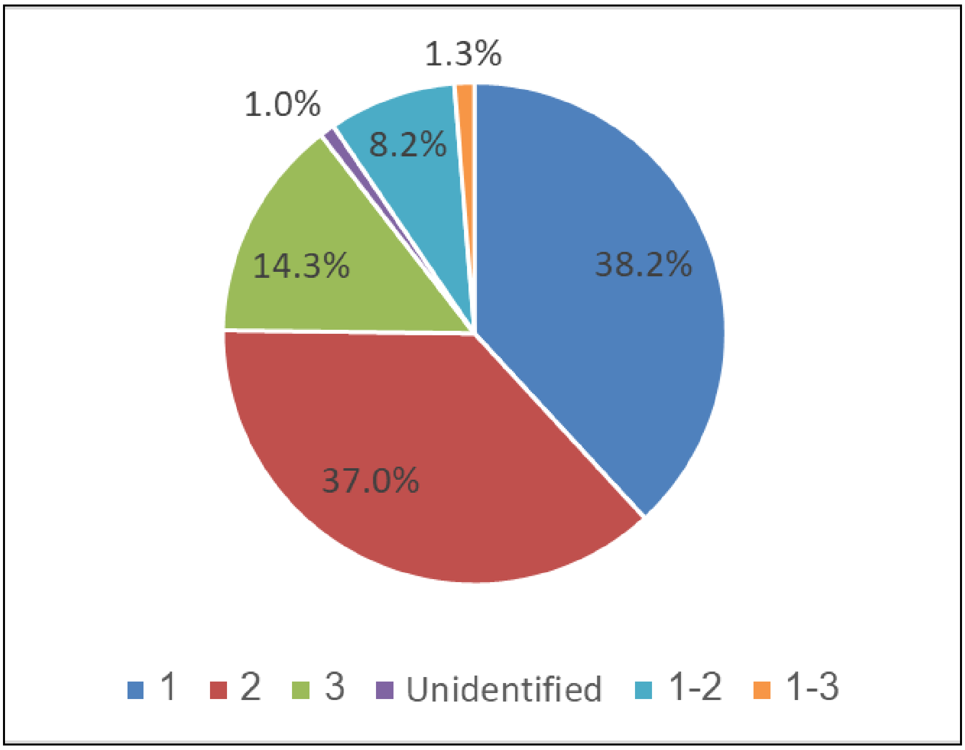

Fig. 111. The texture of artifacts within the Revadim sample. 1: fine-textured; 2: medium texture; 3: coarse texture; 1-2: samples vary between fine texture and medium texture; 1-3: samples vary between fine texture and coarse texture.

Table 58 presents some of the highlights that emerge from the analysis of the different typo-technological categories on a group of flint type level. The most striking result is, again, that of the bifaces. All eight analyzed bifaces are made of Group 1, a group of brecciated flint types (Fig. 112). This result is in accordance with the results from QC and Jaljulia, where bifaces are also mostly made of brecciated flint types. It should be stressed, however, that in this sample only bifaces from Layer C3 at Revadim are included (n=8), out of a total of about 100 bifaces which were found in Revadim (Cohen, 2018). Therefore, these results should be treated cautiously.

Table 58: The main categories standing out among the Revadim results*.

category	**Flint type groups**	**N=**	**% of this flint group out of the examined category***	**General % of this flint group in the Revadim sample**
Bifaces	1	12	**100.0%**	20.4%
	3	0	**0.0%**	22.3%
COFs	1	17	**31.5%**	20.4%
	3	9	**16.7%**	22.3%
	2	7	**13.0%**	8.7%
Products of COFs	1	15	**15.0%**	20.4%
	2	7	**17.5%**	8.7%
Blades and cortical blades	6	10	**30.3%**	24.0%

* Green colour marks fields with values notably higher than the general Jaljulia sample; red colour marks fields with values notably lower than the general Jaljulia sample. None of these differences were statistically significant.

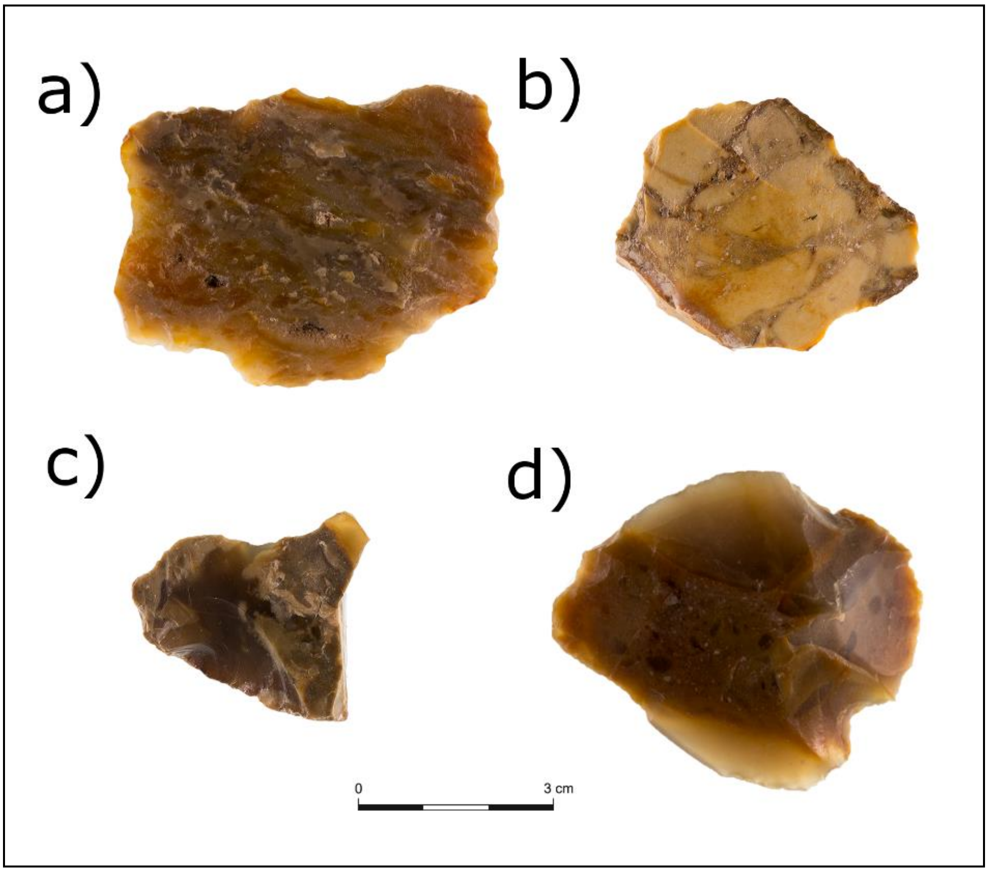

Fig. 112. Examples of Group 1 in Revadim, a group of brecciated flint types.

COFs and their products demonstrate some more interesting patterns. While Group 1 appears in relatively high proportions among the COFs, its proportions are notably lower among the products of COFs, possibly suggesting that some of the products were transported within the site, or out of it. Group 2, on the other hand, a group of grey to orange opaque slightly spotted homogenous flints, is relatively common in both categories. As demonstrated in the past (Agam et al., 2015; Agam and Barkai, 2018a), the production of small flakes from old "parent" flakes was an integral technological trajectory at Revadim, most likely by means of lithic recycling. Therefore, it is possible that the Revadim's hominins selected flint types which suited that trajectory better, rather than other flint types.

Finally, while the production of blades at Revadim was rare, and the samples of blades (n=19) and cortical blades (n=14) are small it is interesting to note that

Group 6, which is the most represented in the Revadim sample in general, is especially prominent among the blades and cortical blades (Table 58). This group is characterized by grey to brown fine-textured homogenous semi translucent flint types. It is, therefore, possible that this group of flint types was preferred for the production of blades at Ravadim, possibly due to their fine texture. Alternatively, as this trajectory was extremely rare at the site, it is possible that Group 6 was more suitable for the occasional production of blades, possibly due to shape of the nodules from which they originated. Currently, however, it is impossible to say whether one of these scenarios is indeed the case.

5.7.3. Discussion of the Jaljulia and Revadim results

While this is only a preliminary analysis, the patterns presented above concerning Jaljulia and Revadim suggest that the inhabitants of both sites were selective in their lithic exploitation strategies. This is not surprising, as selectivity in patterns of raw material exploitation have already been demonstrated in the Levantine Acheulian sites Gesher Benot Ya'aqov (Saragusti and Goren-Inbar, 2001), ~~and~~ Ubeidiya (Bar-Yosef and Goren-Inbar, 1993: 111; Belfer-Cohen and Goren-Inbar, 1994), Bizat Ruhama and Nahal Hesi (Zaidner, 2014).

The resemblance in flint types selected for the manufacture of the bifaces of all three sites included in this study is remarkable. It seems that there was a repeated preference for producing bifaces from brecciated flint types, possibly due to the size of packages in which brecciated flint types tend to be found, or, alternatively, due to the mechanical characteristics of these brecciated flint types.

Interestingly, homogenous flint types are prominent among COFs and their products in both Acheulian sites. In the case of QC, homogenous flint types are also common among the COFs and their products, though in proportions similar to the general sample. The production of small flakes from old parent flakes by means of lithic recycling was demonstrated as an integral technological trajectory in both Revadim (Agam et al., 2015; Agam and Barkai, 2018a) and QC (Parush et al., 2015), while results of lithic analysis in Jaljulia are still pending. We may thus expect to see specific selection processes concerning the COFs and their products.

These results show the high potential which exists in applying the research methodology of this entire study to older contexts, demonstrating patterns of preferences and selectivity. Projects further analyzing these patterns are already underway.

Chapter 5: Discussion and Conclusions

6. Discussion

The results of this study, presented above, focused on the geologic origins of the exploited flint types, and the patterns of exploitation of flint at QC, using a combination of macroscopic, petrographic and geochemical analyses. The following chapter provides a brief overview of the results, and discusses their possible implications. Finally, I try to evaluate the considerations that affected flint procurement at QC.

6.1. An Overview of the Results

QC is located within rich flint-bearing limestone outcrops of the Bi'na Formation (Upper Cretaceous Turonian epoch). Within this local Turonian environment, at a distance of between 0.8 km and 8 km from the cave, 16 potential flint sources were found, both primary and secondary. The results presented above show that flint from local Turonian sources was often brought to the cave and exploited by the QC hominins for the production of stone tools, forming the majority of flint types identified at the cave. However, the petrographic analysis, combined with the visual classification and the geochemical data, shows that flint types from other geologic origins, including Campanian, Upper-Cenomanian – Turonian, Cenomanian/Turonian and Eocene, were also used at the site in noteworthy proportions.

The results demonstrate that some of the observed patterns, such as the strong dominance of Turonian flint in all categories and assemblages, the preference towards homogenous flint types in general and specifically for the production of Quina and demi-Quina scrapers, and the preference for local homogenous tabular flint types for the production of blades, reflect a continuity in human behaviour and lithic choices through time. On the other hand, some differences were observed between specific assemblages. The South-Western Yabrudian assemblage, for example, was shown to be different than the Hearth and South of Hearth assemblages in both the general proportions of material from the different geologic origins and in the use of flint types for the production of specific typo-technological categories, such as cores. The Top Level Yabrudian assemblage was demonstrated to be different than the Top Level Amudian and the Deep Shelf – Unit I assemblages in terms of flint types and groups of flint types used, as well as in the tendency to use more heterogenous flint types.

In terms of specific typo-technological categories, some interesting patterns were also observed. The high frequency of cortical flakes in flint of all geologic origins, for example, indicates that a large proportion of the flake production took place on-site, regardless of the origin from which the flint was brought to the cave. The analysis of the Quina and demi-Quina scrapers demonstrated that while local Turonian flint was often used for the production of Quina and demi-Quina scrapers, Campanian and Cenomanian/Turonian flints were also used for the production of these tools in proportions which are higher than in the general sample, a difference which was shown to be statistically significant.

The bifaces analysis, on the other hand, seems to reflect a different pattern of behaviour. The extremely low number of bifaces at QC, compared to the rich lithic assemblages, suggests that handaxes did not play a major functional role in the QC hominins' everyday lives. The significance of the QC biface assemblage is discussed in the following section.

The preliminary analysis of the samples from Jaljulia and Revadin suggests that even though the two sites sit next to rich flint sources, their inhabitants were selective in the manner in which they exploited flint. Also, a preference for brecciated flint types for the production of bifaces was observed within the bifaces of all three sites (QC, Jaljulia and Revadim), suggesting a technological advantage for such flint types in the production of handaxes.

The macroscopic classification into flint types, which was used as part of this study, was assessed during this research using a blind test evaluation (Agam and Wilson, 2018). The results of this blind test demonstrated that while macroscopic classification of flint cannot be used as a sole classification method in raw materials studies, as it is influenced by human subjectivity, experience strongly affects the reliability of the macroscopic classification, leading to more consistent results. Furthermore, this study suggests that blind tests should be used as an integral instrument in raw materials analyses, aimed at fine-tuning and calibrating the results of classification, therefore increasing its reliability.

6.2. The Significance of the Results

QC is located within an environment of Turonian limestone, which is rich in flint. Indeed, local Turonian flint was often used by the QC hominins (72.2% of the general sample). This should not come as a surprise, as local lithic materials usually dominate Paleolithic assemblages (e.g., Ekshtain et al., 2017; Groucutt et al., 2017; McHenry and de la Torre, 2018). While some scholars argue that the dominance of local materials in archaeological assemblages implies that lithic materials were procured as a by-product of the acquisition of other resources (e.g., Binford, 1979; Ekshtain and Tryon, 2019; Kuhn, 1995), such a pattern might also suggest that the high availability of desired lithic materials around a given locality, and their suitability for the production of the desired tools and blanks, played a main role in the decision to locate the site at this location. Moreover, local flint could be procured by multiple short-distance task-specific forays, so direct procurement is also possible. I suggest that this is the more likely scenario in the case of QC. The suitability of the easily available local homogenous fine-textured tabular nodules for the regular production of blades, and their repeated exploitation for this production trajectory imply that their availability in the area of the cave was one of the considerations to locate the occupation at the cave. Clearly, other subsistence resources, such as wood, water, edible plants and animal prey, could have also been easily available in the area, making the cave a favorable locality (Barkai et al., 2018, and for more about embedded procurement versus direct procurement strategies, see below).

Interestingly, while local flint dominates the cave's assemblages, non-Turonian flint types were also exploited by the QC hominins in notable proportions. This pattern of exploitation repeats itself through time, often in specific typo-technological categories, demonstrating a consistency in accessing sources containing non-local flint types. Such flint types could have been procured either from distant primary or secondary sources, implying a long-distance transport of non-local flint types to the cave, or, alternatively, from local secondary sources which contained non-local flint which got eroded from more distant primary sources and which was carried towards the cave by streams. Currently exposed stream deposits in the area do not have such flints, but during the Lower Paleolithic Wadi Qana, which passes 3 km north of QC, might have been such a source. Preliminary observations in an old stream channel of the wadi, uncovered at the Late Acheulian site Jaljulia, revealed the presence of potentially non-Turonian flint, although further examination is needed to establish its true charecteristics and potential origin. In either of these scenarios, the exploitation of non-Turonian flint types for the production of specific tools and blanks suggests that the QC inhabitants put an effort into procuring specific flint types which best suited the artifacts they wanted to produce (for a discussion concerning the considerations affecting these choices see below). A link between desired blanks and the exploited lithic materials has been demonstrated in the past in several other Levantine Paleolithic sites (e.g., Bar-Yosef and Goren-Inbar, 1993: 111; Belfer-Cohen and Goren-Inbar, 1994; Ekshtain et al., 2017; Saragusti and Goren-Inbar, 2001). Our own previous study concerning QC (Wilson et al., 2016) has also shown such a link, implying that selectivity in the exploitation of lithic materials should be viewed as a common human trait at QC, and possibly in the Lower and Middle Paleolithic of the Levant in general.

The repetition of some of the observed patterns through time, such as the consistent exploitation of Campanian flint for the production of Quina and demi-Quina scrapers, implies the existence of knowledge transmission mechanisms concerning the distribution of flint sources around the cave, as well as concerning the suitability of specific flint types for the production of specific tool types and blanks. Mechanisms of knowledge transmission have been demonstrated to exist at QC regarding flint knapping (Assaf, 2014; Assaf et al., 2016; Barkai et al., 2017), hunting methods and butchering practices (Stiner et al., 2009), the habitual use of fire (firewood collection, the making and maintenance of fire), the systematic recycling of flint (Parush et al., 2015), and meat roasting and cooking (Barkai et al., 2017). This study suggests that knowledge was also transmitted among the QC inhabitants regarding the location of favourable flint sources, as well as concerning the benefits of using specific flint types for the production of specific tools and blanks.

The QC biface assemblage reflects yet another aspect of human behaviour at the cave. Given the low number of bifaces, compared to the rich lithic assemblages at QC, it seems that bifaces did not play a major role in the everyday lives of the QC hominins. Moreover, given the fragmentation of the bifacial *chaîne opératoire*, and the absence of bifacial knapping by-products, it seems that bifaces were not produced at QC, but, rather, were brought to the cave in their current state. It is therefore possible that the QC bifaces originated from older contexts, most likely Acheulian sites, which existed in the vicinity the cave, or further away from it. The presence of at least two Acheulian sites near QC is of note in this context (Jaljulia – 6 km north of QC [Shemer et al., 2018]; and Eyal 23 – 12 km north of QC [Ronen and Winter, 1997]). The collection of old knapped artifacts was demonstrated at QC by several lithic trajectories (Barkai and Gopher, 2016; Caricola et al., 2018; Efrati et al., 2018; Parush et al., 2015), showing it to be a repetitive pattern of human behaviour at QC.

Finally, the analysis of the samples from the Late Acheulian sites Jaljulia and Revadim suggests a link between the exploited flint types and the tools and blanks produced at these two earlier sites as well. Similarly to QC, both sites are located in environments which are rich in flint (Marder et al., 2006; Shemer et al., 2018). Therefore, it is possible that the availability of flint around the two sites played a role in the decision to locate these two sites where they are. Both sites are located in proximity to fresh water sources, which most likely also attracted prey animals, and enabled the growth of edible plants, providing favourable conditions and additional motivations to locate these sites at these localities, as expressed by the supr-imposed layers observed in both sites (Marder et al., 2011; Shemer et al., 2018). On the other hand, it should be stressed that these are two open-air sites, a type of site which is often associated with task-specific short-duration occupations, as opposed to cave sites, which are often viewed as habitation sites (Hovers, 2017). The function of the site is also known to influence the frequencies of different lithic materials within the site's assemblages (Wilson et al., 2018). Therefore, as Jaljulia and Revadim represent a different cultural complex than QC, with most likely a different mode of occupation, differences in lithic choices between them and QC are likely to appear. Future work will explore the potential flint sources around these two sites and beyond using high resolution methods, analyze patterns of flint procurement and exploitation, and compare these results to the QC results, in order to better understand patterns of change and continuity in lithic procurement and exploitation during the Late Lower Paleolithic of the Levant.

6.3. Considerations Affecting Flint Procurement

It is frequently suggested that the acquisition and transportation of any resource to archaeological sites should be measured by cost-effectiveness considerations (Browne and Wilson, 2011). The considerations influencing the attractiveness of potential sources often include the accessibility of the source, its distance from the site, the quality of the material, the size of the available pieces, its abundance, and the physical effort required in order to retrieve the desired material (Wilson, 2007a; Browne and Wilson, 2011). Optimal foraging theory (e.g., Arroyo, 2009; Jeske, 1992) and the various central-place foraging models (e.g, Beck et al., 2002; Hodder and Orton, 1976) are commonly used in such studies.

However, the picture is never straightforward. Several scholars have suggested, for instance, that materials could have been collected as a by-product of other subsistence-related processes, a procedure also known as "embedded procurement" (e.g., Binford, 1979; Ekshtain et al., 2014; Ekshtain and Tryon, 2019; Kuhn, 1995). Even in such scenarios, however, the procurement of flint can be costly and planned in advanced, if, for example, quarrying activity is required (Bamforth, 2006). Moreover, given the major role of lithic materials in the lives of recent hunter-gatherers (e.g., Brumm, 2010; Holen in Bamforth, 2006: 522), it is doubtful that their procurement would be dependent solely on the distribution of other resources throughout the landscape, rather than being directly procured as primary materials.

The decision about which flint types to use for the production of each tool or blank was most probably also influenced by the terrain around a given source (the extent of the source, its accessibility, etc.), and the nature of the rocks themselves within the source (suitability for knapping, durability, size of nodules, etc.) (Wilson et al., 2018). Interestingly, these two sets of considerations may have had different degrees of importance in the decisions about which flint types to use differently at different times (Wilson and Browne, 2014).

In the case of QC, the Quina and demi-Quina tend to be made on flint types which are more homogenous than the artefacts in the general sample, implying a probable technological/functional advantage for these flint types. Wilson et al. (2016) demonstrated that the QC scrapers were often produced of Type K, a light grey-brown slightly translucent homogenous flint type (11.4% of the analysed scrapers in that study), which is completely absent among other flake-tools. However, as Campanian flint appears within the Quina and demi-Quina scrapers in relatively high proportions, and as homogenous flint types are also easily available within both Cenomanian / Turonian and Turonian sources, other considerations, possibly related to certain socio-cultural preferences of the Qesem inhabitants, might also have been in play. Given the relatively uniform low hilly terrain characterizing the surroundings of QC (Frumkin et al., 2016), it seems that the characteristics of the flint nodules themselves had a greater impact over the decision as to which flint types to use than the terrain had, although further investigation is required in order to establish this proposition.

Pop (2013) suggested that physical traits, such as the size of grains and degree of homogeneity, play a role in the attrition rates of stone tools. The original shape and size of the knapped material were also suggested to have an influence over the durability and efficiency of the manufactured tool (e.g., Ditchfield, 2016; Key and Lycett, 2015, 2017; Terradillos-Bernal and Rodríguez-Álvarez, 2017). It is therefore possible that mechanical properties of the flint had an influence on the decision as to which flint types to use for the production of different stone tools. In the case of QC, the shape of the local tabular nodules most probably played a main role in the decision to use them for the production of blades, while homogeneity might have influenced the decision as to which flint nodules to use for the production of Quina and demi-Quina scrapers. In the case of the QC bifaces, the size of the selected nodules might have contributed to the ease of production of the bifaces, while their coarse texture might have contributed to their durability. However, as suggested above, this may reflect the preferences of local Acheulian populations, rather than those of the QC inhabitants.

Another issue that may have played a part in the decision as to which flint type to use, and that should also be taken into consideration, is the human factor, which tends to be unpredictable, and cannot be measured by cost and profit values only (Raven, 1992; Wilson, 2007a). The direction of travel, the time available and variable social and cultural factors, for example, may have also played a part in decisions as to which lithic sources to exploit (Wilson, 2007a).

Ethnographic studies demonstrate the effort recent hunter-gatherers are willing to invest in order to procure materials for the manufacture of specific tools. Some aboriginal groups, for example, are familiar with the value and location of high-quality lithic materials, and were documented making special expeditions mainly, and even solely, for the procurement of such lithic materials, sometimes even over great distances (Gould, 1978:831-832; Gould and Saggers, 1985:121). The Alyawara people were documented by Binford and O'Connell (1984: 407) making special journeys for the acquisition of high-quality lithic materials for the manufacture of stone knives. McBryde (1986) demonstrated, based on the distribution of axes throughout the Southern Australia landscape, that greenstone from Mt Williams was preferred by Aboriginal groups for the production of axes over other comparable materials. Brumm (2010) further demonstrated, based on local oral traditions, that Mt Williams had a special role in the local mythology, as it fills its axes with great power, providing a cultural justification for the preference of this location. These few examples provide evidence for the significance of some lithic materials in the manufacturing of specific tools among traditional societies. Similar motivations could have also influenced lithic decision-making at QC.

Some scholars would argue that a preference towards specific flint types, such as that demonstrated here for QC, does not necessarily indicate that procurement was planned in advance. Indeed, theoretically, lithic materials could have been acquired by a random pattern of movement throughout the landscape, resulting in an arbitrary collection of rocks, which is in accordance with the distribution of flint around the site, just to be exploited afterwards in a non-random manner. Such patterns of random movements throughout the landscape for resource procurement are occasionally suggested concerning both prehistoric groups and modern hunter-gatherers (e.g., Hong et al., 2008; Raichlen et al., 2014; Rhee et al., 2011). This pattern of random movement is occasionally termed "*Lévy Walks*", a pattern of movement commonly associated with a wide range of animal species (e.g., Dai et al., 2007; Schreier and Grove, 2010; for a review of the "*Lévy Walk*" concept see section 1.8).

Horwitz and Chazan (2015) discussed patterns of mobility at the Late Acheulian site of Holon and at QC, suggesting that "*the activities represented at these* *two sites are part of the same continuum of landscape use by Late Lower Paleolithic hominins and reflect a Lévy walk foraging strategy*" (2015: 175). However, the patterns observed in this study imply a high degree of familiarity of the QC hominins with the landscape and its resources, as well as the repeated procurement of the same non-Turonian flint types during a long period of time, as is shown in the case of the Quina and demi-Quina scrapers, for example, resulting in a raw material assemblage which does not reflect the natural occurrences of flint types throughout the landscape, as is shown by the dominance of Turonian materials around the cave, as well as within the general sample. Moreover, mechanisms of knowledge transmission, which I suggest existed at QC concerning the location of potential flint sources and the suitability of different flint types for the production of different tools and blanks, stand in contrast to the unplanned, nature of the Lévy walk models. Therefore, it seems unlikely that the pattern of procurement observed at QC was caused by a random, unplanned acquisition strategy, without knowing the location of the various flint sources, as well as the different traits of the flint types available in each source.

The collection of old knapped artifacts from outside the cave, and specifically that of bifaces, which was suggested above, should also be discussed here. The exploitation of previously produced flint artifacts by means of lithic recycling was often practiced by the QC hominins as a regular procurement strategy for specific technological trajectories, such as for the production of small flakes and Quina and demi-Quina scrapers (Parush et al., 2015). The QC biface assemblage, on the other hand, reflects a different pattern of human behaviour. First, the scope of these other trajectories was far more extensive than that implied by the small biface assemblage. Moreover, the absence of bifacial knapping waste at the site demonstrates that bifacial knapping was rarely performed at the site, if at all. The relationship between the

Levantine Acheulian handaxes and proboscideans, discussed above, provides a possible explanation for the decay in the every-day use of handaxes. It is therefore possible that the QC bifaces originated from older contexts, most likely Acheulian sites, which might have existed in the immediate vicinity of the cave, or further away. The motivations for the collecting of these bifaces are yet unclear, and surely might have involved their technological suitability for specific functional needs of the Qc hominins. However, other consideration which might have played a part in their procurement might be related to their easthetic value (their symmetry, their heft; see Hodgson 2015; Mithen 2003; Wynn and Gowlett 2018), or to the appreciation of their antiquity and their long life history (Berleant, 2007).

To conclude, based on the data collected during this study, it seems that the procurement of flint at QC was influenced both by mechanical and technological considerations, as implied by the blades and Quina and demi-Quina scrapers analyses, and by more elusive considerations which may be referred to the "human factor". The QC hominins were familiar with the different traits of the different flint types, as well as with the technological and mechanical needs relevant to each tool type or blank, and therefore matched the flint types used to the desired blanks. Moreover, the realization of the QC hominins concerning the high availability of flint suitable for their needs in the surroundings of the cave probably played a part in the decision to locate their occupation at this location. Sources containing non-Turonian flint types must also have been known, as they were repeatedly exploited by the QC inhabitants through time in a selective manner.

This study is obviously only but a first step towards understanding lithic-related behaviours at QC. Future work should pursue several research trajectories: First, the mechanical traits of the flint types used at QC should be evaluated, examining their ease of knapping as well as their durability, using experimental work as well as petrographic and geochemical data; the potential flint sources to the east of QC should be explored and studied, as well as the presumable transportation of eastern flint types westwards toward QC, by Wadi Qana, or by other ancient stream(s) in the area; the geochemical composition of the flint from QC and its suroundings should be studied more thoroughly, adding more samples from the examined sources, as well as samples of more potential sources and archaeological flint types; Finally, the possible cultural and social factors which might have affected lithic procuremet and exploitation at QC should be evaluated, using ethnographic analogies as well as other archaeological studies.

7. Conclusions

Qesem Cave was most probably a residential home-base, which was persistently and repeatedly occupied for a long period of time (Barkai et al., 2018), and in which rich accumulations of artifacts representing a wide range of human activities have been exposed. Flint types were procured from geologic sources located both in the immediate vicinity of the cave, with a minimum distance of less than 1 km, and farther away, up to a distance of dozens of kilometres from the cave. The analysis presented above demonstrated the common exploitation of local Turonian flint types, accompanied by the occasional, but not rare, procurement and exploitation of non-Turonian flint types, mostly in a selective manner. The patterns of flint procurement and exploitation at QC imply a correlation between flint types and the desired tools, most probably due to the techno-mechanical traits of the different flint types exploited, but possibly also due to social and cultural considerations. Some flint types were either transported from distant sources, or, alternatively, brought from local secondary sources in which these flint types could have been carefully located and selected.

The results of this study have shown that the QC hominins made lithic-related decisions while obviously trying to be as efficient as possible on the one hand, but also while being influenced by considerations which cannot always be accurately measured by us, archaeologists. These considerations may stem from other aspects, surely related to technological aspects, but also to aspects of movement throughout the landscape, time management, social needs and cultural motivations.

Flint played a major role in the lives of early humans. It was used for the production of tools which helped these early societies gain and process prey, procure and process plant materials, construct shelters, make clothes, and more. Therefore, as every tool has its own production and use requirements, it is only reasonable that the traits of different flint types would influence the decisions as to which flint type to use for the production of which tool. Moreover, it is also likely that the decisions as to which flint types to use would be influenced by social and cultural considerations. I suggest that the results presented above imply the existence of factors which extend beyond mere cost-benefit considerations (though by no means over-ruling such considerations), showing flint to have a major impact over early human decision-making and lifeways during the Late Lower Paleolithic of the Levant.

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תקציר

הקומפלקס התרבותי האשלו-יברודי, השלב התרבותי האחרון בפליאולית התחתון של הלבאנט, כולל מספר חידושים משמעותיים, כולל השימוש הקבוע באש, מיחזור צור, וההפקה השיטתית של להבים ומקרצפי קינה. עבודת מחקר זו בוחנת דפוסי השגה וניצול של צור במכלולים העשירים של האתר האשלו-יברודי מערת קסם.

במסגרת עבודה זו, שנים-עשר מכלולי צור ממערת קסם סווגו לטיפוסי צור, על בסיס מאפיינים וויזואליים, כגון צבע, טקסטורה, גודל וצורה של הבולבוסים, דרגת הומוגניות, מידת שקיפות, מאפייני קליפה, שכבות סאב-קורטיקליות, דפוסים מיוחדים, ונוכחות מאובנים. בנוסף, מקורות צור פוטנציאליים סביב האתר אותרו, בהסתמך על מחשופי צור המופיעים במפות גיאולוגיות של הסביבה, ותוארו. מרכיב מרכזי נוסף במחקר זה הנו ניתוח של שקפים פטרוגרפיים של דגימות צור ממכלולי האתר ומהמקורות הגיאולוגיים הפוטנציאליים. ניתוח זה נועד לזהות את המבנה, המיקרו-מאובנים, ההרכב, והתהליכים המאפיינים את הדגימות, על מנת להתאים בין המקורות הגיאולוגיים וטיפוסי הצור הארכאולוגיים. כמו כן, ניתוח גיאוכימי, הן בשיטת ICP-MS (Inductively coupled plasma mass spectrometry) והן בשיטת ICP-AES (Inductively coupled plasma atomic emission spectroscopy), בוצע, על מנת לזהות אלמנטים עיקריים ונדירים בדגימות הצור.

תוצאות המחקר מראות כי צור ממקורות טורוניים מקומיים הובא לאתר לעתים תכופות, ושימש לייצור רוב פריטי הצור שנמצאו באתר. עם זאת, צור ממקורות גיאולוגיים אחרים, לרבות קמפן, קנומן עליון – טורון, קנומן/טורון ואיאוקן, זוהה גם הוא, בכמויות ראויות לציון.

כמה מהדפוסים שזוהו, כגון הדומיננטיות של צור טורוני בכל הקטגוריות והמכלולים, וההעדפה של טיפוסי צור הומוגניים, משקפים המשכיות בהתנהגות האנושית במערה לאורך זמן. מצד שני, כמה הבדלים זוהו במכלולים ספציפיים, משקפים שינוי לאורך זמן.

כשבוחנים את התוצאות ברמת קטגוריות טיפו-טכנולוגיות, כמה דפוסים מעניינים עולים. כך, למשל, ניתוח מקרצפי הקינה והדמי-קינה מראה כי בעוד צור טורוני מקומי שימש לעתים תכופות לייצור מקרצפי קינה ודמי-קינה, טיפוסי צור קמפניים וקנומניים/טורוניים שימשו גם הם לייצור כלים אלה, בפרופורציות גבוהות מאלה שהובחנו במדגם הכללי. ניתוח הכלים הדו-פניים , לעומת זאת, משקף דפוס התנהגות שונה. הכמות הקטנה של דו-פניים במערת

קסם (n=17), בהשוואה למכלולי הצור העשירים, מציעה כי דו-פניים לא היוו גורם פונקציונלי משמעותי בחיי היום-יום של תושבי המערה. לאור זאת, ובהסתמך על היעדר פסולות דו-פניות במכלולי האתר, ייתכן כי מקורם של הדו-פניים של מערת קסם הוא מקונטקסטים ישנים יותר, ככל הנראה אתרים אשליים שהיו קיימים בסביבת האתר, או רחוק יותר ממנו.

הסיווג המאקרוסקופי לטיפוסי צור, ששימש במחקר זה, נבחן על-ידי מבחן עיוור, שנועד להערכת מהימנות ועקביות סיווג כזה. תוצאות המבחן העיוור מראות כי בעוד סיווג מאקרוסקופי לא יכול לשמש כשיטת ניתוח יחידה בחקר חומרים ליתיים, עקב היותו מסובייקטיביות אנושית, ניסיון משפיע משמעותית על המהימנות של הסיווג המאקרוסקופי, מוביל לתוצאות עקביות יותר. יתרה מכך, המחקר מציע כי מבחנים עיוורים צריכים להוות מרכיב אינטגרלי בחקר חומרים ליתיים, לצורך כוונון עדין של הסיווג וכיול התוצאות, ועקב כך – העלאת מהימנות הסיווג.

אני מציע כי זמינות טיפוסי צור רצויים בסביבת האתר, והתאמתם לייצור הכלים הרצויים, שיחקו תפקיד מרכזי בהחלטה למקם את אתר המחיה במערה. הפרופורציות הראויות לציון של טיפוסי צור לא טורוניים, לעתים קרובות בקרב טיפוסי כלים ספציפיים, מדגימות את העקביות בגישה למקורות צור המכילים צור לא מקומי. צור זה יכול היה להגיע ממקורות ראשוניים או משניים מרוחקים, דבר המציע הובלה של צור למערה ממרחק רב, או, לחילופין, ממקורות משניים מקומיים, המכילים צור לא מקומי שהתבלה ממקורות מרוחקים והוסע על ידי גופי מים לכיוון המערה. ההופעה החוזרת של כמה מהדפוסים לאורך זמן מציעה את קיומם של מנגנוני העברת ידע לגבי פריסת מקורות הצור סביב המערה, כמו גם לגבי ההתאמה של טיפוסי צור ספציפיים לייצור כלים ספציפיים.

השגת צור במערת קסם הושפעה קרוב לוודאי הן משיקולים מכאניים וטכנולוגיים, והן משיקולים חמקמקים יותר, הקשורים בוודאי לגורם האנושי. ההומינינים שחיו במערת קסם הכירו היטב את התכונות השונות של טיפוסי הצור השונים, כמו גם עם הצרכים הטכנולוגיים והמכאניים הרלבנטיים לכל טיפוס כלי, ועל כן התאימו בין טיפוס הצור וטיפוס הכלי. בנוסף, אני מציע כי שהתוצאות מעידות על קיומם של שיקולים שלא ניתנים לייחוס לשיקולי רווח-הפסד (על אף שבהחלט אינם שוללים שיקולים כאלה), ואשר מעידים כי לצור היה תפקיד משמעותי בקבלת ההחלטות ודרך החיים של בני אדם במהלך הפליאולית התחתון המאוחר בלבאנט.

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אסטרטגיות השגה וניצול של צור בפליאולית התחתון המאוחר בלבאנט: המקרה של האתר האשלו-יברודי מערת קסם

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