NEW EXCAVATIONS AT THE TABUN CAVE, MOUNT CARMEL, ISRAEL, 1967-1972: A PRELIMINARY REPORT

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Source: *Paléorient*, Vol. 1, No. 2 (1973), pp. 151-183

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Arthur J. Jelinek, William R. Farrand, Georg Haas, Aharon Horowitz, and Paul Goldberg (1)

ABSTRACT

New excavations were undertaken in the Tabun Cave on Mount Carmel between 1967 and 1972 in an attempt to refine the geological and cultural history of the site. Current results indicate that the structure of the deposits is much more complex than had been believed, with over 60 discernable stratigraphic units and an important hiatus between the deposition of Layers C and D as designated by Professor Garrod. Pollen and sedimentary studies suggest that the lowest deposits in the site date to an interglacial interval equivalent to the Riss/Wurm of Western Europe, and that the deposits of uppermost Layer E and Layer D correspond to a cooler interval when the sea was at a greater distance from the cave. This is confirmed by the limited sample of faunal material from Layer D. Layer C and the overlying deposits appear to have accumulated relatively rapidly, coincident with the opening of the chimney in the inner chamber and during a somewhat warmer interval. The faunal changes observed by Miss Bate at this level seem to be best explained by a partial mixing of material from Layers C and D in the original excavation, and from the use of the cave as a natural trap rather than a place of habitation following the deposition of Layer C.
The industrial sequence thus far analyzed is generally comparable to Garrod's succession with several specific exceptions. The deepest layers sampled precede the hiatus marked by the opening of the "swallow-hole" in the outer chamber and contain an industry that shows features of both Layers F and G. The lower portions of Layer E, which are possibly separated from the upper portions by a disconformity, contain very abundant artifacts, some in a dense concentration which may be natural in origin. Amudian artifacts seem most concentrated near the junction of Layers Ea and Eb, as reported by Garrod. The industry of Layer D, which seems to follow E without a significant time gap, is distinctive in its high concentrations of Levallois blades and points. Layer C, which was deposited following an extensive collapse of sediments in the inner chamber, is essentially as described by Garrod. However, in earlier levels it shows heavier artifact concentrations, including manufacturing debris, and a thin scatter of artifacts in later levels as roof-fall from the chimney becomes more abundant.

RESUME

De nouvelles fouilles ont été effectuées dans la grotte de Taboun sur le Mont Carmel entre 1967 et 1972 dans le but de préciser l'histoire géologique et culturelle du site. Les résultats obtenus indiquent que la structure des dépôts, beaucoup plus complexe qu'on ne l'avait pensé, comporte plus de 60 unités stratigraphiques distinctes et un hiatus important entre les niveaux C et D de Miss Garrod. L'étude des pollens et des sédiments suggère que les dépôts les plus anciens datent d'un intervalle interglaciaire équivalent au Riss-Würm d'Europe occidentale et que les dépôts plus récents des niveaux E et D correspondent à un intervalle plus froid ; la mer était alors plus éloignée de la grotte, ce qui confirme la faune, peu abondante, du niveau D. Les dépôts du niveau C ainsi que ceux des niveaux ultérieurs se seraient accumulés assez rapidement, coïncidant avec l'ouverture de la cheminée de la chambre intérieure durant un intervalle légèrement plus chaud. Les changements observés dans la faune par Miss Bate à ce niveau semblent mieux s'expliquer par un mélange partiel du matériel des niveaux C et D au cours des premières fouilles, et par l'utilisation de la grotte comme piège naturel plutôt que par son occupation comme lieu d'habitation, après le dépôt du niveau C. La séquence lithique, en l'état actuel d'analyse, s'accorde dans l'ensemble avec celle de Miss Garrod, à quelques exceptions spécifiques près. Les niveaux les plus anciens étudiés précèdent l'hiatus marqué par la formation d'une structure d'appel dans la chambre extérieure et contiennent une industrie qui montre des traits des niveaux F et G. La base du niveau E, peut-être séparée du sommet de ce niveau par une discordance, contient un grand nombre de silex, certains en concentrations denses dont l'origine est peut-être naturelle. Les pièces amoudiennes semblent surtout concentrées à la jonction des couches Ea et Eb, comme l'avait remarqué Miss Garrod. L'industrie du niveau D, qui succèderait au niveau E sans coupure très longue, se distingue de l'industrie de ce niveau par une forte concentration de lames et de pointes Levallois. Le niveau C, dont les dépôts se sont accumulés après un vaste éboulement de sédiments dans la chambre intérieure, répond à la description de Miss Garrod. Aux niveaux anciens, on constate des concentrations plus grandes de silex comprenant des déchets de débitage et, aux niveaux récents, une répartition peu dense de pièces alors que les éboulements en provenance de la cheminée deviennent plus abondants.

INTRODUCTION

The Mount Carmel area of the northern coast of Israel has long been recognized as crucial to our understanding of the Late Pleistocene prehistory of the Near East. The importance of this area for prehistory was first revealed by the work of the late Professor Dorothy A. E. Garrod whose excavations between 1929 and 1934 demonstrated a long cultural sequence in three cave sites in the Wadi Mughara. This sequence included Lower and Middle Paleolithic materials in the deep deposits of the Tabun cave, Middle Paleolithic at the Skhul Cave, and Middle and Upper Paleolithic, as well as Epi-Paleolithic, at the El Wad Cave (Garrod and Bate, 1937). The great variety of industries represented in the succession of deposits in these sites, closely associated in space, provides the most detailed sequence of Late Pleistocene cultures in the Near East. In addition to this

1) In this report the senior author has prepared the Introduction, Discussion, and the contribution on the archaeological materials ; sections contributed by the other authors are indicated in the text.

key cultural sequence, the sites of Skhul and Tabun yielded the remains of two apparently distinct Neanderthaloid hominids, finds of major significance for the study of human evolution.

The caves of the Wadi Mughara (Nahal Me'arot) are situated at the western edge of Mt. Carmel about 20 km, south of Haifa, at the point at which the wadi drainage breaks forth between two high promontories of limestone and empties into the coastal plain (Fig. 1). This western edge of Mt. Carmel parallels the Mediterranean coast ; the adjacent coast plain here averages about 3,5 km. in width. Mount Carmel itself consists of relatively low rolling hills (c. 150-200 m) dissected by steep wadis along most of its western margin, gradually rising to maximum elevations of about 500 m along its eastern scarp. The Wadi Mughara drainage covers about 50 km^2 of Mount Carmel, and is thus one of the more important watersheds in the area, although not as large as the Nahal Oren to the north or the Nahal Daliyya to the south. The caves, situated on the south edge of the wadi, vary considerably in form and situation. Tabun is the largest of the three sites, and is located closest to the mouth of the wadi and at the highest elevation (about 60 m). It consists of an outer "chamber" screened by rock walls and open to the sky, and an enclosed inner chamber, above which is a wide chimney. Originally the outer chamber was filled with the deposits referred to as the "terrace", which overlapped the exterior edge of the chamber and continued down the hillside. The inner chamber was filled with sediments to within about five meters of the top of the chimney. Altogether the deposits at Tabun included a section whose total depth exceeded 24 meters prior to Garrod's excavation. Her work was conducted primarily in the terrace and chimney deposits and left a stepped vertical profile under the entrance to the inner chamber. This profile included all of the stratigraphic units defined in her report except those designated Chimney I and II. Her sequence was separated in "Layers" largely on the basis of the included lithic industries, designated, from top to bottom : Layer B, with an Upper Levalloiso-Mousterian industry ; Layers C and D with a lower Levalloiso-Mousterian ; Layer E subdivided into the four sublayers Ea - Ed, with an industry originally described as Upper Acheulian or Micoquian, but later recognized as Yabrudian ; Layer F, with an Upper Acheulian ; and Layer G, with an industry characterized as Tayacian, later termed "Tabunian" (Howell, 1959 : 15). A Neanderthal burial and an isolated mandible were recovered from Layer C. At the close of Garrod's excavation, in addition to the main profile, extensive deposits remained on the lower terrace just to the north of the outer chamber, as well as along the west side of the outer chamber.

The cave of El Wad is situated at the foot of the cliffs at a lower elevation than Tabun and about 60 m. to the northeast of it. El Wad had a completely enclosed inner chamber and passageway and a relatively broad, thin terrace deposit ; it contained a sequence of Middle and Upper Paleolithic industries in the inner chamber, and extensive deposits of Natufian on the terrace, which were completely excavated in the 1930's. The site of Skhul, about 100 m. east of El Wad, is also relatively low in elevation and consists of a rocky shelf which was apparently once roofed as a shelter. It contained mostly Middle Paleolithic industries, with a superficial deposit of Upper Paleolithic and later materials. The remains of nine Neanderthaloid burials were recovered from the Middle Paleolithic (Lower Levallois-Mousterian) layers. Like El Wad, this site was completely excavated by the original expedition.

While these excavations in the Wadi Mughara did provide an extensive record of Late Pleistocene cultural development, as further work was carried out in the Near East it became clear that many specific points in the original interpretation of this material needed modification. A succinct treatment of several of these problems as they were understood some thirty years after the excavation is provided by Garrod (1962) in her interesting appraisal of the status of Middle Paleolithic archaeology in the Levant in the early 1960's. The questions she treated were mostly concerned with the chronological relationships of the various major cultural types represented at Tabun and Skhul with industries from other sites in the Levant and with the major events of the Late Pleistocene climatic succession. Other problems emphasized in her paper concerned the generic relationships between certain of the cultural types at Tabun (e.g. the Yabrudian and the Amudian) and the temporal relationships of the Skhul Neanderthal burials with the single burial from Tabun. However, there were additional important problems, not directly addressed by Garrod, related to the climatic succession and other inferences drawn from the faunal remains at the two sites. Specifically, these concerned the paleontological findings in the establishment of the chronological relationships between Skhul and Tabun, the climatological sequence assigned to the successive major geological layers in the sites on the basis of the fauna, and the "great faunal break" of the mid-Late Pleistocene postulated by Dorothea Bate. This "break", a postulated

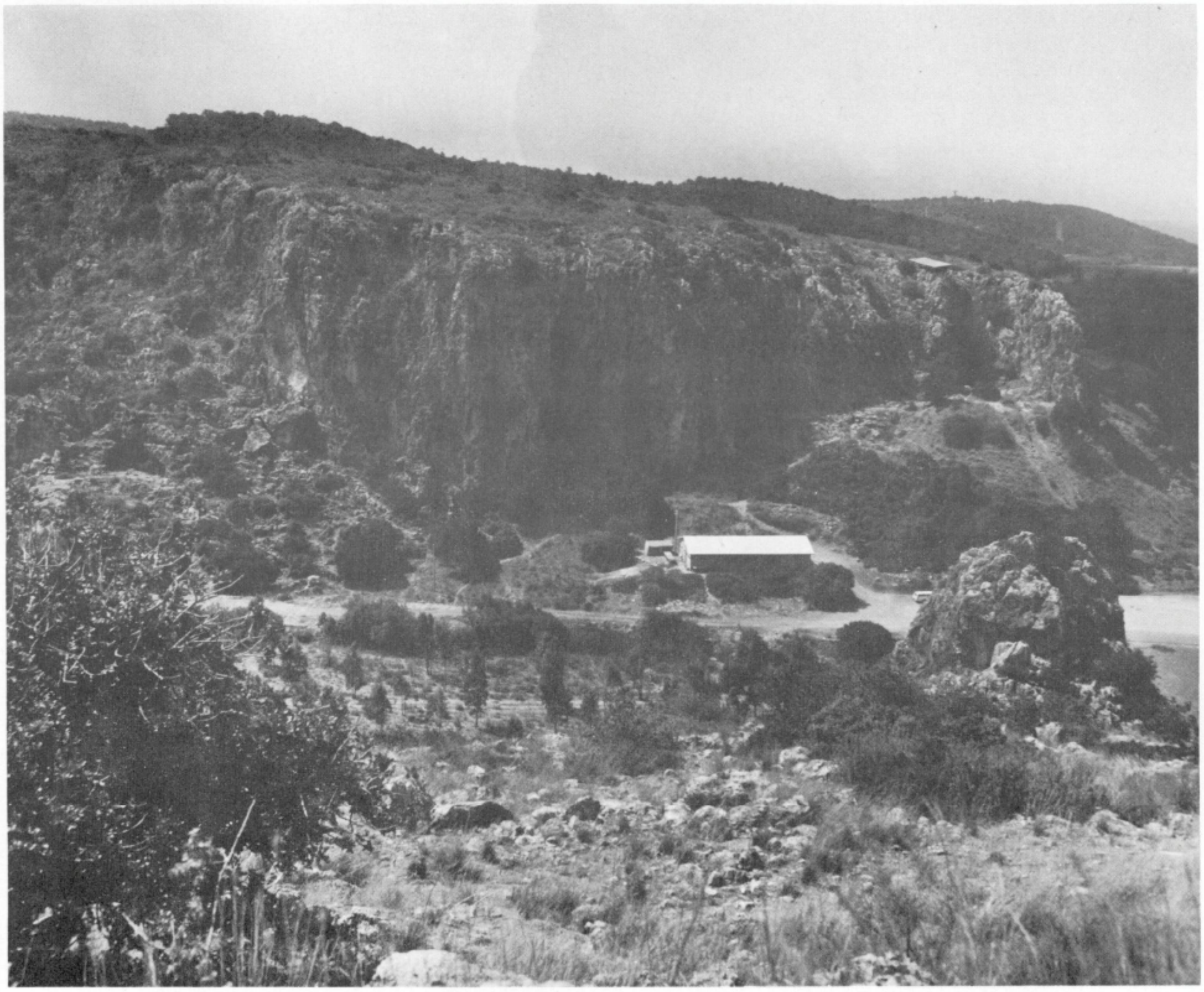

Figure 1. View of the Caves at the mouth of the Wadi Mughara (Nahal Me'arot) seen from the north. Tabun lies just to the left of the cultivated coastal plain at the right margin, below and to the right of the roof covering the chimney opening on the plateau. El Wad is the double opening immediately above the roof of the laboratory. Skhul is visible at the left margin as a shelf in the hill slope in front of a small tubular opening.

dramatic faunal extinction and accompanying climatic shift, had been proposed by Miss Bate largely on the basis of a marked change in the ratio of the number of bones of *Dama* to those of *Gazella* in the sequence from Layer C to Layer B at Tabun (Garrod and Bate, 1937 : 141). The failure of other workers in the Near East to find evidence of this climatic change associated with generally similar cultural horizons called this interpretation into question.

It was with many of these questions in mind that we undertook to carry out a limited test in the remaining deposits at Tabun, beginning in 1967. This work continued for five seasons of excavation through 1971 and an additional season of laboratory work at the site in 1972 (2). The basic design of this project was to sample a limited section of the main stratigraphic profile remaining just inside the entrance of the cave through those deposits pertinent to the major problems mentioned above. This profile survived from the base of the deposits of Layer B down through Layer G, a vertical section of about 14,5 meters. Because of the obviously restricted quantity of remaining deposits, the test was limited to a section 5 meters wide at the center of the profile through Layer C, expanding to 6 meters wide half way through Layer D and continuing at 6 meters wide to a depth of 10 meters (fig. 2). This front of excavation was carried back into the profile approximately 2 meters from the existing face. Thus the minimum area exposed by the excavation below the uppermost gently sloping portion of Layer C was 10 m^2. In order to avoid the greatly expanded cavity left by the collapse of sediments around the tuffaceous spring deposit since the original excavation, and to enable our excavation to sample a more varied portion of the deposits, the six-meter face of the excavation was shifted three meters to the west below the step at about 7 meters below datum on the original profile.

One objective of this excavation was the retrieval of an adequate sample of artifacts through the section tested, with maximum practical control of artifact locus, position, and stratigraphic context. To achieve this control, all artifacts with a diameter larger than about 2 cm. were recorded in place to the nearest centimeter in the horizontal and vertical control system ; also, the geological bed was noted, and the position of the artifact was recorded in terms of such features as the direction of the long axis for cores or of the striking platform for flakes, the direction and degree of dip of the flat plane of the artifact, and, in the case of flakes, the attitude of the bulbar and exterior surfaces. Artifacts smaller than two cm. were collected by square, geological bed, and date of excavation. The excavation was carried out in single meter squares, so scheduled that alternate squares were excavated simultaneously. This exposed stratigraphic profiles at one meter intervals, both parallel and vertical to the original profile. These profiles were recorded individually on detailed drawings and through black and white and color photography, resulting in a complete stratigraphic record at one meter intervals through the entire test. Ultimately, the stratigraphic study revealed a minimum of about 60 geological beds in the 10 meters of profile excavated. In the interest of environmental studies, several other collecting techniques were employed. Approximately one kilogram of soil was routinely taken from each bed of each square for sedimentological studies and a similar sample was collected for palynological analysis. In the event that a geological bed attained a thickness of over 10 cm., additional samples were taken at each 10 cm. of depth. Throughout that portion of the deposits in which bone was preserved, and for some depth beyond this, all excavated earth was retained, segregated by square and bed, and transported to the laboratory, where it was washed through finescreen washers to recover the remains of microvertebrates.

The actual excavation was carried out entirely by students trained in archaeology. The digging was done with ice-picks and small brooms when the texture of sediments permitted, and in tougher deposits with small

2) The major portion of the field work and the construction of research facilities in the field were sponsored by the Foreign Currency Program of the Smithsonian Institution (Grants SFCP 19, SI-FCP 4791, SFC 5746, SFG 0-4977, and SFG 1-5267) ; additional support for student participation was provided by a grant from the Ford Foundation (68-342). Research funds from the University of Michigan supported an initial reconnaissance and a portion of the field equipment. A grant from the National Science Foundation (Gs-2696) has supported research on the excavated materials and a portion of the final season of field research. Administrative sponsorship of the project began with the University of Michigan in 1967 and was assumed by the University of Arizona in 1968. The entire field operation, from its inception, has benefitted greatly from the cooperation and friendship of the French Center for Prehistoric Research in Jerusalem directed by Jean Perrot. The project staff included Professor Arthur J. Jelinek, University of Arizona, Director ; Professor William R. Farrand, University of Michigan, Geologist ; Dr Avraham Ronen, Tel-Aviv University, Archaeological Assistant, 1967-1970, 1972 ; Dr David Gilead, Tel-Aviv University, Archaeological Assistant, 1967, 1968, 1970, 1971 ; Mr Paul Goldberg, University of Michigan, Geological Assistant, 1967-1970 ; and Mrs Eloise Jelinek, laboratory supervisor, 1968-1972.

hammers and chisel with maximum attention to exposing artifacts in situ. In addition to the detailed records of artifact excavation, each square was provided with a narrative record book for daily detailed stratigraphic and qualitative observations.

The goal of this technique was a level of information regarding the excavated portions of the cave equivalent to that which is attained by the more time-consuming techniques of peeling back the deposits over the entirety of each stratigraphic unit and exposing whole layers of artifacts **in situ**. I think that this level of information has been achieved with less time and expense than the "peeling" technique, and possibly, through the close intervals of stratigraphic control, with somewhat greater accuracy in that respect.

While the full results of this study will not be available until the analysis is completed on the more than 40,000 recorded artifacts, and the geological and environmental samples, it is now possible to discuss some important preliminary results.

TECHNICAL REPORTS

Primary to assessing the relationships of the materials recovered by the excavation is the geological interpretation of the deposits of the cave. Professor William R. Farrand of the University of Michigan served as project geologist through the entire period of field work. His preliminary studies, with those of Dr Paul Goldberg, are summarized below.

THE GEOLOGICAL DEPOSITS

DESCRIPTION OF THE CAVE

The cave of Tabun consists of three more or less circular chambers. The interior chamber is exposed to the sky by means of a "chimney" about 5 m. in diameter that developed during the occupation of the cave by prehistoric man.

The intermediate chamber, by far the smallest of the three, communicates with the others by means of very large openings so that for all practical purposes it is really only a minor constriction between the interior and exterior chambers. Nevertheless the intermediate chamber was the locus of excavations carried out in 1967-1971 because of the 13-m high section left there by Garrod.

The exterior chamber is the largest of the three and is completely exposed to the sky. Most of its sedimentary fill was removed during the former excavations, but according to Garrod's description there were very few large limestone blocks in the sediments that could have come from the breakdown of the walls or former ceiling. Therefore, one can conclude that the ceiling of this chamber disappeared well before the sedimentary fill began to form. Garrod's excavation reached bedrock at the base of the fill in this chamber, and this bedrock surface is in the form of a funnel-shaped, karstic swallow hole. The lowermost sediments of the fill (levels F and G) were drawn down into this swallow hole before the middle and upper parts of the fill were deposited. The lowest known point in this swallow hole is about 45 m above present sea level, but the bedrock sill at the entrance to the cave rises to about 53 m above the level of the Mediterranean.

The talus slope in front of the cave is completely covered by back-dirt of the former excavations except at the very top where remains of the original sediments, solidly cemented into a breccia, are exposed. This breccia contains worked flints and bones, but excavation was not attempted in it because of its extreme hardness. It is not possible to examine the lower part of the talus slope without first removing many cubic meters of back-dirt.

STRATIGRAPHY OF THE SEDIMENTARY FILL

Prior to the former excavations the difference in altitude from the top to the bottom of the fill was about 25 m. Garrod divided these sediments into 7 levels (A through G) in most cases primarily on typological grounds.

Level A was the surface layer containing historic and modern debris. No traces of it remain.

Level B (Upper Levalloiso-Mousterian) is composed of red clay and limestone blocks commonly 15 to 25 cm in diameter. It was immediately obvious that this red clay is simply **terra rossa** reworked from the plateau above the cave and washed in through the chimney. The limestone blocks resulted from the gradual collapse of the ceiling and walls.

Level C (Lower Levalloiso-Mousterian), at least what remains of it, is clearly distinguished from the rest of the fill. It is made up of thin layers, brick red, dark red,

Figure 2a. View of the excavation on the main profile at Tabun at the close of the 1971 season. The upper portions are 5 m. wide, the lower portions are 6 m. wide, except for the lowest $1\frac{1}{2}$ m., which is 4 m. wide and terminates at 10 m. below Datum. Note the complex bedding in much of the profile and the cavity in the lower right corner caused by crumbling of the tuffaceous spring deposit.

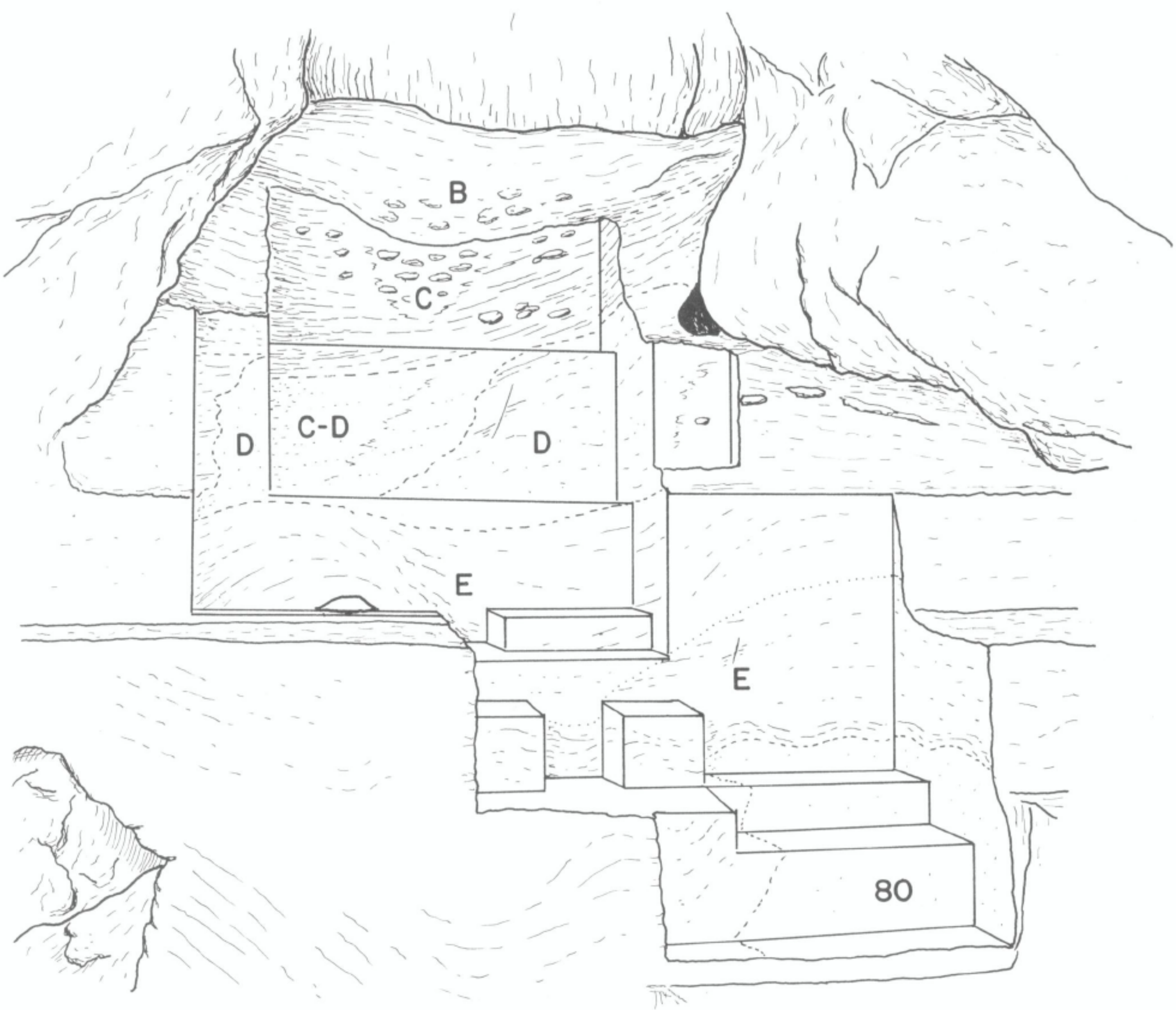

Figure 2b. Drawing of the view in Figure 2a. Dashed lines indicate approximate boundaries of Garrod's layers and our Bed 80. Dotted line follows possible disconformity in Layer E.

white, and black, that resulted from repeated fires that must have engulfed the entire floor of the intermediate and interior chambers. These are certainly not hearths because many individual layers of ashes can be followed from wall to wall across the cave, a distance of at least 8 to 10 m. Apparently these burnt layers occurred only in the interior of the cave because they were not discussed by Garrod in her description of the exterior chamber and not shown on her sections (Garrod and Bate, 1937). In addition to these brightly colored beds one finds in Level C thin beds and lenses of dark red clay identical to that in Level B, as well as scattered limestone blocks, in general less numerous and smaller than those in B. The appearance of red clay and associated limestone blocks begins abruptly at the lower contact of Level C, and neither is found in lower levels of the fill. One can, therefore, conclude that the enlargement of the vault of the cave that brought the chimney into existence began at the same time as sedimentation in Level C. Prior to the time of Level C the interior chamber of Tabun was roofed over and somber, but always weakly illuminated by daylight from the cave entrance.

The lower half of the fill is composed of a single sedimentary ensemble (3) although Garrod divided it into several levels (D through G) according to the flints found in these beds. From the base of the section upwards the sediments change from slightly silty, fine sand (Levels G and F) to sandy silt (Level D). The entire series is clearly eolian in aspect and according to our analyses. Levels F and E especially are very similar to eolianites (**kurkar**) near the present coast only a few kilometers from the cave. These sandy beds in Tabun are alternately unconsolidated or cemented by phosphate (collophane) or $CaCO_3$. Fragments of bedrock are quite rare, but worked flints are very abundant in these layers, especially in levels E and F (Yabrudian, Amudian, Upper Acheulean). We found that bones were nearly completely absent in these sands, although Garrod recovered a moderate number of fossils in her excavations closer to the cave entrance. It is only in the lowest layers, Level G, that we found distinct traces of hearths. Elsewhere living floors were not at all apparent, but analysis of the distribution of flints found in 1967-1971 may localize some living floors.

We have regrouped the levels distinguished by Garrod into three geological units :

- I (= Level B) Red clay washed in from the plateau and limestone blocks from the ceiling ;
- II (= Level C) Alternating layers of ash, charred materials, and baked soil, intercalated with thin beds of sediment like that of Unit I ;
- III (= Levels D through G) Eolian sand, increasingly silty upwards ; the top part of III is strongly disturbed by small erosional channels and slumping.

The transition from Unit II to Unit I is very gradual ; the contact between these units was placed at the horizon where the red clay characteristic of Unit I extends from one wall to the other in the intermediate chamber. The contact between units III and II, on the other hand, is very sharp, being marked by an erosional surface and by the strong differences in weathering, discussed below.

SEDIMENTOLOGICAL ANALYSIS

Approximately 150 samples collected from several different parts of Tabun have been analyzed by Mr. Goldberg. Our analyses include granulometry, chemistry ($CaCO_3$, phosphates, pH, organic matter), heavy minerals ; the clay minerals were studied by Mlle H. Paquet in Strasbourg. The most important analyses are shown in Figure 1 for about 100 of these samples. In Figure 3 "Depth" is given with respect to the zero datum of the 1967-1971 excavations, our zero being 60.7 m above sea level ; "Size" is divided between fine sand (in black), 0.297 to 0.062 mm, silt, 0.062 to 0.0039 mm, and clay, less than 0.0039 mm. Of the total grain-size distribution only a small and constant percentage (less than 3 %) of coarse sand is not shown here. The percentages of silt and clay were not determined for all the samples shown. Calcium carbonate was measured by means of the Chittick apparatus on a pulverized sample of bulk sediment. The amount of phosphorus shown in the figure (in parts per million) represents only that derived from easily soluble phosphates, especially iron and aluminum phosphates ; calcium phosphates (apatite, collophane) are only weakly soluble in the process used. The total amount of phosphorus is known from other analyses to be much higher-as much as 20 to 30 % in the form of P_2O_5, but

3) During our last field season we discovered a break within this sequence indicating an interruption of some, yet undetermined, significance. This unconformity between our beds 59 and 80 in the western part of the excavations may have been structurally controlled, being related to the subsidence into the swallow hole so clearly shown by Garrod's levels G and F on the east side of the cave. The sediments above and below the unconformity are very similar (although detailed laboratory analyses have yet to be made) apparently indicating no change in type of sedimentation. However, see the discussion by Jelinek of the possible differences in artifact assemblages above and below the unconformity.

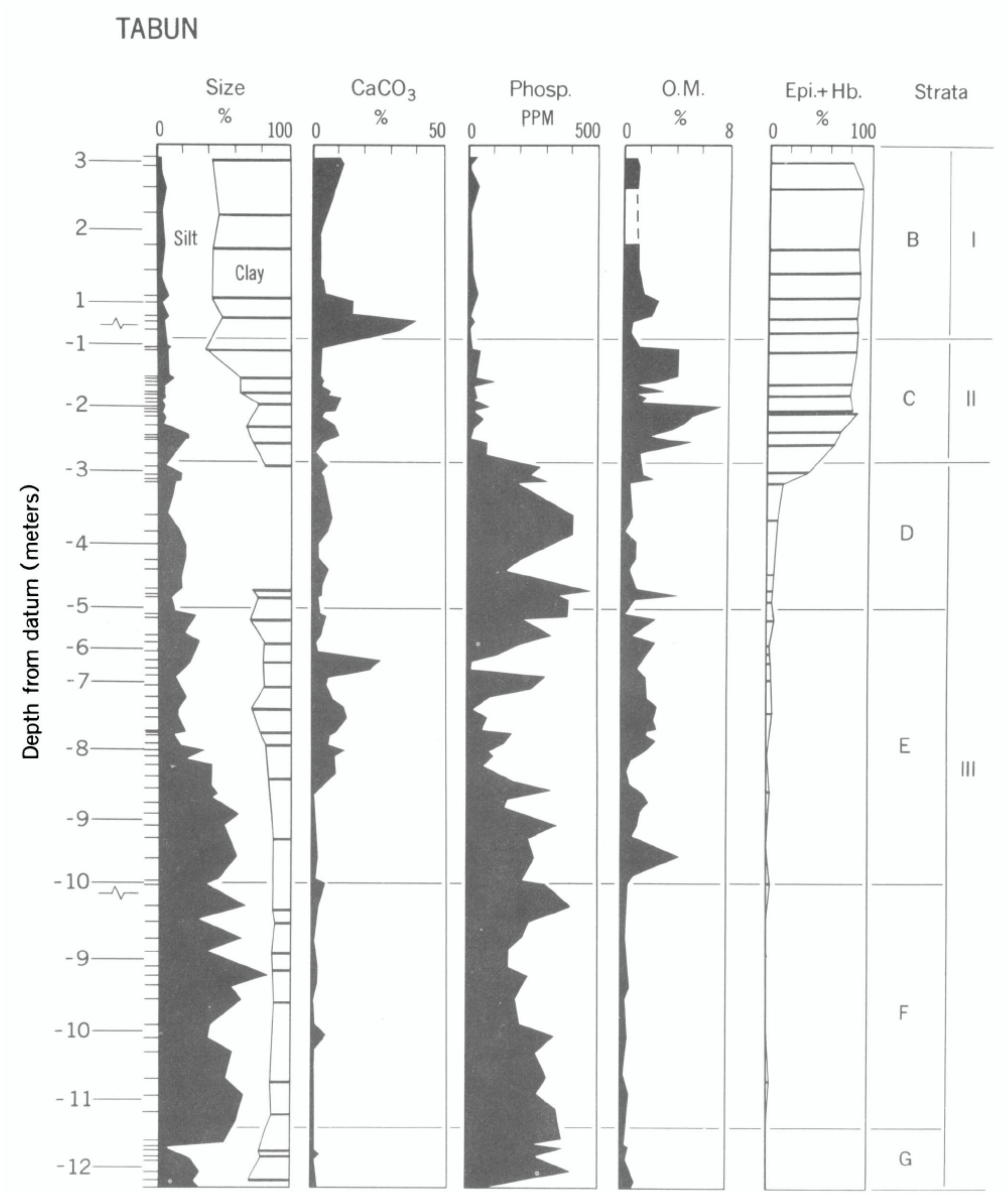

Figure 3. Summary diagram of the more important sedimentological parameters in the cave fill of Tabun. Sampling intervals are shown by the short lines along the left side of the diagram. See text for further explanation.

the values of phosphorus shown in Figure 3 are believed to be very indicative and useful in the interpretation of the history of these sediments. Organic matter ("O.M.") was determined by chemical analysis on bulk sediment. The column headed "EPI + HB" gives the combined percentage of epidote and hornblende relative to the total heavy mineral assemblage ; the remainder is composed mainly of minerals that are very resistant to atmospheric weathering : rutile, zircon, tourmaline staurolite and kyanite.

INTERPRETATION

The grain-size distribution is polymodal, with almost all samples showing three more or less important modes-in the fine sand (0.125 to 0.150 mm), in the silt (0.03 to 0.04 mm), and in the clay (< 0.0039 mm) ; see Figure 4. The evolution of these three modes can be followed through the stratigraphy of the site. From bottom to top in Unit III (Levels F through D) there is a decrease in fine sand, which is very abundant in F, and an increase in silt. Concomitantly there is a slight increase in clay, but apparently this clay-size material is finely divided cement (calcite, collophane) rather than clay minerals. The fine-sand and silt modes in Unit III are very well sorted (Fig. 4).

Units II and I contain but very little sand, a tendency which begins to be seen already in the top part of Unit III (D), and the silt mode is clearly more poorly sorted. Moreover, and especially in Unit I, the percentage of clay becomes predominant. Here we are dealing with the terra rossa washed in through the chimney from the plateau. The granulometry of terra rossa collected on the present plateau surface is practically identical to that of sample 1-6 shown on Figure 4.

In order to explain this polymodality we propose a hypothesis involving a natural combination of eolian phenomena. The fine-sand and silt modes clearly show characteristics of eolian sediments : sorting, skewness, electron microscope morphoscopy, as well as direct comparison with known eolian deposits of this region. On one hand, eolian sand dunes are well known along the Mediterranean coast of Israel, and on the other there are thick accumulations of loess of Late Quaternary age in the northern part of the Negev Desert. In addition, at the present time dust storms originating in the Negev and Sinai spread over the entire country from time to time, especially in winter. We have, therefore, two eolian manifestations that differ with respect to grain size and in provenance. Thus, we suggest that the cave of Tabun was a sort of trap for eolian sediments, the fine sand coming from the littoral and the silt from a more distant source. Normally, eolian silt would be carried much farther than sand, but the cave facing the sea formed a *cul-de-sac* that trapped both sediments in the same place, but perhaps at different seasons of the year. Apparently deposition of sand diminished as the active shore zone retreated during a marine regression, but it is not impossible that the amount of eolian silt being deposited was more or less constant with time-especially if it came from a desert source.

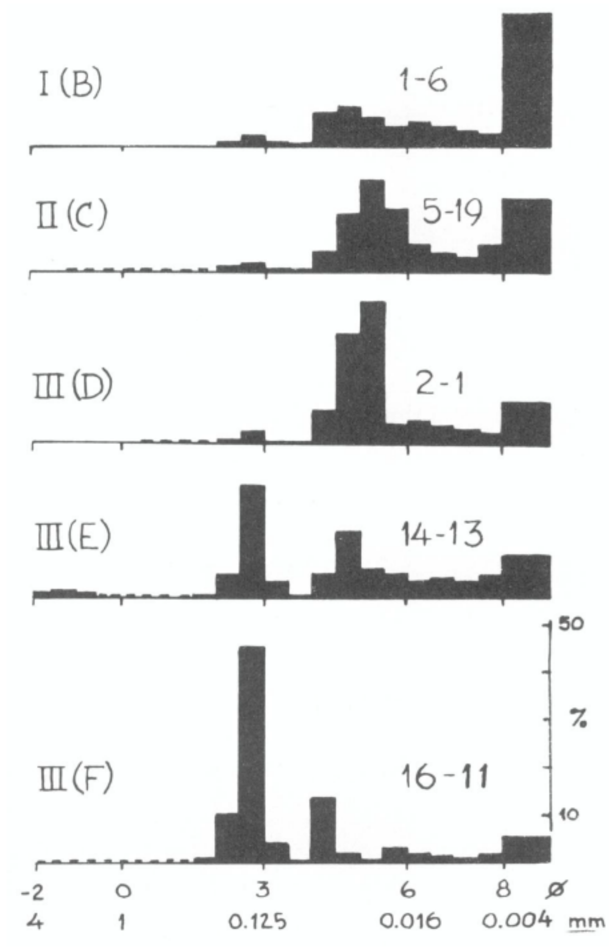

Figure 4. Granulometry of several representative samples from Tabun showing the striking polymodality of the sediments and its evolution through the section. The histograms are based on a logarithmic scale at a half-phi interval ($\frac{1}{2}\varnothing$). The stratigraphic levels are indicated on the left and the sample numbers on the right.

Leaving aside for the time being the analyses of $CaCO_3$ and organic matter, which show that these constituents are present in reduced quantities throughout the entire section (especially in levels F and G) let us consider the phosphates and heavy minerals. The values of these latter substances show a very abrupt change at the level of the contact between Units III and II (Fig. 3). Below this contact the value of soluble phosphorus is rather high-between 200 and 500 ppm in general- and the percentage of epidote and hornblende is zero or practically zero. Therefore, in the same beds where we find phosphatic products resulting from the chemical disintegration of bone, the heavy mineral assemblage is dominated by those minerals that are the most resistant to atmospheric weathering. Furthermore, bone fragments are practically totally absent in these same beds, except close to the rock walls where the sediments have been cemented by $CaCO_3$.

On the other hand, above the II/III contact bones are relatively abundant, especially those of cervids in Unit I and of microfauna in Unit II. Here one finds very little secondary phosphate (< 50 ppm), and epidote and hornblende are abundant ($\geqslant 80\%$). It is therefore readily apparent that the sediments in Units I and II have not undergone nearly as much weathering as those in Unit III. This opinion is reinforced by the presence, in the top part of Unit III (Level D), of numerous erosional channels and small faults that do not continue upward into the immediately overlying beds of Unit II. These phenomena, also, indicate a break in the stratigraphy at this point.

With respect to the samples analyzed, the transition between these two sets of conditions is very rapid, being seen only in the four samples astride the II/III contact. In Unit III there are no gradients in the phosphorus or heavy mineral values. With the exception of several samples from Unit III (E) the phosphorus measured is always much more abundant than in Units I and II, and epidote and hornblende are strongly reduced in all cases. This arrangement of values forms a strong argument in favor of the hypotheses of weathering of phosphates and destruction of heavy minerals progressively as the deposits of Unit III were accumulating, and is in opposition to the view that the weathering observed here occurred only after the deposition of Unit III had ceased.

The discordance, or unconformity, between Units III and II is, therefore, a chronological hiatus during which the kind or the rate of chemical weathering was modified. This modification could have been brought about by a change of the rate of sedimentation, by a climatic change, by a change in the character of sedimentation, or by a change in the configuration of the cave. At least the last two types of changes have been recognized in Tabun. The sediments in Units I and II are clearly more clayey and less sandy than in Unit III, and the clay is much richer in clay minerals. This change in the character of the sediments is due, in turn, to a change in the configuration of the cave, namely the opening of the chimney, which at the same time modified the microclimate of the interior chamber of the cave. We suspect that these changes were accompanied by an increase in the rate of sedimentation, but we do not yet have the information necessary to measure it.

One consequence of the opening of the chimney would have been the removal of a habitat for bats. At the present time rather large colonies of bats live in some of the neighboring caves (el-Wad, Kebara), and the accumulation of bat guano is impressive. Humic acids developed from this guano are very efficient in destroying the primary phosphates (apatites) of bone (Graham, 1925). Once the chimney was wide open the cave would no longer have been very attractive for bats. Without bats, guano would have no longer accumulated, and consequently there would no longer have been massive destruction of bones. The same humic acids would also have attacked the more susceptible heavy minerals. Thus, we suggest that here is a major element in the explanation of the difference in the weathering regimes of Unit III on one hand, and Units I and II on the other.

One might also consider the hypothesis that the two series of sediments (III vs. I-II) were separated by a large time gap so that the age difference would suffice to explain the differences in degree of weathering. This hypothesis does not agree, however, with the chronological interpretation given below. As we shall see, according to our chronology the interval between Units III and II is certainly not longer than the lapse of time since the end of deposition on Unit I ($\leqslant 35{,}000$ yrs.). Yet Unit I is not nearly so heavily weathered as Unit III. Although the difference in age between the top of Unit III and the bottom of Unit II may have played a certain role, it does not seem reasonable to attribute the great differences in weathering uniquely to this cause.

In summary, the sedimentological history of the Tabun cave fill is as follows :

1- Unit III is characterized above all by eolian sedimentation, Level F being practically identical with the ancient dunes of the coastal plain. From bottom to top through Unit III the sediments become more and more silty to such an extent that the upper part (Level D) resembles a true loess. The occurrence of fine sand and silt in two clearly separated granulometric modes leads us to think of two different sources of these sediments. The sand could easily have been derived from the littoral zone, and its decrease in abundance upward through the section can be linked with a regression of the sea. The shore line abandoned during that regression could have been the + 39 m shore line found at the foot of the old sea cliff directly in front of Tabun, although a direct connection with that former beach has yet to be established. Another observation that also suggests a relationship with sea level concerns the attitude of the lower beds in Tabun. As mentioned above, Level G and the lower part of Level F have been drawn down into a bedrock swallow hole in the exterior chamber so that they now plunge vertically at the base of the existing section. These beds must have been pulled down slowly but progressively because they are still intact, although attenuated, and do not show any trace of a sudden collapse. The only mechanism that seems to account for the drawing down of the beds is the slow lowering of sea level which would have produced a simultaneous withdrawal of groundwater, thus removing the hydrostatic support of the lower sediments. This mechanism would probably have been more effective at Tabun if the sea level in question were the + 39 m shore line rather than the younger shore lines, which are only a few meters above present sea level and some 2.5 to 3 km away.

2- With the decrease in sand, eolian silt becomes the most important sediment type in the cave. Apparently eolian transport from the southern deserts, such as still occurs today, took place more or less continuously throughout Late Quaternary time.

3- During their accumulation the sediments of Unit III were attacked by chemical weathering that destroyed the more fragile heavy minerals and bones, leaving behind secondary phosphates. Probably this weathering was strongly accentuated by the presence of large quantities of guano from bats that inhabited the interior chamber of the cave before the chimney was opened.

4- A major change in the sedimentation occurred after the deposition of Unit III. First of all, there are the erosional channels and faults cutting the upper part of Unit III (D) ; in addition, the dip of these beds is quite steep in some places, and directed toward the interior chamber of the cave. Without a doubt there was a collapse of the floor of the interior chamber at that time, a collapse and subsidence similar to that seen in the lower section (G and F) in the exterior chamber. Among the first sediments that accumulated after this collapse, limestone blocks and lenses of red clay make their first appearance. These blocks detached from the roof by solution and the erosional channels in the top of Unit III (D) give evidence of a period of increased available humidity, and we shall see that conclusion confirmed by pollen analysis (Horowitz, this volume). The fact that red clay (terra rossa) appears immediately at the base of Unit II shows that the chimney was beginning to open at that time, probably in the form of narrow fissures at first.

5- Throughout the deposition of Unit II the number and size of limestone blocks increase, and the lenses of red clay become larger. It seems likely that at the end of this episode the chimney had attained essentially its present diameter. In this same unit one finds burnt beds resulting from fires that covered the entire floor of the intermediate and interior chambers. Although we do not yet have any direct proofs, it seems that these repeated fires were the result of human activity, perhaps a means of removing brushy vegetation or bat guano accumulated between successive occupations.

6- The transition from Unit II to Unit I is almost imperceptible from the sedimentological point of view. The contact, placed at the top of the series of burnt beds, is very distinct in the lateral parts of the section, but in the center Unit-I-type sedimentation had already set in well before the end of Unit-II time.

7- Deposition of limestone blocks detached from the walls and of terra rossa washed in from the plateau (Unit I) continued up to the point where the passage between the intermediate and interior chambers was essentially blocked ; only a small crawl space remained. At the end of sedimentation only the uppermost 5 m of the chimney remained empty, and the only access was from the plateau.

CHRONOLOGY

We have seen that the cave fill in et-Tabun begins with eolian sand most probably associated with regression from the + 39 m beach. This shore line at + 39 m is classified as "Tyrrhenian I" by Michelson (1968) because of the presence of *Marginopora.* In spite of its altitude, it is very possible that this shore line dates from the last interglaciation because tectonic movement has been important in this region during the Quaternary (Kafri, 1970). Moreover, if *Marginopora* is truly an index of warmer waters (Reiss and Issar, 1961) then its presence suggests correlation of the + 39 m beach with the Eutyrrhenian stage of the western Mediterranean, which is generally conceded to be of last interglacial age (Bonifay, 1964). The kurkar ridges closer to the present coast can be interpreted as the results of oscillations of sea level also during the last interglaciation, but posterior to the + 39 m shore line (Farrand and Ronen, in press ; Sanlaville, 1969).

The fact that the sediments of Unit III form a single continuous series that changes progressively from bottom to top, combined with the presence of Middle Paleolithic flints in the upper part of that unit (III-D), confirms the hypothesis that we are dealing with the last great marine regression, that is, the one that accompanied the beginning of last great glaciation (the Weichselian of northern Europe).

Several years ago radiocarbon dating of Tabun sediments was carried out (Vogel and Waterbolk, 1963), but they showed some stratigraphic inversions and in general appeared too young. Recently the presence of contamination in some other radiocarbon samples from the same levels has been shown (Bien and Pandolfi, 1972). All that can be said at present is that the age of Level C is at least 41,000 years and probably older.
A limiting date can be placed on the top of the Tabun section, which contains flints called Upper Levalloiso-Mousterian by Garrod. In the eastern Mediterranean and adjacent countries the transition from Middle Paleolithic to Upper Paleolithic is rather well dated at about 35,000 years ago (Farrand, 1970). Therefore, the filling of et-Tabun must have been accomplished before that date.

In summary, the sediments of et-Tabun accumulated between about 120,000 (very approximately) and 35,000 years ago. Therefore, the cave fill can be correlated with a large part of the last interglaciation and the first half of the last glaciation of northern Europe. The only break found in the section, that between Units III and II, must be placed prior to 40,000 and after 75,000 years ago, the latter being the approximate date for the beginning of the last glaciation. It is difficult to correlate this break with one of the known interstades of the last glaciation because, as we have seen, it coincides with a rather important change in the configuration of the cave and that change alone could explain a very large part of the differences that are found in the sediments above and below the III/II contact.

In attempting to correlate our interpretations with those of Garrod and Bate (1937), we see that the sedimentary break between Units III and II is located right in the middle of the Lower Levalloiso–Mousterian levels of Garrod, while the imperceptible transition from Unit II to Unit I coincides with the "great faunal break" interpreted by Bate and with the appearance of the Upper Levalloiso-Mousterian industry. These older interpretations are certainly open for revision ; the least that one can say is that the changes in the fauna and industries mentioned by Garrod and Bate do not seem to coincide with comparable events in our sedimentary history of Tabun.

FAUNAL REMAINS

The analysis of the faunal remains recovered between 1967 and 1971 has been undertaken by Professor Georg Haas of the Hebrew University, Jerusalem. His preliminary report follows.

PRELIMINARY REPORT ON REMAINS OF SMALL VERTEBRATES FROM THE TABUN CAVE BEDS 1 – 23 (Tabun C)

Dr Jelinek has kindly submitted a series of samples of vertebrates to me from the Tabun Cave (Carmel Area). All of the samples except one belong to Bate's Tabun C complex ; the single exception belongs to Tabun D and shows a sharp difference with the others in its faunal composition. The overall bone content differed very much in the different strata in quantity, but also in the quality of preservation ; some strata, as, e.g., 22 and 23, were completely sterile ; even the richer strata yielded almost no remnants of animals bigger than a rat. The few exceptions will be mentioned later.

Most of the fossil remains belonged to the common local vole, *Microtus guentheri* Danford et Alston. Other rodents as *Meriones, Mus, Apodemus Spalax, Philistomys*, were also well represented, but their occurrence was not so general as the vole's practical omnipresence (except in completely sterile strata) and all these forms never reached the often exorbitant numbers of voles. Besides rodents, insectivores, namely several species of whitetoothed shrews, were fairly well represented in several samples (*Crocidura* and *Suncus*). Bats were much rarer in occurence and quantity. In certain strata bones of reptiles (lizards, turtles, snakes) and birds occurred is small quantity. Amphibians (Anura) were almost missing, but, for details, the summarizing list of contents per stratum should be consulted. In this preliminary report several groups, as shrews, bats and the genus *Apodemus* will be rather loosely dealt with, using relative terms as big, medium or small species.

Comparing our combined data of occurences in the sequence of strata with the parallel list given by Bate (Garrod and Bate, 1937) for the same cave, some remarkable discrepancies could be found ; in this way, occurrence limits will have to be changed and corrected in several instances, which will be discussed in the following paragraph.

(1) *Philistomys roachi*, Bate. This primitive glirid formed for Bate one of the main supporters for the hypothesis of a sudden faunal break between the lower and the upper Levalloiso-Mousterian, in other words, between Tabun C and B, which should contain a modern fauna. This rodent was found throughout the Tabun C level in our samples, except for layers 1-5 and 12-16, but appearing in 6-12 and, again, in 15-19 (always inclusively). No explanation can be given now for this strange discontinuity. According to Bate, this dormouse should be restricted to Tabun F, E, and D. Compare, in connection with this question, Haas 1960 and 1966, where a much longer survival of this species has been demonstrated for Israel. The very closely related genus *Myominus (personatus)* is still living in Turkomania and Bulgaria and certainly not under tropical conditions which, according to Bate, formed the biotope of *Philistomys*.

(2) *Ellobius pedorychus* Bate. This "mole vole" was completely missing from all our samples of Tabun C age, where it should occur according to Bate (Ea, D, C) ; it was, however, found in moderate numbers in the single sample from Tabun D seen so far (Square 19,33 cm). Again, we should stress that all the C samples contained huge quantities of the common vole of Israel, *Microtus guentheri* !

(3) *Talpa chthonia* Bate. Bate describes this fossil species of mole from Tabun F exclusively ; but one single humerus of a mole was found in sample 4-19, that means at the base of Tabun C ; this means that moles survived much longer than assumed previously.

(4) *Myotis*, probably *baranensis* Kormos. We found this genus at Tabun C, whereas it should, *fide* Bate, disappear with the end of D, being represented before through all levels of Tabun E.

(5) Sample 16 (Tabun C) contained our only specimen of a sciurid, most probably *Sciurus* cf. *anomalus* Gueldenstaedt. According to Bate, this squirrel should be missing from Tabun Ea to Wad F and reappear during Aurignacian and Natufian levels, namely Wad F to Wad B. No explanation is given for this long interruption in the occurrence of this squirrel, represented (Bate) from Tabun Eb only before the big gap.

At the end of this publication a summarizing list of the faunal content of all samples at hand is given. This list allows for some interesting observations which will be discussed later.

The comparison of this faunule with a likewise Mousterian assemblage from the Qafzeh Cave near Nazareth (kindly given to me by M. B. Vandermeersch, Paris) was very interesting indeed.

TABLE I - VERTEBRATES FROM THE TABŪN CAVE

BED	Crocidura	Suncus	CHIROPTERA	Apodemus (sm.)	Apodemus (lg.)	Mus	CRICITINAE	Meriones	Microtus	Spalax	Philistomys	SM. RUMINANTIA	AVES	Testudo	Ophisaurus	Agama	SCINCIDAE	SAURIA	OPHIDIA	ANURA	
1			X	X	X	?X			X	X			X		?X				X	X	
2	X	X	X	X	X	X			X	X			X		X			X	X		
3		X							X										X		
4									X	X		X	X					X	X		
5	X	X		X	X	X		X	X	?X			X		X	X		X	X		
7								X	X			X	X								
7/8			X	?X		?X			X		X										
8	X	X	X		X	X	X	X	X	X	X		X		X		X	X	X	X	
9	X	X	X	X	X	X	X	X	X	X	X		X		X			X	X		Myotis, Gekko
9/10						X?		X	X				X								
10	X	X	X	X	X	X	X		X	X					X	X		X	X		
10/11				X				X	X				X								
11	X	X	X	X	X	X	X	X	X	X	X	X	X			X	X		X		Procavia, ?Chamaeleon
12	X	X	X	X	X	X	X	X	X	X			X	X	X	X			X		? Mastomys
13	X	X	X	X	X	X	X	X	X	X		X	X					X			
13/14	X?					X		X	X												
14	X	X	X			X		X	X								X				
14/16	X	X	X	X		X	X	X	X				X	X	X			X	X		
15	X		X			X		X	X				X						X		
16	X	X	X	X	?	X	X	X	X	X			X	X	X	X		X	X		Sciurus
17	X	X	X?	X	X	X	X	X	X	X	X		X	X				X			
18	X	?X	X	X		X	X	X	X	X	X	X	X	X		X					Diploid Fish, Pelobates, Gekko,
19	X	X	X	X	X	X	?X	X	X	X	X	X	X	X	X	X		X	X		Talpa, ?Talpa, Myotis,
20	X	X		X	X		?X	X	X	X											Sus scrofa, Gazella
21	?X			?X		X		X	X												
SQ.19 30cm	X			X	X	X		X	X	X				X					X	X	Ellobius

As in the Tabun C material, the soil samples from the Mousterian of Qafzeh (from the cave terrace) contained as the predominant species the vole *Microtus guentheri.* In both sites rodents, insectivores, bats, birds and reptiles were the main constituents of the rich microfauna. But in detail, the faunal composition differed strikingly in both caves geographically so close (distance 30 km.).

(1) The Qafzeh Mousterian from the terrace contained not a single cricetine jaw against thousands of other small mammals. Very few, however, were found in much younger earth samples from the inner cave (Aurignacian). Tabun C faunas contained a modest number of small cricetines, except the seven superficial strata. Also, square 19 material contained small hamsters.

(2) A big rat of the (now tropical) African genus *Arvicanthis,* represented by *A. ectos* Bate appears in small numbers in some strata of the Qafzeh terrace. Bate described the species from Tabun F and Eb (Upper Acheulean), whereas the Qafzeh material was restricted to strata XVI-XIX incl. These layers are, however accompanied by Mousterian implements. The same rat was absent from all Tabun C strata, also of Mousterian age. But this fact seems to point to the conclusion that the Qafzeh Mousterian strata might be older than Tabun C.

(3) Similarly, the appearance of a *Mastomys,* which I named *Rattus (Mastomys) nazarensis* in Qafzeh XI, XII, XIV, (Mousterian and ? 8 = Aurignacian). If we neglect the doubtful occurrence in stratum 8, we may again assume an earlier age of the Qafzeh terrace strata. Bate describes a *Rattus (Mastomys)* from Tabun Eb only, based on just a single mandible. Not a single *Mastomys* was found in the Tabun C material and the little seen so far from Tabun D. This too points to a younger Mousterian for Tabun C ; if not, special ecological differences made a survival at Qafzeh possible for both genera at Qafzeh in contrast to Tabun. Such differences seem highly doubtful to me and I feel rather inclined to ascribe this faunal difference to an age gap.

(4) The genus *Apodemus* seems to be in general more frequent in Tabun C than in Qafzeh.

(5) *Ellobius* and *Talpa* were not found in Qafzeh. These facts contradict and weaken our assumption of an earlier age of the Qafzeh Mousterian, but, in the case of both these subterranean species, special local factors could be involved.

Both sites had the following faunal characteristics in common : highest frequency of *Microtus guentheri*, followed by high frequencies of *Meriones, Mus, Crocidura-Suncus*. In smaller numbers, were represented : *Spalax*, birds, saurians, bats. Both sites contained the small glirid *Philistomys roachi* but in a spotty way, i.e. with certain, so far unexplainable, interruptions ; we should especially mention rather high frequencies of Gekkota in Qafzeh, where birds, bats and snakes seem to be more frequent than in Tabun ; the same might be said about the anguid lizard *Ophisaurus*.. On the other hand, remains of *Testudo* were more frequent in Tabun C.

We may now discuss the occurrence list in detail.

We see at once that *Microtus guentheri* is present in all samples ; in frequency of presence it is followed successively by *Meriones, Mus, Crocidura* spp. and *Apodemus* spp. It might be just by chance that *Testudo* remains were absent from strata 1-11. The single *Talpa* humerus was found in a great richly diversified faunal sample, which, by the way, was the only one containing a few remains of determinable bigger mammals (*Sus, Gazella* ?), and unique in the whole series, a bone of the spade footed toad *Pelobates.* I want to say that the presence or absence of a mole, as a fossorial mammal, says very little ecologically but speaks for uninterrupted humidity of the soil ; compare Bate's find in Tabun F as compared with Tabun C specimen. Ulrich Jasper Seetzen, a travelling naturalist and ethnographer who visited the Levant area in the first decade of the 19th century, describes a mode he got alive from the Lebanon area, mentioning *expressis verbis* the correct tooth formula of the specimen he prepared. This fact indicates that most probably this genus managed to survive and might still survive at appropriate moist localities with deep soil at higher altitudes in the Lebanon mountains. The last publications on the mammals of the State of Lebanon, however, neither mention the presence of voles, nor indicate the data given above

The absence of the mole vole *Ellobius*, however, from the whole Tabun C series has certainly an important meaning, because such a form would not be wanting from so very rich deposits as 9, 16 and 19. The only sample which contained this species, belonging to Tabun D, was very small indeed.

We want to stress the great paucity of Amphibians (single anuran bones) and the almost total absence of fish bones. I have great doubt about the value of the occurrence of land molluscs (which, anyhow, all belonged to recent and locally present species). Since these forms may dig into the soil, they might easily have entered deeper layers, making use of cracks and their fossorial propensities.

We have mentionned earlier (p. 164) the peculiar absence of the dormouse *Philistomys* from certain coherent groups of strata (1-7 ; 12-16). Since this form is never so frequent as in certain strata of the Qafzeh Mousterian, these coherent interruptions seem to be meaningful anyhow ; stratum 16, e.g., was very rich in material and species number, and, nevertheless, contained no *Philistomys* at all. The same can be said about strata 11-13. What does this double period of interruption mean ? It could point to some drastic ecologic change or just to a change of predators responsible for the preservation of disintegrated pellets. Most probably, the second alternative can be excluded, because all strata involved, provided they were rich enough, contained a very similar spectrum in quality and quantity of species, as shown above. There is also something not accidental about the appearance of small cricetids from level 8 (incl.) to level 20, with the exceptions as 13/14, 14, 15. The first seven strata did not contain any hamsters ; these strata were not very rich in general. The first gap coincides more or less with the zone without *Philistomys*, whereas the second gap in the occurrence of the dormouse does not involve the cricetines.

It would be premature to try to give a definite opinion about the ecological conditions at Tabun C times in some detail, based only on the faunal character. But it may be said definitely that the faunal spectrum points to conditions roughly of somewhat moister conditions than today* identical to those of a Mediterranean, *maquis* covered landscape. Especially the considerable number of at least two species of *Apodemus* points to a rather dense cover of vegetation, but the preponderance of *Microtus* and the addition of the fossorial *Spalax* indicate that this evergreen brush-forest had interruptions of grass and lower vegetation of Mediterranean character. The absence of macrofauna in

* **Illustraded by the presence of a mole.**

the samples restricts our conclusions somewhat ; even the list of the macrofauna given by Bate does not give too many hints for a climatic evaluation. In spite of the presence of *Hippopotamus* and a fossil species of *Rhinoceros,* many forms which were considered by Bate as good indicators are of rather doubtful value, as, e.g. the *Hippopotamus*, which survived in this area well into historic times (Haas, 1953) ; the same may be said for *Trionyx and Crocodilus,* the first still surviving at present, the second having disappeared from this area at the start of this century ; similar late date of disappearance in historical times may be assumed for *Panthera pardus,* (which still survives farther north along the Israeli-Lebanese border) ; for *Philistomys*, found in a Hyxos cave near Jaffa-Tel Aviv (Haas, 1960), *Capreolus,* which disappeared during the second decade of this century in the Carmel Area, *Dama mesopotamica,* which disappeared from the Mt. Tabor area some 200 years ago ; *Procavia* is still found in the area today. There remains the Rhinoceros, Equids and a few fossil species, as *Sus gadarensis, Vulpes vinetorum.* We do not know exactly, at which date the Red Deer and *Bos* did disappear, but I think that both disappeared not more than 2000 years ago.

It should be remarked here that strata 22 and 23 were completely sterile. The absence of the earlier frequent genera *Arvicanthis* and *Rattus (Mastomys)* from Tabun C should be stressed ; a tentative chronological evaluation in comparison with the Mousterian Qafzeh fauna, which contained both genera, has been given earlier.

It will be necessary to do special morphological work on the following items :

(1) The shrews. There are certainly three, if not more, species represented, one of them, the smallest, being related or identical with *Suncus etruscus.* Bate describes only a big and medium sized shrew, namely *Crocidura katinka* Bate and *C. samaritana* Bate (instead of C. *xanthippe* Bate). According to the same author both species disappear with the end or during Tabun D. Our rich finds of shrews in C are therefore also a **novum**.

(2) Concerning the few bats, at least an approximative determination to the generic level will be possible with the few edentulous mandibles, based on size, shape and the well preserved series of alveoles.

(3) The *Apodemus* group deserves a special study ; at least one form the size of *A. Sylvaticus* and another the size of *A. mystacinus* is involved. Bate described four species of this genus. The small form is almost certainly identical with Bate's *A. caesareanus* from Tabun C, D, E, F, levels.

(4) The few hamster mandibles deserve a special study ; very small forms, probably belonging to the genus *Cricetulus,* seem to be present. The status of some of Bate's fossil species has been contested by Tchernov (1968).

(5) Birds and reptiles are rather rich in very poorly preserved specimens. Among the reptiles the following forms could be roughly determined : *Testudo,* probably *graeca ; Ophisaurus* sp., *Agama* sp., *Chamaeleon* sp. ? , *Gekkonidae,* Scinco-lacertidae ; several snake vertebrae.

It is strange that this rich material did not contain any traces of hedgehogs, small carnivores and lagomorpha. The slightly bigger mammals, like *Procavia,* and *Sciurus,* were just represented by one single tooth each ; similarly rare was the mole, represented by a single humerus, and anura.

PALYNOLOGY

One of the first glimpses into the Pleistocene floral record in an archaeological site in the Levant is provided by the following palynological study submitted by Dr. Aharon Horowitz of Tel-Aviv University.

PRELIMINARY POLLEN ANALYSIS OF THE TABUN CAVE SEDIMENTS, MOUNT CARMEL, ISRAEL

ABSTRACT

Pollen analyses of twelve samples, collected from the sequence of Tabun Cave in Mount Carmel, Israel, indicate that most of Beds C and D were laid down under somewhat cooler and more humid - pluvial - climatic conditions. Two samples, from the base of the main profile and from the top of Bed C, yielded pollen spectra indicating dry, interpluvial or interstadial climate. It seems that Beds C and D were deposited during the first maximum of the Würm Pluvial, while the top of C was deposited during an interstadial. The base of the main section was deposited during one of the interpluvials, probably Riss - Würm.

INTRODUCTION

Tabun Cave is located (Fig. 5) on the western escarpment of Mount Carmel. The Cave opens north-westward, facing the Mediterranean coastal plain, which was, until recently, covered with open-field vegetation and some marshes. Mount Carmel is covered with a Mediterranean mixed maquis, comprising mainly oaks and pistacio, with some pines and other minor elements (Zohary, 1959). Olive trees are currently cultivated only, but are known to have grown wild in Israel throughout the Pleistocene (Horowitz & Zak, 1968 ; Horowitz, 1971). The prevailing winds in the region are northwesterly or westerly.

The cave was formed by the dissolution of a Cenomanian reef-core that probably occurred in Early to Middle Pleistocene times. It is filled with a sequence of about twenty-five meters of sediments, of which the lower part is a calcareous sandstone, the middle part a loess-type sediment and the upper part a breccia, very rich in loam (Farrand, 1970, personal communication). Most of the layers contain artifacts and bones.

Samples for the present study were collected (Fig. 5) from the base of the main profile and from Garrod's (1937) beds D and C. The samples were collected during the 1970 season by Dr. A. Jelinek, Department of Anthropology, University of Arizona, Tucson, and Dr. W.R. Farrand, Department of Geology, University of Michigan, Ann Arbor, who also provided all the information concerning the stratigraphy and prehistory of the cave. The samples were processed by Mrs. S. Kitchen Fish, Arizona State University.

Palynological studies have never been carried out on cave sediments from Israel, principally because of the poverty of these sediments in pollen grains, due to the semiarid character of the country which, inturn, resulted in a high rate of sedimentation in the caves and low pollen productivity. This difficulty was recently overcome by a technique developed at the Arizona State University (Schoenwetter, 1971, personal communication). The general palynological sequence of the Israel Late Pleistocene was studied both in the Coastal Plain (Rossignol, 1962) and in the Hula Basin (Horowitz, 1971) and may be taken as a reference.

The aim of the present study is to compare the Tabun sequence containing a succession of human cultures, to the climatic sequence known for the Late Pleistocene of Israel. It is hoped that when more material is available a complete analysis of the whole sequence may connect the evolution of the human cultures and modes of life with the ecological conditions.

RESULTS

Most of the samples yielded enough pollen grains ; about 150 were counted in each. The only sample that was poor is the one collected from Bed C, at a depth of c. 150 cm. below datum (N^{o} 8) which will therefore not be discussed. The counts are given in Table 2. Percentages of the constituents of the pollen spectra were calculated. The total sum of counted grains was then taken as a basis (100 %). The percentages are given in Table 3. Problems of the level of identification of the pollen grains have already been discussed in previous works (Horowitz and Baum, 1967) and will not be dealt within this context.

DISCUSSION

Sample N^{o} 10, collected from the base of the main profile, cannot be linked with all the other samples which were collected more than 10 meters above it. This sample contains rather low quantity of arboreal pollen grains, resembling recent (Rossignol, 1961 ; Horowitz, in preparation) and interpluvial (Rossignol, 1962 ; Horowitz, 1971) pollen spectra. The very high percentage of *Scabiosa prolifera* pollen shows that this was probably one of the most abundant plants in the

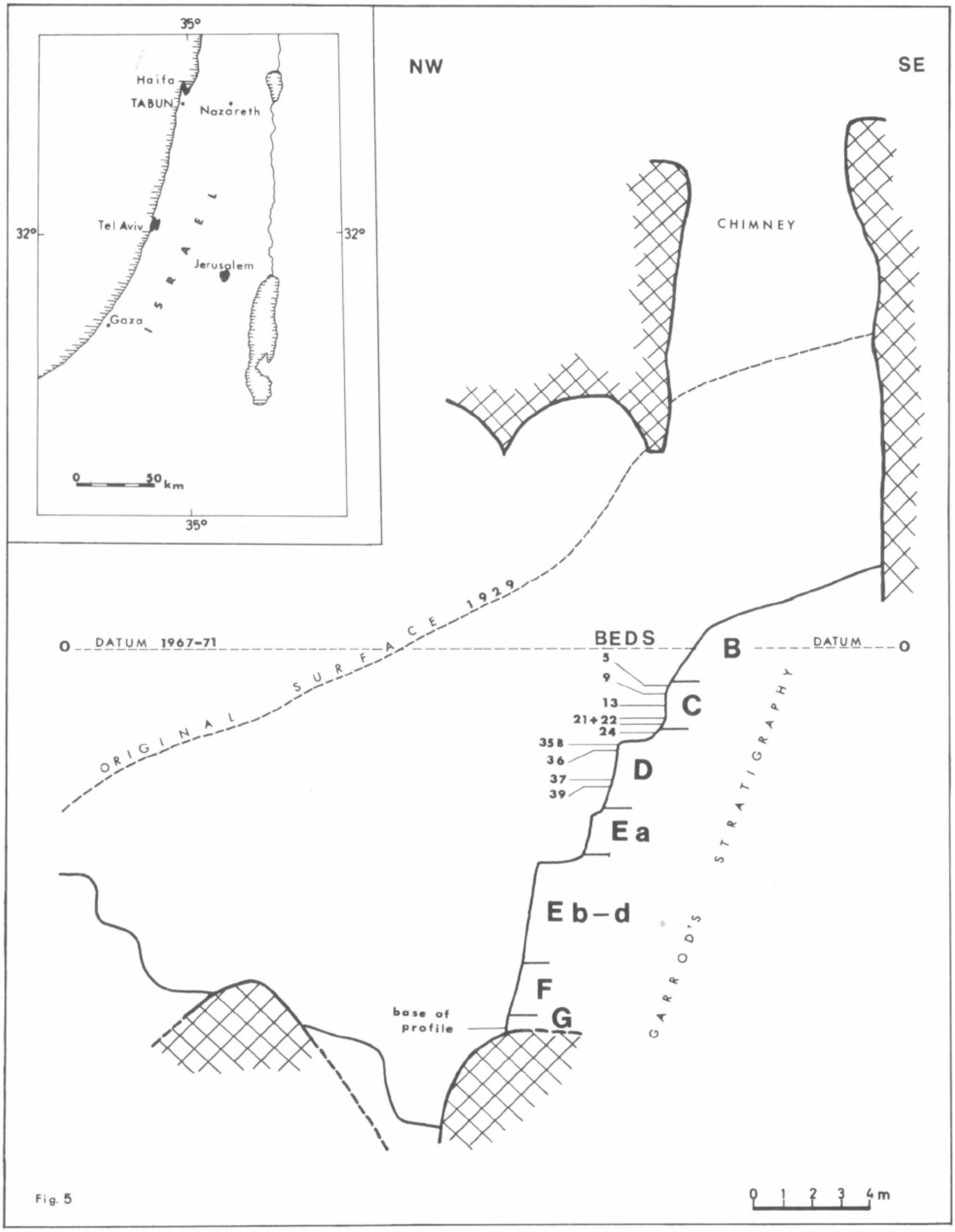

Figure 5. Location map (inset) and schematic cross-section of the Tabun Cave, after Farrand (1971, personal communication). Note : position of beds is correct relative to Garrod's (1937) layers, but only approximate with respect to depth below Datum because of the irregular configuration of bedding planes.

nearby fields. The low percentage of the Cyperaceae may point to the dryness of the coastal plain, in which there were no marshes at that time. This sample was collected from a horizon that was probably deposited under interpluvial climatic conditions. It is impossible to assign the horizon with certainty to one interpluvial or another since only one sample was analysed. It is however, most probable that it represents part of the Riss-Würm Interpluvial rather than the Mindel-Riss, but the second possibility should not be excluded.

If sample 10 represents a real interpluvial and not an interstadial, the poverty in Cyperaceae pollen may have been caused by the occupation of the coastal plain by transgressing Tyrrhenian sea. Sediments of Tyrrhenian (an earlier transgression, if it is of Mindel-Riss age) are known from the Carmel foothills (Michelson, 1968).

The suite of samples from beds D and C (arranged in the tables in their stratigraphic order) are richer in arboreal pollen than in recent sediments. The most common are oak-pollen ; pine-pollen are always present in low percentages, and some other elements appear in minor quantities. This is the typical pollen spectra for sediments deposited under pluvial climatic conditions (Horowitz, 1971). Assuming that westerly and northwesterly winds also prevailed during the time of deposition of this sequence, which seems probable because of the type of sediments comprising these layers, it seems that preference should be given to the contribution of pollen grains from the plants growing in the coastal plain. If this is so, then the arboreal pollen, coming from trees growing mainly on the Carmel Mountains east of the cave, are underrepresented and should really be considered as comprising an even higher part of the mean regional spectrum. This assumption strengthens the conclusion concerning the depositing of sediments under more humid and possibly cooler - pluvial - conditions.

The lowest sample of the C - D series, N° 9, is relatively rich in Chenopodiaceae pollen. This may point to the regressing sea at the beginning of the pluvial period, which left playas and salty marshes. The high percentage of oak pollen indicates a relative spreading of the maquis on the mountains.

The sample (above that) N° 11, shows more or less the same value for arboreal pollen, only the constituents are somewhat different. Oak pollen prevails, but pollen of some northern trees like *Picea* and *Corylus* also appear. These pollen are very rare even in pluvial sediments of Israel, and probably point to a pronounced cooling of the climate. This rather cool phase, however, was not long and those pollen grains do not appear in the samples above. Chenopodiaceae pollen do not appear in this sample, and are replaced by Compositae pollen. This is probably due to the disappearance of the salty marshes, which are being replaced by freshwater ponds, due to further regression and higher humidity. The bank vegetation of these ponds probably comprises large proportions of Compositae, possibly of the *Inula* type.

Sample N° 7 above, is the richest in arboreal pollen, especially. oak. It seems that the oak forest became so well developed that it also occupied some area of the coastal plain, probably as a result of a humid and rather cool climate.

Sample N° 1 is also rich in arboreal pollen, representing more or less the same cool, humid conditions as in sample N° 7, below. The high percentage of Cyperaceae pollen in this sample may indicate the existence of marshes in the coastal plain, dominated mainly by sedges which are indicators of marshes prelevant in the area during longer periods of the year than those marshes dominated by Compositae.

Samples N°s 4, 2 and 6 yielded very similar pollen spectra. They are rich in Gramineae pollen and rather poor in arboreal pollen. Pine and Cypress pollen share higher percentages as compared to oak pollen, and among the non-arboreal pollen those of *Scabiosa prolifera* also appear. All these indicate that the three aforementioned samples represent a dry period, drier than the preceding (Samples 9, 11, 7 and 1), but more humid than present day climate. The marshes presented in the preceding samples, have probably been replaced by open fields, as can be seen from the higher percentages of the Gramineae.

Sample N° 3, is richer in arboreal pollen, probably due to an improvement of the climatic conditions. Excluding sample N° 8, which is very poor in pollen, sample N° 5, above, is once more poorer in arboreal pollen, though richer than the recent spectra. The drop in arboreal pollen becomes extreme in sample N° 0, at the top of bed C, in which no arboreal pollen was seen at all. This seems to indicate a very dry climatic phase.

If the absolute dating for the top of bed C, about 40,000 years B.P., is correct (Farrand, 1970, written communication), which seems possible according to the prehistoric data, then the analyzed sequence of beds D

Sample No.	Garrod's layer	Bed No.	Square No.	Depth-cm below datum 1967-71	*Quercus*	*Pinus*	*Olea*	*Pistacia*	*Cupressus*	*Ceratonia*	*Rhamnus*	*Picea*	*Corylus*	*Alnus*	*Nerium*	Total A.P.	Gramineae	Cyperaceae	Tubuliflorae	Liguliflorae	Chenopodiaceae	Umbelliferae	Cruciferae	Rosaceae	Papilionaceae	*Scabiosa prolifera*	*Asphodelus*	*Mercurialis*	*Echinops*	*Artemisia*	Total N.A.P.	*Adiantum*	Total counted
0	C top	5	2	c. 120												0	2		150							6			10		168		168
5	C	9	4	c. 160	28	9	1		1							39	116	14									2				132		171
8	C	13	6	c. 150	5		1									6	3														3		9
3	C lower	21 & 22	8	c. 291	32	11	1	1								45	80	7	1		2										90		135
6	C lower	22	8	311-319	22	3	1	2	2							30	96	13	10		1						1			2	123		153
2	D	35 B	8	303-315	6	11			6							23	93	22	9							3	1				128	1	154
4	D	35 B	8	375-380	20	3		1	1					1		32	89	23	8			1			1						122		154
1	D	36	8	335-345	25	14	3	3	4						1	50	32	60	5		3	1	1								102		152
7	D	36 A	8	390-395	91	10										101	33	18	3		1	1						1			57		158
11	D	37	8	435	18	2	1		1	1	1	5	2			31	25	13	9	1		3	1	2							54		85
9	D	39	8	442	53	4										57	45	26	2			20								1	94		151
10	G	Base of Main profile			9	5	1									15	41	6	7		2					7		4			141		156

Table 2 - Countings of pollen grains in samples from Et-Tabun, Israel

Sample No.	Garrod's layer	Bed No.	Square No.	Depth-cm below datum 1967-71	*Quercus* spp.	*Pinus halepensis*	*Olea europaea*	*Pistacia* spp.	*Cupressus sempervirens*	Various A.P.	Total A.P.	Gramineae	Cyperaceae	Compositae	Chenopodiaceae	*Scabiosa prolifera*	Various N.A.P.	Total N.A.P.
0	C top	5	2	c. 120							0	1		90		3	*Echinops* - 6	100
5	C	9	4	c. 160	16	5	1		1		23	68	8				*Asphodelus* - 1	78
8	C	13	6	c. 150	60		10				70	30						30
3	C lower	21 & 22	8	c. 291	24	8	1	1			33	59	5	1	2			67
6	C lower	22	8	311-319	14	2		1	1		19	63	9	7	1		*Asphodelus* *Artemisia*	81
2	D	35 B	8	303-315	4	7			4		15	60	14	6		2	*Asphodelus*	84
4	D	35 B	8	375-380	13	6		1	1	*Alnus*	21	58	15	5			Umbelliferae - 1 Papilionaceas - 1	79
1	D	36	8	335-345	16	9	2	2	3	*Nerium*	33	21	40	3			Umbelliferae - 1 Cruciferae - 1	67
7	D	36 A	8	390-395	58	6					64	21	11	2	1		Umbelliferae - 1 *Mercurialis* - 1	37
11	D	37	8	434	21	2	1		1	*Ceratonia* *Rhamnus* *Corylus* *Picea*	36	29	15	12			Umbelliferae - 3 Cruciferae - 1 Rosaceae - 2	64
9	D	39	8	442	35	3					38	30	17	1	13		*Artemisia*	62
10	G	Base of Main profile			6	3	1				10	26	4	9	1	47	*Mercurialis*	90

Table 3 - Percentages of pollen grains in samples from .Et-Tabun, Israel

and C was deposited during the first maximum of the Würm Pluvial. This sequence probably represents most of the pluvial cycle, from the retreat of the sea at the beginning of the pluvial to the interstadial conditions that followed. It should be noted that the climatic record drawn from pollen diagrams for the Hula region (Horowitz, 1971), is almost identical with the sequence discussed here.

THE ARCHAEOLOGICAL MATERIALS

In appraising the materials as they are currently understood, I will not in this report introduce any quantitative results regarding typology, since these studies are still in process, but will restrict my remarks to the general distribution of artifacts and the general typological character of the sequence. It is appropriate, however, to mention here something of the nature of the quantitative observations that are being made on the artifact materials. All flakes and flake tools are being measured by using essentially the system proposed by Leach (1969). In addition, observations are being made on the character of the striking platform, the amount of cortex present on the exterior surface, the condition of the flake in terms of breakage and post-manufacture alteration, and standard typological designation, both in terms of the technique of manufacture and the resulting flake form. Cores are also being measured in three dimensions and classified in a formal system expanded from that proposed by Bordes (1961) for Lower and Middle Paleolithic industries. Flake tools are being recorded both in the standard classification of Bordes (op cit.), and in a more detailed attribute transcription which can be used to test the applicability of this traditional classification to Near Eastern material. The observations being recorded on the flake tools include the shape of the modified edge as viewed from both the exterior surface and the lateral aspect of the tool, as well as metric and angular observation of worked and unworked edges and their relationships around the periphery of the flake. In these observations I feel that the relationships of different kinds of unmodified edges with retouched edges may be crucial in discovering hitherto unrecognized patterns of tool manufacture. Core tools are, in general, being measured and classified in the system proposed by Bordes (ibid.) although it appears that this system will also need to be expanded somewhat before the analysis is completed.

In addition to these observations on all of the artifacts, several pilot studies have been made to determine whether additional observations might be desirable to resolve specific problems. These include the measurement of platform angles and the relationship of this angle to other features of flakes, and the relationships between size and shape of striking platform with such features as the number of preparatory facets, flake shape and size, cortical attributes, etc.

It is already apparent from the preliminary results of these studies that upon the completion of this work it will be possible to distinguish significant associations of qualitative and quantitative features which are common to the full range of lithic manufacture at Tabun from those which are confined to specific geological loci and may be due to traditional (stylistic) or task-specific (functional) origins. As an example of the kinds of general relationships that might be substantiated by further study, one of the pilot studies has indicated that flakes with more cortex tend to diverge to the right of the axis of flaking (viewed from the exterior surface), while those without cortex have more of a tendency to diverge to the left. This may suggest a difference in motor habits during various stages of core preparation and tool refinement. Fully cortical flakes (those with 90% or more cortex on the exterior surface) show a greater tendency for wide divergence from the axis of flaking [extreme "angles of skew" (Leach, 1969)] than all other flakes. This may imply either that less control of direction is exercised in removing the cortex, or that the irregularities of the exterior surface of the nodule do not favor the maximum length of the flake following the axis of flaking. Another pilot study on the same flake population suggests that the angle between the striking platform and the interior flake surface (measured to a point on the axis of flaking in the base of the concavity below the bulb) tends to be smaller on flakes with more elaborate platform preparation and on flakes with less cortex on the exterior surface than on flakes with plain platforms or flakes with heavily cortical exteriors. Here, too, greater control seems to correlate with greater attention to the core. While none of these relationships is particularly surprising, an objective demonstration of the extent of the occurrence of such correlations may provide the groundwork for wider technological comparison of lithic industries.

In reviewing the specific achaeological findings to date, I will begin with the earliest industries that we have tested and proceed up through the later deposits. The earliest deposits sampled by our excavation lie at the western end of the base of our sounding and have been tentatively designated Bed 80 ; this designation was arrived at by a rough calculation of the stratigraphic units visible on the east side of the profile that appeared to correspond with the time period of the disconformity between Bed 59 and these deposits on the west side (See Farrand, this paper). It appears that the sediments of Bed 80 were held in place by an underlying ledge of bedrock while the subsidence that affected Layers F and G (in Garrod's stratigraphy) was underway. Thus there is a question of the relationship of these deposits to those in Garrod's scheme. The possibilities are : (1) that these sediments are equivalent to Layer Ed, with which they appear roughly equivalent in elevation according to the profile published by Garrod (Garrod and Bate, 1937, Pls. 29, 30) ; (2) that the sediments are equivalent to Layer F, to which they appear roughly equivalent in elevation on the basis of our study of the bedding of the present profile ; or (3) that the sediments are earlier than Layer F, representing a cycle of sedimentation in the cave either equivalent to Layer G or no longer represented on the east side of the profile. My present view, in the light of the disconformity above these deposits, a generally more compact and consolidated texture that is apparent in the surviving deposits of Layer F, and the industry it contains, is that Bed 80 is earlier than Layer F on the east side of the profile. The artifact inventory of Bed 80 seems to differ markedly from Garrod's Layer F, in that the percentage of bifaces in our collections appears to be considerably less than in the overlying deposits, and is certainly much lower than the 32 % of all tools recovered by Garrod. The artifact inventory of Bed 80 is remarkable for its diversity. It includes numerous examples of small flake tools and tools made on small angular chunks of flint that do not fit well into present lithic classifications. It suggests, in general, less rigid patterning in lithic manufacture than is seen in the later levels. Artifact material is fairly abundant in Bed 80 ; however, the compact nature of these sediments (a texture soft enough to absorb the blow of a hammer on a chisel, but resilient enough to resist fracturing) restricted the size of the sample that we were able to recover.

Lower Layer E, above Bed 80, including Beds 53 to 59, contained the most dense concentrations of artifact material encountered in the full depth of our test. This heavy deposit of chipped flint, is, on first impression, somewhat puzzling in that it appears to contain a high ratio of finished tools to flakes and cores without any consistency of source material in local concentrations. In other words, it does not appear to be a primary manufacturing floor, and yet the concentration of lithic material argues against any other practical functional occupation surface. An alternative interpretation is that this concentration, which is most intense toward the lowest elevation of the stratum in which it is located, is naturally transported artifact material. That these artifacts represent a significant amount of cultural activity is clear, but the length of time and or the size of the cultural group they represent is, for the moment, unclear. Above these basal deposits Layer E is characterized by fairly dense occurrence of artifact materials which seem, for the most part, to be relatively evenly scattered in space. I am not optimistic about isolating Garrod's Layer Ec in our excavation, which was "distinguished only by a marked increase in hand-axes of la Micoque type" and was only about 20 cm. in thickness (Garrod and Bate, 1937 : 84). At this point I am not aware of any remarkable concentrations of Micoquian hand axes in our excavation, although it is not impossible that this will ultimately be apparent. There are numbers of examples of handaxes of this type from throughout our excavations in Layer E.

One aspect of hand axe manufacture that appears to have escaped Garrod's attention is the frequent appearance of keen-edged bifaces, sharpened by broad, flat, intersecting flake scars. Many of these bifaces derived from our excavation in Layer E are clearly functional cleavers, with **tranchet** sharpening across the long axis at the distal end and marked lateral battering to dull the sides of the implement. The only allusion to cleavers in Garrod's report is in a discussion of square-ended bifaces from Layer Ea, in which she states that, "in no case can the tool be properly described as a cleaver, as the cutting end is not long enough" (Garrod and Bate, 1937 : 79). This suggests that perhaps her typological categories may have been too restricted to permit the recognition of the nature of these implements. Another type of sharp-edged biface, which seems to be present in significant quantities, is a pointed hand axe which has been sharpened along one edge adjacent to the tip by striking long flat flakes from the direction of the tip down the two surfaces that intersect to form the cutting edge. Garrod's illustration of a small hand axe from Layer Ec (Plate XLIII, 4) may be an example of this type. The presence, throughout the sequence of hand axe industries at Tabun, of large numbers of bifaces whose apparent function was for cutting and slicing is an important factor in interpreting the use of the site. It may also be important in determining the relationships between the Yabrudian and Amudian industries.

Artifacts characteristic of Garrod's Amudian industry (1962 : 242) are most heavily concentrated in our beds 47 to 49, which lie, near the center of the profile, between six and seven meters below datum (our datum is approximately equivalent to that employed in the original excavation) ; near the western edge of our excavation they rise to higher elevations. This would roughly correspond to the lower portion of Garrod's Layer Ea and the upper portion of Eb. It appears that several distinct layers of this industry are present ; whether there are three, as suggested by Garrod (1956 : 47) is not yet clear. I believe that there are very few, if any, bifaces in the layers of Amudian artifacts ; and, the associated scrapers seem to have much flatter retouch than is characteristic of the typically Yabrudian layers above, below, and between these layers. In our excavations this industry is represented primarily by well backed points, similar to Chatelperron points, lightly backed or nibbled points and blades, and relatively frequent thick prismatic blades, some of which approximate large burin spalls. In keeping with this, we have several cores which are, in fact, large burins from which similar flakes must have been struck. This assemblage seems notably different from that of Layers 13 and 15 of the Yabrud Shelter I (Rust, 1951 ; Bordes, 1955) in the virtual absence of end scrapers, particularly those of Aurignacian type illustrated by Rust. Perhaps the technique of blade manufacture is also somewhat different, but a more definitive opinion must await a detailed study of both industries. The industry at Tabun does seem to resemble more closely that of the Abri Zumoffen in Lebanon (Garrod and Kirkbride, 1961), which also exhibits an abundance of blades and points and only a few end scrapers. The possibility exists, assuming contemporaneity of the Amudian in these three localities, that we are looking at a coastal facies of this industry at Zumoffen and Tabun, and an inland facies at Yabrud. Another aspect of the problem of the Amudian Industry is raised by possible concentrations of long prismatic flakes in the lower levels of Layer E, observed during the examination of artifacts at the laboratory in 1972. Should these concentrations be verified by final analysis of provenience they would indicate the likelihood of a continuing development of the Amudian in close association with the Yabrudian sequence, perhaps indicating that the Amudian is simply a specialized aspect of the Yabrudian. The close control of artifact position and geology at Tabun promises a more meaningful idea of this relationship of Amudian and Yabrudian as our study proceeds.

The assemblage from our excavation units corresponding to Garrod's Layer D contrasts markedly with that from Layer E, and, in the absence of any visible evidence of chronological discontinuity, suggests a sudden and dramatic cultural change. The frequency of triangular Levallois flakes (Levallois points) in Layer D, noted by Garrod as the most characteristic feature of that industry, was amply confirmed in our sample. However, an additional feature of this industry not remarked upon by Garrod is the high frequency of blades and the general "linear" aspect of a majority of the flakes. It is estimated that the Laminar index (Bordes, 1961) of many of the artifact layers within Layer D will exceed 60, a proportion comparable to many Upper Paleolithic industries of Western Europe. The dramatic change in lithic techniques and the marked differences in the tool types of adjacent beds of Layers Ea and D, with no geological evidence of discontinuity, imply the intrusion of a new culture at the expense of the earlier Yabrudian. The lack of heavy concentration of artifact materials in Layer D, where they are relatively evenly scattered, and the lack of evidence of hearths, suggests intermittent brief occupations of the cave during the deposition of this Layer.

In contrast to the evidence of continuity with preceding deposits at its base, the Layer D sequence ends abruptly with a disconformity, signaling the collapse of the sediments in the inner chamber of the cave into an underlying solution cavity (see Farrand, this report). The succeeding sediments which filled the hole at the back of the cave were not extensively sampled by our excavation, but the preliminary analysis indicates that the artifacts represent a mixture of the forms characteristic of Layer D and Layer C. It is possible that the Levallois points and blades in these levels were largely derived from the unstable and crumbing Layer D deposits, while the broad Levallois flakes, which characterize the Layer C industries, may have an origin contemporary with these "pre-C" beds.

The latest heavy concentration of artifacts and organic debris, suggesting prolonged or intensive occupation, was encountered near the top of the fill in the hole behind Layer D. This occurred at the base of Layer C, in a thick lens of dark soil, chipped stone materials, and fragmentary animal bone. The isolated nature of this lens of material, its confinement to the depression behind Layer D, and the nature of its industry, indicate that this deposit is independent of the two large "hearths" described by Garrod in Layer D (Garrod and Bate, 1937 : 65). The industry is typical of Layer C in the high proportion of broad Levallois flakes, and is striking in the occurrence of numerous examples of very large (over 10 cm. diameter), broad Levallois flake fragments, apparently broken in manufacture. The nature of the deposit, the lack of finished tools, and the lack of cores from which the many flakes were struck, are consistent with a midden or refuse deposit, where various rejected debris from living areas in front of the entrance could be conveniently discarded in the natural depression inside the cave.

Above this heavy concentration there are several layers of relatively continuous artifact distribution in the lower beds of Layer C, with a gradual decrease in number of artifacts and a trend toward scattered distribution proceeding up through that layer. The presence of increasing quantities of large stone from chimney roof-fall and terra rossa, derived from the slopes above the cave via the chimney as Layer C accumulated, may show that this trend toward fewer artifacts in more scattered distribution is due either to the rapid increase in rate of deposition or the decreasing suitability of the interior of the cave as a habitation site. According to Garrod's account (*op cit.* : 61), this scattered distribution continued throughout the overlying layers as they accumulated in the chimney. The scarcity of finished tools noted by Garrod can also be seen in our collections from Layer C, consisting mostly of plain and Levallois flakes as well as small flake debris.

DISCUSSION

Considering the data presented above together with that available prior to our excavation, it is already possible to discuss several new interpretations of the sequence at Tabun. To facilitate this discussion I will begin with the oldest layers at the site and proceed in chronological order through the major units recognized by Garrod (i.e. from Layer G to the Chimney Layers).

We are now fairly certain, on the basis of palynological evidence, that Layer G was laid down at some time during the last major warm dry period in the Levant, assumed to correlate with the last interglacial episode in Europe. Inasmuch as this layer directly overlies the bedrock and appears to have been considerably distorted through having been drawn down into the solution cavity under the outer chamber, the question of the possible effects of earth movement on the artifactual materials must be considered in appraising the industry. I would suggest that the irregular retouch which characterizes the artifacts from Layer G and suggests a resemblance to the Tayacian of La Micoque may in fact be the result of natural forces on otherwise unretouched flakes. The absence of bifaces among the 76 tools reported by Garrod from this layer is in marked contrast to the overlying Layer F inventory, which included over 30 % bifaces in a total count of over 3800 tools. This absence of bifaces does suggest a significant difference between the two layers and the possibility that Layer G represents a distinct cultural unit. I think that it is quite possible that the deposits which we have designated Bed 80 at the lowest point in our excavation on the west side of the cave may contain an additional, and undistorted, sample of that industry. A preliminary sampling of about 200 artifacts from Square 45 at the base of our excavations in Bed 80 is seen in comparison with Garrod's sample from Layer G in Table 4. Of the approximately 200 artifacts, a few were too desilicified for classification ; the remaining 191 included 50 specimens classifiable as tools, which are compared with Garrod's sample from Layers G, F and Ed in Table 5. Lightly retouched and utilized flakes were not separated from unretouched specimens in Table 4, since all flakes listed by Garrod from Layer G are described as "utilized", a circumstance which most likely relates to the post-depositional crushing of the flake edges mentioned above.

TABLE 4

Percentage of Basic Categories of Lithic Artifacts*

	Bed 80	Layer G
Core Tools	5.8	2.6
Flake Tools	20.4	13.8
Flakes and Chunks	61.3	75.0
Cores	12.2	8.6
N	191	464

***Layer G is the only one of her units in which Garrod presents a full inventory of lithic artifacts. In the layers above G only a small percentage of flakes and cores were retained.**

It appears that the ratios of basic categories of lithic artifacts are roughly comparable for Layer G and the test sample from Bed 80.

TABLE 5

Percentages of Basic Tool Types

	Bed 80	Layer G	Layer F	Layer Ed
Hand Axes	6	0	32	20
Choppers	12	16	21	9
Discs	4	0	4	1
Scrapers	34	73	42	69
Burins	2	4	1	1
Other Tools	42	8	1	1
N	50	76	3859	18259

It is apparent from Table 5 that Bed 80 and Layers G and Ed share a relatively low percentage of core tools as opposed to flake tools. In addition, there is a very low frequency of hand axes in Bed 80 as opposed to Layers Ed and F. Bed 80 differs from Layer G and all of the other layers in the high percentage of "Other Tools." This may be in part a product of Garrod's system of classification which did not consider some of the categories utilized by Bordes (1961) as tools. An attempt was made to compensate for this by eliminating the unretouched flake tools (e.g. the naturally-backed knife) of Bordes' system from this classification. Thus, the category here includes mostly notches, denticulates, and other well retouched pieces of diverse form not classifiable as scrapers. In this category Bed 80 is closest to Layer G, although it does seem clearly distinct from any of Garrod's units in the number and diversity of small finished tools. The Bed 80 deposits are overlain by a disconformity which appears to equate with the "fault" mentioned by Garrod (*op cit.*: 80), and is associated with the subsidence of material into the swallow hole. The deposits below this disconformity seem to have remained in place, perhaps supported by an underlying sill of bedrock while Layers F and G were distorted by subsidence. Thus, in Bed 80 we find an industry which is apparently earlier than the period of collapse of the lower beds and which has relatively few handaxes, but has a wide variety of small retouched pieces and tools. The only industry in Garrod's sequence which fits this description is the "Tayacian" of Layer G. However, the presence of a few bifaces of Acheulian form in Bed 80 indicates this distinct industry may in fact be a hitherto undescribed facies of Late Acheulian. The presence of this industry in Bed 80 also suggests that this unit is earlier in time than the beds on the east side of the cave which Garrod designated as Layer F. It appears that either Layer F was never represented on the west side of the cave or that its removal through erosion connected with the subsidence is a part of the disconformity above Bed 80.

The sandy nature of both Layer F and Bed 80, as well as most of the lower deposits of Layer E, may imply the proximity of coastal dunes, resulting from a higher sea level and perhaps associated with the last interglacial period. If this correlation is supported by palynological evidence, we can say that the cultural sequence from Late Acheulian to Early Yabrudian at Tabun all falls within the time period represented by the last interglacial.

The deposits designated as "Layer E" by Garrod are structurally quite complex. There is still a possibility that a significant disconformity exists near the middle of this sequence. Evidence of minor faulting indicates either differential compaction, with greater chemical consolidation of materials near the walls of the cave, or phases of subsidence of deposits in the inner or outer chambers which cannot be discerned from the profiles at hand. Both the shape of the Cave and the exposure of travertine on the east side of our profile at about -6.50 m suggest that the major portion of the profile which we excavated was composed of deposits supported by a sill separating the inner and outer chambers. Thus these deposits would have been less likely to show the effects of subsidence than the sections previously excavated in the outer chamber or those still inaccessible in the inner chamber.

While the sedimentological analysis of the sequence in Layer E is still in a preliminary state, it now appears that there is a reduction in particle size from the lower to higher levels of this unit. If this is taken as an indication of a retreating sea (with less sand available for wind transport as the coastal dunes moved west) it would correlate with the onset of the last major episode of glaciation and would place the appearance of the Amudian, which occurs somewhat above the middle of the Layer E deposits, at the beginning of the last glacial period. This appears to correlate well with the occurrence of the Amudian at the Abri Zumoffen in Lebanon where it immediately follows the retreat of the sea from the 12 m. beach (Garrod and Kirkbride, 1961). The unknown degree of uplift in the Mount Carmel area during the Late Pleistocene leaves the exact position of this beach in doubt, but one evidence of its proximity is provided by the artifact materials. In the lower levels of Layer E small beach-rounded pebbles of flint were encountered with some frequency as "manuports". It is most likely that these pebbles were derived nearbyfrom an exposed pebble beach at the mouth of the Wadi Mughara (Nahal Me'arot). The bed of the Nahal Oren, about 4 km. north of the caves, has exposed a fossil pebble beach within a few hundred meters of the cliffs at its debouchment from the Carmel, and such a beach is assumed to be present, but covered by later alluvium, near the mouth of the Wadi Mughara. It is interesting to note that these pebbles were rare to absent in Bed 80 : this may imply earlier date for that unit, prior to the formation of the pebble beach close to the cave. Until the segregation of cultural units within the Layer E sequence is completed, it would be pointless to attempt to revise Garrod's interpretation of these beds. The presence of many slicing implements among the bifaces noted earlier suggests that the butchering of game may have been a primary concern during this period of occupation. In the light of this functional aspect of many of the bifaces, the apparent mutually exclusive distribution of bifaces and Amudian tools may provide a clue to the significance of the Amudian Industry. The dominant element in the Amudian at Tabun is the backed blade. These blades and the backed points of the Amudian also appear to be cutting tools. It would seem that when they were in use in the cave they replaced the bifacial slicing tools that otherwise occur in Layer E. This substitution of backed elements for bifaces is similar to that of the Mousterian of Acheulian Tradition B for the Mousterian of Acheulian Tradition A in the Middle Paleolithic of Southwestern France, at a presumably later date (Bordes, 1961a, 1968). This latter sequence seems irreversable and ultimately gave rise to the Upper Paleolithic Perigordian industries in France ; while in the Near East the Amudian, wherever it occurs, appears to be followed by later periods of hand axe manufacture, followed in turn by a long period of Mousterian industries before the appearance of the Aurignacian Upper Paleolithic cultures. Whether these two similar industries in Southwest Europe and the Near Eastern Levant owe their development to similar technological relationships is an open question, but the similarity of typological substitution is striking.

The heavily laminar industry of Layer D is separated from the Amudian at Tabun by about 1.5 meters of beds containing only Yabrudian industries. It is difficult to see any connection between the Amudian and the Layer D industry for this reason and because of the sudden appearance in Layer D of intensive use of the Levallois technique for the manufacture of points and blades. There is relatively little evidence of Levallois technique in Layer E and virtually none on the Amudian artifacts.

The Layer D industry is similar to that reported from a number of sites in the Levant. In particular, there is a resemblance based on similar quantities of Levallois points to industries from the Abou Sif, Sahba and Larikba, described by Perrot (1968 : 346) as a Mousterian with Elongated Points. This kind of industry also appears in the arid Negev of Southern Israel (Marks, 1971 : 1240), and above the Yabrudian at the Bezez, leading Copeland (p.c.) to suggest that it is a distinct and widespread horizon of Mousterian culture in the Near East, intermediate in time between the Yabrudian and the later Mousterian, characterized by broad Levallois flakes. The presence of this kind of industry in the Negev and the Judean Desert is of particular interest in the light of the environmental evidence from Tabun. Both the faunal and palynological evidence presented earlier in this report suggest that the period of deposition of Layer D at Tabun represents an interval of much colder climate than is evident anywhere else in the sequence. This cold interval, presumably accompanied by greater precipitation, is precisely the circumstance under which such food-collecting cultures might have been expected to have been able to make widest use of the extreme desertic areas of the Negev and the eastern Judean Hills. It is suggested that this climatic interval represents the Levantine equivalent of the first major cold period of the last European glaciation, corresponding to Wurm II in the French usage, or Wurm I on the rest of the continent. Thus the industry of Layer D and similar industries at other sites can be taken to be equivalent in age to the Mousterian industries of southwestern Europe.

The interval represented by the disconformity between Layer D and Layer C, during which the sediments of the inner chamber apparently subsided into a lower solution cavity and the resulting hole was then filled, is still an unknown factor. Environmental evidence from Layer C suggests that by the time these events had taken place a marked modification in climate had also occurred. Vegetation patterns suggest conditions not markedly dissimilar from those at present, while the microvertebrate fauna is also consistent with conditions with only slightly cooler and more moist than at present. The high percentages of *Microtus guntheri* recovered from the Layer C microfauna are in sharp contrast to the representation of this form in Bate's report (Garrod and Bate, 1937 : 148) and rather similar in proportion to the population of microvertebrates recovered from sediments accumulated in the chimney on top of the old excavation. However, the proportions of *Microtus* in this most recent population probably cannot be considered representative of present natural climatic circumstances since the introduction of massive irrigation of banana and citrus orchards and other crops on the coastal plain adjacent to the cave has undoubtedly increased the habitat available to these voles. Modern agricultural practices have, to some degree, recreated the moisture conditions of the Pleistocene in that area. In the photographs taken at the time of Garrod's excavations in the early 1930's the coastal plain appears to be a barren rocky expanse with grassy vegetation, differing markedly from the present irrigated and lush countryside. The dissimilarity of our population to that studied by Bate is undoubtedly due to the different sampling procedures employed by the two excavations.

Another indication of a significant time difference between Layer D and Layer C is in the contrast between the lithic industries of these two units. The characteristic broad Levallois Flakes of Layer C suggest marked differences in emphasis from Layer D. Whether this change reflects a temporal evolution in techniques of manufacture or a change in the way the cave was utilized remains an open question. However, it is pertinent to note that the thin, broad, Levallois flakes which dominate the Layer C industry do not seem to be present at all in Layer D, while the fine Levallois points typical of Layer D do occasionally occur in Layer C. The interval between these two major units is represented by the deposits that filled the hole in the inner chamber, and by a succession of channel fills at the top of Layer D that appear to represent the termination of drainage into the inner chamber by runoff from the front of the cave as the hole was filled. Each of these deposits appears to contain some elements of the industries of both Layer C and Layer D and it is hoped that further analysis will clarify the relationship of these very distinct assemblages. One general implication of the suggestion that the Mousterian of Layer D and Layer C at Tabun represents a general pattern of industrial succession concerns the Late Pleistocene beach sequence of the Mediterranean. If the assumption that there is a succession of two basic Mousterian industries in the Levant is correct, and if there is a correlation of the later of these two industries with a 6 meter Mediterranean beach at Ras el Kelb, this beach must follow the first major cold interval of the last phase of glaciation. The absence of evidence of an ocean beach of mid-Wurm age above present sea level raises the question of whether the level of the Mediterranean may occasionally have fluctuated independently of the surrounding oceans. Perhaps, if the appearance in the Levant of the Mousterian characterized by broad Levallois Flakes does coincide with the onset of the warm conditions of a major interstadial (as is apparently the case at Tabun), the rise in Mediterranean sea level could be related to a brief period of greatly increased runoff of meltwater through the drainages of southern Europe, which for a time was impounded by the relatively restricted Gibraltar outlet. An alternative interpretation is that the two types of Mousterian industries were contemporary. This is suggested by the single radiocarbon date of >52,000 years (GRO 2556) for Ras El Kelb (Garrod and Henri-Martin, 1961), which is equivalent to or earlier than the apparent age of the first cold episode of the last glaciation in the eastern Mediterranean (Mc Burney, 1967 : 66). In this case, the 6 meter beach may represent a brief period of stability during the retreat of the Mediterranean preceding this cold interval.

By the time of the Layer C occupation the collapse of the roof of the inner chamber had already progressed sufficiently to allow the intrusion of terra rossa from the hillside above the cave via the chimney into the inner chamber. The distribution of roof fall and increasing abundance of terra rossa through the Layer C sequence, culminating in the massive deposit of rock and red clay at the base of Layer B, suggests a rapidly increasing rate of deposition in Layer C and therefore a relatively short time span for that unit. The clear layering of these sediments to the east and west of the central accumulation of roof fall and the obvious indications of periodic intense burning in these layers, suggests intermittent utilization of the cave by man, who from time to time burned off the accumulated underbrush and vegetation either inadvertently or deliberately, in the manner of modern South African or Australian aboriginals who use this technique to clear shelters (J.D. Clark, R. Gould, p.c.). The presence of flint artifacts in these burned layers suggests some utilization of the cave mouth during this interval, although the increasingly sporadic distribution through time, together with the lack of finished tools, suggest that this area of the cave was peripheral to the full range of domestic activities. Perhaps this is predictable in view of the increasing accumulation of roof fall in the area of the entrance.

While Layer C was the uppermost stratigraphic unit sampled by our excavation, it is possible to extrapolate from our findings and reexamine some of the original interpretations of the relationships between the deposits that we excavated, and Garrod's Layer B and the Chimney deposits which followed them. Our evidence indicates that the transition from Layer C to Layer B was continuous, as roof fall and soil accumulation through the chimney spread to cover the entire floor of the interior chamber. Yet it is precisely at this point that Bate postulated her "great faunal break" (Garrod and Bate, 1937 : 149), stating, "From this level onwards the fauna is of modern type. Remains of *Dama mesopotamica* contitute the principal part of the collection and this indicates a considerably increased rainfall." The contrasts in the frequency of *Dama* and *Gazella* through the upper layers of the cave were taken by Bate, at the suggestion of Dr. F. Zeuner (ibid. : 142), to represent relative changes in climate. Specifically, *Dama* were associated with moist, and *Gazella* with dry conditions. This interpretation has received criticism on a number of grounds since it was first proposed with other causal explanations involving selection on the part of hunters living in the cave (Mc Cown, 1961) or relatively minor climatic changes acting on border areas of vegetation (Ducos, 1968). The faunal break itself has been open to question, since studies of other sites, as well as historic records, seemed to bring the early extinction of such forms as hippopotamus and crocodile into question. An examination of the faunal and cultural evidence from Garrod's excavation in conjunction with the results of our work and a study of the natural environment in the vicinity of the cave suggests a different explanation for the faunal sequence than those previously proposed.

Garrod's description of the nature of the sediments and materials recovered from Layer B in the inner chamber and the overlying Chimney I and II layers includes the following important observations : (1) "the division between Chimney II and B was an arbitrary horizontal line ; there was, in fact, no change in the nature and color of the deposit, and the industry remained the same," (*op cit.* : 62) ; (2) "No traces of hearths and no charcoal fragments were observed at any point in the chimney deposits," (*ibid.* : 61) ; (3) Flint artifacts "were not abundant, but the proportion of finished implements to mere flakes was high, and they were distributed with unusual regularity throughout the deposit," (*op cit.*) ; (4) animal bones were abundant and "it was noticable that complete specimens, mostly limb bones and phalanges, were much more abundant than proved to be the case in the lower layers of the cave," (*op cit.*) ; (5) In Layer B flints and animal bones were "extremely sparse" in the inner chamber : bone was "rare everywhere except in the east alcove" (*ibid* : 62-63). From this last statement it would seem, though this is not mentioned in the report, that the total of 630 *Gazella* and 8206 *Dama* bones attributed to Layer B on the graph in Bate's report (*ibid* : 141, 142) includes the abundant bone from the chimney as well as the sparse bone from Layer B.

The evidence on these points taken from Garrod and Bate (1937) and from our data, suggest that as the chimney opening expanded, and the nature of the inner chamber of the cave changed, the use of the site by man also changed. The nature of the materials recovered from the inner chamber in Layer B and the Chimney Layers and their depositional context are not representative of a domestic campsite, but rather of a specialized butchering station, where high percentages of finished tools, abundant animal bone (much of it unbroken), and the absence of evidence of hearths indicates a restricted group of activities. The greater abundance of bone and artifact materials in the Chimney layers reflects an increase in this utilization as the chimney opening expanded. The nature of the chimney structure, which opens as a wide hole in the level ground at the top of the cliffs above the cave, constitutes an ideal natural trap, which would have been most effective if game were driven across it. The cliffs around the cave are in themselves suitable for game drives, and, in fact, form one of the few promontories of vertical exposure of limestone on the western face of the Carmel. There is good reason to believe, therefore, that the locality on the south side of the mouth of the Wadi Mughara functioned as a site for game drives well back into the Late Pleistocene and that a primary activity at the site of Tabun may have been the butchering of animals killed near the cave. This hypothesis is in part supported by the frequency of tranchet cleavers and other sharp-edged bifaces in the earlier levels of the sequence. There seems little doubt that the site was also occasionally the scene of a wider range of activities up through the early occupation of Layer C ; here we find layers which seem to be a domestic refuse midden on the sloping surface of the inner chamber. The terrace in front of the inner chamber of the cave would also have formed a good vantage point from which much of the adjacent coastal plain could be scanned for game. It appears that once the chimney began to expand, domestic occupation of the site was discontinued and the only utilization of the cave was for the entrapment and butchering of game.

The natural environment in the vicinity of the cave consists of three major habitats ; the coastal plain, the wadi floor, and the undulating hilltops of Mount Carmel. The flat coastal plain most probably was dominated by grassy vegetation in its better drained portions, and by marshy areas immediately to the east of the main kurkar ridge bordering the coast about 2 km. west of the cave. The size of these marshes probably fluctuated with the depth of the watertable, which in turn was probably governed in large part by variations in sea level through the Pleistocene. Mount Carmel was most likely covered with arboreal vegetation, similar to or heavier than that to be seen at present. The wadi floors undoubtedly also supported arboreal vegetation as well as occasional marshy zones in areas of water entrapment. Game driven over the cliffs and into the chimney at Tabun would have come from the hills above the cave and thus would be expected to represent an arboreal or scrub forest habitat. This fauna would include a predominance of browsing rather than grazing animals, and in the habitat of Mount Carmel a majority of these browsers would most likely have been deer. The presence of some specimens of *Sus, Capra, Bos,* and *Equus* in this fauna does not seem unlikely, and undoubtedly some gazelle were also to be found on the Carmel. This is precisely the fauna represented in Bate's description of Layer B (which apparently also includes the Chimney Layers since they are not described elsewhere and she speaks of B as a deposit of "very considerable thickness" (*op cit.* : 150). Given the uncertain stratigraphic control at the base of Layer B, it is quite possible that some Gazelle from Layer C were also included in Bate's sample from B and that the ratio of deer to gazelle was even more heavily weighted in favor of deer than Bate indicates. Therefore, given all of the circumstances of the depositional sequence and environmental surroundings of the cave, the change in fauna from Layer C to Layer B and the chimney deposits can be explained more reasonably in terms of differential human utilization of the cave than by any other causal factors. The lack of evidence of hippopotamus and rhinoceros after Layer C at Tabun is most likely explained by the fact that the remains of these animals, derived from the coastal plain or the wadi floor, were not carried up to the cave after it ceased to function as a domestic habitation site, nor were the remains of gazelle which had been killed on the coastal plain.

The disappearance of several elements in the microfauna may require further explanation. While the analysis of the several thousand identifiable specimens of microfauna recovered by our washing operation is not yet completed, sufficient numbers of specimens from Layer C have been identified to make it reasonably certain that several forms attributed to that layer in Bate's report were actually derived from Layer D. This includes, in particular, the cold-adapted forms such as *Ellobius* and the Snow Vole. The identified specimens of *Ellobius* from our excavations come from a small pocket of preserved microfauna near the top of Layer D on the east side of the cave (see the report by Haas above). It seems likely that confusion in defining the boundaries of the natural layers because of the use of horizontal levels in excavation tended to obscure the actual occurrence of these forms and that much of the extinction of the microfauna can be explained by the climatic changes that occurred between the deposition of Layer D and Layer C.

The faunal interpretation outlined above also has implications for the relationships between the sequence at Tabun and that at Skhul, less than 200 meters to the east. Virtually every attempt to equate these two sites in time has relied on the relationships of their vertebrate faunas. Little exception has been taken to Bate's statement that "the presence of *Hippopotamus, Phacochoerus garrodae, Sus gadarensis,* and *Rhinoceros* cf. *hemitoechus* makes it certain that this assemblage must be grouped with the earlier part of the fauna, that is prior to the great change which took place about the time of Level B of Tabun." (4) Bate concluded that the

4) Higgs (1961 : 153) has suggested that these forms postdate the majority of faunal extinctions evident in the Tabun-Skhul sequence, and may therefore be either earlier or later than Tabun B. However, he continues to consider Tabun B as representative of pluvial conditions, and fails to explain why the four forms are not represented in Tabun B if they post-date that level. His statement (in Mc Burney, 1967 : 38) that the hippopotamus remains at Skhul may have resulted from the hunting of this animal at Lake Tiberias, separated from Skhul by over 50 km, of rough country, is open to question. It would seem much more likely that hippopotamus continued to survive in the marshes on the coastal plain west of the Carmel.

Skhul fauna was closest to the latest phase of Tabun C because of relatively abundant *Dama* and *Bos* I believe that it is now possible to say that this line of reasoning is irrelevant to the understanding of the chronological relationships of the sites. Hippopotamus and rhinoceros may have persisted for an unknown interval following the deposition of Layer C, as discussed. *Phacochoerus garrodae* is represented by a single tooth from Skhul and remains unknown in any other context, and so is of no value in determining temporal relationships. The remains of *Sus* from Layer B and the Chimney Layers were identifiable only to genus ; therefore, the possibility of the presence of *Sus gadarensis* in those levels cannot be ruled out. Thus all forms considered by Bate to be crucial in this relationship must be taken to be of questionable relevance for this problem. While several problems do exist regarding the faunas of both Skhul and Tabun, it does not now appear that any of these will resolve the chronogical relationship between the two sites. Further discussion of these problems will be deferred until the completion of the analysis of the Tabun fauna.

In the absence of faunal or absolute dating evidence directly bearing on the problem of the relative ages of Tabun and Skhul, a comparison of the industries from the two sites is a possible source of information on this question. Only excavation dump deposits remain at the Skhul site, completely excavated in the 1930's. We carried out a brief excavation in these dump deposits, in order to obtain a sample of discarded artifact material for use in conjunction with the museum collections from the site, for comparison with the full range of lithic artifacts from Tabun. At present only one aspect of the Skhul artifact material appears to show promise for resolving the relationship between the two sites. This is the occurrence of very small Levallois cores in significant numbers in the Skhul collections. Cores of this size (c. 2 to 3 cm. in maximum diameter) are extremely rare in our collections from Tabun, but several examples were noted in collections in Jerusalem from Garrod's excavation of the Chimney Layers. Further studies are planned to follow up this possible clue and other potential artifactual evidence relating to chronology.

In this preliminary report an effort has been made to present some of the results now accessible in the early stages of the analysis of the materials recovered in our excavations at Tabun, as well as some of the problems which remain to be resolved. Work is now under way on absolute dating by radiocarbon and other techniques which should add another dimension to our interpretation (5) and further results are expected in additional areas of environmental and geological interpretation. The entire body of quantitative analysis of the artifacts also must await the final report. It is hoped that the results of these studies will do justice to the Tabun cave in its well deserved position as a key site for the interpretation of the early Late Pleistocene of the Near East.

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5) A list of radiocarbon dates from Tabun has recently been published by the La Jolla Laboratory (Bien and Pandolfi, 1972 : 371-372) erroneously ascribing these samples to an "Upper Paleolithic Carmel culture," a description originating with the authors of that publication. The samples were sent from our excavation, but, on the basis of correspondence from the laboratory, appear to have been improperly processed for the time range of the Tabun material. They should not be regarded as relevant to the age of the deposits at Tabun. In this respect, the dates originating in the Groningen Laboratory, and cited by Garrod, (1962) and Oakley (1964) of about 40,000 years for the Layer C - B transition, are considered to be closer to the actual age of the sediments

BIBLIOGRAPHY

BIEN, G.S. and PANDOLFI, L.J.
1972 La Jolla Natural Radiocarbon Measurements VI, *Radiocarbon* 14 (2) : 368-379

BONIFAY, E.
1964 Pliocène et Pléistocène Méditerranéens : Vue d'ensemble et essai de corrélations avec la chronologie glaciaire, *Annales de Paléontologie, Vertébrés* 50 : 197-226

BORDES, F.
1968 *The Old Stone Age,* 225 pp.
1961 Typologie du Paléolithique Ancien et Moyen, *Publications de l'Institut de Préhistoire de l'Université de Bordeaux, Mémoire* 1, 85 pp + 108 pl.
1961a Mousterian Cultures in France, *Science* 134 (3482) : 803-810
1955 Le Paléolitique inférieur et Moyen de Yabrud (Syrie) et la question du Pré-aurignacien, *L'Anthropologie* 59 (5-6) : 486-507.

DUCOS, P.
1968 Remarques sur l'alternance Daim-Gazelle en Palestine, in *La Préhistoire : Problèmes et Tendances,* 161-164, Paris.

FARRAND, W.R.
1970 Geology, climate and chronology of Yabrud rockshelter I *Fundamenta : Monographien zur Urgeschichte Reihe A, Band 2, Teil 1 :* 212-223, Vienna

FARRAND, W.R. and RONEN, A.
in press Observations on the Kurkar-Hamra succession on the Carmel coastal plain, Israel, *Quarterly, Institute of Archaeology Tel-Aviv University*, Tel Aviv.

GARROD, D.A.E.
1962 The Middle Paleolithic of the Near East and the problem of Mount Carmel Man, *Journal of the Royal Anthropological Institute* 92(2) : 232-251.
1956 Acheuléo-Jabroudien et "Pré-Aurignacien" de la Grotte du Taboun (Mont Carmel) ; étude stratigraphique et chronologique, *Quaternaria* 3 : 39-59

GARROD, D.A.E. and BATE, D.
1937 *The Stone Age of Mount Carmel,* Vol. 1, 240 pp., Oxford

GARROD, D.A.E. and HENRI-MARTIN, G.
1961 Rapport préliminaire sur la fouille d'une grotte au Ras El-Kelb, *Bulletin du musée de Beyrouth* 16 : 61-67, Paris

GARROD, D.A.E. and KIRKBRIDE, D.
1961 Excavation of the Abri Zumoffen, a paleolithic rock-shelter near Adlun, South Lebanon, 1958, *Bulletin du musée de Beyrouth* 16 : 7-46, Paris.

GRAHAM, W.A.P.
1925 Experiments on the origin of phosphate deposits, *Economic geology* 20 : 310-334.

HAAS, G.
1953 On the occurrence of *Hippopotamus* in the Iron Age of the coastal area of Israel (Tel Qasileh), *Bulletin of the American School of Oriental Research* 132 : 40-44.
1960 Some remarks on *Philistomys roachi,* Bate, *Annals and magazine of natural history*, Ser. 13, 2 : 688-690.
1966 On the vertebrate fauna of the lower pleistocene site "Ubeidiya", *the Israel Acad. of Sciences and Humanities,* 1-68

HIGGS, E.S.
1961 Some Pleistocene faunas of the Mediterranean coastal areas, *Proceedings of the prehistoric Society,* Seris 2,27 : 144-154

HOROWITZ, A.
1971 Climatic and vegetational developments in Northeastern Israel during Upper Pleistocene - Holocene times, *Pollen et Spores* 13 (2) : 255-278
in preparation Pollen Analysis of Cores from Haifa Bay, Israel.

HOROWITZ, A. and BAUM, B
1967 The arboreal pollen flora of Israel. *Pollen et spores* 9 (1) : 71-93

HOROWITZ, A. and ZAK, I
1968 Preliminary palynological analysis of an evaporitic sequence from Mount Sedom (Israel) *Rev. Paleobotan. Palynol* 7 : 25-30

HOWELL, F.C.
1959 Upper Pleistocene stratigraphy and Early Man in the Levant, *Proceedings of the American Philosophical Society* 103 (1) : 1-65 Philadelphia

KAFRI, U.
1970 Pleistocene tectonic movements in the coastal plain of Israel emphasizing the Mount Carmel Area, *Israel Journal of Earth Sciences* 19 : 147-152

LEACH, B.F.
1969 The concept of similarity in prehistoric studies, *Anthropology department, University of Otago, Studies in Prehistoric Anthropology* 1., 159 pp. + 21 figs., + 28 tables, Otago, New Zealand.

MARKS, A.E.
1971 Settlement patterns and intrasite variability in the Central Negev, Israel, *American Anthropologist* 73 (5) : 1237-1244.

Mc BURNEY, C.B.M.
1967 *The Haua Fteah (Cyrenaica),* XV + 387 pp.

Mc COWN, T.D.
1961 Animals, climate and palaeolithic Man, *Kroeber Anthropological Society Papers* 25 : 221-230, Berkeley.

MICHELSON, H.
1968 *The geology of the Carmel coast*, M. Sc. Thesis, Hebrew University, Jerusalem (in Hebrew), 61 pp.

OAKLEY, K.P.
1964 *Frameworks for dating fossil man,* x + 355 pp., London.

PERROT, J.
1968 La préhistoire palestinienne, *Supplément au dictionnaire de la Bible* 8 : col. 286-446, Paris.

REISS, Z. and ISSAR, A.
1961 Subsurface quaternary correlations in the Tel-Aviv region, *Geological Survey of Israel Bulletin 32*.

ROSSIGNOL, M.
1962 Analyse pollinique de sédiments marins quaternaires en Israel. II - Sédiments pleistocènes, *Pollen et Spores* 4 (1) : 121-148

1961 Analyse pollinique de sédiments marins quaternaires en Israel. I - Sédiments récents, *Pollen et spores* 3 (2) : 303-324

RUST, A.
1950 *Die Höhlenfunde von Jabrud (Syrien)*, xii + 154 pp., 110 pl.

SANLAVILLE, P.
1969 Les bas niveaux marins pléistocènes du Liban, *Méditerranée* 3 : 257-292

TCHERNOV, E.
1968 *Succession of Rodent Faunas during the Upper Pleistocene of Israel,* 152 pp., Hamburg and Berlin.

VOGEL, J.C. and WATERBOLK, H.T.
1963 Groningen Radiocarbon Dates IV, *Radiocarbon* 5 : 163-202, New Haven.

ZOHARY, M.
1959 *Geobotany* (in Hebrew), Sifriat Poalim, Merhavia, 589 pp.