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The Excavations in Kebara Cave, Mt. Carmel[1]

by O. Bar-Yosef, B. Vandermeersch, B. Arensburg, A. Belfer-Cohen, P. Goldberg, H. Laville, L. Meignen, Y. Rak, J. D. Speth, E. Tchernov, A-M. Tillier, and S. Weiner

This paper summarizes the results of recent excavations (1982–90) at the Middle Paleolithic site of Kebara Cave. Work at the cave by earlier excavators is also discussed. Although analysis of the Kebara materials is still far from completed, an overview of the current stage of the investigations includes (1) a synthesis of the site's complex stratigraphy and dating; (2) a description of the spatial patterning of hearths, ash lenses, and bone and artifact concentrations; (3) results of in situ mineralogical studies of cave sediments to determine whether the observed spatial distribution of fossil animal bones is an accurate reflection of past human and/or scavenger activities in the cave or an artifact of differential postdepositional bone loss through groundwater dissolution; (4) a synthesis of the Mousterian stone tool assemblages focusing on the technology of tool production as reflected in *chaînes opératoires* (a brief summary of the site's Upper Paleolithic assemblages is also provided); (5) an in-depth taphonomic analysis of the Middle and Upper Paleolithic mammalian fauna looking specifically at the ungulates; and (6) an inventory of the Middle Paleolithic human remains recovered to date, as well as information concerning the deliberate burial of a nearly complete adult man.

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Excavations of prehistoric cave sites during the 1930s in Mt. Carmel and Galilee yielded many extremely important human remains which have contributed to the study of the origin of modern humans and to our understanding of their relationship to the European Neanderthals. Garrod's work on the Mt. Carmel caves and Neuville's on Qafzeh Cave (near Nazareth) uncovered a wealth of human remains as well as rich lithic and faunal assemblages. The lithic industries from these sites were defined as "Levalloiso-Mousterian" and were correlated with similar Middle Paleolithic industries in Europe (Garrod and Bate 1937, Neuville 1951, Rust 1950, Howell 1959).

The dating of these assemblages, as in other Pleistocene sites of the Old World, was based largely on long-distance faunal correlations. Faunal assemblages from stratified European sites were used as a scale for establishing relative chronology in the Levant. The disappearance of archaic species and the appearance of new species reflected change through time that provided a means for establishing the relative age of sites. Biogeographical considerations and the known recent habitats of similar species were taken into account in reconstructing biozones.

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The absolute dating of the Middle Paleolithic Levantine hominids was uncertain until recently, and most of them were attributed to the Last Glacial (Würm in the Alpine terminology) as suggested by Howell (1959). The phylogenetic relationships between the skeletal remains defined as Neanderthals (from Tabūn, Amud, and Shanidar) and the more modern-looking skeletal remains from Skhūl and Qafzeh were seen as the result either of hybridization (Thoma 1965) or of local evolution (Howell 1952, 1957).

The latter view prevailed in the literature until the end of the 1980s. Reviews examined the special situation of the Near Eastern fossils (Howells 1976; Trinkaus 1983, 1984*a*; Wolpoff 1980) and the possibility of interpreting them as representing two different human morphotypes (Howells 1976, Vandermeersch 1981). Howells referred to the two competing models as the "Neanderthal phase" and "Noah's Ark," the first implying continuity of evolution of local populations, the second the possibility of replacement of European populations by incoming Cro-Magnons. The resemblance between the modern-looking fossils from Qafzeh and Skhūl, labeled "Proto-Cro-Magnons," suggested their immediate precedence to Upper Paleolithic *Homo sapiens sapiens* populations.

The renewed excavations in Tabūn Cave (by A. Jelinek and his associates) and Qafzeh Cave (by B. Vandermeersch and his associates), as well as the excavations in Hayonim Cave in the 1960s and 1970s, began to shed new light on the old controversy (Jelinek et al. 1973; Jelinek 1982*a*, *b*; Vandermeersch 1982). Improved techniques of excavation (including piece-plotting and wet-sieving of sediments), together with systematic geological observations and the study of the environment of the sites, rapidly produced new information (e.g., Goldberg 1979, Farrand 1979). The paleoclimatological interpretation of the Tabūn sequence suggested by Farrand (1979) supported an earlier contention by Howell (1959), dating the entire Tabūn sequence to the Last Interglacial and the early part of the Last Glacial. Thus the hominid-bearing layer C was tentatively placed around 55,000 years B.P.

Historically, it was the analysis of the assemblages of microvertebrates which first indicated that there were problems with the accepted chronology. The late George Haas had noted in his report in Jelinek et al. (1973) the discrepancy between the assemblages of microvertebrates from layer C of Tabūn and those from the Qafzeh hominid-bearing deposits (layers XII–XXIV). He suggested that the archaic species present at Qafzeh were closer to the small assemblage described by Bate from Tabūn layers E (Acheulo-Yabrudian) and F (Upper Acheulian) but did not draw the necessary chronological conclusions. The meaning of these paleontological observations was clearly presented in a general overview of Near Eastern faunas prepared by Tchernov (1981), who assigned the microvertebrates of Qafzeh to the Early Mousterian and by this indicated that they represented the oldest known Middle Paleolithic assemblage in the Levant. By combining the paleoclimatic interpretation of the depositional events responsible for the accumulation of the stratigraphic sequences in both Qafzeh and Tabūn Caves with the relative chronology offered by Tchernov for the Mousterian biozones, an estimated date of 80,000–100,000 years B.P. for the Qafzeh hominids was suggested (Bar-Yosef and Vandermeersch 1981). The heavy criticism with which this proposition was met convinced the two of us of the urgency of the need to organize a new field project.

Kebara Cave was the obvious choice for renewed excavation. It was a cave with well-preserved deposits of Middle and Upper Paleolithic age which had already produced a wealth of bones, lithics, and even charcoal. The availability of new dating techniques such as accelerator mass spectrometry, uranium-series, thermoluminescence, and electron spin resonance was expected to offer improved prospects for dating Middle Paleolithic assemblages.

In the following pages we summarize the results to date of the excavations of Mousterian and Upper Paleolithic deposits from 1930 to the present. We also provide a full list of the Middle Paleolithic human remains that have been recovered from the site.

The Cave, Its Environment, and the Early Excavations

Mugharet el-Kebara (Me'arat Kabara) is located on the western escarpment of Mt. Carmel (fig. 1), about 13 km south of Wadi el-Mughara (Nahal Ha-Me'arot) at about 60–65 m above sea level (Israel Reference grid 1442/2182). Its arched entrance, which was essentially the same during Middle Paleolithic and early Upper Paleolithic times, faces north-northwest. The small terrace in front of the cave is formed by a huge rock collapse at least part of which occurred during the Upper Paleolithic.

The escarpment at Kebara is made of limestone of Cenomanian and Turonian age. The cave itself is formed within dolomite. About 4 km eastward, Senonian and Eocene chalks dominate the landscape. The Lower Eocene formations are rich in flint cobbles, although these often contain large fossils and chalk inclusions. Flint also outcrops in small cobbles from the local Cenomanian limestone. Nahal Taninim and its tributaries drain the immediate environment of Kebara, flowing into the Mediterranean about 3 km north of its outlet from the hills. At the foot of the Kebara cliff lies a flat terrace which resembles a Pleistocene shoreline. It was assigned by Michelson (1970) to the Tyrrhenian I on the basis of its altitude above sea level. An outcrop of *kurkar* (consolidated sandstone or eolianite) lies within 100 m southwest of the terrace.

The coastal strip in front of Kebara Cave is about 2.5 km wide. It is built on an elongated alluvial plain, extending from the foot of Mt. Carmel to two *kurkar* ridges to the west, which contain evidence of marine transgressions and regressions (Michelson 1970, Farrand and Ronen 1974, Farrand 1979). During the Last Glacial

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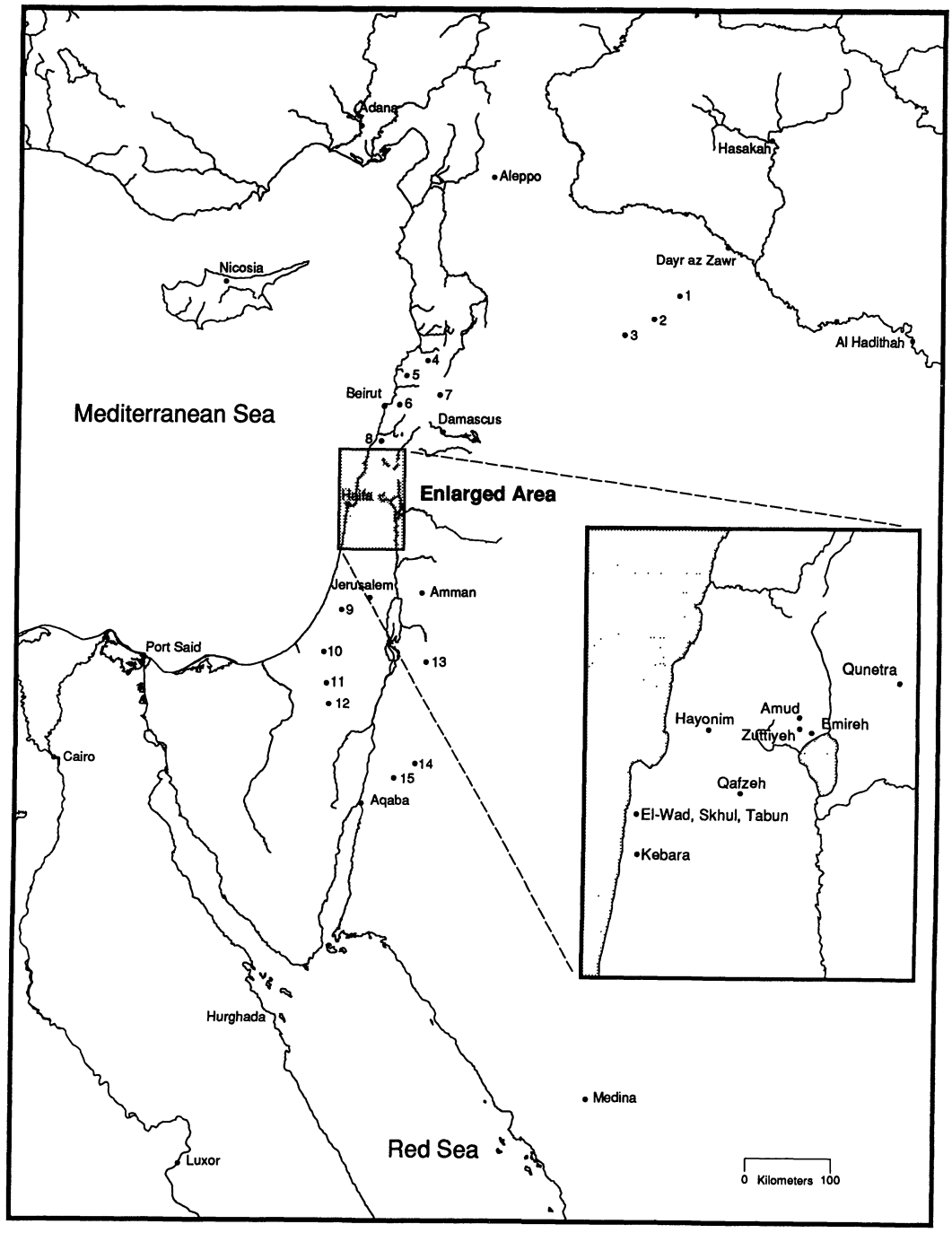

FIG. 1. *The Near East, showing the location of Kebara among other Middle Paleolithic sites.* 1, *El Kowm;* 2, *Douara;* 3, *Jerf Ajla;* 4, *Keoue;* 5, *Nahr Ibrahim;* 6, *Ksar Akil;* 7, *Yabrud;* 8, *Adlun;* 9, *Shukbah;* 10, *Fara II;* 11, *Rosh Ein Mor;* 12, *Ain Aqev;* 13, *Ain Difla;* 14, *Tor Faraj;* 15, *Tor Sabiha.*

sea level was about 130 m lower than today, which means that the coastal plain was about 8–15 km wide at this point. The modern vegetation on Mt. Carmel is the result of many generations of degradation and regeneration. It is a mosaic of *Quercus calliprinos* and *Pistacia lentiscus* with open grassy patches and intermediate dwarf shrubs growing mainly on terra rossa soil. The coastal strip has no relicts of the natural vegetation but would accommodate a more open shrub and grassy association with patches of oak trees. The sediments which constitute this narrow coastal plain accumulated mainly during the Upper Pleistocene and because of their proximity to the sea were subject to numerous vegetational transformations.

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Karstic caves in Israel, if not disturbed in historic times, were almost always filled in during prehistoric and later historic periods so that at the time of excavation one could observe only the outline of the upper part of the walls and the ceiling. Several caves, such as Tabūn, Qafzeh, and el-Wad, have been sufficiently excavated to inform us about their overall configuration (Garrod and Bate 1937, Vandermeersch 1981). From the excavations in Kebara Cave in 1930, 1951–65, and since 1982 it seems that this cavity was basically about 26 m long and 20 m wide (figs. 2 and 3). The chimney at the rear of the cave is about 18 m high. Its top outlet is partially blocked by a few large boulders, but they do not prevent some light from coming in. According to Moshe Stekelis's oral report of his first visit to Kebara in 1927, the entrance was almost filled with rubble which sloped inward. Later, when the top layers were removed, it was realized that the cave was actually wider in its deeper part than the visible outline of its walls in the upper layers. The ceiling preserved three solution domes, a fourth being the chimney. The chimney and the domes were formed along vertical joints and may end in one or more sinkholes. A small portion of the bedrock floor of the cave was uncovered in 1986 near the north wall and in 1990 in the central area. It slopes inward toward the center of the main chamber. There are some indications, based on an exploratory trench, that there may have been an antechamber at the present entrance of the cave. It is clear that the funnel shape of the cave floor had an ongoing impact on its geological history.

The first sounding near the cave entrance was made by Stekelis in 1927, but he was unable to continue. In 1930, Dorothy Garrod, while excavating the caves in Wadi el-Mughara and unaware of Stekelis's test pit, dug a small (2.5 × 2.5 m) trench in Kebara. Below the historic deposits she encountered Natufian remains and underneath them an unknown microlithic assemblage which she only later named the "Kebaran." She invited Francis Turville-Petre, who had previously excavated at Wadi Amud, to work on the site, together with C. A. Baynes. Their 1931 season lasted three months and was sponsored by the British School of Archaeology in Jerusalem and the American School of Prehistoric Research. Only a preliminary report was published (Turville-Petre 1932). Because of his untimely death in Cairo in 1942 and the death of Baynes a few years later, no further reports were available until 1954, when Garrod published a detailed description of the Aurignacian assemblages from Kebara.

The excavations of Turville-Petre extended over the entire surface of the cave from the dripline to the rear wall, an area of ca. 300 m^2 with an average depth of about 3 m (Garrod 1954:159). The stratigraphy of this

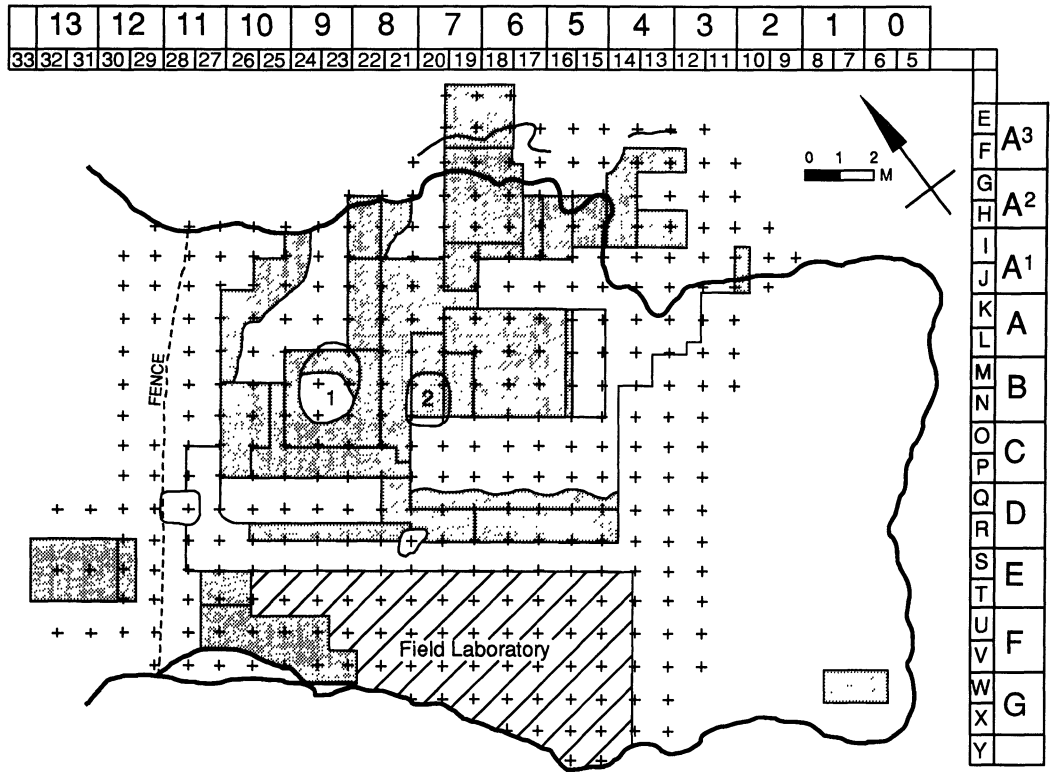

FIG. 2. *Map of the excavations at Kebara, showing both the Stekelis grid (2 × 2 m) and the recent one (1 × 1 m).* Shaded area, *squares excavated during the recent project;* solid line, *the cave contour at 3.50 below datum;* broken line to the north, *the cave wall at 6.50 below datum.*

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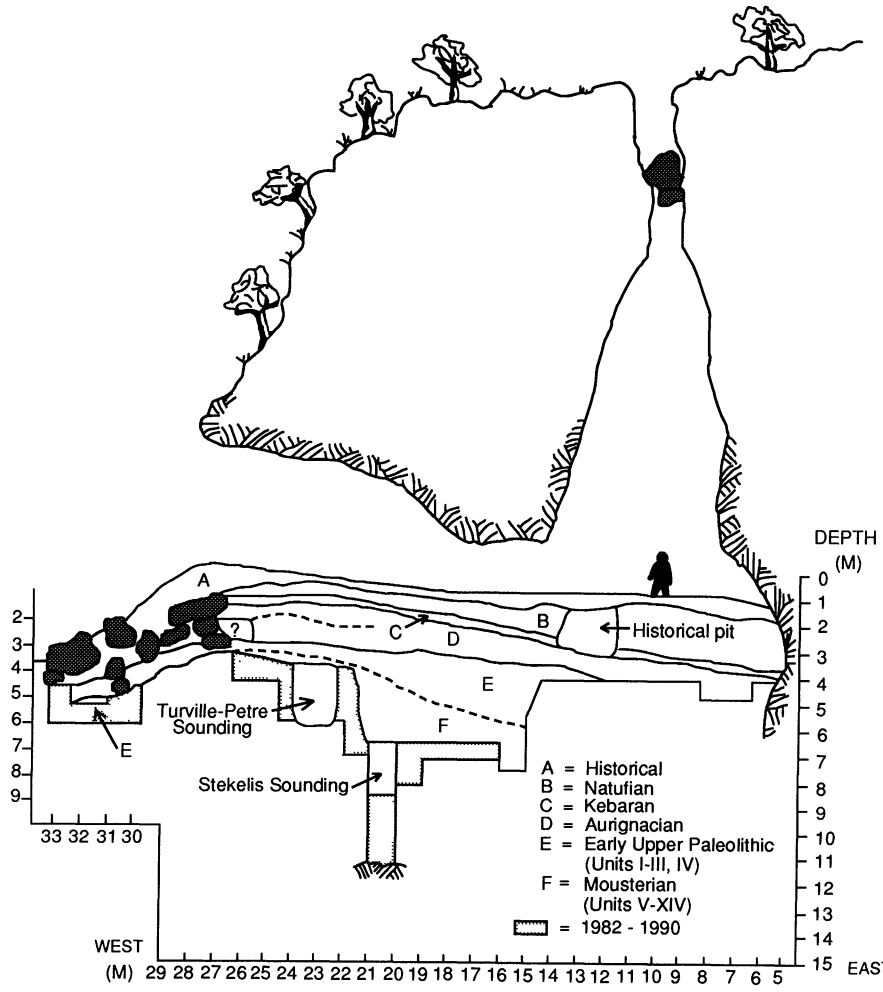

FIG. 3. *General cross section of the cave with stratigraphy as identified by Turville-Petre, Stekelis, and the recent excavations.*

ca. 900 m^3 of deposit was described as follows (Garrod 1954:158, fig. 3): layer A, Bronze Age to recent, a mixed stony layer, very variable in thickness; layer B, Lower Natufian, with black hearths in the upper part, 0–2.20 m; layer C, Kebaran (Upper Paleolithic VI), 0.20–0.30 m; layer D, Aurignacian (Upper Paleolithic IV), dry, reddish cave-earth, with a slight difference in color between sublayers D_1 and D_2, 0–0.80 m; layer E, Aurignacian (Upper Paleolithic III), dry, red cave-earth, 0–0.40 m.

During the recent series of excavations, we encountered an oval pit excavated just inside the rockfall which stretches along the dripline. The pit had been dug with picks to a depth of 6.00 m below datum. We assume that this is an additional test pit dug by Turville-Petre, probably at the end of his 1931 season. The fill in this pit contained only a few artifacts, bones (including human teeth), and a few sherds. The sediment was loose and seemed to contain fill derived from the dumps. This pit was unknown to Stekelis, who began his excavations at Kebara in 1951. The faunal remains from the 1931 season were reexamined by Saxon (1974).

The goals of the excavations conducted by Stekelis (1951–65) were to locate in situ Natufian and Kebaran remains. Unfortunately, the area at the entrance of the cave, where Turville-Petre had dumped his unsieved excavated deposits, had been damaged during medieval and later times. The large boulders of the rockfall at the entrance prevented Stekelis from making a deeper sounding, and none of the prehistoric assemblages he sought were found in place. A smaller trench on the lower terrace in front of the cave (a sounding about 1.0 m deep) yielded no Natufian remains. Inside the cave, Stekelis excavated a transversal trench (north to south) which included his squares $A^1$7 A7, B7 and 8, C7 and 8, D7 and 8 (see figs. 2 and 3). His main concern was the transition from the Mousterian to the Aurignacian. He uncovered a few Upper Paleolithic levels, but most of his excavation revealed Mousterian assemblages (Schick and Stekelis 1977).

Almost from the outset Stekelis recognized that the layers in Kebara Cave dipped eastward toward the rear wall, but he failed to adjust his digging techniques ac-

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cordingly. The grid system established in 1953 was based on 2 × 2-m squares (fig. 2). The excavations were done with small picks and hoes. Arbitrary units 10–15 cm thick were first excavated over a grid of 4 m^2; then, as the work progressed, the units were reduced to 2 m^2 and later to 1 m^2. The sediments were carefully dry-sieved, and flint and charcoal were collected, as well as all bones regardless of their apparent state of completeness or identifiability. From the beginning of the excavations, all of the bones were carefully curated in the Department of Zoology at Hebrew University in Jerusalem. The collections include thousands of small shaft splinters and epiphyseal fragments and hundreds of tiny complete skeletal elements, such as gazelle-sized (and smaller) sesamoids, carpals, and tarsals and isolated premolars and incisors. Each excavated unit received a "spit number." All the lithics were washed and sorted. As a rule, all lithics smaller than 2.0–2.5 cm (often called "waste" in the terminology of those days) were counted and thrown away. Of the unretouched debitage, a portion was discarded after it had been classified and recorded. (It is worth noting that Stekelis was here following the same pattern as most of his contemporaries in Israel.) Thus, part of what was classified as "waste" (cores, core rejuvenation flakes, flakes, blades, points, and bladelets, including Levallois elements) is lost forever (Schick and Stekelis 1977: table 2).

During his excavations, Stekelis was concerned with the recognition of features such as hearths and the definition of industries (Schick and Stekelis 1977). Following his original trench he expanded the excavation to include the central portion of the cave. The north wall was exposed and revealed a series of small domes indicating that Kebara became wider in the lower levels. In the Mousterian layers he identified several "rounded hearths" (Schick and Stekelis 1977: figs. 7–10). In addition, he observed quantities of debitage and animal bones near the north wall which he interpreted as the result of cleaning activities by the Mousterian inhabitants. In 1956, some of the large rocks at the entrance area of the cave were removed, and from the discovery of Upper Paleolithic artifacts in the levels beneath them Stekelis concluded that the main collapse had happened during the Upper Paleolithic. Stekelis's last two seasons (1964 and 1965) were conducted after a lapse of seven years. In these seasons most of his work was concentrated in the Mousterian layers; he excavated a final deep sounding in square B8 (now M, N20) to a depth of 8.59 m below datum. The major discovery of these seasons was the skeletal remains of a baby (8–9 months old) found not far from the north wall (square $A^1$6 or I 18). These were later published (Smith and Arensburg 1977). The age of this layer was estimated by Stekelis at 50,000–60,000 years B.P. Through the years he sent several charcoal samples to various laboratories. The first date, run in 1953 by the Lamont Geological Observatory at Columbia University (Broecker and Kulp 1957), gave an age of 37,000 ± 3,000 years B.P. for what might be an early Upper Paleolithic deposit. The second sample, taken from the Mousterian deposits (6.00 m below datum) and sent to Groningen, resulted in two dates: Grn-2561, 41,000 ± 1,000 years B.P. (bone fraction), and Grn-2551, 35,300 ± 500 years B.P. (residual fraction of sample 2561). (These two dates are sometimes cited as independent but are actually derived from the same sample.)

Stekelis was intrigued by the question of the "Emiran culture" as a "transitional industry" from the Mousterian to the Upper Paleolithic. He rejected the presence of any such industry in Kebara (Stekelis 1956) and collected Emireh points, the "guide fossil" of this "transitional industry," in both Mousterian and Upper Paleolithic layers (for details see Schick and Stekelis 1977: 110–13). (His contention that this point occurred in both Mousterian and Upper Paleolithic contexts has recently been refuted by Volkman and Kaufman [1983] on the basis of the Boker Tachtit assemblages [Marks 1983].) Stekelis also noted the presence of bifacial retouch or removals on the proximal end of a variety of Mousterian artifacts known today as truncated-faceted (Schroeder 1969) or Nahr Ibrahim–technique (Solecki and Solecki 1970) pieces.

The rich faunal collections from Kebara were studied by various scholars. The pioneering work was by Tchernov on the birds (1962) and later on the microvertebrate assemblages (1968). The ungulates received the attention of Davis (1977), who grouped the collections into three assemblages, "Lower" and "Upper" Mousterian and Upper Paleolithic. Most common were fallow deer (*Dama* sp.) and gazelle (*Gazella* sp.). Despite the possible biases in the assemblages caused by differential preservation, sampling by humans, and so forth, he suggested that the major fluctuations in frequency monitored the environmental changes hypothesized by Bate (Garrod and Bate 1937) and recently accepted by Garrard (1982).

In 1968, following Stekelis's untimely death, two of us (O.B.-Y. and E.T.) jointly conducted a short field season in order to establish the gross stratigraphy of the Mousterian deposits in Kebara and to enable Tamar Schick to study selected units from the Stekelis excavations.

The aims of the excavations at Kebara in the 1980s included (*a*) study of the detailed stratigraphy and site formation processes, (*b*) dating of these ancient deposits, (*c*) study of the faunal assemblages, their spatial distribution, and the taphonomic processes responsible for their accumulation, (*d*) analysis of anthropogenic aspects such as the spatial distribution of ashes, hearths, artifacts, and bones and investigation of the technical attributes of the lithic assemblages through an analysis of the operational sequences by which blanks were obtained, and finally (*e*) the discovery of additional human remains. Needless to say, not all of these objectives were achieved.

We began in 1982 by arranging a 1-m grid system which essentially corresponds to Stekelis's grid with only minimal distortion (up to 15 cm) (fig. 2). The same datum level was used, and all the measurements are below zero (i.e., minus levels). The excavation was carried out in quadrants of 0.5 × 0.5 m within each square meter, and the maximum excavated thickness of a unit was

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5 cm. The excavated units in most cases followed the visible stratigraphy. Most artifacts larger than 2.5 cm were recorded in three coordinates. Those which were missed were later registered in the inventory with reference to the square, the subsquare, and the depth of the excavated unit. Small debitage pieces were kept in paper bags and weighed. All bones were recorded by excavated unit except in the central area, nicknamed the *décapage,* where the technique of "horizontal excavation" was practiced and all bones were piece-plotted. All sediments were dry-sieved, and most were also wet-sieved through 3-mm and 1-mm mesh. Numerous excavation units with charcoal were floated in water and the carbonized residues dried inside the cave.

During nine seasons of excavations all the previously damaged sections of the Stekelis excavations were straightened, thus enlarging the central area. Near the north wall (fig. 2) the excavation was expanded in order to clear the unconformity observed in the west profile. Here, following the tilting of the Mousterian layers, an erosional channel that abutted the wall was refilled with later deposits (mainly containing Mousterian implements) designated as unit R. The crack between the wall and this later fill contained Upper Paleolithic artifacts, sometimes deposited 4 m below their original surface. Therefore, the material from these squares was separated from the rest of the excavated units. It seems that unit R did not pass the rocky protrusion in squares H15, 16. Any reference to the area of the north wall here excludes unit R and applies only to the in situ Mousterian deposits. In this area bedrock was reached (squares F, G, H17, 18, 19) at 9.5 m below datum. Stekelis's deep sounding was enlarged—this is how the new burial was uncovered (Bar-Yosef et al. 1986)—and deepened to reach bedrock at 11.5 m below datum (squares L, M20). Additional Mousterian deposits were excavated toward the entrance (squares M, N23, 24), where the previously unknown sounding of Turville-Petre was exposed, thus limiting the extent of our excavation. The largest "horizontal" exposure was the *décapage.* Intrigued by what Stekelis had called "hearths," we opened a continuous surface of about 12 m^2, where we found hearths and ashy lenses that contained some artifacts. Most of the bone concentrations, numerous lithics, and especially small debitage were, however, found beyond the hearths, toward the north wall. It was in this area that mineralogical analyses indicated that the distribution of bones and lithics had not been affected by diagenetic processes. Near the entrance, adjacent to the south wall, a small excavation revealed intact stratified lithics and bones of Upper Paleolithic age, and a trench outside the current dripline confirmed that its current position was essentially the same in late Mousterian and Upper Paleolithic times.

Geological Observations

From our experience with cave sediments in Europe and the Mediterranean area we surmised that some aspects of the sediments and the stratigraphy would prove of more than local interest. As the excavations evolved, a number of specific depositional and postdepositional processes that strongly influenced the geological history of the cave became apparent in the sediments and the stratigraphic relationships observable in the field and in the laboratory results. We therefore identified the following goals for our geological studies: (*a*) clarification of the geological history of the cave and (*b*) detailed examination of the nature of the stratigraphic relationships between the various units and the processes involved in their accumulation and degradation. By achieving these goals we hoped to provide a descriptive characterization of the deposits that would allow comparisons with other cave sites. In addition, we were interested in the correlation of the sediments within the cave with those of the exterior. Several sandstone ridges between the cave and the sea were thought to be tied to glacio-eustatic changes of sea level, and we wished to establish this correlation. Similarly, we wanted to evaluate whether the sediments and sedimentary processes had climatic implications which would not only contribute to our understanding of Pleistocene climatic changes in the Levant but also provide a background against which to examine the human occupation of the cave.

STRATIGRAPHY

The sediments and stratigraphic relationships within the cave have been exposed by the cleaning and excavation of a number of surfaces and profiles during the recent excavations (Laville and Goldberg 1989, 1991). The profiles are labeled west, south, and east, and they display a sequence of Mousterian and Upper Paleolithic layers underlying the Kebaran and Natufian units excavated by Turville-Petre. We divided the stratigraphic succession into a number of "ensembles" or groups (Arabic numerals) that reflected a certain degree of homogeneity of appearance in the field. These ensembles were then broken down into semidiscrete units (Roman numerals), though the sediments within some of the units were in certain cases quite similar to each other (e.g., units IX and X); their distinction in the field was often a functional one which allowed us to relate different strata from different parts of the cave.

The west profile and the northern sector. The west profile extends for about 10 m and exhibits a total thickness of about 8 m, the lower 4.5 m of which is restricted to the deep sounding (figs. 4 and 5). Six depositional ensembles were identified in this sector of the cave.

Ensemble 6 was exposed at the end of the 1990 season (when bedrock was reached in the deep sounding) in square M20 and is about 2 m thick. It is composed of two units, XV and XVI. Unit XV is composed of finely laminated and interbedded yellow- and grey-brown silts and thin laminae of platy opaline fragments; these are intercalated with a 1–2-cm-thick lens of dark reddish-brown, organic-rich clay. Unit XVI rests upon the bedrock, which plunges to the southwest, and is comprised of well-bedded, greyish-yellow and light-brown silts that

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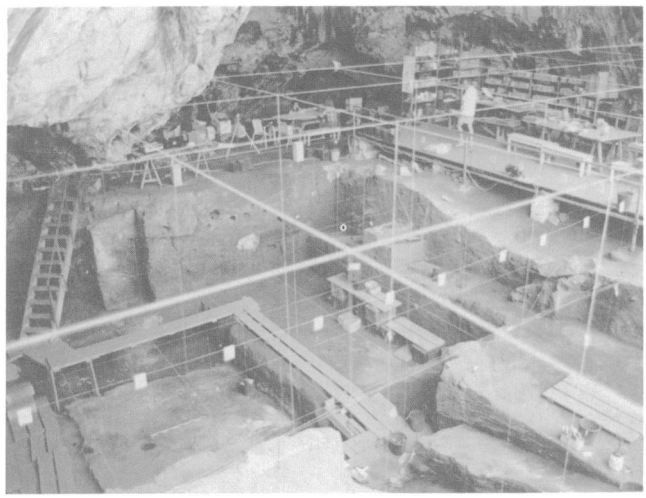

FIG. 4. *The excavations and* (right) *the field laboratory above the southern section (photo: Kebara archives).*

roughly resemble those of the upper part of XV. In the lower part, which is archaeologically sterile, the sediments appear attenuated, although they were drawn into the swallow hole. Notably, between the base of the unit and the bedrock are localized patches of reddish-brown sandstone, composed of angular, poorly sorted silty sand. Its vertical and lateral continuity is not clear.

Ensemble 5, corresponding to unit XIV, rests upon a partially phosphatized bench of bedrock that extends from the north wall. The lower part is composed of brown-grey silts, locally cemented, whereas the upper part of the ca. 1-cm-thick brownish bands is similar but richer in organic matter. The total thickness is ~2 m and it is sterile. Similar sediments occur in the deep sounding but are somewhat more variable. They include irregularly bedded brown silts and white and grey cemented silts; impregnations of yellow phosphatic blobs are common.

Ensemble 4, again, is exposed in the northern part of the cave close to the bedrock walls. The sediment is primarily a friable brownish-red sandy silt whose lower contact is erosional. It is ~30 cm thick and is sterile.

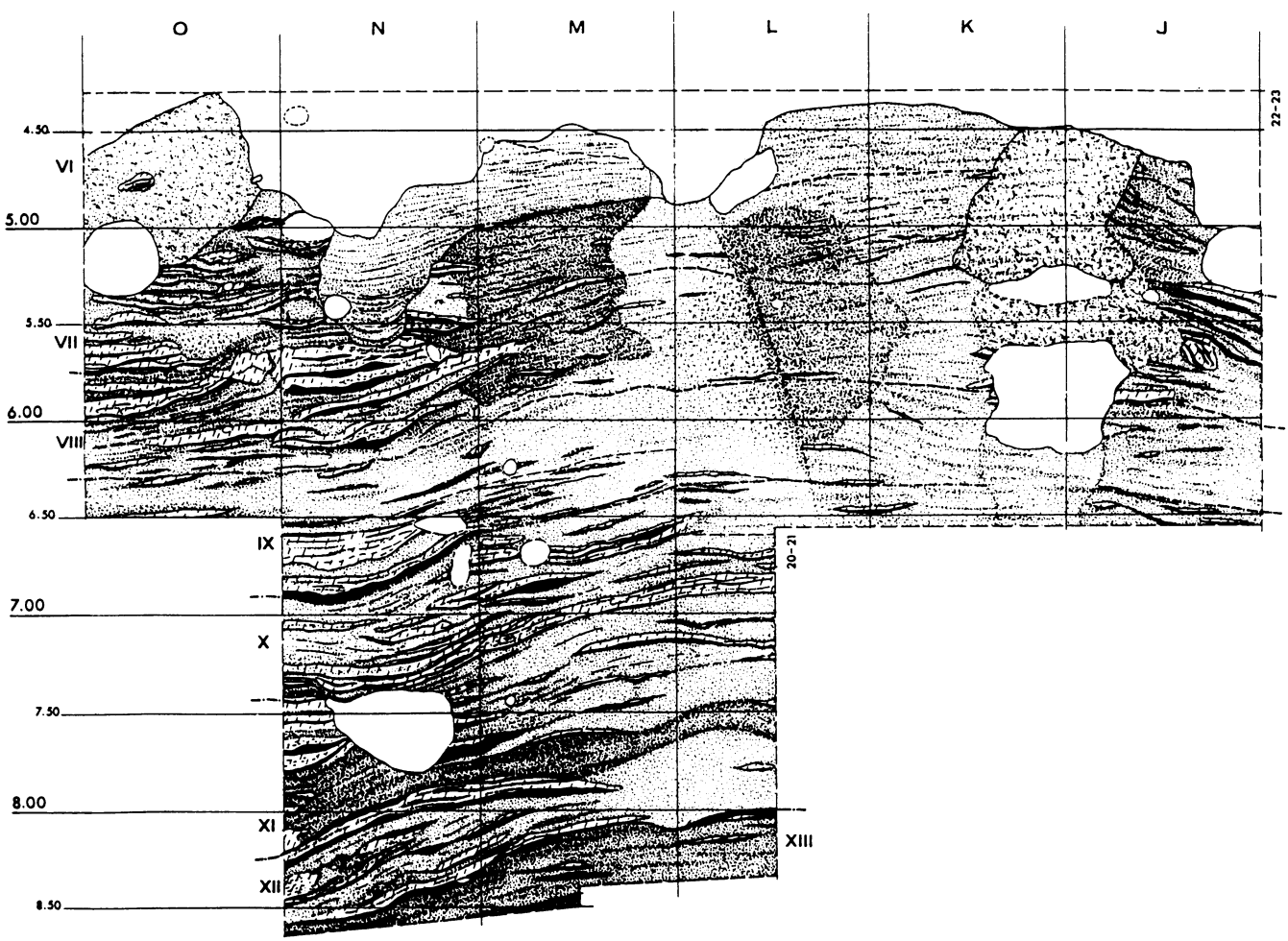

FIG. 5. *The west profile, showing the Mousterian units VI to XII (reprinted from Bar-Yosef and Vandermeersch 1991 with permission).*

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Ensemble 3 is composed of unit XIII, which is characterized by dark-brown sandy silt which contains some burned areas. These are lenticular in cross section and circular in plan. Unit XIII in the deep sounding is at least 80 cm thick; it pinches out in the northern sector about 3 m south of the bedrock wall. Here it is sharply truncated by the overlying unit XII of ensemble 2; this contact dips to the south. A few Middle Paleolithic artifacts were found.

Ensemble 2 is characterized by a succession of superimposed burned layers extending from the deep sounding (~8.50 m) up to ~5 m. In section, these take the form of either bands or lenses of white ashes that are commonly consolidated or partially cemented; between the ashy lenses are generally soft, organic rich silts. In the central part of the excavation we were able to recognize several types of hearths and ashy dispersals. In the upper portions of the ensemble, particularly in the center and northern exposures, the sediments are more or less horizontal, whereas in the lower units they are conspicuously tilted, with different dip directions that correspond to location: units exposed on the west profile dip to the south-southeast, while those in the northeast portion of the cave (e.g., square K13) dip to the east-southeast. These different dip directions reflect subsidence into particular subsurface swallow holes. In view of the overall homogeneity of ensemble 2, it was subdivided somewhat arbitrarily, usually between major ash layers.

Units XII and XI are best exhibited in the deep sounding, with more patchy exposures in excavated squares to the north and east of the *décapage* area. Units IX–VII constitute a major part of this profile, with ashy layers best exposed in its southern portion. In the center these have been cemented by secondary phosphates. In the northern part, the sediments are marked by high concentrations of archaeological material and by calcareous ashy deposits that interfinger with reddish silty clays. Prominent in these units as well as in others throughout the cave are a number of tubular disturbance features that we ascribe to burrows of rodents and other mammals. These become more prominent toward the top of ensemble 2 and are quite abundant in ensemble 1. The archaeological material is Mousterian. A Neanderthal burial was discovered in unit XII at a depth of 7.85 m.

Ensemble 1 is represented by units VI and V, which appear to fill irregular depressions and topography developed in unit VII sediments. Overall, they represent sediments that have been reworked by biological and geological activity. Burrows and tunnels are widespread and take the form of circular to elliptical holes or masses of homogeneous, loose, crumbly sediments that are occasionally roughly stratified. In extreme cases, such as in unit VI, only some of the original sediment is intact, and portions of many of the burned layers described above have the appearance of floating within a homogeneous groundmass. In the southern portion there are numerous channel-like depressions whose banded sediments appear to have been reworked by water. The upper part of the ensemble corresponds to unit V, which extends from the west profile westward toward the entrance of the cave. It consists of homogeneous reddish silty clay that is predominantly calcareous and contains numerous blocks of bedrock, particularly near the walls and at the entrance to the cave. The occurrence of numerous earthworm casts in thin section and some living earthworms suggests that the homogeneity of this unit is tied to biological activity and is consistent with the observation that the lowermost sediments of unit V are often difficult to distinguish from those of unit VI. The industry associated with unit VI is Middle Paleolithic, whereas that from unit V is basically Mousterian with a few intrusive Upper Paleolithic elements.

The thermoluminescence (TL) dates of burned flints obtained mostly from the west profile and the deep sounding were as follows (Valladas et al. 1987, Valladas, Joron, and Valladas 1989): unit VI, 48,300 ± 3,500 years B.P.; unit VII, 51,900 ± 3,500 years B.P.; unit VIII, 57,300 ± 4,000 years B.P.; unit IX, 58,400 ± 4,000 years B.P.; unit X, 61,600 ± 3,600 years B.P.; unit XI, 60,000 ± 3,500 years B.P.; unit XII, 59,500 ± 3,500 years B.P. Electron-spin-resonance (ESR) dating of tooth samples from unit X (Schwarcz et al. 1989) produced an early-uranium-uptake date of 60,000 ± 6,000 years B.P.

The south profile. The deposits exposed in the 8-m-long south profile are about 3 m thick and embody only a partial stratigraphic extension of those found in the west profile. In general, they are lighter in color and siltier and display fewer ashy or organic-rich layers. Moreover, they tend to be finely laminated, especially in the upper part. These latter sediments, however, while well exposed in the eastern part of the profile, are difficult to trace to the west because previous excavations have effectively isolated them. On the basis of composition and bedding characteristics, we recognized two major generalized stratigraphic divisions in this profile. These were subdivided into units that were given Roman numerals, as in the west profile.

Ensemble B (2 of Laville and Goldberg [1991]) is the lower of these and exhibits considerable lateral variation in bedding. Overall, it is the continuation of unit VI of the west profile; it is heterogeneous and consists of reworked sediments that rest with an eroded, distinct contact upon those of unit VII. This contact truncates several burned areas of unit VII and descends steeply (locally, ~1.5 m over a horizontal distance of 2 m) to the south-southeast, ultimately passing beneath the present excavation surface at 6.5 m. To the east these deposits consist of a jumble of intercalated lenses and masses of derived burned material, lenses and fragments of ash, and silty deposits dipping about 15° southeast. Numerous burrows, 10–80 cm in diameter, perforate these sediments. Middle Paleolithic artifacts are found particularly in the base of the unit (unit V) and decrease toward the top; some Upper Paleolithic pieces have been found at the base.

Ensemble A (Laville and Goldberg's 1), comprising units I–IV, is characterized in its lower third (units III and IV) by regular light and dark laminae, 2–3 mm thick, composed of sand and silt. Locally, these have been ce-

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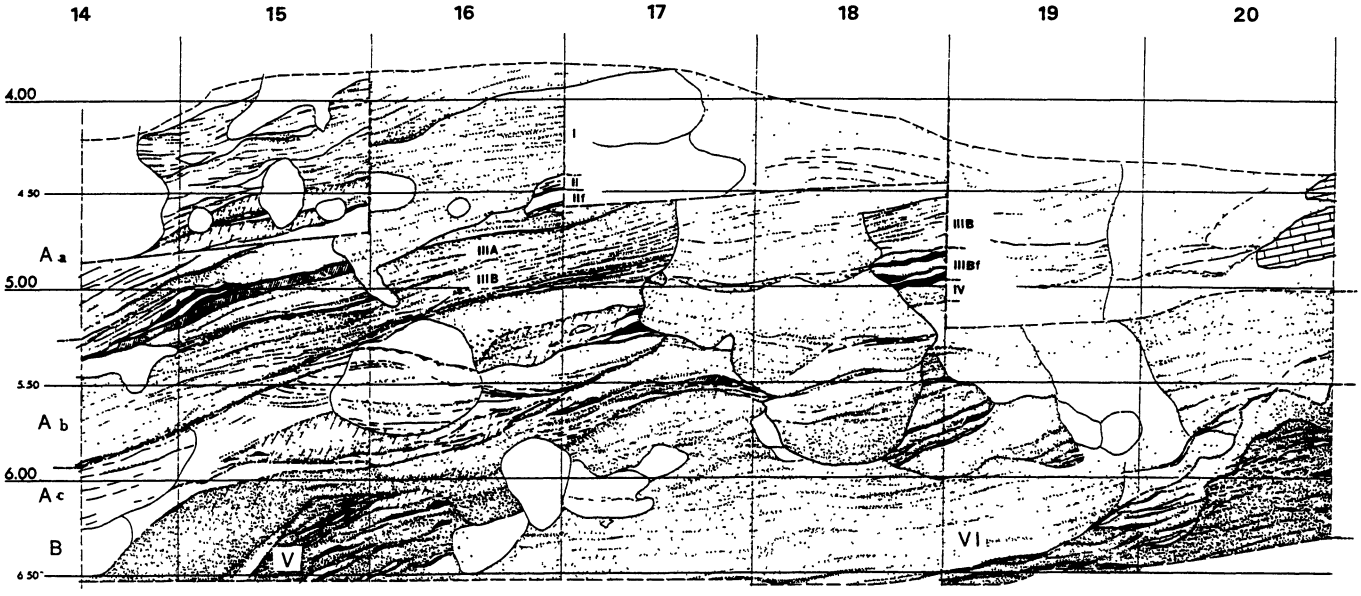

FIG. 6. *The south profile, showing the stratigraphy of the Upper Paleolithic (units I–IV) and the upper Mousterian layers (reprinted from Bar-Yosef and Vandermeersch 1991 with permission).*

mented by various phosphate minerals. In the middle of the ensemble are the remains of a few burned strata (e.g., IIIBf in fig. 6) truncated by regularly bedded silts. At the top (1a;unit I) the silty sediments are more irregularly bedded, occasionally interbedded, and have been disturbed by numerous burrows. In the central portion of the profile an irregular channel ~1.5 m across cuts into the ensemble A and B deposits and is filled with laminated, cross-bedded silts; its upper limit is poorly exposed. Upper Paleolithic artifacts were excavated from this unit.

A series of radiocarbon dates (to be published in detail separately) were obtained for ensemble A (units I–IV) and the top of ensemble B (unit V). The dates range from more than 46,000 years B.P. for unit V through 42,500 ± 1,800 years B.P. for unit IV to 28,700 ± 450 years B.P. for ensemble A. These units contain an early Upper Paleolithic blade industry (with el-Wad points in unit I) that is later on techno-typological grounds than the "transitional industry" known from Ksar Akil and Boker Tachtit (Marks 1983, Ohnuma 1988). We therefore feel that the fragmentary evidence from Kebara supports a date of 45,000 ± 2,500 years B.P. for the Levantine transition from the Middle to the Upper Paleolithic.

The east profile. The east profile has not been systematically excavated, although thorough cleaning shows that it corresponds quite closely to the units of the south profile and consists primarily of finely laminated silts whose upper part has been disturbed by a large channel (square O14) and several burrows. Because of the severe dipping of the deposits to the east-southeast, only a few tens of centimeters of the Middle Paleolithic layers are exposed at the base. A considerable portion of the east-profile deposits has been cemented by secondary phosphates.

SITE FORMATION PROCESSES

These descriptive aspects may be tied together in terms of a variety of processes.

Sedimentation. Most of the sediments within Kebara originated from outside the cave. These include the clayey sediments (terra rossa) that are well exposed near the cave entrance and present within the cave but altered by diagenesis. Another component is quartz silt and sand. These are ultimately of aeolian origin, although these size fractions may have been washed into the cave by runoff. The latter process is particularly well expressed by the well-laminated deposits in the south profile. Colluviation could have been responsible for the deposition of the nonlaminated sediments, but many of the original sedimentary structures and fabrics have been modified by postdepositional processes.

An additional and conspicuous sedimentary agent is associated with human activities and anthropogenic sedimentation. Caves act as trash containers and accumulate a variety of sediments that would not normally be associated in more common sedimentary environments. The most striking of the anthropogenic sediments are the burned layers that are so prominent in the west profile. A major component of these burned layers is plant phytoliths, and we are attempting to determine what type of combustible material was used in the creation of these layers. Preliminary observations of thin sections show that both woody and grassy vegetation was burned (Meignen, Bar-Yosef, and Goldberg 1989). Many of these layers have been modified by phosphate transformation. Less striking anthropogenic (and biogenic) effects on sedimentation are indicated by bone accumulations (well-exposed in the *décapage* area [fig. 7]) and, particularly in the northern part of the west profile, by alternat-

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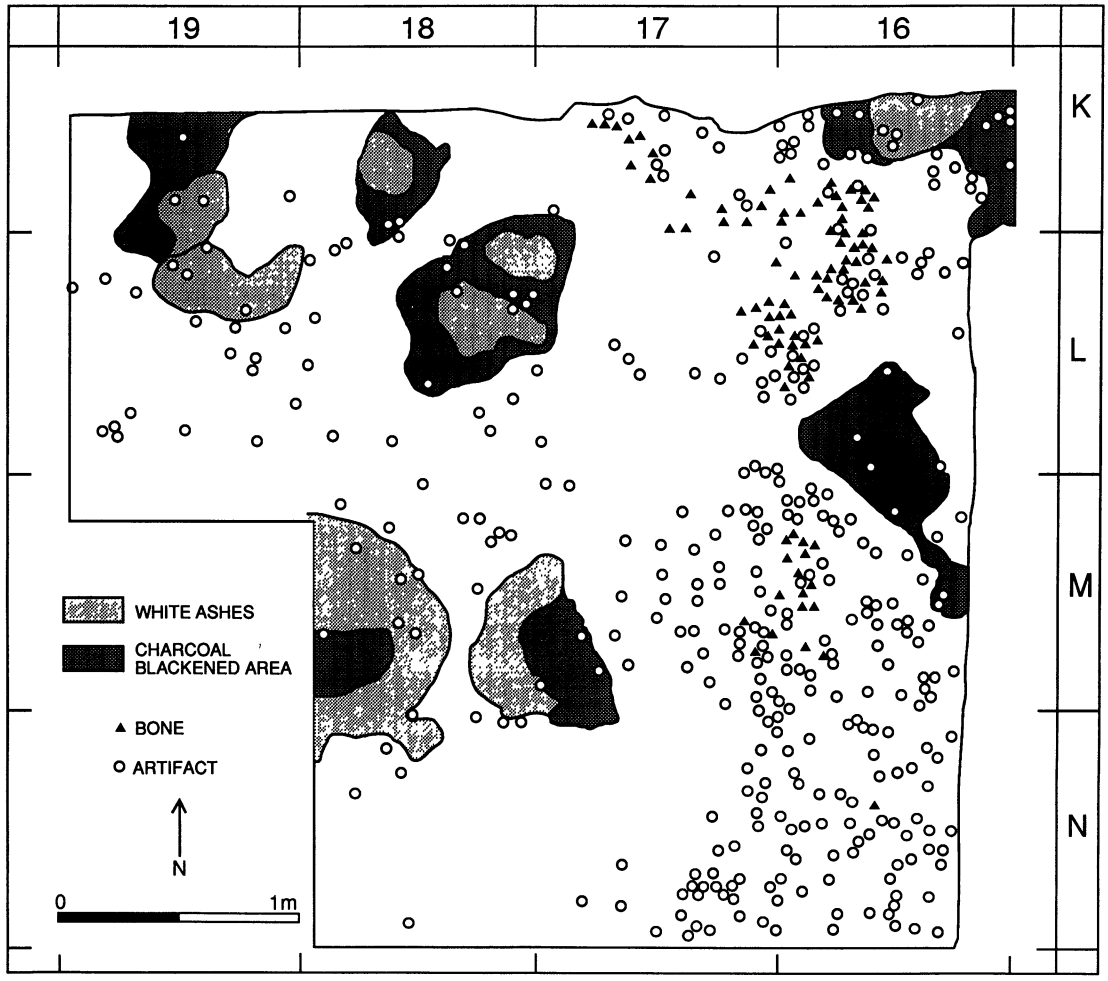

FIG. 7. *Map of one of the levels in the* décapage *area.*

ing thin bands of ash, bone, and flint. On a microscopic scale, anthropogenic effects may be evidenced by the comminuted organic matter in the fine fraction of the sediments. The latter, in particular, may be suggestive of trampling by both humans and animals.

Biological activity. Related to the above is the striking evidence of biological activity, especially in the west profile, where former deposits of unit VII have been homogenized and transformed into unit VI by burrowing or digging. Moreover, unit VI is expressed as a wedgelike trough oriented east to west. Less massive but equally clear rodent disturbances (burrows) can be found throughout the Kebara deposits, particularly the ashy layers. Whereas the smaller burrows seem to have been formed throughout the occupation of the cave, the major disturbance at the unit VI/VII boundary seems to have taken place during the final phase of the Mousterian and continued into the Upper Paleolithic (Laville and Goldberg 1989).

Karstic activity and slumping. Evidence for karstic activity is expressed by the karstic nature of the cavity itself (including several modern drips). In addition, it is clear from the dip directions of the different units that there are several loci of subsurface slumping (swallow holes). For example, burned layers in square P21 dip to the south, whereas deposits in L13 dip more to the east-southeast. Moreover, it is clear that there were several episodes of slumping during the infilling of the cave. The lower burned units in the deep sounding (IX–XII), for example, have dips of several degrees, whereas the upper ones (e.g., VII) are more horizontally inclined. This suggests that at least one phase of subsidence occurred here about 58,000 years ago. The irregularity and vertical relief of the contact between units VII and VI (about 2.5 m over a horizontal distance of 2 m) is due to slumping (see fig. 5). An additional slumping phase postdates the early Upper Paleolithic, as is shown by the strong tilting of layer IIIBf in the south profile (see fig. 6), and is younger than 42,000–38,000 years B.P. Although the exact cause of the slumping has yet to be clarified, we are exploring the hypothesis that such movements may be related to groundwater fluctuations, which in turn are influenced by climatic changes.

Secondary mineralogical transformations. Mineralogical transformations are widespread and on the whole similar to those found in other circum-Mediterranean

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caves such as Tabūn, Qafzeh, and Zuttiyeh in Israel, Arago in France, and Gorham's Cave in Gibraltar (Goldberg and Nathan 1975, Pénaud 1978). Most of these involve the formation of various phosphate minerals whose phosphate is derived from bone or from solutions derived from guano. These phenomena have important archaeological implications that relate to the distribution of bone within the cave. Does the occurrence of bone at a particular location in the site represent primary biological refuse (both human and animal), or is it a secondary phenomenon, in which bones have been dissolved? The current study of this problem with Fourier transform infrared spectroscopy in the field (Weiner and Goldberg 1990) and laboratory analysis including x-ray diffraction and petrography indicates that the bones are well preserved in the northern half of the cave. A diagenetic front beyond which bones were not preserved was identified as an approximate line that begins in the northeast corner of the east profile, cuts across the southeast corner of the *décapage* area, and turns through the southern part of the deep sounding and continues westward.

GEOLOGICAL HISTORY

The deposits at Kebara are still being studied, and the following sketch of the geological history of the site should be considered tentative at best.

The earliest deposits exposed in Kebara are found in the northern and central parts of the cave. In spite of the limited number of exposures of these units (squares G, H19, N, M20), their morphology and their relationship to the topography of the underlying bedrock (e.g., square H19) indicate that there are several meters of older deposits. In addition, because of the considerable amount of diagenesis, it is difficult to establish definitively the original characteristics of the sediments, including their origin. Nevertheless, the clear horizontal bedding and associated organic-rich layers in these sediments indicate that they were waterlain. In addition, the phosphatization of the fine groundmass and the phosphatic cement between individual grains suggest that these postdepositional modifications are tied to conditions of water saturation, whereby the cave was inundated and thus rendered uninhabitable. Two hypotheses with regard to the origin of these lower sediments can be put forward: that of an external one, through runoff, or of a karstic one, through phreatic transport. The latter supposes that the cave was part of an active karstic network. Because the lateral extension of this proposed system is concealed by the overlying deposits, this hypothesis cannot be verified, but the presence of several subsurface sinkholes and the occurrence of numerous slumping events suggest that it is reasonable.

The chronological position of the deposits in unit XIV is unknown, but it is conceivable that they considerably predate the deposition of unit XIII, which unconformably overlies it. The appearance of unit XIII marks a new stage in the dynamic geological history of the cave. Although the base of this unit shows the effects of water deposition, the widespread occurrence of burned layers clearly shows that the cave was inhabitable from this time on. The first signs of occupation took place sometime prior to 60,000 years ago (the date for the overlying unit XII).

This style of anthropogenic accumulation continues up to unit VII, which dates to 48,000 years B.P. The good preservation of the burned layers and the absence of evidence of erosion or runoff indicate a stable regime of sedimentation in which water deposition was minimal; the presence of quartz silt in virtually all the sediments in these units points to external inputs of aeolian dust or silt-rich soil, such as terra rossa. At the same time, the deposition of these units was punctuated by several episodes of slumping caused by subsidence into subsurface swallow holes situated beneath karstic vaults in the chimney. For the most part, these slumps are expressed by a slight localized tilting of the layers. However, in several parts of the cave, larger-scale slumping events are prominent.

The stratigraphic evidence shows that, during the last part of the Mousterian occupation of the cave, the influence of karstic activity became more prominent, affecting both the configuration of the sediments and the types of sedimentary processes that were operating. The most striking expression of this is found in the marked dips to the southeast of most of the deposits in the southern part of the cave (fig. 6). Associated with these dipping intact strata are discontinuous and fragmented remains of burned layers preserved within homogeneous, massive grey and grey-brown silts and clays (unit VI). These phenomena (tilting, bedding, and slumping) are linked to an increase in wetter conditions that began during the final occupational phase of the Mousterian and continued into the Upper Paleolithic. Related to this subsidence is the formation of a depression in the rear part of the cave which, during the Upper Paleolithic, became filled with finely laminated silts derived from the west (i.e., the direction of the entrance). Intercalated into the middle part of the Upper Paleolithic sequence is an irregular layer rich in organic matter and diatoms. These deposits clearly point to the presence of standing water or at least a damp substrate in the rear of the cave over a prolonged period of time. This reinforces the interpretation of a distinctly wetter climate that began during the last part of the Mousterian occupation of the cave and continued through to the end of the Upper Paleolithic as currently exposed in Kebara.

Spatial Distributions of Archaeological Features

In the course of excavation in the central area and in the deep sounding, we exposed a series of features including various ash lenses, hearths, and concentrations of bones and artifacts. The accumulation of hearths is impressive (figs. 5 and 8). The hearths, which are rounded or oval and may be flat or bowl-shaped, are similar to those uncovered in the Upper Paleolithic layers at Kebara and at

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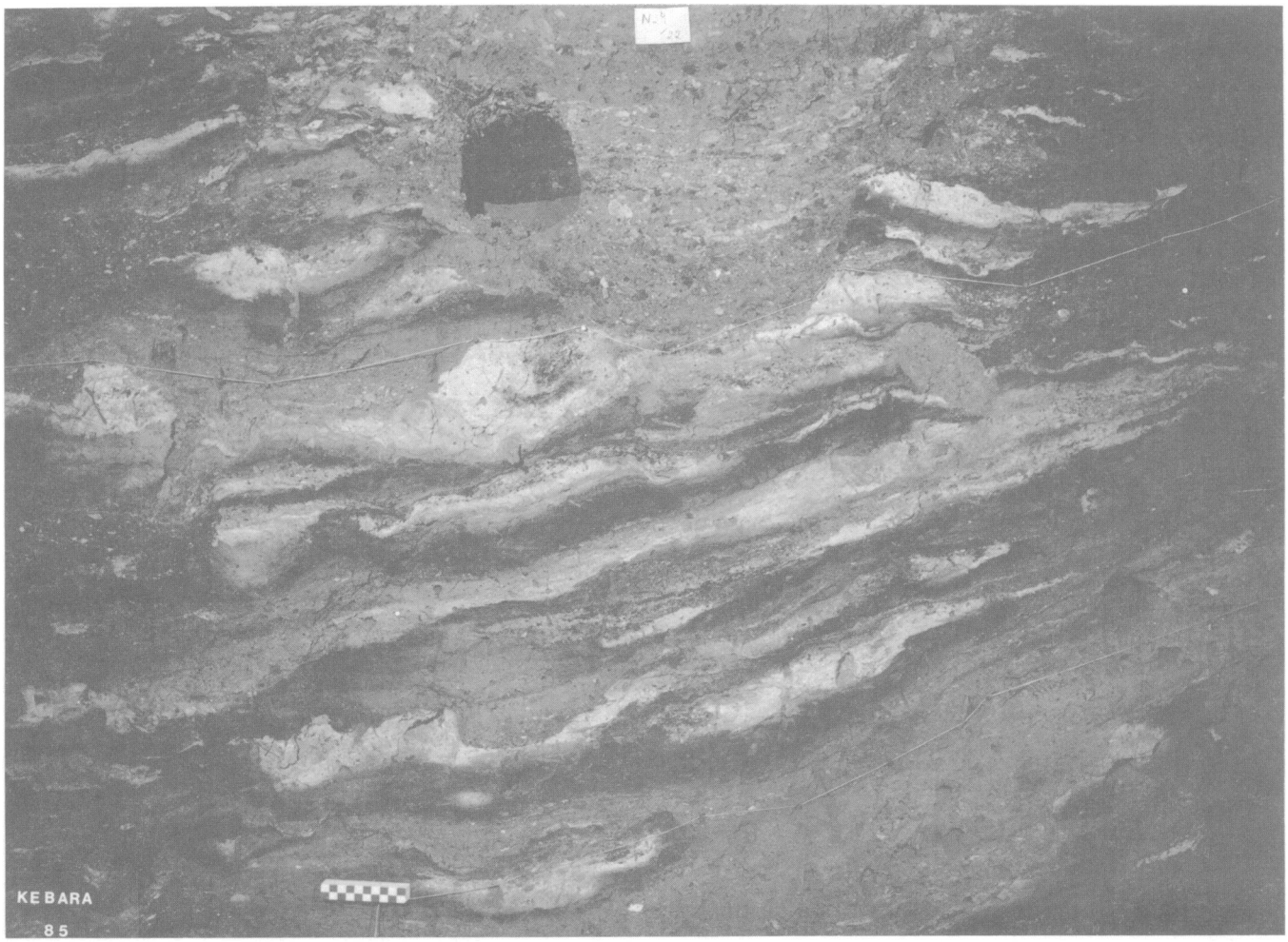

FIG. 8. *A portion of the west profile, showing the accumulation of hearths (photo: Kebara archives).*

other Upper Paleolithic sites (fig. 9; Meignen, Bar-Yosef, and Goldberg 1989). Their thickness generally ranges from 3–5 cm to 15 cm and their diameter from 20 to 80 cm. A few are much larger; for example, in unit XIII a 30-cm-thick lense of black and white ashes with a diameter of more than 100 cm was exposed in the deep sounding. Each feature consists of two sublayers: a lower black organic-rich silty layer which contains pieces of charcoal, sometimes larger than 2 cm, and carbonized seeds and a whitish-yellowish upper layer which is either calcite-rich (near the north wall) or rich in phosphate-bearing potassium, calcium, manganese, and aluminum (in the central area). Not all are well structured. Sometimes the white ashes were dispersed, resulting in irregular shapes. Occasionally we were able to identify the original hearth at the base of such an ash lens and it seemed as if the ashes had been spread intentionally.

Field experiments and the identification of numerous pieces of excavated charcoal indicate that local firewood, mainly Tabor oak (*Quercus ithaburensis*) collected in the immediate vicinity of the site, had been used most often (U. Baruch and E. Werker, personal communication). No evidence of stones was found, and thus there is no indication of warmth banking. The relatively small number of burned bones in the faunal remains from most proveniences at Kebara raises questions concerning the original purposes of these hearths. Numerous carbonized seeds of wild peas (M. E. Kislev, personal communication) indicate that some seasonal (late winter and spring) parching was practiced (Kislev and Bar-Yosef 1988). Further studies of this phenomenon are in progress. More work is needed to identify traces of plant foods and of the possible exploitation of various combustibles available inside the cave, such as guano, or brought in from outside, such as branches and grasses.

Stekelis long ago noted spatial differences in the distribution of bones, ashes, and artifacts within the excavated area inside the cave. The concentration of bones and waste (cores, cortical elements, flakes, etc.) near the north wall in (our) units IX, X, and XI reminded him of a dumping zone. In fact, there are two different bone and lithic concentrations near this wall. One is a fill which took place after the deposition of unit VII, when a narrow gully was formed along the wall (unit R). The fill

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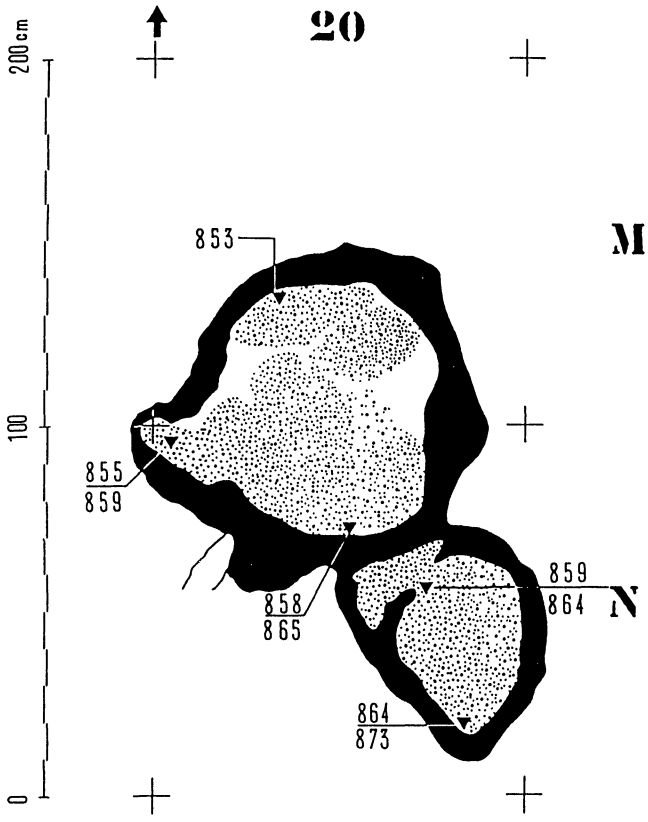

FIG. 9. *Two hearths in unit XIII, squares M, N 20.* Black, *carbonized level;* stippled, *white ashes. Numbers designate levels below datum.*

contains a mixture of Mousterian artifacts and bones removed from their original deposits and bones probably introduced by hyenas. The other includes lateral portions of units XII through IX as well as VII and VIII and is rich in bones and lithics. One of the richest areas is in squares H, I22, 23.

The central area, the *décapage,* contains well-delineated concentrations of bones and lithics (fig. 7), while only the latter are also distributed within the ashy deposits. The bone concentrations are limited to the west by the ashy deposits and to the south by an area of diagenesis. These concentrations were originally seen as oval and thought to be hearths (Schick and Stekelis 1977). As the excavation and the mineralogical analyses progressed (Weiner and Goldberg 1990) it became clear that they were spatially separated from the hearths and that this distribution pattern lasted for a very long time, resulting in highly localized accumulations up to 1 m thick. A preliminary analysis of one large, roughly circular bone-and-artifact concentration encountered in the *décapage* area in unit X indicates that, in terms of most taphonomic and "cultural" indicators (species composition, sex ratio of gazelle horn cores, amount of carnivore damage, proportional representation of major carcass units, incidence of cut marks and burning, and so forth), its contents are virtually indistinguishable from the large Mousterian assemblage excavated many years ago by Stekelis, nearly half of which comes from the north-wall bone concentrations. The processes, whether cultural or noncultural, that gave rise to these peculiar concentrations of material remain to be worked out. In summary, the spatial distribution of bones and lithics in unit X indicates that the largest concentrations occur toward the rear of the excavation area along the north wall and that the hearth areas are devoid of bones and poor in lithics (including debris smaller than 2.5 cm).

In the southern part of the cave few if any bone fragments were found. It is thus of fundamental importance to determine whether the distribution of bones as excavated represents primary burial locations, aside from bioturbation, or secondary dissolution processes that have differentially dissolved bones in some areas but not in others. The basic approach used to address this question was a detailed analysis of the mineralogical components of the sediments and of the bones themselves. The rationale for this was that if a mineral more soluble than carbonate apatite (the mineral of bone itself) was still preserved in the sediment, then the bones were unlikely to have been dissolved. A good candidate for such an analysis is the calcite that is generated in ash as a result of the burning of vegetation. Alternatively, if carbonate apatite was being precipitated in the sediments rather than being dissolved, it is reasonable to expect that the bones would be stable. This, however, assumes without justification that the groundwater associated with the bones was always saturated with respect to carbonate apatite.

Minerals in the sediments were identified by Fourier transform infrared spectroscopy (Midac Corporation) using potassium bromide pellets. The spectrometer was operated on-site inside the cave (see Weiner and Goldberg 1990 for details). The results show that ash-derived calcite is present only in the northern parts of the cave, close to but not directly associated with the large bone accumulations. Furthermore, in some areas (squares G13, 14, unit IX) traces of calcite are still preserved in ash layers that are not in the proximity of bones. This implies that bones were never present in these areas, as the calcite would not have been preferentially preserved as compared with the bones. This then confirms that bone was initially heterogeneously distributed in the northern part of the cave. In the central portion of the cave, primary ash-derived calcite is not preserved. The calcite has been altered through reaction with phosphate-rich groundwaters first to carbonate apatite and then to a series of different phosphate-bearing minerals such as montgomeryite, leucophosphate, taranakite, and crandalite. We did find, however, that in almost all the areas of the *décapage* with bone concentrations, carbonate apatite was also present in the sediments. It is thus reasonable to expect that the bone concentrations are not an artifact of secondary dissolution of bones in other areas. This is supported by the observation that the carbonate apatite of bones at the periphery of the concentrations was not more poorly preserved than that of bones in the center. The states of preservation of the

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bone mineral were assessed using the so-called splitting factor of the infrared spectra, which is an indirect measure of both crystal size and lattice perfection (Weiner and Bar-Yosef 1990). In the southern portion of the cave, few or no bones were found. This also more or less corresponds to the area in which carbonate apatite was not present in the sediments. In fact, bones close to the boundary not only show increasing splitting factors (that is, more diagenetic alteration) but also degrade into some as yet unidentified additional phosphate. It thus appears that the reason for the absence of bones in the southern part of the cave is that they were dissolved after deposition.

The Middle and Upper Paleolithic Lithic Industries

METHODS

Although the Kebara excavations yielded both Middle and Upper Paleolithic assemblages, most of the following description and discussion relates to the former. The various analytical methods employed, especially in Europe, in the study of Middle Paleolithic assemblages have been mainly aimed at the description of retouched pieces, commonly known as "tools." The Bordes method paid special attention to tool morphology, expressed in a detailed type list. Such type lists are useful for inventorying assemblages and conveying their characteristics. Currently a condensed version of the Bordesian type list, in which tool types are clustered into groups, serves as a means for recording assemblages: scrapers, convergent pieces (convergent scrapers, Mousterian points, and canted scrapers), transverse scrapers, Upper Paleolithic items, denticulates (types 42, 43, 54), etc. The original Bordesian "stylistic" (or "tribal") interpretation of the variability among assemblages has been questioned, and other causes, such as function, chronology, and raw material, have been offered as alternatives. The main drawback of the Bordes method is its static approach, which focuses only on the end products—the retouched pieces and blanks—and ignores the specific methods by which these artifacts were made. The attention given to the retouched products has diverted attention from the characteristics of the unretouched debitage products. Thus, the information embedded in the dynamics of core reduction strategies has been largely ignored.

An alternative approach to Middle Paleolithic lithic variability is based on recognizing and understanding the *chaîne opératoire* (operational sequence)—the different stages of tool production from the acquisition of raw material to the final abandonment of the desired and/or used objects. By reconstructing the operational sequence we reveal the choices made by Paleolithic humans. Replication studies have suggested that the behaviors reflected in the various stages of the operational sequence were determined in part by the technical traditions of each human group. Within the group, the methods used for tool manufacturing were probably transmitted by imitation and/or by oral instructions from one generation to the next (Pelegrin 1985:57). The individuals in the group possessed an array of techniques from which they were able to choose in relation to a preconceived notion of the shape of the blank and its potential use and to constraints such as the quality and availability of raw material. Identification of the most frequently recurring of those choices enables the archaeologist to characterize the technical traditions of the social group.

In practice, the first aim of lithic analysis is to identify the methods (also viewed as technical solutions) chosen at each step of the reduction sequence. For example, the shape of a Levallois core, which displays both distal and lateral convexity, can be obtained either by radial flake removals or by unidirectional lateral flake removals from the edge of the core (see Boëda 1988). In addition, Levallois core reduction can be achieved by either radial, unidirectional, or bidirectional removals. All these choices, which can be identified at each stage of the operational sequence, can occur in various combinations. Refitting and replication experiments enable us to identify the choices of prehistoric knappers. Therefore, careful study of the dominant operational sequence in a given assemblage should make it possible to identify a prehistoric group and characterize its particular approach to blank production. In contrast, the percentages of retouched products, debitage products, and cores in a given assemblage reflect the nature of the occupation—for example, the accessibility of raw material and the different activities performed there, such as retooling and curation of selected items—and are therefore less useful for recognizing the prehistoric group.

The study of the assemblages from the Mousterian levels in Kebara Cave was organized in terms of these considerations. In view of the abundance of the lithic material, with more than 25,000 pieces larger than 2.5 cm recorded, our main research aim was to determine the stages of blank production and retouch. Studies of raw-material economy and use-wear by high magnification are still in progress, while the results of edge-damage analysis by low magnification are already available (Shea 1989, 1991).

THE MOUSTERIAN

Raw-material procurement. The analysis of the operational sequence begins with the identification of the raw materials exploited and their geographical sources in relation to the site. This analysis is crucial when the various phases of the operational sequence were executed in different localities and at different times and thus reflect the energy cost of the procurement of raw material and/or the transport of the finished tools (Geneste 1988*a*, *b*). Local raw material was often imported as unmodified nodules and the processing carried out on-site, resulting in a proliferation of blanks and particularly of cortical elements. In contrast, distant raw material was generally brought in as blanks of Levallois products and/or retouched pieces. Numerous examples of this can be found across Europe (Geneste 1988*a*, *b*; Meignen 1988;

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Roebroeks, Kolen, and Rensink 1988). Preliminary results indicate the use of different kinds of flint. Raw-material sources are all within 10–20 km of the site, the most distant being places such as Nahal Me'arot (Wadi Mughara) and Nahal Oren. Most of the products were made from raw material collected in the immediate vicinity of the site (less than 5 km), from places such as Nahal Kebara, near Zichron Ya'acov, and Nahal Ha Taninim, southern Mt. Carmel. The main formations are of Middle Cenomanian and Lower Eocene age. The raw material was imported as blocks, cobbles, and pebbles, and a few, often large, are found in the concentration of bones and waste along the north wall. The abundance of cortical products, unretouched products, and cores suggests that primary knapping activities and cortex removal often took place inside the cave.

Core reduction sequence. A sample of 11,800 artifacts from units VII through XII has been studied. Reduction strategies were classified as follows (Geneste 1985): (1) the core reduction sequence, which comprises core shaping by the removal of cortical products and blank production by systematic removals of Levallois and ordinary products, and (2) the sequence of tool manufacture and tool use by retouching selected blanks which become "tools."

Cortical, semicortical, and core-trimming elements are abundant in all the units (table 1). Core-trimming elements are often *outrepassant* (plunging) and preserve the cortex on their lateral and distal parts. They are fairly short in the upper units (VII and VIII), but in the basal units (XI and XII) they occur as blades, sometimes up to 12–13 cm long, manifesting the general lamellar tendency characteristic of the earliest occupations. The differences in size between the initial blocks, as indicated by the core-trimming elements, and the discarded cores, which generally range from 2 to 5 cm long, reflect the successive sequences of core reduction. The location of the cortex on the blanks and the direction of the flake scars on the dorsal surfaces indicate unidirectional, mainly convergent flaking during the first stage. The removal of extended cortical core-edge and plunging flakes was required to shape the cores into a convex morphology. Our observations indicate that this convexity was probably achieved at an early stage of core preparation. The recurrence of this core morphology in the various units in Kebara (as well as at Tabūn IX, Rosh Ein Mor, and Ksar Akil XXVIII) indicates that a unidirectional Levallois debitage was intentionally chosen by the producers of these assemblages.

The proportions of different Levallois products (flakes, blades, and points) reflect the goals of lithic production through its sequence (table 2). In the upper units (VII and VIII), subtriangular points and subtriangular Levallois flakes were the desired products. An increase in the production of subtriangular blanks and a tendency toward the production of longer pieces characterizes the lower units (IX–X). Units IX and X are marked by the production of short, broad-based Levallois points that have very specific morphotechnical characteristics, including protruding striking platforms such as *chapeau de gendarme* butts and "Concorde" longitudinally arched profiles (named for the plane). Although the lower units (XI and XII) display a tendency toward the production of blades, flakes remain the chief component throughout the sequence.

The cores which are characteristic of the Levallois system in terms of their general shape, the presence of distal and lateral convexities, and the preparation of the striking platform display negative scar patterns of successive, regular flake removals on their dorsal surfaces. This particular morphology, associated with the specific form of removal known as "*enlèvement* 2," reflect the intensive use of the "recurrent Levallois method" (Boëda 1988). This method produces several Levallois blanks from each prepared surface. It is entirely different from the "lineal" ("preferred flake") method, which is characterized by the removal of only one preferred Levallois blank for each prepared surface. Multiple removals from a Levallois flaking surface result in specific flake morphologies, some of which can be easily identified as "technical markers" (fig. 10). One of the consequences of this flaking method is that many of the products display a slightly asymmetrical shape and a slightly twisted profile, seen from the proximal and distal views, that is referred to as "lateralization." These asymmetrical blanks occur frequently at Kebara during this stage

TABLE 1
General Composition of Mousterian Assemblages from Kebara

	Ordinary Blanks		Core-trimming Elements		Levallois Products		Cores		Retouched Tools		Cortical Blanks		Total without Cores	
Unit	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%		Total
VII	1,762	72.4	193	7.9	442	18.1	83	3.3	81	3.3	833	34.2	2,434	2,517
VIII	444	64.3	95	13.8	134	19.4	22	3.1	27	3.9	287	41.6	690	712
IX	1,858	79.2	167	7.1	277	11.8	101	4.1	59	2.5	866	36.9	2,346	2,440
X	1,544	69.9	181	8.2	442	20.0	88	3.8	55	2.5	703	31.8	2,207	2,295
XI	2,054	62.6	351	10.7	740	22.6	147	4.3	144	4.4	1,086	33.1	3,280	3,427
XII	233	60.7	22	5.7	117	30.5	9	2.3	12	3.1	92	23.9	384	393

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TABLE 2
Technological Attributes of Levallois Products from Kebara

Attribute	Unit VII $N = 254$	VIII $N = 98$	IX $N = 87$	X $N = 338$	XI $N = 259$	XII $N = 72$
Type of striking platform						
IFs	53.1	54.1	78.1	71.9	64.1	83.3
IF1	58.2	59.1	79.3	75.4	70.2	87.5
Chapeau de gendarme	6.7	9.2	40.2	26.0	10.0	19.0
IT1	20.9	19.4	11.5	10.4	18.1	8.3
Dorsal scar pattern						
Total unidirectional	44.5	51.0	68.9	52.9	56.0	62.5
Unidirectional convergent	35.0	41.8	67.8	48.5	43.6	51.4
Radial	25.6	28.6	10.3	17.4	17.4	6.9
Bidirectional	19.3	11.2	9.2	14.5	20.1	25.0

NOTE: *IFs*, restricted index of platform faceting; *IF1*, total faceted platforms. Number of scars is 4 except in unit IX, where it is 3.

of production. On the contrary, fully symmetrical, broad and well-centered Levallois products and radial cores that display the scar of a broad central removal (the preferred-flake method), are uncommon except in units VII and VIII, where they are found in low frequencies.

The coexistence throughout the Kebara Mousterian units of the two knapping systems ("recurrent" and "lineal") is noteworthy. However, the recurrent method is predominant. A cautionary note concerns the study of cores which exhibit only the last stage of the reduction sequence. A core reduction sequence might have begun with the recurrent method but ended with a final broad removal (a preferred flake). Morphometric studies of blanks can help to identify this phenomenon; the blanks of the uni/bidirectional recurrent method will be systematically larger than the radial (or lineal-method) blanks.

In any method, core management may be achieved through the removal of numerous flakes from different positions and orientations. Throughout the levels of Kebara, as we have said, core reduction was predominantly unidirectional, with converging flake removals. This observation is particularly obvious in units IX and X, where they were produced by the same process as the Levallois points; in the upper units (VII and VIII), radial preparations are somewhat more numerous. The bidirectional pattern is infrequent and corresponds mainly to distal core convexities shaped by short removals from opposite striking platforms. This does not apply to unit XII, in which genuine bidirectional flaking occurs. An additional characteristic of all the Kebara assemblages, as well as similar ones elsewhere, is that the cores were minimally prepared. Often the surface of the striking platform remains cortical and the striking platform itself is limited to a restricted zone (one-third of the periphery at the proximal end). The number of removals from the cores remains low, on average four or five. Crew (1975) identified these Levallois products, obtained with minimal preparation of the block, as characteristic of the Levantine Mousterian. The preparation of striking platforms by faceting the butt is prevalent at Kebara, particularly in the lower units (IX–XII). Careful preparation of the butts in the *chapeau de gendarme* shape helps the knapper to adjust the blow and is closely related to the production of Levallois points.

The average size of Levallois products at Kebara is 5–6 cm, far longer than the last removals as measured on the cores (1–2.5 cm). The cores themselves are often small, ranging in size from 2 to 5 cm. Even if the cores were originally flakes, their small size seems to be related to the high degree of exhaustion, which often makes it difficult to identify the Levallois system (Marks and Volkman 1986:11). However, this can be done in a different way. Following the removal of a series of Levallois blanks, the removal of numerous core-edge flakes with cortical backs reflects the intended renewal of the convex profiles of the core. The original convexities needed for the detachment of Levallois blanks had been "destroyed" by the removals from the primary prepared Levallois surface. At that point the knapper had the choice of reshaping the core by various methods, including the one characterized by core-edge flakes. At Kebara the latter type displays a crested back formed by the primary flake removals on the cortical back, along the edge of the core, while the final striking platform is located on a restricted surface. All these observations demonstrate that a series of Levallois products was obtained from each flaking surface and that this procedure was repeated several times until the cores were exhausted. We conclude that, contrary to the notion that Levallois debitage is a wasteful system, this method of core reduction exhibits a certain level of efficient productivity.

The following description of the production of the tri-

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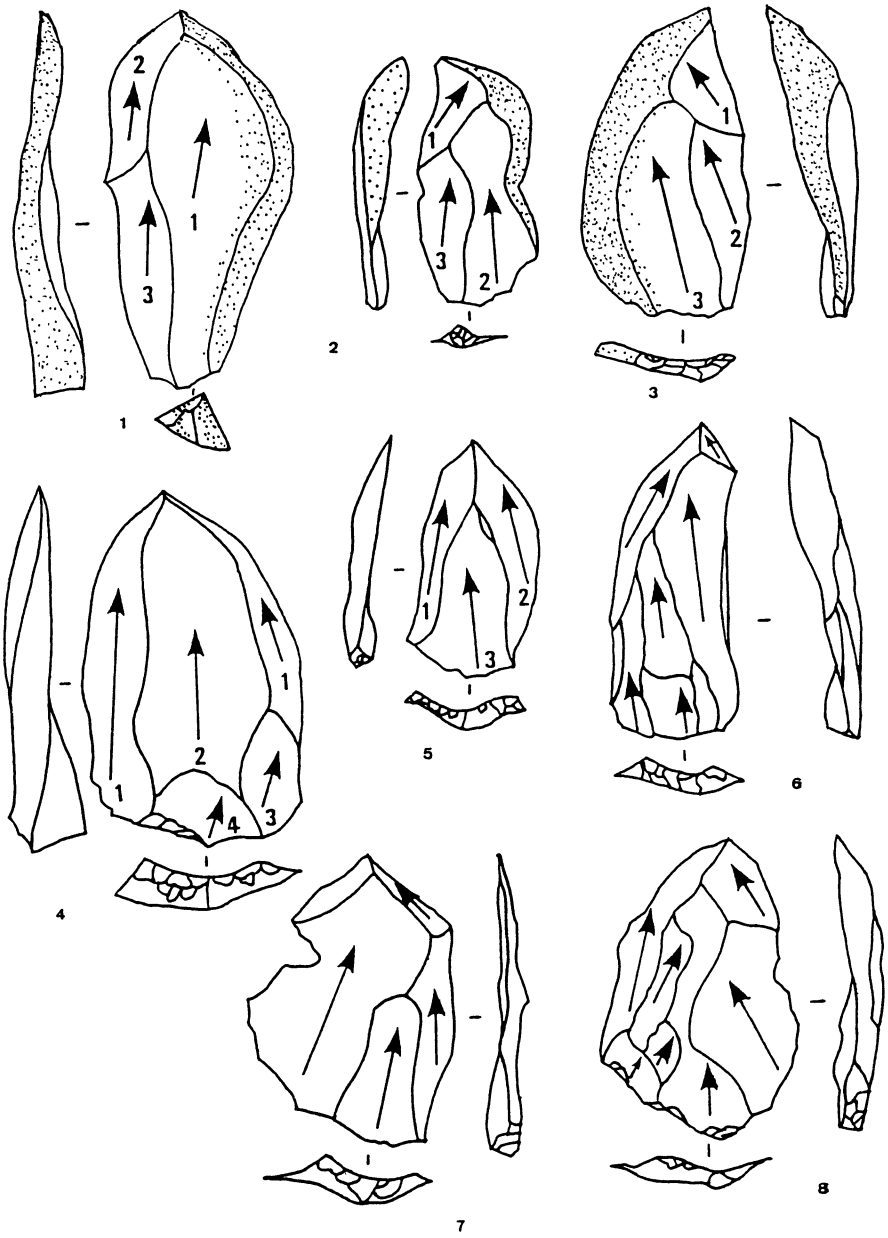

FIG. 10. *Products typical of the* chaîne opératoire *in Kebara.* 1–3, *extended cortical core edges and plunging flakes;* 4–5, *triangular Levallois flakes;* 6–8, "enlèvement 2" *Levallois flakes.*

angular blanks prevalent in the assemblages of units IX–X is an attempt at understanding the core-reduction sequence:

Step 1. Removal of cortex from the original nodule and core shaping by elongated removals that are mostly cortical, unidirectional, and more or less converging.

Step 2. The shaping of a large striking platform limited to the proximal end of the core.

Step 3. The formation of lateral and distal convexities by the removal of large core-edge flakes that are sharply oblique and plunging, mainly by unidirectional flaking.

Step 4. The removal of recurrent series of convergent blanks from the entire flaking surface of the core using the large proximal striking platform. This step produces subtriangular blanks (flakes and points and, to a lesser degree, blades) and especially points that exhibit the peculiar *chapeau de gendarme* striking platform.

The successive sequences of core exploitation, with lateral and distal trimming of the core convexities, were achieved by the removal of cortical core-edge flakes, sometimes *outrepassant.* Progressive trimming of the convexities was also accomplished by the removal of lateral flakes that exhibit an asymmetrical cross section and are plunging at the distal end and slightly twisted.

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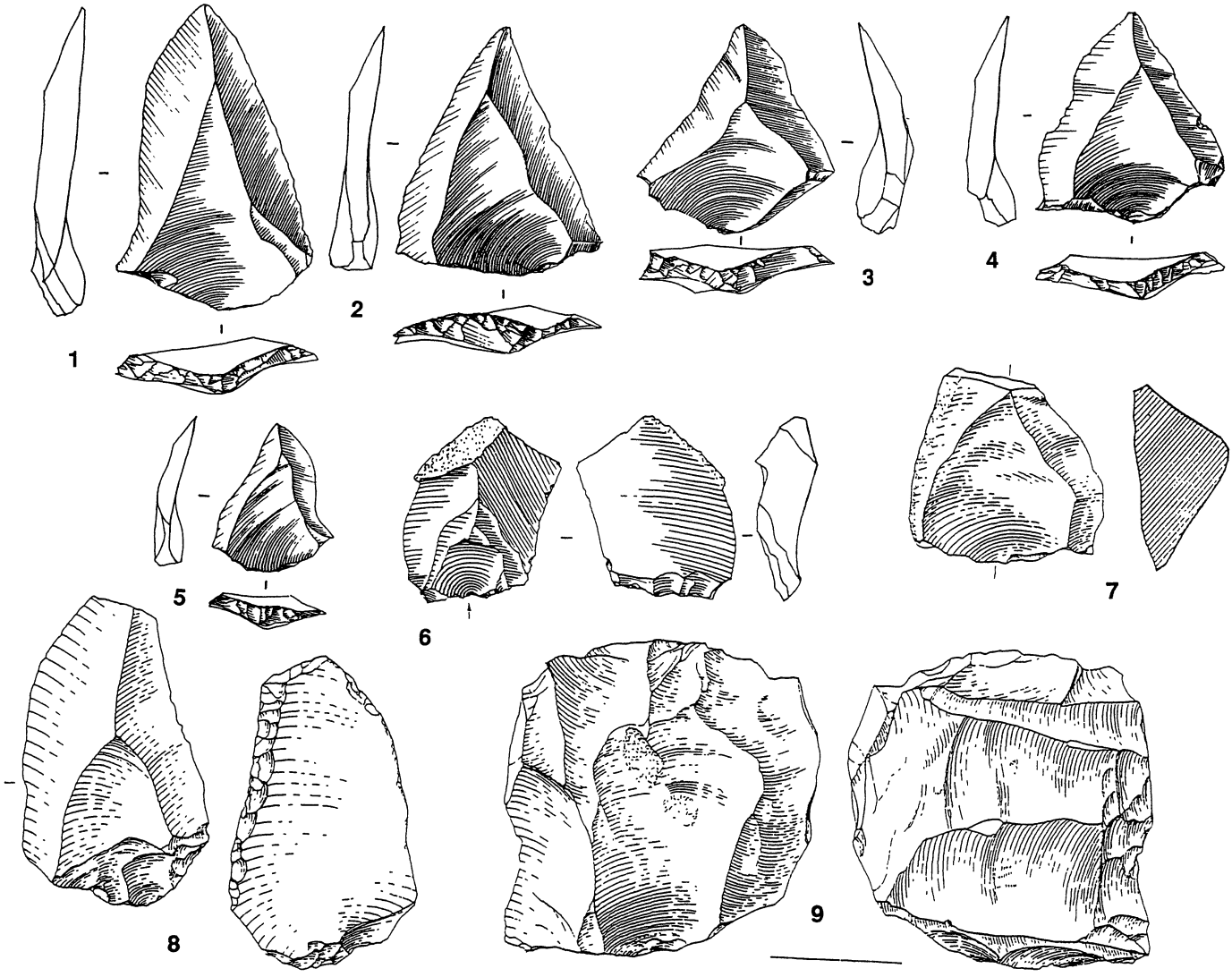

FIG. 11. *Selected artifacts. 1–5, broad-based Levallois points; 6, Nahr Ibrahim–technique (truncated-faceted) pieces; 7, triangular Levallois core; 8, inverse side scraper; 9, bipolar Levallois core (reprinted from Bar-Yosef and Vandermeersch 1991 with permission).*

This process was repeated until the core was exhausted. The Levallois points display a curved profile, known as the Concorde profile (fig. 11), that results from the previous removal of oblique lateral flakes and the distal convexity of the core.

Tool manufacture and use. The Mousterian levels are characterized by few retouched pieces. Given the low frequencies of formal tools, their detailed study, including the analysis of blank selection, is unwarranted. The Mousterian tool group, which includes retouched Levallois points and side scrapers, is well represented. Side scrapers made on Levallois blanks are generally convex and display a thin or sometimes scalar, slightly invasive retouch. The dominance of inverse retouch on side scrapers and points, which results in low edge angles, is characteristic of these levels and may be related to their function. The category of becs, notches, and denticulates is underrepresented, and the latter are mainly noncontiguous notched pieces on thick flakes or on unretouched blocks. Upper Paleolithic tool types rarely occur in large numbers in the upper units but are more abundant in the lower levels, especially in unit XI. They include burins, sometimes on truncations, and a few scrapers. Noteworthy in all the levels is the presence of a large number (15–25% of the tools) of the pieces known in the Levant as truncated-faceted pieces (Schroeder 1969) or products of the Nahr Ibrahim technique (Solecki and Solecki 1970). These are flakes or blades with abrupt or semiabrupt retouch at one or two ends which were used as striking platforms for the removal of small flakes. They have been interpreted as sinew frayers (Leakey 1931), flake cores (Newcomer and Hivernel-Guerre 1974), and flake tools formed by thinning following their removal from the cores (Solecki and

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Solecki 1970). Examination of the Kebara sample demonstrates that there is a continuum of objects from small cores on flakes to retouched products exhibiting some miniflake removals at the proximal end. All were derived from the same succession of technical motions. We will consider them as "miscellaneous objects" until the completion of the high-magnification microwear analysis. Finally, a striking aspect of this tool assemblage is the partial and/or slight retouch on the retouched pieces. Commonly, Levallois blanks are only slightly retouched, though they bear more traces of use than other blanks (Shea 1989). Therefore, it seems that the desired shape of the implement was obtained directly by the knapping method. Light trimming of the edge was occasionally used to modify the blank to the desired shape. This observation concurs with the low percentage of retouched Levallois flakes.

According to use-wear analyses (Shea 1988, 1989, 1991), half of the triangular blanks, including points and triangular flakes, exhibit wear traces, an incidence that is nearly five times higher than for any other debitage category. This supports the above contention that pointed blanks were the desired end products although they are not the most abundant blanks. According to Shea (1989), points were more frequently hafted (35% of all points) than blades and flakes and were used with cutting motions. Several points bear impact fractures interpreted as resulting from their use as projectile points, but this conclusion is contested by high-power analysis (S. Beyries, personal communication). Finally, blades also display a consistent pattern of use located mainly along the longitudinal cutting edge. Worn flakes display the greatest variability in terms of the motions in which they were employed.

Summary. The main characteristic of the core reduction strategy at Kebara Cave is the recurrent Levallois production method, through which numerous flakes, as well as blades or points, were struck from the same flaking surface. In addition, this removal sequence was often repeated on the same core, thus increasing the degree of productivity of this method. Throughout the levels, core management is evidenced by the presence of unidirectional removals, a phenomenon that is rather common in the Near East. However, it is important to stress that the convergent pattern often gives the products a triangular or subtriangular shape. All of these elements constitute a dominant feature of the assemblages. This means that in spite of the availability of other flaking methods, such as the preferred-flake method or radial or bidirectional reduction, the local artisans made a clear choice. Additional research should clarify whether the two different Levallois strategies, lineal and recurrent, merely reflect different steps in a continuous reduction sequence or coexisted as distinct core reduction strategies practiced on different blocks of raw material in the same lithic assemblage. For example, the constant presence of small preferred flakes obtained by the lineal method among large blanks removed by the recurrent method would support the first hypothesis. It is worth stressing that the dominance of the recurrent, unidirectional, convergent method is most obvious in units IX and X and is already very evident in units XI and XII. In the upper units (VII and VIII), the production of preferred flakes through radial preparation slightly increases. These chronological variations in production methods coincide with changes in blank production. In the lower levels (IX–XII), core reduction is characterized by a high frequency of triangular blanks, with more elongated pieces in units XI and XII, while in the upper units (VII and VIII) it is more diversified and oriented toward the production of both subtriangular and quadrangular flakes.

Briefly, the lithic analysis has enabled us to demonstrate the presence of an industry produced by the recurrent Levallois method, in which the unipolar convergent style is dominant. The blanks are often short with a subtriangular and subquadrangular morphology, among which short, broad-based Levallois points are a characteristic item if not the predominant product.

UPPER PALEOLITHIC INDUSTRIES

Three lithic assemblages from the Upper Paleolithic layers excavated by Turville-Petre in 1931 were published by Garrod (1954). She managed to classify only 693 of the 830 retouched pieces because of the dispersal of the collections among six museums (layer E = 260; D_2 = 211; D_1 = 222).

Layer E was interpreted by Garrod (1957) as the local variant of the Aurignacian and was attributed to the "Lower Antelian" or Upper Paleolithic stage III in Neuville's classification (Neuville 1951). The main characteristics of the lithic assemblage were Aurignacian carinated scrapers, endscrapers, and numerous el-Wad points. Mousterian-derived pieces were also found in this layer.

The assemblage of layer D, which was further subdivided into D_1 and D_2, was designated as "Upper Antelian" or Upper Paleolithic stage IV. The lithics of both sublayers are dominated by endscrapers, Aurignacian carinated scrapers, and some nosed ones, with rare el-Wad points. Garrod (1954) noticed that the quality of workmanship is finer in D_2 and in addition there is a difference in the ratio of scrapers to burins: the former are dominant in D_2 and the latter in D_1. In addition, among the nonlithic artifacts Garrod published two bone points from layer D_2.

The detailed study of the Upper Paleolithic material from the Stekelis excavations was done by Ziffer (1978). Stekelis, Ronen (1976), and Ziffer believed that Turville-Petre had removed almost all of layer D and what was excavated by Stekelis was part of Turville-Petre's layer E. Ziffer subdivided the Stekelis assemblage into two and considered the upper part a mixed assemblage of layers D and E. Therefore he studied only the lower assemblage that was correlated with layer F. He found it to be very rich in el-Wad points, Aurignacian carinated scrapers, and ordinary endscrapers.

During the present excavations three areas yielded Upper Paleolithic material. In the area of the south pro-

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file (ca. 16 m^2), four units (I–IV) defined stratigraphically were radiocarbon-dated to 42,000–28,000 years B.P. In brief, units IV and III are blade assemblages with pointed and retouched blades as the dominant forms, together with simple endscrapers. Units II and I contain some carinated, nosed, and shouldered endscrapers and are reminiscent of what is called the Levantine Aurignacian. A more detailed study is in progress. Near the cave entrance, a small area produced Upper Paleolithic remains characterized by blade tools and only a few Aurignacian carinated or nosed endscrapers.

The nonlithic finds of the Upper Paleolithic assemblages comprise some (mostly broken) bone tools, including an Aurignacian split-base point, a few lumps of ochre, a few groundstone items and a broken limestone plate.

The Fauna

The excavations in Kebara Cave have yielded an immense collection of well-preserved larger-mammal remains. The mammalian bones from the Stekelis excavations were studied by Davis (1977), who identified within the Mousterian and Upper Paleolithic deposits the following species: *Gazella gazella, Alcelaphus* sp., *Capra* cf. *aegagrus, Bos primigenius, Capreolus capreolus, Dama dama mesopotamica, Cervus elaphus, Sus scrofa, Equus* cf. *caballus,* and *E. hydruntinus.* In addition, a few remains of *Rhinoceros* sp. were found in the Mousterian assemblages. Most species occupied the Mediterranean region of the southern Levant, including *Alcelaphus buselaphus* and *Capra aegagrus* (rather than *C. ibex*). It is worth mentioning that the specific identifications of the Middle Paleolithic equids are still in dispute. Vera Eisenmann (personal communication) has identified *E. hydruntinus* as the most common equid species at Kebara, but *E.* cf. *tabeti* and *E. caballus* may also be represented within the local equid fauna. According to Claude Guérin (personal communication), the Middle Paleolithic rhinoceros of Southwest Asia is *Dicerorhinus hemitoechus.* We regard *D. dama* and *D. mesopotamica* as separate species. On the basis of this fauna, Davis (1977, 1980) argued that the dominant ungulates exploited by humans were *D. mesopotamica* and *G. gazella,* but *B. primigenius* and *C. elaphus* were probably of equal importance as sources of meat due to their large size. He emphasized that animal species bone counts do not necessarily reflect the entire dietary spectrum. He concluded that the sex ratio of gazelles and fallow deer remained equal throughout the sequence of the Middle and Upper Paleolithic in both Kebara and Hayonim Caves.

Carnivore remains are relatively rare and include hyena, canid, fox, and several others (Dayan n.d.). The hyaenids are represented by *Crocuta crocuta,* which was present in the region from the Villafranchian to the Epipaleolithic, and by *Hyaena hyaena,* which still exists in the Levant today. The presence of carnivores at Kebara is also indicated by gnaw marks and punctures on many bones, occasional acid-etched bones, and coprolites. The coprolites have been tentatively identified by Horwitz and Goldberg (1989) as the scat of spotted hyena (*C. crocuta*) rather than of striped hyena (*H. hyaena*).

In addition, microvertebrates were recovered from the Stekelis excavations (Tchernov 1968). The micromammals of Kebara are conspecific with those from Sefunim, Geula, Amud, and upper layer E of Hayonim, all dating to a time in the Middle Paleolithic after the archaic forms had disappeared (for additional details concerning faunal correlations in the Levantine Mousterian, see Tchernov 1991).

The only attempts at the identification of birds from Mousterian deposits in the southern Levant are those of Bate (1932) for Zuttiyeh and Tchernov (1962) for Kebara. (Pichon and Tchernov [1987] have revised the galliforms from Kebara.) Therefore the only available list of Mousterian birds in this region is based on a very small number of sites. The list of birds from Kebara is based on Stekelis's excavations up to 1957 and includes a large number of species that no longer exist in the area, some of which are found at present far outside the Levant. Of these it is worth mentioning a few examples: of the Corvidae, *Pica pica* and *Pyrhocorax graculus* are not found south of the Lebanese mountains; of the Sturnidae, the Asian genus *Sturnia* was still extant in this region, but an Oriental form of *Oriolus* sp. and *Gallus gallus* (wild fowl) (Pichon and Tchernov 1987) have also been identified from the Mousterian deposits of Kebara. Other species which are not known in the recent Mediterranean avifauna are *Onychognathus* sp. (Sturnidae), *Aegypius monachus* (Falconiformes), and *Megaceryle* sp. (Alcedinidae). The Mousterian avifauna seems to represent a much more diversified community than the present one, in which more Oriental, northern Palearctic, and Ethiopian species were included.

A taphonomic and behavioral analysis of the larger-mammal remains was begun in 1987. To date, work has focused on the bones of the two most abundant ungulate species in the faunal assemblage—gazelle and fallow deer (similar studies of the other larger-mammal species will be reported later). Moreover, since the tedious task of washing, labeling, and sorting the thousands of animal bones from the recent excavations is still in progress, analysis has concentrated on the large collections from the Stekelis excavations. As these materials have already been the object of a detailed study by Davis (1977), the focus here has been to collect additional observations on them such as the frequency and placement of cut marks, carnivore damage, and burning. With these combined data sets in hand, the principal long-range goals of our analysis are (*a*) to assess the role of carnivores, particularly hyenas, and humans in forming the Kebara assemblage of larger-mammal bones and (*b*) to explore the insights these faunal remains can provide us concerning the hunting (and/or scavenging) behavior of the Pleistocene human inhabitants of the cave. Since the behavioral capacities of Middle Paleolithic hominids have become the focus of considerable debate in recent years (e.g., Binford 1984, Mellars and Stringer 1989,

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Stiner 1990, Trinkaus 1989), we decided to include in the present analysis the Upper Paleolithic faunal remains recovered by Stekelis as a baseline against which to compare the Mousterian data. The information presented here must be regarded as preliminary, as the sample analyzed is still far too small, especially when subdivided into chronological periods, taxa, skeletal elements, element portions, presence or absence of cut marks, and so forth, to allow us to examine the material on a horizon-by-horizon basis. Only after a larger proportion of the material from the recent excavations has been fully analyzed and coded can we begin to explore the properties of individual horizons within these immense temporal units. Finally, in light of the sample limitations, we have not evaluated the statistical significance of the many percentages we present in the discussions that follow; at this stage we are more interested in the convergence of multiple lines of evidence.

The faunal collections from Stekelis's excavations are curated at the Hebrew University in Jerusalem by taxon (e.g., gazelle, cervids, *Capra, Sus, Bos,* equids). In addition to these identified specimens, the collection includes a vast quantity of material that remains to be systematically sorted. Included in this category are thousands of fragmentary bones that cannot be identified with confidence to a particular taxon but that can be assigned to body part and approximate body size. There are also many specimens in these unsorted materials—particularly postcranial elements—that can still be identified securely to species. The integrity and unbiased condition of the Stekelis macrofaunal collections is strikingly borne out by the fact that its composition, in terms of species and skeletal-element frequencies as well as in the proportions of cut-marked, burned, and carnivore-damaged specimens, is virtually identical to the compositon of the materials recovered from the *décapage* during the recent excavations.

By 1990, we had coded slightly more than 11,000 bones (NISP = 11,375) of larger mammals—8,105 from the Mousterian and 3,270 from the Upper Paleolithic. These include all of the gazelle bones in the Stekelis collection that had been sorted to taxon by previous workers, as well as hundreds of additional specimens of gazelle that we culled from the unsorted material (NISP = 6,052; MNI = 248, based on the astragalus). Our sample also includes roughly a third of the previously sorted fallow deer bones (NISP = 1,421; MNI = 36, based on $M^1 + M^2$). Also included here are more than 1,000 "unidentifiable" bones culled from the unsorted materials that we have assigned to body part (e.g., vertebral body and process fragments, limb-shaft fragments) and approximate body size (e.g., gazelle-sized, fallow-deer-sized, etc.).

In both the Middle and the Upper Paleolithic, bones of larger mammals, numbering in the thousands, are densely concentrated in a relatively narrow zone along the north wall of the cave, and the location of these concentrations appears to have remained relatively stable for millennia. This is strikingly illustrated by the fact that almost 50% of the bones coded to date come from a single 4-m-wide strip adjacent to the north wall of the cave (Stekelis's excavation grid unit lines A^2 and A^3 [see fig. 2]). Understanding the mechanism(s) by which so many animal bones ended up concentrated in this one area of the site is a critical first step in the analysis of the Kebara fauna. We obviously cannot simply assume that the human inhabitants of the cave were the primary agents of bone transport and accumulation and proceed to interpret the assemblage as though it provided an unbiased and direct record of past human behavior at the site. We must first determine the role that carnivores (and other agents or processes) may have played in the formation and subsequent alteration of these bone concentrations.

With the possible exception of the faunal materials deposited adjacent to the north wall of the cave at the end of unit VII, there is no compelling geological or stratigraphic evidence to suggest that the bulk of the faunal remains in these concentrations represent lag deposits formed as a result of erosion, slumping, or other natural depositional processes within the cave. Furthermore, mineralogical analyses of the sediments indicate that the bone accumulations adjacent to the north wall, as well as the localized concentrations in the central area, most likely represent the original burial distribution. In contrast, the absence of bones in the southern area is due to dissolution of the bones following burial.

Humans clearly played an important role in the formation of these bone accumulations, as is indicated by the presence of many cut-marked and burned bones, as well as ash lenses, hearths, and extremely large numbers of lithic artifacts along the north wall. In fact, the concentration of humanly derived detritus near the north wall was sufficient to lead Stekelis (Schick and Stekelis 1977:102) to refer to this area of the cave as the "kitchen midden."

At the same time, several lines of evidence clearly point to the involvement of carnivores in the formation of these bone concentrations. The most obvious of these is the presence of many bones that have been gnawed, punctured, crenulated, or pitted by medium-sized to large carnivores, as well as numerous sharp-edged specimens—particularly astragali and phalanges of gazelles—that have been heavily acid-etched in the gut of a predator (Horwitz 1990). Also striking is the virtual absence in the larger-mammal sample of soft, spongy limb epiphyses, such as the proximal humerus, proximal tibia, and distal femur—a telltale sign of severe modification by attritional processes, almost certainly among them bone chewing by predators (Binford 1981, Brain 1981). The assemblage also displays a sharp bias against elements of the upper limb, most particularly the proximal epiphyses of upper limb bones—another sign of loss through attrition, again probably involving carnivores. In addition, the bones of several different species of carnivore, including bones and scats of spotted hyena (*C. crocuta*)—a pattern which taphonomists have often noted as a characteristic feature of carnivore dens (e.g., Binford 1981, Klein 1975, Straus 1982)—have been found in the north-wall concentrations (Horwitz and Goldberg 1989,

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Dayan n.d.). Porcupine gnawing is rare, suggesting that this animal played at best a very minor role in the taphonomic history of the site.

Thus, carnivores, not just humans, contributed to the formation of the north-wall bone concentrations. Of this there seems little doubt. The critical question, then, is the nature and extent of their contribution. Did they primarily damage, consume, or remove bones that had been brought to the site by humans, or did they actually transport significant numbers of carcasses into the cave themselves? If the north-wall bone concentrations are largely a product of hyena feeding and denning activities, with only a small admixture of humanly transported materials, the assemblage may be of great value for paleontological and paleoenvironmental studies but of limited use to archaeologists for investigations of past human behavior. If, in contrast, the overall human contribution to the assemblage outweighs that of the carnivores, then we can begin, albeit cautiously, to explore the behavioral implications of these materials.

Several lines of evidence lead us to the conclusion that the major bone concentrations in Kebara Cave, almost certainly those in the Mousterian and probably also those in the Upper Paleolithic, are in fact largely a product of human, not carnivore, transport. First, many of the bone concentrations along the north wall actually grade into the dark, ash- and organic-rich cultural horizons that form the core of the Kebara sequence. While this in no way proves absolute contemporaneity between these bone concentrations and human presence in the cave, it does suggest that periods of cultural activity were also periods of bone accumulation. This was not invariably the case, particularly in the Upper Paleolithic, but it certainly was often the case. During periods of intense (and presumably recurrent) human occupation at Kebara such as are evidenced for example by the extremely high lithic densities and superimposed horizons of hearths and ash lenses that characterize much of the 4-m-thick Mousterian sequence, hyenas are unlikely to have constructed their dens in the cave. Modern spotted hyena cubs often remain in or close to their den for up to 15 months (e.g., Mills 1990:215–20), which would not have been possible if the site's human occupants had returned there each year. Under such conditions, hyenas might have scavenged fresh bones from the floor of the cave when the human occupants were temporarily elsewhere and would almost certainly have transported them to more protected locations where they could be consumed in relative security (e.g., Binford, Mills, and Stone 1988). Thus, although the bone concentrations that accumulated during periods when Kebara Cave was regularly used or visited by humans were almost certainly ravaged by scavengers, with many bones damaged or destroyed and others removed, most of the contents of these piles nevertheless were probably brought to the cave by humans.

This is not to say that hyena feeding and denning did not take place within the cave. In fact, there is convincing evidence that they did, particularly during the Upper Paleolithic. First, human use of the cave appears to have been more ephemeral during the Upper Paleolithic than during the Mousterian. Hearths and ash lenses are much less in evidence, and lithic densities are noticeably lower. In addition, carnivore damage to bones is greater in the Upper Paleolithic, an indication that scavengers were more active in the cave. Both the absolute number of carnivore remains (Dayan n.d.) and the ratio (using NISP values) of carnivore (all species) to gazelle remains (an approximation of the carnivore-to-ungulate ratio employed by taphonomists as a means of estimating the intensity of hyena denning/feeding activities [see, e.g., Klein 1975]) are greater in the Upper Paleolithic (carnivore NISP = 209; nine taxa; ratio of carnivores to gazelles, 0.11) than in the Mousterian (carnivore NISP = 100; nine taxa; ratio of carnivores to gazelles, 0.02), indirect clues that carnivores frequented the cave more regularly in the later period. In addition, while both periods produced skeletal remains of the hyenas themselves (Mousterian, NISP = 15; Upper Paleolithic, NISP = 25), only the Upper Paleolithic deposits yielded the remains of hyena pups (NISP = 8), a telltale sign of at least some denning (Dayan n.d.).

But even during the Upper Paleolithic the faunal remains in the north-wall concentrations display many features that suggest that they are largely humanly derived rather than the food remains of hyenas. First, while carnivore damage to bones in the form of gnawing, puncturing, and acid-etching increases in the Upper Paleolithic, the levels are still modest compared with what one might expect if the assemblage were largely or entirely the food remains of carnivores (e.g., Binford 1981, Brain 1981, Stiner 1991). Also striking is the fact that, in both time periods, the proportion of carnivore-damaged bones and of cut-marked and burned bones, as well as the proportion of lower versus upper limb elements and the ratio of gazelles to fallow deer, all appear to be relatively constant across the site, in contrast to what one would expect if bones accumulating close to the north wall were largely the detritus of feeding or denning hyenas while those out on the cave floor were left there by humans.

TEMPORAL COMPARISONS OF TAPHONOMIC INDICATORS

As has already been noted, carnivore damage (e.g., gnaw marks, crenulated edges, grooving and pitting, punctures, acid-etching) is present on many of the larger-mammal bones (see Binford 1981 and Brain 1981 for descriptions and illustrations of typical damage patterns), regardless of time period, but it is consistently more in evidence in the Upper Paleolithic remains (table 3). Thus, for example, the proportion of carnivore-damaged specimens in the overall faunal sample, combining bones of all species and excluding loose teeth, is 6.7% for the Mousterian compared with 16.7% for the Upper Paleolithic (these and subsequent percentages, unless otherwise indicated, are based on NISP values). The proportion of damaged specimens is higher for fallow deer than for gazelle in both periods. Damage to the astraga-

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TABLE 3
Temporal Comparisons of Taphonomic Indicators (%)

	Middle Paleolithic	Upper Paleolithic
Incidence of carnivore damage		
Total assemblage	6.7	16.7
Total gazelle	5.2	14.5
Total fallow deer	17.7	37.8
Astragalus		
Gazelle	8.5	20.5
Fallow deer	37.1	85.2
Acid-etched bones	+	0.6
Upper limb		
Gazelle	10.1	21.3
Fallow deer	31.3	65.4
Lower limb		
Gazelle	6.6	14.8
Fallow deer	17.0	40.2
Front limb		
Gazelle	8.5	15.8
Fallow deer	18.5	35.3
Rear limb		
Gazelle	6.7	17.8
Fallow deer	17.5	48.5
Cranial/postcranial ratio	34.5	34.2
Age structure		
Crown heights (dP_4 and M_3)		
Gazelle (Davis's youngest age-class)	21.5–26.5	39.5
Gazelle (Wolf's youngest two age-classes)	54.0	71.0
Fallow deer (Wolf's youngest two age-classes)	57.0	73.0
Unfused limb epiphyses		
Gazelle (metapodial)	15.0–22.0	26.0
Gazelle (calcaneus)	22.0–26.0	41.0
Fallow deer (metapodial)	9.0–19.0	31.0
Fallow deer (calcaneus)	22.0–23.0	42.0
Sex ratio (female)		
Gazelle (horn core)	75.7	36.8
Gazelle (innominate)	68.4	50.0
Incidence of burning		
Total assemblage	4.1	1.9
Gazelle	4.5	2.0
Fallow deer	5.0	1.5
Incidence of cut marks		
Total assemblage	9.6	5.8
Gazelle	12.1	6.7
Fallow deer	15.7	12.4

+ present.

lus, the single most common postcranial element, follows the same pattern, being greater in the Upper Paleolithic than in the Mousterian and much more extreme in fallow deer than in gazelle. These data indicate not only that the later remains display more evidence of carnivore damage than the earlier ones but that the bones of fallow deer are more heavily gnawed and damaged than the bones of the smaller gazelle.

Acid-etched bones, identified by their sharp, wafer-thin edges (e.g., Horwitz 1990), also point to greater carnivore damage in the Upper Paleolithic. Only 3 gazelle bones in the Mousterian (1 second phalanx and 2 astragali) are acid-etched compared with 20 in the Upper Paleolithic (4 first phalanges, 4 second phalanges, 1 third phalanx, 9 astragali, 1 distal metapodial, 1 horn core). In contrast to gnawing and punctures, acid-etching is much less common on fallow deer bones (possibly 1 tooth in the Mousterian, 1 distal metapodial in the Upper Paleolithic). Interestingly, although the fallow deer astragali show extensive evidence of gnawing, none are acid-etched—perhaps because there was an upper size limit for items that could be swallowed intact by the predators, presumably hyenas, at Kebara (Horwitz 1990; see also Payne and Munson 1986).

The striking underrepresentation of softer, less dense articular ends or epiphyses of the upper limb elements such as the proximal humerus, proximal tibia, and both epiphyses of the femur points toward heavy attrition by carnivores in both time periods and again underscores the heavier attrition suffered by the faunal remains in the Upper Paleolithic. Thus, for example, among gazelles, the ratio of distal to proximal humeri is over 28 to 1 in the Mousterian, and there are no proximal humerus fragments but 78 distal humeri in the Upper Paleolithic. Similarly, the ratio in gazelle of distal to proximal tibiae is almost 25 to 1 in the Mousterian and 46 to 1 in the Upper Paleolithic. Interestingly, there are 6 complete or nearly complete fetal gazelle limb bones (4 humeri, 2 radii) in the sample, and consistent with the patterning in the more mature elements, 5 of them were encountered in the Mousterian levels. In fallow deer, the sample sizes are too small to make reliable comparisons between the Middle and Upper Paleolithic, but the patterning is similar to that seen in gazelle, with proximal humeri and tibiae either absent entirely or at best represented by only a few fragments.

The ratio of proximal (upper) to distal (lower) limb elements provides another way of examining the degree of attrition suffered by an assemblage. The assumption here is that the meaty and grease-rich elements of the upper limb (e.g., humerus, femur) are more attractive to carnivores than are those of the lower limb and are also less resistant to attritional processes such as carnivore gnawing, trampling, leaching, compaction, and so forth. They are also of course more prone to destruction through human processing activities (e.g., bone breaking for marrow), so their underrepresentation in an assemblage, while suggestive, is not an unambiguous indicator of nonhuman attritional processes.

It is interesting in this regard that signs of carnivore damage are concentrated more heavily on the surviving upper limb bones than on those of the lower limb, especially in the fallow deer, and this pattern becomes pronounced in the Upper Paleolithic. For example, in fallow deer 31.3% of Mousterian-period upper limb bones have been gnawed by carnivores compared with 17.0% of lower limb bones, while for Upper Paleolithic bones the corresponding figures are 65.4% and 40.2%. These data show not only the greater activity of carnivores in the Upper Paleolithic but the specific targeting by these predators of the meaty or marrow-rich upper limb bones of the larger-bodied species.

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Interestingly, front and rear limbs seem to have been brought to the site and subsequently scavenged from the assemblage or destroyed in roughly equal proportions, regardless of time period or body size (larger-bodied mammals such as *Cervus*, equids, rhinoceros, and *Bos* are not considered here). Even the first phalanges of gazelles, which could be assigned to front and rear limb on the basis of clear bimodality in the ratio of maximum length to proximal breadth (GLpe:Bp, using the attributes defined by von den Driesch 1976), were evenly divided between front (Mousterian 55.9%, Upper Paleolithic 53.5%) and rear (Mousterian 44.1%, Upper Paleolithic 46.5%). Moreover, in most gazelle elements there is no clear tendency for gnawing damage to be concentrated on the front or rear limb in either time period. In the Mousterian 8.5% of gazelle front limb elements and 6.7% of rear limb elements are gnawed; in Upper Paleolithic gazelle, gnawing is also evenly divided between the front and rear limb, 15.8% and 17.8% respectively. The first phalanges are a notable exception. In the Mousterian very few, regardless of limb, are chewed (6.4% of front first phalanges, 2.0% of rear first phalanges); in the Upper Paleolithic, however, not only are many of the first phalanges gnawed but much more of the gnawing is concentrated on the rear foot (23.7% of front first phalanges, 42.4% of rear first phalanges). Curiously, despite the much greater overall incidence of chewing on first phalanges in the later period, the proportion that are broken is nearly identical in the two periods (47.1% in the Mousterian, 49.7% in the Upper Paleolithic). We could not determine the proportion of broken front versus rear phalanges, since assignment to appropriate limb could be done only with complete specimens. Very few gazelle second phalanges are broken in either time period (Mousterian 4.0%, Upper Paleolithic 6.6%).

The patterning in the fallow deer differs somewhat from that seen in gazelle. In this species, gnaw marks and other signs of carnivore damage are equally represented on both limbs only during the Mousterian; during the Upper Paleolithic, carnivore damage becomes more heavily concentrated on the meatier rear limb than on the front limb. The sample of fallow deer foot bones for both time periods is too small and fragmentary to allow us, as we did for gazelle, to determine the proportions of front versus rear first phalanges in the assemblage or the incidence of carnivore damage on the phalanges of each limb. Interestingly, in both time periods much higher proportions of fallow deer first and second phalanges are broken: in the Mousterian 75.9% and 50.0%, in the Upper Paleolithic 81.8% and 54.6%, respectively. The sharply higher incidence of fragmentation seen in fallow deer second phalanges, a comparatively robust bone, is intriguing and could reflect greater interest in the marrow content of these elements on the part of either predators or humans.

Differences between the Middle and Upper Paleolithic in the ratio of cranial to postcranial skeletal elements provide another potential avenue for exploring the role of carnivores in transporting and modifying the Kebara faunal remains. The rationale here is simply that one might expect a significantly greater proportion of crania in the Upper Paleolithic if hyenas were the principal agent of bone transport in that period (e.g., Binford 1981; Klein 1975; Skinner, Davis, and Ilani 1980; Stiner 1990, 1991). This is not the case; the proportions (calculated using the total assemblage, including loose teeth) are nearly identical in the two periods.

The proportion of immature gazelles and fallow deer, as seen in both dental and epiphyseal fusion data, increases in the Upper Paleolithic—another possible sign, albeit an ambiguous one, of greater carnivore activity. The assumption here is that carnivores, including spotted hyenas, often kill prey that are young (or very old), whereas humans are more likely to target prime adult individuals (Mills 1990:37–43; Smith 1974; Stiner 1991; but see Speth 1991). The increase in immature animals might therefore be seen as an indication that hyenas were actively transporting the carcasses of young animals into Kebara during the Upper Paleolithic. One could of course argue the reverse as well. Immature elements are normally more vulnerable than mature ones to attrition by large bone-chewing carnivores (Binford 1981, Brain 1981); the increase in the former could therefore be seen as evidence in the later period for a decline in the level of carnivore attrition, not an increase in hyena transport. This interpretation seems unlikely, however, given the many other lines of evidence that point to higher levels of attrition in the Upper Paleolithic. Finally, it is possible that the change in age structure, a pattern clearly seen in the region toward the close of the Pleistocene (Davis 1977), represents a shift in the seasonality of site use or in its human inhabitants' techniques of animal procurement.

The age structure of gazelles and fallow deer in the Kebara assemblages can be approximated in two different ways: on the basis of crown height measurements of teeth and on the basis of the frequency of unfused epiphyses. Two independent studies of the Kebara gazelle and fallow deer dentitions in the Stekelis collections have been undertaken (Davis 1977, Wolf 1988). Davis measured crown heights of a sample of lower third molars (M_3) and presented his results in terms of numbers of specimens per crown height class (expressed in millimeters); he also included the number of posterior mandibles with fully formed unerupted M_3s. Wolf measured crown heights of a sample of two teeth, one permanent (lower M_3) and one deciduous (lower dP_4). She expressed her results as proportions of individuals in 10%-of-lifespan age-intervals (see Klein and Cruz-Uribe 1984). While their age-classes are not equivalent and hence the proportions of individuals they assigned to each class differ, their results are nevertheless broadly similar. For gazelles, both researchers note a striking underrepresentation of the youngest age-classes, a pattern typical of most Paleolithic faunal assemblages and very likely a reflection of carnivore or other attritional processes selectively eliminating the youngest and most fragile specimens (Klein and Cruz-Uribe 1984, Shipman 1981). When Davis's data are subdivided into four arbitrary groups, the proportion of individuals in the youn-

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gest of these (values between 18 and 21 mm, plus unerupted teeth) increases slightly, from 21.5% in his "Lower" Mousterian (material from a depth greater than 6.30 m below datum) to 26.5% in his "Upper" Mousterian group, and in the Upper Paleolithic jumps to 39.5%. Wolf's (1988) results show a very similar overall pattern for gazelles. Wolf's (1988) data for fallow deer teeth show a similar shift toward younger individuals in the Upper Paleolithic. (Because the samples were small, Davis [1977:160] did not present his fallow deer data broken down by time period.)

Epiphyseal fusion data show essentially the same age trend as that seen in teeth (Davis 1977:162). Of gazelle metapodials, the elements most frequently found in an unfused state at Kebara, 15% ("Lower" Mousterian) to 22% ("Upper" Mousterian) are unfused in the earlier period compared with 26% in the Upper Paleolithic. In fallow deer, the proportion of unfused metapodials rises more dramatically over time. The samples of unfused fallow deer bones, however, are very small and may not be reliable. Calcanea of the two species show a more striking difference between the two periods.

While the increase in immature animals in the Upper Paleolithic levels might be seen as evidence for increasing hyena transport in the later period, Davis's (1977:160) crown height data for gazelles show a decline in the proportion of very old individuals, a strong argument against hyenas' having become the principal bone transporters in the Upper Paleolithic (e.g., Stiner 1990, 1991). Unfortunately, crown height data broken down by period are not yet available for fallow deer; therefore it is not known whether a similar trend also occurs in a larger-sized ungulate.

The sex ratio of gazelle horn cores, determined from their basal diameters, may also provide evidence for greater carnivore activity in the Upper Paleolithic, but here again the patterning, while clear-cut, is difficult to interpret. Interestingly, in the Mousterian most of the horn cores derive from females: 75.5% in the "Lower" Mousterian (total NISP = 37), 75.6% in the "Upper" Mousterian (total NISP = 45). This somewhat unexpected sex ratio is unlikely to reflect selective destruction by hyenas; if this were the case, male, not female, horn cores should predominate. In the Upper Paleolithic the sex ratio of the horn cores is reversed, though the bias toward a particular sex is not as pronounced as in the Mousterian. For at least two reasons this shift could point toward greater hyena activity in the Upper Paleolithic. First, modern spotted hyenas, at least in some circumstances, are known to focus disproportionately on male prey (Mills 1990:42–43), and this could be what is reflected in the later Kebara material. If so, this would be another line of evidence pointing toward the transport of carcasses into the cave by predators, presumably spotted hyenas, during the Upper Paleolithic. It must be borne in mind, however, that human foragers also often selectively hunt male or female prey, their choice depending on a variety of factors that include the season of site occupation, the physiological condition and behavior of the animals at that time of year, and the nutritional needs of the hunters themselves (Speth and Spielmann 1983, Speth 1989).

The increase in the proportion of male horn cores in the Upper Paleolithic, rather than being a sign of carcass transport by hyenas, could merely reflect the greater selective destruction by hyenas of the much more gracile female horn cores. However, a similar change in sex ratio is also seen in gazelle innominates. In the innominates, which were sexed on the basis of the size and configuration of the eminentia iliopectinea of the pubis and the width of the ventro-medial border of the acetabulum (see illustrations in Boessneck 1969), males make up only 31.6% of the Mousterian sample while females comprise fully 68.4% (total NISP = 38). In the Upper Paleolithic the shift in sex ratio is not as dramatic as that seen in horn cores—an indication that female horn cores probably have been selectively lost to hyenas or other destructive processes—but the change is nevertheless in the same direction, with males rising to 50.0% of the sample (total NISP = 24). In contrast to the situation with horn cores, it is difficult to envision hyenas selectively destroying the pubis of a particular sex. As with the horn cores, the sample of innominates is extremely small, but further work with the collections, particularly with the bones from the new excavations, should augment the number of specimens and improve the reliability of the sex ratio estimates.

Attempts have been made to sex two other gazelle postcranial elements, the distal humerus (Davis 1977) and the astragalus (Cope 1990). Our own results for these elements were ambiguous, and as a consequence we have been forced to rely entirely on elements that can be sexed on the basis of their morphology alone—the horn cores and the pubis.

The proportion of burned fragments in the Kebara faunal assemblage may also point to less human involvement in the accumulation of bones during the Upper Paleolithic. Traces of burning were identified visually on the specimens. Since much or all of the surface of the Kebara bones is covered by a thin black veneer, perhaps a manganese deposit, that sometimes closely mimics the appearance of burning, a very conservative approach has been used in coding specimens for this attribute. Nevertheless, while the estimates presented here are minimum values, they should be reasonably close approximations of the "real" values. Of the assemblage as a whole, regardless of species (and excluding loose teeth), 4.1% of the Mousterian bones are burned compared with 1.9% of those in the Upper Paleolithic. It is difficult to determine with the data at hand whether the burning of these bones was primarily a result of roasting meat and bones on a fire or of largely accidental charring of bones previously abandoned on the cave floor. If we assume for the moment that most of the burning occurred during food preparation, the question arises whether the Mousterian values of 4.5% and 5% for gazelle and fallow deer, respectively, are high or low. To answer this question, we can compare the Kebara values with the incidence of burned bone in a large late prehistoric (ca. A.D. 1275) roasting pit excavated by one of us (JDS) in a

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Pueblo village in the southwestern United States (Rocek and Speth 1986; J. D. Speth, unpublished data). The feature, a meter-deep pit filled with hundreds of kilograms of fire-cracked rock, as well as ash, charcoal, heavy-duty flaked-stone chopping and butchering tools, and several thousand broken bones, appears to have been used primarily if not exclusively for roasting the meat (and bones) of American bison (*Bison bison*) and pronghorn antelope (*Antilocapra americana*). Just under 6% of the bison bones and slightly over 7% of the antelope bones in this feature were burned—values not very different from those we observed for the Mousterian gazelle and fallow deer bones at Kebara. Meat roasting, therefore, may well have been an important function of at least some of the hearths in the cave, despite what at first seem like modest amounts of burned bone. This of course in no way rules out other functions for the hearths; they very likely served as sources of heat and light, and they may well have been used in preparing vegetal foods as well (Meignen, Bar-Yosef, and Goldberg 1989).

Finally, the frequency of cut-marked bones in the two periods also points to somewhat greater carnivore activity (or less human activity) in the Upper Paleolithic, although again the differences between the two periods are not striking. Combining all species and again excluding loose teeth in the calculations, 9.6% of the Mousterian bones compared with 5.8% of the Upper Paleolithic bones have cut marks. Similar results are obtained when gazelle and fallow deer are considered separately.

To summarize the taphonomic evidence presented thus far, it seems that carnivores played an important part in modifying both the Mousterian and the Upper Paleolithic faunal assemblages at Kebara. In both periods, bones are gnawed and punctured by carnivores and softer limb epiphyses largely obliterated, biasing the assemblages toward elevated proportions of lower limb parts, especially metapodials, carpals and tarsals, and phalanges. Carnivore damage is generally greatest on the meaty, marrow-rich bones of the upper limb and particularly on those of the larger species. Not only is carnivore damage in evidence on many of the Kebara bones, but in almost every aspect we have considered up to this point the faunal remains from the Upper Paleolithic deposits show a stronger carnivore signature than do those from the earlier deposits. Thus, the incidence of gnawing is higher in the later material, especially on fallow deer bones, and the biases against softer limb epiphyses and more meaty upper limb elements are greater. In addition, the elevated proportion of immature animals in the Upper Paleolithic assemblage, reflected both in the dental remains and in the proportions of unfused epiphyses, as well as the increase in the proportion of male animals seen in the sex ratios of gazelle horn cores and innominates, may point toward more active transport of animal carcasses into the cave by hyenas during the later period.

At the same time, that (at least in gazelles) the proportion of very old animals declines rather than increases in the Upper Paleolithic raises serious doubts about hyenas as the major carcass transporter in the later levels, and the cut-mark and burning data are perhaps the clearest signs we have of human involvement. While these two indicators mirror the taphonomic results, with slightly lower incidences of both cut-marked and burned bones in the Upper Paleolithic, the differences between the two time periods are relatively minor. If the Upper Paleolithic faunal materials were largely the product of hyena feeding and denning, they should display much lower levels of cut marking and possibly also burning than the Mousterian remains. This does not appear to be the case. These results therefore hint at the possibility that humans played broadly similar roles in the formation of the north-wall bone concentrations in the two time periods.

SPATIAL COMPARISONS OF TAPHONOMIC INDICATORS

If the north-wall bone concentrations were formed largely by carnivore feeding and denning, they should differ significantly in a suite of taphonomic indicators from bones found in the central area of the cave, where human occupation appears to have been most intense. Consideration of this hypothesis is handicapped to some extent by the fact that relatively few bones in the Stekelis collection, particularly from Mousterian levels, come from proveniences well removed from the north wall and only a small fraction of the recently excavated bones from the central area of the cave has so far been analyzed and coded. Nevertheless, the results, while tentative, provide fairly compelling evidence that the bulk of the north-wall assemblages in both time periods are of human origin.

We have arbitrarily divided the Kebara faunal assemblages into three spatial groups; from north to south in the cave these are (1) the north group, comprising all bones within Stekelis's grid units A^3 and A^2, (2) the intermediate group, comprising all bones in Stekelis's grid units A^1 and A, and (3) the floor group, comprising all other bones from the site. For certain comparisons, we also present data for a fourth group comprising just the materials from the *décapage* area in unit X. This group is the only large sample of bones from the recent excavations that has so far been fully analyzed and coded and thus provides us with an unbiased look at the composition of the faunal remains deposited in the central floor area of the cave during a relatively thin slice of time within the Mousterian. In those comparisons for which the unit X sample was large enough to work with, the values generally turned out to be identical or very similar to those from the larger and more inclusive floor-group sample, an encouraging indication that the Stekelis collections are not seriously biased by either recovery techniques or selective retention practices. We have not yet analyzed a comparable sample of Upper Paleolithic materials from the recent excavations in areas well removed from the north wall, but there is no reason to suspect any greater degree of recovery or retention bias in the younger remains excavated by Stekelis.

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The bones in the unit X group come from a 40-cm-thick section of deposit (6.50 to 6.90 m below datum) in grid squares K, L16, 17. This small volume of deposit yielded 2,323 complete and fragmentary mammalian bones that were identifiable to taxon (i.e., either to genus or species or at least to approximate body size) and skeletal element. An additional 1,519 unidentifiable fragments, less than about 1 cm in maximum length, were counted but not coded, and an as yet undetermined number of bird, rodent, and tortoise remains await analysis.

In signs of carnivore damage (gnawing, puncturing, pitting, etc.), the three spatial groups in the Mousterian show only minor differences from north to south (table 4). In the Upper Paleolithic the fall-off in carnivore damage from north to south is more pronounced, pointing to greater carnivore bone-chewing activity close to the north wall of the cave in the later period. For example, in the Mousterian, the proportion of carnivore-damaged gazelle bones remains nearly constant as one moves away from the wall, but in the Upper Paleolithic the fall-off is much more evident. In fallow deer, as in gazelle, the Upper Paleolithic sample shows the expected fall-off in carnivore damage as one moves away from the wall. The Mousterian fallow deer sample coded to date is too small for reliable analysis.

The proportions of lower versus upper limb elements in gazelle are very similar for the three groups in both periods. (The unit X group had a value of 82.0% for the Mousterian.) The fallow deer samples are much smaller and therefore less reliable, but these remains show a tendency toward higher proportions of lower limb elements in the floor group. Thus, attritional loss of meaty upper limb bones is higher in these larger animals than in gazelle and is somewhat more pronounced in the central portion of the cave—an expectable result if carnivores were scavenging edible remains from an area of human habitation. Trampling and other taphonomic processes, of course, may also have played important roles in eliminating more of the less resistant elements of the upper limb in the central area of the cave.

Elevated proportions of cranial parts in the north-wall bone concentrations might be expected if carnivores played a major role in the transport and accumulation of these deposits (e.g., Binford 1981; Brain 1981; Stiner 1990, 1991). Alternatively, because of their bulk, cranial parts might also have been discarded on the peripheries of the major zone of human habitation. The Kebara data are consistent with either interpretation. For the sample as a whole, the proportions of cranial parts in both time periods are consistently lower in the central portion of the cave than close to the north wall.

Another way of comparing the assemblages spatially is to examine the proportion of immature elements in each of the three groups. Because of sample size limitations, we must confine our analysis here to gazelle. Unfortunately, we do not have dental crown height information broken down by spatial grouping as yet and must focus instead on epiphyseal fusion in limb elements. However, even in gazelle our sample sizes for individual elements (i.e., metapodials, calcanea) become too small in the floor group to be reliable. To circumvent this, we have been forced to lump all of the limb elements together and calculate a composite figure for the proportion of unfused specimens. In the Mousterian the composite proportion of unfused elements decreases, but only slightly, from north to south. (The unit X group sample is too small for reliable comparison.) In the Upper Paleolithic the values also decrease from north to south, but again the differences are small. Thus, while the proportion of immature animals is slightly higher in the later period (an observation consistent with those made earlier on the basis of both fusion and dental data) and there is a slightly greater proportion of immature remains in the north-wall bone concentrations, the differences between the spatial groups are small and in no

TABLE 4
Spatial Comparisons of Taphonomic Indicators (%)

	North Group	Intermediate Group	Floor Group
Incidence of carnivore damage			
Total assemblage			
Middle Paleolithic	7.7	5.3	5.5
Upper Paleolithic	18.6	16.7	10.6
Gazelle			
Middle Paleolithic	4.4	2.8	3.1
Upper Paleolithic	13.4	9.6	6.3
Fallow deer			
Middle Paleolithic	–	–	–
Upper Paleolithic	24.3	33.6	14.5
Lower/upper limb ratio			
Gazelle			
Middle Paleolithic	83.5	88.1	83.1
Upper Paleolithic	84.8	81.3	81.4
Fallow deer			
Middle Paleolithic	95.1	92.6	100.0
Upper Paleolithic	85.8	91.6	98.2
Cranial/postcranial ratio			
Middle Paleolithic	38.0	41.3	12.8
Upper Paleolithic	36.0	35.9	28.2
Age structure (unfused elements)			
Middle Paleolithic	8.1	7.2	5.1
Upper Paleolithic	9.6	11.2	5.7
Sex ratio (female) (horn cores)			
Middle Paleolithic	84.3	70.0	60.0
Upper Paleolithic	45.4	36.8	40.0
Incidence of burning			
Middle Paleolithic	4.4	2.4	6.0
Upper Paleolithic	2.2	1.6	2.0
Incidence of cut marks			
Total assemblage			
Middle Paleolithic	9.4	9.0	10.8
Upper Paleolithic	6.3	4.5	6.6
Gazelle			
Middle Paleolithic	9.0	7.9	9.7
Upper Paleolithic	5.7	4.1	6.0
Fallow deer			
Middle Paleolithic	–	–	–
Upper Paleolithic	8.8	5.2	7.6

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way single out the north-wall concentrations as distinct from the remains out on the floor of the cave.

The sex ratio of the gazelles, based as before on the basal diameter of the horn cores, displays some intriguing spatial patterning (the spatial distribution of gazelle male and female innominates has not yet been examined). Again, however, samples are small and the results must be seen as tentative. In the Mousterian males constitute only 15.7% of the north group (total NISP of both sexes = 51). This value increases steadily toward the south, reaching 30.0% in the intermediate group (total NISP = 30) and 40.0% in the floor group (total NISP = 5). In the Upper Paleolithic, on the other hand, the values for males across the site are not only higher but much more uniform: north group 54.5% (total NISP = 22), intermediate group 63.2% (total NISP = 19), floor group 60.0% (total NISP = 5 only). Thus, while there is patterning, it seems to run counter to what one might expect if hyenas were the primary agent at work in the formation of the north-wall deposits. For example, in the Mousterian gracile female horn cores are most numerous in the north-wall group, whereas they might be expected to be least well represented there if hyenas were largely responsible for bone accumulation and subsequent attrition. Moreover, in the Upper Paleolithic, the period showing the clearer overall signature of carnivore activity, the proportion of male horn cores is more or less constant across the site, with no disproportionate representation of the more robust male elements close to the north wall.

Fluctuations through time in the proportions of fallow deer and gazelle have attracted considerable attention as paleoenvironmental indicators (e.g., Bate 1937, Davis 1977, Ducos 1968, Garrard 1982, Hooijer 1961). Their proportions in the spatial groups at Kebara might provide an additional way of assessing the role of hyenas in the formation of the site's faunal assemblages. However, since we have not yet coded all of the fallow deer bones in the Stekelis collection, our data are unsuitable for deriving estimates of the proportions of fallow deer and gazelle.

The incidence of burning in the Mousterian period shows only a slight increase as one moves away from the north wall. (The unit X group yielded a figure of 5.3%.) In the Upper Paleolithic the values are slightly lower and spatially even more uniform. The slightly elevated value seen in the central portion of the cave during the Mousterian may be misleading. During the coding of the unit X material, it appeared that burning was more common on smaller fragments, particularly on tiny ones that for the most part were not even identifiable to skeletal element. To test this impression, the coded unit X sample was arbitrarily subdivided into two size-classes at a maximum fragment length of 2.0 cm. Only 4.4% of the specimens greater than 2.0 cm in length were burned, while 7.2% of those less than or equal to 2.0 cm were charred or partly charred. Since virtually no fragments less than 2.0 cm in length in the Stekelis material have yet been coded, although many tiny pieces were retained in the collection, the best comparison between the two assemblages involves just the larger size-class from unit X. Since the incidence of burning in this size-class was 4.4%, the unit X group again turns out to be indistinguishable from the north-wall group. This result of course says nothing about why the incidence of burning at Kebara should be higher among the smaller fragments. If bones lying on the surface of the cave were accidentally burned by later human activities in the site, one would not expect there to be a correlation between the incidence of burning and specimen size; or, if anything, larger bones should display a higher incidence of burning than the smaller ones, since the larger ones are less likely to become buried by trampling under a protective layer of sediment. This curious size-related pattern, therefore, appears to support the view that burning is related to food preparation, and it may eventually offer us valuable clues about the way meat (and bone) was processed by the Mousterian inhabitants of Kebara and clarify the function of the site's many hearths and ash lenses.

The proportion of cut-marked bones in the sample as a whole shows very little clear-cut evidence, in either period, of increasing values as one moves away from the wall.

In conclusion, the gnawing data and sharp biases against fragile skeletal elements point toward heavy carnivore attrition throughout the sequence and highest in the Upper Paleolithic, while both the cut-mark and the burning data seem to point to a remarkably uniform level of human involvement in the formation of these assemblages regardless of time period. We suggest that the uniform cut-mark and burning values imply transport of the assemblage into Kebara largely by humans, while the evidence of carnivore gnawing and depletion of soft epiphyses and upper limb elements largely reflects attritional processes operating on these bones after they had been discarded by the site's human inhabitants. The results of our spatial analyses reinforce this conclusion. If hyenas were the major bone transporters at Kebara, accumulating masses of material close to the north wall of the cave, these assemblages should differ dramatically from those out on the floor of the cave. For the most part, this does not appear to be the case. While our conclusions in no way preclude the occasional denning of hyenas within the cave, especially in the Upper Paleolithic, they suggest that the quantity of bones brought into the cave by hyenas was always small compared with the contributions made by humans (horizon-by-horizon analyses in the future should help to clarify changes in the frequency and intensity of hyena denning through time). Where carnivores appear to have played a major and more continuous role in the taphonomic history of the Kebara larger-mammal remains is in modifying fresh bones that they encountered on the floor of the cave each time the site was vacated by its human inhabitants, damaging or destroying many of the bones and probably removing many others from the cave altogether.

The north-wall concentrations, it would seem, are accumulations of bones resulting largely from human ac-

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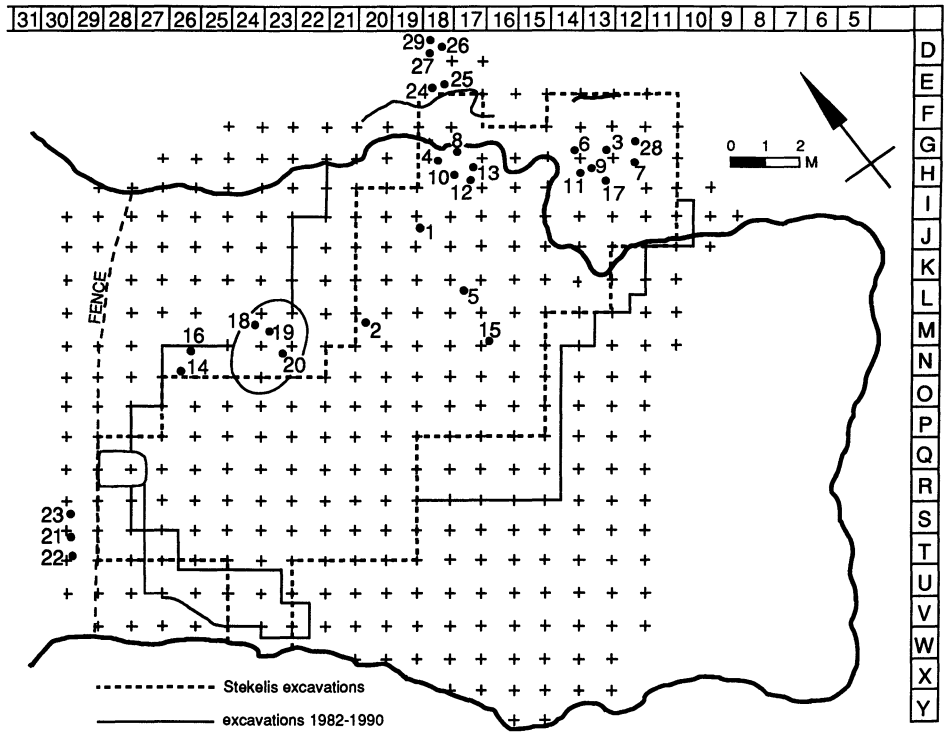

FIG. 12. *Distribution of human remains in the Mousterian deposits. (Numbers correspond to inventory in text.)*

tivities, probably from the intentional sweeping, tossing, or dumping of trash into this portion of the site. This conclusion, at least with respect to the Mousterian bone concentrations, fits comfortably with the lithic evidence; the lithic debris close to the north wall is comprised of larger pieces than elsewhere in the cave and includes an abundance of cores, cortical elements, flakes, and other waste, precisely the kinds of material one might expect to be tossed or dumped along the periphery of the occupation area (so far we lack comparable data concerning the spatial characteristics of the Upper Paleolithic stone artifacts).

Finally, if our conclusion is correct that the Kebara larger-mammal faunas are largely the product of human transport, then the increase from the Mousterian to the Upper Paleolithic in the proportion of immature gazelles and fallow deer, the decline in the later period in the proportion of very old gazelles, and the apparent shift in the sex ratio of gazelles from mostly females to an equal or perhaps even male-biased sex ratio become extremely interesting issues for further research. The reasons for these shifts are unclear at present, but they may reflect changes in the seasonality of site use or perhaps even more fundamental changes in the technology and organization of animal procurement. While we feel it is premature to speculate here on what these patterns mean, knowing that they probably derive from the activities of humans rather than carnivores is a critically important first step.

The Human Remains

Mousterian human remains were found during the various series of excavations at Kebara. The better-known finds are the infant discovered by Stekelis and the adult burial uncovered by the current team in 1983. Numerous additional fragments were collected from various parts of the excavated area (fig. 12). Of the following list, some were identified in the faunal collections curated in the Department of Zoology of the Hebrew University in Jerusalem, originating from the time when Stekelis was collaborating with Haas; these have not yet been published in detail. The earlier finds are located within the new grid wherever possible and assigned to the current stratigraphic sequence. All except items 18–23 come from the Mousterian layers. To distinguish these remains from the Natufian and Kebaran series excavated by Turville-Petre, we use the appellation KMH (Kebara Mousterian Hominid) and a serial number.

KMH 1 (1965, A^{1}6, Unit X, 6.83–6.90 m): Fragmentary skeleton of an infant about 7–9 months old (Smith and Arensburg 1977).

KMH 2 (1983, M20, Unit XII, ca. 7.80 m): Skeleton of an adult male missing the cranium, right lower limb, and most of the lower left limb (Arensburg et al. 1985; Bar-Yosef et al. 1986, 1988; Rak and Arensburg 1987; Arensburg et al. 1989; Tillier et al. 1988; Tillier et al.

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1989; Arensburg et al. 1990; Rak 1990; see also Bar-Yosef and Vandermeersch 1991).

KMH 3 (1957, $A^2$3-$A^2$4, Unit IX, 6.07–6.37 m): First deciduous upper right molar of a child 8–10 years old (Smith and Tillier 1989).

KMH 4 (1965, $A^2$6, Unit X, 6.63–6.67 m): Upper and lower deciduous teeth of a 9–12-month-old infant, including left and right upper central incisors, right upper first molar, right lower lateral incisor, lower canine and first molar (left and right), lower right second molar, germ of first lower left permanent molar (Smith and Tillier 1989).

KMH 5 (1965, A6, Unit IX/X, 6.20–6.30 m): Fragment of a mandibular symphysis, minus the dentition, of a child ca. 2 years old.

KMH 6 (1956, $A^2$4, Unit IX, 6.43–6.53 m): Fragment of a right maxilla of an adult (older than KMH 2) with two first molars.

KMH 7 (1965, $A^2$3, Unit X, 6.98 m): Lower right deciduous incisor of a child 3–5 years old.

KMH 8 (1965, $A^2$6, Unit X, 6.63–6.67 m): Upper left deciduous lateral incisor of an infant 9–12 months old.

KMH 9 (1956, $A^2$4, Unit IX, 6.43–6.53 m): Fourth right metatarsal of an adult younger than KMH 2 (Courtaud 1989).

KMH 10 (1956, $A^2$6, Unit X, 6.52–6.65 m): Right distal phalanx of the first toe of an adult younger than KMH 2 (Courtaud 1989).

KMH 11 (1956, $A^2$4, Unit IX, 6.43–6.55 m): Acromial extremity of a right clavicle of an adult younger than KMH 2.

KMH 12 (1986, H17, Unit XI, 7.60–7.65 m): Upper right deciduous second molar of a child 8–10 years old.

KMH 13 (1986, H17b, Unit XI, 7.65–7.70 m): Upper left germ of a first deciduous molar of an infant 6–8 months old.

KMH 14 (1988, N26a, Unit V/VI, 3.51 m): Lower second permanent molar of a child ca. 12 years old.

KMH 15 (1988, M16d, Unit X, 6.87 m): Upper central right deciduous incisor of a child ca. 12 months old.

KMH 16 (1988, N26a, Unit V/VI, 3.77 m): Lower left central deciduous incisor of a child 5–6 years old.

KMH 17 (1956, $A^2$4, Unit IX, 6.43–6.53 m): Acromial extremity of a left clavicle.

KMH 18 (1988, in fill of sounding excavated by Turville-Petre): Small fragment of an adult mandible with a permanent second molar.

KMH 19 (1988, in fill of sounding excavated by Turville-Petre): Fragmentary crown of an adult permanent right lower molar.

KMN 20 (1988, in fill of sounding excavated by Turville-Petre): Small fragment of a parietal bone.

KMH 21 (1989, S, T30, about 4.55–4.70 m): Germ of upper left first permanent molar of a child ca. 5–6 years old.

KMH 22 (1989, S, T30, about 4.55–4.70 m): Upper left deciduous canine of a child ca. 5–7 years old.

KMH 23 (1989, S, T30, about 4.55–4.70 m): Lower right lateral deciduous incisor of a child ca. 3–5 years old.

KMH 24 (1990, E18a, Unit XIN, 8.30–8.35 m): Upper third left molar of a young adult.

KMH 25 (1990, E18a/c, Unit R2, 7.65–7.85 m): Three germs of upper left deciduous teeth (canine, first and second molars) of an infant 6–9 months old.

KMH 26 (1990, D18, Unit R2, 7.85–8.00 m): Germ of an upper right lateral deciduous incisor of an infant 6–9 months old.

KMH 27 (1990, D18, Unit R2, 8.15–8.35 m): Upper left lateral permanent incisor of an adult.

KMH 28 (1965, $A^2$3): Lower right lateral permanent incisor of an adult.

KMH 29 (1990, D18d, Unit R1, 7.50–7.70 m): Lower left lateral deciduous incisor of an infant ca. 7–9 months old.

The burial of KMH 2 was uncovered in 1983 (figs. 13 and 14), at a depth of 7.80 m below datum, in unit XII (Arensburg et al. 1985; Bar-Yosef et al. 1986; Bar-Yosef et al. 1988; Tillier, Arensburg, and Duday 1989), dated by thermoluminescence to 61,000–59,000 years B.P. (Valladas, Joron, and Valladas 1989) and by electron spin resonance to 64,000–60,000 years B.P. (Schwarcz et al. 1989). It was exposed when the northern section of the deep sounding was excavated in order to study the details of the stratigraphy. Originally, an area 1 m long along the existing section and 50 cm wide was excavated. When the burial was reached, it became obvious that the original deep sounding had cut through the left femur. Below it we recognized that the lower limit of the burial pit, cut obliquely through two hearths visible in the northern section (fig. 13), continued into the eastern section of the deep sounding. The base of the pit coincided with the charred horizon of an additional hearth, which continued into the western section. The eastern and northeastern limits of the pit were clearly observable; the sediments inside the pit were yellow-brown while those outside were blackish. This limit, however, was not clear on the northern and western ends. The rest of the southern part of the pit had, as has been mentioned above, been removed by Stekelis in 1965.

The skeleton was lying on its back in a general west-east orientation. The right hand lay on the thoracic cavity at the level of the left scapula. The left hand lay a little lower at the level of the lumbar vertebrae. The cranium was missing. The cervical vertebrae were in anatomical sequence, with the atlas positioned between the branches of the mandible. The latter was tilted toward the vertebral column, indicating that the head of the skeleton originally leaned forward. The head lay at a slightly higher level than the rest of the body against the steep northeastern side of the burial pit. In its primary position the head was probably facing westward.

The right humerus was turned inward with its lateral side facing up. The right innominate was in place, and the typical sideward collapse after the decay of the flesh had not occurred. These observations mean that the right side of the body was leaning against the northern wall of the burial pit, limiting the amount of bone move-

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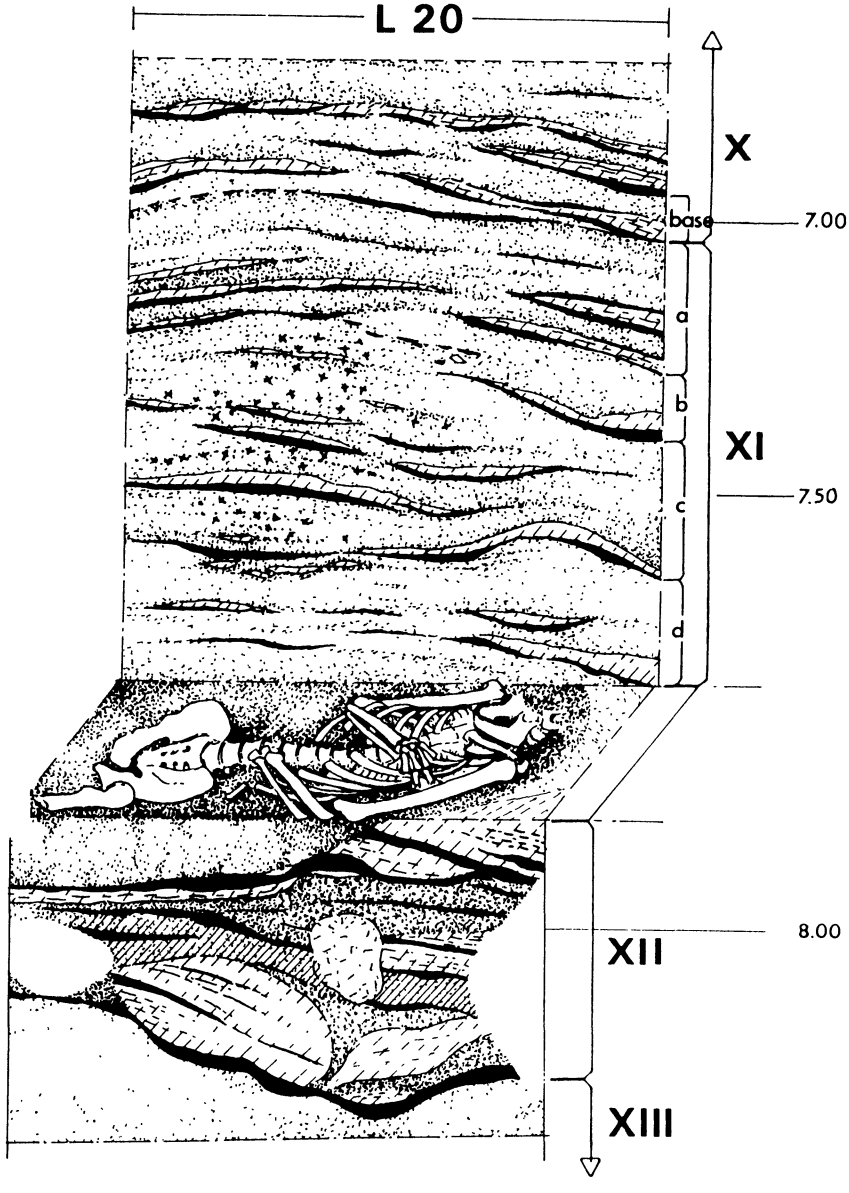

FIG. 13. *Section of the deep sounding, showing the stratigraphic location of the burial (after Bar-Yosef et al. 1988, reprinted from Bar-Yosef and Vandermeersch 1991 with permission).*

ment which normally occurs with the decomposition of the soft tissue. The exact position of the bones therefore furnishes the needed information concerning the existence of the northern and northwestern edges of the pit. The western side of the pit remains unknown, as the right lower limb is missing. The left side of the skeleton has been affected by diagenetic processes which caused the alteration of the elbow, the pelvis, and the proximal part of the left femur. The poor preservation of the femur is probably the reason Stekelis missed this part of the skeleton. It is worth noting that the left innominate was lying relatively flat and the preserved altered femur was skewed from the axis of the skeleton by about 45°.

There was no displacement of the bones beyond the initial volume occupied by the body. Most of the anatomical connections were still intact; for example, the extremely mobile hyoid bone remained in place between the branches of the mandible. There was no evidence for the collapse of the thoracic cavity after decomposition of the soft tissue. The position of the components of the scapular girdle and the obliquity of the left clavicle indicate that the shoulders were contracted slightly upwards. These observations suggest that the body decomposed in a filled grave and that the burial pit was somewhat deeper at the level of the thorax. Despite the abundance of evidence for hyena-gnawed bones in the cave, no carnivore marks were noticed on these bones. The position of the upper limbs, especially the right

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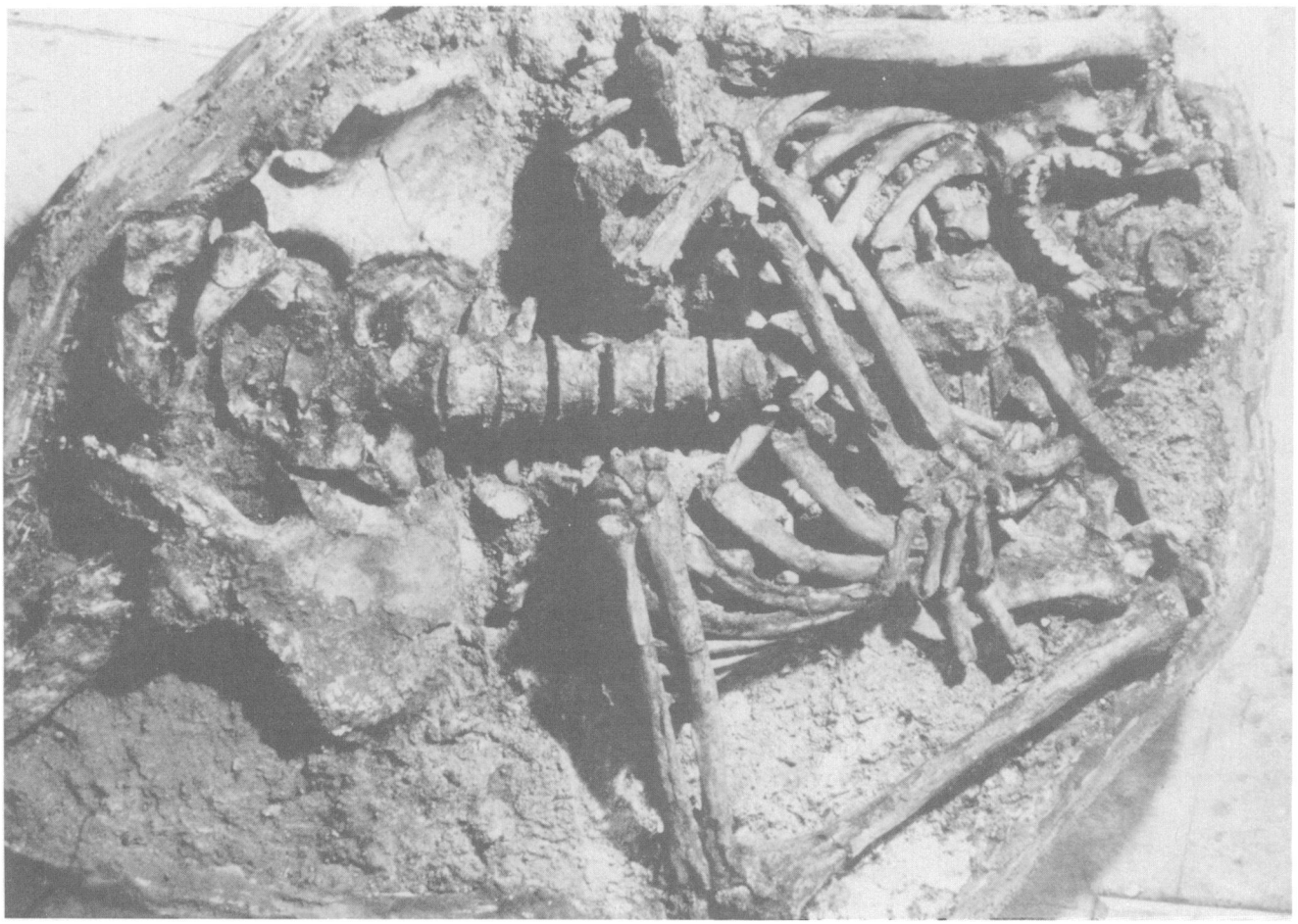

FIG. 14. *The burial as exposed in the laboratory (photo: Kebara archives).*

hand reaching the left shoulder, supports the hypothesis of immediate inhumation, perhaps preceding rigor mortis. The positions of the mandible, the hyoid bone, and the right upper third molar, which fell from its socket next to the right lower third molar, exclude the hypothesis that the skull was removed by an animal. Furthermore, no cranial fragments were found. These observations suggest that the skull was removed by humans following the complete decay of the atlanto-occipital ligaments. This is, in our view, the first clear-cut case recorded in a Mousterian context for later human intervention in a primary burial. The absence of the skull precludes any further interpretations in terms of mortuary practices. Numerous lithics and a few bones were discovered within the burial pit. Their distribution, however, would not indicate any explanation other than that they were a part of the refill of the pit, which was dug into layers rich in artifacts and bones. The use of the same sediment would also mean that no major color changes resulted from the refilling of the burial pit.

Judging by the degree of ossification, the morphological changes at the costo-endochondral joint, dental attrition, and pelvic morphology, KMH 2 was an adult male 25–35 years old. Its excellent state of preservation provides accurate information on postcranial elements such as the vertebral column, thorax, upper limb bones, and pelvis. The study of these bones has direct implications for the interpretation of the morphology of Levantine Middle Paleolithic humans. Comparisons with the Neanderthals from Tabūn, Shanidar, and Amud or with the early modern humans from Skhūl and Qafzeh (McCown and Keith 1939, Suzuki and Takai 1970, Vandermeersch 1981, Trinkaus 1983) are most informative. The estimation of the stature of KMH 2 at ±1.74 m, for example, is consistent with observations previously made on Near Eastern Middle Paleolithic hominids suggesting a mean stature greater than that of European Neanderthals (Vandermeersch and Bar-Yosef 1988).

The KMH 2 mandible displays a combination of gracile and robust features (Tillier, Arensburg, and Duday 1989, Tillier 1991). Several measurements exceed those in modern humans as well as those in other Middle Paleolithic hominids. The corpus is extremely robust and tall, especially in the symphyseal region, which lacks a

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chin. The dimensions of the mandibular teeth and of the isolated upper third molar fall within the Middle Paleolithic range of variation.

The more significant features of the vertebral column of KMH 2 are the relatively horizontal spinous process of the last two cervical vertebrae, the relative proportions of the different segments of the presacral vertebral column, the dimensions and shape of the last lumbar vertebra, and the thickness, cross-sectional profile, and curvature of the ribs (Arensburg 1989, 1991*a*). The cervical region displays no significant morphological differences from modern humans in terms of neck length and cervical lordosis.

The various components of the upper limb bones are well preserved. The scapulae are large and robust with a clear predominance of the left one. Their characteristics fall within the range of the Neanderthals. Of the hands the left is better preserved and resembles in its morphology and metrics the Shanidar-Amud group (Vandermeersch 1991).

The unique characteristics of the complete pelvic inlet are due to posture-related biomechanics (Rak and Arensburg 1987, Rak 1990) and do not support previous hypotheses suggesting that obstetric requirements were different for Neanderthals and modern humans (Trinkaus 1984).

Another aspect of Neanderthal behavior is illustrated by the hyoid bone and the reconstruction of the neck region. Previous assertions that these Middle Paleolithic hominids were not capable of producing modern human speech (Lieberman 1984, Laitman 1985, Crelin 1987) are not supported by KMH 2, which strongly suggests that Middle Paleolithic hominids were equally capable of speech when hyoid positioning and supralaryngeal space are the criteria considered (Arensburg 1989, Arensburg et al. 1988, Arensburg et al. 1990, Tillier et al. 1991).

The analysis of the various morphological features recorded for KMH 2 does not provide any clue to the cause of death. There is no evidence of trauma. Pathological changes are marked by the ossification of vertebrae, ribs, and sternum (Duday and Arensburg 1991), and dental pathology is limited to traces of enamel hypoplasia and hypercementosis (Tillier, Arensburg, and Duday 1989).

The morphological features of KMH 2 can be classified as follows: (1) plesiomorphic traits, especially on the jaw and the iliac blade, which are in accordance with the general robusticity of the skeleton; (2) Neanderthal features on the mandible, the upper limbs, and the pelvis; (3) features within the modern human range of variability, such as the morphometrics of the hyoid, the ribs, and the vertebral column (unfortunately, most of these traits are uniquely preserved on KMH 2 and cannot be compared with other Middle Paleolithic hominids or their predecessors); and (4) traits in which KMH 2 differs from other Levantine Mousterian skeletons, such as the overall robusticity of the mandible, the dimensions of the sacrum, and the cotylo-sciatic breadth. The KMH 2 hominid undoubtedly has affinities with the Amud-Tabūn-Shanidar group rather than with the Skhūl-Qafzeh sample but occupies a special position among them. With regard to many features it is the most robust individual known from the Levant.

Discussion

One of the unique aspects of the excavations at Kebara was that a multidisciplinary approach was employed on a daily basis during all nine seasons of excavation by the participation of at least six or seven of the original group of "ten directors." Discussions took place in the field, and numerous observations were made jointly. This somewhat complex procedure undoubtedly slowed the pace of the excavations. In addition, delay in the study of certain aspects was caused by the year-round nature of the retrieval of the fauna from the dried wet-sieved sediments. In spite of this we hope that, when all the final results are published, the quality of the information will turn out to be a major contribution to the study of the complex issues involved in the emergence of modern humans. Given the limited area of the excavated Upper Paleolithic layers, our discussion will deal only with the Middle Paleolithic sequence.

Much of the evidence acquired in Kebara contributes to the understanding of Mousterian human behavior, including the processes responsible for the formation of hearths and ash lenses, the processes responsible for the accumulation of different bone assemblages in various parts of the cave, and the operational sequences employed in manufacturing the lithic industries, including the ways in which artifacts were used. The following remarks are only preliminary conclusions derived from these studies.

HEARTHS

The white ashy deposits often indicated two phases in hearth use. First a rounded or oval hearth was established, and later the white ashes were distributed over a larger surface, creating an irregular ashy lens. Well-preserved hearths were uncovered mainly in unit XIII, the lowermost occupational deposit, where occupations seem to have been more ephemeral than in units XII–VII. The hearths contained very few bone fragments but a large number of burned lithic pieces. The absence in them of small stones or cobbles indicates that there was no warmth banking. Cooking or parching methods seem not to differ much from those found in the residues of Upper Paleolithic hearths in Kebara. Currently we are examining the possibility that they were used for baking geophytes. The discovery in the blackish lower level of many hearths of carbonized seeds of wild peas, available in patches on the slopes of Mt. Carmel in April and May (Kislev and Bar-Yosef 1988), could indicate that the cave was at least occupied during these months. The Mousterian hearths from Qafzeh, Douara (Akazawa 1987), and Kebara differ considerably from the ashy deposits in layer C of Tabūn Cave (Jelinek et al. 1973, Garrod and Bate 1937) that have been interpreted as the result of brush fires. Micromorphological evidence suggests that

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different types of combustibles (e.g., wood, grass) were burned in the various hearths in Kebara.

BONE AND LITHIC ACCUMULATIONS

There are only minor differences between the bone accumulations in the central area (the *décapage*) and those at the northern edges of the layers (including the post- or late Mousterian accumulations of bones near the northern wall in unit R). Detailed lithic and faunal analysis indicates that the zone in the central area near the north wall was probably a dumping zone. The spatial distribution of bones and lithics in unit X, including the small debris, indicates an intentional arrangement, with hearths and ashes located toward the cave's entrance while most of the lithics and all of the bones are dispersed from the hearths toward the rear part of the cave. A similar arrangement was observed in squares L, M 21, 24 in unit VII. This pattern, currently under further investigation, was not produced by natural agencies and therefore points to human activities over a considerable period of time (from unit XI through VII). (These spatial limits are not to be confused with the wavy diagenetic front which marked the disappearance of bones from the entire southern portion of the Mousterian deposits [Weiner et al. in preparation].)

The accumulations of Mousterian deposits reflect two major occupational episodes. The first occupations are represented by accumulations of hearths and ashes, with very few artifacts, in the central part of the cave. Following an erosional gap of unknown duration, repeated occupations were responsible for the accumulation of about 3.0–3.5 m of sediment, mostly of biogenic origin, at the back of the cave, under the chimney, and in the center near the north wall (units XI–X and possibly IX). (The area near the entrance is as yet unexcavated.) In later Mousterian times (units VIII–VII) a similar spatial distribution existed at least in the front part of the cave (squares N, M26–20). The rear portion of these layers, toward the back of the cave, was removed by post-Mousterian erosion. The distribution of bones in units VII–VIII resembles the distribution in the earlier units (IX–X), with the hearths closer to the entrance and the bone and lithic accumulations toward the rear part of the cave and the north wall. The importation of lithic materials by humans is clearly demonstrated by many finds. Flint pebbles and cobbles were brought in and knapped inside the cave. One well-shaped basalt pebble which probably served as a grinder could have been collected in the Mt. Carmel area.

Anthropogenic materials, the occasional remains of ephemeral hyena dens, and blown-in dust and sand gradually filled the cave. Near the entrance, washed-in colluvial red soil with some angular fragments became mixed with the residues of the late Mousterian occupations. It was only after the slumping of the swallow hole which caused the folding, faulting, erosion, and redeposition of sediments from unit VII (labeled unit VI) that more colluvial material was washed into the cave. This type of sediment, which continued to accumulate mainly near the entrance, grading into the fine-grained sediments in squares 22–19, contains the artifacts of unit V, possibly mixed with some earlier material derived from unit VI.

THE LITHIC INDUSTRY

The best-studied sequence of Mousterian industries in the Levant comes from Tabūn Cave, 13 km north of Kebara and in a similar environment. The Mousterian layers D, C, and B at Tabūn, as defined in Garrod's excavations, still serve as designators for the subdivision of the Levantine Mousterian. Jelinek, whose main excavation was concentrated in layers D and C (units IX, VIII–I), obtained only a minute sample of Tabūn B because of its limited preserved surface, while the chimney deposits had been entirely removed prior to his excavations (Jelinek et al. 1973). When the Kebara assemblages are compared with those from Tabūn, the unidirectional convergent method of core preparation is superficially reminiscent of that reported from Tabūn D and B. However, two major features make the Kebara assemblages different from Tabūn D: the frequency of the various Levallois products (table 5) and the type of Levallois points. Levallois flakes in Kebara are always the dominant group, while in Tabūn D blades and points are the more frequent products (Jelinek 1982*a*). Second, Levallois points at Kebara are short, with broad bases; their striking platforms often take the form of a *chapeau de gendarme,* and their average length/width ratio ranges from 1.94 to 2.12 (Jelinek 1982*a*). In Tabūn the points are elongated, the majority having a length/width ratio of >2.45. Thus it seems that the two industries differ considerably. Assemblages similar to Tabūn D are described from Abu Sif (Copeland 1975), Jerf Ajla (Schroeder 1969), and Douara layer IV (Nishiaki 1989).

At the same time, the upper layers in Kebara (units VII–VIII) are represented by Levallois products, dominated by flake production, which resemble unit I (18–26) in Tabūn (Tabūn C), but at Tabūn radial preparation is largely dominant, while in Kebara unidirectional con-

TABLE 5
Frequencies of Levallois Products, Kebara and Tabūn

Level	Flakes	Points	Blades
Kebara			
VII	73.8	6.8	19.4
VIII	78.4	4.5	17.1
IX	63.2	14.4	22.4
X	59.3	18.1	22.6
XI	61.1	8.4	30.5
Tabūn			
I, 1–17	53.3	28.0	18.5
I, 18–26	73.8	7.9	18.3
IX	23.5	34.4	42.1

SOURCE: For Tabūn, Jelinek (1982*a*).

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vergent preparation prevailed, resulting in triangular blanks. Because the sample from Jelinek's excavations in Tabūn B is too small for reliable comparisons, the best available description of the lithics from this layer is that of Copeland (1975), based on the sample collected by Garrod. According to her observations, this industry is characterized by the production of short, broad-based Levallois points obtained from cores with unidirectional or radial preparation, as well as thin flakes among which narrow laminar forms prevail (Copeland 1975:335). It seems that the Kebara assemblages, and in particular those of units IX and X, would fall into Tabūn B. Similar assemblages, in our view, were recovered from Bezez Cave layer B (Copeland 1983), Keoue Cave (Nishiaki n.d.), and Amud Cave (Ohnuma in preparation). A small collection from Skhūl Cave stored at the Peabody Museum, Harvard University, resembles the Tabūn C material as well as the assemblages from Qafzeh (Boutié 1989). The Qafzeh assemblages are characterized by the production of Levallois flakes mainly through radial removals and are therefore comparable to unit I (18–26) at Tabūn (Tabūn C). The Qafzeh lithic assemblages differ from those of Kebara even if we take into consideration the material from layer XV (same as layer 12 inside the cave), where the frequency of Levallois points is the highest within the Qafzeh sequence. Similar assemblages were found at Naamé (Fleisch 1970) and Ras el-Kelb (Garrod and Henri-Martin 1961).

We therefore concur with Copeland (1975) that the previously defined distinct industrial facies within the Levantine Mousterian, corresponding to the main stratigraphic units in Tabūn Cave (D, C, and B), have correlates in other Levantine assemblages (Bar-Yosef 1989). However, these industries are probably only some of the varieties that existed in the Levant, others being represented by assemblages such as those at Quneitra (Goren-Inbar 1990) and Fara II (Gilead 1988).

The dates for the Mousterian sequence (Valladas et al. 1987) and for unit XI (Schwarcz et al. 1989) indicate that the Kebara industries are of "Late Mousterian" age, roughly 64,000/60,000–48,000 years B.P. (fig. 15). Given the dates from other sites, it is conceivable that this Tabūn B–type industry lasted from 80,000–90,000 to 46,000–48,000 TL years. The Tabūn C–type industry could have been in the range of 90,000–120,000 TL years, while the Tabūn D–type industry could have been as early as 150,000–180,000 TL years. It is worth mentioning that the industry which preceded the Levantine Mousterian is the Mugharan Tradition or the Acheulo-Yabrudian, which is geographically limited to the northern and central Levant. Its absence from the southern Levant is not due to insufficient fieldwork and probably indicates the presence of a social boundary (Bar-Yosef and Meignen n.d.). A date for the late Acheulo-Yabrudian assemblage in Yabrud Rockshelter I is 195,000 ± 10,000 years B.P. The earliest age for this entity is unknown, but the date for the Late Acheulian at Berekhat Ram of more than 233,000 years (Goren-Inbar 1990) could be interpreted as indicating an age in the range of 250,000–300,000 years.

THE FAUNA

Placing the faunal assemblages from Kebara in the context of other Upper Pleistocene Levantine sites is important for testing the relative chronology of biozones proposed by Tchernov (1981). We therefore briefly summarize the available information on the fossil faunas of Acheulo-Yabrudian and Middle Paleolithic sites. It is unfortunate that poor recovery techniques, especially where preservation was poor, as in layers F and G of Tabūn, affected the sample sizes used by Bate, especially for the micromammals.

Tchernov's (1968, 1981, 1984, 1988) studies of the micromammals identified from the Middle Paleolithic of Kebara show that none of the archaic species found in the Mousterian sequence of Qafzeh, Tabūn D, and lower layer E at Hayonim Cave are present in Kebara. In contrast to the assemblages of Tabūn D and Hayonim lower layer E, the micromammals of Kebara survived in the region at least to the end of the Pleistocene. Intra-Mousterian faunal changes occur in the time interval between the early level of Tabūn D and layers XIV–XXIV of Qafzeh (Tchernov 1988, Bar-Yosef 1989) and the uppermost level of Tabūn D, Tabūn C, Tabūn B, Kebara, and upper layer E at Hayonim Cave. Current information on the micromammalian assemblages enables us to outline the sequences of different lineages during the Levantine late Middle and Upper Pleistocene:

The fossiliferous beds of Oumm-Qatafa (F-E-D) have a limited time range within a glacial period (isotope stage 10 or 8?). The Upper Acheulian micromammals from this site may be used as a baseline for all later micromammalian lineages in this region. Biochronologically, the lower micromammalian assemblages in Qafzeh (XIV–XXIV) bear a strong African stamp and should be correlated with a very early Mousterian phase. This phase could be placed in the proposed hiatus between layers E and D of the Tabūn sequence (Farrand 1979; Jelinek 1982*a*, *b*). The dates for Qafzeh of 90,000–115,000 years B.P. indicate isotope stage 5 age, which would explain the largely savanna-semiarid conditions in the region reflected by the mammal community. Our observations contradict the inclusion of the Mousterian of Qafzeh in the "Upper Mousterian" or "Mousterian Phase 3" (Jelinek 1982 *a*, *b*). Five fossil species indicate that it is closely affiliated with the assemblages from Oumm-Qatafa and Tabūn F and E. In this context the position of Tabūn D within the Mousterian sequence remains enigmatic, because of the contradiction between the biochronological status of Tabūn D (Tchernov 1988) and the ESR dates (Grün, Stringer, and Schwarcz 1991). The information concerning the community composition of the micromammals of Tabūn D is based on descriptions of very small samples (Bate 1937,1942, 1943). The problems involved in placing Tabūn D may be solved by direct TL dating of this layer or by excavation of a Mousterian site that includes both Tabūn D and C industries. (Hayonim Cave is probably such a site.)

During the later part of the Mousterian period faunal

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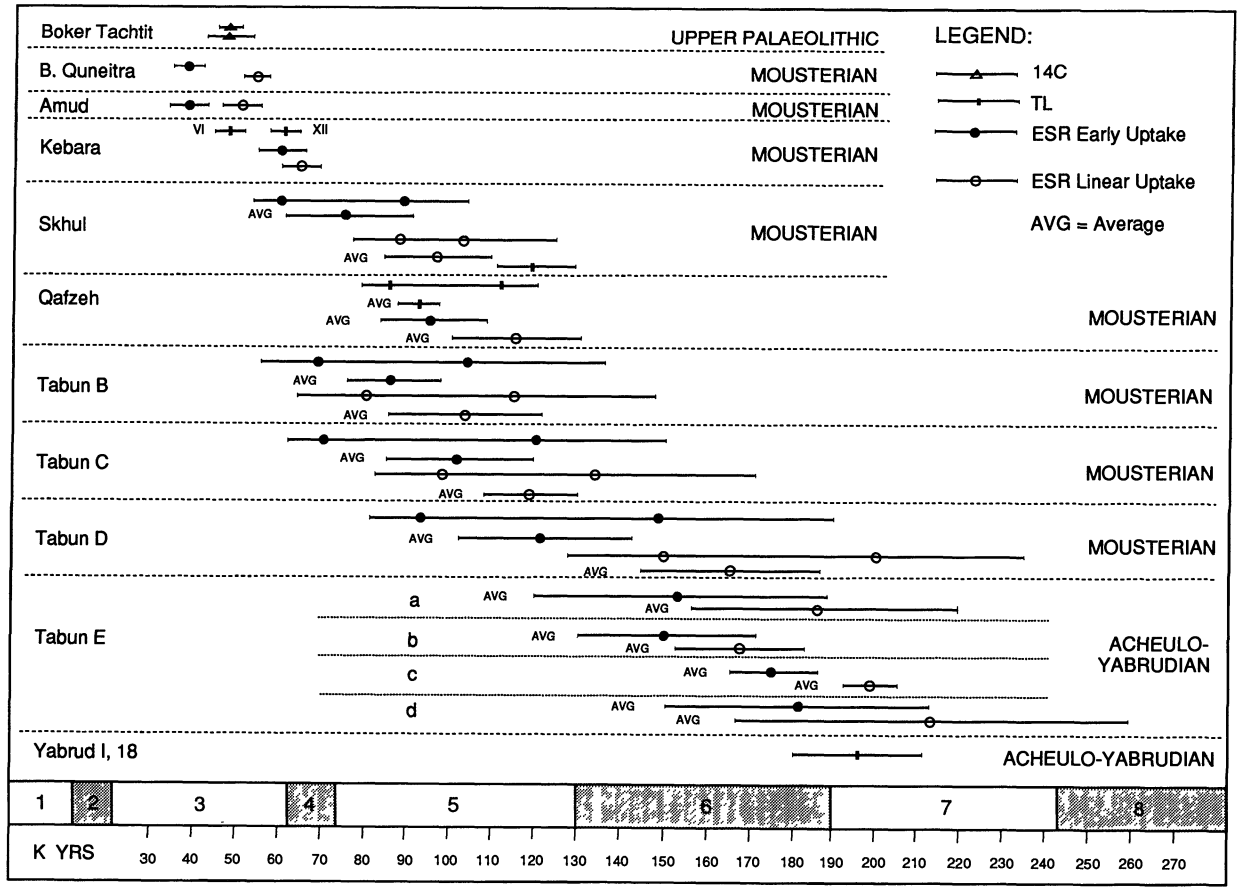

FIG. 15. *Dates from Levantine sites.*

communities in the southern Levant seem to have stabilized (Saxon 1974; Davis 1977; Tchernov 1981, 1984*a*, *b*). The few ossiferous beds from the early Upper Paleolithic, such as Qafzeh 7–9 and Kebara, indeed indicate that no faunal change took place during the transition from the Mousterian to the Upper Paleolithic or throughout the Upper Paleolithic. In sum, during the Upper Pleistocene there is a gradual elimination or exclusion of faunal elements from the region rather than faunal breaks.

In assessing the role of humans versus hyenas as the main agent for the formation of bone accumulations inside Kebara Cave, we have concluded that the assemblages were transported into the cave largely by humans, evidence of carnivore damage for the most part reflecting attritional processes operating on these bones after they had been discarded. The increase from the Mousterian to the Upper Paleolithic in the proportion of immature gazelles and fallow deer and the decline in the proportion of very old gazelles, as well as the apparent shift in the sex ratio of gazelles from mostly females to an equal or perhaps even male-biased sex ratio, may prove on examination to reflect seasonality or technological change.

THE HOMINIDS

Although the exact location of the first of the two almost complete skeletons uncovered in the Mousterian layers of Kebara is unknown, it seems that the second was intentionally buried. Most of the human skeletal remains, belonging to infants or children, have been found near the north wall, an area which we believe was a dumping zone. It is therefore possible that KMH 1 was also dumped there, although we cannot exclude the possibility that its disposition was the result of intentional burial.

The morphological features of KMH 2 include plesiomorphic traits on the jaw and the iliac blade that are in accordance with the general robusticity of the skeleton. Neanderthal features are observed on the mandible, the upper limbs, and the pelvis. The morphometrics of the hyoid, the ribs, and the vertebral column fall within the range of variability of modern humans. These traits are uniquely preserved in KMH 2 and therefore cannot be compared with those in other Middle Paleolithic hominids. Features in which KMH 2 differs from other Levantine Mousterian skeletons include the overall robusticity of the mandible, the dimensions of the sacrum,

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and the cotylo-sciatic breadth. KMH 2 has undoubted affinities with the Amud-Tabūn-Shanidar group rather than with the Skhūl-Qafzeh sample and is the most robust individual known from the Levant.

FINAL REMARKS

The information in this interim report, together with the papers already published and those which are still in press, provides some new insights concerning the Middle Paleolithic occupations of Kebara Cave. There are clear indications that during Mousterian times the cave was inhabited for more than one season but this occupation did not involve the degree of sedentism that is known from the Natufian. We tentatively suggest that Middle Paleolithic humans were in the cave during the winter, spring, and early summer. They built fires in what seems to be a well-organized manner that differs from what is often associated with the Upper Paleolithic Cro-Magnons only in the absence of evidence for the use of stones for warmth banking. Hearths were used at least for parching gathered wild legumes and probably for roasting meat. After use the ashes may have been intentionally spread, perhaps as sleeping grounds. Additional analyses of dumping zones, both adjacent to hearths and near the cave wall, are needed in order to establish whether there are any signs of labor division. The numerous lithics indicate well-planned, efficient use of raw material despite the proximity of the sources. Again in this respect the Middle Paleolithic humans do not differ from available descriptions of similar behaviors among Upper Paleolithic humans. Hunting and butchering as reflected in the faunal assemblages convey the same impression, and the well-organized burial of an adult in unit XI strengthens it. In sum, the commonly Eurocentric summaries which attempt to show major archaeological differences between Neanderthals and Cro-Magnons are not supported by the evidence exposed in Kebara Cave. The implications of these data for understanding the Middle-to-Upper-Paleolithic transition are beyond the scope of this report.

Comments

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This splendid site report is both a history of paradigm change in the Levant and an up-to-date synthesis of the current work. The treatment of site formation processes is particularly informative, especially in regard to the contributions of hyaenas to the various patterns in the bone assemblages and the notion of the "diagenetic front," which reminded me of a similar situation in the Mousterian levels at Cueva Morín (Santander, Spain), where bone preservation, sediment color, and texture were markedly different on either side of a natural linear feature (González Echegaray and Freeman 1973). Bar-Yosef et al. have made sense of a long, complex sequence of cultural and natural activities in the cave, an achievement all the more admirable because of the scarcity of published reports by their predecessors.

It is refreshing, too, to see a shift in emphasis to technology and to the *chaîne opératoire* in the treatment of the lithics, although whether these very commendable efforts should be directed toward the identification of technological "traditions" is questionable. It appears to me that vectored and modal technological change in the Middle Paleolithic operates at a scale far beyond that of "traditions" (i.e., ways of making stone tools transmitted by enculturation from generation to generation in a social context). Because of this, what we think of as Mousterian technology *(sensu lato)* probably constituted a range of options very broadly distributed in space and time, held in common by all circum-Mediterranean Middle Paleolithic hominids, and invoked differentially under the "right" conditions. The challenge of future work will be to determine what general factors constrained choice among these options (e.g., range and size of and distance to raw materials, mobility strategies, anticipated tasks, group size and composition, structural pose of the occupants of a given site/level within an annual round, etc.). Whatever may come of this, I seriously doubt that it will prove to have had much to do with "traditions."

Levallois systematics can also be considered from this perspective (see, e.g., Clark and Lindly 1989:646–70). What does "Levallois" really mean in behavioral terms? It seems to me that the Levallois technological concept has been so overextended that it has lost any analytical utility. In light of the Geneste (1985, 1988*a*) revision of Levallois systematics, I wonder whether *any* technology that involved a degree of core preparation (and thus predetermination of blank shape) would not be considered Levallois. The classic Levallois "turtle core" flake technology was indeed incredibly wasteful, and it seems illogical to me that prehistoric humans would have employed it anywhere to any great extent (or, better put, would have sought as the end product only the "Levallois flake of predetermined form"). Leaving aside the question of what Levallois "is," the central issue is identifying the factors that would have constrained choice between the two major kinds of "Levallois" reduction strategies (linear and recurrent).

The excellent treatment of carnivore ravaging appears to indicate more carnivore involvement in the accumulation of the archaeofaunas than is implied by the discussion of the anatomical parts. This raises the question just what the different taphonomic approaches actually can tell us about the factors involved in the formation of archaeological faunas. The faunal analyses converge, however, to support a picture of more predator/scavenger involvement in the Upper Paleolithic of Kebara than in the Middle Paleolithic. While this squares with the Marks and Freidel (1977) model of greater sedentism and a more "tethered" and functionally differentiated settle-

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ment/subsistence system, European work implies the reverse (i.e., more carnivore involvement in the Middle than in the Upper Paleolithic [Straus 1982, Clark and Yi 1983]). Why this should be the case is probably tied to differences in site-use intensity in the two regions, differences which are linked to climatic factors, resource distributions, and human population density.

Taking the results of the Kebara excavations as a whole, there seems to be little evidence to support differences in adaptation between the Middle and Upper Paleolithic occupations there—a picture of archaeological continuity that stands in marked contrast to the biological replacement scenarios advocated by Bar-Yosef, Vandermeersch, and Meignen (cf. Clark and Lindly 1989, Clark 1992). The essentially "modern" behaviors in which the Kebara Neandertals engaged also tend to discredit Lewis Binford's widely publicized portrayal of them as little more than animals (see, e.g., Fischman 1992).

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1 VI 92

Over the past five years there has been an upsurge of interest in issues relating to the emergence of modern humans. This has been stimulated by molecular biologists' arguments for an African origin for modern humans and the development of a battery of new techniques for dating beyond the range of carbon-14. New dates for the Middle and early Upper Pleistocene have forced a complete reevaluation of the chronologies developed over previous decades. These trends have coincided with an increased awareness of the complexities of site formation and the development of a range of more sophisticated methods for unraveling occupational histories and with an increased interest in behavioural evolution stimulated by observations in sociobiology, primatology, and anthropology.

The Middle and early Upper Palaeolithic of the Near East have been drawn onto centre stage by these developments as new dates for fossil human finds made since the 1930s have demonstrated that populations of Neanderthals and "moderns" were inhabiting this region between 50,000 and 100,000 years ago. It is still unclear whether the two species/subspecies coexisted throughout this time range or whether there were temporary incursions by one or the other. Inevitably this has led to greatly increased interest in the contexts in which these fossils have been found and in determining whether any behavioural differences reflecting two separate populations might be observed in the archaeological record.

This report on the 1982–90 excavations in Kebara Cave documents a major stride forward in the Near East in terms of the application of modern excavation and analytical techniques and interpretive procedures to the reconstruction of Middle Palaeolithic behavioural patterns. The application of micromorphology as well as geochemical and more conventional sedimentological techniques has allowed a detailed reconstruction of the cave's geological and cultural history; three-dimensional plotting as well as detailed studies of all categories of chipped-stone debris have allowed the modelling of the operational chains involved in tool manufacture and use and provided information on the distribution of human activities; detailed studies of the spatial arrangement and differential survival of the various body parts of animals brought into the site have allowed the reconstruction of the potential roles of humans and carnivores in the formation of the bone accumulation and added to our knowledge of the distribution of activities within the cave; and the flotation of carbonised remains from hearths has made possible the recovery of potential food plants. In addition, the careful excavation of new hominid remains and particularly the extremely well-preserved KMH 2 has provided confirmation of deliberate burial and later skull removal in a Middle Palaeolithic context. Detailed morphological studies of this skeleton have revealed the size of the pelvic inlet as well as the probable morphology of the vocal tract, putting to rest earlier theories concerning differing gestation length in Neanderthals and their physical incapacity for modern speech. We look forward to more details on all these issues and also for information on the distribution of imported materials/exotics such as ochre in the cave deposits, which are of interest to those concerned with other aspects of early hominid behaviour.

The results from Kebara highlight the rewards of close interdisciplinary cooperation in cave excavation and also of the potential complexities of site formation processes within cave systems. It is hoped that the excavation of open sites, which were the more usual living areas for Middle Palaeolithic populations and where there has often been less disturbance from superimposed occupations, can gain from these procedures. The recent publication of Goren-Inbar (1990) on the Mousterian site at Quneitra represents an advance in the application of modern techniques to the excavation, analysis, and interpretation of early open sites in the Near East.

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The recent excavations at Kebara Cave furnish an excellent model for a long-term paleoanthropological research program. My comments center on the analysis and interpretation of the lithic artifacts.

Tracing the *chaîne opératoire* (Leroi-Gourhan 1964, Geneste 1985, Pelegrin, Karlin, and Bodu 1988) greatly expands the interpretive potential of an artifact assemblage. (The notion of operational sequence parallels the concept of reduction stages or streams [Collins 1973, Ahler 1975, Bradley 1975, Hassan 1976, Brose 1978, Johnson 1989, Usik 1989, Gladilin and Demidenko 1989].) In many ways the studies at Kebara reflect the

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emphasis upon the technological aspects of lithic artifact assemblages that has come to characterize analytic programs in the Levant (recently summarized by Bar-Yosef 1991). In conjunction with variations of the Bordesian type-list, observations on the dimensions/weight of blanks and tools, the qualitative attributes of debitage, core classifications, and ratios between artifact categories have become common, and in certain settings the refitting of artifacts has provided an even more detailed understanding of the reduction strategies followed by the prehistoric inhabitants of sites (Marks and Volkman 1983).

At the most fundamental level, researchers explain these patterns in material culture as resulting from either functional or ethnic behaviors (Henry 1989). In focussing upon the *chaîne opératoire* reflected in the Kebara assemblages, Bar-Yosef et al. seek to distinguish between patterns derived from economic behaviors (e.g., raw-material acquisition and subsistence activities) and those that "characterize the technical traditions of the social group." The "methods or technical solutions" employed at each point in the reduction stream are viewed as a kind of technical style which makes it possible to "identify a prehistoric group and characterize its particular approach to blank production." Although I share their general assumption that certain technical patterns in raw-material reduction are likely to be good indicators of ethnicity, I have some reservations about interpreting the "recurrent" or "lineal" knapping systems defined at Kebara as such indicators. If the recurrent technical style of producing Levallois products at Kebara resulted from functionally insensitive, ethnically induced behaviors, then the style should remain constant across intra- and intersite settings in which raw-material or activity variation is present. Unless this has been demonstrated, the identification of a particular knapping method is merely pattern recognition; it does not inform us as to the kind of behavior (i.e., whether functional or ethnic) responsible for the pattern. Although the technical style is here identified in the production of blanks (i.e., Levallois products) in contrast to secondary retouch (Close 1989; Sackett 1977, 1985), the process of testing for style is identical (see Henry and Odell 1989: comments, pt. 1). Given the relative lack of emphasis on secondary retouch in Levantine Mousterian assemblages, searches for technical styles such as that at Kebara are likely to be the most productive avenue for investigating ethnicity at various scales in the early Late Pleistocene. In order to determine if such patterns are indeed reflective of ethnicity, however, they need to be checked against functionally sensitive data sets (e.g., fauna, botanics, microwear, features, site setting) for evidence of covariation.

At a more technical level, I question whether the broad-based Levallois points should be viewed as having been produced by the recurrent as opposed to the lineal method. While the presence of blanks with parallel and convergent scars is a technical marker (*enlèvement 2*) of recurrent Levallois blade and flake production, it does not imply recurrent point production. As I see it, the removal of the broad-based Levallois points with the classic *chapeau de gendarme* butts more closely resembles the lineal method, in which only one preferred blank was removed for each prepared surface. The requisite thick platforms, isolated protuberances, and wide angles of the controlling *Y-arrète* scars and ridges for point production would have necessitated extensive reshaping of the core's face and platform before another point could have been removed. In contrast, elongated Levallois points with narrow bases, diamond-shaped/triangular butts, and convergent scars would have required little if any core rejuvenation for multiple point production. While this may appear to be an overly detailed argument, I think it is important to understanding the technological evolution of the Levantine Mousterian, at least in the arid zone. Assemblages from the highland Negev (Crew 1976, Munday 1977, Marks and Kaufman 1983) and central (Lindly and Clark 1987) and southern (Henry 1982, 1992) Jordan appear to show a succession leading from broad-based points with *chapeau de gendarme* butts to narrower-based elongated points with diamond-shaped/triangular butts that stretches from ca. 90,000 to 50,000 years B.P. This technical evolution may have been related to the onset of drier conditions after ca. 70,000 B.P. and the attendant increased mobility required of the Mousterian occupants of the arid zone. The shift from single to serial point production would have increased efficiency and lowered transport costs. In short, the changes in these technical styles would have been driven more by functional concerns than by ethnicity.

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This is a collection of preliminary reports on excavations and subsequent analyses of material from Kebara Cave, much of which is published elsewhere. As such it is less amenable to CA☆ treatment than a more focused or original piece would be. In the limited space available, I shall deal with three points: (1) KMH 2, a spectacularly preserved partial skeleton found in Middle Paleolithic deposits and attributed Neanderthal morphology, (2) implications of the lithic analysis, and (3) interpretation of activities at the site.

1. The stratification of KMH 2 is somewhat difficult to interpret because apparently only the bottom of the burial pit was discovered in the recent excavations and there is no direct indication of its overall depth or of the surface into which it was dug. The offset section in figure 13 shows the burial ostensibly overlain by continuous layers of ashy material, presumably because the upper part of the pit had been removed by Stekelis. The question is of relevance only insofar as the materials used to date the skeleton derive not from the bones themselves but from lithics (TL date) and gazelle teeth (ESR dates) whose temporal relation to the burial cannot be ascertained definitively. Whereas the authors have

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chosen to assign the oldest possible date to the skeleton, it possibly could be considerably younger. Their revisions of the relative dating of Neanderthals and modern humans have depended largely on the use of TL and ESR dates. The ages of the skeletons in question could be resolved more confidently if ESR dates were obtained from the teeth of these individuals rather than from presumably contemporaneous fauna.

Because the skeleton is unusually well preserved, KMH 2 also sheds light on Neanderthal morphology. The authors assert that the pelvis does not support the Trinkaus hypothesis concerning the need for a larger birth canal. As an archaeologist rather than an anatomist, perhaps I can be forgiven for asking how one can tell what the female pelvis would have looked like by examining only a male. On the subject of the pelvis, it would be interesting to learn what the presumed locomotor differences from the modern human were that resulted in the "unique characteristics of the pelvic inlet."

It is an interesting coincidence that KMH 2 is described in terms very similar to those used for the 31 early Natufian skeletons from the same site. Most died in the same age range; most of those identifiable were male; they are almost precisely the same height (1.74 vs. 1.73 cm) and tall for the period (Belfer-Cohen, Schepartz, and Arensburg 1991:415); both exhibit robust and gracile characteristics; however, there is no comparison between the sizes and robusticity of the mandible of KMH 2 and those of the Natufian population. Most curious of all, we note that the Natufians sometimes detached the skulls from the skeletons, in precisely the manner that affected KMH 2. Did an Early Natufian grave digger discover this burial and remove its skull?

2. To identify prehistoric groups, that is, ethnic or culturally separate entities, the authors analyze the "operational sequence" by which flints were chipped into useful implements. On this basis they establish correlations among sites and strata that help to support and are supported by their new chronological interpretations based on several lines of evidence. This raises an interesting theoretical question: Can one use lithics, ceramics, or other mundane material objects as markers of social entities—"social boundaries"? Most archaeologists have abandoned such hopes, yet there is a powerful appeal to the idea. Is there an objective way to decide whether the lithics convey this kind of information? A traditional way is to find traits that cluster in time and space—a logical, intuitive approach. Another is to focus on elements that are produced "unconsciously" and have no functional value, on the assumption that they will have been learned by rote and reflect very local solutions to problems. The specific sequence or technique by which an activity is carried out would be an example. The authors emphasize the latter, but their case would be more convincing if the results more closely conformed to the former. It is somewhat disquieting to discover that the operational sequence and the resultant blanks at Kebara have no perfect match at any other site, including nearby Tabūn. Thus, while one can point to the inherent idiosyncrasy of lithic reduction at Kebara, one cannot thereby establish a community of chippers. Insofar as the authors try to do so, they find that the Kebara reduction sequence most closely relates to sites and strata that are widely separated in time and space. In short, the picture is coarse at best and perhaps quite misleading.

When virtually the only evidence that might pertain to social identity is in the lithics, it is understandable that analysts grasp at straws. Certainly the evidence tells us something, but is it saying that there was biological-social-cultural continuity that is reflected in habits of making tools at this site over 10,000 years? This seems improbable to me, but the more important question is whether it matters. It seems to matter largely in the context of determining which sites are contemporary, a subject that assumes importance principally in connection with the succession of archaic and modern *Homo*—not coincidentally the question that stimulated the reexcavation of Kebara.

It is not my intent to cast aspersions on the validity of individual findings; rather I am trying to point out the internal logic that drives the research and that must affect its outcome. The article does not provide us with the means to reach alternative conclusions.

3. In the end, most of us wish to learn how the Neanderthals lived. How did it happen that the people at Kebara discarded so much organic refuse in the rear of the cave? Since the authors ignore this beyond establishing that it was humans and not hyenas that were responsible for the prodigious bone middens, I shall offer some speculation. Clearly Neanderthal sensibilities were different from mine, but I wonder whether there wasn't something more to it than meets the nose. If we were planning to use a site for some time, we would probably throw our trash out the front of the cave. If, on the other hand, we weren't planning to stay long, we might toss the remains of our last meal against the back wall and take off for cleaner pastures. Alternatively, it might be imagined that the cave was occupied during a very cold period, when ambient temperatures were so low that bones would not stink and attract vermin, or that throwing food remains in front of the cave could have attracted hyenas and other predators, thus lowering the property value. It is interesting that people behaved in the same way in the Upper Paleolithic, thus reinforcing the notion that the Neanderthals weren't very different.

If the site was occupied only sporadically (I don't see compelling evidence for multiseason use as alleged) over a period of some 10,000 years, it would not be particularly surprising to find bones and other detritus simply left at the picnic site. What is remarkable, given such a scenario, is that there should be such continuity in lithic reduction techniques, for over such a span of time most lineages would have died out or moved out, and idiosyncratic behavior would likely have shifted. Perhaps there is a good project here for some graduate students. We might gain some insight into intensity and duration of occupation through replicative studies in which a small group of archaeologists lived in a cave and measured the

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accretion of material associated with their activities and its implications for their quality of life.

I don't wish to seem negative or facetious. I applaud the innovative reexamination of the site, the pioneering use of new techniques, and the production thereby of stimulating new avenues for research. Perhaps some of the questions I raise will stimulate further research in this unending quest for an understanding of Neanderthal.

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22 V 92

This is a most valuable and informative interim report, on which I would like to congratulate the distinguished team of authors. It has clearly been highly beneficial to have so many of the experts together as a team at the site for long periods during the fieldwork itself rather than their merely receiving material afterwards for post-excavational study. While that arrangement undoubtedly reflects the regard those concerned have for each other, it should also remind us of the great importance of Kebara as a Middle and Upper Palaeolithic site. When this work started in 1982, the current surge of interest in the origins of modern humans was only just beginning: for example, chronometric dating of the Qafzeh and Skhūl hominids was still to come. Kebara has made its own contributions to that continuing debate, most notably the dated Neanderthal remains, including the important KMH 2 burial. Since 1982, it has become common knowledge that in the Near East there is a long period of overlap between Neanderthals and *H. sapiens sapiens,* but that makes it all the more important to examine in detail the two contemporary lifestyles: economies, settlement strategies, social patterns, technologies, and everything else. This report shows that the Kebara Middle Palaeolithic levels are full of relevant evidence of high quality. Therefore it is important, as well as rather refreshing, to be reading about unashamedly Neanderthal hominids and comforting to know that the "early modern humans" bandwagon cannot roll on out of sight while one does so.

I wonder whether others felt a hint of nostalgic pleasure in reading the long and closely argued account of the remarkable bone accumulations and finding that, for all the clear evidence of carnivore activity, they were still predominantly the work of humans. If so, there is little else nostalgic about this study, and clearly the final report on all the material recovered from inside the cave will be a major and permanent source of information for this crucial period. The study of the stone artefacts is of great interest. Turville-Petre would have been amazed at the potential of the *chaîne opératoire* approach, which has certainly proved its value over the last few years as an important advance in the endless task of winning useful information from lithic assemblages. We have an excellent and controlled example of this approach in action here. I note that already *chaîne opératoire* seems to have become one of the magic phrases which writers of theses that include study of stone tools dare not omit. I hope that the essential humanity of the original manufacturing processes will not be forgotten or the information gained about them drowned in over-elaborate terminology as time passes. Such things do happen. In passing, I myself find it hard to envisage that the teaching of the various kinds of prepared core technology by Neanderthals to Neanderthals did not involve well-developed verbal communication, though that is at best an indirect argument for the existence of such at this time. One must of course guard against making assumptions that would really spring from the elegance of the *chaîne opératoire* methods and reflect our own habits and abilities: one could almost catch oneself assuming that the Neanderthals had fluent French and had read the literature we have read. It will certainly be interesting to see how far these approaches can take us, in this or other segments of the Palaeolithic. Might it be possible, in some regions with many closely contemporary sites, to trace the presence of the same individual knapper at more than one of them, or catch some other hint of the social networks? I am reminded of François Bordes's willingness to speculate on the effect on lithic typology of intermarriage between members of the different "Mousterian tribes," as he perceived them, in Southwest France (e.g., Bordes and de Sonneville-Bordes 1970:65).

These comments are passing somewhat beyond Kebara Cave, and I will not take them further: it is the quality and fullness of this interim report and the nature of the finds that lead one to such speculation. I look forward to the final reports from Kebara on all the aspects of the operation in which work is still in progress and am happy meanwhile to know that members of the same team are already busy elsewhere in this vitally important region.

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The Kebara team is to be commended as a truly interdisciplinary group that has excavated an important site in a careful and responsible manner. As Bar-Yosef et al. point out, the strategic placement of this site in space and time makes it uniquely valuable for our understanding of both the behavioral capacities of Neandertals and the origin of modern humans. If anything, they *understate* the importance of the Kebara data for addressing a number of controversial hypotheses.

One important finding from this work relates to the hominid burial. At a time when the very existence of purposeful burials in Neandertals has been questioned (Gargett 1989), the Kebara excavation provides a case of an intentional burial rigorously excavated and clearly documented. The authors offer a tantalizing hypothesis when they state that the absence of the skull of KMH 2

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but the presence of an upper third molar, suggesting that the skull was removed following placement of the body, is evidence for secondary mortuary treatment in a Mousterian context. If correct, this hypothesis would demonstrate human intervention in a primary burial, a type of mortuary behavior not previously known for archaic humans; however, the possibility of nonhuman mechanisms for the removal of the skull deserves further analysis and discussion.

The authors present considerable evidence from lithic and faunal analyses in support of the idea of behavioral continuity through time, although they do suggest some possible behavioral shifts in the transition from the Middle to the Upper Paleolithic, such as a change in seasonality of site use or possibly "more fundamental changes in technology and organization of animal procurement." They hint at some of the behavioral inferences that might be made from the morphology of the skeleton, specifically from the hyoid, mandible, vertebral column, upper limbs, and pelvis, but these are not discussed at length. An increasing body of data from other sites in the Levant and further understanding of geochronology mean that Kebara can be placed in an evolutionary and comparative context. This paper gives an indication of the information available from Kebara and the kinds of issues that can be addressed. We can look forward to further application of these data towards resolving questions of the behavioral and morphological variability of archaic humans in the Levant and the origin of modern humans.

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The Kebara team is to be commended both for its innovative approach to exploring the Middle and Upper Palaeolithic of the Levant and for publishing this extensive report on its progress in CURRENT ANTHROPOLOGY, where it is accessible to a broad array of readers. As the article makes clear, paleoanthropological research has come a long way from its pioneering days in the Levant. Anthropogenic factors are no longer givens but must be carefully evaluated as the Kebara team has done with its analysis of the cave's geology, hearths, fauna, and burial. The identification of several factors (diagenesis, carnivore damage, hominid activity) involved in the formation of the Kebara deposits makes clear the importance of using all conceivable lines of evidence.

It is, however, somehow reassuring to know that Stekelis's original assumption of human dumping by the north wall is still the best explanation for the bulk of the bone accumulation there. Obviously not all behavioral interpretations by earlier excavators should be summarily dismissed. Along the same lines, the detailed forensic description of Kebara 2's anatomical position leaves no doubt as to its intentional inhumation, *contra* recent arguments against the evidence for Middle Palaeolithic burial.

The higher incidence of smaller burned bone fragments at Kebara is considered unexpected because they would be more likely to have been removed from the surface by trampling and thus protected from burning. Larger bone, less likely to be trampled and buried, should show more evidence of burning. However, if bones were in fact dumped to the north after use, then larger bones may have been transported away from hearth areas in the central portion of the cave prior to burning (either by hominids or scavengers); smaller bone fragments may have been burned simply because they were unobtrusive and randomly incorporated into later hearths.

The importance of the Kebara 2 hominid for understanding the range of morphological variability of Middle Palaeolithic populations in the Levant cannot be overstated. Not only does this individual display a combination of "Neandertal" and "modern" features but also it represents the extreme of robusticity for several characters. With the recovery of more hominids from the region, this robusticity may be its most noteworthy aspect. The current popular usage of the terms "Neandertal" (Amud-Tabūn-Shanidar *and Kebara?*) and "early modern" (Skhūl-Qafzeh) may ultimately be useful only as a temporal rather than as a taxonomic categorization.

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Bar-Yosef et al. have provided a thorough summary of their work in the Kebara Cave. This is a valuable contribution to the current research into the origin of modern humans in Southwest Asia. As much of what is reported in this article is still work in progress, any too exacting criticism may be premature. However, some issues raised by this article do seem to require further comment.

Perhaps the most striking feature of the Kebara Mousterian levels is the hearths and ashy lenses that form a deep sequence of levels in the central part of the cave. The discrete nature of these ashy concentrations leaves little doubt as to their origin in human activity, but the nature of that activity—beyond the obvious ones in providing heat and light—remains unclear. Burned bones, as the authors admit, are rather rare. Moreover, the carbonized legume seeds in these ashy sediments that they interpret as resulting from deliberate parching could also have been deposited if leguminous brush had been used as fuel. It will be easier to evaluate these hypotheses once the abundant flotation samples from the Kebara sediments have been described in full.

While the *chaîne opératoire* approach applied by Meignen and Bar-Yosef to the Kebara lithic assemblages does indeed shed light on the decision-making strategies of prehistoric knappers, it is not clear why they automatically equate the technological *comportement* evident in a lithic assemblage with the social traditions among prehistoric flintknappers. This kind of interpreta-

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tion assumes that (1) all of the stone tools in a particular sedimentary bed were the output of a single hominid group and (2) hominid groups are characterized by a single lithic "signature" that does not vary in response to seasonal or situational variation in circumstances requiring the making and using of stone tools. Neither of these assumptions is by any means justifiable, or even testable, strictly in terms of the available archaeological evidence.

The location of Kebara Cave above the convergence of two shallow valleys overlooking the coastal plain would have allowed its inhabitants to monitor game movements and to launch hunting forays into the surrounding countryside. Recognizing this, any number of Levantine Mousterian groups may have produced and "stockpiled" hunting equipment at this site. In Levantine Mousterian times, Kebara Cave could have been visited by any number of hominid groups, possessing any number of distinct social identities. That many of the flintknappers among these hominid groups chose predominantly unidirectional-convergent modes of lithic blank preparation may owe less to a shared social identity than to the facility with which unidirectional-convergent flaking can produce numerous pointed artifacts suitable for use as hafted stone spear points.

It is a little disappointing to see so little exploration of the implications of the Kebara evidence for hominid evolution in the Levant. The occurrence of such robust anatomically archaic hominids so "late" in the Levantine Mousterian (ca. 55,000–65,000 years B.P.) certainly calls into question the long-standing hypothesis that hominid evolution during this period was in the direction of more modern-looking humans (Howell 1959, Jelinek 1982*a*, Trinkaus 1984). On the whole, however, this is a good interim account of the work being done at Kebara and a preview of similar research soon to be undertaken at Hayonim Cave.

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This excellent summary report on the excavation and analysis of the remains from Kebara Cave demonstrates clearly why the Kebara project has become a model for the investigation of Middle and Late Pleistocene human occupation sites. The key to the success of this project is certainly its cooperative, multidisciplinary approach, the utility of which is evident in the impressive breadth of the data and the interpretations these data permit about this site and its prehistoric occupants. A second contribution, of equal importance in my opinion, is the fact that the Kebara project has served as a training ground for a large number of students from many universities in several countries. Most of these students would not have had the opportunity to get this type of "hands-on" experience in paleoanthropology but for the willingness of the project directors to include them. It may well be that the more enduring impact of the Kebara project will come not from the factual information derived from the analysis of the site and its contents but from its methodology and its influence on the next generation of professional paleoanthropologists.

The factual information for Kebara is, however, impressive in its own right. The various analyses of lithics, fauna, and features have contributed greatly to our understanding of the behavior of Mousterian peoples in the Levant and in general. In my opinion, the most significant contributions lie in correcting some recent misconceptions about the Mousterian people responsible for the Kebara deposits, the Neandertals. For a number of reasons, it has recently become the vogue to suggest that Neandertals were not really quite "human" in behavior. Specifically, it has been suggested that Neandertals were incapable of any type of "planning depth" in terms of lithic technology or subsistence, did not organize their use of habitation space in a systematic manner, and probably did not bury their dead. The lithic, faunal, and feature data from Kebara show that on the first two of these points Neandertal capabilities do not differ in any major way from those of the early "modern" Skhūl-Qafzeh Levantine hominids or from available descriptions of Upper Paleolithic people. More recent work in the Levant, partially based on the Kebara data, may indicate some differences in resource utilization between Tabūn B and Tabūn C Mousterian, but there is still no evidence of *qualitative* behavioral difference between Neandertals and early modern people in the Levant.

The Kebara 2 Neandertal burial, carefully excavated in 1983, demonstrates the deliberate, organized practice of inhumation by Neandertals and thus helps counter the third point noted above. Kebara 2 has also contributed to the correction of certain anatomically based misconceptions about Neandertals. Prominent among these is the argument that Neandertals were not capable of a full range of human speech (e.g., Lieberman 1989), an interpretation that has also been used to indicate the existence of a behavioral rubicon between Neandertals and modern people. This argument is countered by the morphology of the Kebara 2 hyoid, which is fundamentally identical to that of recent humans and suggests that this Neandertal was "as 'anatomically capable' of speech as modern humans when hyoid positioning and supralaryngeal space are the criteria considered" (Arensburg et al. 1990:145). This position is now supported by the new reconstruction of the Neandertal cranium from La Chapelle-aux-Saints (Heim 1989), which shows that the basicranium exhibits a degree of flexion well within the modern human range (see also Frayer 1992). Thus the argument of a high position for the larynx in Neandertals, precluding the production of a full range of modern human speech, is no longer anatomically convincing.

There are several morphological aspects of Kebara 2, in addition to the hyoid, that are quite interesting, but I will limit my comments to only one other region, the pelvis. Kebara 2 provides our first opportunity to study a reconstructable Neandertal pelvic inlet. The major surprise resulting from the analysis of this pelvis is that

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the elongated, thinned pubic ramus so typical of Neandertals did not result in an increased pelvic inlet (Rak and Arensburg 1987, Rak 1990), as had been the general speculation. As this report notes, this would seem to render a parturitional explanation for Neandertal pubic morphology unlikely. Bar-Yosef et al. state that the morphology is the result of posture-related biomechanics, but neither Rak (1990) nor Rak and Arensburg (1987) have systematically presented the presumed biomechanical basis for these differences or why they exist. One possibility is that the more anterior position of the symphysis pubis documented by Rak and Arensburg (1987) may be the result of the same growth pattern responsible for the deep, or barrel-shaped, thorax in Neandertals (Smith 1992). However, this suggestion is little more than speculation at this time.

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This is a timely summary of one of the most important late-20th-century excavations and analyses of a Middle Paleolithic site at a major crossroads of the Old World. The presentation of the site is excellent, even though many aspects of the interpretation of the lithic, faunal, and hominid remains discussed here are clearly in a preliminary stage. This paper pulls together and ideally will help to focus attention on a number of important issues regarding Middle Paleolithic hominid adaptations in the Near East.

Inasmuch as one of the primary motivations for the reexcavation of Kebara Cave during the 1980s was the resolution of the relative chronology of Near Eastern Middle Paleolithic hominids and the discovery of the KMH 2 partial skeleton has called attention to numerous aspects of their morphology, it appears appropriate to comment here on a related ongoing issue concerning these fossil hominids: Can we indeed define two human groups, one "late archaic" and the other "early modern," from among the Near Eastern Middle Paleolithic hominid remains? This is particularly important to resolve conclusively, since the kinds of technological, foraging, and overall behavioral questions for which the Kebara Middle Paleolithic archaeological data are of particular relevance will only be confused if we cannot decide whether the Near Eastern Middle Paleolithic represents one adaptive system produced by one lineage of hominids at a variety of sites or two technologically similar adaptive systems produced by two morphologically distinct, albeit closely related, human groups (whatever their phylogenetic relationships to each other and to other, later Pleistocene human groups).

This issue appeared to be resolved in the early 1980s, as a growing wealth of Near Eastern fossils (including mostly associated partial skeletons) and a series of analyses and syntheses (e.g., Howell 1957, 1958; Stewart 1960, 1962; Suzuki and Takai 1970; Stringer 1974, 1978; Tillier 1974, 1984; Howells 1975; Trinkaus 1976*a*, *b*, 1981, 1983, 1984*a*; Vandermeersch and Tillier 1977; Hublin 1978; Santa Luca 1978; Brace 1979; Wolpoff 1980; Stringer and Trinkaus 1981; Vandermeersch 1981; Condemi 1985) documented, phenetically and cladistically, the morphological distinctiveness of two groups, represented (as mentioned in this article) by the Qafzeh and Skhūl "early modern" and the Amud, Bisitun, Kebara, Shanidar, and Tabūn "late archaic." Further work (e.g., Rak 1990; Holliday and Trinkaus 1991; Simmons and Smith 1991; Trinkaus 1991, 1992; Bar-Yosef and Vandermeersch 1991) has only reinforced this interpretation. Recently, however, (e.g., Arensburg 1991; Wolpoff, Frayer, and Caspari 1991; Crummett, Kramer, and Wolpoff 1992), the division of these groups has been challenged on the basis of the shared cranial robusticity of the samples, their similar body sizes, and the common presence of some cranial discrete traits.

In light of this, it is important to reiterate the number of morphological contrasts between these two groups. Clear contrasts include (among others) neurocranial vault shape (in *norma occipitalis* and *norma lateralis*, when comparisons are limited to minimally distorted specimens), occipito-mastoid morphology (particularly of the juxta-mastoid region and the mid-transverse occipital torus), temporal morphology (including the spatial relationship of the external auditory meatus and the zygomatic root), the *shape* of the supraorbital torus, anterior to posterior dental proportions (but not absolute dental size), dental occlusal morphology (especially maxillary incisor shoveling and molar occlusal sulcal complexity), cervical vertebral spinous process size (but not orientation), relative clavicular length, relative scapular breadth, brachial indices, carpal and metacarpal musculoligamentous attachment area development, thumb phalangeal length proportions, distal apical tuft breadth, superior pubic ramus cross-sectional morphology and relative length, crural indices, femoral midshaft diaphyseal cross-sectional morphology, and limb to body core length proportions. In addition, there are marked contrasts in the distributions of a few features despite overlaps in their ranges of variation: scapular axillary border morphology, radial diaphyseal curvature, femoral neck angle, and overall appendicular robusticity.

Despite some overlap in ranges of variation of some features, there is simply no difficulty in assigning the relatively complete remains to one or the other of these samples. It is only the isolated pieces, such as the Tabūn C2 mandible or the Shovakh 1 molar, that are (in some respects) ambiguous as to their morphological affinities. In this, the discovery of KMH 2 has served to reinforce the contrast between these two samples. Although these comments are insufficient to document the contrasts between these two samples and the internal cohesiveness of each, I hope that they and the above references will be sufficient to lay the matter to rest, although the divesity of approaches to the material and the intellectual baggage with which we all approach the subject (Trinkaus and Shipman n.d.) undoubtedly means that it will continue to haunt us.

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The largely complete pelvis of KMH 2 has also been important in testing a series of hypotheses (Wolpoff 1980, Trinkaus 1984*b*, Dean, Stringer, and Bromage 1986, Rosenberg 1986) regarding the reproductive and developmental biology of the Neandertals, promoting the retraction of two of these hypotheses (Trinkaus 1988, Stringer, Dean, and Martin 1990, Trinkaus and Tompkins 1990). It is expected that it (and the other KMH remains) will continue to contribute to our understanding of the biology and behavior of these Near Eastern Middle Paleolithic hominids, furthering the human paleontological and archeological integration which has been an important aspect of the Kebara project and remains an essential element of our attempts to understand late archaic and early modern humans in this important geographical region.

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The authors identify hominid remains at Kebara Cave as Neanderthal, particularly the adult burial KMH 2. In addition to KMH 2 there were 28 other hominid specimens, some of them isolated infant or juvenile teeth but all classified as Neanderthal. While the taxonomic identification of KMH 2 as Neanderthal is clear, that of isolated teeth of children is much less certain.

According to this article, modern humans were in the Levant as early as 100,000–90,000 years ago, occupying the sites of Qafzeh and Skhūl. Subsequently, in response to an intensely cold episode in northern latitudes about 70,000 years ago, Neanderthals migrated southward from Europe into the Levant and took possession of the sites of Kebara, Tabūn, Amud, and Shanidar, apparently remaining at those locations until about 45,000 years ago. Is it logical that each hominid taxon enjoyed exclusive possession of certain caves for many thousands of years? Given their temporal and geographical coincidence, it seems more plausible that both groups of hominids used all the caves in the area intermittently as the need arose, thereby increasing the probability that some of the juvenile teeth found at Kebara belonged in fact to modern *sapiens*, not to Neanderthal.

Diffusion of Neanderthals into the Levant presumably took place from the north. Could they not have come from the south? Numerous Mousterian sites have been discovered in Arabia, many with Levallois and some defined as Mousterian of Acheulean Tradition (see *Atlal* 1–11 [1977–88]). During the Riss glacial, Arabia became exceedingly arid, prompting human dispersion toward moister coastal zones (Brown, Schmidt, and Huffman 1989). Unfortunately the Arabian sites are surface finds lacking firm dates. In the Negev, however, Marks (1981) has described Mousterian sites with uranium-series dates of 80,000 years B.P., substantially earlier than the intrusion of Neanderthals from Europe. If the makers of those Mousterian artifacts in the Negev were Neanderthal, then the possibility of a shift of population from the south cannot be excluded.

The consistent agreement of ESR and TL dates may reflect these methods' similarity of underlying principles—accumulation of trapped electrons absorbed through time. Both techniques rest upon basic assumptions extended through vast periods of time, and therefore errors made in estimating the amount of radiation absorbed during burial would affect the date and raise questions about reliability. Application of supplemental methods (e.g., uranium-series dating) would help to confirm the dates. It seems that no attempt was made to correlate faunal remains or pollen samples with the oxygen-isotope record of the Pleistocene as a broad independent dating source. Since most of the sediments within the cave originated from outside, transported by aeolian action, it seems highly probable that pollen was blown in and intermingled with the sedimentary deposits.

The most complete Neanderthal skeleton was KMH 2, located in the upper part of stratigraphic unit XII. Both ESR and TL dates for the burial average 60,000 years. The ESR date came from the tooth enamel of gazelles, located in unit X, between 0.40 and 0.65 m higher up in the profile and between 4 and 5 m north of the burial. Could not ESR dates be obtained from teeth in the mandible of the Neanderthal rather than from gazelles several meters away? The assumption that unit X was ground-floor level at the time of burial may be questioned on the grounds that the stratigraphic profile (fig. 13) fails to show any evidence of a pit's having been dug to inter the body into unit XII.

Large quantities of herbivore bones, in various stages of attrition, were recovered from the cave, mainly from the north wall. Many were brought in by humans, some by carnivores. While the prey are well described, there is little mention of predators. Carnivore tooth marks on bone and measurements of the diameter of puncture marks and the width between them could help to identify carnivores responsible for bone transport and attrition, but this seems not to have been done. One carnivore frequently mentioned is the hyena.

A disappointing aspect of the report but one which promises to be corrected later is the absence of any analysis of the function of the artifacts. Fortunately, Shea (1989) has acquired access to the artifact collection from the lower Mousterian levels at Kebara and also tools associated with modern *sapiens* levels at Qafzeh and contrasted the two assemblages. The same Levalloiso-Mousterian industry characterizes both collections, demonstrating that in the Levant modern humans and Neanderthals engaged in the same tasks with artifacts that were practically identical. Therefore, no distinction exists between these hominid taxons on the basis of artifact assemblages; both Neanderthals and modern *sapiens* used Mousterian tools.

This preliminary report on the Kebara Cave excavation is a significant contribution to our understanding of the Middle and Upper Palaeolithic in the Levant. It comes out at a time when the relationship between Neanderthal and emerging modern *sapiens* is in a state of

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flux. The disciplines represented in this study have combined to make this report a broad, penetrating, and useful analysis.

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This is a full and diverse account of site investigation as it should be done: with close collaboration of as many experts in as many diverse fields as possible. Although, as the authors say, this procedure may slow down the excavations, the potential benefits may far outweigh the drawbacks. This article is very informative and stimulating; I have a few comments but only very few, very minor criticisms.

A multidisciplinary investigation such as this can identify and attempt to resolve problems posed by the finds at the site. For instance, at Kebara the identification of the differential distribution of bone concentrations throughout the site led to an effort to determine whether the absence of bones in some areas was due to diagenetic effects in the sediments, which would have dissolved the bones, or to the actual deposition of the bones. This is an excellent example of the interaction of geology and archaeology.

The authors say that the spatial arrangement of the finds, with most of the lithics and all of the bones dispersed from the hearths toward the rear of the cave, was not produced by natural agencies. Could it be because people sat behind the fire, using it as a screen of warmth between themselves and the cold outside, and consequently discarded their food and lithics near and behind them? (Incidentally, it would have been interesting to have some indication of the authors' reasons for stating that this distribution was not due to natural agencies.)

The descriptions of the hearths will allow comparisons with hearths or burned layers from other sites. It is interesting that the smaller bones tended to be burned more often than the larger ones, as if they were debris that fell or was thrown into the fire while the larger bones were treated differently. Bones that were cracked for marrow would probably have ended up being discarded away from the fire (since the job of cracking them could not have been done in or over it).

The discussion of human vs. carnivore effects on the faunal debris is admittedly based on small samples, and it might have been better to give the actual sample sizes in the tables as well as the percentages so that the reader could judge the significance of the figures. All in all, however, the argument that the differences in the age and sex ratios of the fauna between the different layers and zones are more related to human activity than to carnivore activity is convincing. I agree that this is the first thing which needs to be determined and that the explanation of the changes requires further research.

The *chaîne opératoire* approach to the study of lithic assemblages is very valid and informative because it includes all stages of lithic material use, from the collection of the raw material through the tool making to the final discard of the piece. It sees lithic artifacts not as static tool shapes out of a catalogue but as stages in a process, and it examines the role of the lithics in the lives of the prehistoric humans. It includes not just the tool typology but the technology, petrography, use-wear analysis, reconstitution of cores from dispersed flakes, and so on. The authors' conclusion that "the numerous lithics indicate well-planned, efficient use of raw material despite the proximity of the sources" seems fully justified.

The overall conclusion of the study is that "the commonly Eurocentric summaries which attempt to show major archaeological differences between Neanderthals and Cro-Magnons are not supported by the evidence exposed in Kebara Cave." I see no reason to argue with this conclusion and do not find it surprising. I suspect that re-examination of other sites using this multidisciplinary approach might result in some changes to the traditional interpretations.

In general, this paper is an excellent contribution to our understanding of Mousterian behavior, both because of its description of the finds themselves and their interpretation and because the multidisciplinary approach employed in the investigation can serve as an example to other researchers, opening our eyes to questions, problems, interpretations, methods, and techniques.

Reply

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We are grateful to the many colleagues who have taken time to comment on this paper. We also acknowledge the very positive and constructive nature of their remarks. As all of them clearly recognize, our paper was intended as an interim report on the Kebara research, not the definitive statement of Middle Paleolithic paleoanthropology in the Levant that is obviously our ultimate goal. All of us still have a great deal of basic data gathering and analysis to complete before we will feel prepared to delve into the broader issues. We were therefore surprised by the editor's decision to have this preliminary and largely descriptive paper receive CA☆ treatment. Nevertheless, the comments raise a number of interesting issues and point to some critical areas in which our presentation was either unclear or incomplete. This reply therefore offers us a valuable opportunity to address and clarify some of these ambiguities and omissions.

One of the most critical ambiguities in our presentation appears to be the stratigraphic position of the KMH 2 burial (Hole, Whalen). The section drawing (fig. 13) represents the situation in our excavation when the burial was exposed. Stekelis's main deep sounding was in square N20 (fig. 2), and we uncovered the burial when

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half of the next square (M20) was excavated from about 6.50 m below datum to the level of the human bones (7.80 m below datum). There is no doubt that the burial was in a pit. The position of the thoracic elements indicates that the pit was narrow and at least 20–30 cm deep; this is why many of the ribs remained intact. The eastern and part of the northern side of the pit around the skeleton were clearly visible. However, no pit walls were discernible in the overlying levels (i.e., in mid- or upper unit XI or unit X). This is an important point because the walls of rodent tunnels and other such disturbances (see figs. 5 and 7) were easily identified and traced in the Middle Paleolithic deposits. Moreover, several distinct, laterally continuous hearths in units X and XI directly overlay the grave, and these showed absolutely no signs of truncation or disturbance. One of these hearths sealed the northeastern area of the burial and may have been the source of the signs of burning observed on the upper right arm of the skeleton. Given these observations, it is almost certain that the burial pit originated in the lower part of unit XI (labelled "XId" in fig. 13).

We also see no reason to question the burial's chronological placement at about 59,000–61,000 years ago on the basis of the ESR and TL dates. We certainly agree with Hole and Whalen that the dating of the burial ideally should be done directly on the human skeletal material itself (e.g., on one of the teeth) rather than on nonhuman remains stratigraphically associated with it. However, given the uniqueness of the human remains and the destructive nature of these dating techniques, we hesitate at the present time to sacrifice part of the skeleton.

The burial was found 5 m below the base of the Natufian deposits, which had been removed many years earlier by Turville-Petre. In light of the thickness and coherent stratification of the deposits overlying the burial, it is inconceivable that the KMH 2 skull had been removed by the Natufian occupants of the cave as Hole suggests.

Hole wonders whether a male pelvis can provide useful insights about the nature and functional morphology of the female pelvis. We believe that it can. The Kebara specimen clearly shows that the acetabulo-symphyseal elongation of the Neanderthal pubis is not a female-specific accommodation to childbearing. In fact, the assumption of neurocranial enlargement in Neanderthal neonates relative to modern ones no longer seems to be supported. We therefore agree with Smith that current functional explanations for the anterior pelvic morphology of Neanderthals need to be reexamined. We believe, however, that it is premature to introduce speculative notions linking pelvic functional morphology and thorax anatomy. Smith's proposal, while interesting, is based on growth associations between pelvis and thorax that remain to be demonstrated.

Whalen suggests that the isolated deciduous teeth found in Kebara may belong to anatomically modern children rather than to Neanderthals. We fully concur that this is possible. There is at present no way to distinguish the dentitions of these two hominid forms. Furthermore, all of the immature bones belonging to the Kebara 1 individual are nondiagnostic. That is why we list the immature specimens from Kebara as "Mousterian," not "Neanderthal."

Whalen also suggests that scholars should keep in mind the possibility that Neanderthals may have moved into the Levant from the south rather than from the north. While notions concerning the movements of Neanderthals remain speculative whatever the posited direction, current evidence makes a southerly origin highly unlikely. There are no known Neanderthals in North Africa, and Anthony Marks (personal communication, 1992) has argued against this idea on the basis of the lithic evidence.

Shea comments on our having devoted very little space to the relationship between the Kebara hominid and other Middle Paleolithic hominids found in Near Eastern sites. While this is obviously an extremely interesting and important issue, it was beyond the scope of our interim site report. Obviously, the phylogenetic relationship among the various Near Eastern hominids is a contentious and hotly debated issue, and those who follow the literature on this topic are aware that even within the Kebara team there are divergent interpretations.

Several readers comment on various aspects of the lithic analysis. We do not concur with Clark's suggestion that the Levallois concept has been extended to include "any technology that involved a degree of core preparation." Boëda (1988) has defined a blank production system characterized by five criteria: (1) two intersecting core surfaces, each with a different role in the sequence of removals or knapping process (one used for the preparation of the striking platform, the other for the removal of Levallois by-products); (2) a core that is both distally and laterally convex in section; (3) a sequence of removals more or less parallel to the plane of intersection between the two faces of the core; (4) a prepared striking platform; and (5) use of the hard-hammer technique. Variations in some of these criteria may serve to define other technological systems of lithic production. The current detailed definition of "Levallois" is certainly much more precise than the now-dated Bordesian usage emphasizing predetermination of blank shape.

We entirely agree with Trinkaus and others that it is difficult to determine whether the different Near Eastern hominids in the Middle Paleolithic shared an adaptive system or had technologically similar but nevertheless distinct adaptive systems. Nevertheless, there appears to be a general correlation between the industry from Tabūn B and the Mousterian industry from Kebara. These sites both produced robust hominids. According to the excavator, the woman from Tabūn was associated with either layer B or layer C. Given this uncertainty, it is entirely possible, even probable, that it belongs to Tabūn B, and therefore there may yet prove to be a correlation of sorts between the different types of hominids and the lithic industries. This is obviously a suggestion that must be explored further.

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Henry raises an interesting problem concerning the production of Levallois points. It seems to us that a few short, broad-based Levallois points (at least some of the largest ones) could have been produced by the lineal method but that most of the points from Kebara (units IX and X) were the product of the unidirectional convergent recurrent method. Following the removal of the first point, three consecutive convergent removals allow the production of a second point. In this way, continuous convergent flaking produces a series of points and triangular flakes without the need for the complete reshaping of the core. In addition, the short, broad-based points from Kebara are different from the elongated ones of Rosh Ein Mor and Tabūn D. It should be stressed that there is a major difference in blank production systems between Rosh Ein Mor and Boker Tachtit level 1. While the former are typical Levallois products, the latter more closely resemble products of Upper Paleolithic blade production using opposed-platform cores and the crested-blade technique.

In discussing the lithic assemblages we stressed technological traditions composed of specific operational sequences that were employed repeatedly by the site's inhabitants over long spans of time. We disagree with Henry's assertion that this emphasis ignores or denies the importance of situational or functional constraints on the choice of raw materials for tool manufacture or the way in which these raw materials were reduced or used. It is clear that the economic strategies adopted by Mousterian hominids arise from the interaction of at least three principal domains (Geneste n.d.): (1) input constraints on the technological system, such as the availability of suitable raw materials, patterns of mobility, and so forth; (2) output constraints that reflect the group's needs for particular blanks and end products; and (3) the technological know-how of the group at the level of methods and procedures for flaking, which is transmitted from generation to generation by learning and enculturation and is therefore at least partly constrained by tradition. Although the technological variability that one observes in a lithic assemblage results from the adaptation of a technological system to particular environmental and situational needs and constraints (i.e., the "functional" aspects alluded to by Clark, Henry, Hole, Shea, and Whalen), there are underlying rules—the technological know-how and arbitrary choices deemed "appropriate" on the basis of tradition—that remain stable for long periods of time. It is these enduring patterns, referred to by Lemonnier (1992) as "social representations," that provide archaeologists with a valuable means for identifying broad human groups that share technological traditions.

When a tool is selected to perform a particular function, its morphological characteristics are undoubtedly linked to its anticipated use. For example, to cut one selects a tool with a sharp, more or less rectilinear edge. Obviously, depending on the industry many different types of product offer these characteristics (e.g., points, Levallois flakes, side-scrapers with retouch on the ventral face). The particular method that is chosen to produce the desired cutting edge (e.g., the flaking technique or the sequence of preparatory removals) depends to some extent on the technological know-how of the group and the techniques it deems appropriate for the purpose. Different technological solutions may produce the same morphology. In the case of units IX and X at Kebara, for example, the triangular Levallois products (Shea 1988, 1989, 1991) were frequently used for cutting (many for butchering animal carcasses) and piercing, and specimens used for both functions were obtained by unidirectional convergent removals. But the same morphology (Levallois point) can be obtained via the bidirectional Levallois system, as in the Negev, or by other methods. This particular method was systematically chosen by the Mousterian inhabitants of Kebara units IX and X. The morpho-functional characteristics of the tool were clearly dictated by its use, but the particular method selected for obtaining a tool with these characteristics reflects the technological traditions of the group (see Lemonnier 1992 for a detailed discussion of the arbitrary nature of many technological choices).

Turning now to issues relating to the fauna, Hole raises some interesting questions concerning the existence of differences in site formation processes during the Middle and Upper Paleolithic. There clearly were differences in seasonality and intensity of occupation. Evidence for multiseasonal occupation is available from recent analyses of seasonally deposited cementum increments of gazelle teeth from the site. Lieberman (n.d.) has demonstrated that gazelle in the Middle Paleolithic levels were killed in both wet and dry seasons while in the Upper Paleolithic they were taken only in the dry. This conclusion, moreover, appears to be consistent with preliminary assessments of the age and sex ratios of the gazelle from the Middle and Upper Paleolithic levels and with other archaeological correlates of occupational intensity such as the significantly higher density of artifacts and hearths in the Mousterian levels. However, we have no clear-cut criteria for distinguishing between long-term multiseasonal occupations and repeated short-term occupations at Kebara. This is an extremely important problem that we are now trying to resolve.

Another interesting issue not addressed in the present paper but being actively explored by members of the Kebara team is how the Mousterian hominids at the site procured ungulates. Employing dental and other criteria recently developed by Stiner (1990), preliminary studies of the remains of gazelle and fallow deer—the two ungulate species for which we now have large enough samples—have produced results entirely compatible with a pattern of ambush hunting. Nothing in our results would suggest that these two ungulates were routinely scavenged by the Middle Paleolithic inhabitants of Kebara. Whether this conclusion will also apply to larger ungulates, such as equids, red deer, and *Bos*, remains to be seen.

Obviously, a great deal of work remains to be done on the Kebara material. Nevertheless, we hope that the

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results we have presented here, despite their preliminary nature, will prove useful to scholars interested in the paleoanthropology of Middle Paleolithic hominids. Again, we thank our many commentators for their useful and constructive input.

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