Early Pleistocene Hominins Outside of Africa: Recent Excavations at Bizat Ruhama, Israel

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ABSTRACT

The earliest evidence of hominin presence outside of Africa is scarce. Although it is clear that hominins reached Eurasia at the beginning of the Early Pleistocene, equipped with an Oldowan-like tool-kit, the Eurasian Early Pleistocene archaeological record is actually limited to a few occurrences, many of which are not in primary archaeological context. Consequently, much of the paleoecological and behavioral aspects of the earliest occupation of Eurasia remain poorly understood. Here we report on the renewed excavations at the Early Pleistocene core-and-flake site of Bizat Ruhama, Israel, located on the southern coastal plain of the southern Levant. The site yielded several lithic and faunal assemblages in primary anthropogenic context and is dated to the Matuyama paleomagnetic chron (1.96–0.78 Ma), based on paleomagnetic and faunal evidence.

The results of the current study at Bizat Ruhama reveal a spatially extensive single-horizon open-air occurrence with indications for fast burial and good preservation of the original site features. The Bizat Ruhama industry shows no Acheulian affinities and exhibits technological simplicity. However, it demonstrates the hominin ability to adapt to unfavorable raw material conditions. Technological simplicity and absence of bifacial and discoidal knapping suggest that the site represents Mode 1 dispersal out of Africa. The faunal assemblage of the site was accumulated primarily by anthropogenic agents, preserving signs of hominin butchery. Geological and faunal evidence indicate open homogeneous semi-arid environment with no evidence for river or lake in the immediate surroundings, thereby broadening our knowledge of the range of habitats exploited by early hominins and their adaptive skills. Altogether, the results point to short-term hominin occupation and suggest that animal carcasses were processed in place, along with knapping activities.

INTRODUCTION

Early Pleistocene hominin sites in Eurasia are scarce, but their importance for studying the first dispersals out of Africa, and for illustrating early hominin adaptations and life ways, is immense. Currently, the evidence for the earliest hominin presence in Eurasia derives from Dmanisi in Georgia, dated to 1.78 Ma (Ferring et al. 2008; Gabunia et al. 2000) and the lowest level of Majuangou in the Nihewan basin, China, dated to 1.66 Ma (Zhu et al. 2004). Both occurrences yielded simple core-and-flake assemblages comparable with East African Mode 1 assemblages (de Lumley et al. 2005; Zhu et al. 2004). Given that the age of the earliest known Acheulian sites in Africa is 1.65–1.5 Ma (Asfaw et al. 1992; Roche et al. 2003; Semaw et al. 2008), it seems that the earliest out-of-Africa sorties took place before the emergence of the Acheulian lithic technology.

Although the interpretation of the timing of the earliest out-of-Africa dispersal and the technological affinities of the earliest migrants seem to be quite compelling, the Eurasian Early Pleistocene record *de facto* is extremely sparse. Large numbers of Early Pleistocene artifacts in primary depositional context were reported only from Dmanisi in Georgia and 'Ubeidiya in Israel (Bar-Yosef and Goren-Inbar 1993; Bar-Yosef and Tchernov 1972; de Lumley et al. 2005; Gabunia and Vekua 1995; Gabunia et al. 2000). In other Early Pleistocene occurrences either the number of artifacts, or the size of the excavated areas are very small, or the context of the artifacts is questionable (Arzarello et al. 2006; Carbonell et al. 1999, 2008; Chauhan 2009; Dennell 2009 and references therein; Derevianko 2009; Oms et al. 2000; Santonja and Villa 2006). The scarcity of archaeological evidence makes the prospects of studying hominin

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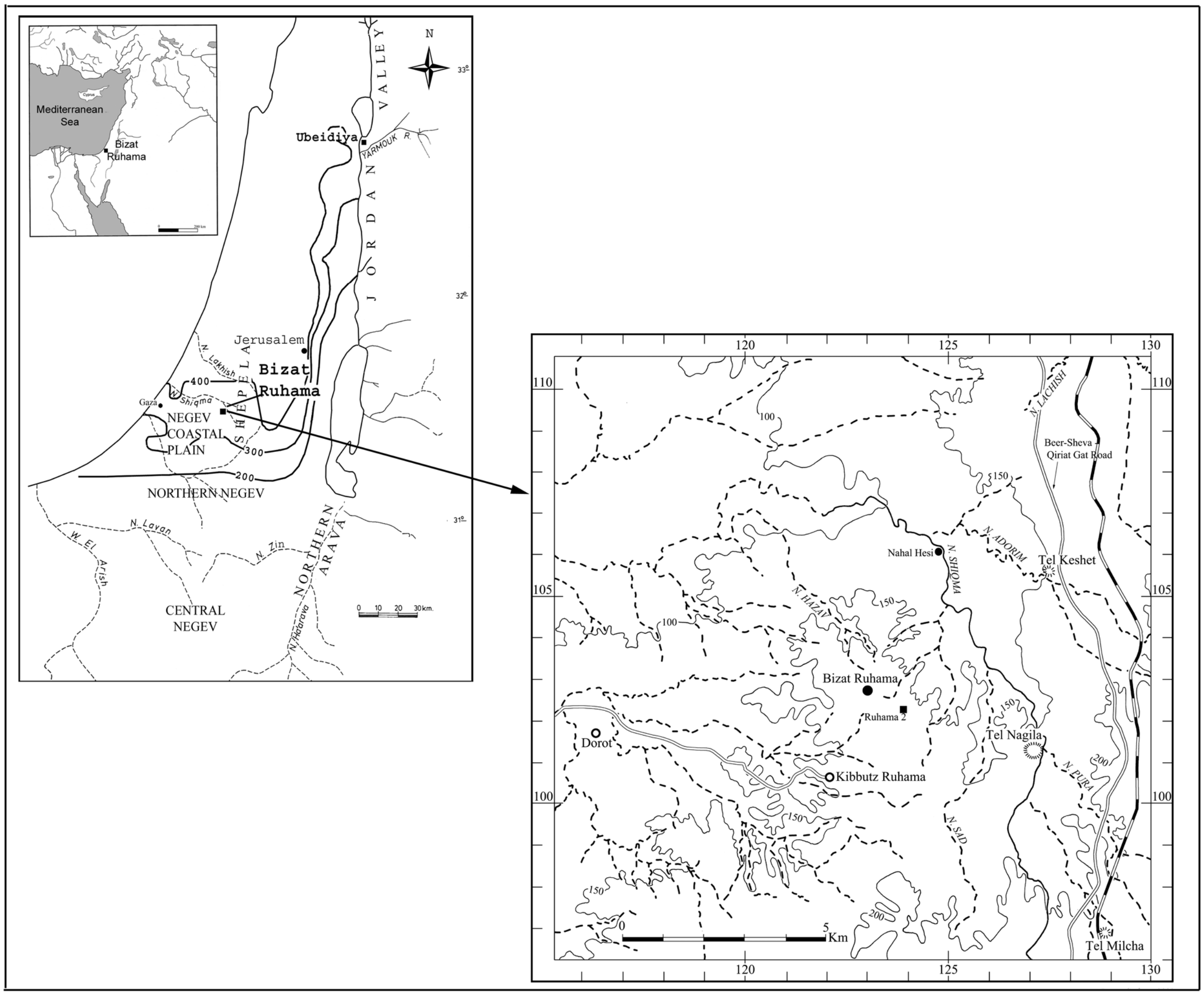

Figure 1. The location of Biszat Ruhama.

paleoecology and behavior very limited. As a result, the conditions that allowed the earliest dispersals, the range of Eurasian habitats exploited by early hominins, as well as behavioral adaptations and technological skills of the earliest Eurasians, remain poorly understood.

Here we report on the renewed excavations at the Early Pleistocene site of Bizat Ruhama, Northern Negev, Israel, located on the southern coastal plain of the southern Levant. Bizat Ruhama is an open-air single-horizon site that yielded several lithic and faunal assemblages in primary anthropogenic context. The site was first excavated in 1996 and is known for its unique (in the Levant) Lower Paleolithic industry, characterized by the absence of bifaces and the small size of the artifacts (Ronen et al. 1998; Zaidner et al. 2003). Renewal of excavations in 2004–05 was directed toward two major goals—first, to determine whether the lithic industry best fits within the Mode 1 or Acheulian techno-complexes; and, second, to study the hominin paleoecology at the site.

In this paper we discuss the general aspects of the site including geology, site description, site formation processes, and distribution of the finds, and summarize some of the new data resulting from different aspects of the research (geoarcheology, zooarchaeology, and lithic technology), full reports of which will be published elsewhere (Mallol et al. in press; Yeshurun et al. in press, Zaidner submitted, Zaidner in preparation).

LOCATION AND GEOLOGY

Bizat Ruhama is located at the fringe of the Negev Coastal Plain, 25km east of the present Mediterranean shoreline (Figure 1). The site is situated in a transition zone between the Mediterranean and the arid climatic belts in Irano-Turanian phytogeographical region with the average yearly rainfall of 300–400mm. The geographic position in the desert fringe makes the area highly sensitive to environmental changes deriving from fluctuations of climatic belts during the Quaternary (Horowitz 1979; Magaritz 1986; Magaritz and Goodfriend 1987; Vaks et al. 2006, 2007).

The area is characterized by low undulating topography (Figure 2). Low sand and loess hills (160–190masl) descend gently to the east and the north toward Nahal Shiqma, the largest stream in the region. The loess hills are occasionally disturbed by erosion that creates typical bad-

Figure 2. Undulating loess hills in the Bizat Ruhama area.

land landscape in which the site of Bizat Ruhama is situated (Figure 3).

The base of the Quaternary sequence in the area is the Pliocene Pleshet and Ahuzam formations (Figure 4; Bar-Yosef 1964; Gvirtzman 1990; Gvirtzman and Buchbinder 1969; Horowitz 1979; Issar 1961; Sneh and Buchbinder 1984; Sneh et al. 1998; Zilberman 1984, 1986). The Pleshet Formation is composed of a littoral facies of the Pliocene sea transgression and includes sandstones, conglomerates cemented by calcareous sand, beachrock and, to a lesser extent, un-cemented sands and marls. Ahuzam is a fluvial formation deposited along rivers that followed the regressing Pliocene sea. Both formations contributed the only available lithic raw material source in the area.

Figure 3. Bizat Ruhama badland field.

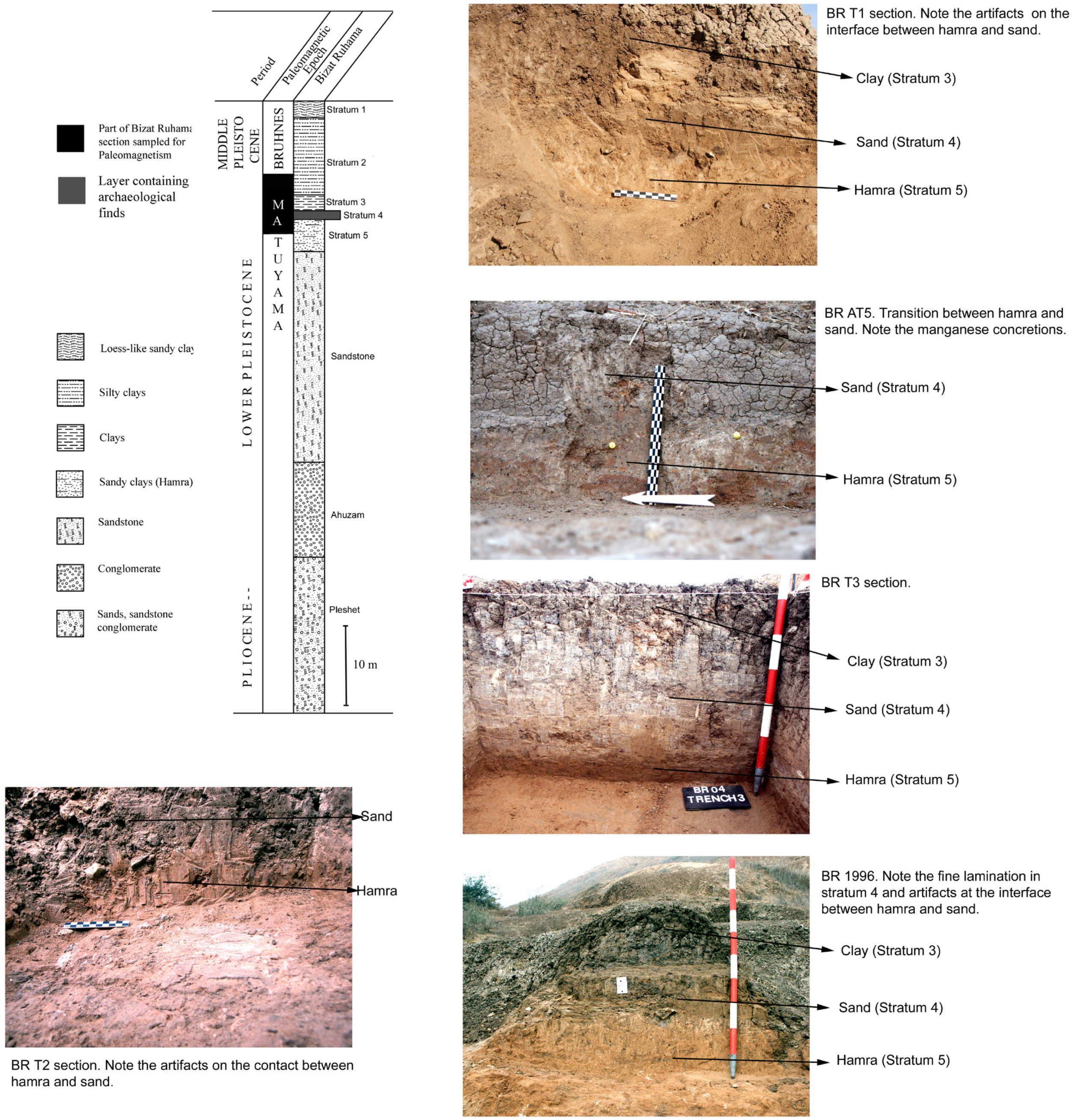

Figure 4. Bizat Ruhama composite stratigraphic section and microstratigraphy of the excavated areas. Composite stratigraphical chart is based on the study of the Bizat Ruhama type-section (Strata 1-5; Ronen et al. 1998, Laukhin et al. 2001; Mallol et al. submitted) and on Bar-Yosef (1964).

During the Early and Middle Pleistocene, the Negev Coastal Plain was influenced by sea level fluctuations, the vicinity of the desert, and pedogenic processes. The major parent material of the sediments that cover the coastal plain is quartzitic sand swept from the Nile Delta along the eastern Mediterranean shoreline. The sands were transported eastward from the current coast during numerous sea transgressions that took place during the Quaternary. Western winds typical to the Israeli coastal plain drew the sands further inland. Sands often were transformed either into sandstone (locally known as *kurkar*) or red sandy loam (*hamra*). Sandstones appear in almost all boreholes around Bizat Ruhama (Bar-Yosef 1964; Sneh and Buchbinder 1984). Their thickness reaches 30m and they directly overlie the Ahuzam Formation. The sandstone is exposed only in a few locations west of Bizat Ruhama, where it is known as the Hirbet Harev *kurkar* ridge (Bar-Yosef 1964; Horowitz 1979; Issar 1961; Nir and Bar-Yosef 1976; Nir 1989). The sandstone is overlain by *hamra* that constitutes the surface on which the Bizat Ruhama archaeological remains are located (see Figure 4).

The desert influence in the region is evident in the deposition of Peri-Saharan loess accumulating from the Middle Pleistocene to the present. The thickness of the loess deposits in the Negev reaches 12–15m (Bruins and Yaalon 1979; Yaalon and Dan 1974), but it is lower in the study area because of the proximity to the northern boundary of loess deposition in Israel. Loess provides the upper sedimentological cover of the area, but around the site it was largely removed by erosion that created the badlands and exposed the underlying *hamra*, thereby enabling the discovery of Bizat Ruhama site.

THE QUATERNARY STRATIGRAPHY OF THE BIZAT RUHAMA SECTION

Bizat Ruhama is located in a badlands area intersected by gullies, channels and depressions. The archaeological layer was discovered at the bottom of two erosional channels on the edge of the badland field between Nahal Shiqma and kibbutz Ruhama (Figure 5; see also Figure 1). The erosion of the loess exposed a sequence of approximately 17m of deposits. The geological sequence is most complete on the western slope of the northern channel (Figure 6). The stratigraphy was studied by Laukhin in 1995, Ronen and Burdukiewicz in 1996, and Zaidner and Mallol in 2004–05 (Laukhin et al. 2001; Mallol et al. in press; Ronen et al. 1998). Additional pedological and paleomagnetic studies of an outcrop (henceforth Ruhama 2) located 700m southeast of the Bizat Ruhama section on the other edge of the badland field (see Figure 1) was conducted by Dassa (2002), Ron and Gvirtzman (2001), and Wieder et al. (2008). Their results are incorporated in the following presentation of the stratigraphy.

The stratigraphic sequence at the western slope of the northern channel constitutes the type-section of Bizat Ruhama badland field and is composed of five strata (see Figure 4) (from base to top):

- Stratum 5: unknown depth. Reddish-orange sandy clays (*hamra*); massive, sticky. Ferruginous crust at the top. Carbonate nodules at 25–30cm depth, becoming columns at 1.5–2m depth. Few artifacts and bones occur in the upper 5cm of the stratum. A similar layer was identified at the Ruhama 2 section (Dassa 2002; Wieder et al. 2008). This layer was formed on terrestrial sand dunes that underwent pedogenesis (Weider et al. 2008). The stratum is placed in the Matuyama reverse polarity chron (1.96–0.78 Ma). Locally sharp or diffuse contact with Stratum 4.
- Stratum 4: 0.2–1m. Gray-yellowish gray sand and clay; horizontal scatters of fossil plant fragments. Manganese impregnation towards the bottom. The bulk of archaeological remains are located in the lower part of this layer. The thickness of this layer

Figure 5. The Bizat Ruhama site and excavation areas.

Figure 6. The southern channel with BR AT5 and 17 meter high slope—the type-section of the site.

as documented in seven different sections ranges between 0.2 and 0.5m. It reaches 1m of thickness in only one location, as reported by Laukhin et al. (2001). This layer was not found in the Ruhama 2 section. According to Laukhin et al (2001) Stratum 4 was deposited on the margin of a small lake. However, no evidence supporting the existence of a lake was found during the 2004–05 seasons. The stratum is placed in the Matuyama reverse polarity chron (1.96–0.78 Ma). Locally sharp (and microlaminated in some areas) and diffuse contact with Stratum 3.

- Stratum 3: 1–3m. Grayish black clay; massive, prismatic, greasy. Manganese and iron impregnation. This layer was excavated and studied in the type-section and in additional seven locations. This unit was not found in the Ruhama 2 section. The stratum is placed in the Matuyama reverse polarity chron (1.96–0.78 Ma). Diffuse contact with Stratum 4.
- Stratum 2: 11–12m. Brown silty clays; massive, prismatic with slickensides. Manganese impregnation and carbonate horizons (with nodules and concretions). A similar unit in the Ruhama 2 section was classified as "Brown Grumosol" and divided into four paleosol units (Dassa 2002). The basal 2–3m of the unit are placed in the Matuyama reverse polarity chron (1.96–0.78 Ma). Locally sharp and diffuse contact with Stratum 1.
- Stratum1: 0.1–2m. Pale-yellow, loess-like sandy clays; highly porous, carbonaceous; local horizontal bedding. A similar unit in Ruhama 2 section was classified as "Loessial Arid Brown Soil" by Dassa (2002) and Ron and Gvirtzman (2001). Unknown age.

CHRONOLOGY

The age estimation of the site is based on paleomagnetic studies, and bio- and geo-stratigraphic considerations. The site is located on the edge of the southern coastal plain of Israel, the easternmost bound of the invasion of coastal sediments. The *hamra* directly underlying the artifacts is located 28km from the current coastline on an elevation of 160masl, and thus must be connected to one of the earliest Pleistocene sea ingressions.

The *hamra* in the site area was subjected to three paleomagnetic studies (Ronen et al. 1998; Laukhin et al. 2001; Ron and Gvirtzman 2001), all showing reversed polarity. In the study conducted by Laukhin et al. (2001), Strata 4, 3 and the lower 1.5m of Stratum 2 of the Bizat Ruhama type-section showed reversed polarity indicating that at least three meters of sediments above the archaeological layer are still within the reverse polarity zone (see Figure 4). Since no evidence for normal polarity was found in the studied samples, the entire sampled section was probably accumulated during the Matuyama chron, thereby indicating that the site was occupied sometime between 1.96–0.78 Ma. The new paleomagnetic study started at the site in 2009 aims to sample the entire section and to provide better magnetostratigraphic resolution.

The faunal evidence from the site supports an Early Pleistocene age (Yeshurun et al. in press). The equid found at Bizat Ruhama is identified as *Equus cf. tabeti*, resembling the group of equids from 'Ubeidiya, Latamne, Aïn Hanech, and Gesher Benot Ya'aqov, and generally dissimilar to the species closer to extant equids, which are known from the Middle Pleistocene onwards (Eisenmann 2006). The antelope identified as *Pontoceros ambiguus* or *Spirocerus* sp. is present at 'Ubeidiya (Martínez-Navarro et al. in preparation) and Dmanisi (Buhksianidze 2005) but absent from Gesher Benot Ya'aqov (Martínez-Navarro and Rabinovich in press). According to the evidence from the faunal assemblage, especially the presence of the antelope *Pontoceros* / *Spirocerus*, the site is probably comparable in age to 'Ubeidiya (see also Belmaker 2009, and references within).

THE SITE

HISTORY OF RESEARCH

The site was discovered by Yehuda Bach of kibbutz Ruhama in the 1960s. Lithic material collected on the surface of the site was first published in the 1970s (Lamdan et al. 1977). The black clay of Stratum 3 was mistakenly interpreted as an archaeological layer and the name Bizat Ruhama (Ruhama swamp) was introduced (Lamdan et al. 1977: 55). In 1996 the site was excavated by a joint Israeli-Polish team headed by Avraham Ronen and Jan-Michal Burdukiewicz (Burdukiewicz and Ronen 2000; Ronen et al. 1998). During the project, the general stratigraphy and chronology of the site were established (Laukhin et al. 2001; Ronen et al. 1998). An area of 11m^2 was excavated (henceforth BR 1996 - Bizat Ruhama 1996; Table 1, Figure 7; see also Figure 5). The stratigraphic section constitutes of Strata 3–5 of the type-section (see Figure 4). Sediments from 4m^2 were sieved through a 1mm mesh. Artifacts and bones occur in a thin horizon at the bottom of the sandy layer (Stratum 4) close to the top of the *hamra* (Stratum 5). The lithic material was studied by Zaidner (2003a, b; Zaidner et al. 2003). In the course of the study of the lithic assemblage, an area of c. 80km² (radius of c. 5km around the site) was surveyed in search of potential raw material sources (Zaidner 2003a, b).

THE 2004–05 EXCAVATIONS AND FIELD WORK

A new project was launched at the site in 2004. The main goals were to:

1. find and excavate areas with good bone preservation;
2. record spatial differences in lithic artifact size, technology and typology; and,
3. determine the spatial extent of the site.

Fieldwork included survey, geological trenching, and archaeological excavations. During the survey, outcrops bearing archaeological remains were found in two small modern channels (henceforth northern and southern channels), tributaries of a larger channel (henceforth eastern channel) running on the east (see Figures 5, 7). The distance between the northern and the southern channels is 50–120 meters. The slopes of the northern and the southern channels were cleaned and sampled in sixteen locations and two geological trenches (BR T4; BR T6; see Figure 7). The archaeology-bearing Stratum 4 was found on both sides of the northern and in the western part of the southern channels and in BR T4. In BR T6 the archaeological layer was not detected. There, the *hamra* is unconformably overlain by laminated alluvial deposits. At the contact between the *hamra* and alluvial deposits, a large, 3.8 kilogram broken chert boulder with few small removals was found, suggesting that the archaeological layer was present there but was washed away. In the eastern channel, Stratum 3 and artifact-bearing Stratum 4 were not found. The section there includes *hamra* (Stratum 5) overlain by brown clay (Stratum 2 of the type section).

Archaeological excavations were conducted in three trenches (BR T1, BR T2 and BR T3) and at area BR AT5 (see Figures 4, 5 and 7; see Table 1). All excavated areas exhibit a generally similar stratigraphy that includes Strata 3 to 5 of the type-section. The main differences are in the thickness of the archaeology-bearing sand (Stratum 4), ranging between 20 and 50cm and in the nature of the contact between the sand and the underlying *hamra* (see Figure 4; see Table 1). The differences are likely due to the local topography of undulating *hamra* surface. During the excavations each artifact, regardless of its size, was recorded in three dimensions with a total station. While artifacts were found in all excavated areas, bones are only frequent in BR AT5 where they are clearly associated with the lithics (Figure 8). In BR T3 bones also are well preserved, but only a small area was excavated. About half of all excavated sediments were wet sieved through a 1mm mesh.

SITE FORMATION PROCESSES

GEOARCHAEOLOGICAL ASPECTS

Depositional Processes Based on Field Observations

During excavation of the different areas, it became evident that the archaeological remains are embedded at the bottom few centimeters of sand of Stratum 4 (see Figure 4). The transition between Strata 5 and 4 is variably sharp and diffuse in different areas but could be clearly recognized in the field. The change in sediment texture and color is quite obvious and was fairly easy to trace during excavation. As a result, it was possible to expose the top of Stratum 5. It was clear during the field work that the finds were associ-

TABLE 1. SIZE OF THE EXCAVATED AREAS, DENSITY OF THE FINDS, AND MICROSTRATIGRAPHY.

Area	Area Size (m^2)	Finds	Lithic Density (per m^2)	Archaeological Layer Bottom (below datum)	Microstratigraphy
BR AT5	25	Lithics 701 Bones ~1000	28	~4.55m	Archaeological Stratum 4 is ca 0.3-0.5m thick. Contact with grayish black clay (Stratum 3) and with *hamra* (Stratum 5) is diffuse.
BR 1996*	11	Lithics 993 Bones ~50	90.2	~ 5.13m	Archaeological Stratum 4 is 0.2m thick. Contact with grayish black clay (Stratum 3) and with *hamra* (Stratum 5) is sharp. The top contact is finely laminated—with alternating sand and clay laminae.
BR T1	2	Lithics 44 Bones – only a few small splinters	22	~4.95m	Archaeological Stratum 4 is 0.3m thick. Gray-yellowish gray sand gradually becomes partly-colored with greenish-gray and purple-red patches at the bottom. Contact with grayish black clay (Stratum 3) and with *hamra* (Stratum 5) is diffuse.
BR T2	4	Lithics 149 Bones – only a few small splinters	37.3	~5.4m	Archaeological Stratum 4 is disturbed by clay and yellow sand lenses and pockets. The contact with *hamra* (Stratum 5) is sharp.
BR T3	1	Lithics 28 Bones 20	28	~4.15m	Archaeological Stratum 4 is 0.25m thick. Contact with grayish black clay (Stratum 3) and with *hamra* (Stratum 5) is diffuse.

ated with a paleosurface represented by the top of Stratum 5 (see Figure 4).

The sand of Stratum 4 shows some features that indicate low energy water deposition. For example, in the BR 1996 section (see Figure 4), part of Stratum 4 exhibits fine laminations. In the field, it was not possible to establish whether such processes were related to the archaeological horizon or to a subsequent, unrelated depositional event.

Micromorphological Observations

Results of a micromorphological study involving sediment samples from BR AT5 and BR 1996 (Mallol et al. in press), have provided several clues concerning the depositional and postdepositional processes associated with Strata 4 and 5 and the archaeological assemblages. Stratum 5 exhibits microscopic features in accordance with previous descriptions of hamra paleosols (Yaalon 1967)—it is a dune-like aeolian deposit made up of massive subrounded to rounded quartz sand, with traces of bioturbation, clay illuviation, and pseudogley. The latter feature in relation with the lithology, and the low relief and uneven microtopography of the entire area around the site as manifested in the different sections, point to an inter-dune depression.

Stratum 4 is massive, and lithologically similar to Stratum 5, but with higher proportions of coarse sand and very little clay. It displays microscopic features of incipient pedogenesis similar to those observed in the hamra unit and hence possibly represents the continuation of the same kind of sedimentary environment. Although both layers are bioturbated, none of the postdepositional features (such as clay infillings or pedotubules) from Stratum 4 penetrate down to within Stratum 5, indicating that the soil material at the contact between the two layers was not strongly disturbed and could be in a primary position. Occasional rounded aggregates of sandy clay were identified at the base of Stratum 4 and at its contact with Stratum 5. These particles represent relicts of an episode of sedimentary stasis during the early stages of formation of Stratum 4, and indicate that the top of Stratum 5 represents a buried surface.

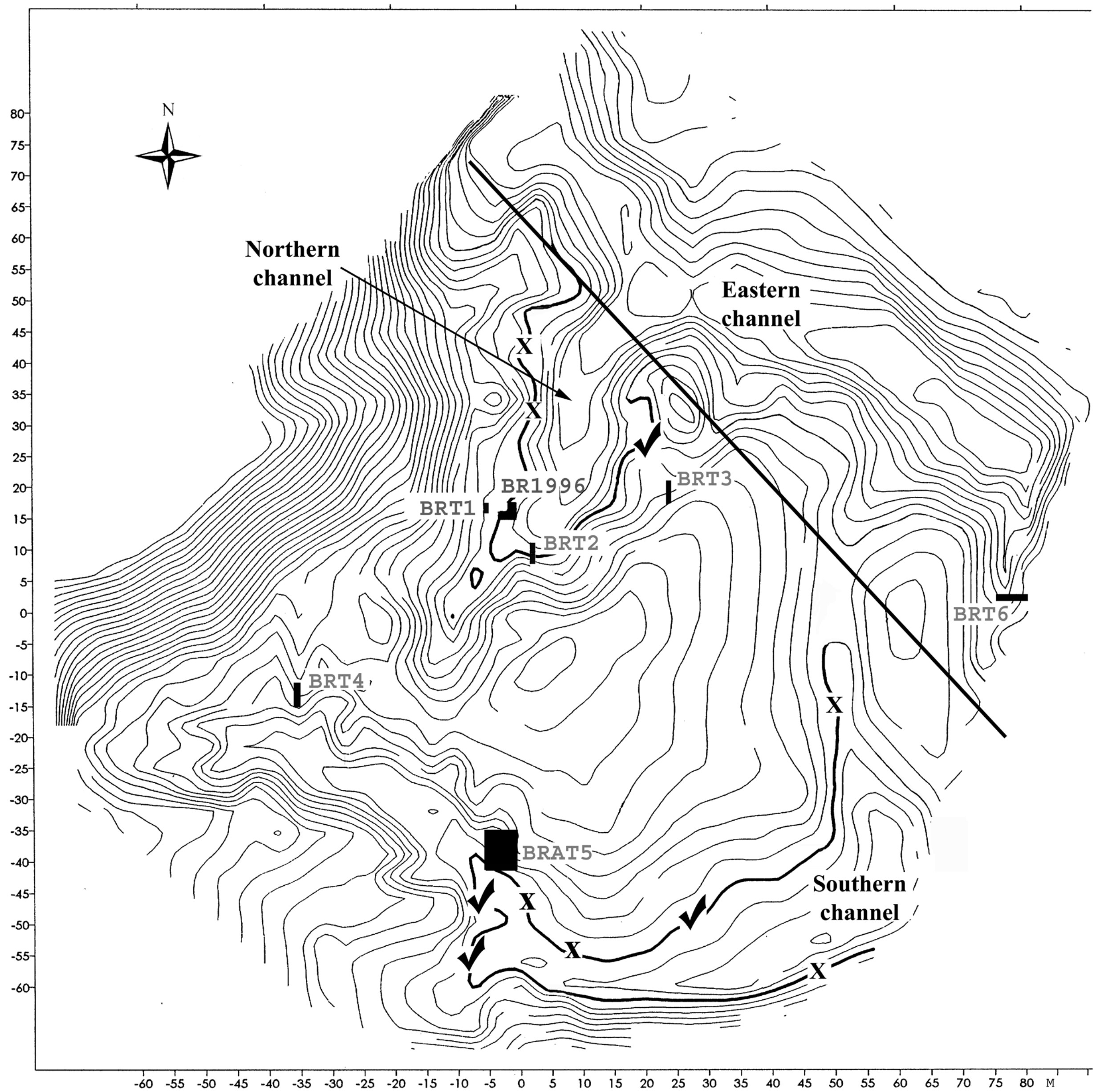

Figure 7. Plan of the site. Note: BR 1996 means Bizat Ruhama, 1996 season of excavations. BR AT5, BR T1, BR T2, BR T3, BR T4, BR T6 are the 2004–05 excavated areas and trenches. √: Sampled locations with in situ *artifacts or bones. X: Sampled locations without artifacts or bones. Thick curved black lines mark a contour of the erosional channels along which the archaeological layer is exposed. The black line stretching from NW to SE marks the eastern border of the archaeological occurrence.*

Different kinds of low energy deposition in BR AT5 and BR 1996 are suggested by the different microstructures observed in micromorphological samples. BR AT5 shows stronger bioturbation, pseudogley and more abundant ferruginous rootlets, whereas the sediment from BR 1996 exhibits well preserved fine laminations of silt and clay. This points to water deposition involving slightly higher energy at BR 1996 and stagnation at BR AT5.

The rest of the strata (1, 2 and 3) represent a different type of sedimentation and pedogenesis. Strata 2 and 3 are much more clayey, and exhibit features that resemble vertisols, such as very little porosity, strongly granostriated b-fabrics, and prismatic microstructures. Such features, together with the low chroma of these sediments indicate hydromorphism of the kind resulting from a semi-permanently waterlogged setting (Stoops and Eswaran 1985). Only the base of Stratum 1 was sampled, yielding fine silt and clay laminations indicative of low energy sedimentation. Further data is needed to characterize the corresponding sedimentary environment.

Figure 8. BR AT5. The area during the excavations. Note: a: General view; b: Lithics and bones exposed during the excavations.

THE SURFACE CONDITION OF THE ARTIFACTS

The ample literature that deals with preservation of the lithic artifacts ties post-depositional alteration of their surfaces and edges with two major mechanisms—fluvial transportation and trampling (Flenniken and Haggarty 1979; Gifford-Gonzalez et al. 1985; Harding et al. 1987; McBrearty et al. 1998; Nielsen 1991; Petraglia and Nash 1987; Petraglia and Potts 1994; Pryor 1988; Schick 1986; Shackley 1974; Shea and Klenck 1993; Villa and Courtin 1983). Although experimental studies show that the effects of trampling should not be underestimated while investigating the edges of stone artifacts, no clear criteria distinguishing between damage caused by fluvial transport and trampling exist (Shea 1999). Artifact surface abrasion, on the other hand, is soundly correlated with the sedimentary setting and degree of fluvial disturbance in open-air sites (e.g. Bar-Yosef and Goren-Inbar 1993; Harding et al. 1987; Isaac 1997; Petraglia and Nash 1987; Petraglia and Potts 1994; Schick 1986; 1992; Shackley 1974).

In the description of the artifact surface abrasion in Bizat Ruhama, a threefold division was adopted from Bar-Yosef and Goren-Inbar (1993) and Shea (1999). The state of preservation of the artifacts was defined as fresh, slightly abraded, or abraded. There are no heavily rolled artifacts in any of the studied assemblages. As a rule, the material shows minor signs of macroscopic post-depositional abrasion (Table 2). The frequencies of abraded artifacts range between 0%–2%. We can conclude that the mechanisms for abrading chert artifacts at Bizat Ruhama were rather minimal, and at BR AT5 and BR T3 virtually absent.

Archaeological and experimental studies show that heavily rounded and abraded stone artifacts in open-air sites either occur within coarse-grained fluvial contexts or indicate long transportation from their original locations by high-velocity and long- duration flows (e.g., Bar-Yosef and Goren-Inbar 1993; Harding et al. 1987; Isaac 1997; Schick 1986; Petraglia and Nash 1987; Petraglia and Potts 1994). Since numerous factors influence the degree to which a stone tool is abraded (texture and hardness of material, sedimentary context, water velocity, duration of the flow event, etc.) it remains unclear how much post-depositional disturbance is needed to develop abrasion that can be distinguished macroscopically. According to a four-level division of water flow disturbed sites proposed by Isaac et al. (1997), the artifact surface abrasion will be evident only at level 4, i.e., on artifacts transported for a long distance (tens and hundreds of meters) from their original location in strong fluvial events. Levels 2 and 3 designate small-scale events that winnow small-sized artifacts, and rearrange them within the living area without leaving a mark that can be distinguished macroscopically on the artifact surfaces (Isaac 1997; Schick 1986). The experimental study conducted by Harding et al. 1987 shows that for handaxes transported in a river bed, the abrasion became evident after 150m. To sum up, it seems that while the presence of abraded artifacts is a good indication for post-depositional fluvial disturbance, the lack of such evidence does not provide required resolution to claim that artifacts are archaeologically in primary context. In this view, the fresh condition of Bizat Ruhama artifacts can only indicate that they were not subjected to large-scale water disturbance.

The degree of patina development is another aspect that assists in understanding the formation of archaeological sites. Patination results from exposure to the light combined with the composition of the surrounding matrix and can be developed in a short time (up to few months) (Bar-Yosef 1993; Nadel and Gordon 1993). The degree of patina development was recorded only for artifacts made on Mishash Formation chert from BR 1996 (N=192) and BR AT5 (N=203), because it was difficult to distinguish patina on artifacts made on other raw material types. The observations were made by naked eye. Striking differences were observed in degree of patination between the areas. At BR 1996 most of the artifacts are patinated and only a few show no patina that can be distinguished by naked eye (see Table 2). At BR AT5 the majority of artifacts are only slightly patinated and 25% show no patina. Since the sedimentological settings in both areas are similar, these differences might be evidence for longer exposures of artifacts at BR 1996.

TABLE 2. SURFACE CONDITION OF THE ARTIFACTS.

		BR AT5	BR 1996	BR T1	BR T2	BR T3
Preservation		N=689	N=950	N=41	N=138	N=28
	Fresh	95%	83%	88%	81%	96%
	Slightly abraded	4%	15%	12%	17%	4%
	Abraded	1%	2%	0	2%	
Patination		N=203	N=192	-	-	-
	Unpatinated	25%	2%	-	-	-
	Slightly patinated	70%	18%	-	-	-
	Patinated	5%	80%	-	-	-

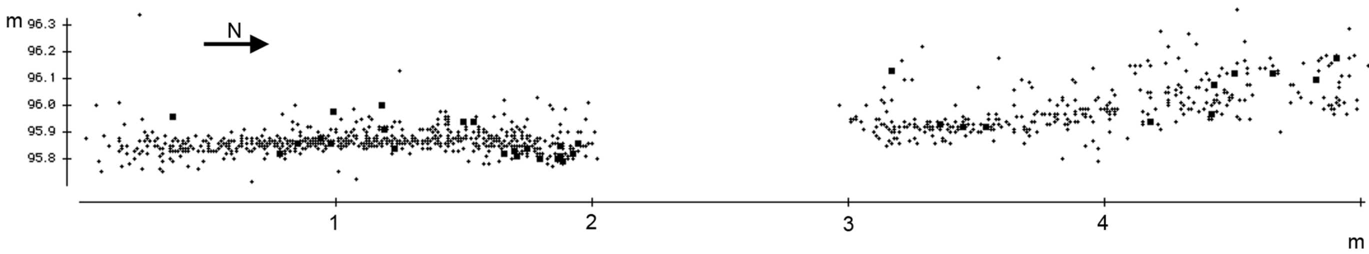

Figure 9. Vertical distribution of the finds in BR 1996. Note: large black dots represent bones.

PATTERNS OF VERTICAL AND HORIZONTAL DISTRIBUTION OF ARTIFACTS AND BONES

The horizontal and vertical distributions were studied only in BR AT5 and BR 1996. During the excavations of both areas, artifacts and bones were plotted in three coordinates using a total station. The exceptions are squares DN 116 and DP 111 in BR AT5, in which artifacts were not piece plotted. In squares DS-DR/111, only the upper part of the clayey sand layer was excavated, and only a few artifacts and bones were unearthed. Eighty artifacts and a few hundreds of bone splinters that were retrieved during sieving in BR AT5 are not included in distribution maps.

Vertical Distribution

The vertical distribution of the artifacts and bones in BR 1996 is presented in Figure 9. The artifacts appear in a highly distinct, 3–5cm thick horizon in the southern squares and are more scattered in the northern squares. The southward inclination of the archaeological horizon in the northern part of the area probably reflects the paleotopography of the *hamra* surface. About half of the bone assemblage is concentrated in the center of the excavated area. In BR AT5 the artifacts and bones appear in 10–15cm horizon in the lower part of Stratum 4 on the top of the *hamra* (Figure 10). A few artifacts were found in the top few centimeters of *hamra*.

The vertical plots of BR AT5 and BR 1996 show that artifacts and bones form a zone 10–15cm thick with the densest cluster a few centimeters thick occurring in the center of the zone. The cluster is on, or immediately above, the contact between *hamra* and clayey sand indicating that the deposition followed the undulating paleotopography of the *hamra* surface. The undulation is also evident in general topography of the *hamra* surface within the Bizat Ruhama site complex. The *hamra* occurs at different elevation along it exposures in both channels and in different excavated areas (see Table 1).

Two hypotheses can explain the deposition of the archaeological finds. The objects could have been accumulating on the *hamra* surface during a continuous occupation episode. The alternative hypothesis is that the artifacts represent a palimpsest of several ephemeral episodes, accumulating on the surface of the *hamra* during a period of low sediment input inadequate for formation of distinct superimposed occupation horizons. Be that as it may, the good preservation of bone and artifact surfaces, and homogenic composition of the lithic assemblages (see below), speak in favor of fast burial of the occupation horizon(s).

The fact that artifacts and bones form a zone and not one well distinct "living surface" probably stems from the vertical displacement of the finds after primary deposition. The experimental and archaeological work in Koobi Fora shows that "where the east African Plio-Pleistocene open-air sites formed on loose sandy or silty substrates, post-depositional processes could have readily dispersed an archaeological zone through a thickness of at least 10–15cm

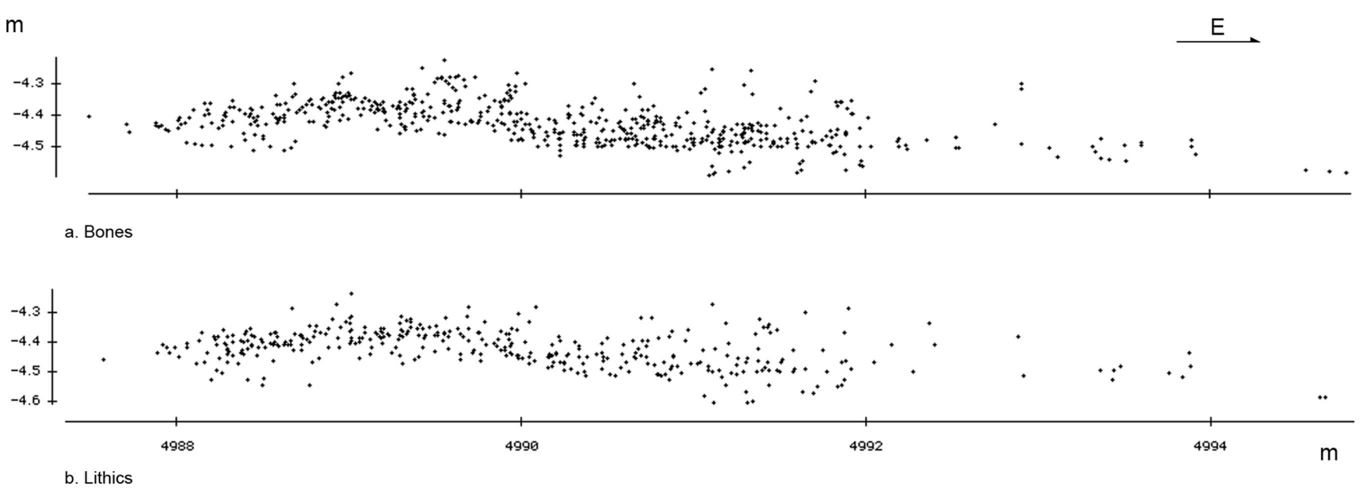

Figure 10. Vertical distribution of bones and artifacts in BR AT5.

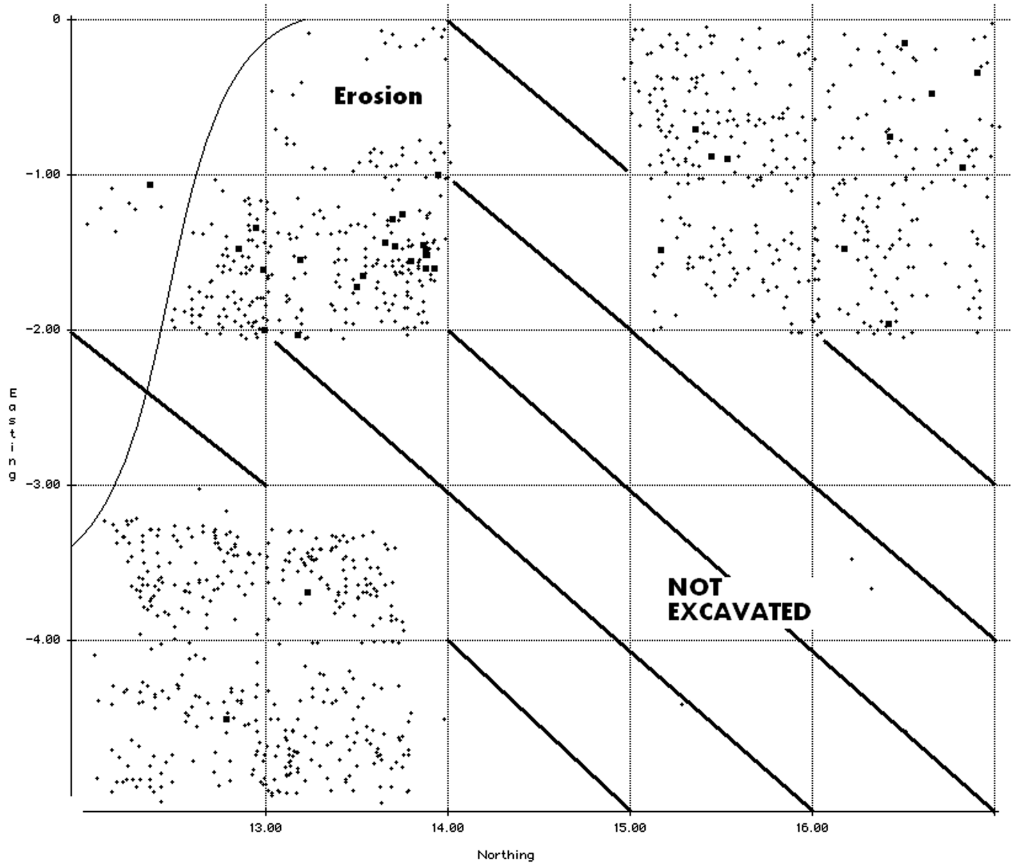

Figure 11. Horizontal distribution of the finds in BR 1996. Note: Large black dots represent bones. The thin curved line marks the edge of the erosion slope.

of sediments" (Kroll and Isaac 1984: 12). The vertical post-deposition movement seems to occur even when spatially the objects were largely preserved in place. Micromorpological evidence of bioturbation, especially in BR AT5, supports this hypothesis.

Horizontal Distribution

The horizontal distribution of the finds in BR 1996 is presented in Figure 11. Lithic artifacts are distributed over the entire excavated area without any apparent clusters. Unlike artifacts, most of the bones are concentrated in southwestern corner of the area.

In BR AT5 the patterns of horizontal distribution of artifacts and bones are generally overlapping (Figure 12). Both materials are scattered over the excavated surface and do not form distinctive clusters. The only distinctive feature is a narrow (ca. 50cm wide) strip with low density of artifacts and bones in squares DT115 and DS115 (see Figure 12). Because this low-density strip occurs at the highest point on which *hamra* emerges, it can be linked to post-depositional moving of the artifacts to slightly lower places. In an attempt to gain more insights into the spatial arrangement of the site, density distribution maps were generated (Figure 13). The maps show that squares in the middle of the excavated area are somewhat denser in artifacts and bones. The densest areas of both types of finds are roughly overlapping. There is an additional cluster of artifacts in the northeastern corner of the excavated area.

The spatial distribution was checked from four additional perspectives. First, water disturbance can create a pattern in which artifacts will be spatially arranged according to their size or weight (e.g., Lenoble 2005; Schick 1986). The artifacts were grouped into size categories to test whether the size-sorting is evident within the excavated area. The results show no size-sorting effect within BR AT5 (Figure 14). The comparison with other areas shows that size distribution is similar in all excavated areas (Figure 15). The distribution is unimodal showing a peak at the 20–24.9mm group in all assemblages. Thus, the assemblages do not show a degree of size-sorting that would be expected if water disturbed the site. Yet, there are noticeable variations in frequency of artifacts 10–19.9mm long between the areas. The size-class of 10–19mm is formed largely by thin and light Clactonian notch waste flakes, which are considerably more frequent in BR AT5 and BR T3 (Table 3). The differences in Clactonian notch waste flakes frequencies do not seem to result from hominin activities. Clactonian notches from which they were detached were found in all excavated areas, thereby suggesting a post-depositional origin for this phenomenon.

Also noteworthy is low quantity of chips and fragments smaller than 1cm in all the excavated areas at Bizat

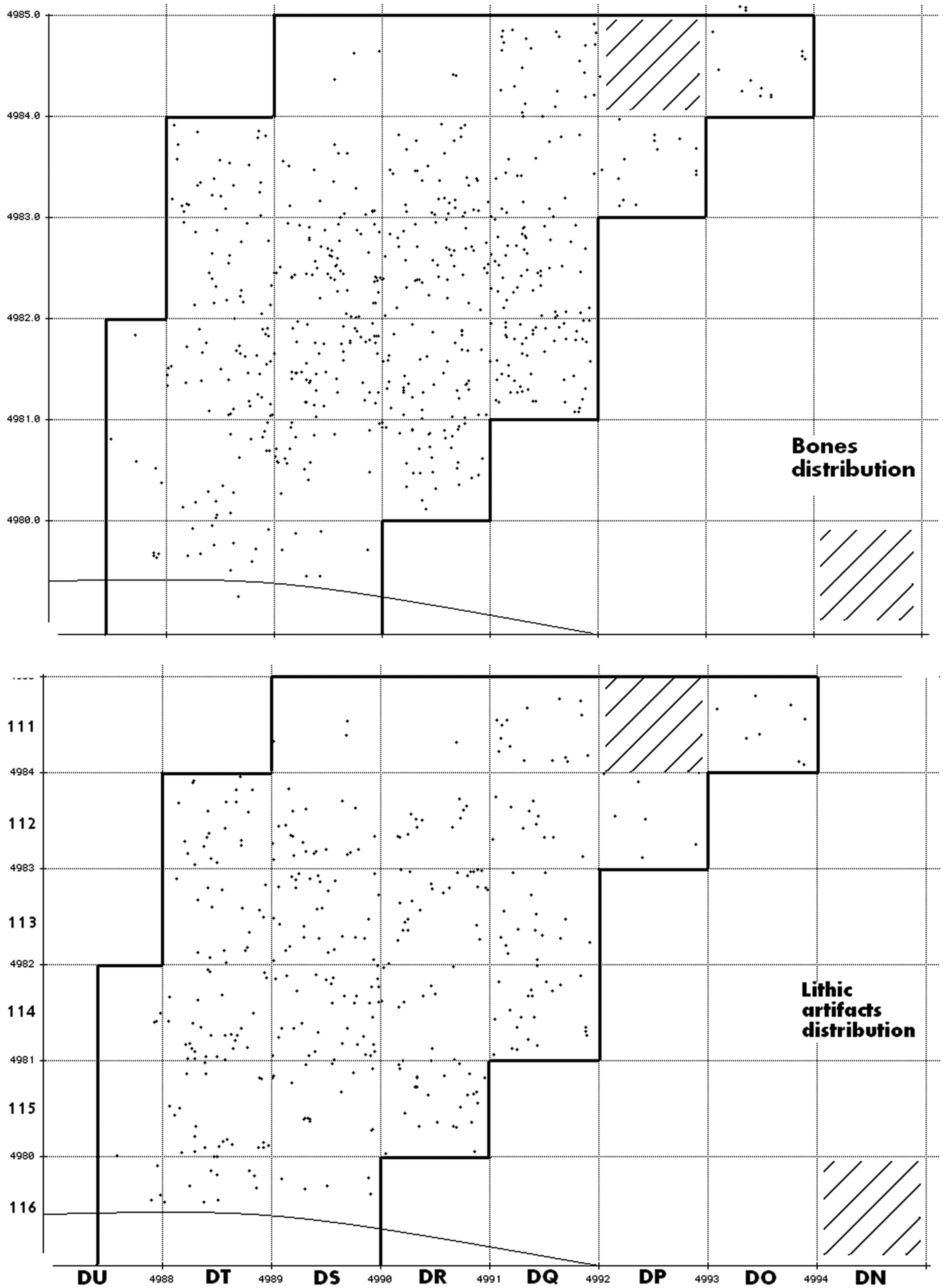

Figure 12. Horizontal distribution of artifacts and bones in BR AT5. The thin curved line marks the edge of the erosion slope.

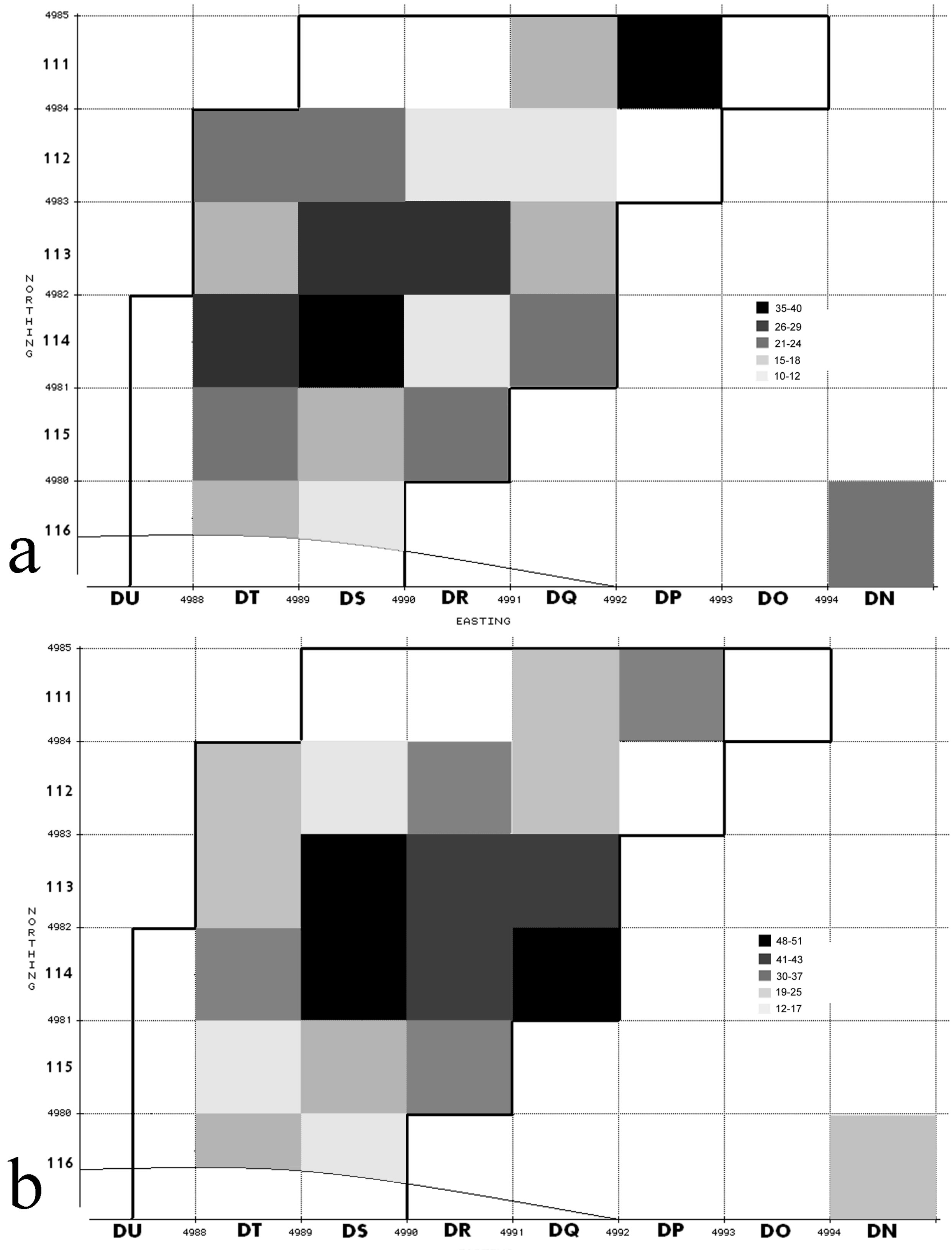

Figure 13. Density distribution of artifacts (a) and bones (b) in BR AT5. Note: the numbers in the legend indicate the number of artifacts/bones in each density group. The thin curved line marks the edge of the erosion slope.

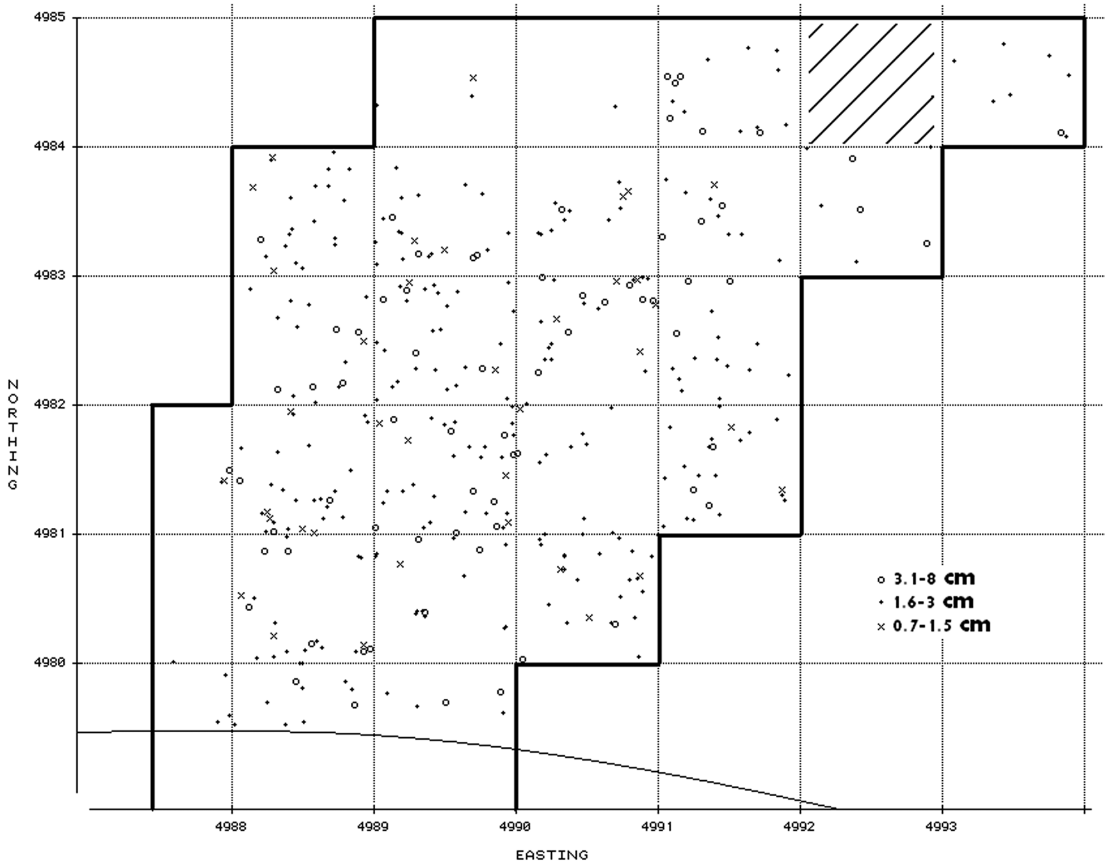

Figure 14. Horizontal distribution of the artifacts according to size-groups.

Ruhama (261 in BR AT5 from sample of 6m^2; 138 in BR 1996, from sample of 4m^2), despite sieving with 1mm mesh. If at least some knapping did take place at the site, as the composition of the assemblages suggests, then according to knapping experiments, the number of pieces smaller than 1cm is expected to be higher (Delagnes et al. 2006; Schick et al. 1991).

Both deficit in chips and variation in Clactonian notch waste flakes frequencies might be connected to post-depositional winnowing of small particles during the burial of the site. Stratum 4 contains higher proportions of coarse sand and very little clay, when compared with Stratum 5. This suggests that the fine fraction was either deposited elsewhere or postdepositionally winnowed. Micromorphological evidence of seasonal waterlogging (indicated by the presence of pseudogley) suggests that the removal of sand-sized material from the surface might respond to a complex process of combined seasonal deflation and low energy deposition. These processes may cause the displacement of small and light artifacts as well.

Secondly, the bones identifiable to species or body size-class were plotted according to skeletal parts. Although no clear anatomical articulation was noted during fieldwork, the distribution of several fragments hinted at the possibility of some articulated elements disintegrating in place (i.e., two concentrations of antelope teeth from the same jaw that were found isolated, but in proximity to each other; and, a concentration of antelope rib fragments including one conjoin consisting of two fragments with ancient fractures found 80cm apart from each other) (Figure 16). Two additional conjoins, one consisting of two tibia fragments of a middle size ungulate, and the other—of two antelope calcaneus fragments—were found. The spatial distribution of the bones and the conjoins indicates that the faunal assemblages are largely in primary deposition.

Also, hominin activities may create concentrations of functionally-related artifacts (e.g., concentrations of tools, pieces with use-wear signs, sharp flakes, etc.). The distribution of artifacts by groups that comprise the lithic assemblage is presented in Figure 17 (the definition of lithic categories is presented in Appendix 1). Because the majority of the distribution maps reveal no distinctive patterns, only general maps are presented here. Overall, the artifacts from different groups are distributed over the entire excavated area and do not form clusters or concentrations that can be interpreted as distinct activity areas. Except for the group of five Flaked Pieces (FP's) on the boundary between squares DR114–115 (see Figure 17), no correlation between and within different groups of artifacts was detected.

Finally, knapping should create concentrations of artifacts that belong to the same raw material type. Six chert types were identified in BR AT5. The raw material types correspond with the types previously identified in BR 1996 (Zaidner 2003a). Raw material distribution maps demon-

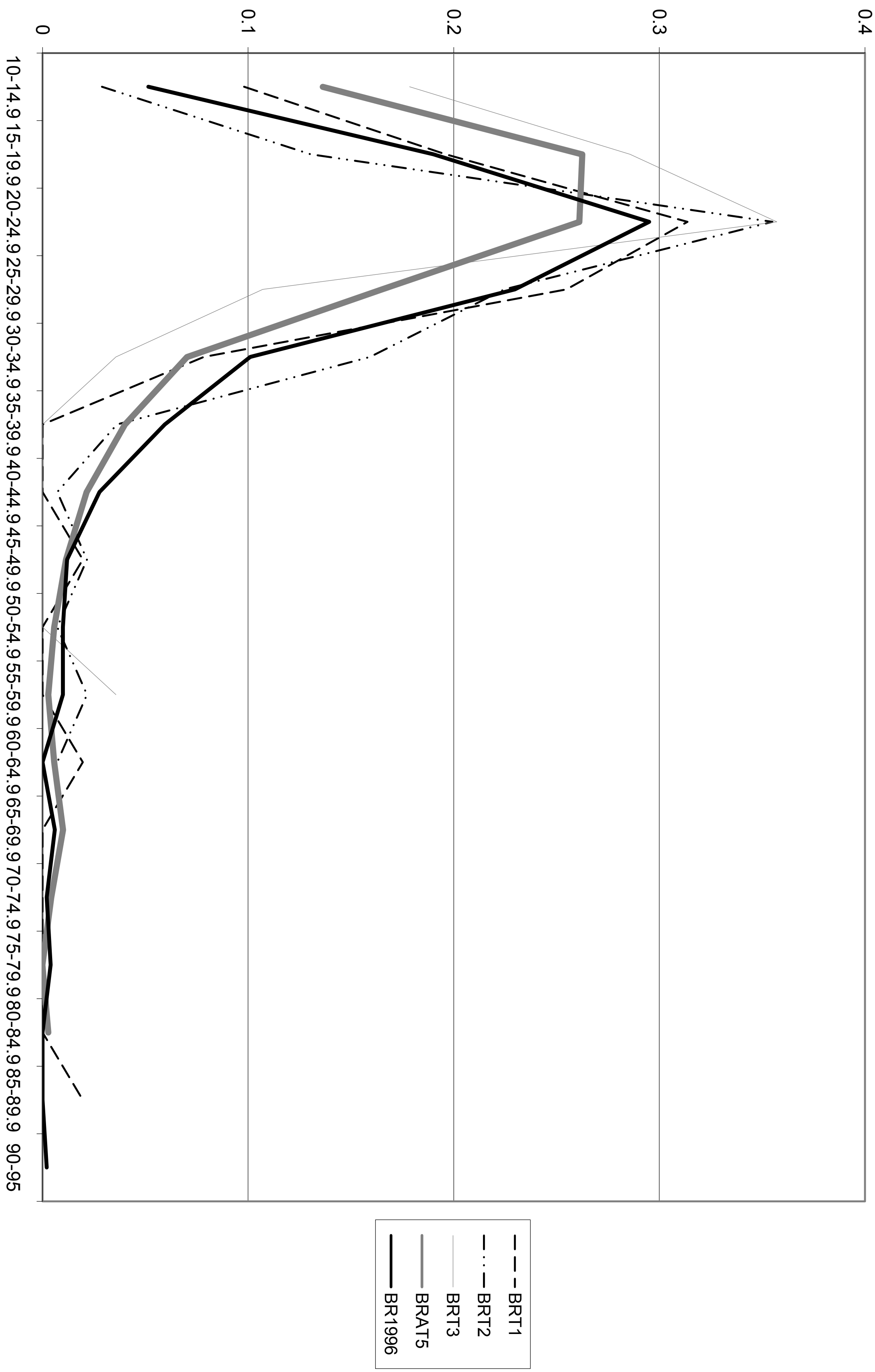

Figure 15. Distribution histogram of the maximum length values of the artifacts from all excavated areas.

TABLE 3. COMPOSITION OF THE LITHIC ASSEMBLAGES.

		BR AT5		BR 1996		BR T1		BR T2		BR T3		TOTAL	
		N	%	N	%	N	%	N	%	N	%	N	%
Pebbles		19	2.7	24	2.4	5	11.1	8	5.4	1	3.6	57	3
Anvil		-	-	-	-	1	2.2	-	-	-	-	1	0.1
Flaked Pieces	Pebbles with few removals	8		14		3		5		-		30	
	Cores	23		22		1		8		-		54	
	Exhausted cores	7		33		2		4		1		47	
Sub-total		38	5.4	69	6.9	6	13.3	17	11.4	1	3.5	131	6.9
Detached Pieces	Complete Flakes	89		93		2		15		4		203	
	Other	208		306		19		45		10		588	
Sub-total		297	42.4	399	40.2	21	46.7	60	40.3	14	50	791	41.3
	Flaked flakes	2		21		-		4		-		27	
	Anvil flakes	58		114		-		17		1		190	
Further Knapped Flakes	Clactonian notches	68		139		5		18		-		230	
	Modified flakes	77		157		4		19		4		261	
Sub-total		205	29.2	431	43.4	9	20	58	38.9	5	17.9	708	36.9
Clactonian notch and retouch flakes		137	19.5	20	2	1	2.2	3	2	7	25	168	8.8
Chunks		5	0.7	50	5	2	4.4	3	2	-	-	60	3.1
Total		**701**		**993**		**45**		**149**		**28**		**1916**	

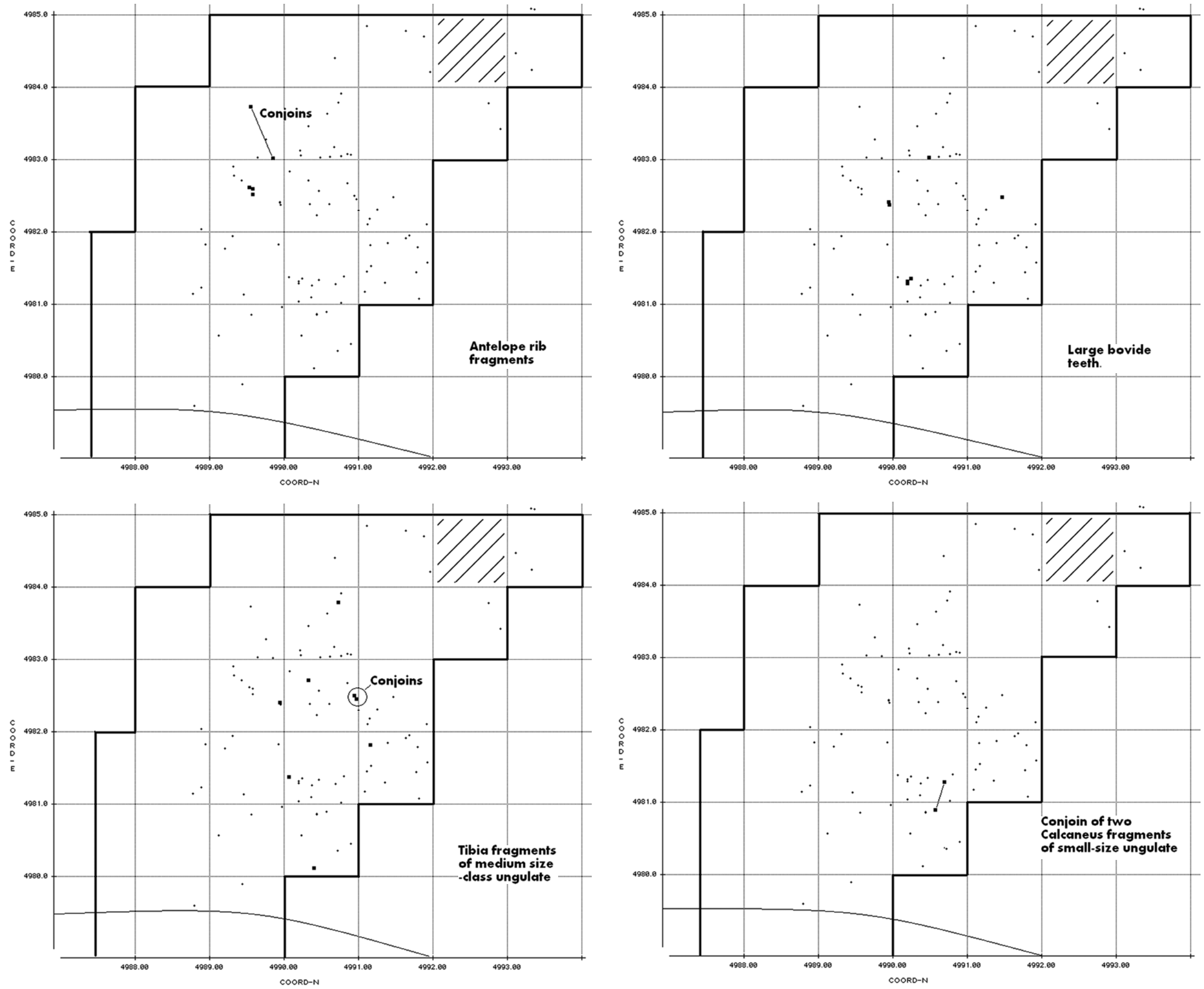

Figure 16. Distribution of bones identified to species or size-class. Note: the black rectangles mark a cluster of bones of the same species that probably belong to the same specimen or conjoins.

strate that artifacts are scattered over the entire excavated area and, with one exception, do not form areas where only one type of raw materials prevails (Figure 18). The exception is a group of Mishash chert Detached Pieces (DP's) in the northeastern square of the excavated area, which otherwise contains only one Eocene chert artifact. The attempts to refit the artifacts within the group were unsuccessful. The distribution maps of two major types of raw material in BR AT5, Mishash chert and Eocene chert (Group 1) show a scatter of Detached and Flaked Pieces that may reflect a knapping area. The smaller assemblages that provide better integrity and resolution show distribution patterns not characteristic for knapping areas. The distribution patterns of Eocene chert (Group 4) and translucent chert demonstrate that FP's are grouped together and isolated from DP's. Assuming that FP's were not removed by hominins, this sort of spatial arrangement does not correspond to knapping spots (e.g. Newcomer 1980; Schick 1986; Toth 1982).

Systematic refitting attempts have not yet been conducted within the BR AT5 and BR 1996 areas. Hopefully, in the future they will provide additional insights into the spatial organization of the site and the site formation processes. As demonstrated by one conjoin of two flake fragments found in BR T3, refitting is feasible. The conjoin consists of flake probably broken on an anvil. Since the artifacts in this trench were collected in quarter meter squares, we are able to determine that the maximum distance between the two pieces is no more than 150cm.

Overall, the horizontal distribution of the bones and artifacts does not indicate large-scale disturbance events. The remains are largely in primary deposition, though the deficit in small chips probably resulted from post-depositional winnowing. Several cases of bone conjoins and elements preserving the traces of anatomical articulations show that bones were accumulated on place by hominins and that post-depositional bone attrition was taking place at or near the position where they were found during the excavations.

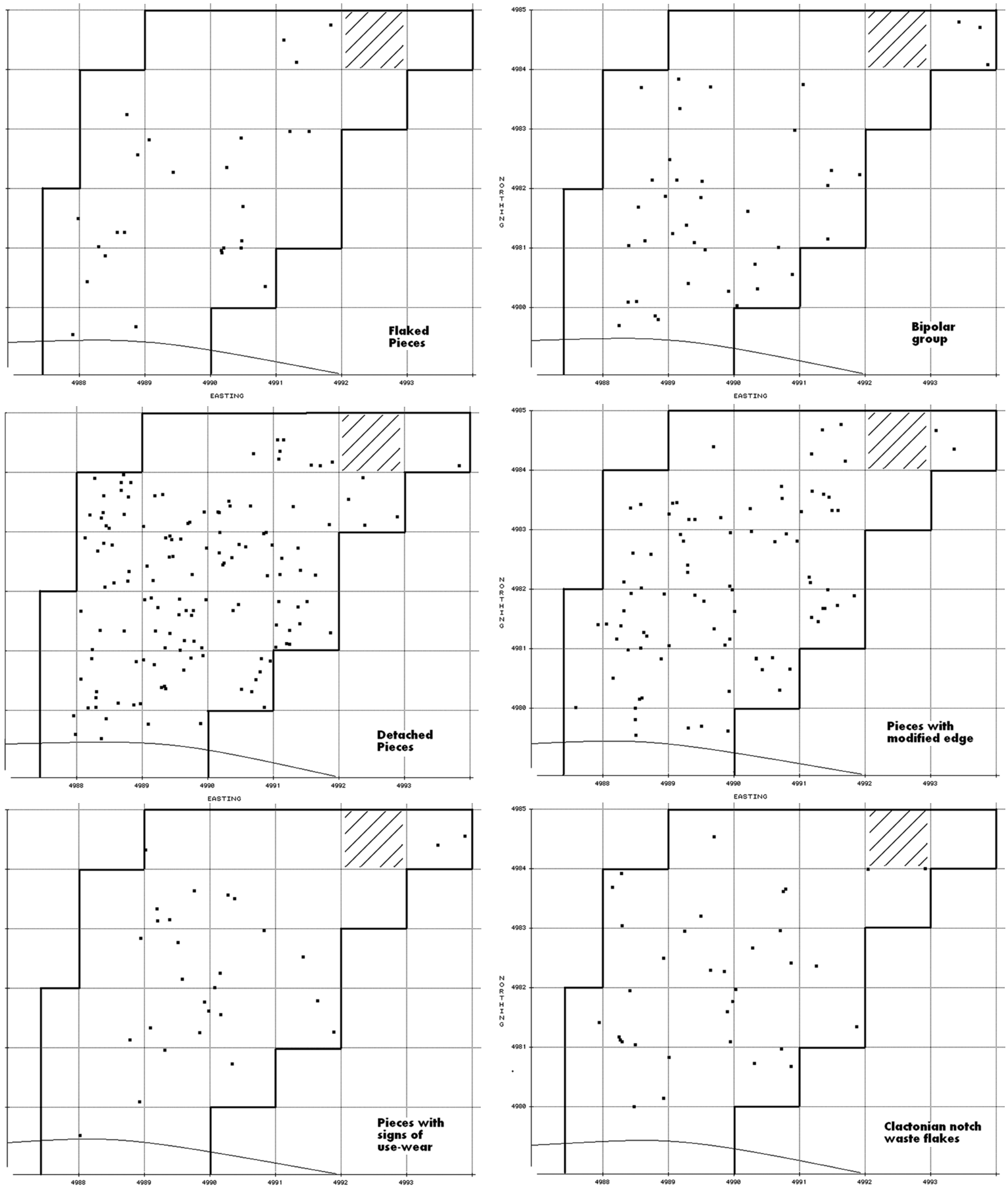

Figure 17. BR AT5. Horizontal distribution of artifacts by groups that compose the lithic assemblage. Note: the bipolar group includes flakes and cores with impact signs presumably caused by an anvil. The circle marks the concentration of FP's on boundary between squares DR 114–115.

The distribution of lithic artifacts shows no patterning that can be interpreted in terms of hominin use of space.

THE LITHIC INDUSTRY

The excavations conducted at Bizat Ruhama in 1996 and 2004–05 have yielded relatively large lithic assemblages. The industry was subjected to in-depth technological and experimental studies (Zaidner in preparation). Here we present a summary of the data. The lithic industry was studied using the *chaîne opératoire* approach. This approach, originally developed in studies of Middle Paleolithic and later periods (e.g., Geneste 1985, Boëda 1986, Pelegrin et al. 1988), has been successfully applied during recent years to the study of Plio-Pleistocene sites in Africa and beyond

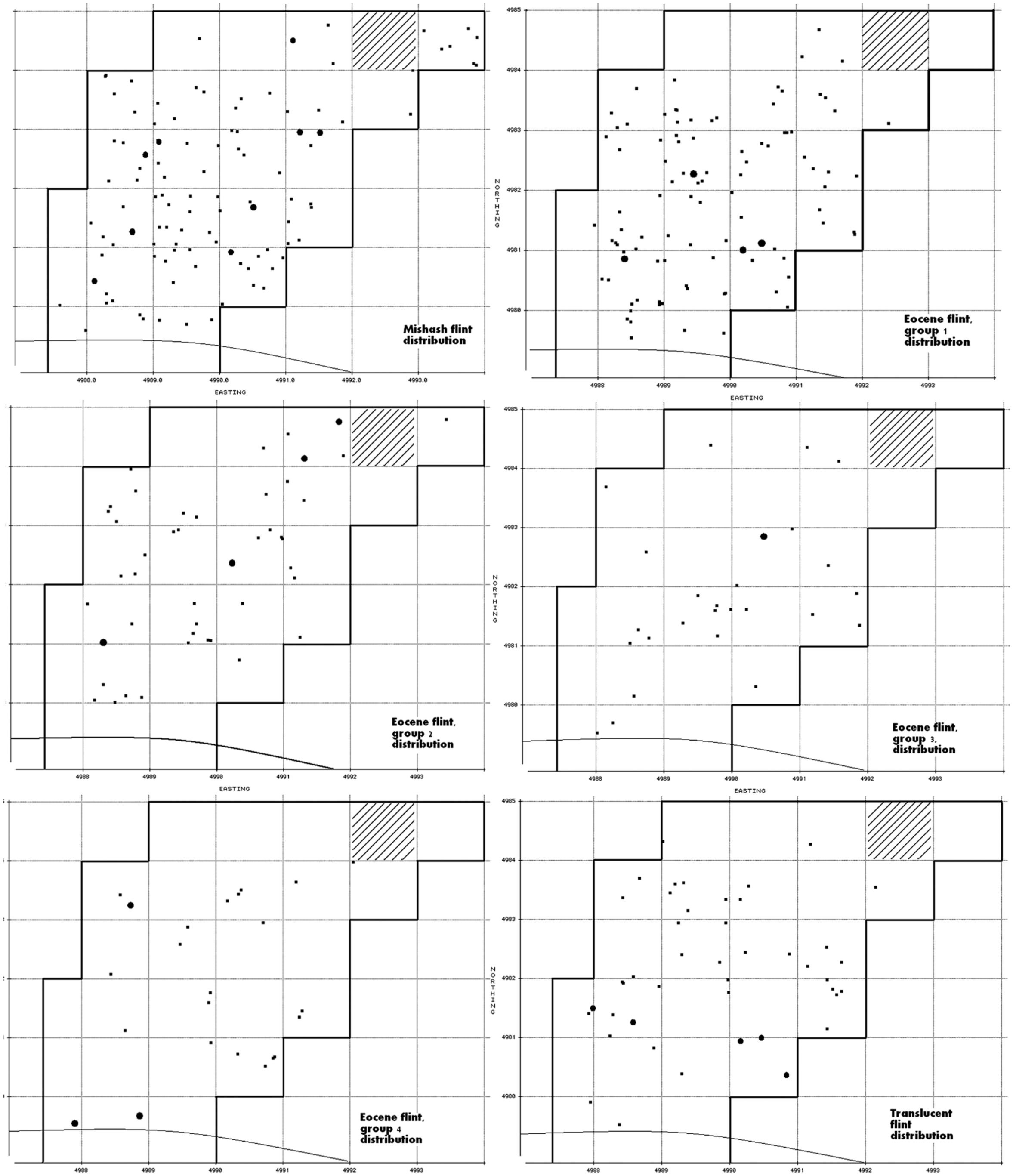

Figure 18. BR AT5. Horizontal distribution of artifacts by raw material groups. Note: large black dots are FP, small black dots are DP, pieces with modified edge and Clactonian notch waste flakes.

(Barsky 2009; Braun et al. 2009; Delagnes and Roche 2005; de la Torre et al. 2003; de la Torre and Mora 2005; de Lumley et al. 2005; Harmand 2009; Roche and Tixier 1991, 1996; Roche et al. 1999; Tixier and Roche 1995). The Bizat Ruhama lithic industry, as presented in Table 3, 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, modified flakes, etc.). The technological categories are defined in Appendix 1.

The technological study reveals similar traits for all assemblages recovered from each of the excavated areas. The resemblance in production methods and techniques, and morphology and size of the artifacts, suggests that the studied assemblages are part of the same industry. All the knapping activities performed at the site seem to be a part of a debitage system in the sense of Inizan et al. (1999: 138), i.e., they were aimed at flake production. Classical Early Pleistocene core-tool forms are exceptionally rare. Only two small cores morphologically resembling choppers were found (Figure 19: 2, 6). Bifaces, or any other forms of bifacial or discoidal knapping, also were not found.

Raw materials used at the site were chert pebbles from the nearby Pleshet Formation (Zaidner 2003a). Seven types of chert were identified, all of which occur in the vicinity of the site. The unknapped pebbles and remnants of the cortex on the artifacts indicate that rounded pebbles were used for knapping. The complete pebbles found at the site are usually of small size, but some large cores and pebbles also are present. The largest object found *in situ* is a limestone pebble (18cm long) in BR T1. A large core fragment (11cm long) was discovered in 2004 during cleaning of the section at BR 1996. The largest piece was found on the contact between *hamra* and laminated clays and sands in BR T6. It is a broken boulder weighing 3.8kg, exhibiting the scars of six small flakes removed along one of its edges (Figure 20: 7).

The sequence of pebble reduction was initiated by splitting the pebble in two halves or by removal of an opening flake (cortical flake). Some of the cores still preserve a bulb of percussion from the initial splitting of the pebble (see Figure 19: 9). The fracture plane created by the opening blow was then used as the striking platform. Flakes with cortical butts are very rare, indicating that the cortical surfaces of the pebbles were not used as striking platforms. The principal debitage method involved a frequent use of bipolar technique. The cores were placed on an anvil and first unifacially reduced around their circumference by a number of removals (see Figure 19:1, 5, 8). Elongated flakes with cortical backs struck from the lateral edges of the pebbles correspond to this stage of the *chaîne opératoire* (see Figure 20: 2–4; Figure 21: 6–7). The striking platform was usually abandoned after a few removals because of hinge fractures or loss of appropriate angles. The cores were then rotated and a new series of removals were struck from new platforms. The flake in Figure 20 (no. 5), exhibiting three unipolar scars but struck from the other side of the core, corresponds to this stage of pebble reduction. Some of the bipolar cores were rotated three or four times. The final products of this multiple rotation are cores of polyhedral and subspheroid shapes (see Figure 19: 4, 7). Most of the flakes produced in this flaking mode are thick and have steep edges. The signs of bipolar technique are evident at the distal edge of the flaking surface of the cores (see Figure 19: 1, 5, 8; see Figure 21: 1, 2, 3). On flakes, the diagnostic signs of bipolar technique include signs of opposite impacts on lower faces and crushing on the distal end of the ventral surfaces (see Figure 20: 3, 4, 6; see Figure 21: 7). The use of an anvil during knapping procedures at Bizat Ruhama is not an exceptional phenomenon in early core-and-flake industries; rather, it seems to be an integral part of the earliest technologies (Barsky 2009; Carbonell et al. 2009; de la Torre 2004; Diez-Martin et al. 2009; Gao 2000; Longo et al. 1997; Ludwig and Harris 1998; Peretto 1994).

Only three cores show more complicated patterns of exploitation with a clear hierarchy between striking platform and flaking surface (see Figure 20: 1). They show a number of unidirectional removals and signs of rectification of the striking platform and were classified as preferential surface cores.

In the next stage of the *chaîne opératoire*, many of the flakes were further modified. Flakes were frequently used as cores for the removal of thin small flakes (see Figure 21: 4, 5, 6). In other cases, they were knapped or broken on an anvil, creating a number of broken fragments. A large group of flakes were further modified either by Clactonian notching or rough trimming (see modified flakes in Table 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). Some of the Clactonian notches were shaped by relatively large removals similar in size to the scars on flaked flakes (see Figure 20: 3). It is possible that some of them are cores for the production of small sharp flakes, rather than tools.

The differences that do exist between the two main excavated areas are of economical or depositional, rather than technological character. It seems that the intensity of flaking in BR 1996 was higher in comparison to BR AT5. The frequency of identifiable (less reduced) cores and complete flakes is slightly higher in BR AT5 than in BR 1996 (see Table 3). Frequencies of categories that indicate more intensive flaking and modification (exhausted cores, anvil flakes, and modified flakes) are higher in BR 1996. The most remarkable difference, however, was recorded in the relative frequencies of the group of the smallest and the thinnest artifacts, which include products of flake knapping, Clactonian notch waste flakes, and retouch flakes. This is probably connected to varying degrees of winnowing during the burial of the different areas of the site (see above).

Another important intra-site difference is in the artifact densities between BR 1996 and BR AT5. The density varies between 90 artifacts per square meter in the former and 28 pieces per square meter in the latter. Larger areas need to be excavated to understand the significance of these marked differences. The data from Olduvai, Koobi For a, and 'Ubeidiya show that the density in Plio-Pleistocene open-air sites is usually within the same range. It rarely exceeds 30–40 pieces per meter in a horizon up to 50cm thick (Bar-Yosef and Goren-Inbar 1993; Isaac 1997; Kroll and Isaac 1984; Leakey 1971) and in only a few cases such as FxJj 20AB and FxJj i8NS in Koobi Fora, Lokalalei 2C in West Turkana, and A. L. 894, Hadar, Ethiopia (Delagnes and Roche 2005; Goldman-Neuman and Hovers 2009; Kroll and Isaac 1984) does it exceed 100 stone artifacts per square meter.

To sum up, the Bizat Ruhama industry is technologically simple, with no evidence for bifacial or discoidal knapping. The small size and rounded shape of the pebbles used at the site were probably the major factors determining core reduction technology. The pebbles were reduced on one or several surfaces with frequent use of bipolar technique. The flakes were often further knapped and broken in order to produce thin, small, and sharp flakes.

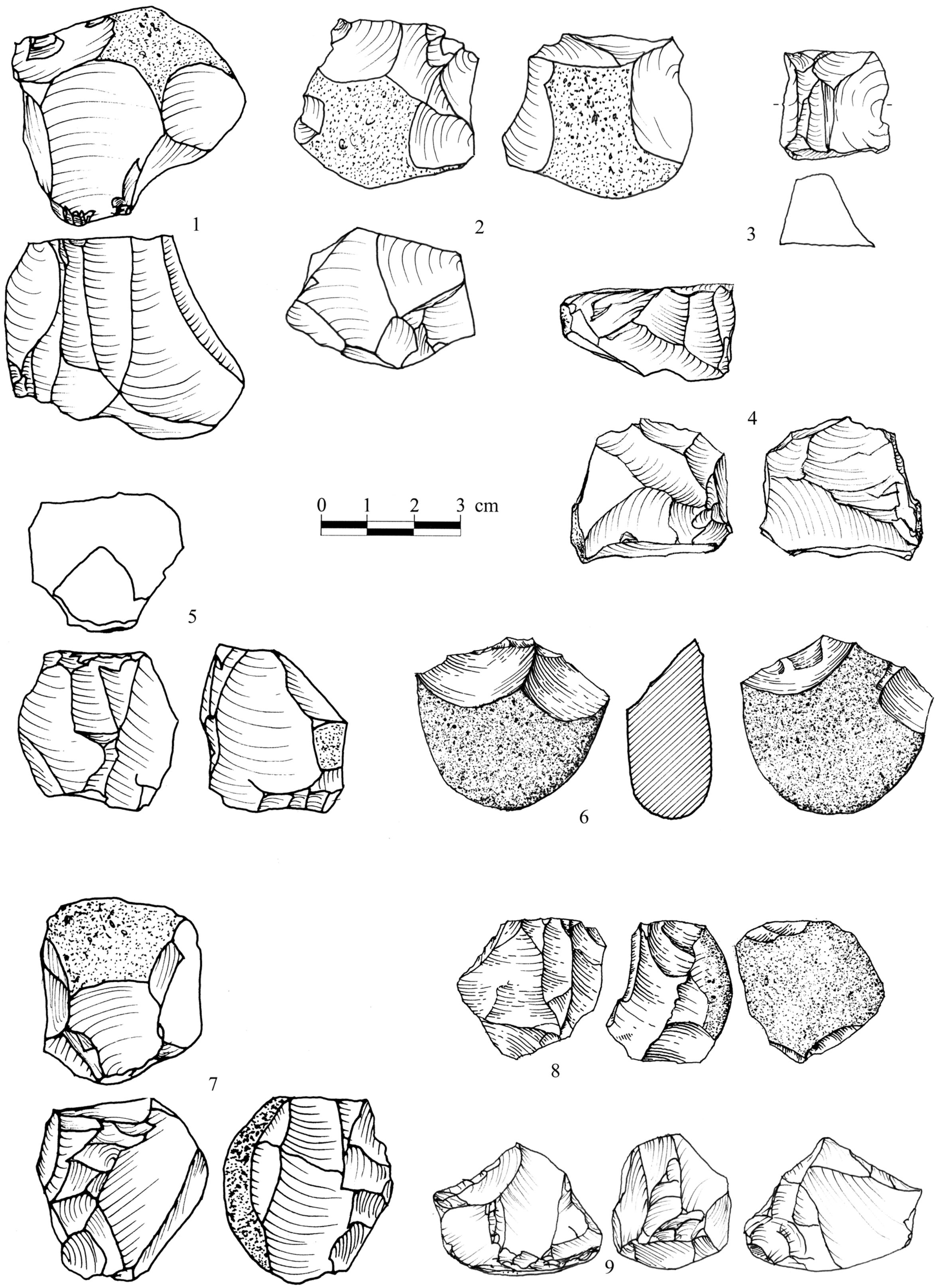

Figure 19. The Bizat Ruhama industry. Cores (1, 4-5, 7–9), choppers (2, 6), Clactonian notch (3).

Figure 20. The Bizat Ruhama industry. Preferential surface core (1), flakes (2–6), large knapped boulder (7). Note: a black arrow point on f opposite to the bulb of percussion impact signs presumably caused by an anvil.

THE FAUNAL ASSEMBLAGE

The renewed excavations at Bizat Ruhama produced a relatively sizeable faunal assemblage from BR AT5 and few faunal remains from other excavation areas. The BR AT5 assemblage also is significantly larger than the assemblage from the old excavations (Dayan in Ronen et al. 1998) and was the subject of a detailed taphonomic study (Yeshurun et al. in press). A summary of the data is given here.

The BR AT5 assemblage is composed of several hundreds of bone and teeth fragments, many of which are small splinters. Isolated teeth and long-bone shaft fragments are the most abundant skeletal elements. Bone cortical surfaces exhibit fair preservation, allowing for an in-depth analysis of bone-surface modifications. Three bone conjoins, several cases of possible former articulations (e.g., isolated teeth from the same jaw that remain clustered despite the disintegration of the jaw; see above) and the rarity of abrasion, exfoliation, rounding of edges, and severe weathering all point to rapid burial and minimal postdepositional movements of the bones. This, coupled with the provenience of the bones from a distinct level rich in lithic pieces, indicates that the faunal assemblage of BR AT5 is in primary anthropogenic context.

The assemblage is dominated by two medium-sized ungulates—*Equus* cf. *tabeti*, amounting to more than half of the specimens identified to species, and Antelopini gen. et

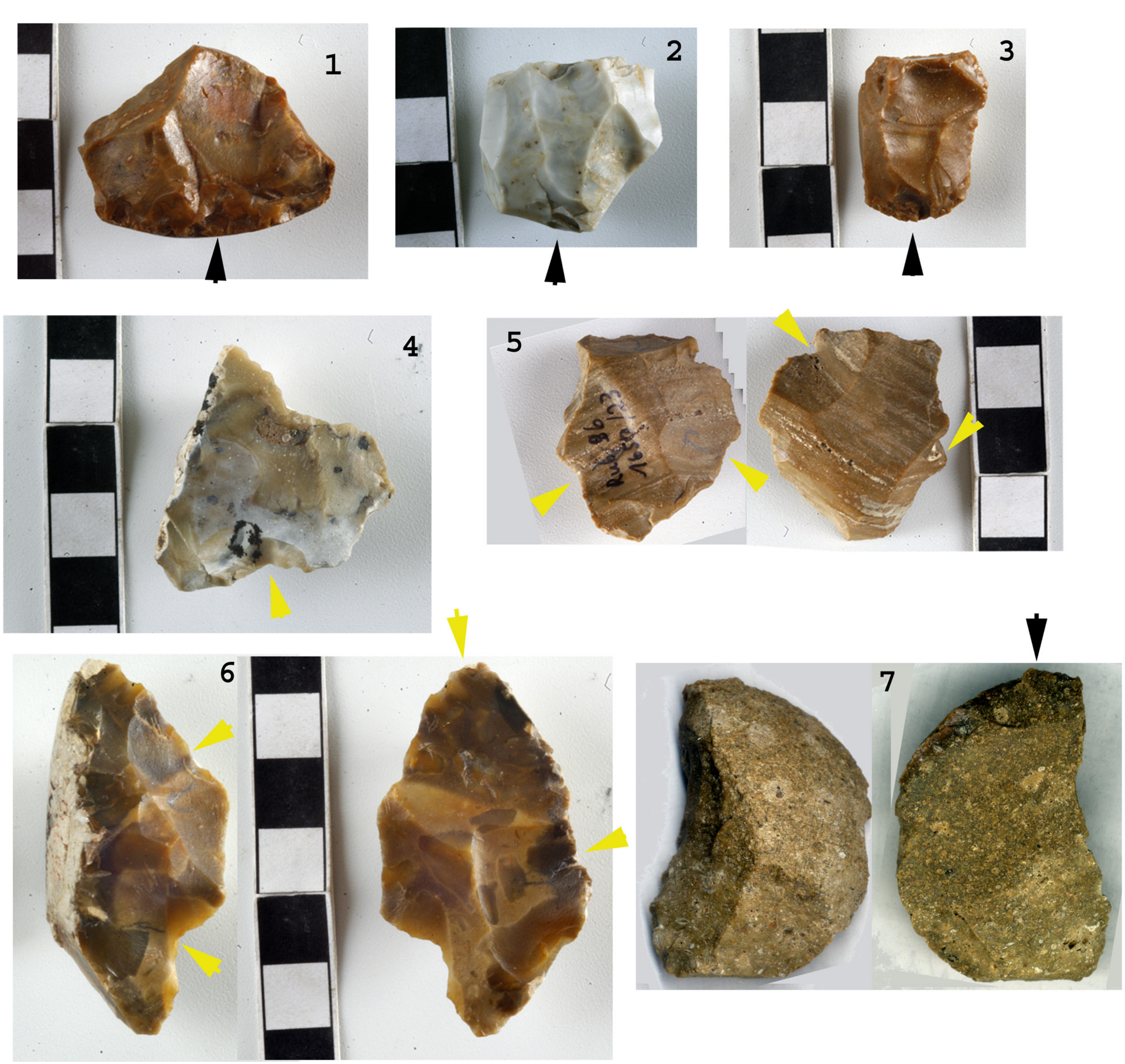

Figure 21. The Bizat Ruhama industry. Bipolar cores (1–3), flaked flakes (4–6), flake with signs of crushing presumably caused by an anvil (7). Note: black arrows point to the signs of the anvil impact. Yellow arrows mark the directions of removals on the flaked flakes.

sp. indet. (cf. *Pontoceros antiquus* or *Spirocerus* sp.), a spiral-horned small-medium antelope of Asian origin. A large bovine, probably *Bison* sp., and gazelle (*Gazella* sp.) were also identified (Table 4). Note that species identification is almost entirely based on teeth, due to the strong fragmentation of the assemblage.

All identified specimens to either species or size-class, and also all shaft fragments ≥4cm in length, were subjected to a systematic microscopic analysis of bone surfaces and to limb-bone fracture analysis. Results show that root (biochemical) marks (e.g., Dominguez-Rodrigo and Barba 2007) and trampling striations (e.g., Behrensmeyer et al. 1986) appear on ca. one-third of the specimens. The latter may be induced either by sediment compaction or by hominin and animal trampling. Both agents are expected as the faunal remains were deposited in the context of hominin and carnivore activities (see below), which could trample the bones, and within fine, abrasive sediment. As noted above, other marks of geological destruction processes are infrequent.

Bone surfaces bear some evidence for hominin modifications. One definite cutmark was found, on a rib shaft of a medium ungulate. Hammerstone-percussion marks, including pits, microstriations, and conchoidal notches, were found on five specimens, all from medium-size ungulates (11% of relevant NSP [Number of Specimens]). This figure rises to 25% if considered as a proportion of MNE (Minimum Number of Elements), meaning that at least one-quarter of limb bones were cracked open for marrow. Almost half of limb bone shaft fragments from all size classes display 'green' (fresh) fractures, and nearly all shafts retain less than half of their original circumference, supporting

TABLE 4. SPECIES COMPOSITION AT BIZAT RUHAMA AND BREAKDOWN OF THE FAUNAL ASSEMBLAGE.

	NISP		NISP teeth		MNI	NUSP
	N	%	N	%	N	
Equus cf. *tabeti*	27	57%	27	61%	3	
Gazella sp.	3	6%	1	2%	1	
Antelopini gen. et sp. indet. (cf. *Pontoceros ambiguus* or *Spirocerus* sp.)	11	23%	10	23%	2	
Bovini gen. et sp. indet. (cf. *Bison* sp.)	6	13%	6	14%	1	
Total ID to species	*47*	*100%*	*44*	*100%*	*7*	
Small ungulate (gazelle)	3					2
Medium ungulate (*Equus* / antelope)	36					22
Large ungulate (cf. *Bison*)	6					25

Note: the table specifies the number of specimens identified to species and the number of specimens identified to size class (NISP) as well as the number of unidentified but recorded specimens attributed to size-class (NUSP).

the notion that bone marrow was routinely exploited by the Bizat Ruhama hominins.

Four bones with probable carnivore gnawing marks were recorded, including a tooth score and crenulated edges, all from middle-sized ungulates. One crenulation was found on a proximal shaft of a tibia (the anterior crest) and the others on unidentified portions of shaft fragments. Unfortunately the faunal sample of Bizat Ruhama is too small for a detailed quantitative study of the hominin and carnivore marks to assess the timing of access of each agent to the ungulate carcasses (e.g., Blumenschine 1995; Dominguez-Rodrigo and Pickering 2003). However, the absence of carnivore remains in the assemblage and the systematic marrow fracturing seen on limb bones, coupled with its provenience from a hominin living surface rich in lithics, leads us to suggest that the bones represent accumulation by hominins, even if not necessarily as primary consumers.

The dominant skeletal parts in the medium ungulate group, which comprises the largest sample, are heads represented by teeth and petrosum. Limbs are less represented and axial parts are almost absent. The survival of bone parts correlates significantly with their mineral density and, overall, the densest elements in the body, which best resist a plethora of pre- and postdepositional destruction processes, are the best represented (teeth). The next densest parts, limb bone shafts, are the next best represented. Almost no elements with low density values have survived. While limb-bone ends and skull pieces are nearly absent, denser parts of these elements do exist in the assemblage (long bone shafts and the skull teeth and petrosum), indicating that more porous parts of the skeleton were indeed brought to the site but were differentially preserved and subsequently were deleted as a result of destruction processes.

To conclude, it can be suggested that the BR AT5 faunal assemblage represents anthropogenic food debris; and that ungulate heads and (less frequently) limb units were acquired by hominins, possibly following scavenging from carnivore kills. These carcass parts underwent some marrow-oriented hominin butchery and subsequently suffered from density-mediated postdepositional decay, which was largely taking place *in situ* (Yeshurun et al. in press).

DISCUSSION

The excavations at Bizat Ruhama unearthed a site complex that yielded a number of lithic and bone assemblages in a low energy depositional context. The site was systematically sampled during the survey and archaeological remains were found to occur over an extensive area in a distinct horizon 10–15cm thick. A few areas were excavated at various points where the site was exposed. From stratigraphic position and composition of the assemblages it is clear that all the excavated areas belong to one site complex. Subsequent laboratory studies provided valuable information on site formation and hominin paleoecology and technology. The information collected allows us to confront some broader questions concerning the hominin occupation at the site:

1. How large is the archaeological site of Bizat Ruhama? Does the site constitute a continuous scatter of artifacts or it is built of separated and distinct concentrations?
2. Does the site represent a single occupation episode, a number of distinct episodes or a palimpsest?
3. Is the co-occurrence of artifacts and bones related principally to human activity or to natural causes?
4. What is the place of the Bizat Ruhama industry within the Early Pleistocene archaeological record?

SITE SIZE AND SIZE OF INDIVIDUAL CONCENTRATION

The size of the site is reconstructed using the results of the survey and the sampling of the sandy layer that bears archaeological remains. Although the *hamra* is exposed at the bottom of the sequence across the entire badland field, the sand is found only in the area marked in Figure 7 indicating that it is a restricted, local phenomenon.

The sand outcrops along two channels, some 60m to 120m from one another. The sand also occurs in Trench 4, some 30–40m west of the main excavated areas. In total, the sand was found over an area of a few thousand square meters, most of which is covered by the clays of Strata 2 and 3. For instance, some 50 meters separating BR AT5 and BR 1996 are still covered by 2–3 meters of clay. Whether the area between them was continuously occupied will be resolved only when additional excavations are conducted. The results of the survey indicate that artifacts do not occur over the entire exposure of the artifact-bearing deposit; rather they appear in patches (see Figure 7). For that reason, at this stage it seems reasonable to view the site as repeated occupations in the area by a group or a few culturally related groups, over an unknown period of time.

The excavation margins did not reach the limits of the concentrations in the excavated areas. Thus, it is hard to determine what the size of the individual concentrations are and what fraction of each was sampled by our excavation. In BR AT5 it is likely that the concentration is far more extensive than the excavated area, because in square DN 116 (see Figure 13) and on the slope at the opposite side of the channel (5 meters south) artifacts and bones occur in similar densities. It is also possible that BR 1996, BR T1 and BR T2 are all parts of another concentration, since they are located only a few meters apart (see Figure 7).

ANTHROPOGENIC VERSUS NATURAL AGENTS IN THE FORMATION OF THE BIZAT RUHAMA ARCHAEOLOGICAL RECORD

The formation history of Bizat Ruhama will be better understood when a larger portion of the site is excavated. At present, one should bear in mind that the size of the largest area excavated so far is 25m^2. This is a small area that samples a hominin refuse concentration which might be bigger. Nevertheless some initial inferences can be made.

The formation of early hominin open-air sites is an outcome of a number of sometimes interrelated processes that include hominin activities (food processing, knapping, etc.), animal activities, and postdepositional biogenic, geogenic, and anthropogenic agencies. To assess the agencies accountable for the formation of the Bizat Ruhama archaeological record we applied an interdisciplinary approach, bringing together the evidence from geoarchaeological, archaeological, faunal, and lithic studies. The evidence from geological and micromorphological studies coupled with the state of preservation of the lithics and the faunal remains indicate that Bizat Ruhama is a well preserved site in its primary anthropogenic context. Although the site is largely undisturbed, it is not a pristine archaeological occurrence. The fact that lithics smaller than 1cm are underrepresented is probably due to winnowing that occurred during the burial of the site due to the combined effect of wind and surface runoff. This movement (wind and runoff) was not strong enough to create an effect of size-sorting of the larger remains. However, light reworking of the surface sand on a poorly vegetated landscape, both by wind in the dry seasons and by water in the wet seasons, could account for the local rearrangement of the assemblages, thereby masking the patterns of hominin use of space. The unpatterned distribution of the artifacts in BR AT5 might be explained by such a rearrangement or by lack of spatial patterning on the part of Bizat Ruhama hominins.

Bizat Ruhama hominins occupied an inter-dune depression within an undulating sandy landscape. Field observations combined with a micromorphological study and the patterns of vertical distribution of the finds show that the paleosurface of *hamra* was the surface that hominins occupied. The surface condition of the artifacts and bones attest to relatively fast burial of the site, which accounts for its good resolution for study of hominin behavior. Yet, it remains an open question whether each of the individual concentrations excavated represents a single occupation event or a few episodes during a short period of time.

The artifacts and bones at Bizat Ruhama are found in what seem to be hominin-induced association. First, the distribution of bones and artifacts clearly overlaps. There are no areas along the exposures of the archaeological horizon in which bones were found without artifacts. Second, the spatial distribution, the pattern of preservation, the conjoins, and the surface modification marks indicate that bone processing and postdepositional decay took place at or near the place where they were found during the excavations. Third, the faunal assemblage shows evidence for hominin modifications in the form of green-fractured limb bones and percussion marks, probably indicating marrow extraction, and one cutmark indicating butchery. Although some evidence exists for carnivore involvement in the form of several gnawed and tooth-scored bones, the absence of large carnivore remains is noteworthy. On the whole, the evidence points to an accumulation resulting largely from anthropogenic activities representing butchery of large ungulate carcass parts. The ungulate remains may have been acquired by hunting. An alternative likely scenario is the acquisition of ungulate carcass parts by scavenging from carnivore kills, accounting for the gnaw marks (as a result of carnivore defleshing before hominin involvement) and for the evidence for extraction of marrow, which may be left unexploited after carnivore consumption (Yeshurun et al. in press).

To sum up, it seems that among the factors responsible for site formation at Bizat Ruhama, hominins rather than animals or geogenic agencies played the major role. The site thus preserves significant data regarding Early Pleistocene hominin behavior and paleoecology. The results point to short-term hominin occupation and suggest that animal carcasses were processed in place, along with knapping activities.

BIZAT RUHAMA LITHIC INDUSTRY IN THE CONTEXT OF THE EARLY PLEISTOCENE ARCHAEOLOGICAL RECORD

A comparison of the Bizat Ruhama lithic industry with other Early Pleistocene sites and discussion on the place of the site within the sequence of the Lower Paleolithic is beyond the scope of this paper. Only a few general points will be presented here. Bizat Ruhama is the only Early Pleistocene site in the Southern Levant that shows no traces of Acheulian biface production or any other form of bifacial or discoidal knapping. The 2004–05 fieldwork and subsequent interdisciplinary studies finally confirmed that the absence of Acheulian tools does not result from a biased sample or post-depositional erosion. We also reject the possibility that Bizat Ruhama represents a functional variation within the Acheulian, because the site is spatially very extensive and no Acheulian technological traits were found within its different assemblages. Furthermore, the absence of bifaces cannot be explained by absence of suitable raw materials alone. Some lines of evidence show that the bifaces, if desired, could be produced. First, a few pebbles found during the excavations are large enough to shape a biface. Second, pebbles suitable for biface production were found in all exposures of the Pleshet and Ahuzam Formations sampled during the raw material survey (Zaidner 2003a, b). And, third, the lithic assemblage of the Middle Pleistocene site of Nahal Hesi, located 4km north of Bizat Ruhama provides evidence for use of local pebbles for handaxe production and gives a clue as to how the raw material problems were overcome. Nahal Hesi is one of the very few cases in the Southern Levant where limestone was used as one of the major raw material types. Limestone pebbles are largest in the Bizat Ruhama - Nahal Hesi area, and they were used in the latter for production of larger tools—choppers and handaxes (Zaidner in preparation). Other raw materials used for handaxe production at Nahal Hesi were Mishash Formation chert pebbles, which were used at Bizat Ruhama for core and flake production. In line with this evidence and taking into account that Bizat Ruhama is a large site with approximately 3,000 artifacts collected to date, it might be suggested that bifacial knapping was not a part of the Bizat Ruhama hominins' technological repertoire.

Having said that, it is clear that the technology at the site was highly influenced by the shape and size of the raw materials in the vicinity. The rounded pebbles used at the site, the majority of which are small, are hard to knap. The use of the anvil technique was one of the means to overcome these difficulties. The other way was intensive secondary knapping of flakes. The flaked flakes, the use of the anvil in flake knapping and breakage, and the production of large Clactonian notches may all be means to overcome raw material constraints and to produce small and sharp flakes.

Recent studies indicate that earliest dispersal from Africa were made by hominins possessing Oldowan-like core-and-flake technologies as early as at the beginning of the Early Pleistocene (Ferring et al. 2008, de Lumley et al. 2005), preceding the first Acheulian assemblages in Africa (Asfaw et al. 1992; Roche et al. 2003; Semaw et al. 2008). The age, the absence of bifacial or discoidal knapping, and the simplicity of core reduction techniques suggest that Bizat Ruhama belongs to one of these Mode 1 out-of-Africa sorties.

In this respect it is interesting to note the paleoecological setting of the site. It is located at the fringe of the Negev desert in a present-day semiarid environment. According to the evidence from the faunal assemblage, the environment during the Early Pleistocene was similar (Yeshurun et al. in press). No evidence for a large body of water and no amphibious or woodland animals were found, attesting to an open and uniform environment with patchy water sources and trees during the time of occupation, much like the region today. In this ecological setting, Bizat Ruhama markedly differs from other Early Pleistocene sites in the Levant and Africa, in which preferable settings were on lake-margin or riverbanks and fauna indicate mosaic environments of woodlands, open areas, and water bodies (e.g., Bar-Yosef 2006; Bar-Yosef and Goren-Inbar 1993; Bar-Yosef and Tchernov 1972; Belmaker 2006, 2009; Chavaillon and Berthelet 2004; Ditchfield et al. 1999; Feibel 2001, 2004; Feibel et al. 1989, 1991; Goren-Inbar et al. 2000; Guerin et al., 1993; Haas 1966; Horowitz 1996; Isaac 1997; Leakey 1971; Leakey and Leakey 1978; Martinez-Navarro 2004; Plummer et al. 2009; Raynal et al. 2004; Sikes 1994; Tchernov et al. 1994). Bizat Ruhama thus widens our knowledge about Early Pleistocene non-Acheulian hominins' ecological range and demonstrates that, equipped with a simple toolkit, they were capable of adapting to a broad spectrum of environments.

SUMMARY AND FUTURE PERSPECTIVES

The results of the current study of Bizat Ruhama reveal a well preserved archaeological site in its primary anthropogenic context, containing rare evidence for hominin technology, ecology, and subsistence in the Early Pleistocene. The archaeological remains appear over an extensive area in a thin single horizon. The artifacts and bones are found in a few large concentrations, the edges of which were not exposed during the excavations. Geoarchaeological data, along with the state of preservation of artifacts and bones, attest to fast burial and minor postdepositional disturbance, thereby providing good resolution for studying hominin behavior. The notion that the fauna of Bizat Ruhama is anthropogenic is important in the context of the Lower Paleolithic, and allows for the study of early hominin large-mammal butchery. The Bizat Ruhama industry is technologically simple but demonstrates hominins' capabilities to adapt to unfavorable raw material conditions. The way to overcome the difficulties imposed by raw material constraints was by employing an anvil during the knapping procedures and secondary knapping of flakes. Technological simplicity and absence of bifacial and discoidal knapping suggest that the site represents Mode 1 dispersal out of Africa. Overall, the results point to short-term occupation at an inter-dune depression, where animal carcasses were processed in place, along with knapping activities.

Future study at the site should focus on extending the excavated areas in order to understand the differences in the composition of lithic and faunal assemblages and shed more light on early hominin space organization; to retrieve larger lithic and faunal samples from all excavation areas in order to reinforce and extend our subsistence and technology conclusions; and to refine the chronology of the site by radiometric and other means. Together these will allow the illumination of the hominin behavior and ecology in one of their entry points to Eurasia in the Early Pleistocene.

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APPENDIX 1. DEFINITION OF THE TECHNOLOGICAL CATEGORIES.

Flaked Pieces (FP's) are raw material chunks from which flakes were removed (after Isaac 1986). FP assemblage includes:

1. Pebbles with 1–3 removals
2. Cores: pebbles from which more than 3 flakes were removed
3. Exhausted cores: small heavily reduced cores lacking identifiable striking platforms and debitage surfaces

Detached pieces (DP's) are all artifacts that were detached from the cores and pebbles, and which exhibit identifiable ventral faces (after Isaac 1986). DP assemblage includes:

1. Complete flakes: flakes with butt, distal, and lateral edges intact
2. Other fragments: proximal, distal, and medial flake fragments and waste

Further Knapped Flakes are flakes that were knapped, broken on an anvil, or modified after their detachment from FP's.

1. Flaked flakes: after Ashton (1992, 2007)—"flakes that have had further flakes removed from lateral, proximal or distal edges and from both the ventral and dorsal. There are characteristically between one and four removals on a single piece, but sometimes several more." (Ashton 2007: 1).
2. Anvil flakes: Anvil flakes show signs of the impacts on the intersection of ventral/lateral and dorsal/lateral surfaces that according to knapping experiments (Zaidner, in preparation) were produced during flake breakage on an anvil.
3. Modified: Detached Pieces that show signs of further modification on one or several edges. The modification consists of scars of different morphology, size and regularity. Some of the scars resemble retouch, but could be by-products of anvil breakage as well (e.g., Bergman et al. 1987; Crovetto et al. 1994; Longo et al. 1997; Peretto 1994).
4. Clactonian notch: see Bordes (1961).

Clactonian notch waste flakes are flakes detached from Clactonian notches (Inizan et al. 1999).