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THE CORE-AND-FLAKE INDUSTRY OF BIZAT RUHAMA, ISRAEL : ASSESSING EARLY PLEISTOCENE CULTURAL AFFINITIES

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Introduction

Since its discovery, Bizat Ruhama has drawn the attention of Paleolithic archaeologists because of its unique industry. The first scholars studying the lithic artifacts from the site were participants of the Nahal Shiqma archaeological survey (Lamdan *et al.* 1977). They described the industry as composed of "unique tools, which are very difficult to classify by conventional typological means" (Lamdan *et al.* 1977:55). In order to emphasize its exceptional nature, the industry had been assigned to a separate cultural unit called the Nagilan, after the name of the nearby Tel Nagila (Ronen 1979). The age of the site was unknown, but according to the stratigraphic position and simplicity of the tool forms it was assigned to the Lower Paleolithic (Lamdan *et al.* 1977; Ronen 1979).

The excavations conducted at the site in 1996 and subsequent lithic studies (Ronen *et al.* 1998; Zaidner 2003a; Zaidner *et al.* 2003) confirmed that the industry of Bizat Ruhama has no clear parallels among known Lower Paleolithic sites in the Southern Levant, which usually show Acheulian affinities (e.g. Bar-Yosef 1998; Goren-Inbar 1995; Ronen 1979). The characteristics of the lithic assemblage excavated during the 1996 campaign can be summarized as follows:
1. Absence of handaxes and handaxes' preparation flakes.
2. Flake-oriented, rather than core-tool-oriented technology.
3. Small size of the flakes, many of which were subsequently modified.

Especially, the small size of the artifacts was viewed as the major characteristic distinguishing Bizat Ruhama from other Lower Paleolithic assemblages in the Levant and beyond, and was used for comparison with other industries (Burdukiewicz & Ronen 2003; Derevianko 2009). The industry was often called "microlithic", not only to emphasize the small size of the artifacts, but also to link it to the "microindustrial complex" of the Lower Paleolithic in Europe (Burdukiewicz & Ronen 2003; Derevianko *et al.* 2000; Derevianko 2009).

Recent dating efforts led to a breakthrough in the understanding of the Bizat Ruhama industry. The site is now robustly dated to the Matuyama paleomagnetic chron (1.96-0.78 Ma), based on paleomagnetic and faunal evidence (Dassa 2002; Laukhin *et al.* 2001; Yeshurun *et al.* in press; Ron & Gvirtzman 2001; Ronen *et al.* 1998; Zaidner *et al.* 2010). According to this evidence, Bizat Ruhama is an Early Pleistocene site representing one of the earliest records of hominin presence outside of Africa.

Currently, the Eurasian Early Pleistocene archaeological record is extremely fragmentary. Large assemblages of Early Pleistocene artifacts in primary depositional context were reported only from Dmanisi (Georgia) and 'Ubeidiya (Israel) (Bar-Yosef & Goren-Inbar 1993; Bar-Yosef & Tchernov 1972; de Lumley *et al.* 2005; Gabunia & Vekua 1995; Gabunia *et al.* 2000). In other Early Pleistocene occurrences either the number of artifacts or the size of excavated/available for excavations areas are very small, or the context of the artifacts is questionable (Ronen 1991a; Arzarello *et al.* 2006; Carbonell *et al.* 1999, 2008; Chauhan 2009; Dennell 2009; Oms *et al.* 2000; Santonja & Villa 2006). At present, Bizat Ruhama and Dmanisi are the only large Early Pleistocene core-and-flake assemblages discovered in Europe and south-western Asia. The scarcity of other evidence makes the prospects of studying the paleoecology, the technological behavior, and the cognitive and motor skills of Bizat Ruhama hominins paramount for understanding the earliest hominin adaptations in Eurasia.

It is from this standpoint that a new field project was launched at the site in 2004. The excavations (2004-5) had two major goals: firstly to provide large lithic assemblages for a detailed technological study, and secondly to verify the primary context of these assemblages. This paper focuses on a few general aspects of the newly studied assemblages. Following a general description of the industry, it discusses the question of the small size of the artifacts - the feature previously viewed as the main characteristic distinguishing between Bizat Ruhama and other Lower Paleolithic industries in the Levant and beyond. Finally, based on the new data, the paper assesses the place of Bizat Ruhama industry within the Lower Paleolithic record.

The site and the excavations

Bizat Ruhama is located at the fringe of the Negev desert, on the southern part of the Israeli coastal plain, 25 km east of the

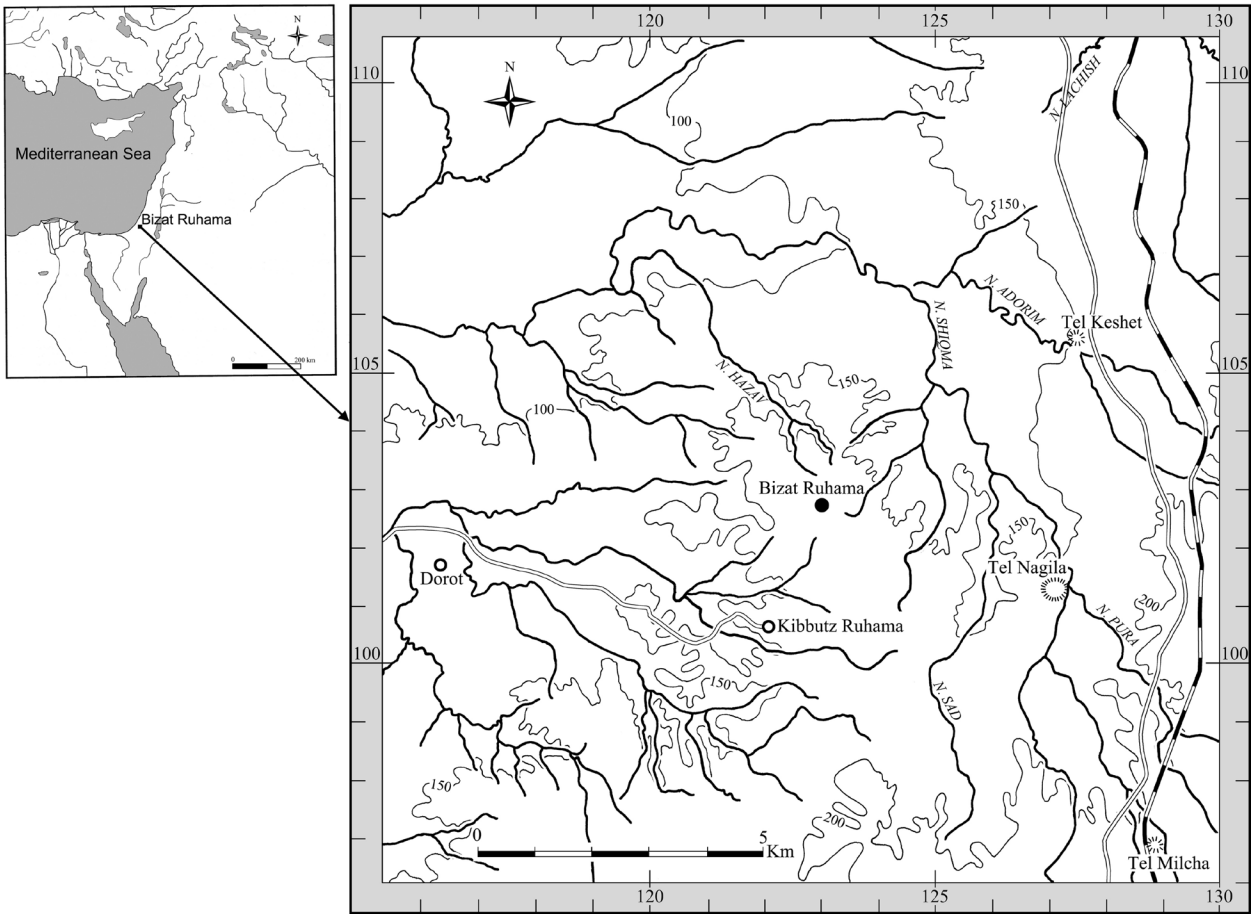

Figure 1 - Location map.

present Mediterranean shoreline. The area is characterized by a landscape built of low undulating loess and hamra hills (160-190 m.a.s.l), intersected by a number of badland fields. The archaeological layer was discovered at the bottom of one of these fields located between Nahal (stream) Shiqma and Kibbutz Ruhama (fig. 1).

OR T4, excavated in the western part of the site, the characteristic sandy layer with few bones and a single flake was detected underlying 1.5 meter of clay deposits, suggesting that the artifact-bearing deposit extended to the west of 1996 excavation area, where it is buried under massive (up to 15 m thick) clay and loess deposits. BR T6, excavated in the eastern part of the

Area	Size of the area (square meters)	Finds	Density of the lithics (per square meter)	Bottom of the archaeological layer (below datum)	Microstratigraphy
BR AT5	25	Lithics 701 Bones ~1000	28	~4.55 m	Sandy layer is ca 0.3-0.5 m thick. Contact with grayish black clay and with hamra is diffuse.
BR 1996	11	Lithics 993 Bones ~50	82.5	~ 5.13 m	Sandy layer is 0.2 m thick. Contact with grayish black clay and with hamra is sharp. The top contact is finely laminated –with alternating sand and clay laminae.
BR T1	2	Lithics 44 Bones – only few small splinters	22	~4.95 m	Sandy layer is 0.3 m thick. Gray-yellowish gray sand is gradually getting partly-colored with greenish-gray and purple-red patches at the bottom. Contact with grayish black clay and with hamra is diffuse.
BR T2	4	Lithics 149 Bones – few small splinters	37.3	~5.4 m	The yellowish-gray sand is highly disturbed by clay and yellow sand lenses and pockets. The contact with hamra is sharp and erosional.
BR T3	1	Lithics 28 Bones 20	28	~4.15 m	Sandy layer is 0.25 m thick. Contact with grayish black clay and with hamra is diffuse.

Table 1 - Size of the excavated areas, density of the finds and microstratigraphy.

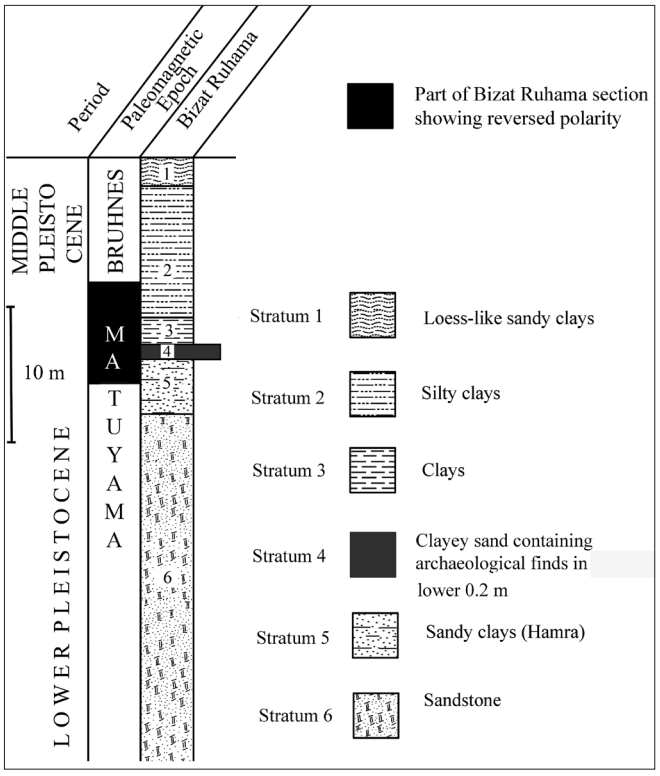

Figure 2 - Bizat Ruhama composite stratigraphic section. Composite stratigraphical chart is based on study of Bizat Ruhama type-section (strata 1-5; Ronen *et al.* 1998; Laukhin *et al.* 2001; Mallol *et al.* 2011) and on Bar-Yosef 1964.

site, probably marks the south-eastern border of the archaeological occurrence. Here, the archaeological layer was washed away by post-occupational flows that deposited sand and clay on top of the hamra.

The results of the spatial reconnaissance allow for reconstructing the overall extent of the site. The thick black line on figure 4 marks the border of the archaeological occurrence. The occupation level and characteristic artifacts were not found east of this line. West of the line artifacts and bones appear in patches of varying density. On the west and north-west the archaeological deposit is buried under 10-15 meters of paleosols and loess, making it difficult to discern its western and northern boundaries. Given this, the minimally estimated extension of the artifact-bearing layer is of few thousands square meters.

The site was excavated in three trenches (BR T1, BR T2, and BR T3) and an area of 25m² (BR AT5) (figs. 3, 6). The excavations were conducted at the locations where, during the survey, concentrations of artifacts and bones were recorded. The lithics were found in different densities in all excavated areas (tab. 1). The bones were only found to be well preserved in BR AT5 and BR T3. In BR AT5 lithics and bones appear together in a ca. 15cm thick layer over a total excavated area of 25m² (see Yeshurun *et al.* in press for a full account of the faunal remains). Flint microdebitage and bone splinters appear as well. Scarce microfaunal remains were also found.

In all the excavated areas artifacts appear in the lower part of the sandy layer close to, or immediately on the contact with the underlying hamra (Zaidner *et al.* 2010). It should be emphasized that although the general stratigraphy is similar to the one established by Laukhin *et al.* (2001), variations in thickness and in nature of transition between the hamra and artifact-bearing sand occur in the areas excavated in 2004-05 (tab. 1). The variations in microstratigraphy are probably due to the unevenness of the hamra surface on which the artifacts were accumulating. The hamra surface was encountered at different elevations along the outcrops of both channels and in the excavated areas (tab. 1).

The settlement pattern of the site could only be briefly discussed at this stage. Geological and faunal evidence indicate that hominins inhabited inter-dune depressions in an open homogeneous semi-arid environment with no evidence for river or lake in the immediate surroundings during the occupation (Mallol *et al.* 2011, Yeshurun *et al.* in press, Zaidner *et al.* 2010). The archaeological remains occur over an extensive surface in distinct layer at an essentially identical elevation. Most of this area, however, is still covered by 2-4 meters of clay (Stratum 3). Based on minimal estimation of the site's extent, less than 5% were excavated and the excavation areas opened to date should be viewed as probes only. Combined results of the survey and excavations show that artifacts are not evenly distributed over the entire exposure of the artifact-bearing deposit. At this stage it seems reasonable to view the site as a series of repeated occupations over relatively short period of time (see Mallol *et al.* 2011, Zaidner *et al.* 2010).

The lithic industry

The excavations conducted at Bizat Ruhama in 1996 and 2004-05 have yielded relatively large lithic assemblages (tab. 2). Together with the artifacts collected during earlier surveys, the Bizat Ruhama assemblage consists of ca. 3000 artifacts. The entire assemblage was subjected to in-depth technological and experimental studies (Zaidner in preparation). Here I present the general account of the assemblages excavated in 1996 and 2004-05 (N=1918). All the knapping activities performed at the site were aimed at producing flakes, many of which were subsequently modified. Thus, the knapping at the site is classified as debitage in the sense of Inizan *et al.* (1999). The Bizat Ruhama lithic industry as presented in table 2-5 is a combination of well-known, previously described technological types (e.g. cores, flakes, Clactonian notches, Clactonian notch waste flakes etc.) with newly introduced categories (e.g. anvil flakes, flakes with trimmed edges etc.).

Raw materials

The most frequent types of rock used at Bizat Ruhama were Senonian-Paleocene, brecciated (Mishash Formation) and Eocene, fine-grained (Adulam Formation) chert pebbles (Zaidner *et al.* 2003). In the vicinity of the site, both occur in conglomerate exposures of the littoral Pleshet Formation. Today, the nearest available exposures of the Pleshet Formation are located some 2.5 km to the east of Bizat Ruhama. Since the Plio-Pleistocene sediments in the area are covered by Middle/Upper Pleistocene loess and clays it is reasonable to suggest that during the occupation, the conglomerates were more extensively exposed and could occur closer to the site.

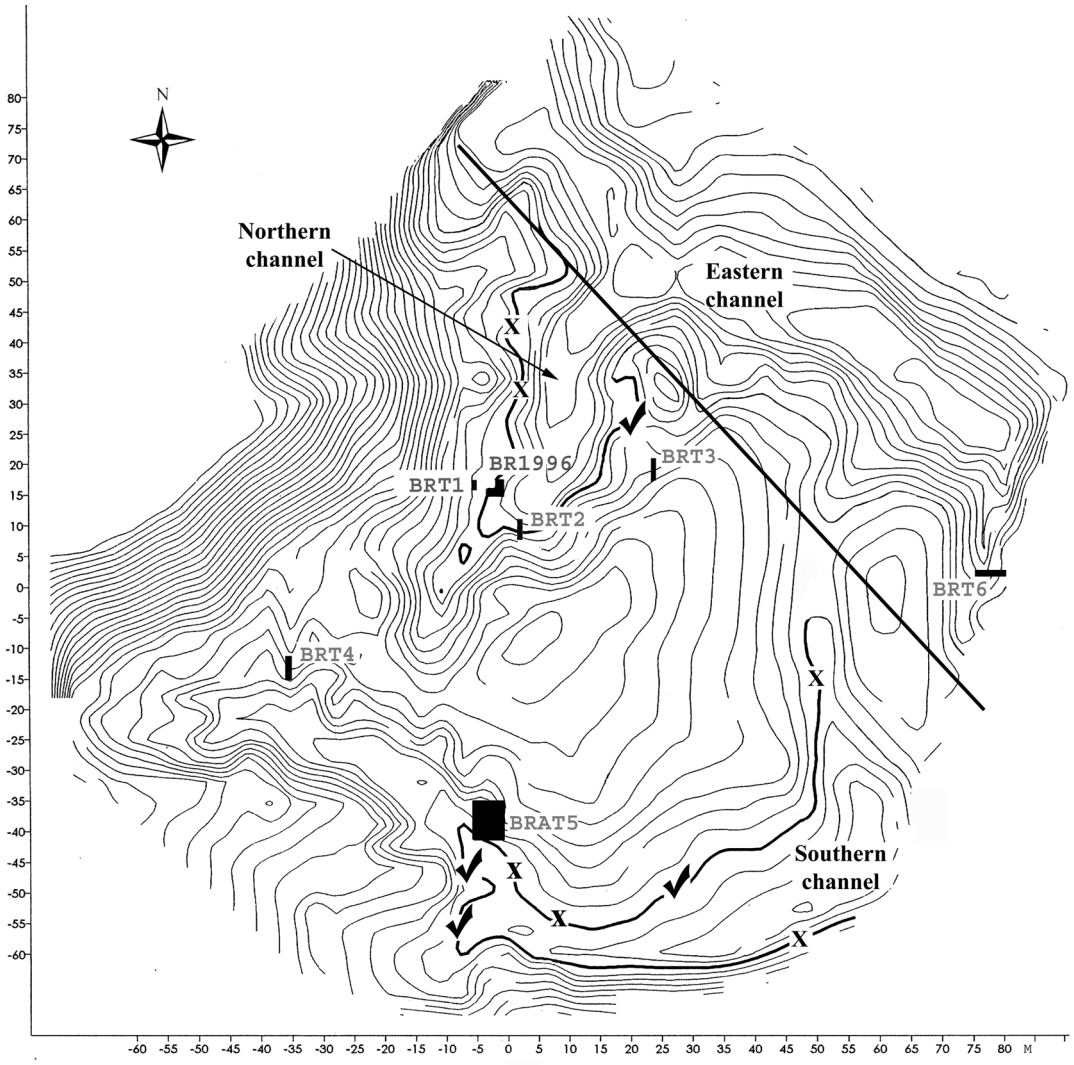

Figure 3 - Plan of the site. Note: BR 1996 means Bizat Ruhama, 1996 season of excavations. BR AT5, BR T1, BR T2, BR T3, BR T4, BR T6 – 2004-05 excavated areas and trenches. ✓ – Sampled locations with in situ artifacts or bones. X – Sampled locations without artifacts or bones. Thick curved black lines mark a contour of the erosional channels along which archaeological layer is exposed. The black line stretching from NW to SE marks the eastern border of the archaeological occurrence.

	BR AT5		BR 1996		BR T1		BR T2		BR T3		BR T4	BR T6	Total
Pebbles	17	2%	23	2%	5	11%	8	5%	1	4%			**54**
Hammerstones	2	0%	1	0%									**3**
Anvils		0%			1	2%							**1**
Flaked pieces	38	5%	69	7%	6	13%	17	11%	1	4%		1	**132**
Detached pieces	297	42%	399	40%	21	47%	60	40%	14	50%	1		**792**
Further knapped flakes	205	29%	431	43%	9	20%	58	39%	5	18%			**708**
Clactonian notch waste flakes and retouch flakes	137	20%	20	2%	1	2%	3	2%	7	25%			**168**
Desilicified pieces and chunks	5	1%	50	5%	2	4%	3	2%		0%			**60**
Total	**701**		**993**		**45**		**149**		**28**		**1**	**1**	**1918**

Table 2 - Composition of the lithic assemblages.

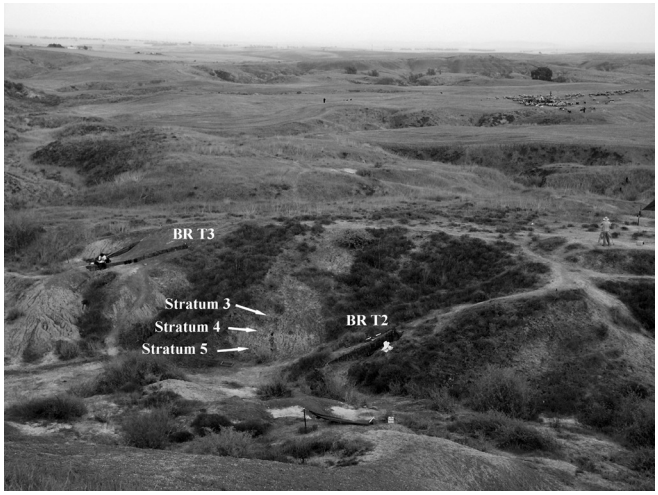

Figure 4 - Bizat Ruhama site. The northern channel during the 2004 season of excavation.

Figure 5 - Bizat Ruhama site. The southern channel during the 2005 season of excavation.

The pebbles in Pleshet Formation exposures are highly rounded and do not provide good knapping angles (fig. 7). The size of the pebbles differs significantly according to their lithology (tab. 6). Eocene chert pebbles are very small; none of them is larger than 80 mm. Brecciated chert pebbles are significantly larger with many specimens larger than 150 mm. As discussed below, the size and shape of the raw materials had a crucial impact on the knapping methods and techniques as well as on the size of the artifacts.

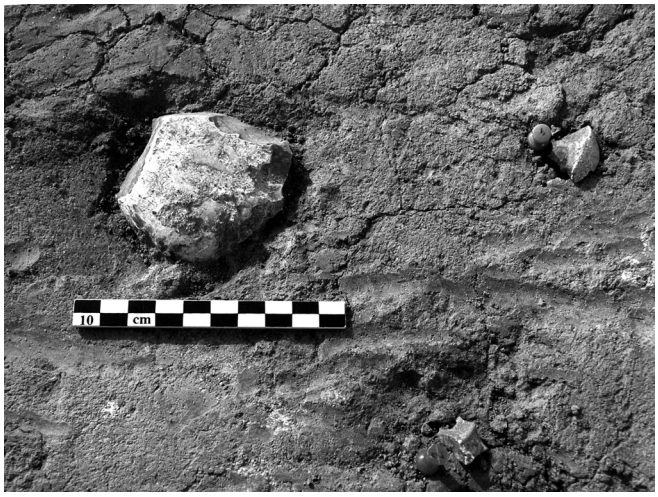

Figure 6 - Excavated surface in BR AT5.

Pounded Pieces and Unmodified

The group includes unmodified pebbles, hammerstones and one 18 cm long flat limestone pebble presumably used as an anvil. Three pebbles 7-8 cm long exhibiting concentrated percussion damage on one of the edges were interpreted as hammerstones. More than 70% of the unmodified pebbles are 1.5-3 cm long.

Flaked Pieces (FPs)

This term was introduced by Isaac (1986) to include all pieces from which flakes were removed including retouched pieces. It is much less in use recently, since most authors prefer to separate between cores and retouched flakes (e.g. Shea & Bar-Yosef 1998; Sahnouni 2006; de la Torre *et al.* 2003; Roche *et al.* 1999). In Bizat Ruhama, due to the simplicity in core forms, the large number of broken pebbles and the high frequency of exhausted and shattered cores or core fragments (tab. 3), the term was retained to include all forms from which flakes were detached. "Further knapped flakes" (see below) are excluded from this category.

Figure 7 - Chert pebbles found at the site, 1 brecciated chert pebble found in BR 1996, 2 Eocene chert pebble found in BR AT5.

Broken/tested pebbles

This category includes broken pebbles and pebbles with few small removals. Noteworthy is a size of the most of the pieces in the category, which do not exceed 3 cm.

Choppers

Choppers are exceptionally rare in the assemblages. Only two bifacial choppers were found in BR 1996 (fig. 8:2). Both exhibit sinuous and not well shaped worked edges, suggesting that they were cores for removing flakes rather than configured tools.

Flaked pieces	BR AT5		BR 1996		BR T1		BR T2		BR T3	BR T6	Total
Broken pebbles	10	26%	14	20%	3	50%	5	29%			**32**
Choppers		0%	2	3%							**2**
Cores	15	39%	10	14%	1	17%	7	41%		1	**34**
Bipolar cores	6	16%	10	14%		0%	1	6%			**17**
Exhausted cores	7	18%	33	48%	2	33%	4	24%	1		**46**
Total	**38**		**69**		**6**		**17**		**1**	**1**	**132**

Table 3 - Flaked Pieces assemblages.

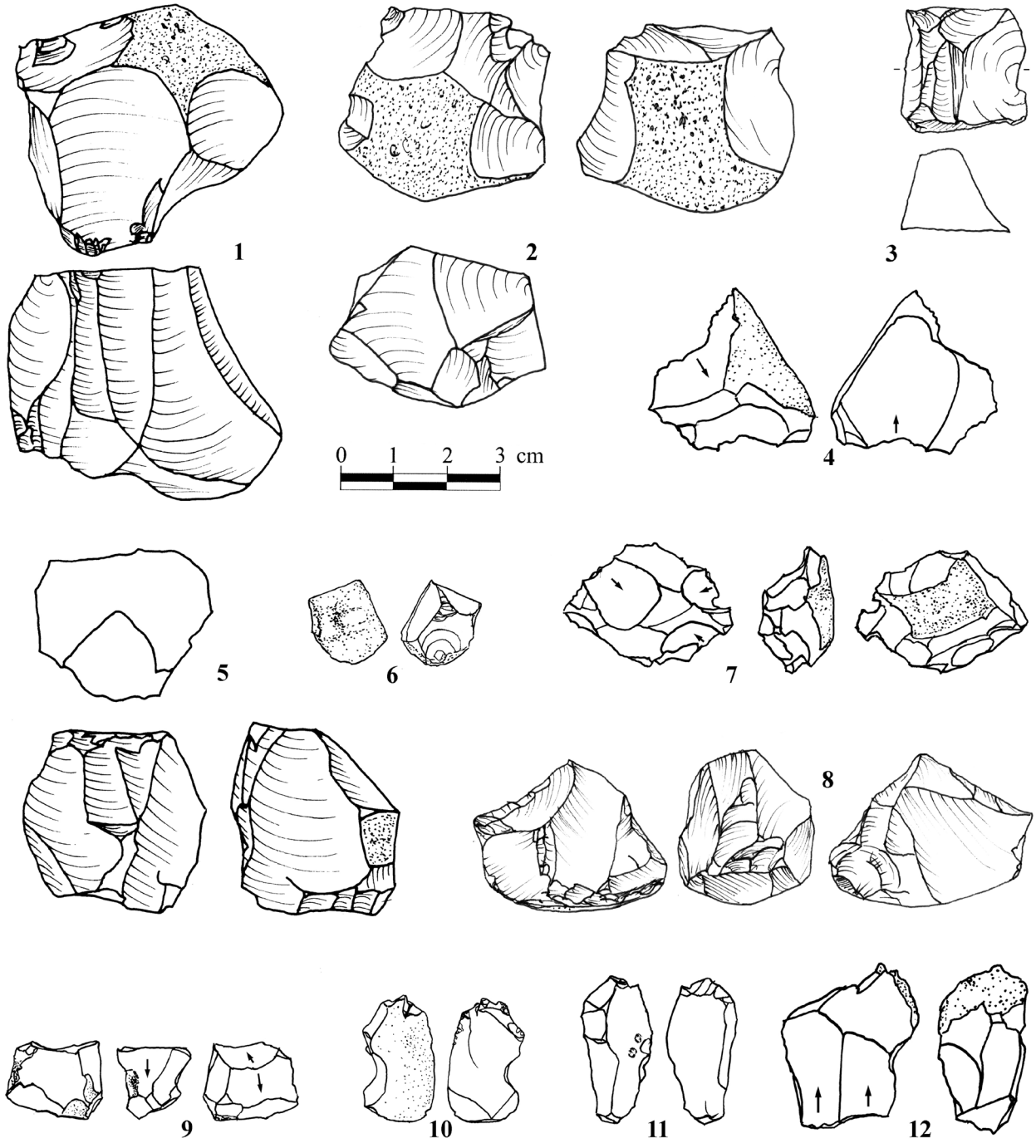

Figure 8 - 1: unifacial unidirectional core, 2: chopper, 3: clactonian notch, 4, 12: flaked flakes (arrows mark post-detachment removals), 5: bipolar core, 6, 10-11: bipolar flakes, 7, 9: exhausted cores (arrows mark scars of the small flakes removed on the final stage of the reduction), 8: multifacial multidirectional core.

Cores

The Bizat Ruhama assemblages include 43 cores knapped by a number of flaking methods. Both bipolar and free-hand hard hammer technique were used at the site. The choice of the methods and techniques was largely determined by the size and the shape of the available pebbles. Thus, probably because of the rounded shapes, the natural surfaces of the pebbles were not used as striking platforms. Instead, the striking platforms were prepared by a single blow splitting the pebble in two halves or removing an opening flake. Although the same methods and techniques were used during the knapping of both raw material types, Eocene chert was more frequently knapped by bipolar technique (fig. 8:5-6, 10, 12). This chert is by far more common among bipolar cores (62.5%) than among other types of cores (32.4%). The predominant use of the bipolar technique during the knapping of the Eocene chert cores is clearly linked to the small size of pebbles.

Larger pebbles were reduced by unifacial unidirectional, multifacial unidirectional, multifacial multidirectional and preferential surface methods. During unifacial and multifacial unidirectional reduction methods a series of 2-5 flakes were removed from a single platform (fig. 8:1). Multifacial multidirectional reduction involved constant opportunistic rotation of the cores in search for appropriated angles (fig. 8:8). Preferential surface cores show more complicated patterns of exploitation with a clear hierarchy between striking platform and flaking surface. They are made on relatively flat pebbles and show a number of unidirectional removals and signs of rectification of the striking platform. Only three such cores were found in the assemblages (1 in BR AT5 and 2 in BR 1996). Many of the cores were intensively reduced resulting in a high number of exhausted core forms.

Exhausted cores

Many cores in Bizat Ruhama assemblage were knapped to the point where the knapping methods and techniques could not be identified. These are small and heavily reduced pieces, which often lack identifiable striking platforms and debitage surfaces. Some of them bear a few scars of small and thin flakes removed from the cores on the last stage of the reduction before their abandonment (fig. 8:7, 9). The length of those scars is 1-2 cm; they are shallow and sometimes reminiscent of Clactonian notches in the characteristic concave shape of the edge.

Exhausted cores are especially dominant in BR1996 (tab. 3). Their presence in the studied assemblages is most likely a result of utilization of small pebbles conjoined with high level of core reduction intensity.

Detached Pieces (DPs)

The distribution of flake types according to breakage patterns is presented in table 4. The DP's assemblages contain only a small number of complete flakes in all excavated assemblages. Most of the flakes are thick and have steep edges. Opening flakes are rare and flakes with cortical platform are virtually absent. The absence of the latter is a result of the core reduction method in which the cortical surface of the pebble was not used as striking platforms. Angular fragments are dominant in all assemblages. Experimental study suggests that the high frequency of broken DPs is a characteristic outcome of the bipolar flaking (Zaidner, in preparation). Similar results were obtained in other experimental studies as well (Kuijt *et al.* 1995; Jeske & Lurie 1993; Amick & Maudlin 1997).

Further Knapped Flakes

The secondary knapping of the flakes in Bizat Ruhama assemblages was a highly common practice (tab. 2). Many of the flakes were further knapped, broken or notched. In BR1996 and BR T2 "further knapped flakes" outnumber unmodified Detached Pieces.

The flakes were knapped by a number of techniques. They were frequently used as cores for free-hand removal of thin small flakes (flaked flakes in table 3; fig. 8:4, 12). The number of flaked flakes is highest in BR 1996 (tab. 5). Usually 1-3 thin flakes were removed from either the ventral or dorsal faces. In other cases flakes were knapped or broken on an anvil, creating a number of broken fragments (Anvil Flakes in table 5). Anvil flakes show signs of the impacts on the intersection of ventral/lateral and dorsal/lateral surfaces that according to knapping experiments were produced during flake knapping on an anvil (Zaidner, in preparation).

Detached pieces	BR AT5		BR 1996		BR T1		BR T2		BR T3		BR T6	Total
Complete flakes	89	30%	93	23%	2	10%	15	25%	4	29%		**203**
Proximal fragments	51	17%	60	15%	5	24%	7	12%	3	21%		**126**
Distal and mesial fragments	41	14%	69	17%	7	33%	8	13%	4	29%		**129**
Lateral fragments	18	6%	35	9%			3	5%	1	7%		**57**
Siret fragments	19	6%	18	5%	1	5%	5	8%				**43**
Angular fragments	79	27%	124	31%	6	29%	22	37%	2	14%		**233**
Total	**297**		**399**		**21**		**60**		**14**			**791**

Table 4 - Detached Pieces assemblages.

Further knapped pieces	BR AT5	BR 1996	BR T1	BR T2	BR T3	BR T6	Total
Flaked flakes	2 1%	21 5%		4 7%			**27**
Anvil flakes	44 21%	73 17%		13 22%			**130**
Anvil flakes?	14 7%	41 10%		4 7%	1 20%		**60**
Clactonian notches	68 33%	139 32%	5 56%	18 31%			**230**
Flakes with trimmed edge	77 38%	157 36%	4 44%	19 33%	4 80%		**261**
Total	**205**	**431**	**9**	**58**	**5**		**708**

Table 5 - Further Knapped Detached Pieces assemblages.

	N	Min.	Max.	Mean	Std. Dev.
Becciated chert	149	18.9	235.2	80.35	43.36
Eocene chert	59	13.8	86.3	39.32	17.28

Table 6 - Length im mm of the pebbles collected during the survey conducted around the site in 2001 (Zaidner 2003a).

		Brecciated flakes	Eocene flakes	Flaked flakes
Techno-logical Length	N	80	111	12
	Min.	13.5	8.4	17.9
	Max.	54.2	67.5	60.7
	Mean	26.39	20.3	35.3
	Std. dev.	8.72	7.06	16.48
Maxi-mum length	N	88	124	27
	Min.	17.1	12.9	17.8
	Max.	60.2	67.9	63.1
	Mean	28.79	24.26	33.43
	Std. dev.	9.47	6.48	11.48

Table 7 - Length in mm of selected artifact categories in Bizat Ruhama lithic assemblages.

A large group of flakes was further modified by Clactonian notching. Many of the Clactonian notches were shaped by relatively large removals similar in size to the scars on flaked flakes (fig. 8:3). The technological differences between the two are vague and it is possible that some of the Clactonian notches were cores for the production of small sharp flakes as well. The last type of modification consists of signs of rough trimming on the flake edges (tab. 3). It is unclear how intentional the trimming is, since similar signs can be produced unintentionally during anvil breakage of the flakes (e.g. Bergman *et al.* 1987; Crovetto *et al.* 1994; Longo *et al.* 1997; Peretto 1994; Zaidner in preparation). In fact, the entire spectrum of "retouch" morphologies identified in Bizat Ruhama assemblages could be produced unintentionally, as shown during experimental knapping of the flakes on an anvil. Thus, previous descriptions of the industry as containing high number of retouched flakes (Ronen *et al.* 1998; Zaidner *et al.* 2003) are questionable, given the results of the recent study.

Clactonian notch waste flakes and retouch flakes

Small thin flakes with specific morphology were identified as Clactonian notch waste flakes. Clactonian notch waste flakes are 1.5-3 cm in maximum dimensions. The flakes are usually wider than they are long. In some cases the butt is the widest and thickest part of the flake. In BR AT5 137 such flakes were found. Most of them are complete and show no sign of physical abrasion.

The significance of the artifacts size in light of the recent studies

The 1996 season of excavations indicated that Bizat Ruhama industry is composed of diminutive artifacts (Ronen *et al.* 1998; Zaidner 2003a; Zaidner *et al.* 2003). Only a few pieces larger than 5cm were found (Zaidner 2003b). During the 2004-05 seasons of excavation a number of larger pebbles, cores and flakes were unearthed. Among the largest are a limestone pebble (18 cm long) interpreted as an anvil in BR T1, a large core fragment (11 cm long) found in 2004 during cleaning of BR 1996 section and a large core 22 cm long exhibiting scars of 4 small flakes removed from one of the edges found in BR T6. All together, the evidence now indicates that large pebbles were available and were knapped. However, the majority of the artifacts found during 2004-05 excavations are still smaller than 3 cm.

The size of Bizat Ruhama artifacts was previously used as a major consideration in assessing the genesis of the industry and establishing its place among Lower Paleolithic taxonomic units (Burdukiewicz & Ronen 2003; Derevianko 2009; Ronen 1979; Ronen *et al.* 1998; Zaidner *et al.* 2003). The site was often discussed as part of the "microlithic complex" of the Lower Paleolithic (Burdukiewicz & Ronen 2003; Derevianko *et al.* 2000; Derevianko 2009). The more recent studies reported here indicate that artifacts dimensions in Bizat Ruhama are influenced by the size of the available raw materials, the intensity of flaking, and the selection of larger flakes for further knapping. Among 1500 Detached Pieces in the assemblages the technological length could be measured only for 203 complete flakes. Other Detached Pieces are either broken, or, more significantly, were

further knapped. Among 708 further knapped flakes the technological length could be determined only for a few. Nonetheless, the evidence suggests that the largest flakes were chosen for further knapping. For instance, the mean maximum length of flaked flakes is significantly higher than the maximum length of complete unmodified flakes (tab. 7; Kolmogorov-Smirnov test: Z = 2.37; p = 0.000). The length values of anvil flakes, which size was significantly diminished by breakage on an anvil, are only slightly lower than the length values of complete flakes. Thus, it is likely that the selection of the large flakes for secondary reduction biased the average length of complete flake assemblages toward the smaller values.

The intensity of the core reduction is another reason for the small dimensions of the artifacts. The cores constitute only 14-40% of the Flaked Pieces in the assemblages. Many pieces in the FPs' category are exhausted cores that are considerably smaller than the cores (tab. 7). The intensity of the reduction is evident in the very little cortex that exhausted cores exhibit on their surfaces (fig. 9). Given the small size of the used pebbles the absence of cortex on many of them is especially remarkable. Such an intensive reduction undoubtedly affected the size of the Detached Pieces.

The evidence for the influence of raw material size on the size of the artifacts is clearly visible while comparing the length values of Eocene and brecciated chert complete flakes (tab. 7). Because of the tiny size of the pebbles, Eocene chert flakes are significantly shorter than brecciated chert flakes (Kolmogorov-Smirnov test: Z = 2.04; p = 0.000). All in all, the available evidence indicates that the small size of the pebbles together with the desire of the knappers to maximize the raw material exploitation led to the small dimensions of Bizat Ruhama artifacts.

It should be emphasized that the length of Bizat Ruhama artifacts does not differ much from values recorded in other Early Pleistocene sites. A short survey of the published data shows that both Acheulian and Oldowan techno-complexes contain sites with very small flakes. In fact, the brecciated chert flakes in Bizat Ruhama are longer than flakes in many other Pliocene/Early Pleistocene assemblages in the Levant and Africa, which were never previously linked to the "microlithic complex". For example, both other Early Pleistocene sites in the Levant, 'Ubeidiya and Evron Quarry, contain assemblages with complete flakes shorter than brecciated chert flakes in Bizat Ruhama (fig. 10). Unlike Bizat Ruhama, both sites contain handaxes and core-tools and show Acheulian affinities (Bar-Yosef & Goren-Inbar 1993; Bar-Yosef 1998; Ronen 1991b; Tchernov *et al.* 1994). Some Plio-Pleistocene sites in Africa, identified as Oldowan, also show length values lower than brecciated chert flakes in Bizat Ruhama (fig. 10). The small size of the flakes in many Oldowan assemblages was previously noted by other authors as well (Barsky 2009; Ludwig & Harris 1998). In some of these sites (Fejej FJ-1a, Omo sites, FtJi1, Senga 5), as in Bizat Ruhama, the size of the artifacts was clearly predetermined by the small size of the used pebbles (de la Torre 2004; Ludwig & Harris 1998; Harris *et al.* 1987; Barsky 2009; Merrick & Merick 1976).

The place of the Bizat Ruhama industry in the context of the Lower Paleolithic record

The study indicates that Bizat Ruhama is a core-and-flake industry lacking traces of biface production or any other form of bifacial knapping. With the results of new studies at the site, there is sufficient evidence to claim that Bizat Ruhama industry is not a part of Acheulian techno-complex. The 2004-05 fieldwork and subsequent interdisciplinary studies finally confirmed that the absence of Acheulian tools is not the result of a biased sample or post-depositional erosion (Zaidner *et al.* 2010). Bizat Ruhama is a spatially extensive site with lithic industry composed of approximately 3000 artifacts and exhibiting no Acheulian technological traits in any of the excavated assemblages. Furthermore, the absence of bifaces cannot be explained by absence of suitable raw materials. Some pebbles and cores found during the excavations are large enough to shape a biface. Moreover, pebbles suitable for biface production were found in all exposures of the Pleshet Formation sampled during the raw material survey (Zaidner 2003a, b). And finally, handaxes from locally available raw materials were produced in Bizat Ruhama area during the Middle Pleistocene. For instance, in the Middle Pleistocene site of Nahal Hesi, located 4 km north from Bizat Ruhama, local limestone and brecciated chert pebbles were used for production of handaxes, while small Eocene pebbles were used for production of flake tools.

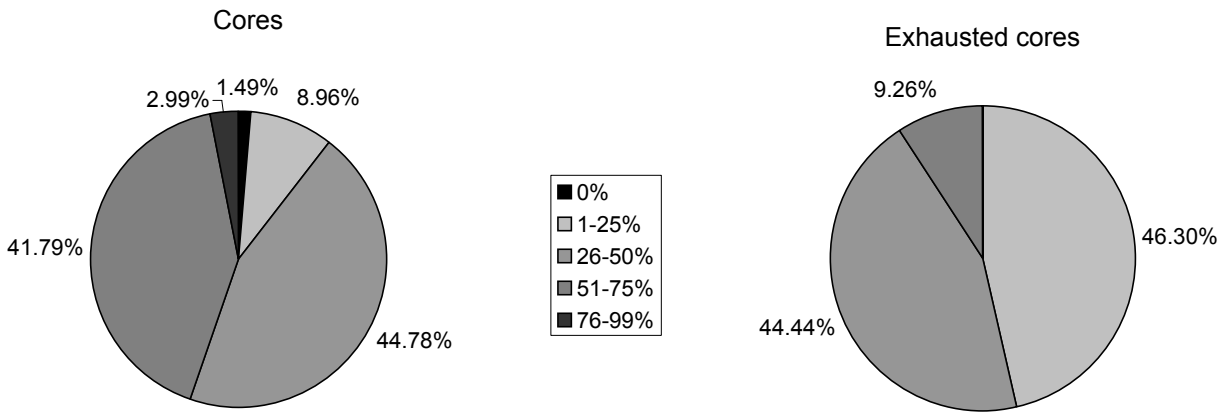

Figure 9 - Chert pebbles found at the site, 1 brecciated chert pebble found in BR 1996, 2 Eocene chert pebble found in BR AT5.

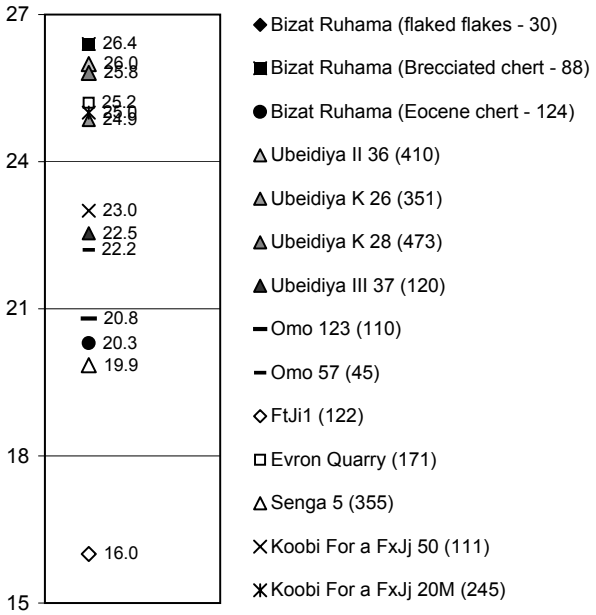

Figure 10 - Average length in mm of whole flakes from selected Early Pleistocene assemblages in the Levant and Plio-Pleistocene assemblages from Eastern and Central Africa. The number in parentheses is the total number of measured artifacts. The data for Ubeidiya, Koobi Fora, Omo, Senga 5 and FtJi1 are from Bar-Yosef & Goren-Inbar 1993; Isaac & Harris 1997; de la Torre 2004; Harris *et al.* 1987; Merrick & Merrick 1976. The data for Senga 5 and FtJi1 includes whole flakes and broken fragments.

Previous suggestions that Bizat Ruhama might be linked to the "microlithic complex" identified in the eastern and northern Europe do not hold true against the recent evidence. First, Bizat Ruhama is much earlier than the European microlithic sites, dated to the second half of the Middle Pleistocene (Burdukiewicz & Ronen 2003). Second, the size of the lithic artifacts in Bizat Ruhama is a feature of economical character closely linked to the availability of the raw materials, and thus cannot be used to establish cultural affinities. And third, as it was highlighted above, the small size of the artifacts is a feature common to many other Plio-Pleistocene lithic assemblages.

The evidence that has accumulated during the last decade indicates that the earliest sorties out-of-Africa were made by hominins possessing Oldowan-like core-and-flake technologies at ca. 1.8-1.7 Ma (Ferring *et al.* 2008; de Lumley *et al.* 2005; Zhu *et al.* 2004), preceding the first Acheulian assemblages in Africa (Asfaw *et al.* 1992; Roche *et al.* 2003; Semaw *et al.* 2008). The chronological context and the absence of Acheulian tools suggest that Bizat Ruhama may belong to one of these Oldowan out-of-Africa sorties. The recent studies broadened our understanding of the Oldowan. Its technological, geographical and chronological boundaries had been extended by research in the last few decades (e.g. papers in Hovers & Braun 2009). The Oldowan is now considered to be a wide technological phenomenon preceding the emergence of Acheulian technology, dated to Pliocene and Early Pleistocene, and present in the African continent, the Levant and possibly southern Europe and China as well. Bizat Ruhama with its Early Pleistocene age and relatively simple core technology seems to match well within the variability of the Oldowan techno-complex.

Concluding remarks

The results of the recent excavations and studies at Bizat Ruhama revealed the significance of the site to the study of Early Pleistocene hominin adaptations in Eurasia. The site contains lithic and faunal remains in primary anthropogenic context and exhibit evidence for a number of roughly contemporaneous occupations. Bizat Ruhama hominins inhabited inter-dune depression in an open homogeneous semi-arid environment with no evidence for river or lake in the immediate surroundings during the occupation.

The lithic technology is characterized by free-hand and bipolar techniques reduction of the small pebbles in order to obtain flakes which were often further knapped. Core-tools are virtually absent and intentionally retouched tools are probably very few. The small size of the artifacts at the site is a feature of economic nature and cannot be used for establishing cultural affinities. The dimensions of Bizat Ruhama artifacts are by no means exceptional for the Pliocene and Early Pleistocene. In fact many of the sites from these periods in Africa and the Levant show similar or lower length values. All in all, Bizat Ruhama's lithic industry fits well within the Oldowan techno-complex and, thus, represents one of the earliest occurrences of the Oldowan technology outside of Africa.

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