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A Study of the Mousterian of Acheulean Tradition Industries of Southern England

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List of Contents

ABSTRACT

FACULTY OF ARTS

ARCHAEOLOGY

Doctor of Philosophy

A STUDY OF THE MOUSTERIAN OF ACHEULEAN TRADITION INDUSTRIES OF SOUTHERN ENGLAND

by Myra Lesley Shackley

This study identifies and describes a series of new Mousterian of Acheulean Tradition sites in southern England, many of which are associated with the deposits of the 7.5m beach.

All the extant Mousterian artifact finds from collections in southern England were examined, and a series of discrete assemblages of Mousterian of Acheulean Tradition type were identified on typological grounds. Where adequate documentary evidence existed these were accurately provenanced, thus trebling the number of recognised British Mousterian of Acheulean Tradition sites. The assemblages were then compared with type sites such as Oldbury and Kents Cavern, and with Continental examples. An attempt was made to locate the actual find spots on the ground, and in many cases sections of the deposits survived. These were then measured, described and sampled, several yielding further implement finds.

Detailed laboratory study of the sediments enabled their depositional environment to be determined, and showed that several of the sites, notably Cams, Warsash and Stone, consisted of fragments of deposits related to the 7.5m raised beach. Others, including Great Pan Farm and Christchurch, had a more tenuous association with the same beach.

Experimental work was carried out on the abrasion of flint implements, permitting the characterisation of the type and relative degree of abrasion received by each artifact in an assemblage. An 'abrasion index' was proposed and conclusions drawn concerning the unity and status of each assemblage and the precise relationships between the matrix deposits and the artifacts.

The hitherto unknown association between the Mousterian of Acheulean Tradition and the 7.5m raised beach, which is considered to be of Ipswichian date, suggests that the cultural tradition began earlier in Britain than was generally supposed. This study describes the nature, relationships, contexts and chronology of these assemblages, which seem to have been made during a comparatively short period between the late Ipswichian interglacial and the first Devensian interstadial.

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Laboratory facilities were kindly provided by the Departments of Archaeology and Geology, University of Southampton, together with the use of the University ICL 1907 computer. The greater part of the work described in this study was carried out during the tenure of a University of Southampton Research Studentship.

Original papers by the writer, referred to in the text, are collected in an appendix, (in pocket).

Section 1.

Methodology (Sediments)

Introduction

This study is concerned with an examination of the relationships between a series of implements and the types of sediment which contained them, in a manner not previously attempted elsewhere. Little attention has, in the past, been given to a study of implement contexts, since it has been tacitly assumed that if the implements were not obviously associated with an occupation or chipping site their context would be capable of yielding little information. This is far from the case, since the human and natural processes which result in implement concentrations are of the greatest intrinsic interest, and it is important to distinguish between them and thus to determine the archaeological value of the assemblages.

The exploration of these sets of relationships required the development of a methodology specifically orientated to the study of both implements and sediments. Very often the standard geological techniques were inadequate in some respects, and certain modifications had to be made requiring a series of decisions on the relative suitability of various methods and techniques. Original work on sedimentology was principally concentrated on the development and improvement of laboratory analytical techniques, and with the development and modification of computer storage and data-manipulation facilities. Much attention was devoted to grain size analysis, since this was the method likely to yield the greatest information about depositional environment, and a confirmation of the conclusions thus obtained was sought by other methods, such as thin-sectioning or scanning electron microscopy. It was hoped to obtain information about the structure, origin, and depositional environment of the sediments, which could then be combined with field description and an analysis of the implement assemblages.

It was felt that a quantification of the degree of natural abrasion which the implements had received was crucial. The relationship between sedimentary context and implement concentrations is of necessity a complex one, and is manifested particularly clearly in the case of abraded artifacts. The old verbal methods of describing abrasion were felt to be inaccurate, and a new 'abrasion index' was developed on the basis of experimental work and the measurement of implements from known sedimentary contexts. The experiments involved the manufacture of new implements and their subsequent abrasion under a variety of pseudo-natural conditions, using different types of sediments as abrasives. The abrasive effects of particular sediments could therefore be examined, and notes made on wear variations resulting from differences in abrasion time, texture of the abrasive, quantity of fluid present and the hardness of the implement being abraded. This basic work was then applied to implements from known sedimentary contexts, often from well documented archaeological assemblages, before being used on the implement associations here considered.

It was felt that a study of the implement abrasion characteristics together with those of the matrix sediments was likely to give the best results for a consideration of the unity of the assemblages. This was then combined with more conventional typological studies to establish the nature and affinities of the industries, to help in establishing their chronology. The site context had also to be considered, and, in the case of raised beach segments, the geomorphology of the deposit.

THE SEDIMENTS

1.1 Field recording

Much information could be recovered from careful field description of the sediments, which saved wasteful use of laboratory time. In this case standard record sheets were designed to cope with routine recording, not only of the composition of the sediment but of the general characteristics of the sequence, for example the presence of any sedimentary structures, or evidence of cryoturbation. (p. 80).

It was neither possible nor desirable to record all the aspects of the sedimentology of a site and it was necessary to make a careful choice of exactly what characteristics to record, and a judgement on whether or not it was necessary to take a sample. The recording criteria vary with the nature of the sediment and of the site, as well as with the set of problems posed and the anticipated use of the results. Various manuals have been produced for standardising field notes, the most useful being that published by the Soil Survey of Great Britain, (1960), soon to be superseded by a new edition (Avery 1974). This contains a methodology for recording a soil profile which may be adapted for the qualitative recording of sediments in an archaeological context.

General information noted included the precise position of the site and exposures, grid reference, height above sea level, and locality, together with the date, feature and stratum numbers and detailed information about the structure and composition of the exposure. The shape and dimensions of each stratum were then noted, as well as the main characteristics, the nature and mode of formation of the sediments (if known) and a description of their texture.

1.11 Texture

Field description of sediment texture was made quantitatively using a verbal scale based on the 'feel' of the sample, (Avery, 1974), and the coherence and cementation of the sediments was also noted. The cementation is a measure of the degree with which the grains have been chemically bound together by some substance other than clay minerals, common cements being calcium carbonate, silica and iron oxide.

1.12 Colour

Variations in natural sediment colour are often extremely significant, and may be a valuable aid to description (Cornwall, 1958). Colour was described by using a standard soil colour chart, namely the Munsell system of soil colour notation. The use of such a chart eliminated the subjective ambiguous verbal colour descriptions often used, such as 'light brown', or 'medium red'. The reading of a sediment colour was taken by comparing a small sample, held on the end of a clean spatula, with the colour chips on the chart, and reading the notation of the chip nearest in colour to the soil. Colours were measured in daylight, from a freshly cleaned face.

1.13 Information storage

Information obtained from field description and the analyses described below was stored in Southampton University's ICL 1907 computer on magnetic tape transferred from punched card input. This system had an advantage over the conventional card index in its permanence, but could be used solely for verbal or numeric data. Current trends in computer graphics make the storage of diagrams, plans and charts a possibility for the future. Computerised information storage systems are already widely used in geology and information sciences (Shackley 1973b). The storage of data within the computer means that it was available for data manipulations, such as the calculation of grain size descriptive parameters, or for statistical tests.

The writer has experimented with computer-based storage and retrieval methods for archaeological purposes, using the recently developed PLUTARCH system (Wilcock 1974). This was used for a pilot scheme during the 1973 excavation season at the Iron Age hillfort of Danebury (Stockbridge, Hampshire) to record the distribution and sedimentation of the numerous chalk-cut pits which occur on the site, and which contained at least 90% of the archaeological material. The pit fills were recorded directly onto computer coding sheets, and other information of environmental and archaeological significance was added later from laboratory analyses. The PLUTARCH handling and retrieval system, based on Boolean algebra, proved extremely successful, and field recording at the site during future seasons will use the system for all excavation records. (Wilcock and Shackley 1974, Shackley 1975a. ~~Appendix~~).

The idea of combining field records and laboratory data onto one computer storage-retrieval system did not prove practicable for this project, since with the continual appearance of new ideas and lines of evidence the retrieval criteria were not sufficiently standardised. This would not, of course, arise in the case of a normal archaeological excavation, and the increased use of such systems is to be encouraged.

1.2 Sampling and pretreatment

1.21 Sampling

All the laboratory work relied heavily upon reasoned, accurate, sampling. It was obviously impossible to analyse the whole of a stratum, and a comparatively small portion of it had therefore to be used as a sample, the problem being to make this fraction representative of the whole, (Rootenberg 1964). A proper sample is one taken from a population in such a way that statistical theory is applicable, (Binford 1964, Heitzer 1959, Cowgill 1964) and in addition the size of the sample needs to be large enough to permit satisfactory conclusions about the problem being studied. The random sample is one that is taken without bias on the part of the operator. It is possible to eliminate conscious bias, which manifests itself, for example, in taking a sample only from the most accessible part of the section, or choosing a portion which does not contain inconveniently large pebbles. Unconscious bias can only be eliminated if a proper sampling plan is used, (Cochran 1963), and for this project such precautions were taken to ensure that the sample for analysis was truly representative of the parent population. If this was so then any one item, parameter or characteristic in the original population was as likely as any other to be represented in the sample. A sample was never taken without a specific reason, since this avoided wasteful use of laboratory time, and ensured that the sample type and size could be related to the specific problem for which the sample was required.

The samples taken were of three types, a 'grab' sample of fixed volume from within a relatively small area of an exposure, a 'channel' sample taken from an elongated strip extended into the interior of the section, and a series of stratified samples. The size of the sample was directly proportional to the coarseness of the material and to the tests required. Table (1) lists the minimum required sample weights for different particle sizes, assuming that a grain size analysis was planned. This scheme was followed in this study. For sediments with average particle sizes of less than 5mm a sample of standard size (generally 1 kg) was taken, but for very fine material such as clay a much smaller sample was required. If tests in addition to a particle size analysis were planned then the original sample size was larger. If necessary the bulk sample was split into smaller sub-samples in the laboratory, rather than a series of smaller samples in the field being taken. Table (1) illustrates the very large sample sizes required from very coarse deposits, and it was often simpler to carry out description and analysis of such material in the field.

The first step in sampling was to clean the face thoroughly. If a completely vertical section could not be obtained then the face was 'stepped'. All faces from which samples were taken were drawn and photographed, with the precise sampling locations being carefully marked. If a

Table (1). Approximate sample sizes required for accurate particle size analysis of sediments.

Particle diameter (mm.)	Minimum weight required (kg.)
64	50
50	35
40	15
25	5
20	2
12.5	1
10	0.5
5	0.2

vertical stratified series of samples was taken this was done starting from the base upwards, to avoid contamination. Samples were placed in thick heavy-duty plastic bags, well sealed and labelled with the labels outside. The label on the sample bag recorded the location, number and reason for taking the sample, together with the site name and a grid reference. Further details were set out in a sample notebook, with pages composed of computer coding sheets. This ensured that the full samples details were recorded in a standard format. Cards were then punched for each sample and the program SAMPLERS activated, which stored the data in the computer. A printout of a specimen page of SAMPLERS is shown in Fig. (1). Time was saved by using this method since samples tended not to get lost or mislaid. The SAMPLERS program was directly linked to a program storing information from laboratory analyses (e.g. SIEVETTE).

1.22 Pretreatment

After the samples taken had arrived at the laboratory various different pretreatments were required before analysis could begin. These varied with the type, nature and size of the sample, with the type of analysis for which the sample was destined, with the degree of accuracy required and proposed mode of expressing the results. Before any pretreatment was begun a description of the sample was made, based on the field notes and material in the sample notebook, and entered on the head of the laboratory worksheet (Fig. 2). If the initial sample was damp it was oven dried for several hours at 105-110°C, care being taken to note any colour variations in the dry sample and compare these with the Munsell colour notation taken in the field. If the sample had a high clay content then the drying temperature was lowered and drying time extended, a suitable value being 50°C for 2-3 days. This prevented heavy 'caking'. During drying any contamination from laboratory dust was prevented, and the actual drying was carried out on steel drying trays, labelled with a spirit pen.

SITE*NAME	*FEATURE***	GRID*REF**	PLAN******	REASON****	IDENT*NO**	DATE*	DESCRIPTION
CHILLING 0	25FBEACH	SU508045	STRAT SAMP	PSA ETC	CHILL 1	7/72	SHINGLE
CHILLING 0	25FBEACH	SU508045	STRAT SAMP	PSA ETC	CHILL 2	7/72	SAND
CHILLING 0	25FBEACH	SU508045	STRAT SAMP	PSA ETC	CHILL 3	7/72	LOWER BEARTH
PIPETTE ANALYSIS REQUIRED AND TEST FOR CARBONATES 0							
CHILLING 0	25FBEACH	SU508045	STRAT SAMP	PSA ETC	CHILL 4	7/72	UPPER BEARTH
COMPARE COMPOSITION WITH CHILL 3 0							
HOOK 0	BLUFFGRAV	SU512052	STRAT SAMP	PSA ETC	HOOK A	24/1	GRAVEL
HOOK 0	BLUFFGRAV	SU512052	ODD SAMP	PSA ETC	HOOK C	24/1	COARSE COBBLES
LARGE BOX WITH HEAVY COBBLES DIRECT MEASUREMENT AND WEIGH CORES AND AXES 0							
HOOK 0	BLUFFGRAV	SU512052	STRAT SAMP	PSA ETC	HOOK B	24/1	GRAVEL
HOOK 0	BLUFFGRAV	SU512052	STRAT SAMP	PSA ETC	HOOK D	24/1	SANDY GRAVEL
HOOK	BLUFFGRAV	SU512052	STRAT SAMP	PSA ETC	HOOK E	24/1	SANDY GRAVEL

Fig. (1) Printout of a specimen page of the program SAMPLERS.

The field sample often contained more material than was actually required for an analysis, and was therefore subdivided. This was done so that the original characteristics of the main sample were exactly represented in the subsample. Since bagged sediments may become resorted during transport from the site, and concentrations of heavy minerals or larger grains may have formed in the corners of the bags re-mixing and splitting was generally carried out as a matter of course, to homogenise the sample. Obtaining representative sub-samples from a main sample may be done by 'hand' methods, but some form of mechanical splitting is preferable and results in greatly increased accuracy. In this case use was made of a riffle box (Shackley 1975 (b)), to divide a large initial sample of coarse material such as gravel into two approximately equal sub-samples. The box consists of a metal frame with a series of slots of different dimensions according to the approximate grain size of the material to be divided. The riffle box was especially suitable for coarse and medium sized pebbles, and for dry sands, but was not recommended for finer sediments. The dry sample was poured in at the top of the apparatus, in one smooth movement along the length of the box. This ensures that each particle has a theoretically equal chance of falling down any of the slots, which lead alternately into two metal boxes. The riffling procedure was repeated until samples of the required size had been obtained.

1.23 Disaggregation

The dry sample was gently crushed in the fingers, or with a rubber pestle and mortar. Vigorous crushing was avoided since this removes both the natural as well as the artificial grain aggregates, and may also crush individual particles, (Waters and Sweetman 1955). If the sample was at all aggregated than the percentage of aggregates was noted, since this affects the particle size distribution. This was done by scattering a few grams of the dry sample on a filter paper and examining them under a low power binocular microscope with incident light, preferably at X10 or

Fig. (2). Sample record sheet

Site	Sample No.	Exact location

Field record on section/notebook Sample sent by .... Sample taken by .... Pretreatment done by .... Analysis done by	Remarks .... Date ....
LABORATORY DESCRIPTION Colour Texture etc.	 Included archaeological/organic matter Reason for analysis
PRETREATMENT Drying only required	Organic matter removed
Weight of bulk sample	Carbonates removed
Splitting method	Iron Oxides removed
Weight(s) of subsample(s)	Other pretreatment (specify)
Weight of sample no. ( ) after pretreatment	
TESTS REQUIRED Particle size analysis	Grain shape description
Thin section	Heavy mineral analysis
Examination and description	Chemical tests (specify)
Scanning electron microscope	Examination of organic material
Other (specify)	Other (specify)

X20 magnification. The aggregates were noted, their sizes measured using a micrometer scale and their frequency calculated. A decision was taken in the case of each sample on whether or not to remove carbonates, organic matter, iron oxides or other constituents of the sample, depending both on the nature of the sample and the planned analysis. The procedure described below for the removal of organic matter using hydrogen peroxide is also effective for disaggregation, and was sometimes used before a particle size analysis since it had no effect on the composition of the silt/clay fraction.

Fine sediments were disaggregated using ultrasonics, a suspension of the material in a beaker being lowered into a small ultrasonic tank for a few seconds. This procedure was not used, however, if a scanning electron microscope examination was planned since it affects the surface textures of the individual grains, but it is an excellent pretreatment for particle size analysis or chemical tests, (Genrich and Bremner 1972). Prolonged ultrasonic treatment is an effective dispersant for the most indurated or consolidated sediments.

1.24 Removal of fine material from a bulk sample, for particle size analysis

If the bulk sample contained a great deal of silt and clay it was impossible to process it by dry sieving, and any splitting method tended to be inaccurate. The fine material (finer than 63μm) was removed by washing through on a 63μm sieve into a beaker, and drying the coarse fraction retained on the sieve in the oven for a few hours at 100°C. The fine fraction was gently evaporated in the beaker at about 50°C, and the resulting powder stored in an airtight sample phial.

1.25 Dispersion of suspended sediments.

De-flocculating agents were generally required for the particle size analysis of suspended sediments. The use of 'Calgon' (sodium hexametaphosphate) in 10% solution was recommended, 1 ml of solution being required for each gram of estimated clay in the sample.

1.26 Removal of unwanted constituents.

Organic material

This often constituted a significant contaminant and was therefore removed. It was not normally heavy enough to affect the particle size distribution, if this was obtained by sieving, but it bound together the constituent particles and reduced the accuracy of a sedimentation analysis. Organic matter was never removed simply by burning it off the dry sample, since this causes fracturing of the sand grains and may fuse together the clay particles.

The organic material was generally removed using hydrogen peroxide, except where the sediments contained free manganese oxide, for example clay with flints, where the manganese oxide catalyses the reaction and causes the violent emission of oxygen (Catt and Weir 1975). The sample was placed in a large beaker and 15% H_2O_2 was added to cover it. After a short time the mixture started to 'boil', giving off water vapour and oxygen. When the reaction had stopped, generally after several hours, the peroxide was poured off and the sample washed several times with distilled water. If the greater part of the organic material had not been removed then the procedure was repeated. If the reaction was very slow in starting it could be speeded up by adding a few millilitres of KOH, and by the application of a little gentle heat. The sample was then thoroughly washed with distilled water and dried.

Removal of carbonates

Carbonates were removed by placing a weighed quantity of the sample in a large beaker with 25ml de-ionised water and adding 10% HCl until the effervescence stopped. If the reaction was very slow gentle heat was applied. A high percentage of carbonate in the sediment hinders the removal of organic matter with hydrogen peroxide and precipitates calcium oxide if the method described below for the removal of iron oxides is carried out. After removing the carbonates the residue was washed and dried and the weight loss recorded.

Removal of iron oxides

This procedure was often necessary if highly ferruginous sands or gravels were sampled, especially if their surface texture were to be examined. The sample was placed in a beaker with deionised water and a small sheet of cylinder aluminium added. Fifteen grams of a concentrated solution of oxalic acid were then added and the mixture boiled for 10-20 minutes. More acid was added if required (Leith 1950).

1.3 Grain characteristics

1.31 Measurement of grain size by direct methods

The component grains of a very coarse sediment were sized by a direct method, since it was impractical to transport a sufficiently large sample back to the laboratory. Doehring and Clausen (1967) in advocating direct measurement for large particles note that alternative methods, such as sieving, produce errors and make the definition of depositional environments extremely difficult.

The technique of direct pebble measurement has been described by Pettijohn (1949) and involves measuring the dimensions of the three main axes of the particle, namely the long (a) axis, the short (c) axis and the intermediate (b) axis. This may be done very simply either in the field or the laboratory by the use of a graduated rule, tape and graph paper, or preferably by the use of calipers. If a large sample was to be measured the use of a fixed block with sliding arms, covered with graph paper was preferred. This consisted of a flat piece of wood with two narrow pieces of wood (graduated in millimetres) nailed to it to form a right angle. The third arm was left free but may be constructed so that it slides along one of the others. The pebble to be measured was placed at the junction of the fixed arms and the readings of the (a) and (b) axes were taken directly. It was then rotated so that the (c) axis could be measured, and held in place by the free arm. This method was used by the writer for particle measurements in the field. For laboratory measurements the ingenious method of Burke and Freeth (1969) utilising an overhead projector, was found more suitable. The pebbles were placed on a transparent sheet of graph paper on the projector and were spread out with their (a) and (b) axes parallel to the surface, The measurements were then read directly, and the length of the (c) axis found by rotating the particle until this dimension reached a minimum value. The method is an improvement on the 'fixed block' described above, since the effects of parallax are eliminated. The results of such measurements were recorded in simple tabular form. Both these methods are also suitable for measuring implements, and have been used for that purpose in this study.

Griffiths (1967) recommends that the measured results of such analyses be transferred to the logarithmic Ø scale (p. 25), for ease in later mathematical treatment. It is usual to express the results as axial ratios rather than to leave them as simple measurements, and these ratios can then be plotted as graphs or histograms for inter-sample comparison. Excellent results may be obtained by comparing different populations using simple statistical tests such as Students t or Chi square (p. 121), as shown, for example, on the pebbles from the fluviatile gravels at Great Pan Farm, (p. 121).

1.32 <u>Grain Shape</u>

The roundness or flatness of particles are significant indicators of depositional environments, stratigraphic horizons and certain palaeoclimatic conditions (e.g. Laville, 1975). They may be used to distinguish pebbles belonging to different populations and to determine the rate of downslope movement of sediments. There are numerous methods for describing the shape of a grain, some of which involve comparing it with standard charts and some which rely on accurate dimensional measurements, or the combination of such measurements into indices. The simplest method of describing grain shape is by reference to a verbal scale (e.g. 'platy' or 'columnar') but these descriptions are not only qualitative but also extremely subjective. The triangular shape diagram of Sneed and Folk (1958) is a useful way of classifying pebble shape by reference to axial ratio measurements, and it is time saving if the values have already been measured in the course of a direct size analysis.

An alternative system is the use of the visual comparator chart. Grains are compared with the standard shapes shown on the chart and a certain degree of objectivity therefore assured. These charts generally refer to the two most important characteristics of grain shape, the grain roundness and the grain sphericity.

The roundness of a grain is the relative sharpness of the grain corners, or the general grain surface curvature. It must be clearly distinguished from sphericity, which is best described by relating grain surface area to the surface area of a sphere of the same volume. Roundness is independent of grain shape, and is to a large degree a function of the mineral composition of the grain, its depositional history and final depositional environment. Numerous verbal classifications of grain roundness have been made, for example those of Russell and Taylor (1937) and Pettijohn (1949). Many methods have been devised for the mathematical expression of roundness indices, the most widely used being those of Wentworth (1933), Cailleux (1947) and Wadell (1933), all of whom constructed roundness indices based on various parameters measured from the grains.

Powers (1958) combined the Wadell calculation with descriptive roundness classes and produced a visual comparator chart. The chart used in this project is that of Krumbein (1941). However Griffiths (1967) has pointed out various difficulties inherent in its use. Measurements were made either from a hand specimen or from a silhouette projected by the method of Burke and Freeth (1969), described above. Similar methods have been used for the quantification of particle sphericity, a concept that was first introduced by Wadell (1932). The visual comparator charts of Rittenhouse (1943), are particularly useful, and have been used here, although they lack the mathematical sophistication of concepts like the working sphericity of Wadell (1935) or the intercept sphericity of Krumbein (1941). Results of the roundness and sphericity measurements are generally expressed as histograms (e.g. Fig. 58).

1.33 Grain Surface Texture

The surface textures of quartz sand grains generally show characteristics that help in determining their origin and depositional history, and as such provide a valuable source of information. Surface textures may be described either by examining the grains under a low power light microscope, or by the use of more sophisticated methods involving a scanning electron microscope. A combination of surface texture description and particle size analysis should enable the origin of a sediment to be determined with some accuracy.

For the examination of sand grains under a light microscope a small sample was first washed with distilled water, and any required pretreatment (see p. 8) was then applied. It was generally necessary to remove the iron oxides, since these tended to cement the grains and obscure the surface textures. The fraction sized between 0-1∅ (0.5-1.0mm) was separated off by dry sieving. The grains were then mounted on a standard microscope slide in Canada Balsam.

Cailleux (1945) distinguished four principal varieties of sand grains:

1) Unworn angular grains These are of recent origin and have been freshly produced by some form of weathering. They have angular edges, low roundness values and appear clean and shiny under the microscope.

2) Worn, rounded and glossy grains Cailleux considered that this type of surface texture indicated the action of running water, and the characteristics are found on sand grains from marine or fluviatile deposits. The roundness values, measured on the Krumbein chart, tend to be rather high.

3) Clean, well-rounded matt-surfaced grains The surface of the grain has been dulled by wind action. The grains may occasionally be facetted but generally have high roundness and sphericity values.

4) 'Dirty' rounded and matt surfaced grains This texture is quite unmistakable. The grains are coated with many tiny particles that give them a 'dusty' appearance under the microscope. The effect is produced by a coating of small grains of the original cement, since the grains are likely to have been recently derived from the weathering of sandstones or similar rocks. The occurrence of this type of sand grain, weathered out from the Greensand, has been noted in the sediments of Great Pan Farm (p. 101).

In practice the distinctions are easy to make but have the disadvantage of being rather subjective. However a simple description of the grain surface is an aid to sediment characterisation, and the method may be semi-quantified by counting the number of grains of each type that are present, and expressing the results as percentages of the total. The method was especially useful for distinguishing freshly-weathered sand grains, and those immediately derived from local outcrops in sediments with mixed sand grain populations, for example p. 101 .

The use of a scanning electron microscope offered a more sophisticated and accurate way of describing surface textures, although the method still relies on the hypothesis that the surface texture accurately reflects the depositional history of the grain. The numerous papers written on this subject have recently been summarised by Krinsley and Doornkamp (1973). These writers consider that it is possible to distinguish certain depositional environments from sand grain surface textures, but emphasise the various conditions that must be born in mind if quantitative interpretation is planned.

Their definitive variables are described within the broad framework of quartz crystallography, the importance of such features as flat cleavage plains, conchoidal breakage patterns and the surface precipitation of silica being especially recognised. Grain size is considered to be critical, since in grains larger than 2Ø (about 200μm) conchoidal breakage patterns tend to occur, which produce irregular blocks and mask other surface characteristics. It is possible to make useful observations about sediment source, diagenesis, and to distinguish the products of glacial, littoral, aeolian and other environments. In this project the method was used to provide additional evidence (or the opposite) for the depositional environments of certain sediments about which there was some doubt, for example p. (105).

Table (2) summarises the important diagenetic surface characteristics of sand grains. Despite a recent paper by Brown (1973) which casts some doubt on the validity of interpretation made by this method the basic hypothesis seems to be accepted by most workers, if the correct sampling procedures are undertaken.

After the samples were examined under low power binocular microscope, and their characteristics described, they were prepared for the scanning electron microscope by being boiled with concentrated HCl for ten minutes. After thorough washing, and the removal of iron oxides or organic matter where necessary, 20 grains were selected at random, of a size less than 200μm (2Ø) in diameter, and cemented to the metal specimen stub. This stub was then coated with a thin layer of gold in a vacuum evaporator (Bradley 1965) and inserted into the apparatus.

The instrument used was the Cambridge Model S4-10 'Stereoscan' which enabled the specimen to be 'viewed' with great clarity in three dimensions at magnifications from X10 to X200,000. Several specimens were generally examined during any one stretch at the machine, together with 'control' samples from known depositional environments.

Table (2). Diagenetic surface characteristics of quartz sand grains. (after Krinsley and Doornkamp 1973).

Marine, fluviatile and lacustrine environments.	
High energy (surf) 1) V-shaped patterns of irregular orientation. 2) Straight or slightly curved grooves. 3) Blocky conchoidal breakage patterns.	Medium and low energy 1) 'En echelon' V-shaped indentations at low energy. As energy increases random orientated V-patterns replace them.
Aeolian	
Tropical desert 1) Meandering ridges. 2) Graded arcs. 3) Chemical or mechanical action giving regular pitted surfaces replacing the above features in many cases. 4) Upturned cleavage plates and well rounded grains.	Coastal dune 1) Meandering ridges. 2) Graded arcs. 3) Disc-shaped depressions.
Glacial	
Normal 1) Large variations in size of conchoidal breakage patterns. 2) Very high relief. 3) Semi-paralleled and arc-shaped steps. Parallel striations of varying length. 4) Imbricated breakage blocks which look like a series of steeply-dipping hogback ridges. 5) Irregular small scale indentations associated with conchoidal breakage patterns. 6) Prismatic patterns.	Glacio-fluvial 1) Rounding of the normal glacial patterns.

1.4 Chemical tests

Little use was made in this study of the chemical properties of sediments, since it was felt that, on the whole, the problems posed could best be answered by physical analyses, such as obtaining particle size distributions. However on several occasions simple qualitative chemical tests were employed, and it was often necessary to measure the pH of a sample. The majority of sediments have values between 5-9, although the pH scale ranges from 0-14. Various chemical processes in the sediment determine and influence the pH value, as do the mineral constituents and moisture status.

In this study pH measurements were made using an electronic pH meter (the Pye-Unicam 293 portable meter), both in the field and the laboratory, in preference to the use of more qualitative tests such as 'Universal' indicator or test papers. Jackson (1962) considers that field pH measurement is the most valid method, since the pH of a sediment varies with the amount of preparation, and with factors such as the moisture content, the amount of drying done during preparation, the content of soluble salts and the amount of grinding. The more dilute the sediment suspension the higher the pH value, and some degree of standardisation in preparing samples for a pH tests was therefore aimed at. The meter measures the 'effective' pH of a sediment, including all sources of hydrogen ions such as those produced by the dissolution of soluble acids. The sediment sample was prepared without grinding and not allowed to remain in suspension any longer than necessary. It was mixed to a thin paste with de-ionised water so that the surface of the water-saturated material could be seen to glisten, and the reading taken by immersing the electrode in the sample and noting the scale value.

Carbon and carbonates

Carboh was occasionally present in the sediments, either as organic carbon or as carbon compounds, generally carbonates. The organic carbon could be detected by visual examination of a sample under a binocular microscope, and it was thought unnecessary to measure it quantitatively, although this could have been done by the methods of Walkley (1947) or vanMoort and deVries (1970). The presence or absence of carbonates in a sediment was occasionally important and routine tests with hydrochloric acid were made on all fine grained material such as the 'brickearths' (p. 79). It is possible to measure the total carbonate content of a sediment, for example by the methods of Gastner (1971), although this was felt to be unnecessary. The carbonaceous material was sometimes removed from a sediment using hydrochloric acid for particle size analysis.

Humus and other substances

The presence of humus in a sediment was detected by boiling a small sample with sodium hydroxide, when it produces a brown precipitate. This test was sometimes useful in establishing the nature of an unknown brown colouration, but again quantitative measurement, generally done colorimetrically (Cornwall 1958) was thought to be unnecessary. The presence of ferric iron was established by a spot test in acid solution using potassium ferrocyanide, when a strong 'prussian blue' precipitate was obtained. Manganese was detected by fusing some of the dry sample with excess sodium carbonate, and extracting the melt with dilute sulphuric acid. The purple colour of sodium permanganate indicated the presence of the metal radicle.

1.5 Preparation and examination of thin sections

An initial examination of the sediments was carried out under a low power binocular microscope and incident light, to aid in sediment description and in the extraction of alien particles or inclusions, such as shell or bone (p. 105).

For a more sophisticated analysis, perhaps involving particle shape quantification, or if the fabric or micromorphology of the sediment were to be examined, it was necessary either to mount the grains in a loose slide mount, or in a suitable mounting medium, or to consolidate a small portion of the sediment and cut a thin section. Loose grain mounts were made by the methods described above (p. 15) either in a cavity slide or with the grains held by Canada Balsam.

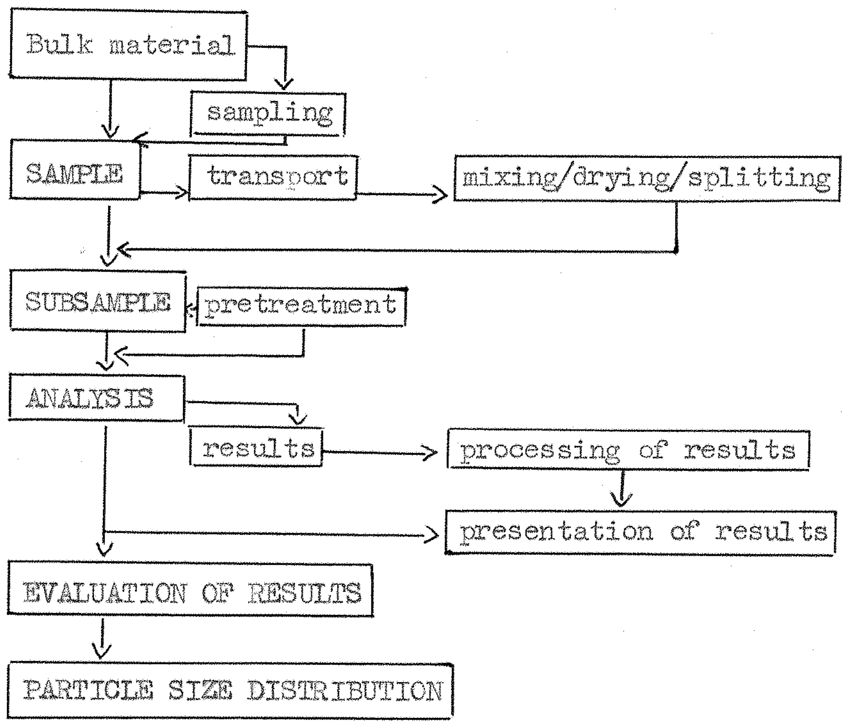
In order to make a thin section from an unconsolidated sediment it is first necessary to impregnate a sample with some suitable medium, in order to render it sufficiently hard to stand cutting and grinding. In this study '<u>Carbowax</u>' (polyethylene glycol) was used, since it is particularly suitable for slightly moist sediments, and after the impregnated sample had dried it was cemented to a microscope slide with 'Araldite'.

The interpretation of thin sections of archaeological sediments has been recently discussed by Catt and Weir (1975), Proudfoot (1958) and Cornwall (1958). Sediment or soil profiles change in response to such factors as the formation of humus, or the translocatation of very fine particles, and these are apparent in thin section. Kubiena (~~1959,~~ 1963, 1970) and Dalrymple (1958) quote examples of the micromorphological examination of buried soils, using thin sections as aids to reconstructing past environmental conditions, and Jamagne (19~~72~~69) discusses the interpretation of soil thin sections as palaeoclimatic indicators. In this study the manufacture and examination of thin sections has been used as an aid to the characterisation of various 'brickearths' (p. 79), together with particle size analyses and various chemical tests.

1.6 <u>Particle size analysis</u>

Completing the particle size analysis of a sediment is without doubt the most useful way of obtaining detailed information about its characteristics, and of describing them. Accurate completion of such analyses and the correct plotting and interpretation of results enables samples to be described in terms of statistical measures, permitting correlations to be

Fig. (3). <u>Flow chart for particle size analysis</u>



made between similar deposits, stratigraphic units or sediments that have been produced or influenced by similar sets of processes. The particle size analysis should make possible the detection of the agent of deposition (for example, wind, river, sea), the process of deposition (for example suspension or saltation) and the environment of deposition (for example beach, flood plain, dune). In some cases diagenetic factors which have affected the sediments in situ can also be detected. Particle size analysis has, for these reasons, been chosen as the analytical technique most likely to give informative results for the type of problems being dealt with in this study.

1.61 Defining particle 'size'

All methods of measuring particle size are empirical, because 'size' cannot be defined except for geometrically simple shapes, and even for them the chosen analytical method influences the results. Studies of size distributions usually relate the 'size' of the particles being studied to an equivalent spherical diameter, or dimension, i.e. to the diameter of a spherical particle whose volume is equal to that of the particle whose size is being measured, (Rosen and Hulbert 1970).

A spherical particle may be characterised by its diameter and a cube by the length of one edge, similar processes being employed for other regularly shaped particles. However the majority of mineral grains are far from regular in form, and can be platy, needle-like or amorphous. They may even consist of aggregates of smaller particles, and this presents problems for measurement (Pietsch 1968). The particle 'size' being measured is totally dependent on the method employed, and there is a significant lack of appreciation of the influence of technique over results. (Littlejohn 1970).

Table (3) presents a summary of some of the most commonly-used definitions of particle 'size'. The relationships between certain of these measurements have been discussed by Heywood (1946), Krumbein (1935), Chayes

(1950) and Van der Plas (1962). Direct comparison of results obtained from different sizing methods may not always be possible, and this presents a complication when the final particle size distribution curve is drawn up. The methods of sizing used in this study, sieving and sedimentation, measure two different particle 'sizes', and the combination of results obtained will produce a distinct 'kink' in the size distribution curve. However both these methods produce a volume or weight/size distribution, whereas optical sizing generally results in a number/size distribution since individual particles are being measured.

1.62 Particle size grades

Although all the particles composing a sediment differ from each other only by very small size gradations along a continuum it is convenient to group them into size grades, distinguished on fairly arbitrary criteria. These grades refer only to the particle size of the sediment and are not in any way related to its mineralogical composition. Thus a 'sand' may be composed of particles of coal or calcite instead of the more usual quartz, as long as the predominant particle size falls within the grade limits for sand on the classification scheme chosen. The distribution of particle sizes within a sample is often very wide, for example a cave sediment may contain great blocks of rock with diameters millions of times that of the clay particles filling their interstices. An ordinary linear scale for particle size is therefore impractical, and a graduated or geometric scale is necessary. Many scales and grade classifications have been devised, a correlation between the most commonly used being shown in Table (4). The Udden scale, (Udden 1898) was geometric, taking 1mm as the starting point and using the ratios $\frac{1}{2}$ or 2, depending on the direction, to obtain grade limits. The resulting system was useful but non-cyclic and non-regular. The Udden scale was modified by Wentworth (1922) who refined and elaborated it. The Wentworth scale is not, however, suited to the analysis of well sorted deposits such as dune sand, since the grade limits are too wide. The

Table (3) Measurements of particle 'size'

Method of measurement	Name	Definition
Sieving	Sieve diameter	The width of the minimum square aperture through which the particle will pass.
Sedimentation	Free falling diamter	The diameter of a sphere having the same density and the same free falling speed as a particle in a fluid of the same density and viscosity.
	Stokes diameter	The free falling diameter in the laminar flow region
Microscopy	Nominal sectional diameter	The diameter of a circle of the same area as the grain projection (Wadell 1935)
Optical statistical diameters:		
Microscopy	Martin's diameter	The length of the line which divides the projected area of the grain into two equal parts (Martin 1923)
	Feret's diameter	The maximum projected length of the grain size on a fixed line (Feret 1931)
	Maximum horizontal intercept	The maximum length of a line parallel to a fixed direction limited by the contours of the grain (Krumbein 1935)
	Longest dimension	A measured value equal to the maximum value of Feret's diameter for each particle (Brown 1971).

Table (4) Scales for particle size analysis

d_A (mm)	Ø scale	Udden (1914)	Wentworth (1922)	British Standards (1967)
64	-6		Cobbles	Cobbles
45.3	-5.5	Boulders		
32	-5			
22.6	-4.5			
16.0	-4		Pebbles	Gravel
11.2	-3.5			
8.0	-3	Gravel		
5.65	-2.5			
4.00	-2			
2.82	-1.5		Granules	
2.00	-1			
1.41	-0.5	Coarse	V. Coarse	Coarse
1.00	0			
700 μm	+0.5	Medium	Coarse	
500	+1			
345	+1.5	Sand Fine	Sand Medium	
251	+2			Sand Medium
178	+2.5	V. Fine	Fine	
124	+3			
88	+3.5	V. Coarse	V. Fine	Fine
62	+4			
44	+4.5	Coarse		Coarse
31	+5	Silt		
22	+5.5	Fine	Silt	Silt
16	+6			
11	+6.5	V. Fine		Medium
7.8	+7			
5.5	+7.5			
3.9	+8	V. Coarse		
2.8	+8.5			Fine
2	+9	Clay Coarse	Clay	
1.4	+9.5	Fine		Clay

classes may be divided into two subgroups, but this produces irrational numbers which are difficult to memorise. For this reason the Tyler standard (Tyler 1930) was developed, which had the mid-point of each class as a whole number or a fraction. The British Standard classification (British Standards, 1967) has been widely used, but by far the best system is the ∅ (phi) scale of Krumbein (1934) to which reference has already been made. This is based on the fact that the class limits of the Udden scale can be expressed as powers of 2. Krumbein preferred to use the logarithm of the diameter (to the base 2) rather than the measured diameter, and to avoid negative numbers this logarithm was multiplied by -θ. Thus ∅ = $\log_2$ x diameter (mm). The system is easily memorable and mathematically sound, its value is shown in the processing and interpretation of results (p. 31). It forms the basis of nearly all recent work on particle size, and has the additional advantage of being standardised. A correlation between the ∅ values and their metric equivalents is shown in Table (4) for ½∅ intervals.

1.63 Particle sizing methods

The flow chart (fig. 3) illustrates the processes undertaken in this study which together compose a complete particle size analysis. All the substages, for example pretreatment, are just as important to the accuracy of the analysis as the actual analytical method chosen. Numerous techniques for obtaining a size distribution are available, the ones used in this study being dry sieving, for the fraction coarser than 4∅, and pipette sedimentation for the fine material. In addition use was made of a more sophisticated technique, automated electronic particle sizing, using a Coulter Counter, for sizing two samples of brickearth.

1.64 Presentation of results

In order to obtain the maximum amount of information the results of a particle size analysis must be presented in a suitable manner, ideally one which permits direct inter-sample comparison. The raw data was available

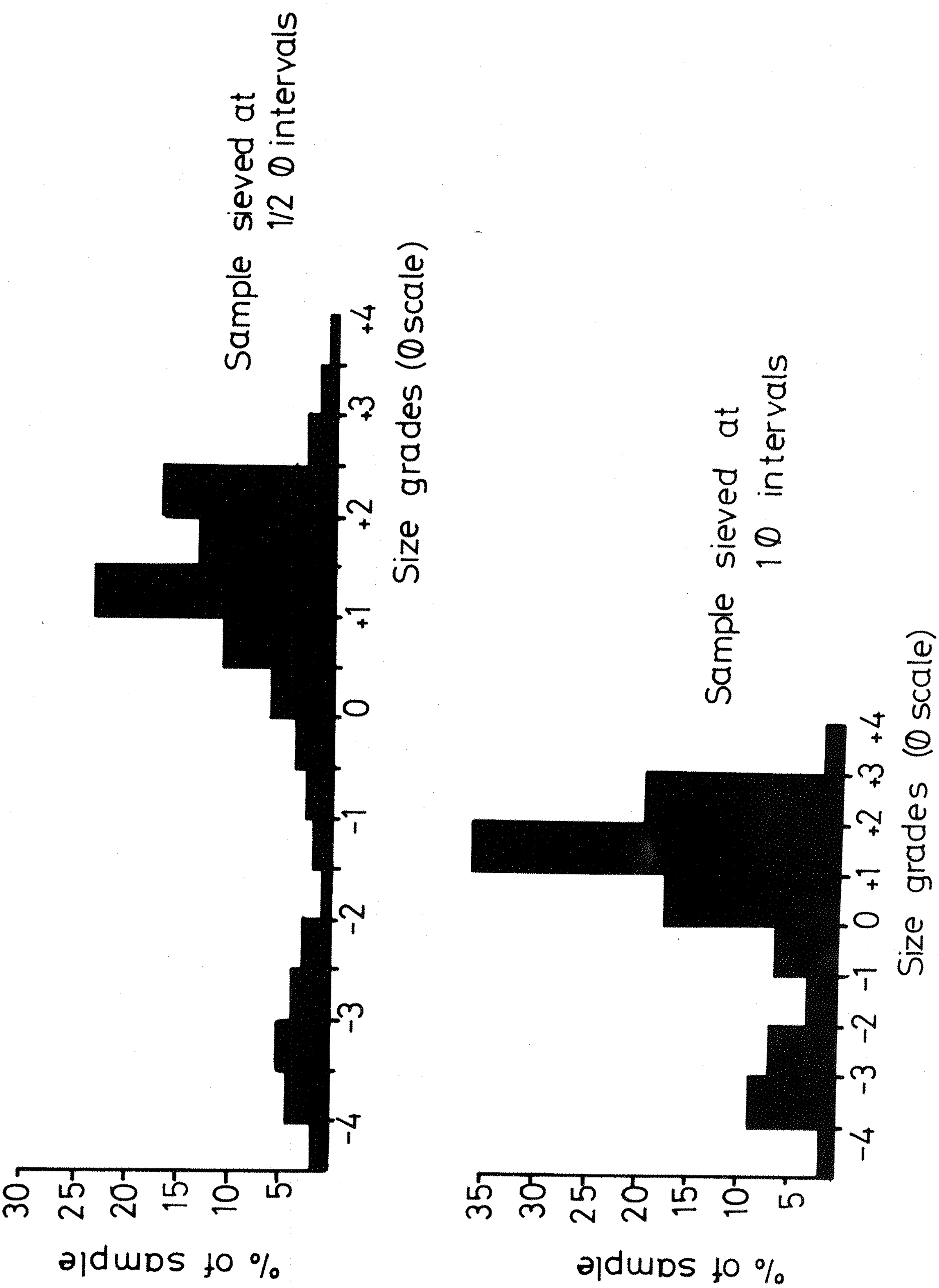


Fig. (4) The appearance of the same sample particle size distribution, expressed as histograms with different class widths.

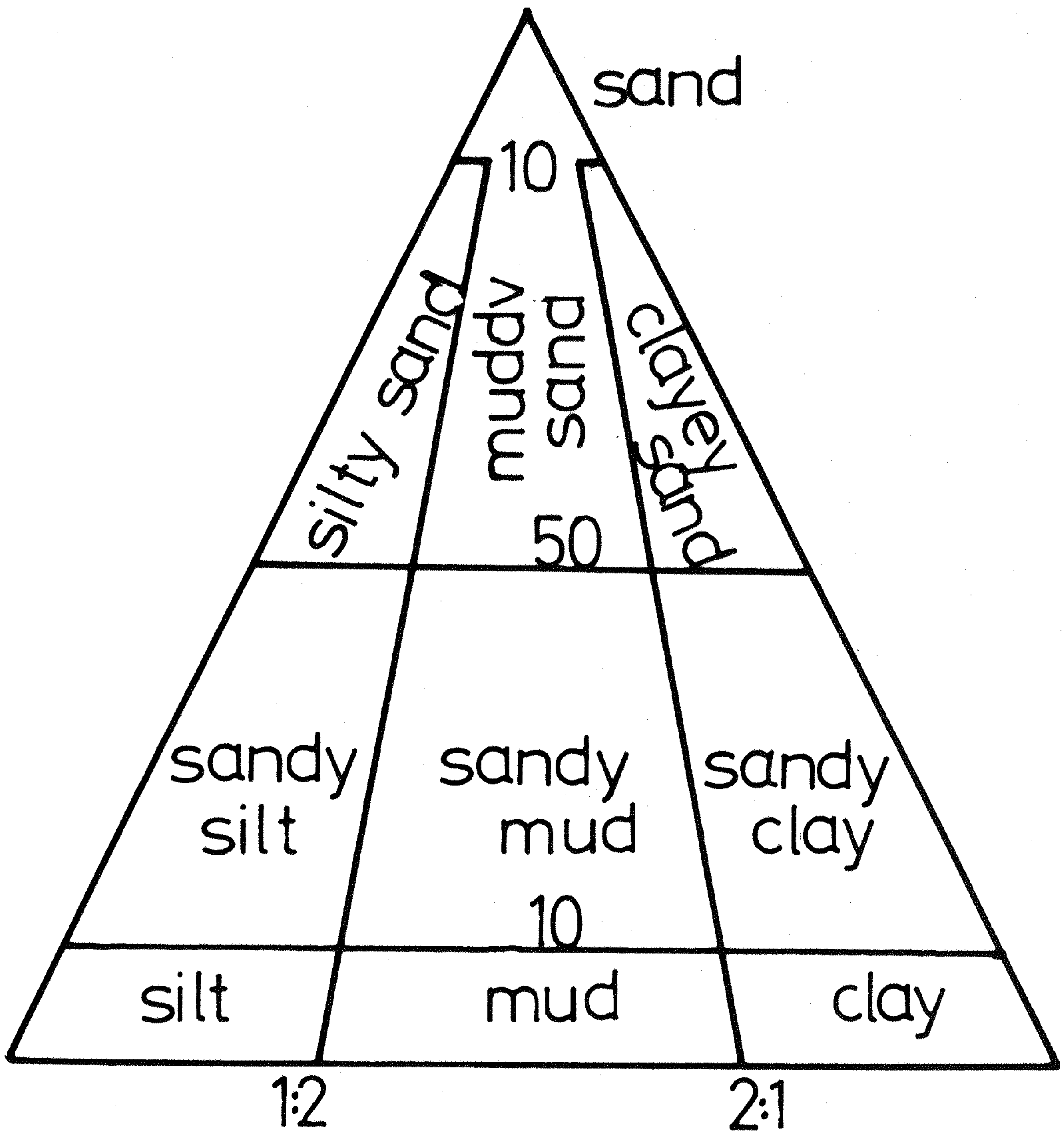


Fig. (5) Triangular diagram for sand/silt/clay mixtures, after Folk (1954) in tabular form, weight or volume/size distribution expressed in ∅ units.

The histogram or bar graph may be used to show the percentage of grains in each size class. It has the advantage of being very simple to construct but is unstandardised. The choice of class widths on the histogram is very important. With a narrowly divided sediment, for example one sieved at ½∅ or ¼∅ intervals, an arithmetic distribution is acceptable, but it is more usual to use a logarithmic scale. The shape of the histogram depends on the class intervals used, and Fig. (4) shows the appearance of two histograms constructed from the same set of data but using different class widths. The final appearance is quite different. The histogram is not a particularly good method of presenting particle size distributions, although in some cases its visual impact is useful, particularly for detecting bimodality or polymodality in samples. For this reason the histogram has only been used in this study for the presentation of results obtained by more subjective analyses than particle sizing, especially visual roundness and sphericity results, (e.g. Fig. 58).

An alternative method of presenting particle size results is the triangular diagram, which visually indicates the relative proportions of three components in a sediment. Fig. (5) shows the triangular diagram of Folk (1954) for sand/silt/clay mixtures. The diagrams are simple to construct and have been used in this study to obtain standardised sediment descriptions, which are combined with calculated statistical parameters to obtain a fuller description of the samples. This has generally been done by computer, using the SIEVETTE program described on p. (29).

The use of a semi-pictorial graph has long been a popular method for the presentation of obvious changes in particle size composition in a stratified series, and it may often be used where sampling characteristics or some other factor render the use of more sophisticated methods unsuitable. The writer has elsewhere pointed out the inadequacy of the form (Shackley 1972, Appendix) and compared the potential of such diagrams with calculated

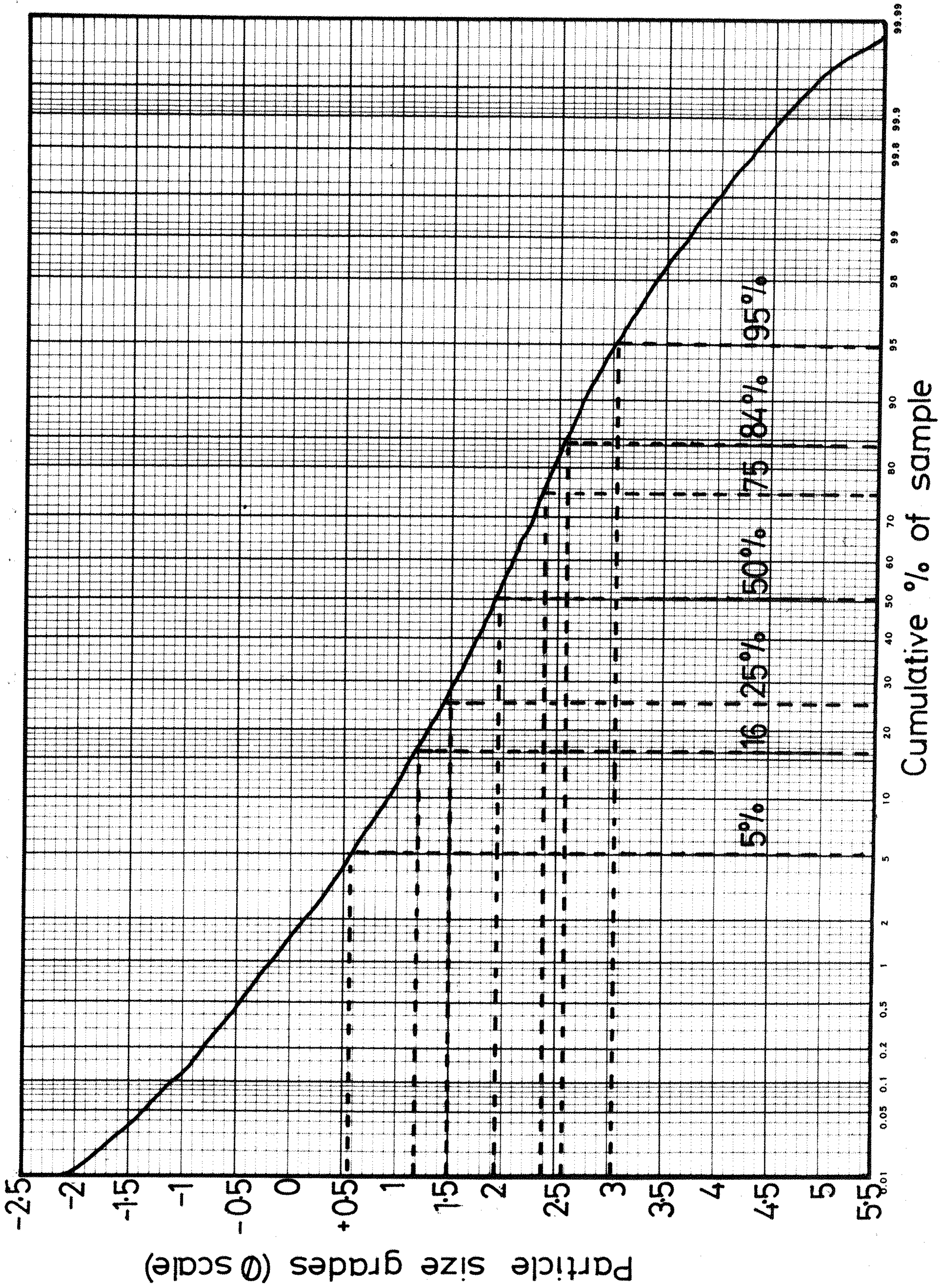


Fig. (6) Specimen particle size distribution curve to show the percentile values. Drawn on arithmetic probability paper.

statistics. The method is particularly suitable for the presentation of textural changes in cave sediments (Lais 1940, Schmidt 1958, Laville 1970, Shackley 1972, 1973a). In this study it was felt that the form was not sufficiently precise to express the analytical results, and a more statistical approach was substituted.

The construction of a cumulative frequency curve is the preferred method of presenting a particle size distribution, and consists of plotting the grain size grades (on the ∅ scale) against the cumulative percentages of the samples occurring in them. Early work was done using an arithmetic scale, which tended to produce S-shaped distributions, but this is now considered to be inaccurate. The drawing of such a curve is a necessary preliminary to the calculation of graphic statistics and use has been made here of arithmetic probability paper for greater accuracy. Since virtually all natural sediments will have a log normal distribution the curve for a unimodal sediment on this type of paper will approach a straight line.

After a curve has been constructed for each analysis (Fig. 6) percentile values are read off, and used to standardise the descriptions of the size frequency distributions. If a series of curves was to be drawn the semi-transparent variety of probability paper was used to help in visual comparison. Percentile values were obtained by drawing a line from the required point on the horizontal (cumulative percentage) axis to intersect the curve, and another line at right angles from the intersection to cut the vertical (∅ unit) axis. The value was then read directly. Thus in Fig. (6) the median (50%) grain diameter occurs at 1.94 ∅. Arithmetic probability paper permits accurate readings to ±0.01% (Folk and Ward 1957) and expands the 'tails' of the size distribution.

These graphic computational techniques help in comparing the characteristics of two different sediments, and in identifying processes and depositional environments. Many different indices have been proposed to describe the curves by various combinations of percentiles, the most commonly used being those of Inman (1952), and Folk and Ward (1957) which are summarised in Table (5). The latter series have been used in this study, and were calculated for each sample using a computer program (Fig. 8). The first step in the calculation without the program was to plot a curve from a set of values, and then to read off the percentiles required for a particular series of statistics. The Inclusive Graphic statistics of Folk and Ward (1957) require the reading of the 5∅, 16∅, 25∅, 50∅, 75∅, 84∅ and 95∅ percentiles. Folk (1966) presented a comparison of the efficiency of the various statistics proposed by such writers as Trask (1930), Otto (1939) Inman (1952), Folk and Ward (1957) and Krumbein and Pettijohn (1938).

Fig. (7) shows the cumulative particle size distribution of a dune sand deposit stratified within a series of marine terrace gravels at Christchurch, Hampshire. Control samples of beach and dune sands from modern contexts are shown for comparison, and it can be seen that the cumulative curve brings out the distinctions and similarities very clearly. These curves have been plotted from data obtained from a dry sieve particle size analysis, dividing at $\frac{1}{2}$∅ intervals, using a computer program (SIEVETTE) to perform all the calculations and to describe the curves. The actual printout from the analysis of the ancient dune sand is shown in Fig. (8), run on Southampton University's ICL 1907 computer. The program, which was used for the processing of all particle size analyses completed in this study, requires the data input of the weights of sediment retained on each sieve, and will then calculate and cumulate weight percentages. If a pipette analysis has been carried out on the finer fraction of a sample the variables of Stokes Law (p. 35) are entered, and the particle size distribution of the suspended sediment is calculated according to the initial aliquot method of Creager and Sternberg (1963) the results being combined with those of the dry sieve analysis. The percentile values are obtained by a linear extrapolation, moment measures of the

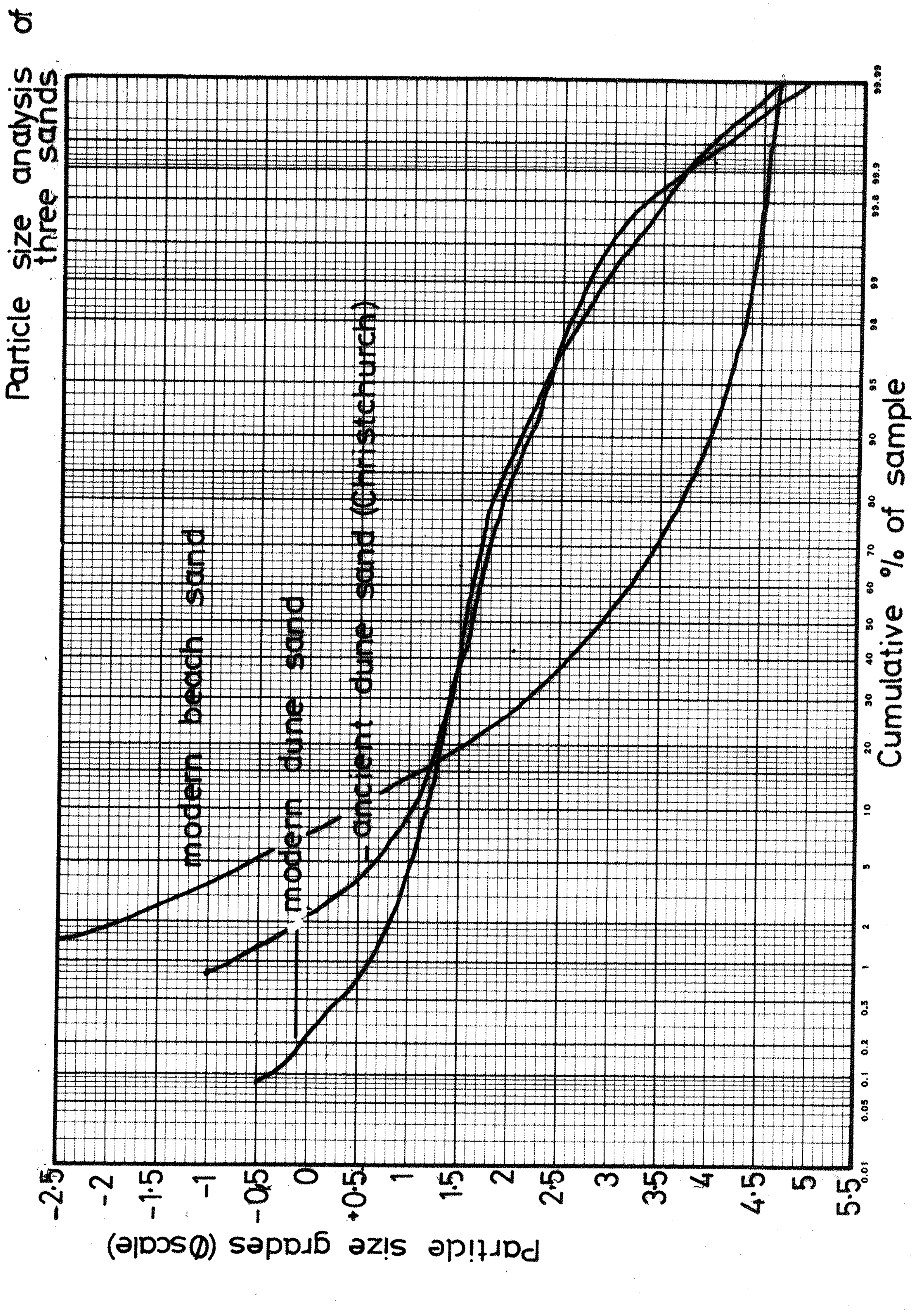


Fig. (7) Particle size distribution curves for three sand samples.

Drawn on arithmetic probability paper.

PARTICLE SIZE ANALYSIS

XCHURCH SAND

PHI	WEIGHT	PERCENT	CUM.PERCENT
-1.000	3,400	0.852	0.852
-0.500	2,070	0.519	1.372
0.000	4,200	1.053	2.425
0.500	7,640	1.916	4.340
1.000	17,630	4.420	8.761
1.500	226,740	56.851	65.612
2.000	71,900	18.028	83.640
2.500	56,430	14.149	97.789
3.000	6,820	1.710	99.499
3.500	1,040	0.261	99.759
4.000	0,290	0.073	99.832

SIEVED WEIGHT = 398.160 SEDIMENTED WEIGHT = 0.000 TOTAL WEIGHT = 398.830

POINTS FOUND BY LINEAR EXTRAPOLATION
****

PERCENTILE	PHI VALUE
1.0	-0.858
5.0	0.575
16.0	1.064
25.0	1.143
50.0	1.363
75.0	1.760
84.0	2.013
95.0	2.461

SEDIMENT DESCRIPTION
****
****

GRAIN SIZE PARAMETERS
****

MEDIAN GRAIN DIAMETER = 1.363

PARAMETER	MOMENT MEASURES	FOLK	INMAN
MEAN	1.423	1.480	1.538
STANDARD DEVIATION	0.581	0.514	0.475
VARIANCE	0.337	0.264	0.225
SKEWNESS	-0.413	0.254	0.370 0.264
KURTOSIS	2.246	1.212	0.925

PERCENTAGES OF CONSTITUENTS
****

GRAVEL = 0.853 SAND = 98.980 MUD = 0.168

FOLKS TEXTURAL DESCRIPTION
****

SLIGHTLY GRAVELLY SAND

MODERATELY SORTED

LEPTOKURTIC

FINE SKEWED

Fig. (8) Printout of the program SIEVETTE, using data from the particle size distribution of a sand from Christchurch.

distribution are calculated and the statistics of Inman (1952) and the Inclusive Graphic Statistics of Folk and Ward (1957) are obtained. The program also calculates the percentages of gravel, sand and 'mud' (silt and clay) in the sample, and produces a textural description according to the criteria of Folk (1954). If the fine fraction is analysed by sedimentation the data accepted ~~is~~ are the weights of sediment taken by evaporating suspensions of the sample extracted from the sedimentation cylinder at ½ø or 1ø intervals, according to Stokes Law. A full size distribution can be obtained from this program, which standardises the descriptions and facilitates comparisons between samples. The program can be linked to the initial data storage system SAMPLERS (p. 8), to further programs for statistical testing of results (for example, p. 121), or a graphic display to draw the curves. The SIEVETTE program was compiled in the University of Southampton by Dr. D. Frederick, and modified by the writer, from Bork (1970), Kane and Hulbert (1963) and Pierce and Good (1966). Similar programs for the processing of particle size data are described by Schlee and Webster (1967), and Petersen et al (1969) ~~Kay and Treasure (1966) and Henson ( ).~~.

SIEVETTE requires the actual cumulative curve to be drawn by hand, if it is required, unless graphic software facilities are employed. Although the curve is not strictly necessary, since the statistical parameters can be obtained from linear extrapolation within the computer, it is difficult to detect bimodality or experimental errors without it, and visual inter-sample comparison is facilitated.

1.65 Interpretation of results

The mean size parameter reflects the average size of the sediment, and is influenced by the source of supply and the agent and environment of deposition. The existence of gaps in the size distributions of natural sediments has long been noted, and Wentworth (1933) remarked on the absence of the -1ø grade and -8ø grade in a large number of samples. Udden (1914)

Table (5) Graphic Statistics

Measurement	Inman (1952)	Folk and Ward (1957)
Mean Size	$M_{\phi} = \frac{\phi16+\phi84}{2}$	$M_z = \frac{\phi16+\phi50+\phi84}{3}$
Standard Deviation	$\phi = \frac{(\phi84-\phi16)}{2}$	$x = \frac{\phi84-\phi16}{4} + \frac{\phi95-\phi5}{6.6}$
Skewness	$\phi = \frac{\phi16+\phi84-2(\phi50)}{\phi84-\phi16}$	$SkI = \frac{\phi16+\phi84-2(\phi50)}{2(\phi84-\phi16} + \frac{\phi95-\phi5}{2(\phi95-\phi5)}$
Kurtosis	$\phi = \frac{\phi95-\phi5}{\phi84-\phi16-1.0}$	$K_g = \frac{\phi95-\phi5}{2.44\ (\phi15-\phi25)}$

found a gap of $3-4\phi$ in the sand fraction of aeolian sediments, and these and other suggestions have been summarised by Wolff (1964). However Griffiths (1969) attributes the gaps to inefficient laboratory techniques. The role of the source material is fundamental in controlling the size distribution, especially the eventual value of the mean. (Folk 1962, Folk and Robels 1964).

The distinction between various types of sands has often been made by reference to the standard deviation and skewness parameters. Several writers have devised verbal limits for the parameter measurements, the most useful being those of Folk and Ward (1957)~~, shown in Table (   )~~. Sediments consisting largely of fine sand are generally the best sorted, and it therefore follows that wind transported material shows this characteristic as well. Sorting becomes progressively worse for coarser or finer sediments (p. ~~126~~ 78), which Inman (1949) explains as a result of fluid dynamics, although Folk and Ward (1957) consider that it is the result of a polymodal source.

It is usual to plot the parameters or statistics obtained against each other on two dimensional scatter diagrams (p. 82), to diagnose the origin of the sediment and to locate general trends in series of analyses (Folk and Ward 1957, Shackley 1972). The commonly-used method of drawing circles around likely clusters is very inaccurate, and should be replaced by properly calculated correlation and regression co-efficients for the scatter diagram being considered, (Moroney 1951, Shackley 1972). Plots of skewness against kurtosis are particularly useful, and Mason and Folk (1958) found that they could use them to distinguish dune, beach and river sands. Skewness and kurtosis values seem to be the result of the mixing of two normal populations in various proportions in the resulting sediment. Beach sands generally have negative skewness values although dune and river sands tend to be positively skewed. Kurtosis values tend to be high in lagoonal silts but low in beach sands (p. 127), since the latter are more efficiently sorted. It has been suggested that the parameter values depend to a considerable extent on the amount of coarse material present, which tends to weight the distribution on one side, Fuller (1962) noted that the 2Ø size grade is often missing from sediments deposited in shallow water environments, ~~(p.)~~ and Friedman (1961), in discussing the negative skewness of beach sands, concluded, after an analysis of over 250 samples, that it was a function of two forces of irregular strength which operated in different directions in a beach environment, namely the coming waves and the backwash. The former agent deposits the material whereas the latter tends to remove the fine fraction, which results in the negative skewness. The relationship between the current required to move particles of different sizes has been discussed by Allen (1970) and Inman (1949).

Numerous geological papers have been written on the interpretation of grain size distributions, including those of Shepherd and Young (1972) Fuller (1962) Asseez (1973) and Mason and Folk (1968). Archaeological work has included studies of cave sediments, reconstructing palaeoclimatic changes by fluctuations in particle size compositions, for example the work of Laville (1975) on French Perigordian sites, Shackley (1972, 1973a) on English cave sites, Tankard and Schweitzer (1975) on South African caves, and Dakaris et al (1964) on the Greek cave of Kokkinopolis. Davidson (1973) studied the evolution of the tell site at Sitagroi by carrying out a particle size analysis and measurements of the total phosphate content, and Cornwall (1959) described a combination of particle size analysis and chemical tests on soil samples from the ditch section of the Nutbane long barrow (Hampshire, England).

The particle size distribution of a sediment may be used as the best way of quantifying and describing it, and as an objective method for comparing individual samples, stratigraphic series and different sites. In this study particle size analysis was used to comment on and characterise the nature of the deposits, and to distinguish the products of different depositional environments.

1.66 Sieve analysis

Dry sieve analysis, used in this study to obtain the particle size distributions of sediments from -6ø+4ø, is probably the most commonly used sizing method. Numerous varieties of sieves are available, those used here being the American ASTM series (ASTM 1968). The series consists of a set of sieves of different mesh apertures, the mesh in the coarser sieves being of woven brass, and for the finer sieves of phosphor bronze. 8" diameter sieves were used, spaced at ½ø intervals and divided into nests of a size convenient to the sieve shaker, with a pan and lid to each nest. The samples were prepared by any of the methods already described, and it was often necessary to remove fine material and to pre-treat by removal of carbonates or iron oxides. Sieving was carried out on a vibratory sieve shaker for 10 minutes per nest, a total of 21 sieves being used from -6ø to +4ø. Each empty sieve was weighed on an accurate balance and the weight recorded on the laboratory worksheet (Fig. 9), to three decimal places. Since these weights remained constant for the set of sieves being used they were printed onto the sheet. Material coarser than -6ø was sized directly by hand (p. 13). The sample was poured in at the top of the coarsest nest, shaken for 10 minutes, and then decanted from the pan into the next nest. Each sieve was then re-weighed, the sample weight calculated and the sieve cleaned. Material which passed the finest sieve (+4ø) was stored in a labelled plastic phial for sedimentation analysis, which was carried out if this fine fraction represented more than 5% of the total sample.

1.67 Pipette analysis

Particle size analysis of the finer sediments was carried out using pipette sedimentation, following Stokes Law, and the results combined with those of the dry sieve analysis and processed by the SIEVETTE program described above. Stokes Law, stating that

Fig. (9) Record sheet for dry sieve analysis
Sample GPF/ISD

Site: Great Pan Farm, Newport, I of Wight.	Sample No. GPF/ISD	Exact Location: see section drawing
Pre-treatment: removal of iron oxides	Analyst	Date 2.1.71.
General description: sand	Notes	

Ø value	Sieve weight (gms.)	Total weight (gms.)	Sediment weight (gms.)	Sediment % age	Cumulative % age
-6	501.10		0.00		
-5.5	500.35		0.00		
-5	545.38		0.00		
-4.5	565.82		0.00		
-4	566.56	571.32	4.76	1.39	1.39
-3.5	532.45	545.62	13.17	3.84	5.23
-3	531.74	548.66	16.92	4.94	10.18
-2.5	513.16	526.98	13.82	4.03	14.21
-2	494.34	503.60	9.26	2.70	16.92
-1.5	465.48	468.76	3.28	0.95	17.87
-1	472.12	477.76	5.64	1.64	19.52
-0.5	454.27	462.74	8.47	2.47	22.00
0	437.46	449.69	12.23	3.57	25.57
+0.5	415.84	436.67	20.83	6.08	31.65
+1	401.10	438.55	37.45	10.93	42.59
1.5	365.77	444.39	78.62	22.96	65.56
2	361.72	406.34	44.62	13.03	78.59
2.5	357.33	414.47	57.14	16.69	95.28
3	350.03	358.74	8.71	2.54	97.83
3.5	351.33	355.44	4.11	1.20	99.03
4	339.67	344.25	1.58	0.46	99.49
Pan 1					
Pan 2					
Pan 3	340.61	342.35	1.64	0.45	

(% age finer than 4Ø)

$$V = \frac{2}{9} \frac{(d_1 - d_2) g r^2}{\eta}$$

where V = settling velocity (cm/sec)

d_1 = density of the particle (gm/cm^3)

d_2 = density of fluid (gm/cm^3)

g = gravity acceleration (gm/cm^2)

r = radius of particle (cm)

η = viscosity of fluid (poises)

governs the frictional resistance of a fluid to a particle falling through it. For particle size analysis it is the variable r (particle radius) which is required, which may be calculated from the above equation

since $V = \frac{h}{t}$

where h = falling height (cm)

and t = falling time (seconds)

This enables the time required for a sphere of a given size and density to fall through a given height in a given medium to be calculated, if the particles are finer than 4.5Ø. The 'size' of a particle being measured is the Stokes diameter (p. 24), or the diameter of a particle which falls the same distance as a mineral sphere in the same time, through the same medium and at the same velocity (Müller 1967). Thus if the variables are known then the settling velocity and the particle size may be calculated for any suspension of sediment. A slight problem arises if the sediment is poly-mineralic, since the density chosen (d_1) must be that of the predominant particle type, but in this study a value of 2.65 was taken, since the sediments were principally composed of quartz.

The particle concentration must not be less than 1%, nor too high since that causes the particles to interfere with each other during settling. A maximum weight of 10-25 grams of sediment per 1000 ml of fluid was used for pipette analysis, the lower concentration often giving more accurate results, (Irani and Callis 1963).

Fig. (10) Record sheet for pipette analysis

SITE	SAMPLE NO.	LOCATION	DATE
Pre Treatment	Previous analysis	NOTES	
Weight sieved	Weight sedimented	Dispersant Calgon	Cylinder volume 1000 ml
Pipette volume 25 cc	SG of particles 2.65	Temperature 20°C	

Clock time	Withdrawal time	Ø value	Depth	Wt.dish	Wt.+sed	Wt.sed.
	0 1 56	4.5	20			
	(restart)					
	0 1 56	5	10			
	0 3 52	5.5	10			
	0 7 42	6	10			
	0 15 0	6.5	10			
	0 31 0	7	10			
	1 1 0	7.5	10			
	2 3 0	8	10			

The density and viscosity of the sedimentation fluid varies with temperature, so in this study the temperature of the sedimentation cylinder was controlled at 20°C, by the use of a water bath, and both values taken as 1. Atmospheric pressure was assumed and gravity acceleration conventionally taken as 980gm/cm^2. The settling time of particles at fixed temperatures and fall heights were calculated from Table 6, and the particle size distribution of the sediment suspended was determined by withdrawing samples at separate pre-arranged time intervals.

The pipette apparatus used was a modified version of the Andreasen (Andreasen et al 1929) connected to a vacuum pump. The method is rather time consuming but accurate, and measures concentration changes within the settling suspension according to Stokes Law. The principle governing pipette analysis states that if two particles begin falling at the same time the larger will fall faster than the smaller. Pipette samples taken at constant depth will therefore contain fewer and fewer coarse particles as settling time increases. The first sample, or initial aliquot, will determine the quantity of material in suspension, if this is not already known. (Creager and Sternberg 1963). This assumes total dispersion and instantaneous withdrawal of samples, neither of which is quite realistic but which do not contribute any substantial errors. Table (6) shows the withdrawal heights and times used. Since there are large time-gaps between the sample withdrawals in the finer grades the apparatus could be left for long periods in the constant temperature waterbath. Pipette analysis was taken down to 8 Ø, the silt/clay boundary, although analysis down to 11 Ø is possible.

The modified Andreasen pipette was mounted on a stand with a moveable rack (Fig. 11). The pipette bulb, of 25cm^2 volume, was connected to the reservoir by a two-way tap, permitting samples to be drawn up from a predetermined depth and then allowed to flow through an outlet tube into an evaporating dish without disturbing the sedimentation cylinder. The

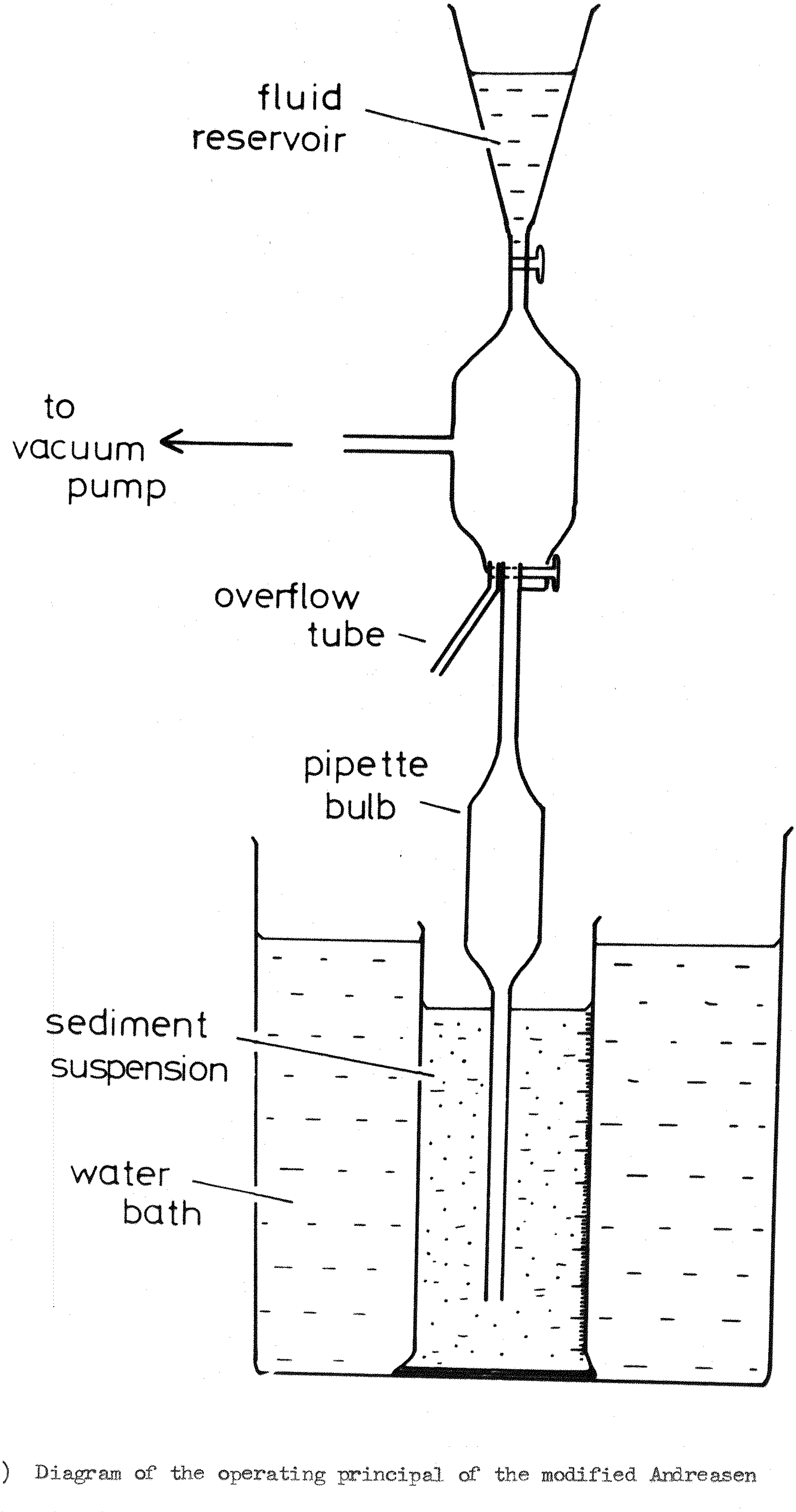


Fig. (11) Diagram of the operating principal of the modified Andreasen pipette.

Table (6). Particle settling times. (after Galehouse 1971).

Temperature = 20°C; Specific gravity of particle = 2.65					
Particle size (finer than Ø units)	μm	Withdrawal depth (cm. below surface)	Withdrawal time		
			Hours	Minutes	Seconds
4	62.5	20	-	-	58
4.5	44.2	20	-	1	56
5	31.2	10	-	1	56
5.5	22.1	10	-	3	52
6	15.6	10	-	7	42
6.5	11.0	10	-	15	-
7	7.8	10	-	31	-
7.5	5.5	10	1	1	-
8	3.9	10	2	3	-
8.5	2.8	10	4	5	-
9	1.95	10	8	10	-
9.5	1.40	10	16	21	-
10	0.98	10	32	42	-

suspension reservoir and outlet tube were then flushed through with water from the clear fluid reservoir after each reading. The pipette was mounted in a clamp on a moveable rack, attached to a stand calibrated in mm. The side arm was joined to a simple suction pump, consisting of a vacuum tube joined to a tap, which could establish sufficient suction to withdraw a sample very fast. The errors inherent in using this type of apparatus, for example the 'shock' effect due to the impact of the pipette into the suspension, or the small sampling error resulting from the retention of sediment in the tube, were less significant than in any other sedimentation method, for example using a hydrometer. The sample for analysis was either obtained by splitting and pretreating a field sample of very fine material, and then passing it through a 4ϕ sieve, or else was already available from the fine fraction of a dry sieve analysis. It was dispersed with 15 ml of 10% 'Calgon' (sodium hexametaphosphate) in distilled water, making a total volume of 1000 ml. The apparatus was assembled as shown in Fig. (11), and a series of clean evaporating dishes were weighed. Samples were withdrawn at selected intervals and heights, the experiment being re-started each time, if the time interval between readings was very short, by re-stirring with a mechanical stirrer. Timing was carried out by starting a stopwatch at the same moment that stirring finished. The with-drawal heights were calculated by carefully lowering the pipette in the stand until the tip just touched the surface of the suspension, the rack could then be moved down to the appropriate withdrawal depth using the calibrated stand. The sedimentation cylinder was allowed to stand until the temperature had reached 20^{o}C, before being placed in the water bath. A samples was withdrawn by sinking the pipette to the required depth and opening the tap, which filled the bulb by suction. As soon as the bulb was filled the tap was closed, at a time exactly coinciding with the calc-ulated withdrawal time. The vacuum pump was then turned off, the sample emptied into an evaporating dish and the outlet tube washed through.

Samples were evaporated to constant weight in a drying cabinet, and placed in a dessicator before weighing. All results were noted on the standard worksheet (Fig. 10), and then processed using the SIEVETTE program.

Section 2. Methodology (Implements)

2.1 Information collection

The first stage in the study of the implement assemblages was the evaluation of data on the original implement distribution and the present location of finds. The survey of Roe (1968) was found especially useful, and was supplemented by other papers, such as Calkin and Green (1949) where find spots were also reliably and accurately recorded. Further information was gathered from museum accession registers and local collectors, a frequent source of accurate but unpublished material. The major difficulty encountered in trying to make a comprehensive survey of find locations was the lack of systematic recording, even in quite recently-assembled collections. Very often the records only describe the find of a series of implements from an imprecise location, seldom giving a grid reference or locating the material by the use of sketch maps or sections. There were, however, some notable exceptions to this rule, for example the excellent work of Poole on the Great Pan Farm material (Poole, 1924), or of Blackmore on the Fisherton area (Blackmore, 1867).

Wherever an accurate reference to an implement find spot was traced this was then checked on the ground, searching for extant sections or exposures and examining their correlation with published material. Since many of the implement finds came from gravel a surprisingly large number of sections were still available for study, although some had been filled in.

Where the implements were not exactly located it was necessary to use great care in deciding where the original finds were likely to have come from, since it was tempting to relate a vaguely-provenanced group to a visible section, if the evidence warranted this. Early workers often referred to find spots only by local names, and these were, in many cases, impossible to identify in the area today. Much detective work was needed in chasing portions of the same assemblage in different museums, or in reconstructing the position of old gravel workings where important collections had been made, from maps in use at the time. Where the location of an assemblage was not sufficiently precise, or where there was no visible section, the implements were simply described and commented on, for example at Bleak Down, on the Isle of Wight (p. 159). There were sometimes, however, strong reasons for connecting a less well provenanced implement group with a group of better provenance, the limitations of the evidence in the case of the former being born in mind. An example of this occurs at Warsash, where the Mousterian of Acheuelean Tradition assemblage designated 'Group A' was ~~with~~ from the 7.5 m beach, whereas another implement assemblage, typologically identical but not so accurately provenanced, and described as 'Group B' was considered as part of the same general collection. This connection was supported by detailed examination, but the evidence was still not felt to be strong enough to permit the groups to be combined.

After the literature search and preliminary fieldwork had been undertaken all the reported find spots were examined, and local workers interviewed if necessary. This resulted in a series of supplementary implement finds from the original locations, and a great deal of additional information being obtained. The product was a detailed analysis of the distribution of implement finds in the area, made on a series of base maps, with the find spots being subdivided on the basis of their accuracy. This information was superimposed on geological maps (1" Drift editions), to examine the correlations between the distributions of implement finds and the distribution of the drift deposits, in particular between the raised beach segments and their industries. As described above (p. 1) the 7.5m raised beach was selected for a more detailed study for a variety of reasons, not least because it was firmly associated with a series of distinctive assemblages which on detailed examination proved to be Mousterian of Acheulean Tradition.

These Mousterian industries were then studied in detail, and the results combined with those of an analysis of their matrix deposits, where reference had been made to precise stratigraphic contexts, or where these could be confirmed by field examination. The constituents of the assemblages were

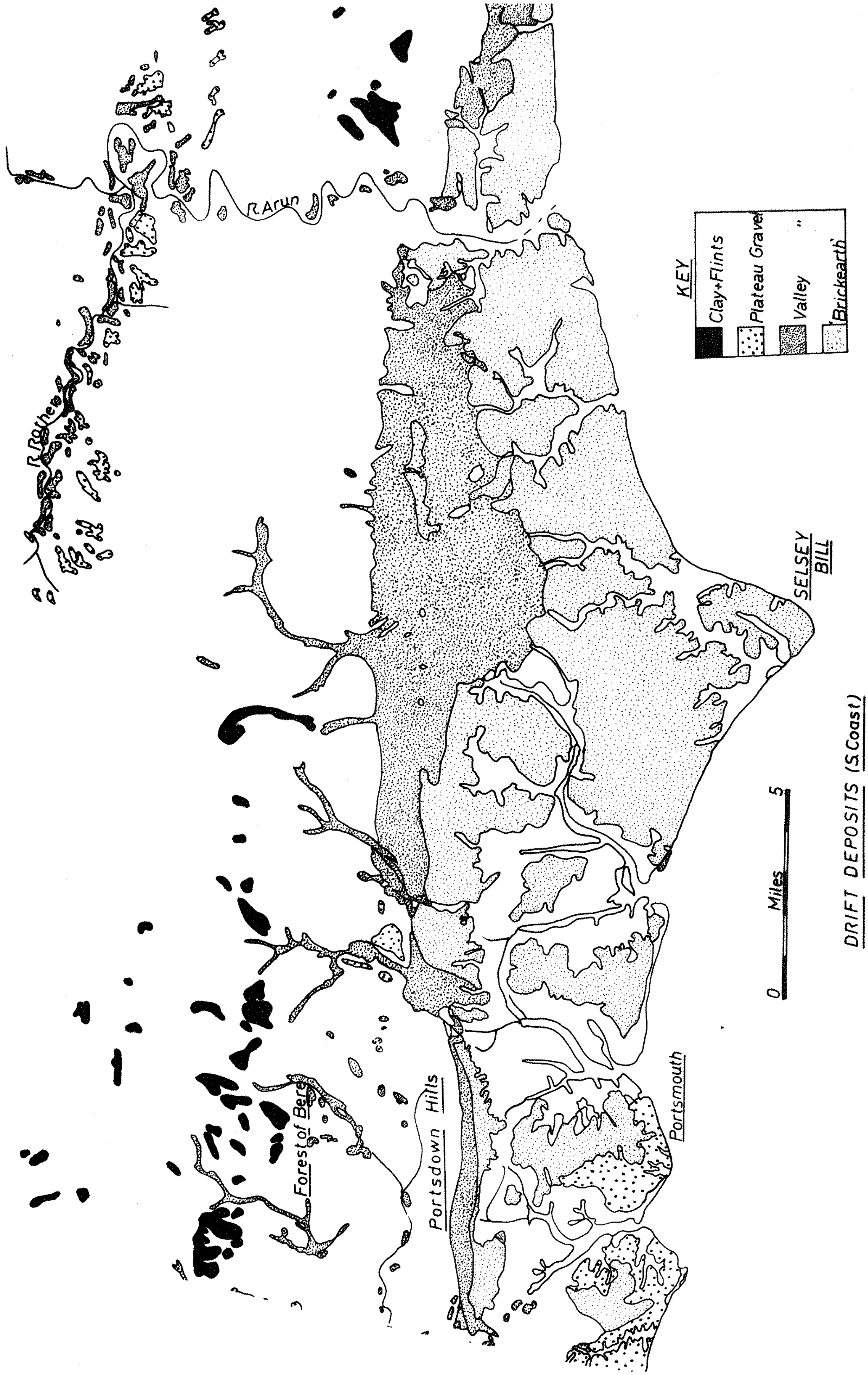


Fig. (12) Drift deposits of the south coast.

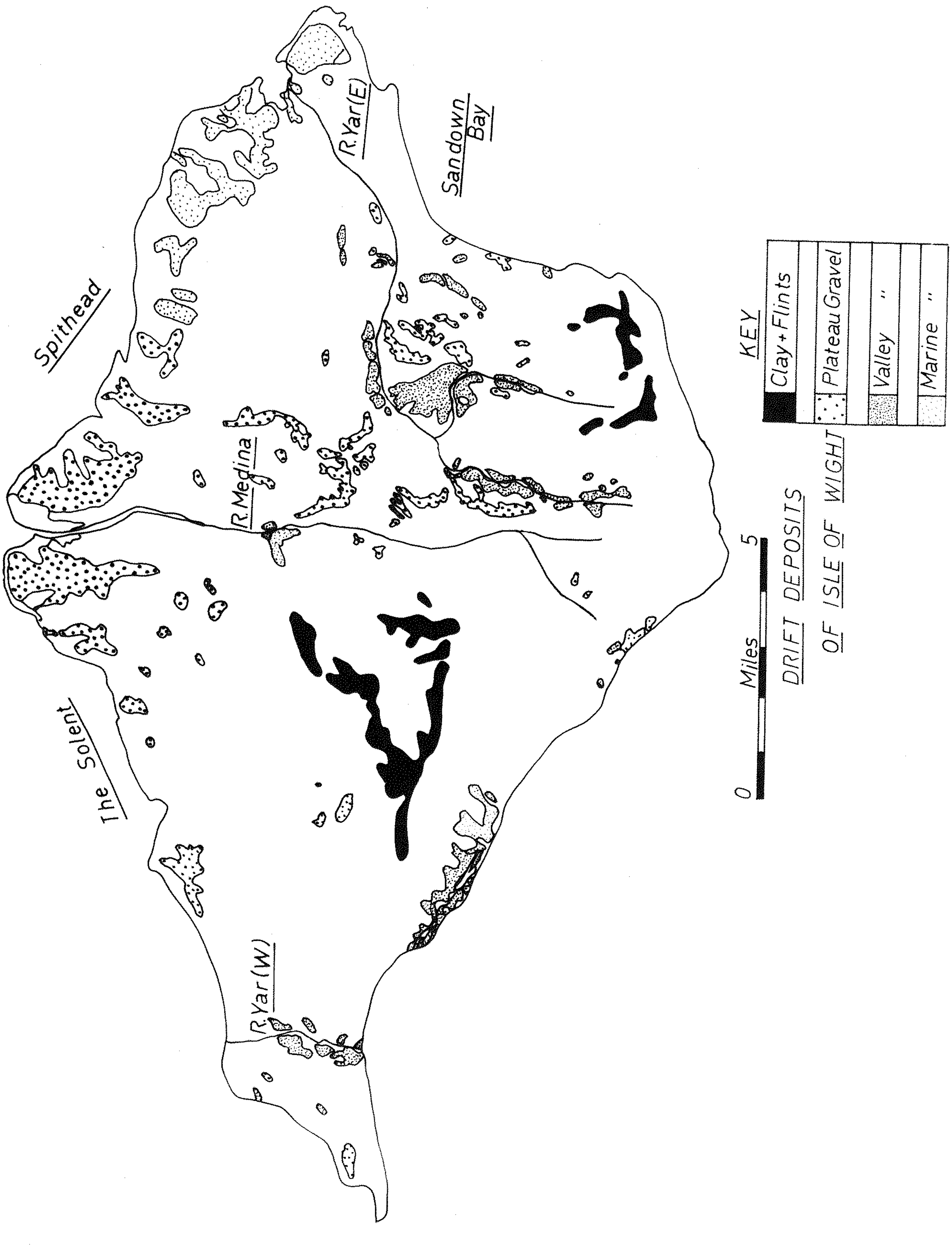


Fig. (13) Drift deposits of the Isle of Wight.

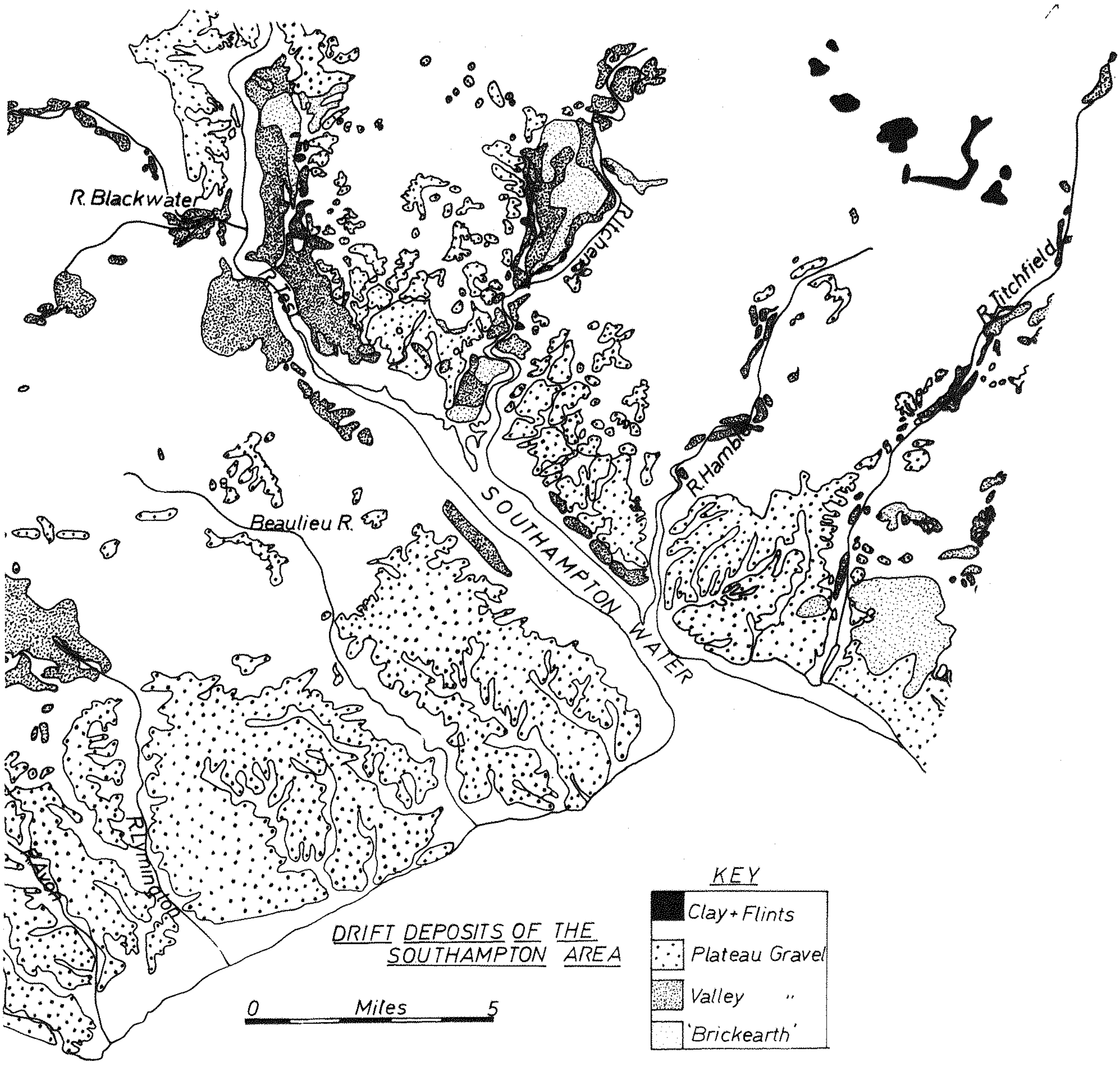


Fig. (14) Drift deposits of the Southampton area.

Fig. (15) Drift deposits of the lower Avon valley.

often widely scattered between various museums, and great care had to be taken when claiming related or identical find spots, which was only done if precise grid references were available for each fragment of the collection. Where the evidence for detailed provenance was not sufficient the assemblage was not included in the detailed study, and this has probably resulted in an under-estimation of the numbers of artifacts from particular find spots.

After the assemblages had been provenanced and identified the morphology and typology of their constituents was considered, and combined with an examination of the natural abrasion that each artifact had received.

2.2 General features of the assemblages

The general features noted included a description of the raw material of each artifact, which was frequently some kind of flint, but occasionally chert. At Great Pan Farm, where the gravels containing the implements consisted principally of chert, a specific type of flint appeared to have been deliberately imported for the manufacture of implements, probably for its attractive colouring and the fact that it was easier to work than the chert. The presence of large cortex areas on artifacts was also noted, and the incidence and type of patination. Patination studies must be used with care, since percolating groundwaters do not affect each implement in the same way, and may result in patination inconsistencies within an assemblage, but in some cases it may provide additional useful evidence. Weathering was also noted, for example the thick creamy-white chalky patina on the Holybourne material, and signs of frost cracking or ~~marine action~~ (the crescent shaped impact craters caused by percussion in a high energy environment). The type and degree of retouch, the use or neglect of the Levallois technique or other specific manufacturing methods, and the use of a soft hammer were also noted, as was the presence of waste flakes, cores, or hammerstones in an assemblage or specific features such as the manufacture of all handaxes from flakes. All these features assist in establishing and describing the nature of the assemblage.

2.3 Morphological description

After the typological affinities of the implement had been described, and its raw materials, manufacturing technique and special features considered, it was then measured. The three axes (a, b and c) were measured either on a fixed block, or by the projector method described above (p. 13) and the results expressed as the axial ratios a/b and b/c. Each implement was then weighed and its degree of abrasion quantified (p. 45).

This resulted in a series of standard parameters describing each implement, namely its weight, abrasion and axial measurements. Each variable thus obtained was plotted against each of the others on bivariate scatter diagrams, the values for any given assemblage being shown on the same diagram. Any groupings that emerged were tested by correlation and regression co-efficients. The mean, variance, standard error of the mean, skewness and kurtosis were then calculated for the values of each parameter among the component parts of the assemblage, and used for inter-sample comparison. These numerical results were then combined with a description of the typology of the group to permit conclusions about the nature and validity of the assemblage and sub-groups to be drawn.

2.4 Implement abrasion

The implement groups considered in this study came from three basic types of context, marine or fluviatile deposits (varying in texture from cobbles to fine silt), periglacial deposits such as coombe rock, or from other drift deposits, as for example 'brickearths' or clay-with-flints. The nature of the abrasion which the implement had received was related to the type and hardness of its raw material, its shape, and the transport and depositional processes to which it had been subjected. Some implements were recovered from matrix deposits which had clearly formed under periglacial conditions, and these typically showed a thick chalky-white patina and intensive frost cracking. Unless these implements had been derived from other deposits and were not thus truly 'in situ' it was rare to find that their ridges had been abraded, although they were often heavily cracked. The grinding and polishing action observed on artifacts deposited in a fluid medium was absent, and the implement ridges showed a maze of fine lines and fresh breaks attributable to frost action. The nature and type of abrasion which an implement receives under marine or fluviatile conditions varies with the particle size distribution of the abrasive and the velocity of the current responsible for transport and deposition. It follows, therefore, that a collection of artifacts recovered from fine-grained silts are likely to be less heavily abraded than implements recovered from coarse cobbles, although their abrasion time and distance travelled might have been similar. It was often thought that the inclusion of an artifact within coarse material automatically meant that it had been redeposited, although this does not now seem to be the case. One problem presented during a consideration of implement abrasion was the need to develop some adequate descriptive terms, on a quantitative basis, and to analyse the actual processes which produced the abrasion. The results obtained from this type of experimental approach could then be applied to the assemblages under discussion.

2.5 Experimental Abrasion

It was felt that there was a need for a more accurate measure of the natural abrasion (or 'wear') which an implement has received, to replace such loosely-employed terms as 'fresh' or 'heavily worn'. Such a proposal does, however, meet with a number of problems, for example the selection of measurable points on the implement which have not been contaminated by wear occasioned by use of the tool. The widths of the ridges between flake beds increases as the implement becomes naturally abraded, and if such widths are measured one can obtain an index of the relative amount of abrasion that the tool~~s~~ has received, after its manufacture and before its excavation. However this relative measurement would have little meaning unless one could relate it to some fixed standards, and this was the object of the experiments described below.

Mr. M.H. Newcomer (Institute of Archaeology, London), kindly furnished the writer with a series of freshly-made handaxes of Acheulean type, copied from specimens of different shapes found in Hampshire gravels. These handaxes were described using the methods of Roe (Roe, 1964), and drawn and photographed in the fresh state. Each was then divided into imaginary thirds so that the abrasion of the tip, middle and butt could be compared, and a number of fresh ridges were chosen in each of these zones.

The initial widths of these ridges were then measured by placing the specimens under a microscope, using X 75 magnification. Two incident lights were arranged to illuminate the ridge being examined, the width of which could be measured to within 0.1μm, by using a calibrated eyepiece. Seminov (1964) recommends various chemical coatings to improve the optical properties of flint under the microscope, but it was found that these tended to obscure the ridges, which could be seen best in the natural state.

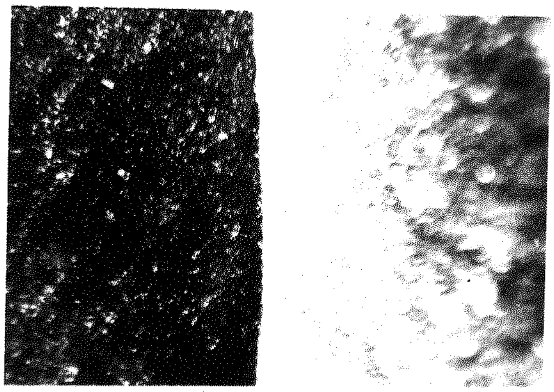
The fresh flint implement was then placed in a tumbling apparatus with water, and a known quantity of sandy Pleistocene river gravel, of measured particle size distribution, to act as an abrasive. The tumbling mill consisted of a large heavy plastic barrel, with a rubber lining to prevent abrasion from the sides, fitted with a watertight lid and rotated once every 2.35 seconds by an apparatus similar to that used for the polishing of gemstones. The specimen was then abraded for a total of 100 hours, ridge widths being measured at the same point after 0.25, 0.5, 0.75, 1,5,10,20, 40,60,80 and 100 hours. The process was then repeated with five other implements of different shape, and with abrasives of different textures from sand to clay.

It is not claimed that this apparatus exactly reproduces conditions in a Pleistocene river, but the use of a tumbling mill for this experiment was preferred to the dry or wet sandblasting methods used by Kuenen (1947) to abrade rock, or to the revolving apparatus devised by the same writer, (Kuenen 1956). The tumbling mill theoretically enables equal wear to be received by all parts of the object, if it is made large enough for the artifact to rotate along all its axes. Under natural conditions the abrasion rate is proportional to the relative hardness of the flint, the velocity of the current, the shape of the implement and the amount and particle size distribution of the abrasive. This experiment therefore only reproduces one set of conditions, leaving a large number of other possible permutations. Its importance lies in the proof of the feasibility of quantifying abrasion, and in an understanding of how an implement abrades, rather than in an exact duplication of river conditions.

Fig. (17) shows the pattern of ridge width increase in two typical specimens, an ovate and a pointed handaxe, abraded in sandy gravel. None of the other implements produced patterns that differed substantially from these, and this in itself is important as one would, perhaps, except greater variations in the abrasion rates of handaxes of different types. The graphs are drawn with the ordinate on a logarithmic scale, which has the advantage of expanding the distribution for the first, more crucial, periods. The readings for the tip and middle of the implements lie roughly in a straight line. The butt end of all the specimens abrades very rapidly at first, but thereafter has a wear pattern very similar to that observed in the other zones.

2.6 Measuring abrasion

As expected, the ridges abraded differently in different abrading media, and the degree of abrasion increased with time. Different patterns of wear could be seen to emerge, seemingly unrelated to the quantity of



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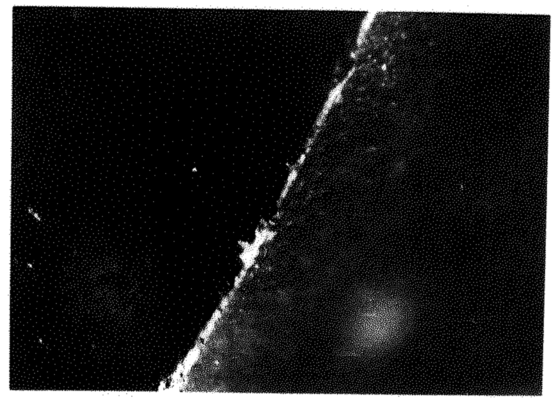

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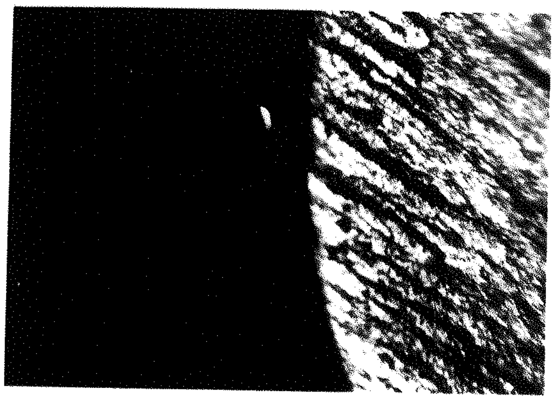

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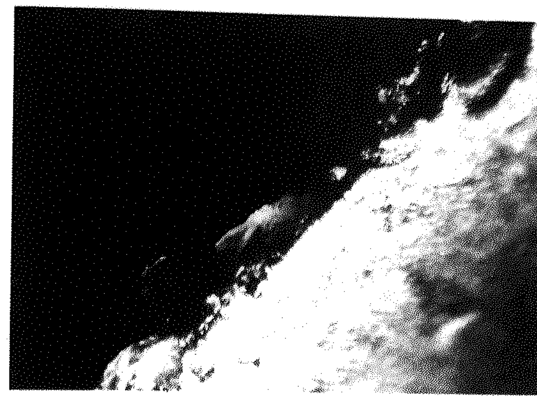

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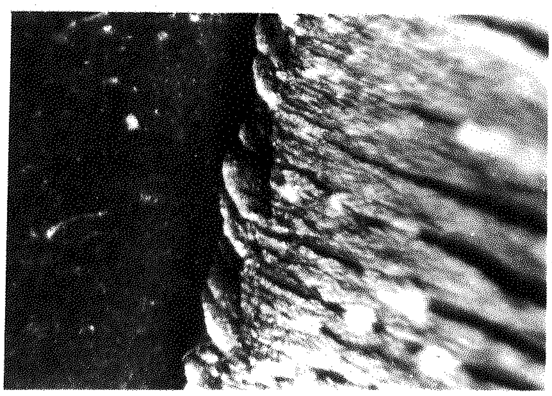

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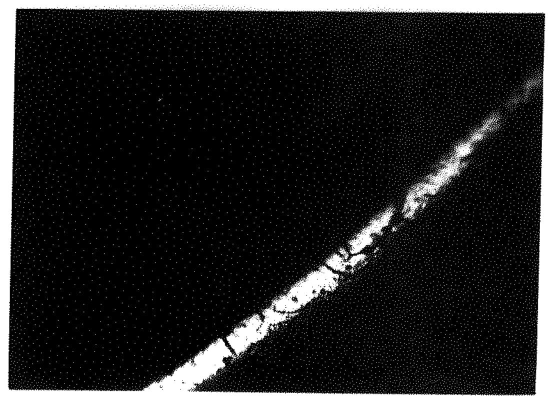

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Fig. (16) Photomicrographs of the appearance of experimentally abraded ridges, ~~magnified~~ originally photographed at x 75

(1) Fresh ridge, average width 5μm.

(2) Appearance of stress cracks, average width 15μm.

(3) A 'braided' ridge, average width 53μm.

(4) A 'braided' ridge ground in fine clay, average width 34μm.

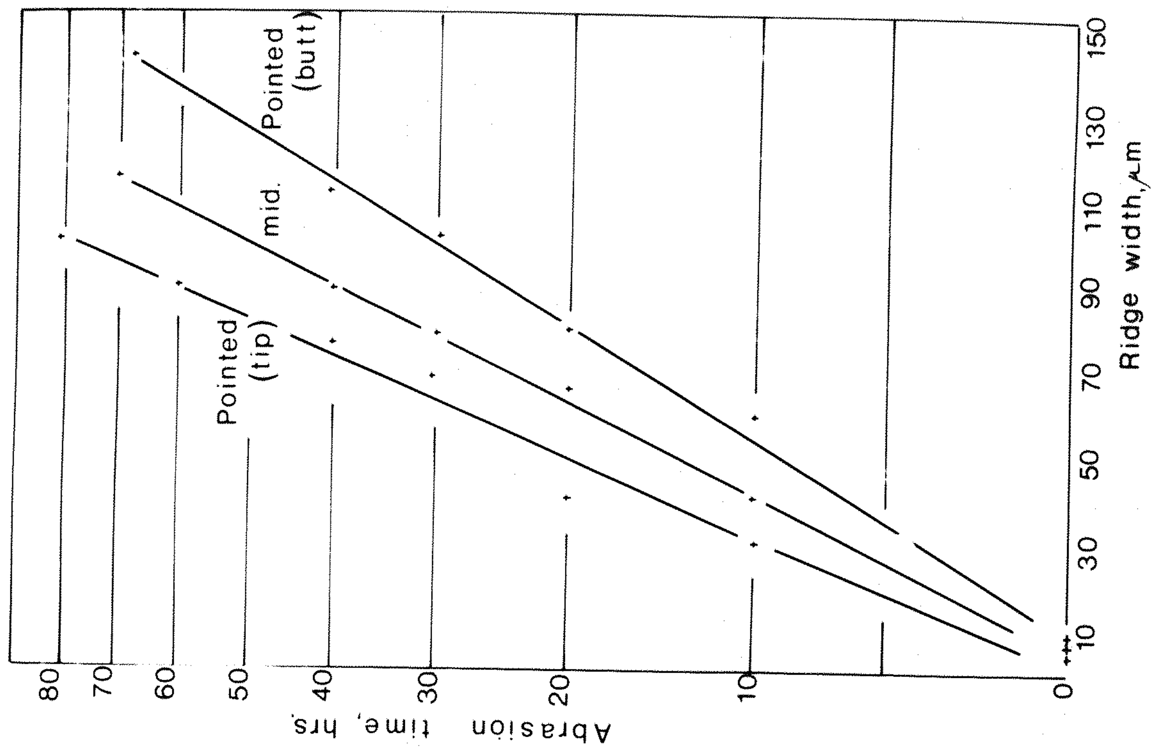
(5) Ridge with percussion craters, average width 8μm.

(6) Heavily abraded ridge, Average width 279μm.

fluid present or the shape of the implement, but as a function of the type of abrasive and the length of time involved.

Fig. (16) show stages in the natural abrasion of a ridge. They are intended to illustrate the process and act as standards for the terminology employed. (16·1) shows the appearance of a fresh ridge in a photomicrograph taken at a magnification of X 75, in incident light. The ridge width here averages 5 μm. The abrasion process consists both of chipping at the implement by other natural and humanly-worked nodules during transport, and a slow grinding down of the ridge by an abrasive consisting of the finer elements carried by the stream. The chipping process is much more active soon after the beginning of the abrasion, but continues throughout the process at the places nearest to the centre of gravity of the nodule. Initial stages are marked by the appearance of stress cracks (16·2) which then develop a 'braided' appearance. This braiding is the result of pebbles hitting the ridge at an acute angle, striking off microscopic flakes. The braided ridge is then ground away (16·4), resulting in a gradual increase of ridge width, irrespective of the flaking angle of the ridge. An alternative sequence involves the rapid appearance of percussion craters, caused by the impact of a heavy pebbles (16·5) but the final product is always a smooth ridge crossed by hairline cracks (16·6). Such a worn ridge reaches a width of 4mm in heavily abraded specimens. The nature of the abrasion process is largely a function of the type of abrasive, and it is possible to distinguish implements which have been abraded in different environments.

If the abrasive is fine grained, silt or clay, the relative abrasion is very slow, but the rounded appearance of the ridge (16·4) is attained very quickly. Table (7) presents a correlation of the observed ridge widths and the commonly used verbal descriptions of abrasion. An 'abrasion index' value is suggested, based on these metrical criteria, facilitating easy quantification of results.



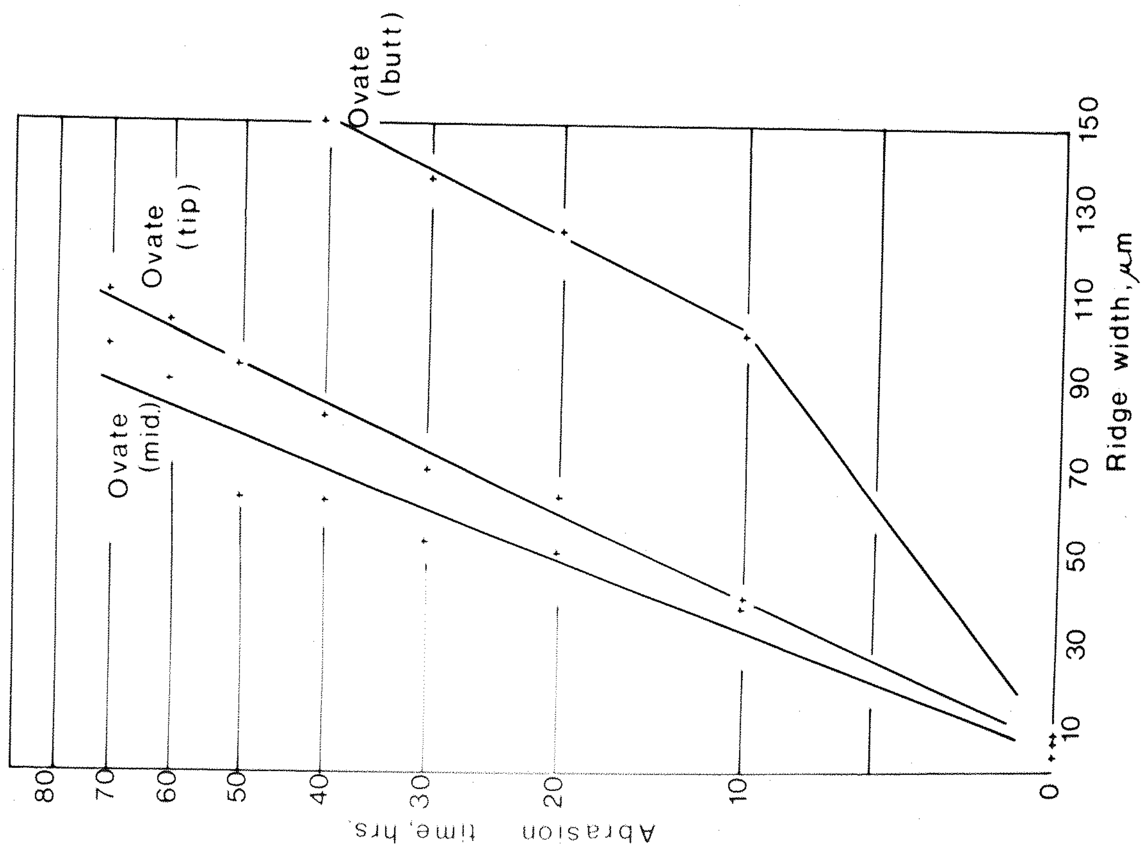


Fig. (17) Graphs showing ridge width increase with time in experimentally abraded handaxes.

(a) Ovate handaxe.

(b) Pointed handaxe.

After these observations had been made and the index developed time was spent in an examination of well-documented implement assemblages from known sedimentary contexts, and a close correlation was observed between the experimentally obtained wear patterns and the patterns observed on ancient implements. This provided support for the experimental results. Each implement included in the present study was then examined and measured, and the abrasion characteristics noted. The method proved useful in defining the depositional environment of stray artifact finds, by illuminating the textural character of the abrasive material which must have been present in the stream, and in distinguishing groupings within apparently homogeneous artifact populations. An example of its application may be seen in the Great Pan Farm assemblage (p. 109). Abrasion results were generally expressed as histograms (p. 95), or the index values were combined with morphological analysis in parameter scatter diagrams constructed for each assemblage. (p. 94).

2.7 Typology

The typological study of these assemblages initially involved the examination of each individual implement. Handaxes were classified numerically according to the table shown below (Table 9), on a shape basis, the classification being based on those of Bordes (1953) and Wymer (1968) with subdivisions made for commonly-observed patterns of manufacturing technique, such as the <u>tranchet</u> sharpening blow. Choppers, picks, cores, retouched and unretouched flakes were also classified, and the percentages of each type of artifact computed for each assemblage.

The Mousterian lithic industries have been the subject of much recent quantitative work, resulting in their subdivision into the different Mousterian variants, the Ferrasie, Quina, Denticulate and Typical Mousterian and the Mousterian of Acheulean Tradition. (Bordes 1973, 1961, Mellars 1967, 1969). The relative chronology of these variants has been discussed by

Table (7) Correlation between observed ridge widths and commonly-used verbal descriptions. (Appendix)

Observed ridge width (μm)	0-10	10-20	20-50	50-100	100-200	200-300	300+
Common verbal description	Mint condition	very fresh	fresh	slight abrasion	abraded	heavily abraded	very heavily abraded
Suggested index value	0	1	2	3	4	5	6

Mellars (1967), and Bordes (1973). They are distinguished by technological and typological attributes, present in different degrees within the variants, which are best viewed as parts of a single evolving techno-complex, rather than a series of distinct sub-cultures. Bordes classifies Mousterian tool types into 63 different variants, a system which was used for the assemblages considered in this study, and which is shown below in Table (8). The system uses technological and typological attributes to define the types, characterising assemblages by the relative proportions of implements present.

Controversy exists at present over the significance of the various industries. One school of thought, following Bordes, views the industries as the products of different cultural traditions (Bordes 1973), with culture groups co-existing in the same area, but having different tool making traditions. The second school holds the view that the different assemblages are the result of different activities, and that the tool assemblages themselves represent specialised activities or activity complexes (Binford and Binford 1966, 1969).

The existence of the variant called 'Mousterian of Acheulean Tradition' was first recognised by Peyrony (1930) and more closely defined by Bourgon (1957), and Bordes (1961). It is a stoneworking tradition related to the Acheulean, bearing a complex relationship to the Micoquian and Final Acheulean cultures. Collins (1970) considered that it is the only Mousterian variant significantly present in Britain. Mousterian of Acheulean Tradition (often abbreviated to M.A.T.) assemblages are typified by cordiform handaxes, backed knives and a racloir frequency never greater than 50%, together with a comparatively high percentage of denticulate tools. The tradition is divided (Mellars 1969) into Mousterian of Acheulean Tradition Type A, (with a variable percentage of handaxes and racloirs, and many denticulates) and Mousterian of Acheulean Tradition Type B (with a low percentage of racloirs, many Lavallois points and backed knives). All known occurrences of Type B are stratigraphically later than Type A, for example at Le Moustier and Pech de l'Azé in the Dordogne (France). The two subdivisions should be considered as variants of a single evolving tradition, although Collins and Collins (1970) consider that the M.A.T. should be viewed as a seriation continuum, rather than a strictly bipartite division. The same writer created a number of metrical indices for the definition of M.A.T. handaxes, including an 'elongation index' ($= \frac{100 \times \text{breadth}}{\text{length}}$) which distinguished M.A.T. handaxes from those produced by other cultures. The M.A.T. handaxes from Le Moustier have elongation index values of about 73, whilst the Acheulean implements from Hoxne (Suffolk, England) have values averaging about 61. The boundary distinguishing the traditions would appear to fall at about 72. ~~Acheulean~~ Handaxe industries earlier than the ~~last glaciation~~ Devensian are usually distinguished by the presence of straight or concave sided handaxes, which can be described by the 'CV' index (Collins, 1970) where

$$CV = \frac{\text{Total concave sides}}{\text{Total concave + convex + straight sides}} \times 100$$

The CV index values for the Lower Middle gravel industries from Barnfield Pit (Swanscombe) is 30.6, and Collins (1970) considers that a value of below 75 is indicative of a non M.A.T. assemblage. These index values have been calculated for the Mousterian handaxes considered in this study.

The British Mousterian of Acheulean Tradition industries are characterised by the presence of flat semi-cordiform handaxes known as the bout coupé type (Roe 1968, Shackley 1975(c), ~~Appendix~~). They may be triangular or D-shaped (Fig. 72), and are always very well refined, often completed using a soft hammer. Collins (1970) identifies the form as his 'Paxton' type, which has an angular butt and straight or convex sides. Even before the existence of definite British Mousterian industries had been confirmed, the connection between the bout coupé handaxe and artifacts of Levallois facies had been realised, and Roe (1967) stated that 'there is a strong case for supposing that the distribution of bout coupé handaxes is mainly a reflection of the movement over open ground of Mousterian man'.

Unfortunately many of the bout coupé handaxes are stray finds, but where-ever the form is associated with an implement assemblage that assemblage is Mousterian of Acheulean Tradition. One of the first features that led to the assemblages being considered in this study to be defined as M.A.T. was the plentiful occurrence of bout coupé axes, as well as other equally characteristic Mousterian tool forms.

The bout coupé form acts as a cultural and typological marker for the beginnings of the British Mousterian industries, and enables correlations to be made between the rather crude provincial variant of the tradition present in Britain and the classic, better-made series occurring in France and north-western Europe. The bout coupé provides a chronological and typological datum line for the arrival of Mousterian man. Smith (1926) and Calkin and Green (1949) illustrate typical forms of the implement, which is quite unmistakable, with carefully flaked corners and a straight or slightly convex cutting edge. Occasionally a gently twisted profile occurs, although a straight edge is more common.

The Mousterian industries present in Britain are poor in comparison with Continental assemblages, but there are several recognisable M.A.T. sites, notably Oldbury (Kent), Kents Cavern (Devon) and La Cotte de St. Brelade (Jersey). This study considers in detail the further series chiefly associated with the 7.5m raised beach in southern England, all of which include bout coupé axes. This trebles the number of acknow-ledged British M.A.T. sites, and in addition recognises a number of occurrences of small artifact groups whose relationship to the main tradition is slightly more nebulous, for example Fisherton (Wiltshire) or Bleak Down (Isle of Wight). The stratigraphy of the British M.A.T. cave sites is sparse and poorly developed when compared with the Contin-ental material, and the implements are often thick, crude and 'provincial' in appearance. The lack of systematic early work on many of the import-ant assemblages has led to the loss of much material, often unpublished,

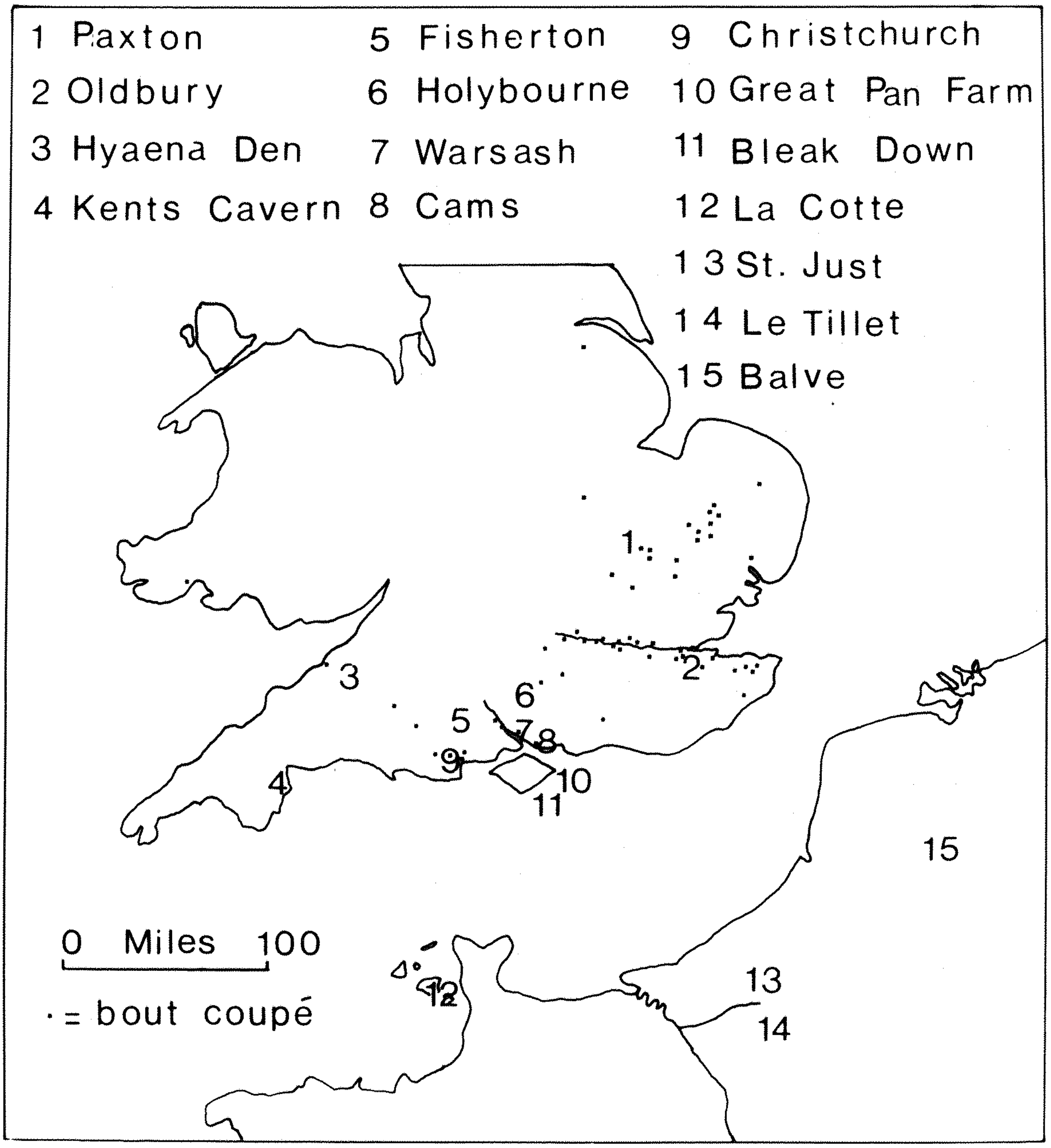


Fig. (18) Location and distribution of the sites studied, together with stray finds of bout coupé handaxes; bout coupé distribution after Roe (1967) and Collins (1970).

and it was in many cases difficult to extract descriptions of the implements from the original excavation reports (e.g. p. 64).

Due to the small size of the assemblages it was felt that the calculation of many of the descriptive indices of Bordes (1972), for example the Levallois, Quina and backed knife indices, was not justified. The methods rely heavily on the construction of cumulative percentage diagrams, and were developed with regard to the vast Perigordian Mousterian collections. They are too sophisticated for the rather poor British assemblages, and a simpler typological approach has therefore been preferred.

Table (8) Identification of Mousterian implement types

Bordes type no. (Bordes 1953)	Implement description.
1	Typical Levallois flake
2	Atypical Levallois flake
3	Levallois point
4	Retouched Levallois point
5	pseudo-Levallois point
6	Mousterian point
7	Elongated Levallois point
8	Limace
9	Single straight racloir
10	Single convex racloir
11	Single concave racloir
12	Double straight racloir
13	Double straight/convex racloir
14	Double straight/concave racloir
15	Double convex racloir
16	Double concave racloir
17	Double convex/concave racloir
18	Convergent straight racloir
19	Convergent convex racloir
20	Convergent concave racloir
21	Offset racloir
22	Straight transverse racloir
23	Convex transverse racloir
24	Concave transverse racloir
25	Racloir on ventral surface
26	Abrupt retouch racloir
27	Racloir with thinned back
28	Racloir with bifacial retouch
29	Alternate retouch racloir
30	Typical end-scraper
31	Atypical end-scraper
32	Typical burin
33	Atypical burin
34	Typical piercer
35	Atypical piercer
36	Typical backed knife
37	Atypical backed knife
38	Natural backed knife
39	Raclette
40	Truncated blade
41	Mousterian tranchet
42	Notch
43	Denticulate
44	Bec burinant alt.
45	Ventrally retouched piece
46	Abrupt retouched piece (thin)
47	Alternate retouched piece (thick)
48	Abrupt retouched piece (thick)
49	Alternate retouched piece (thin)
50	Bifacially retouched piece

Table (8) contd.

51	Tayac point
52	Notched triangular piece
53	Pseudo microburin
54	End notched piece
55	Hachoir
56	Rabot
57	Tanged point
58	Tanged tool
59	Chopper
60	Inverse chopper
61	Chopping tool
62	Divers
63	Leaf shaped bifacial tool

Table (9) Classification of handaxes

Handaxe shape	Identification No.	(made on flake)	(with twist)	(backbend)	('tranchet')
Pointed triangular	100	125	143	160	178
Sub-triangular	102	127	145	162	180
Ogivo-triangular	103	128	146	163	181
Ficron	104	129	147	164	182
Lanceolate	105	130	148	165	183
Micoquian	106	131	149	166	184
Cordiform	107	132	150	167	185
Long cordiform	108	133	151	168	186
Sub cordiform	109	134	152	169	187
Long sub cordiform	110	135	153	170	188
discoid	111	136	154	171	189
ovate	112	137	155	172	190
limande	113	138	156	173	191
Amydaloidal	114	139	157	174	192
Cleaver	115	140	158	175	193
Flake cleaver	116	-	159	176	194
Abbevillian type	117	142	-	177	195
Pick	118	-	-	-	-
Core	119	-	-	-	-
Roughout	120	-	-	-	-
Chopper	121	-	-	-	-
Unretouched flake	122	-	-	-	-
Retouched flake	123	-	-	-	-
Trimming flake	124	-	-	-	-

Table (15) Composition of some British M.A.T. Industries

Site	Grid Ref.	Publication	Associated Fauna	Total implements ever recorded	Total available	Number of axes	Number of retouched implements	Number of cores	Number of Levallois Flakes	Flakes and waste
Oldbury (Kent) (composite assemblage)	TQ 582562	Collins (1970)	X	c.600	88	43	28	0	11	316
Kents Cavern (Devon) (A2 cave earth)	SX 93456415	Campbell & Sampson (1971)	X	c.1000	45	5	14	0	15	25
Great Pan Farm (I.O.W.) (composite terrace assemblage)	SZ 507866	Poole (1924)	-	c.5000	125	55	39	1 (tortoise)	17	3
Warsash (Hants.) (composite assemblage from 7.5m terrace)	SU 507060	Unpublished	Group(1)	??	98	19	18	3 (tortoise)	47	11
			Group(2)	??	42	0	3	1	24	10
Cams. (Fareham, Hants) (composite assemblage, from 7.5m terrace)	SU 590057	Unpublished	-	c. 20	18	2(frags)	6	1 (tortoise)	3	6
Bleak Down (I.O.W.) (composite assemblage, see text)	SZ 51287	Poole (1931)	-	13	13	8	3	1	1	0
Fisherton (Wilts.) from brickearth	SU 138302	Evans (1872)	X	2	0	0	2	0	0	0

ST 532479 *Hyaena Den.* (Wookey, Somerset)	Tratman et al. (1971)	X	11	11	9	0	0	0	2
La Cotte de St. Brelade (Jersey) Wurm 'head'	Marett (1916) McBurney (1971)	X	c.15,000	9,634	174	c.3,600+	250+	??	??

Section 3. British Mousterian of Acheulean Tradition type sites.

Introduction

It is important firstly to consider the better known British Mousterian of Acheulean Tradition sites, in order to examine their chronological and typological relationships to the classic French Perigordian sites. This establishes a background and framework of reference for the littoral southern British sites under consideration. The major British M.A.T. type sites have not, on the whole, been well excavated or published, with the exception of the recent work by Collins at Oldbury, (Collins 1970) and that of Campbell and Sampson at Kents Cavern, (Campbell and Sampson 1971). The site of La Cotte de St. Brelade is here included as M.A.T., although reasons are advanced for its being considered atypical, not least because the bout coupé handaxe form, which characterises all the other British M.A.T. assemblages, is apparently absent. However the site has yielded an artifact collection with certain typological relationships to that of Bleak Down (p. 159), and it is therefore relevant. The distribution of British M.A.T. sites is shown on Fig. (18), compiled from the writers own data and information published by Collins (1970). The coastal distribution of the assemblages is most striking, and is discussed below (p. 172).

3.1 Kents Cavern

The site of Kents Cavern (Fig. 18) in Devon was first investigated on an unsystematic basis over fifty years ago, and has recently been re-excavated by Campbell and Sampson (1971) who were, however, only able to trace 26 accurately provenanced implements out of an original total of several thousand. These come from the layer of loamy cave earth designated A_2, and were associated with faunal remains. The extant industry includes four handaxes of bout coupé type, several racloirs, a denticulate tool and some flakes (Table 10). Despite the poverty of the assemblage both Campbell and Sampson (1971) and Collins (1970) considered that it is to be classed as Mousterian of Acheulean Tradition. Campbell and Sampson (1971) list the fauna from the A_2 loamy cave earth, in a table compiled from the tooth-counts given by the earlier excavator, Pengelly. As can be seen from Table (11) the fauna is dominated by cave hyaena, woolly rhinoceros and horse. It seems to include animals adapted both to sub-arctic and boreal habitats, and the authors infer from this that there may have been more than one M.A.T. horizon present in the cave, although at present there seems little evidence to support this claim. Since the fauna includes both mammoth and reindeer, severe conditions are certainly indicated, and this is confirmed by the presence of grains of the pollen of *Salix* and *Juniperus* in the associated sediments. The occurrence of cave bear, hyaena and lion would, of course, be expected in a site of this nature but perhaps the lack of small animals such as the lemming or souslik is unusual. The low percentage of deer and bovids is surprising, and perhaps emphasises cold climatic conditions.

Table (10) M.A.T. assemblage from Kents Cavern (after Campbell and Sampson 1971)

Tools	Pengelly Collection	Ogilvie Collection	Total
Cordiform and bout coupé axes	4	1	5
Burins	1	0	1
Awl	5	2	7
Side scrapers	5	2	7
Saw (denticulate)	2	1	3
End scraper	1 (frag)	1	2
Retouched flake fragments	1	0	1
			26
Waste			
Flake	9	3	12
Blade	2	0	2
Snapped flake/blade	4	2	6
Thermally fractured flake/blade	2	2	4
Fractured pebble	1	0	1
			25

Table (11) Fauna from A_2 cave earth (total tooth counts from Pengelly's diary, after Campbell and Sampson 1971)

Carnivora		Rodentia	
Crocuta crocuta	228	Castor fiber	?
Felis leo spelea	16	Arvicola terrestris/ amphibius	?
Gulo gulo	?	Microtus agrestis	?
Meles meles	2		
Canis lupus	4	Lagomorpha	
Vulpes vulpes	19	Ochotona pusilla	?
Ursus arctos	20	Lepus timidus	?
Proboscidea			
Mammuthus primigenius	17		
Perissodactyla			
Coelodonta antiquitatis	131		
Equus germanicus	309		
Cervus/Rangifer	75		
Megaloceros giganteus	25		
Bison/Bos	7		

? = species very rare

(precise number not known)

3.2 Oldbury

The extant Mousterian of Acheulean Tradition series from Oldbury is far more extensive than that from Kents Cavern. Collins (1970) has completed a series of metrical analyses of the assemblage using Bordes' methods and typology, the results of which are summarised in Table (12). This detailed comparative breakdown of the industry shows that it contains some 43 handaxes, nearly all of cordiform or bout coupé type, together with 19 other retouched pieces and nearly 500 flakes. No cores were found. The handaxes were measured using the elongation index (p. 51) and the CV index (p. 51) and yielded results placing the assemblage firmly within the M.A.T. complex. Collins attempted to quantify the presence of the bout coupé form by calculating a 'Paxton index', on the basis of the frequency with which it occurs. This value is highest at the later M.A.T. sites, such as Le Tillet. No classic Mousterian points or denticulates were found at Oldbury, and the flake total seems to consist largely of handaxe 'trimmers'. A variety of racloirs makes up the total, together with a naturally-backed knife and some notched tools. The industry is not dissimilar from that of the coastal Hampshire Mousterian of Acheulean Tradition sites, although it is more refined. The Oldbury axes are superior in working technique, but the Levallois technique seems to have been of greater importance in the coastal southern British industries.

The faunal remains from Oldbury are more extensive than those recovered from Kents Cavern or La Cotte, and are summarised in Table (16). Superficially the fauna is similar to the others, containing cold loving species such as mammoth and reindeer, but it is remarkable in having few large animals and many species of rodents and birds. Two species of lemming are present, as well as the souslik and various cold-loving voles. The two species of bat indicate the presence of both woodland and open water, an assumption supported by the avifauna. However if woodland was present the absence of various species of deer and pig is surprising. Newton (1899) notes the similarity of the skulls of the souslik and those from the site of Fisherton, described below (p. 140). On the whole the fauna indicates a rather mixed biotype, perhaps not so cold as that indicated by two cave sites, but markedly similar to the other open air site of Fisherton. (p.141).

Table (12) M.A.T. assemblage from Oldbury, combined results of the 1890 and 1965 excavations, after Collins 1970. Without handaxes and flakes

Bordes Type No.	Description	found 1890	found 1965	Total
1-2	Levallois flake	11	0	11
5	pseudo-Levallois point	1	0	1
9	straight racloir	1	0	1
10	convex racloir	4	2	6
11	concave racloir	1	0	1
13	straight/convex double racloirs	2	0	2
15	Convex/convex double racloirs	1	0	1
18	convergent straight/~~convex~~ double racloirs	1	0	1
19	concave-convex double racloirs	1	3	4
25	ventral surface racloirs	1	0	1
30-1	end scrapers	2	0	2
38	natural backed knives	1	0	1
42	notch	5	1	6
43	denticulate	1	0	1
45-50	retouched pieces	6	0	6
				45

3.3 La Cotte de St. Brelade

The cave site of La Cotte de St. Brelade has been included in this study since it yielded a large Mousterian industry separated into two divisions by a sterile, windblown sand. Although at the present time it could be argued that the Channel Islands have culturally more in common with France than with Britain it is probable that quite a different situation existed at the time of the manufacture of the Mousterian industries. The distance between the Channel Islands and the Isle of Wight is not great, and at times of low sea level during an interglacial communication between the two areas would be perfectly feasible. Since the Mousterian industries of La Cotte and that of Bleak Down on the Isle of Wight have many features in common there seems little difficulty in including the former site in this survey.

The assemblages have been divided into 'Middle' and 'Lower' Mousterian by Marett (1916), who considers that they are very similar in wormanship, except that the lower bed material is slightly thicker and coarser, and that the Upper Bed includes some fine, thin flakes. A total of some 15,070 pieces has been recovered, nearly two thirds of which is retouched. Unfortunately the latest publication of the assemblage is that of Marett (1916) and it has not been analysed using the methods of Bordes. This makes correlation with the mainland coastal sites difficult. Marett divides the material into 'first quality tools', of which his breakdown, on size criteria, is shown below (Table 13), and 'second quality tools' which include 'all trimmed flakes showing some typical form, other than the oval or pointed flake implements of symmetrical shape' (Table 13). Thanks to his excellent figures and descriptions it is possible to relate his categories to those of Bordes, to a limited extent. For example Marett's 'long flakes with one trimmed edge' could be considered as Bordes type 9 (single straight racloirs), a suggestion supported by examination of his illustrations. It is not possible to repeat this procedure with all the Marett types, but a very tentative breakdown of the industry using this method is shown in Table (13), for purposes of comparison. The industry appears to contain a number of notched and denticulate tools, varied racloirs and some Levallois flakes. By including the category 'Mousterian discs' as handaxes, a diagnosis suggested by Marett's Figs. 20-22 , one arrives at a total of at least 174 axes. These do not seem to have included any bout coupé forms. At least 250 cores are recorded, many of the tortoise core type, and about 10,000 flakes of non-Levallois facies.

The industry is undoubtedly Mousterian, although at first glance it does not appear to accord well with the Mousterian of Acheulean Tradition seen at Oldbury, Kents Cavern and the Hampshire coastal sites. It was included as M.A.T. in the Collins survey of 1970, but the lack of really adequate publication makes it difficult to establish its precise affinities.

Maretts Figs. 7-9 and 12 show implements bearing a strong relationship to the continental '<u>Faustkeilblatter</u>', a form common in the German Micoquian industries (Bosinski 1961) and apparently present in ~~some of~~ the industry from ~~Warsash~~ Bleak Down (p. 162). Mellars (1969) has noted similar occurrences of Micoquian tool forms in some of the M.A.T. assemblages which come from open sites, but they are not found in the cave and rock shelter sites of Perigord. Mellars cites examples from the Younger Loess of northern France, first described by Commont (1912) and Bordes (1953), where the M.A.T. implement forms differ markedly from those of the classic Perigordian sites. He also points out that these basal loessic industries contain the characteristic bout coupé handaxe type, which is absent from La Cotte. Marett does not mention the presence of naturally-backed knives, another Mousterian of Acheulean Tradition type fossil, but the seemingly high percentage of racloirs and denticulates is again suggestive of Mousterian of Acheulean Tradition. However this high racloir frequency can also occur in the Quina Mousterian, as can the low ratio of Levallois/non-

Table (13) 'First quality Mousterian tools' (after Marett 1916)

Flake implements Total = 155	
Shape	Number
Pointed	70
Round tipped	50
Square tipped	33
other	2
	155
Size	
Length 130-140 mm	2
120-130	1
110-120	1
100-110	5
90-100	12
80-90	39
70-80	38
60-70	32
50-60	25
	155

Table (13) Mousterian industries of La Cotte de St. Brelade (from Marett 1916).
(types longer than 40 mm.) Correlation with Bordes on basis of examination of Marett's text and figs.)

Tool Type	Number Found	Bordes Category
A.		
Long flakes with two trimmed side edges		
Parallel sides and round ends	252	
Parallel sides and pointed ends	133	
Parallel sides and square ends	50	Double racloirs(type nos. 12-17)
Sub triangular with round ends	136	
Sub triangular with pointed ends	122	
	703	
B.		
Long flakes with one trimmed side edge		
Straight edge with other side parallel	154	Single straight racloirs (type no. 9)
Convex edge with other side parallel	114	Single convex racloir (type no. 10)
Straight edge with other side convex	81	Single straight racloir (type no. 9)
Subtriangular	20	-
	369	
C.		
Rectangular top, three trimmed edges	133	- ? point
Obtusely rounded top, three trimmed edges	124	-
Obtusely rounded top, two trimmed edges	91	Double racloirs
Rectangular top with one trimmed edge	39	- single racloir
Both sides ringed, two trimmed	172	
	459	
D.		
Hollowed flakes		
Deeply indented	122	Notches (type no. 42)
Slightly indented	115	
Slightly indented with both sides winged	38	
	275	

Table (13) contd.

E.		
Curved flakes		
With slight curve	48	
With pronounced curve	12	
	60	
F.		
Sharpened flakes	20	
G.		
'Keeled' pieces		
long	113	
square	51	
	164	
H,		
Discoidal pieces		
One face trimmed flat, other formed by crust	66	
Both faces trimmed flat	55	? Discoid handaxes
One face trimmed flat, other polygonal	52	
	173	
L.		
Dwarf implements		
Oval and sub triangular flakes	268	
long flakes (some hollowed)	203	? some denticulates
Rectangular flakes	206	
'sharpened' flakes	78	? some burins and piercers
	755	
K.		
Broken Implements		
longer than 40 mm	346	
less than 40 mm	127	
	473	
TOTAL =	3,551	

Levallois flakes which is found here, but the thick flake tools, transverse racloirs and plentiful limaces of Quina facies are absent.

It is difficult to find an assemblage within the British M.A.T. that exactly parallels the one from La Cotte, since it does not resemble those from Oldbury or Kents Cavern. If the assemblage is accepted as M.A.T. then it may perhaps be related to the small group of implements from Bleak Down (Hampshire, p. 160), which shares the absence of the bout coupé form, the presence of well-refined lanceolate handaxes within a Mousterian group, and a typical 'Faustkeilblatter'. This last mentioned specimen is remarkably similar to that figured by Marett (his Fig. 143) as is his Fig. 19 to the Bleak Down specimen illustrated below (Fig. 78).

The composition of the fauna from La Cotte is summarised in Table (16). It is composed of animals principally which inhabit a steppe-tundra biotype, the bones representing only a remnant of those which were originally recovered. They seem mostly to be connected with the activities of man (McBurney 1971). The occurrence of rabbit may be the result of a mis-identification of arctic hare (Marett 1916). Reindeer and banded lemming are both tundra species, and mammoth and woolly rhinoceros also thrive under severe conditions. The rodents and birds, especially ptarmigan, will also breed in arctic conditions, many of them being familiar in latitudes north of Scandinavia in the present day. No mollusca were identified from the site.

3.4 Hyaena Den

There are a number of minor sites which appear to be related to the British Mousterian of Acheulean Tradition, and indeed the general distribution of the bout coupé handaxe form may represent the range of the makers of the industries (Roe 1967). At the Hyaena Den (Wookey, Somerset) Tratman et al. (1971) recognised two distinct cultural layers, one of them a Mousterian variant, probably Mousterian of Acheulean Tradition. The group consisted of only 11 implements, the composition of which is shown below (Table 14).

Table (14) Mousterian assemblage from the Hyaena Den (after Tratman et al., 1971).

Type No.	Description	Total
111	Irregular discoid handaxes	4
102	Sub triangular handaxes	1
127	Sub triangular handaxes on flakes	1
132	Bout coupé	2
112	Irregular ovates	2
124	Large trimming flakes	2
		11

The bifacial tools are small and trimmed with fine resolved flaking, the bout coupé being a perfect specimen of the type. (Tratman et al, 1971 fig. 43.5). Typologically the forms are less well refined than the Oldbury series, and it is perhaps surprising that no typical racloirs or points have been found. Collins (1970) includes the site as an M.A.T. variant.

Additional support for this assignment has been obtained from the recent find of another bout coupé handaxe in a stratified context, from the Rhinoceros Hole which closely adjoins the Hyaena Den. (I am indebted to Dr. E.K. Tratman for permission to quote the find of this unpublished specimen).

The fauna associated with the 'Mousterian' level at the Hyaena Den is an extensive one, and is in many ways similar to that of Kents Cavern. Tratman et al. (1971) consider that it is typical of an early Devensian environment, and the presence of cold-loving species such as woolly rhinoceros and mammoth support this theory. The dominant animals are the cave hyaena, woolly rhinoceros and horse (Table 1b). The other large carnivores such as bear and lion are poorly represented, and the occurrence of fox and badger is thought to be intrusive. The presence of the souslik is interesting, since this small rodent occurs at both Oldbury and Fisherton, but not at Kents Cavern. The absence of microtines is perhaps due to the lack of owls, but the absence of other cold-loving forms such as the banded lemming, arctic hare or musk ox is surprising. The presence of the steppe rhinoceros was thought by the excavators to be discordant, as it is generally considered to have become extinct in Europe at the end of the Ipswichian. At least one authority (Kurtén, 1969) considers that although it was unable to colonise the tundra biotype and had its main habitat in temperate areas there is some evidence to suggest that it survived into early last Glacial times in some areas. The pollen and associated sediments of the faunal layer at the Hyaena Den indicate that it was formed in a very cold period, but the excavators suggest that the layer which contained the maximum number of hyaena teeth, and presumably the artifacts, possibly dates to before the maximum cold of the early Devensian.

Tratman et al (1971) mention other sites with small industries and faunas that might be associated with the M.A.T. of the Hyaena Den. Torbryan cave (Devon) contained a fauna of hyaena, reindeer, 'deer', fox, horse and ox, possible associated with a biface of Mousterian type, (Walker and Sutcliffe 1968), and at Pontnewydd cave (North Wales) similar bifaces were associated with hyaena, bear, horse and steppe rhinoceros (Hughes 1887, Tratman et al 1971). In view of the lack of confirmatory data the inclusion of these sites is virtually unsupported, and the presence of the steppe rhinoceros in the latter cave could be taken as a pointer to the fauna being of a date preceeding the arrival of the Mousterian in Britain.

3.5 Typological relationships between recognised British M.A.T. sites and the littoral southern British industries

It can be seen from the general correlation table (Table 15) that the British M.A.T. industries of Oldbury, Kents Cavern etc. have many features in common with the Hampshire sites, and that there is little difficulty in envisaging a typological relationship. All the sites, with the exception of La Cotte and Bleak Down, contain the characteristic bout coupé handaxes, the varied racloir forms and the backed knives which typify the Continental M.A.T. assemblages. There are, of course, minor typological variations, for example the general lack of, notched or denticulate tools, but this can perhaps be accounted for by considering the small size of the assemblages, and the poverty of the whole tradition when compared to the continent.

The British assemblages are far from being dominated by the Levallois technique, and the presence of the occasional pointed handaxe in addition to the more typical cordiform variety may indicate that the relationship of

British M.A.T. industries is closer to Acheulean flaking traditions than is commonly realised. It is unfortunate that the lack of a really adequate study of the La Cotte or Kents Cavern assemblages makes the plotting of graphs of the calculation of descriptive indices invalid, since this would no doubt have stressed the relationships between these sites and the littoral southern British industries. Minor sites, such as the Hyaena Den, are difficult to fit into the general typological sequence, although the presence of the bout coupé axe form indicates that they are likely to be related. The chronological and typological relationships of all the industries shown in Table (15), and of their associated faunas, is discussed below (p.165-).

Table (16) Faunas associated with British Mousterian of Acheulean Tradition Industries

Common name	(1) Species name	(2) Fisherton	(3) Oldbury	(4) Kents Cavern	(5) La Cotte	(6) Hyaena Den
Carnovora						
Cave hyaena	Crocuta crocuta G.	x	-	x	x	x
Cave lion	Felis leo spelea G.	x	-	x	-	x
Otter	Lutra lutra L.	-	x	-	-	-
Glutton	Gulo gulo L.	-	-	x	-	-
Polecat	Mustela putorious L.	-	x	-	-	-
Weasel	Mustela nivalis L.	-	x	-	-	-
Badger	Meles meles L.	-	x	-	-	x
Bear	Ursus sp.	-	x	x	-	x
Wolf	Canis lupus L.	-	-	-	x	-
Fox	Vulpes vulpes L.	x	x	x	x	x
Brown bear	Ursus arctos L.	x	-	x	x	x
Cat	Felis catus L.	-	x	x	-	x
Cave bear	Ursus spelea R.	-	x	-	-	x
		-	-	-	-	-
Proboscidea						
Straight tusked elephant	Palaeoloxodon antiquus F.	-	-	-	x	-
Mammoth	Mammuthus primigenius B.	x	x	x	x	x
Perissodactyla						
Steppe rhinoceros	Dicerorhinus hemitoechus F.	-	-	-	-	x
Woolly rhinoceros	Coelodonta antiquitatis B.	-	-	x	x	x
Horse	Equus sp.	x	-	-	-	-
Caballine horse	Equus germanicus N.	-	-	x	-	-
Wild ass	Equus hydruntinus R.	x	-	-	-	-
Artiodactyla						
Pig	Sus scrofa L.	x	-	-	-	x
Red deer	Cervus elaphus L.	x	-	x	x	x
Reindeer	Megaloceros giganteus L. ↕	-	-	x	x	x
~~Roe~~ Giant deer	Rangifer tarandus B. ↕	x	x	x	x	x
Musk ox	Ovibus moschatus L.	x	-	-	x	-
Steppe Wisent	Bison priscus Bo.	x	-	-	-	-
Bison	Bison minor L.	x	-	x	-	-
Auroch	Bos primigenius L.	x	-	-	x	-
Sheep/goat	Oves/capres	-	-	-	x	-
Ox (sp.)	Bos sp.	-	-	-	-	x
Lagomorpha						
Steppe Pika	Octotona pusilla P.	-	x	x	-	-
Hare	Lepus europeus P.	-	x	-	-	-
Varying hare	Lepus timidus L.	x	-	x	x?	x
Rabbit	Oryctolagus cuniculus L.	-	x	-	x?	-
Rodentia						
Souslik	C.Citellus erythrogenoides	x	x	-	-	x
Beaver	Castor fiber L.	-	-	x	-	-
Vole	Arvicola terrestris/amphib.	x	x	x	x	-
Common vole	Microtus arvalis	-	x	-	-	-
Field vole	Microtus agrestis L.	-	x	x	-	-
Tundra vole	Microtus ratticeps K.	-	x	-	-	-
Snowvole	Microtus nivalis M.	-	x	-	-	-
Lemming	Lemmus lemmus L.	x	x	-	-	x
Arctic lemming	Dicrostonyx [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table (16) contd.

Insectivora						
Shrew	Sorex araneus L.	-	-	-	x	-
Chiroptera						
Bechsteins bat	Myotis bechsteini Le.	-	x	-	-	-
Water bat	Myotis daubentoni Le.	-	x	-	-	-
Aves						
Goose	Anser palustris	x	x	-	-	-
Pink footed goose	Anser brachyrhinus	-	x?	-	x	-
Goose (unknown)	Anser sp.	-	-	-	-	-
Wild duck	Anas boschas	x	-	-	-	-
Barnacle goose	Bernicla leucopis	-	-	-	x	-
Brent goose	Bernicla brenta	-	-	-	x	-
Shoveller duck	Spatula clypeata	-	x	-	-	-
Swallow	Hirundo rustica	-	x	-	-	-
Moorhen	Gallinula chlorus	-	-	-	x	-
Red backed shrike	Lanius collunio	-	x	-	-	-
Chaffinch	Gringilla coelebs	-	x	-	x	-
Wader		-	-	-	-	-
Hedge sparrow	Accentor modularis	-	x	-	-	-
Dipper	Cinclus aquaticus	-	-	-	x	-
Blackbird	Turdus merula	-	x	-	-	-
Blackcock	Tetrao sp.	-	-	-	-	-
Ptarmigan	Lagopus mutus	-	-	-	-	-
Kestrel	Falco tinnunculus	-	-	-	x	-
Peregrine falcon	Falco peregrinus	-	x	-	-	-

x = present - = absent

(1) Names taken from Kurtén (1968)
(2) From brickearths, (Blackmore 1867)
(3) From fissures, (Newton, 1889)
(4) From A_2 loamy cave earth (Campbell and Sampson, 1971)
(5) From Devensian head, (Marett, 1916)
(6) General fauna (Tratman et al, 1971)

Section 4. Mousterian of Acheulean Tradition sites in southern England.

4.11 Warsash

Introduction

The Warsash area (lower Hamble River, Hampshire), consists of a flight of gravel spreads, much dissected by extensive quarrying, which it is difficult to divide morphologically. This dissection, illustrated by the broken contours of Fig. (19), means that the greatest care must be exercised in using Ordnance Survey spot-heights, which are not invariably measured from the original ground surface.

The area is mapped as Plateau gravel on all geological maps, which make no attempt at any further subdivision (Fig. 14). The gravels are much eroded by the tributaries of the Hamble and by other small streams flowing into Southampton water, but this dissection, frequently out of proportion to the size of the stream, is likely to be of ancient origin.

Careful examination of the topography shows the presence of two pronounced bluffs, one sloping down from the 100' contour to about 50'OD, and a second, very fragmentary due to quarrying, sloping from the 50' gravel flat to a second comparatively level area at about 25'OD, which occupies the territory between the lower bluff and the sea-cliffs, generally between 15-30' high.

In the western part of the area, towards Warsash, the cliffs are low and much eroded, but they attain their maximum height about halfway between Warsash and Hill Head. Fig. (19) illustrates the general topography of the area, and marks the approximate position of the bluffs. Much attention has previously been paid to these deposits, principally because of the number of visible sections that existed in the days when the gravels were being worked, the most useful surveys being those of Everard, (1954) and Jarvis, (1957).

This quarrying has also resulted in the discovery of a large amount of archaeological material, over 500 implements being recorded by Roe (1967)

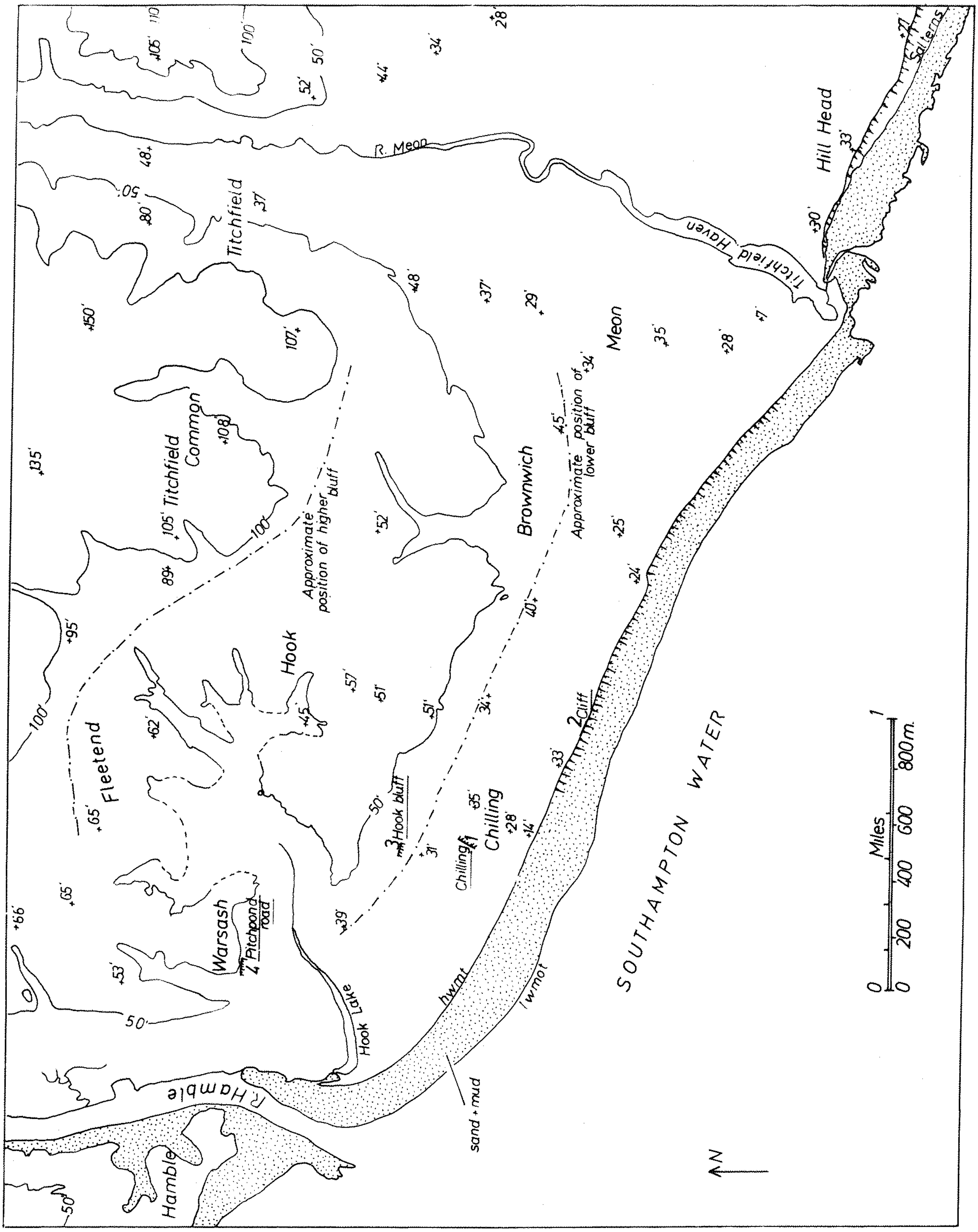


Fig. (19) General topography of the Warsash area, showing the approximate position of the bluffs.

from the Warsash pits alone. Most of this quarrying took place in the early years of this century, with the result that the magnificent museum collections are largely uncatalogued and tend to record the find of an implement simply in relation to the name of the owner of the pit, for example 'Large ovate, Dykes pit, Warsash'. Jarvis (1957) recorded as many of the pit-names as he could trace, but in the years following his survey the old workings have often been reclaimed, and it is now very difficult to obtain precise locations for implement finds. Thus many fine collections are rendered virtually useless, and the sections and finds of workers such as Burkitt, Paterson and Mogridge (1929) are difficult to relate to the modern relief of the area. Few recent finds of material 'in situ' have been made, probably since the advent of mechanical excavation in the two pits still working has minimised the chances of finding undisturbed material.

The writer was fortunate in being able to record two fine stratified implements in the gravels of the 50' spread (Shackley 1970), and a series from the lower levels ~~(Shackley 1970 1971)~~, but quantities of material must have been missed.

Several factors have suggested that it might be profitable to examine these deposits, with a view to testing whether any former shore lines are preserved in detail. These include the discovery of a fine collection of Mousterian tools and handaxes from the lower level gravels, and conflicting views of earlier investigators concerning the depositional environment of the deposits, some claiming fluviatile origin and some marine. The fact that there were two very marked gravel flats, one at 50' and the other at about 25', argued again for the presence of at least one raised beach. Accordingly three sections were examined, one at the coast, one at Chilling and a third at Hook, the locations being marked on Fig. (19). The first two sections were cut into the deposits underlying the morphological 'flat', whilst the third was excavated in the disturbed area at the foot of the lower bluff, and is not described in detail.

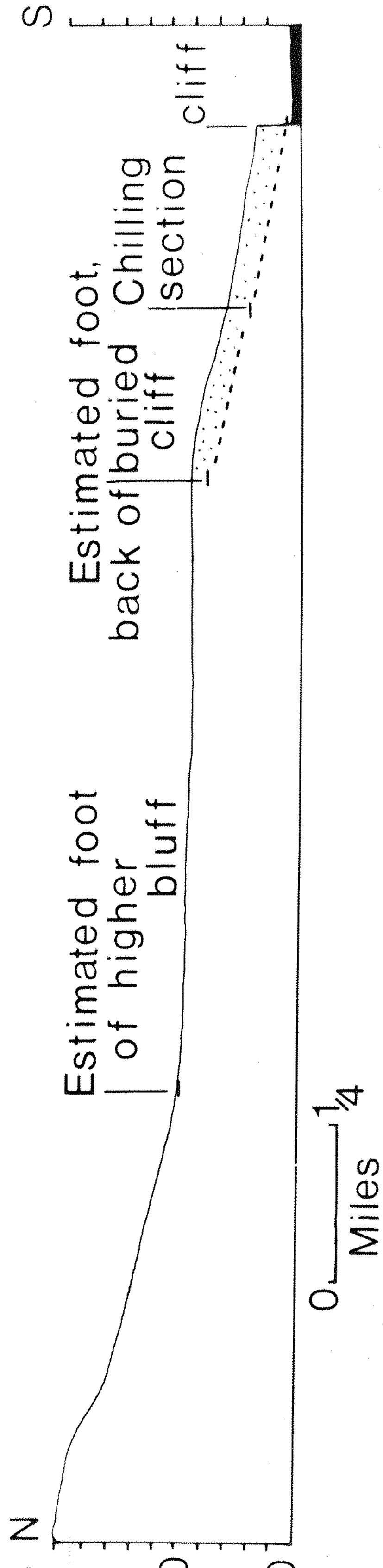


Fig. (20) Transverse section across the Warsash area.

Section 1 (Chilling, SU 507060).

Introduction

This section was cut into the side of an old gravel working, now deserted, situated in a field to the east of the 'Solent Breezes Caravan park' (Fig. 21), and had a face stretching some 30' (N/S). As can be seen from the drawing the deposits rested conformably on Barton sand, little basal disturbance being visible, and consisted mainly of featureless, un-bedded compact shingle with varying degrees of patination. Redeposited pebbles originating from the underlying Tertiary beds were present in the general flint matrix, and tended to occur in greatest numbers towards the base of the section. There was no evidence for current bedding but at least one clear example was seen of inverted graded bedding, a marine feature, with a lens of fine sand graded upwards into coarse cobbles (see Fig. 21). The base of the gravels lay at about 29' OD.

The gravels and sand were capped by a reddish-brown clayey material of the series often termed 'brickearths'. This was divided in some areas into two distinct beds, separated by a bed of white-patinated cryoturbated shingle. In this case the lower 'brickearth' was more cohesive and compacted, and had a high iron content, evidenced by some ferruginous mottling, whilst the upper 'brickearth' tended to be more porous and friable. The separ-ating shingle showed evidence of periglacial conditions in the form of a small fossilised ice-wedge (Fig. 21).

The shingle

Most of the sections showed medium-sized sub-angular shingle, with a mean diameter of about -3.0 ∅. This was very poorly sorted and lepto-kurtic, its particle size distribution curve being shown in Fig. (22), and the descriptive parameters summarised in Table (17). The roundness and sphericity measurements are shown in Table (18). The shingle had a mean roundness value of 3.58 and a mean sphericity of 0.74. The deposit

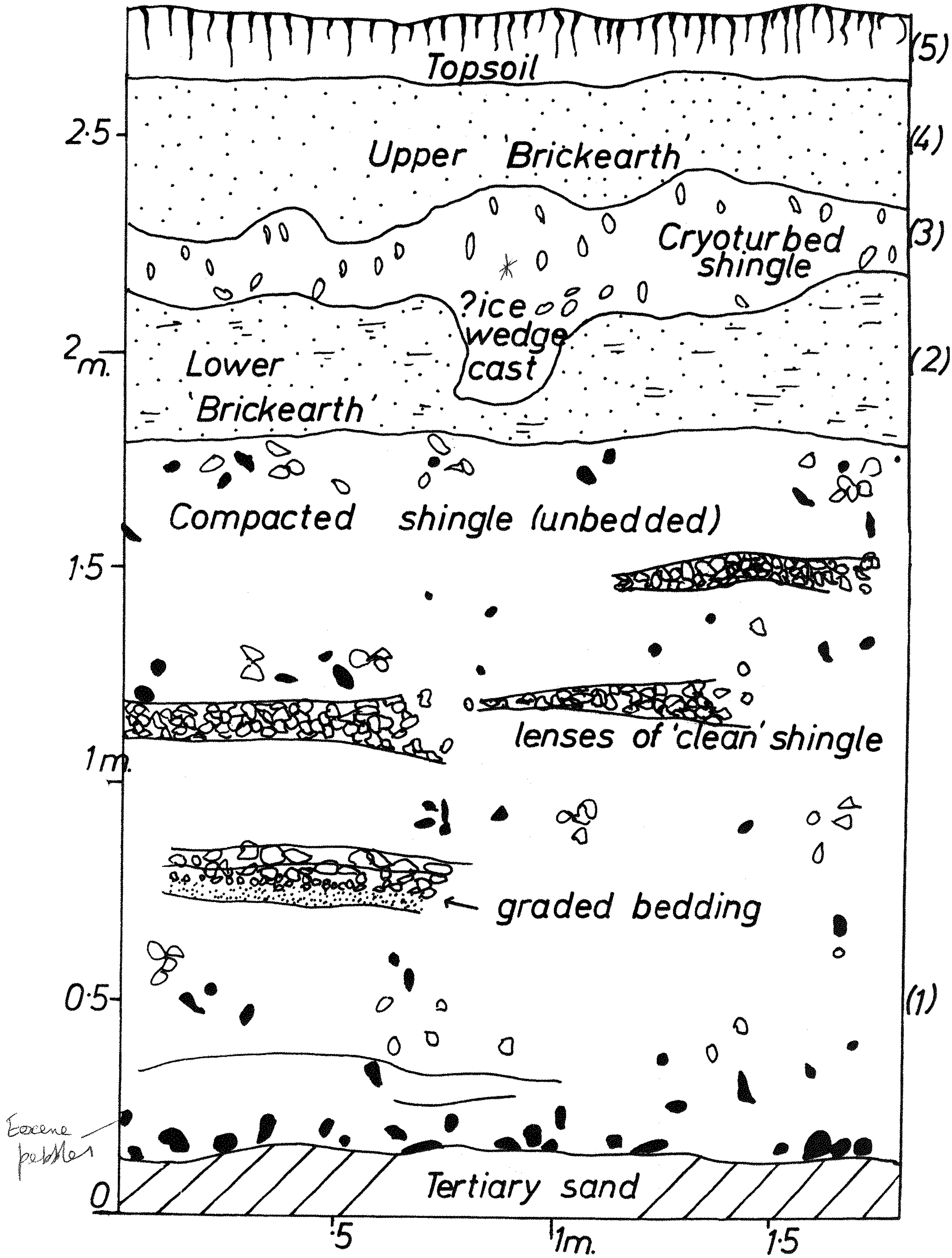


Fig. (21) Section through the deposits at Chilling, Warsash.

* Probably an involution

was occasionally stained with iron, with pan formation in some areas. The particle size distribution curve of this shingle can be seen to be very similar to that of the raised beach deposit of Christchurch (Fig. 65), but quite different from the river gravels described in the third Warsash section at Hook. ~~(p. and Fig.)~~.

The sand

Small lenses of sand occurred in the graded structures, but far less sand was present than was visible, for example, in the cliff section. The sand was marine in character, negatively skewed, very leptokurtic and similar to that contained in the raised beach deposits of Stone (p.126) (Friedman, 1961). The particle size distribution curve (Fig. 22) shows the presence of a small quantity of shingle (6.76%), but very little silt or clay (0.76%).

The 'brickearth'

Two samples of this deposit were analysed, one from above and one from below the shingle layer shown in Fig. (21). The particle size distribution curves (Fig. 22) are seen to be very similar, although the lower 'brickearth' is slightly finer and has a higher proportion of mud. The two distribution curves (Fig. 22), are seen to be remarkably similar, but quite different from the 'brickearths' capping the raised beach deposits of Stone and Christchurch. The composition of the samples, shown in Table (17), shows that the lower brickearth has a slightly higher mud content (11.69% against 10.13%), and is richer in clay minerals. The more friable, open structure of the upper deposit suggests the beginnings of soil formation, the minerals and clays of the upper (eluviation) horizon being leached into the lower (illuviation) zone. Despite the fact that both samples consist principally of sand these do not resemble the weathered sands of Christchurch. The clay content may be due either to aolian action or to fluviatile deposition from one of the tributary rivers that have greatly dissected the gravel spread, formed during a period when the river had much greater volume than at the present day.

The convoluted and cryoturbified shingle that separates these two beds is clear evidence of severe, probably periglacial, conditions. The cast of a fossil ice-wedge seems to support this suggestion.

Although the shingles are at first sight more angular than would be expected from a marine deposit, this characteristic has already been recorded elsewhere (p. 136). The sand within the graded bedding structure is undoubtedly marine, and on sedimentological grounds there seems to be much evidence for considering these deposits to represent the remnant of a raised beach.

Table (17) Characteristics of the Warsash gravels

Sample	% gravel	% sand	% mud		Folk & Ward statistics (Folk & Ward 1957)				
					Mean	Standard Deviation	Variance	Skewness	Kurtosis
Chilling 1. (shingle)	82.67	16.89	0.43		-3.06	2.15	4.64	0.50	1.31
Chilling 2. (sand)	6.76	92.46	0.76		1.39	0.98	0.96	0.10	1.95
Chilling 3. (lower 'brickearth')	9.87	78.43	11.69		2.18	2.03	4.13	0.35	1.59
Chilling 4. (upper 'brickearth')	12.63	77.23	10.13		1.93	2.13	4.57	0.42	1.59

Table (18) Roundness and Sphericity (Chilling shingles)

Parameter	Mean	Variance	Standard Deviation	Standard Error of Mean	Skewness	Kurtosis
Roundness	3.58	0.81	0.90	0.25	0.15	-0.42
Sphericity	.745	.204	0.04	0.01	0.007	-0.006

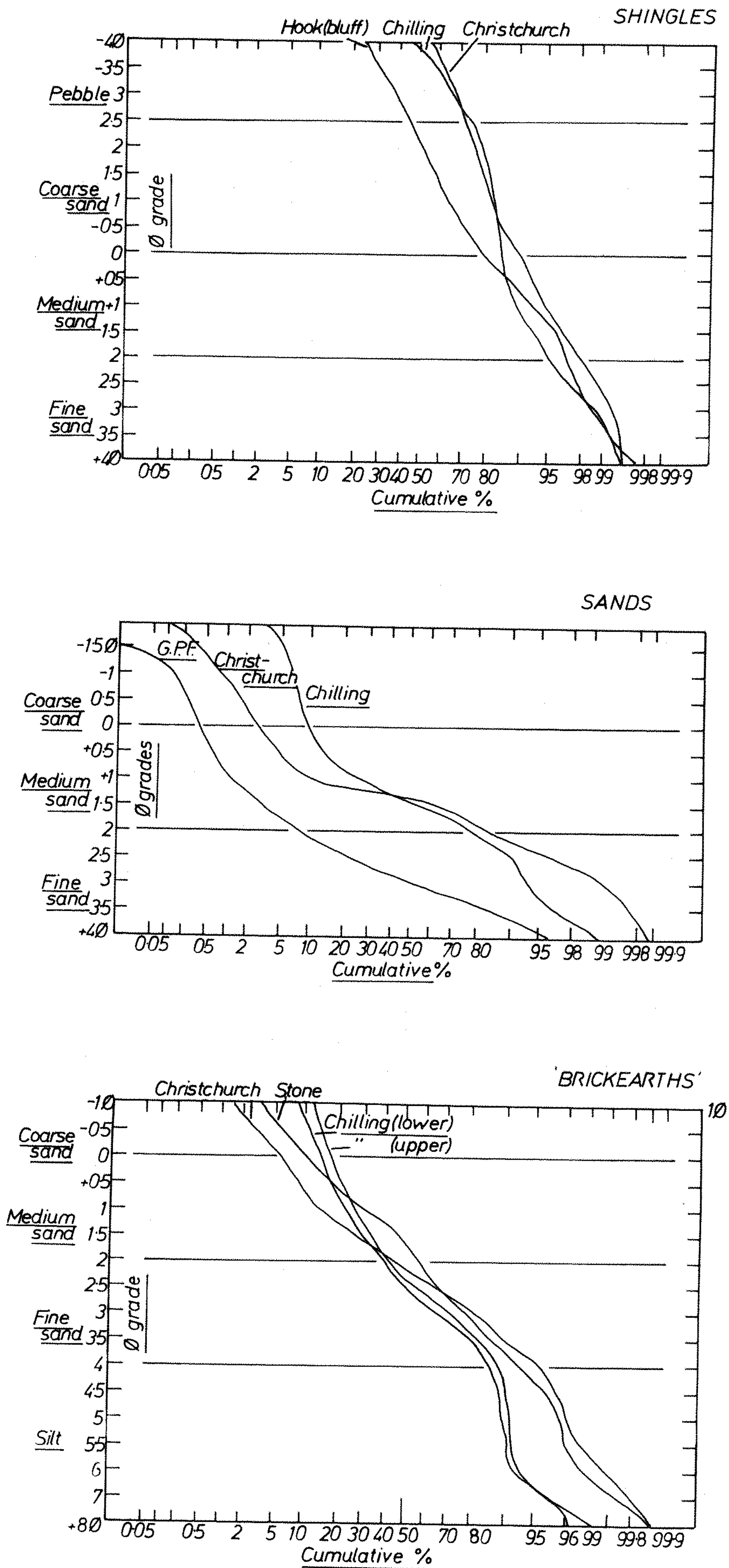


Fig. (22) Particle size distribution curves for samples from Chilling, Warsash.

Cliff section (Warsash/Hillhead) SU 507060

Introduction

There is an excellent section of the 'raised beach' in the cliffs between Chilling and Hillhead, two segments of which (marked on Fig. 19) are drawn in Fig. (23). The base of this deposit lies, on average, at 8'OD, where the beach shingles rest unconformably on Barton sand. In places the deposit may attain thicknesses of up to 10 m.

Section 1

This section is to the west of the face shown on Fig. (19), and consists of 5 m of gravel and sand capped by 'brickearth'. At the base there is a marine shingle, nearly identical to that of Chilling (p. 80) capped by a thick bed showing inverted graded bedding of sands and shingles/cobbles, and then by more beach shingles with horizontal sand lenses that occasionally show current bedding. Nearly at the top of the section are two thick beds of sand, one containing varying amounts of small shingle. Into this bed is inserted a layer of fine cryoturbified shingle, with a marked vertical alignment, containing another ice-wedge cast similar to that shown in Fig. (21). This layer is covered by more sand, occasionally laminated, possibly the remnant of fossil dunes and finally capped by the 'brickearth'. The whole deposit greatly resembles that of Chilling, differing only in the relative amounts of sand and shingle.

Section 2.

The second section, nearer the Hill Head end of the bluff, shows the topsoil and brickearth capping removed by erosion, but still consisting of nearly 9 metres of drift deposit. At the foot of the section there is again some graded bedding, much thicker than that of Section 1, resting on beach shingle overlying the Barton sand. The two sections are only separated by some 15 m.

This type of graded bedding, and the whole character of the deposits,

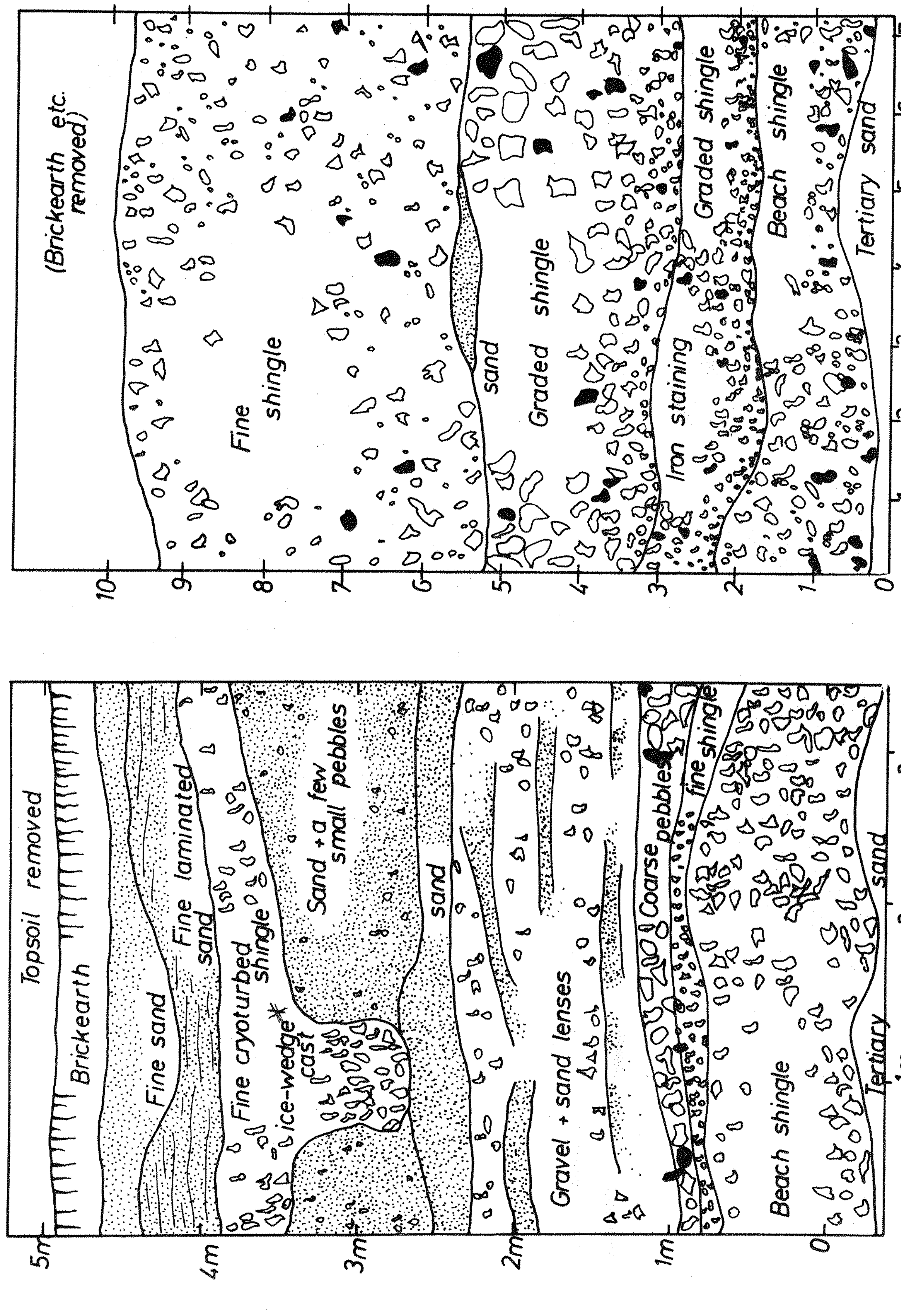


Fig. (23) Two sections through the deposits exposed in cliffs at Warsash.

* imbrication, not ice wedge cast

is quite typical of a marine environment of deposition, and there seems little doubt that this is the remnant of a raised beach. Along the entire length of the cliff line other sections of varying thickness are visible, which decrease in height to less than a metre in places, due to erosion, but the character of the deposits differs little from the sections drawn in Fig. (23). At the extreme eastern end of the cliff line (Fig. 19) an area of land has been reclaimed as 'Salterns', with the result that the old cliffs have been 'fossilised' about 150 yards beyond the present high water mark.

Implements

The large quantity of material recovered from the Warsash area has already been mentioned (p. 76), but much difficulty was experienced in locating artifacts reliably associated with the raised beach segment described above.

Group A

The writer has traced only 76 pieces undoubtedly coming from this segment, recovered at different dates from the various workings, and widely scattered among museum and private collections. This material (listed in Table 19), is described as Group A, some examples being shown in Figs. (24-25). The group includes some 17 handaxes, 2 of bout coupé type and 4 of the distinctive so-called 'Wolvercote' type. A number of re-touched Mousterian tools are also present, including a thick Quina-type scraper and a fine Mousterian point (Fig. 24 nos. 6, 4), together with numerous Levallois flakes and some tortoise cores. The handaxes, apart from the above-mentioned specialised forms, are generally cordiform or discoid, but there is one splendid Micoquian ficron (Fig. 24 No. 8). The whole assemblage is Mousterian of Acheulean Tradition in type, very similar to that of Great Pan Farm (p. 96), but contains certain atypical features such as the 'Wolvercote' handaxes.

Table (19) Composition of Warsash Group A

Type No.	Description	Total
1/2	Levallois flakes	17
6	Mousterian point	1
8	proto-limace	1
9	single straight racloir	3
10	single convex racloir	5
12	double straight racloir	1
13	double straight/convex racloir	2
14	double straight/concave racloir	3
15	double convex racloir	1
24	concave transverse racloir	1
25	racloir on ventral	1
30	atypical end-scraper	1
36	typical backed knife	1
38	natural backed knife	1
62	divers	1
119	tortoise core	3
122	non-Levallois flakes	10
132	bout coupé handaxes	2
160	Wolvercote-type handaxes	4
	handaxes (varied)	17

76 (Total)

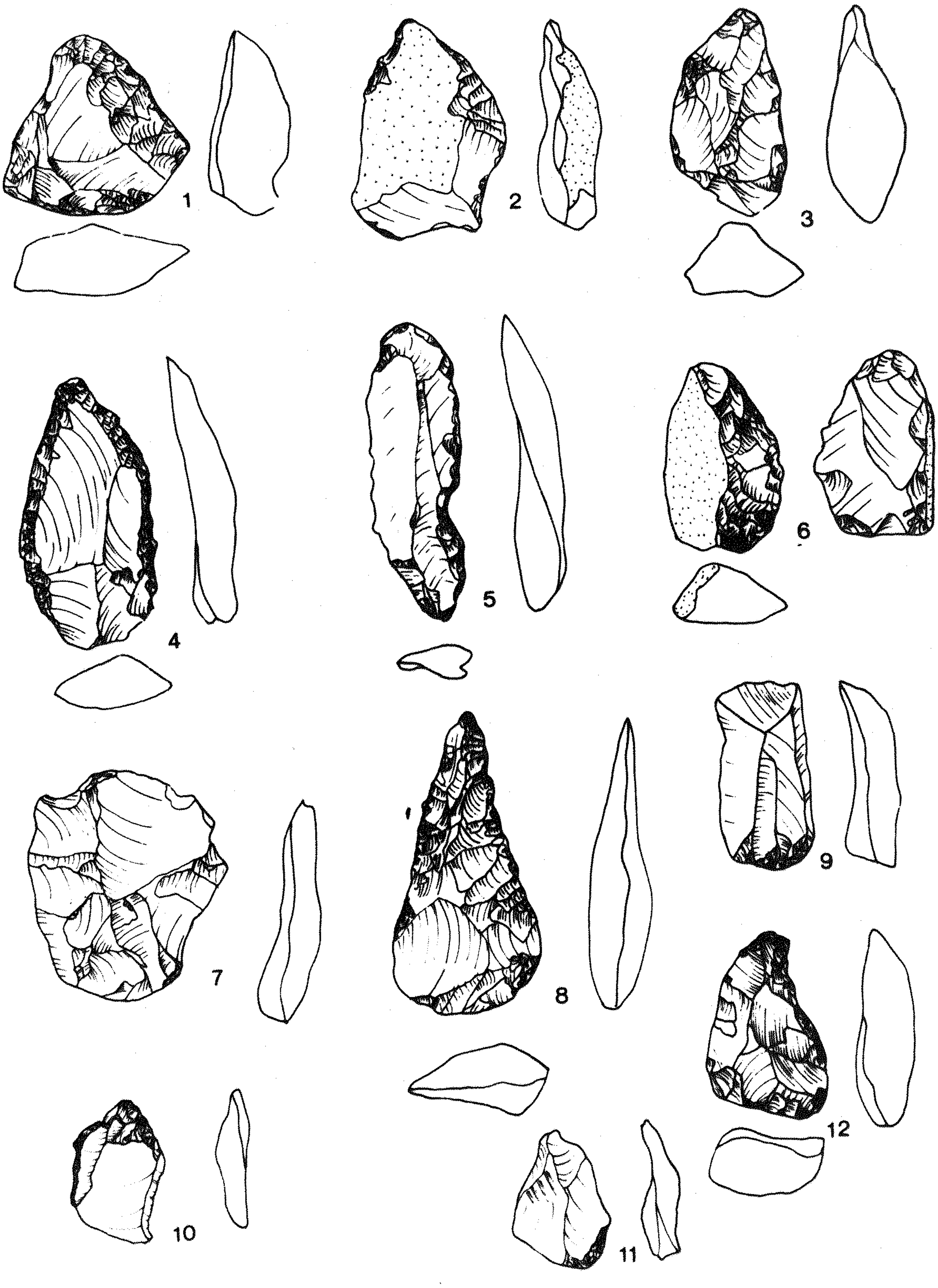


Fig. (24) Implements (Group A) from Warsash. (1/2.5)

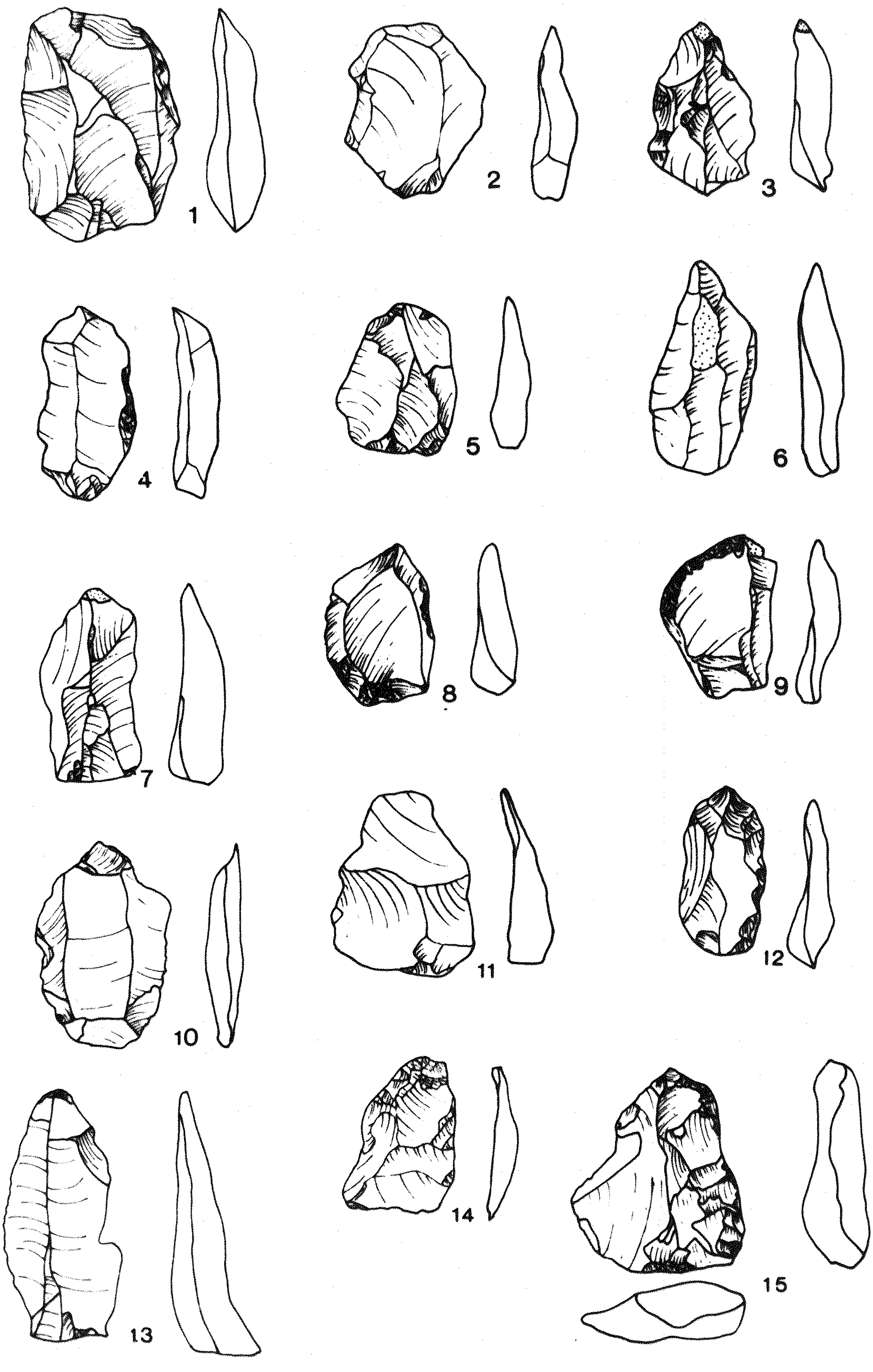


Fig. (25) Implements (Group A) from Warsash cont'd. (1/2.2)

Fig. (26) shows that the relative abrasion of this material is slight, the vast majority of the tools having an index value of less than 1. Table (20) lists the statistical distribution of the measured parameters. Scatter plots of all the combinations were made, and the figured example (l/b to b/t ratios) had a significant negative correlation coefficient of -0.48. This shows that the tools tend to be quite large, but thin, flat and well-refined, a useful comparison being made with Table (30), p. (111).

Table (20) Statistical summary of the parameter measurements, Warsash Group A.

Parameter	Mean	Variance	Standard Deviation	Standard Error of mean	Skewness	Kurtosis
Abrasion	14.34	1196.04	34.58	5.27	3.62	14.03
l/b	1.72	0.20	0.44	0.06	1.22	2.55
b/t	2.83	2.35	1.53	0.23	1.74	3.45
Weight	93.31	6176.73	78.59	11.98	1.37	1.68

Warsash Group B

In addition to the artifacts considered already, there are at least 50 other pieces that may possibly be associated with the same beach segment, but which are not precisely located. In many cases the material is typologically related to Group A, but vaguely provenanced as simply from the Warsash area. These implements, listed below as Group B, include many forms identical to those of Group A, especially the Mousterian scrapers, Levallois flakes and tortoise cores. It is unlikely that this category includes all the material which has been found. The Levallois material of this group shows no preferred butt form, some 43% having facetted butts, 34% plain, and 22% where the butt was removed or cortex-covered. The

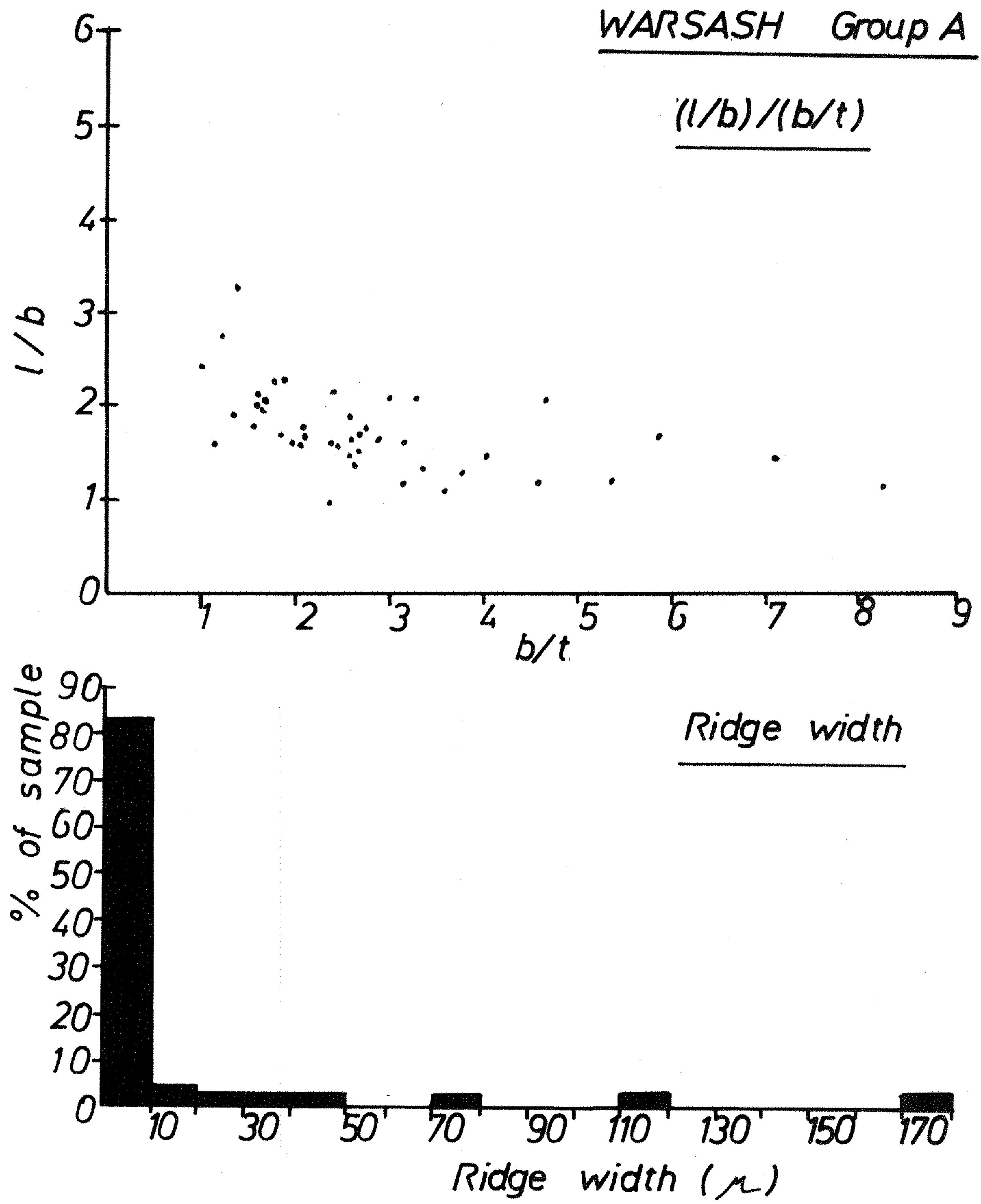


Fig. (26) Scatter diagram and histogram. Parameters from Warsash implement Group A.

implements are, on the average, slightly more abraded than those of Group A, only 57% having an Index value of less than 1, but this is still light abrasion. There is again a significant correlation between the axial ratios l/b and b/t scatter plot, with a value of -0.36. The general appearance of the material in the two groups is very similar, and the presence of Group B emphasises the size of the Mousterian of Acheulean Tradition industry present in the area.

The Micoquian and Wolvercote-type material from these deposits

The gravels at Warsash contain several implements of Micoquian type, unusual in predominantly Mousterian industries, together with a series of handaxes of the distinctive 'Wolvercote' type, described by Roe (1964) as 'slipper-shaped', and elsewhere occurring only at Wolvercote in Oxfordshire, apart from a few scattered finds. Since the distribution of these distinctive forms is so limited, it was thought worth while to examine it in greater detail, in order to elucidate the relationship betwen this tool type and the raised beach, chronologically and typologically.

Wolvercote

The assemblage from the Wolvercote channel has been described by Duigan (1947), Sandford (~~1924 and~~ 1926), Arkell (1947) and Bishop (1958), and summarised in the work of Wymer (1968) and Roe (1964, 1967). Sandford and Baden-Powell were working on a fresh account of the stratigraphy of the site, unfinished at the time of the former's death in 1971.

The Wolvercote channel is cut into the 50' gravels of the Wolvercote terrace of the upper Thames, near Oxford, and is filled with layers of gravels, sands and clays. The stratigraphy of the site, (Wymer 1968) shows that the distinctive handaxes came from a zone of current-bedded sandy gravel with some red deer and mollusca, between two layers of sand. The gravels are often heavily iron-stained.

Roe (1967) describes his detailed metrical analyses of the handaxes,

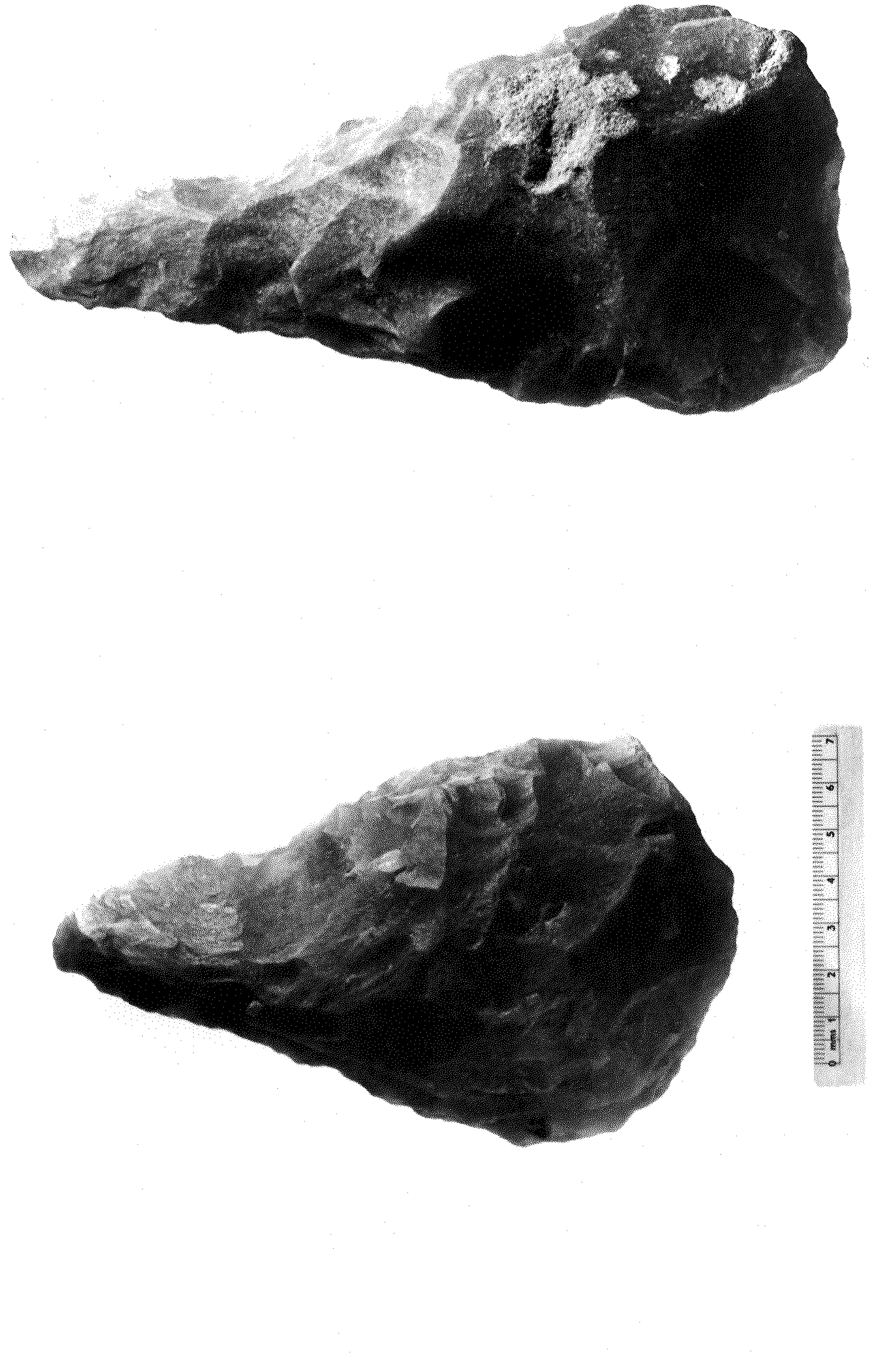


Fig. (27) Two handaxes from Warsash. (a) 'Wolvercote' type (b) Micoquian ficron.

Table (21) Composition of Warsash implement Group B

Type No.	Description	Total
Warsash Group B		
1/2	Levallois flakes	25
8	limace	1
9	single straight racloir	3
11	single concave racloir	1
12	double straight racloir	1
13	double straight/convex racloir	3
24	concave transverse racloir	1
25	racloir on ventral	1
28	racloir + bifacial retouch	3
31	atypical end-scraper	1
38	natural backed knife	1
119	tortoise core	2
122	unretouched flakes	4
123	retouched flakes	1
124	trimming flakes	5
		53 (Total)

Table (22) Summary statistics of parameter measurements. Warsash Group B.

Parameter	Mean	Variance	Standard Deviation	Standard Error of Mean	Skewness	Kurtosis
Abrasion	16.81	1038.15	32.33	4.42	3.49	13.96
l/b	1.54	0.25	0.50	0.06	0.11	2.94
b/t	3.19	3.31	1.82	0.25	1.99	6.44
weight	134.56	13361.44	115.59	15.87	3.09	13.67

and Wymer (1968) gives an account of the whole assemblage, which included trimming flakes, scrapers and some unfinished pieces. The handaxes are remarkably fresh, with abrasion index value of 0 or 1, plano-convex in section, 'slipper shaped', made on flakes, often side struck, and frequently have the bulb of percussion remaining. Roe (1968) places the handaxes in the Group 3 variant of his 'Pointed Tradition'. There has been much discussion about the date of the channel and the industry, and two distinct schools of thought have emerged, one which supports a Hoxnian date and another favouring a date in the Ipswichian. For this reason it is especially interesting to have another stratified group from Warsash, which is actually of greater size than the Table (15) indicates, although it is not all precisely located.

Continental Affinities

It is therefore necessary to seek parallels for this material from Continental sites, where many of the forms occur in industries of Micoquian facies. This term was defined by Bordes (1973) as 'one of the branches of Final Acheulean, partially contemporary with the Mousterian and characterised by finely-worked lanceolate handaxes'. A typical ficron of this type is seen in Fig. (24) No. (8). Several north German sites, especially Bocksteinschnide and Klausenische, contain material similar to that of the English sites. The most important horizon at the former site, an open area in front of a cave, is Bockstein 3, which is characterised by an assemblage containing the ficron, *Halbkeile* (handaxes with a flat ventral side) and *Fausel* (similar handaxes but less than 6 cm. long), *Faustkeilblatter* (flat handaxes of varied shape) and numerous Bockstein knives. The Wolvercote handaxes are virtually identical to the Halbkeile. This industry is described by Bosinski (1969) and Wetzel (1958), and is considered by them to belong to the earlier of the two stages of the Middle European Micoquian, which can be divided typologically into an earlier phase (numerous ficron, broad Faustkeilblatter and big Bockstein knives)

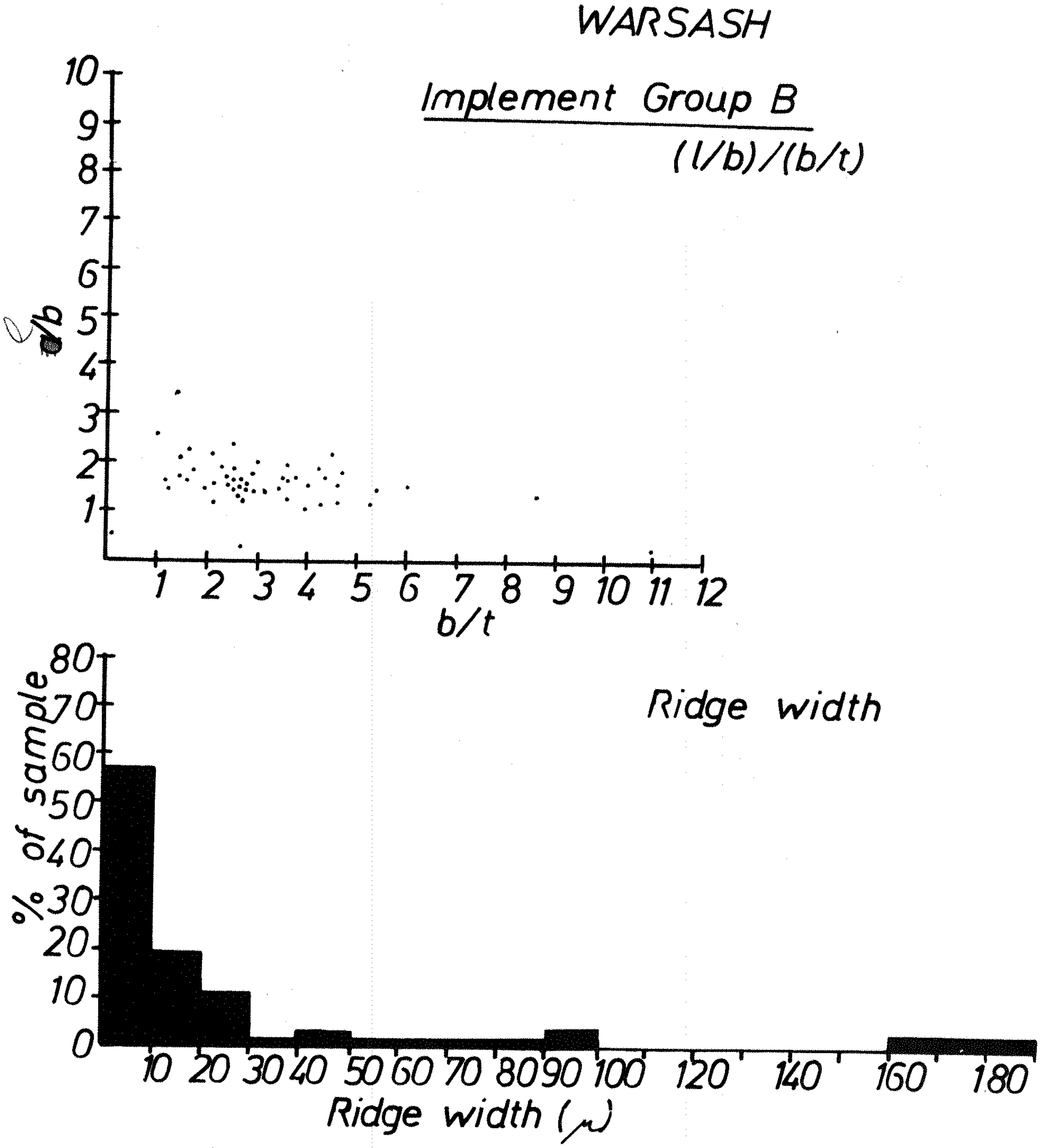


Fig. (28) Scatter diagram and histogram. Parameters from Warsash implement Group B.

and later phase (small sub-triangular Faustkeilblatter and bifacial side scrapers).

Dating

The Warsash/Wolvercote group contains many of the implement forms found in the earlier German Micoquian, especially the Bockstein 3 group. In Germany these industries are generally younger than the Late Acheulean, although older than the Mousterian, except for a few cave sites where Mousterian and Micoquian industries appear to run parallel. The distinctive Micoquian form appears to have been manufactured during a comparatively short period stretching from the late Eemian (Ipswichian) interglacial into the ~~Wurm (Weicselian)~~ Weichselian (Devensian) glaciation. Both Roe and Wymer agree that the Wolvercote material is typologically later than the Late Acheulean, and it seems reasonable to suggest that the British examples of these distinctive industries were made at a period roughly contemporary with that indicated for their German parallels. This would suggest that the Wolvercote channel is more likely to date to the later (Ipswichian) interglacial, rather than to the earlier Hoxnian.

The inclusion of the Wolvercote-type material within the 7.5m raised beach at Warsash supports the hypothesis that the formation of the beach must also have taken place during the Ipswichian. However since Mousterian and Micoquian material are found together it seems possible that several different stone working traditions or cultures were present in Britain at the same time, strengthening the theory that the period was one of extreme cultural complexity. The industries could, of course, be the result of sporadic visits to Britain made by different hunting bands, separated by comparatively short periods of time. No industries of the Warsash/ Wolvercote type are found in Mindel-Riss (Hoxnian) contexts on the Continent, nor at a date later than the Wurm 1/2 interstadial. Since the British examples are all remarkably fresh it is unlikely that they could have been selectively redeposited, and the most likely explanation is therefore that there was, in Britain, a certain degree of overlap between the visits of bearers of Mousterian and Micoquian tools.

<u>Conclusions</u>

There is clear sedimentological evidence for the presence of a raised beach deposit in the area under consideration, south of the lower bluff and terminating in the sea-cliffs. This gravel segment contains a Mousterian of Acheulean Tradition industry, with an admixture of certain Micoquian forms.

A section through these deposits is shown in Fig. (20), illustrating the gentle bluff marked on Fig. (19) and the general topography of the area. It must be remembered that since the area is much dissected, this section, taken through spot heights on the original ground surface, represents the ideal, rather than the actual case. At the top of the bluff the deposits merge into another, wider, gravel flat, backed up against the higher bluff.

At the Chilling section (p.78), the base of the gravels at the junction with Barton sand occurs at 29'OD. The sea-cliff in direct line nearest this point was heavily eroded, with no section visible, but at the slightly offset section of the cliff (Fig. 19, and Fig. 20) the gravel base was observed at 8'OD. The distance on a straight north/south line between these points is some 704 yards, giving the slope of the terrace bench at 1:241. If this slope is projected from the Chilling section to the estimated position of the foot of the bluff (Fig. 19), it is seen that the back of the base of the bluff must occur at about 32'OD. The tidal amplitude for this area is 13', which gives an estimated Mean Sea Level of 24' ~~corresponding to HWM of 24.01' for the base of the bluff~~, with a slope of 1:200. These figures confirm the suggestion that the segment is a dissected remnant of the 7.5m sea level, ~~additional confirm-ation being provided by~~ containing a the stratified Mousterian of Acheulean Tradition industry. (In a slightly different location Jarvis (1957) estimated the gravel base at Chilling to be 15.86'OD, and at the cliff to be 14.30'OD. The measured distance between his two points was much less, only 150 yards, but a slope of 1:288 was calculated, in reasonable agreement with the present figures). Some additional dating evidence for this segment is provided by the presence of a distinctive handaxe form, only found in significant quantities at one other British site (Wolvercote), which is precisely dated on the Continent to a period at the end of the Riss/Wurm (Ipswichian) interglacial, and the beginning of the Wurm (Weichselian) glaciation. Since these handaxes are found here in a fresh condition this tends to confirm the attribution of this sea-level to late last interglacial times, and also suggests that the makers of the Mousterian industries were not the only hunters to venture as far as Britain in this period.

4.12 Cams (Fareham) SU 5805

Introduction

The area between Fareham and Portsmouth, at the base of the Portsdown hills, has extensive and variable drift deposits. These are mapped by the Geological Survey (Figs. 12, 29) with the usual meaningless division into 'Plateau' and 'Valley' gravels, but with the addition of two other classes 'Valley gravel and coombe rock' and 'Raised beach'. The latter bears no relationship to the extensive raised beaches of the area. There are also extensive deposits of brickearth. The higher valley gravels with coombe rock are ~~discussed~~ shown on ~~p.~~ Fig. (12), but the lower gravels in the area of Cams are of particular interest here since they have yielded a series of Mousterian artifacts. The geology and location of Cams is shown on Fig. (29).

The valley gravel of the higher reaches of Fareham Water seems to fall into the general pattern of river terraces (p. 98), but at the junction of the river with the beginning of the estuary at Cams Bay there is a more extensive area of gravel, underlying the old village of Cams. Although the geological map shows this connected in the same block with the higher

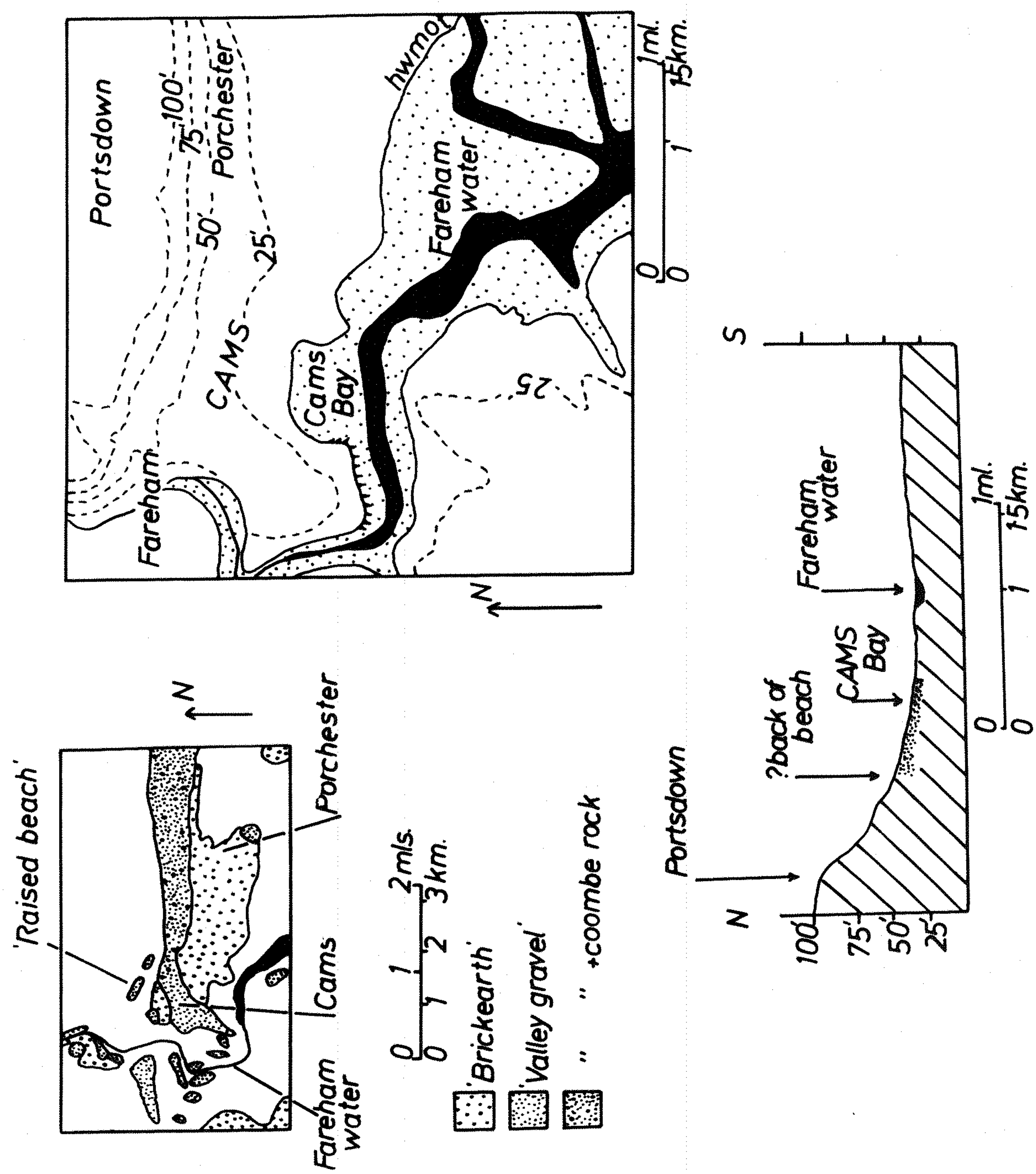


Fig. (29) Geology and topography of the Cams area.

(1) Drift deposits (2) Topography (3) Cross section of deposits.

gravels and coombe rock, the deposits south of the A27 road are marked simply as valley gravel, without the coombe rock. The deposit overlies Tertiary sands and clays, whilst the higher gravels and 'raised beach' occur on the southern edge of the Chalk Portsdown anticline.

The topography of the area (Fig. 29) is seen to consist of a flat plain, stretching from Cams Bay to a marked bluff a little south of the main A27, at SU 595058. The maximum height of this plain is 30'OD, although the bottom of the gravels can be seen at 22'OD at Cams Bay, and the bluff falls sharply from 47-32'OD. There is no perceptible north/south gradient, and the position and topography are suggestive of a raised beach.

Earlier in this century a series of implements which now form part of the Mogridge Collection of Southsea Castle museum (accession no. 25-50) were collected by Mogridge from this 'flat'.

Implements

The series from this Cams gravel 'flat' consists of a small number of refined tools together with a great many heavily rolled flakes. Roe (1967) lists only 1 handaxe and 'several beach-rolled flakes' from this site. Table (23) shows the composition of the industry, which includes flake tools of Mousterian type, Levallois flakes and tortoise cores. It is unfortunate that Mogridge did not record the exact provenance, other than the fact that the industry was stratified in gravel between 25-32'OD.

The Mousterian types are atypical, often being rather thick and crudely worked. Many of the artifacts are very heavily rolled, and a thick creamy-white 'marbled' beach patina is common, frequently accompanied by iron streaking along the most prominent ridges, and by some signs of frost action. A high proportion of the assemblage consists of unretouched blades and flakes, very heavily worn and of varied shape. However, thinner better refined Mousterian tools do occur with the same patination. Different parts of the flakes have occasionally been rolled to different

Table (23)

Type No.	Description	No. present
1	Levallois flakes/blades	12
9	Single straight racloir	2
10	Single convex racloir	4
12	Double straight racloir	1
16	Double concave racloir	1
24	Transverse concave racloir	1
31	End scraper	1
33	Burin	1
65	Handaxe fragments	2
120	Handaxe roughouts	2
119	Tortoise core	3
124	Trimming flakes	1
65	Hammerstones	2
123	Unretouched flakes	32
123	Retouched flakes	1
		66 (Total)

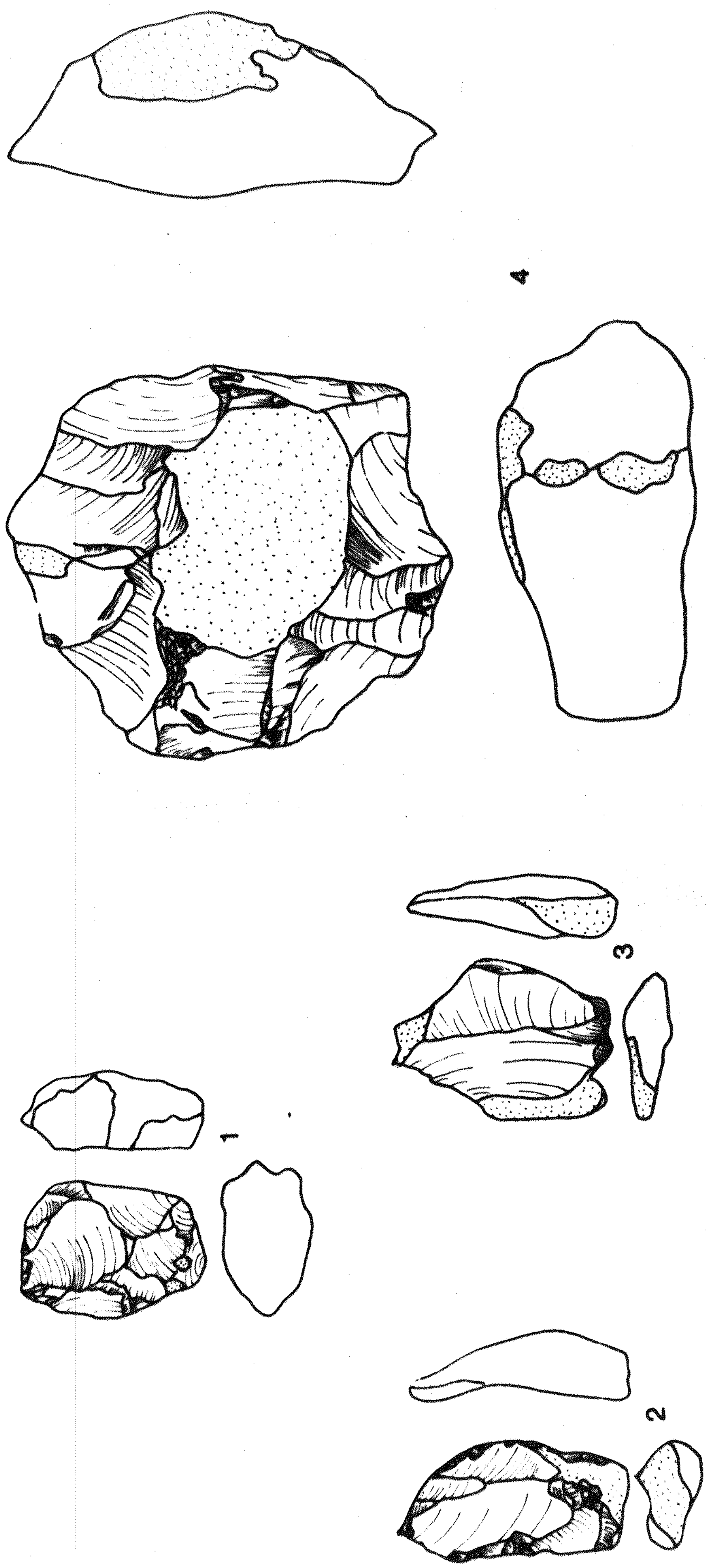


Fig. (30) A 'tortoise' core and some flakes from Cams. (1/1.5) degrees, and there is some evidence to suggest that tools were sometimes made on previously patinated pebbles.

Fig. (31) shows a scatter diagram of the a/b and b/c (length/breadth and breadth/thickness) ratios. The distribution is almost random, the correlation co-efficient being only mildly negative at -0.18. The implements tend to be thick and broad, not well refined, and a useful comparison may be made with the industry from Great Pan Farm (Fig.45 p.113). Table (24) presents a summary of the statistics from the implement measurements.

Fig. (31), a scatter diagram of weight/abrasion, again shows a random distribution, with an insignificant positive correlation co-efficient of +0.01. A scatter plot of weight a/b gave a higher coeffieient of 0.38, but this would be expected since larger implements naturally tend to be heavier. These figures illustrate the fact that the implements do not form a unified series, but this may be attributable to selective beach rolling. A similar discrepancy, the result of very heavy weathering, may be seen in the Mousterian series from Holybourne (p.156). The broad spectra of abrasion measurements seen here (histogram, Fig.32) show the variability of the series, which has only 8 implements with average ridge widths of less than 10/mm. This is clearly due again to the beach-rolling, where implements dropped at the same time may be subject to very variable abrasion, as can be seen from the juxtaposition of very heavily worn pebbles with comparatively fresh ones on modern beaches.

The presence of cores, hammerstones and trimming flakes is a strong argument for the existence of a true 'site', perhaps even a former working floor. The industry is very similar to that of Warsash, although more heavily rolled, and there seems to be little difficulty in including it in the Mousterian of Acheulean Tradition industries of the 7.5m. raised beaches.

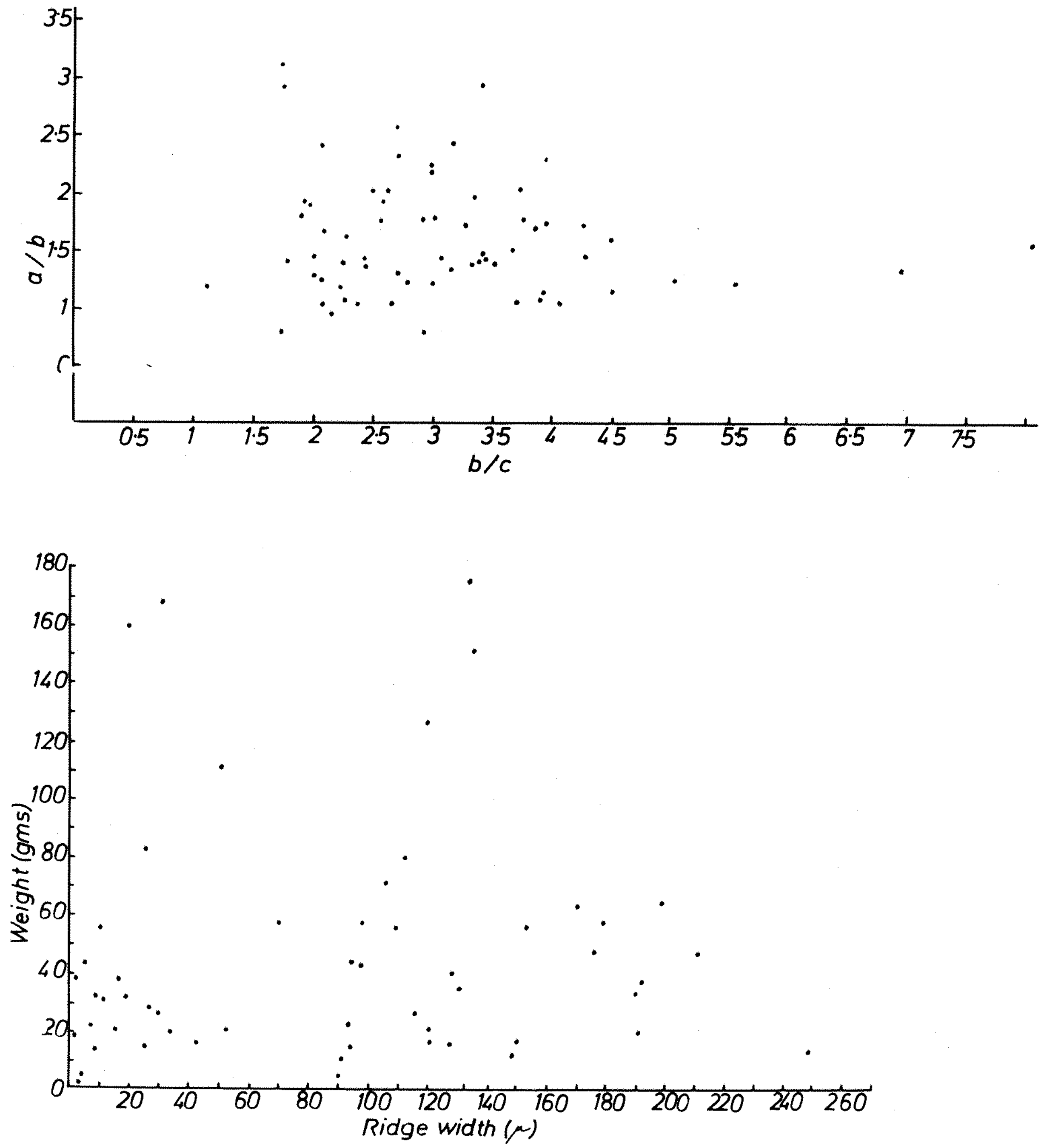


Fig. (31) Scatter diagrams, Cams implements.

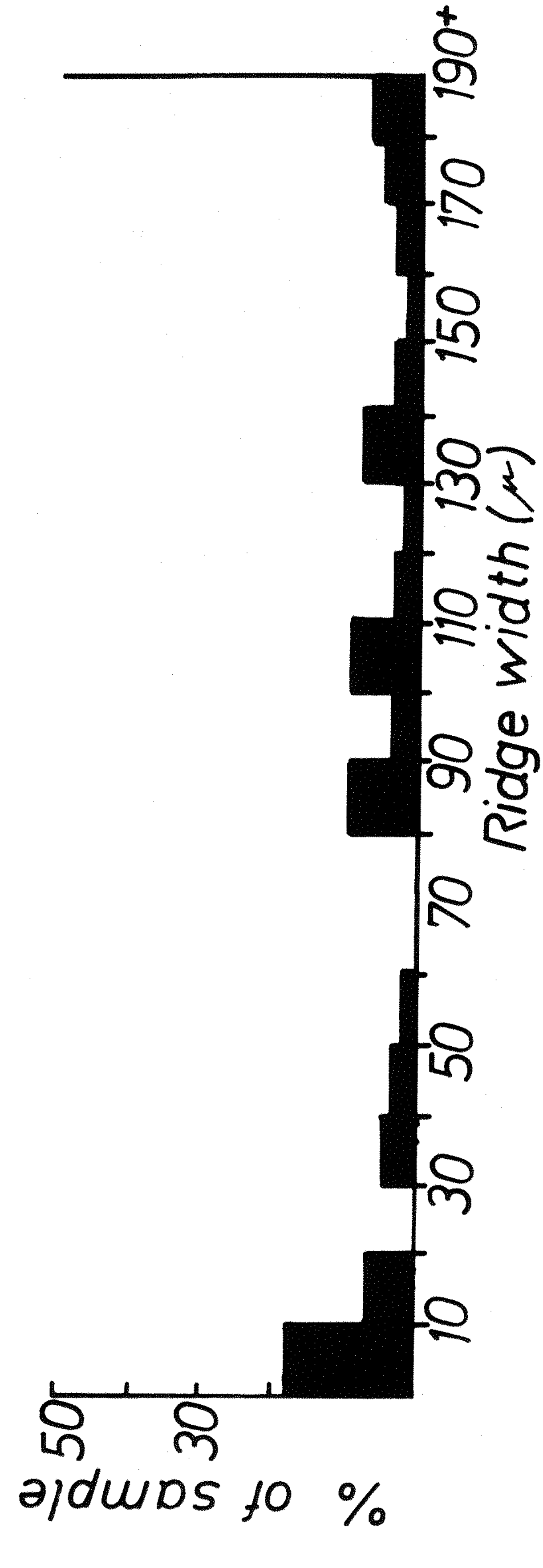


Fig.(32) Histogram of ridge widths,Cams implements.

Table (24) Summary statistics from Cams industry

Parameter	Mean	Variance	Standard Deviation	Standard Error of Mean	Skewness	Kurtosis
a/b	1.99	2.60	1.61	0.21	3.57	12.84
b/c	3.00	1.44	1.20	0.15	2.11	7.14
Weight	47.67	1822.23	42.68	5.55	1.75	2.46
Abrasion(ridge width in µm).	98.23	4672.01	68.35	8.89	0.10	-1.15

Conclusions

Several features of this site, including the distinctive patination and wear on the implements, suggest that the gravel spread might be a raised beach. Kirkaldy and Bull (1940) consider that the bluff at the back of this terrace is the 'weathered extension of the old cliff against which the 25' raised beach is banked at Black Rock, Brighton', and regard the deposits as fluviatile or semi fluviatile gravels overlying a marine beach graded to the present foot of the bluff at 30'OD. Everard, (1952 p. 24) described the variable abrasion of pebbles in the gravel and assigned the deposit to the higher reaches of his 'Gosport Stage', which was composed of an amalgam of his 25' and 10' horizontal segments. He calculated a transverse slope of only 7' per mile for this stage, nearly horizontal. He attributed the angular nature of the gravel to the limited tidal fetch (see p. 129).

The figure of 30' for the base of the bluff for this area is consistent with examination of the topography. There is no section visible at the present time. The bluff is extremely marked, and slopes steeply from 47-32'OD (surface heights). At Cams Bay there is a small exposure of the underlying Tertiary sand with a thin spread of gravel, much resorted

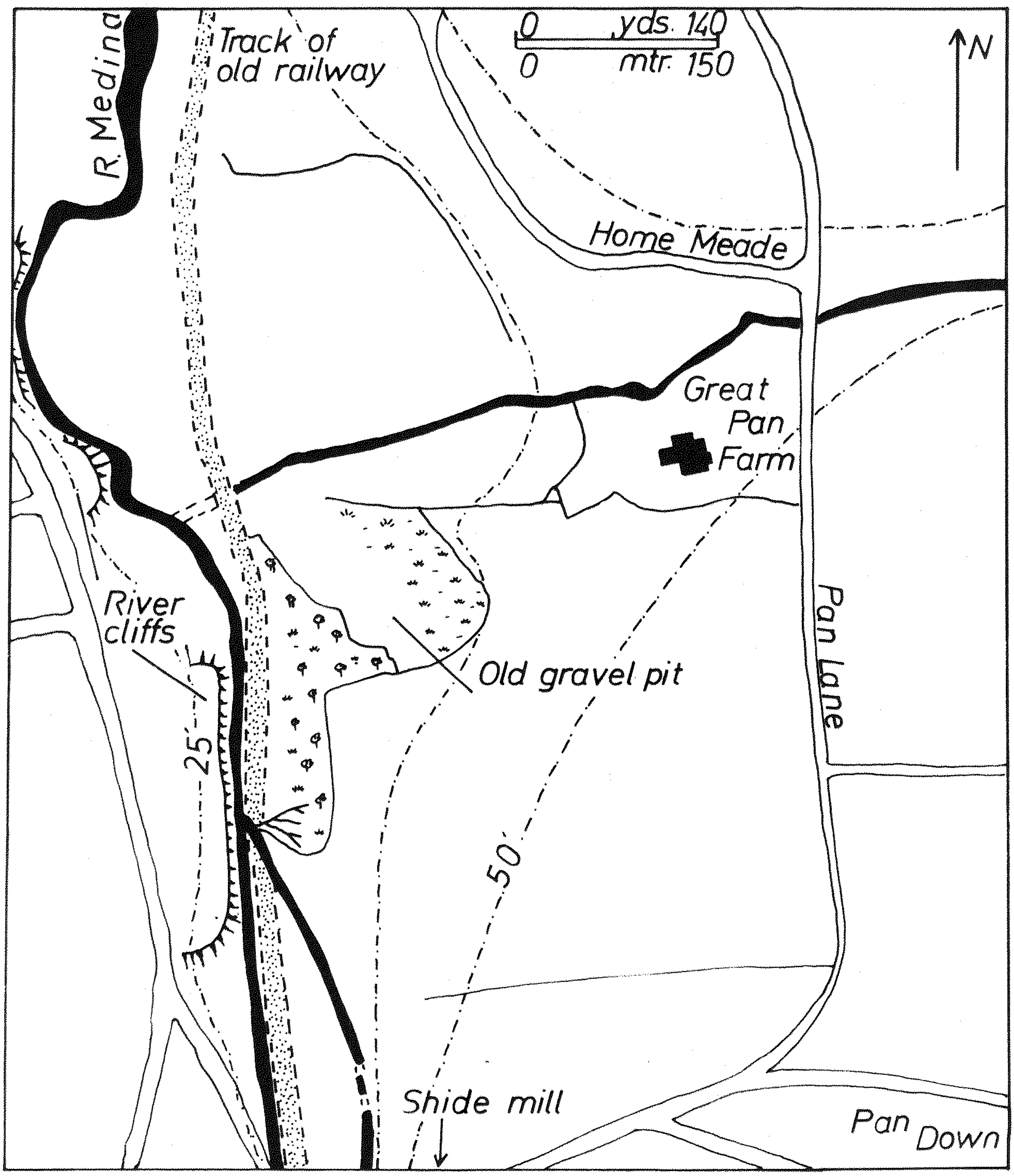


Fig. (33) General location map, Great Pan Farm.

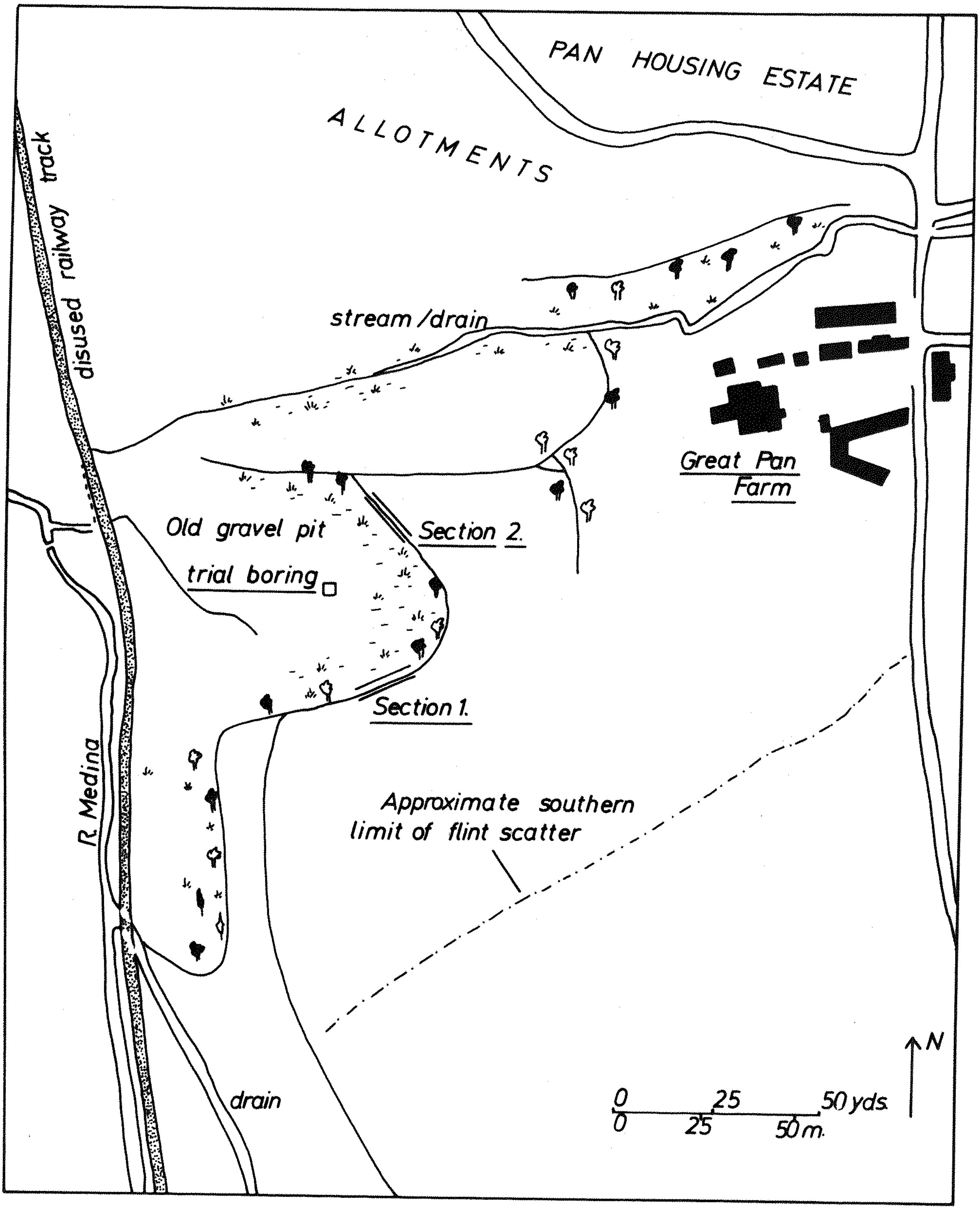


Fig. (34) Detailed location map showing position of old gravel pit, Great Pan Farm.

and showing that the foot of the gravel must lie at about 22'OD. Although it is impossible to be certain, the bluff foot seems likely to lie between 32-30'OD, which gives a slope of less than 1/300 for the terrace, markedly similar to that of Stone (p. 129), and well within the range for a raised beach deposit. Since the modern tidal range of the area is 13', and was probably little different in Pleistocene times, this would mean that the base of the bluff was graded to a Mean Sea Level of 6.7-7.3m. (23-24.4'), within the range for the 7.5m raised beach.

In conclusion, therefore, it could be stated that there is a great deal of evidence, both from the implements and from the topography, to suggest that this gravel 'flat' at Cams once formed part of the 7.5m. raised beach of the south coast, together with other similar deposits at Stone, Christchurch and Warsash.

4.13 Great Pan Farm

The site of Great Pan Farm, Newport, Isle of Wight, yielded the largest well provenanced collection of Mousterian of Acheulean Tradition artifacts found in Hampshire. It is located just south of the town of Newport, to the ~~west~~ east of the River Medina (Grid Reference SZ 507866) and consists of a deposit of gravel bounded at the west by the river and sloping gently upwards to the chalk scarp of Pan Down in the east, (Fig. 33). Poole (1924) records the opening of a new gravel pit at the site in 1912, the workings of which he observed and recorded from 1920-1924. Soon after this date the workings were abandoned, and the extensive series of accurately-located implement finds passed into Poole's private collection. However owing to his efficient and accurately drawn sections and plans an excellent record of the stratigraphy of the pit has survived, although only 112 of the original finds, lodged in Carisbrooke Castle museum, are now available for study.

The pit, approximately 150 yards across (Fig. 34) was dug into the extensive gravel deposits, and little undisturbed material is now left. At present the old workings are waterlogged and heavily overgrown, but two faces were still partly visible along the southern and eastern walls of the pit (Fig. 34). The line of the old railway (Fig.33) is to be used as the mid-line of a southern relief road for Newport, planned to start in 1974, which will effectively destroy all the remaining gravel remnants. In view of this, and of the excellent series of implements found, plans were made to excavate the remaining areas of gravel, in order to confirm the stratigraphy and, hopefully, to explore the possibility, suggested by Poole (1924) and Roe (1968), that an occupation site might exist nearby. The Department of the Environment kindly provided the money for an investigation, but because of unforeseen circumstances it proved impossible to carry it out on the scale planned. However, extensive trial trenching was undertaken, with the use of a machine, and it was found that the height of the water table was such that normal excavation was quite impossible, trenches flooding to depths of over 1m overnight, even in fine summer weather. A decision was made to concentrate on clearing and examining the two most accessible sections, and digging a trial pit in the centre of the area to see if any undisturbed deposit remained.

The location of these sections is shown on Fig. (34). The object of the investigation was firstly to examine the nature and extent of the deposits, secondly to survey the stratigraphy and validate Poole's remarks, thirdly to see if any further finds of implements could be made, and lastly to examine the composition of one layer of the deposits in some detail. This layer was described by Poole as a 'greenish-grey sand with plant remains', stratified within the gravel, and it was hoped that it might yield identifiable palaeoenvironmental evidence.

Since the interior of the pit proved to have virtually no undisturbed deposit, and the difficulties of excavating it were very great, it is not,

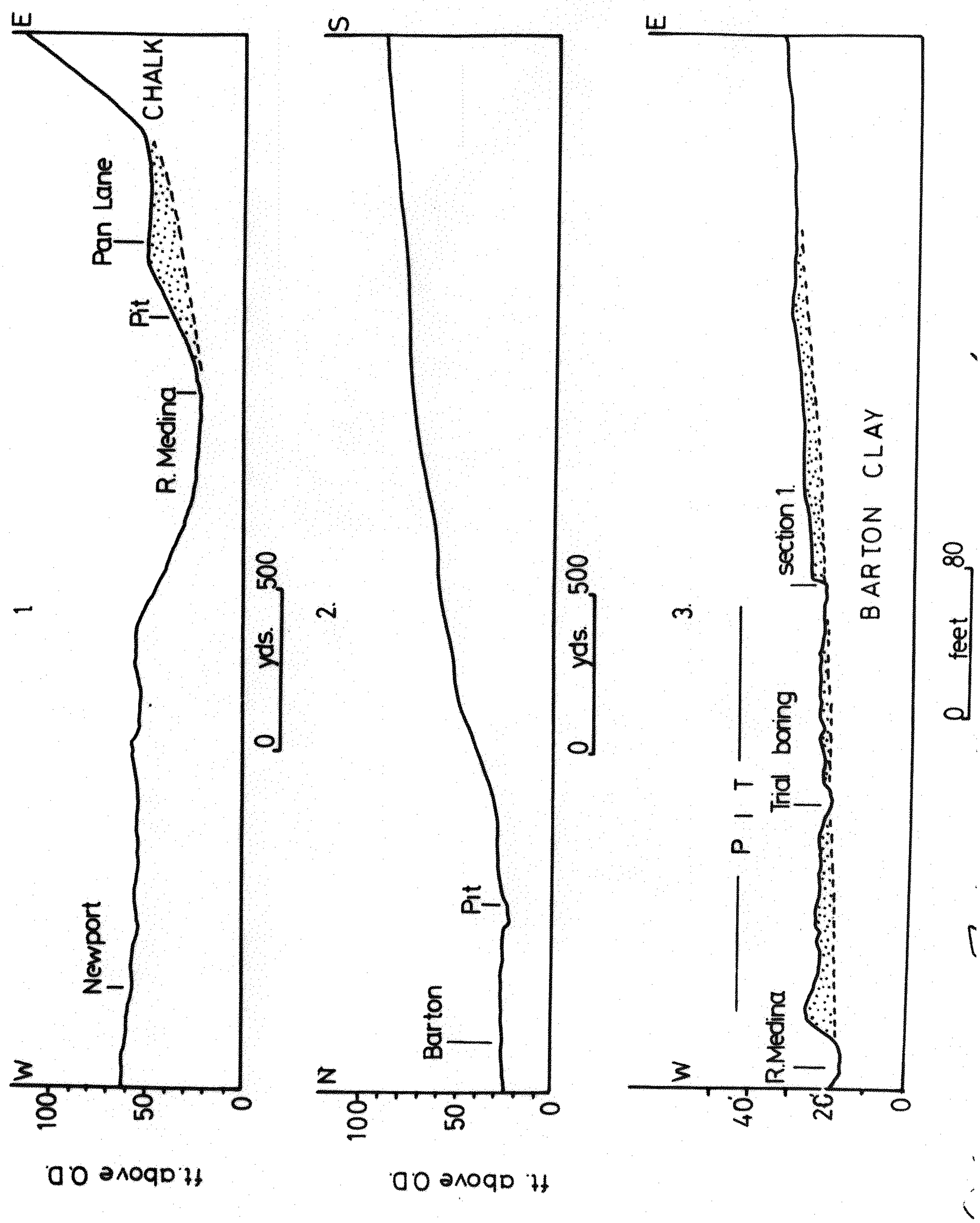


Fig. (35) Transverse sections, deposits at Great Pan Farm.

perhaps, surprising that no further palaeoliths were found, since Poole (1924) estimated their proportions at 1 per 200 tons of gravel. However it was found possible to confirm Poole's stratigraphy, and comment on the nature and depositional environment of the sediments. The accuracy with which he recorded his sections and implement find locations enabled the assemblage to be related to the extant layers, and its component sub-groups to be analysed by the methods described above. It was therefore possible to comment in some detail on the relationship between the total implement assemblage and its sub-groups, and between the implement finds and their matrix deposit.

The long profile of the Medina shows that it falls rapidly from over 120' in the chalk downlands to approximately 25'OD in the Newport area, crossing Tertiary deposits after leaving the Chalk. A cross section of the river valley at Great Pan Farm (Fig. 35) shows the terrace remnant, and it is probable that a similar, paired terrace, exists on the west bank of the river, although this is not exposed, due to building. Drift is marked on both banks by the Geological Survey 1" and 6" drift edition maps, although its marked extent on the east bank is far less than that actually present. The Medina is now a very narrow and insignificant river not having sufficient velocity to transport gravel except in times of flood, and it is navigable only in the tidal estuary. The total length is some 14 miles, and a number of other gravel terraces are recognisable along it. The gravel at Great Pan Farm appears, therefore, to be geomorph-ologically a remnant of a paired terrace of the River Medina. Fig. (35) shows a cross section of the deposits compiled from measured sections and levelling carried out by the River Authority as part of their proposed re-direction of the course of the Medina, and it can be seen that the base level of the gravel is to be found at approximately 21'OD.

Table (25) Correlations between sections drawn by Poole (1924) and fresh sections shown in Figs. 37 and 38.

Layer Numbers (Poole 1924)	Layer Numbers. Section 1.	Layer Numbers. Section 2.
7		
6	1	1
5		
4	2	2
3	7	-
2	8	11
1	9 (Barton Clay)	13 (Barton Clay)

The composite section drawn by Poole (1924) as illustrated in Fig. and can be seen to show deposits consisting of two bands of yellow gravel separated by a clay lens and topped by disturbed and redeposited material. The gravel rests on a blue sandy clay (Barton Clay). Poole does not illustrate any 'red' gravels, although these are mentioned in his text as the location of various implement finds. He states that many implements were found in 'a bed of heavily stained flints, in a harder matrix, at a distance of 1' from the top of the lower yellow gravel', which is presumably a reference to the iron pan shown in Fig. 37. Poole also mentions a 'stained bed' in the upper yellow gravels, which may be the equivalent of the manganese and iron pan forming Bed 3, Section 1 (Fig. 37). The topmost beds shown in Poole's section are clearly redeposited topsoil, also shown in Fig. 37. The correlation between Poole's section and the ones freshly exposed are shown in Table (25).

It is important to note that Poole's section is composite, compiled from over 20 measured sections, and that he mentions the fact that the 'greenish grey sand with plant remains' was of variable thickness and not

Bed		variation in thickness	average thickness	Tools
6	Clay rainwash	6-20"	12½"	bronze palstave
5	White gravel	4-12"	7"	Thames pick
4	Upper yellow gravel	15-23"	15½"	Mousterian Acheulean 2
3	Greenish grey clayey sand with plants	1-11"	5"	as 4 + la Micoque
2	Lower yellow gravel	18-42"	29"	as 3 + Acheulean 1 & late Chellean
1	Bluish sandy clay	seen to 3'		Acheulean 2

Fig. (36) Composite section through the deposits at Great Pan Farm, after Poole (1924) found at all locations. He considers that the tusk of Elephas antiquus (FY, found with a mollusc cast and some implements at the base of the section came from the blue (Barton) clay, but since the clay is a Tertiary deposit it seems more likely that the finds occurred in pockets or craters within its irregular surface. Elephas antiquus, the straight tusked elephant, is typical of interglacial climates in Britain. It seems to have retired southwards during glacial phases, being found in Spain during the last glaciation, when it was already extinct north of the Pyrenees (Kurtén 1968). It was adapted to a temperate climate, and a parkland or forest environment.

Despite the fact that the implement typology used by Poole is now obsolete it is interesting to note that he records very early ('Chellean') material only from the base of the section. Since this is stated to be much rolled, and has now, in any case, been lost, it is reasonable to suppose that it either represented material redeposited from higher terraces, and thus of earlier date or else referred to material stratified within these deposits, perhaps crude axes or roughouts which did not appear to be connected with the industry. The typological distinctions of Poole are not to be relied upon since he was using the term 'Mousterian tools' to indicate only retouched flake implements, and in fact the majority of the implements which he described as Acheulean appear to be related to the Mousterian of Acheulean Tradition industry.

The trial boring made in the centre of the pit (Fig. 34), yielded less than a metre of disturbed gravels and topsoil over Barton clay. It seemed unlikely that undisturbed sections were to be found here, and attention was concentrated at the two accessible faces, whose location is marked on Fig. 34 .

<u>Section 1.</u>

This section, exposed for over 4 metres along the former southern

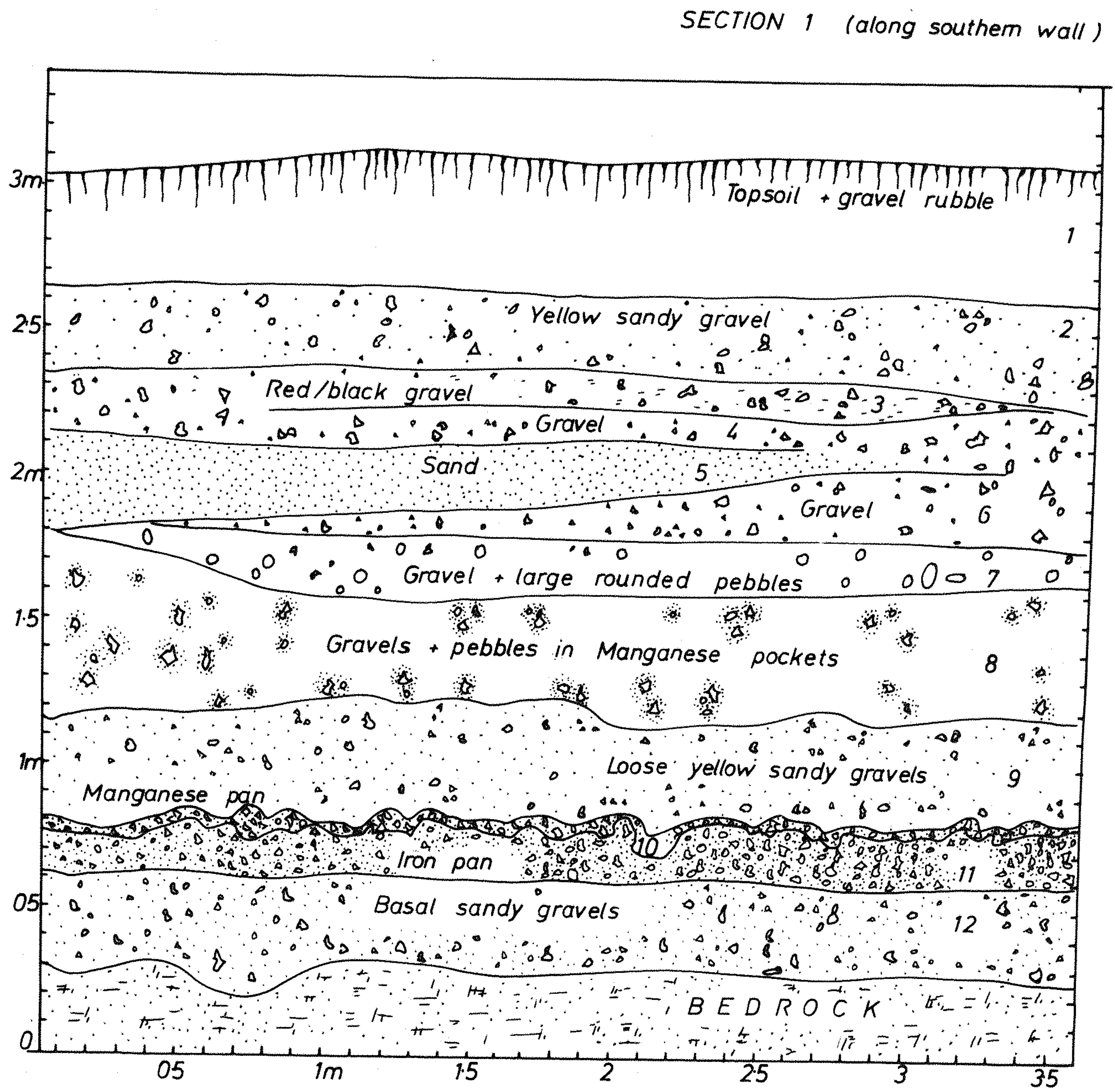


Fig. (37) Section 1, deposits along the south wall of the pit, Great Pan Farm.

wall of the pit, consisted of less than 3 m of stratified gravels, comprising 12 distinct layers, resting on Barton clay and capped by layers of topsoil and general rubble. After the section had been exposed and cleared, it was dug down to below the bedrock level, drawn and photographed, samples were taken and the composition of the deposits examined in some detail.

The basal layer of the deposits consisted of a thick bed of loose yellow sandy gravel (Layers 9 and 12, Fig. 37), divided by Layers 10 and 11, a compacted iron and manganese pan. This bed corresponds to the lower yellow gravel of Poole (1924), Table (25). Above this, layer 8 was also a sandy gravel, with occasional pockets of manganese, and was succeeded in the stratigraphy by the more sandy gravels of layers 7, 6 and 2. The 'clayey sand' mentioned by Poole was identified with layer 5, but was much better exposed in Section 2. A further incipient iron pan forming layer 3 was observed in the upper part of the section, and is presumably equivalent to Poole's 'upper red gravels' (Table 25).

No sedimentary structures such as current bedding were observed, and the yellow gravels were remarkably homogeneous in appearance, consisting largely (up to 70%) of chert pebbles derived from the Lower Greensand, combined with flint pebbles freshly eroded from the chalk, and some material derived from older terrace gravels. It was interesting to note that the chert and flint pebbles differed markedly in roundness and sphericity. Fig. (39) illustrates histograms drawn of the values obtained by examining all the pebbles in a gravel sample, taken from layer 9, section 1. The flint pebbles are significantly less rounded than the chert, and are actually fresh and angular in appearance, although there is little difference in the sphericity values. Table (27) shows the mean roundness of the flint pebbles to be 2.46, whilst that of the chert is 5.75, and it seems likely that the chert pebbles had been redeposited from higher gravels, whilst the flint had been freshly eroded. This difference in composition is not reflected by the implements found stratified within the deposits, which with only one exception are made of flint, not chert. In addition they are not made of the same kind of flint which occurs in the gravels, since this would presumably not have been especially good for the making of implements, but are manufactured of imported speckled grey flint, of an especially attractive colour, which is not found naturally in the gravels.

Samples were taken from each layer and analysed for their particle size distribution. The resulting curves for layers 2, 9, 10 and 12 are shown in Fig. (40), and their descriptive parameters summarised in Table (26). Their composition can be seen to be remarkably uniform, consisting of mixtures of 55-65% gravel with 30-45% sand, and less than 2% silt and clay. All are poorly sorted and platykurtic.

The manganese pan, layer 10, differs from the other layers since it contains appreciably more sand, causing the resulting size distribution to be coarse skewed and mesokurtic. Layer 9 was slightly more compacted and patinated than layer 12, and the flints were heavily frost fractured. This is a marked contrast to the flint implements from this layer, which are extremely fresh, providing additional evidence that the implements were incorporated into the gravel 'in situ' and were not made of stream re-deposited material.

With the exception of layers 1 and 5 the deposits are typically poorly sorted fluviatile gravels.

Table (26). Composition of samples, Great Pan Farm.

Sample		% gravel	% sand	% mud	Mean	Variance	Skewness	Kurtosis
Section 1, Layer 2	Sandy gravel	55.33	43.75	0.90	-1.65	6.15	-0.09	0.60
Section 1, Layer 9	Sandy gravel	62.60	36.63	0.77	-2.02	6.34	-0.7	0.65
Section 1, Layer 10	Sandy gravel 104.99	38.83	65.27	0.89	-0.49	4.89	+0.08	0.94
Section,1, Layer 12	Sandy gravel	65.55	33.02	1.42	-1.89	5.33	+0.80	0.82
Section 2, Layer 3	Gravelly sand	19.52	79.96	0.50	0.38	3.98	0.62	1.27
Section 2, Layer 7	Slightly gravelly sand	0.17	96.93	2.89	2.86	0.40	-0.14	1.15

Table (27) Roundness and sphericity statistics. Flint and chert pebbles, Layer 9, Section 1.

Parameter	Mean	Variance	Standard Deviation	Standard Error of Mean	Skewness	Kurtosis
Flint						
Roundness	2.46	1.12	1.06	0.27	-0.31	-1.13
Sphericity	78.86	35.69	5.97	1.54	-0.72	-0.75
Chert						
Roundness	5.75	1.26	1.12	1.12	0.56	-0.77
Sphericity	79.87	43.18	6.57	6.57	-0.18	-0.84

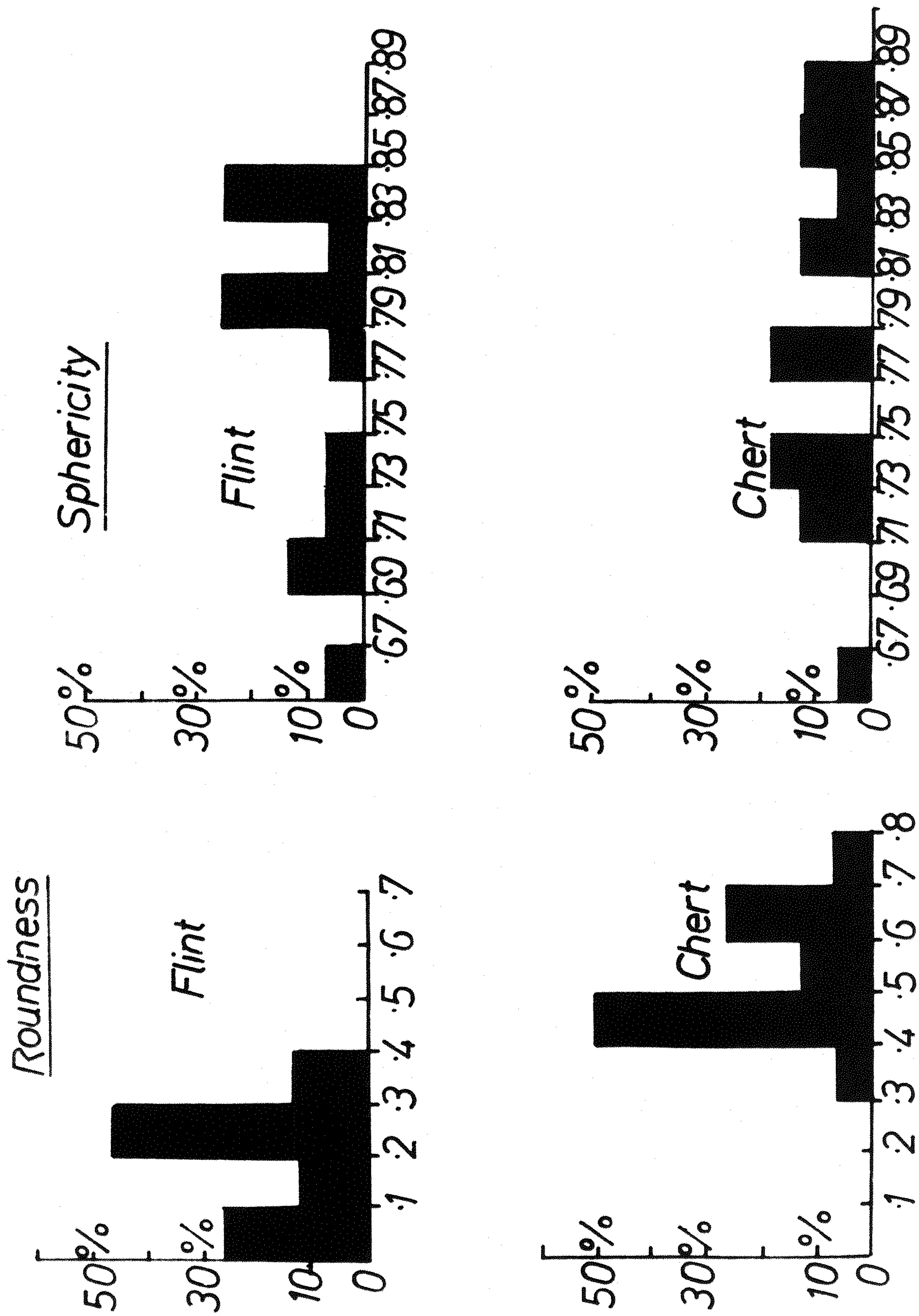


Fig. (39) Histograms of the roundness and sphericity values of pebbles from Bed 9, Section 1, Great Pan Farm.

Section 2

Section 2, along the east wall of the pit, consisted chiefly of sand, with a bed of loose patinated river gravel at the base. It contained an excellent example of the 'clayey sand' described by Poole (1924), which he thought contained plant remains. A sample of this sand, layer 7, was closely examined, in a hand specimen, under the microscope and in thin section, and with the exception of rootlets and twigs of blackberry and oak no plant remains, microfossils or pollen were found. It seems possible, therefore, that the reported plant remains could be a mis-identification of modern material, a credible mistake when the nature of the deposits is taken into consideration. This so-called 'clay lens', layer 7, consisted of about 96% sand, less than 1% gravel and less than 3% silt. It was moderately well sorted, in contrast to the rest of the deposits, coarse skewed and leptokurtic, and is considered, by virtue of this negative skewness and other characteristics, to be a beach sand, a suggestion confirmed by examination of certain grains under the scanning electron microscope. The Munsell colour of the deposit was 2.5 6/4 (light yellowish brown), and its pH 7.3.

This sand was completely different from the fine grained gravelly sand forming layer 3, section 2. Although this also consisted primarily of sand (80%) it was poorly sorted, positively skewed and leptokurtic, and in appearance strongly suggested a fluviatile sand. The particle size distribution curves for layers 3 and 7 are shown in Fig. 26 , and their descriptive parameters summarised in Table (26).

The two sections are thus seen to be very different in character, and Poole (1924) comments on this lack of general stratigraphic homogeneity, and on the variable thicknesses of the layers. The most interesting feature is, of course, the layer of beach sand stratified within the layers of river gravel. At present the estuary of the river Medina lies only a mile north of the site, and the river drops very little in height. The

SECTION 2 (along east wall)

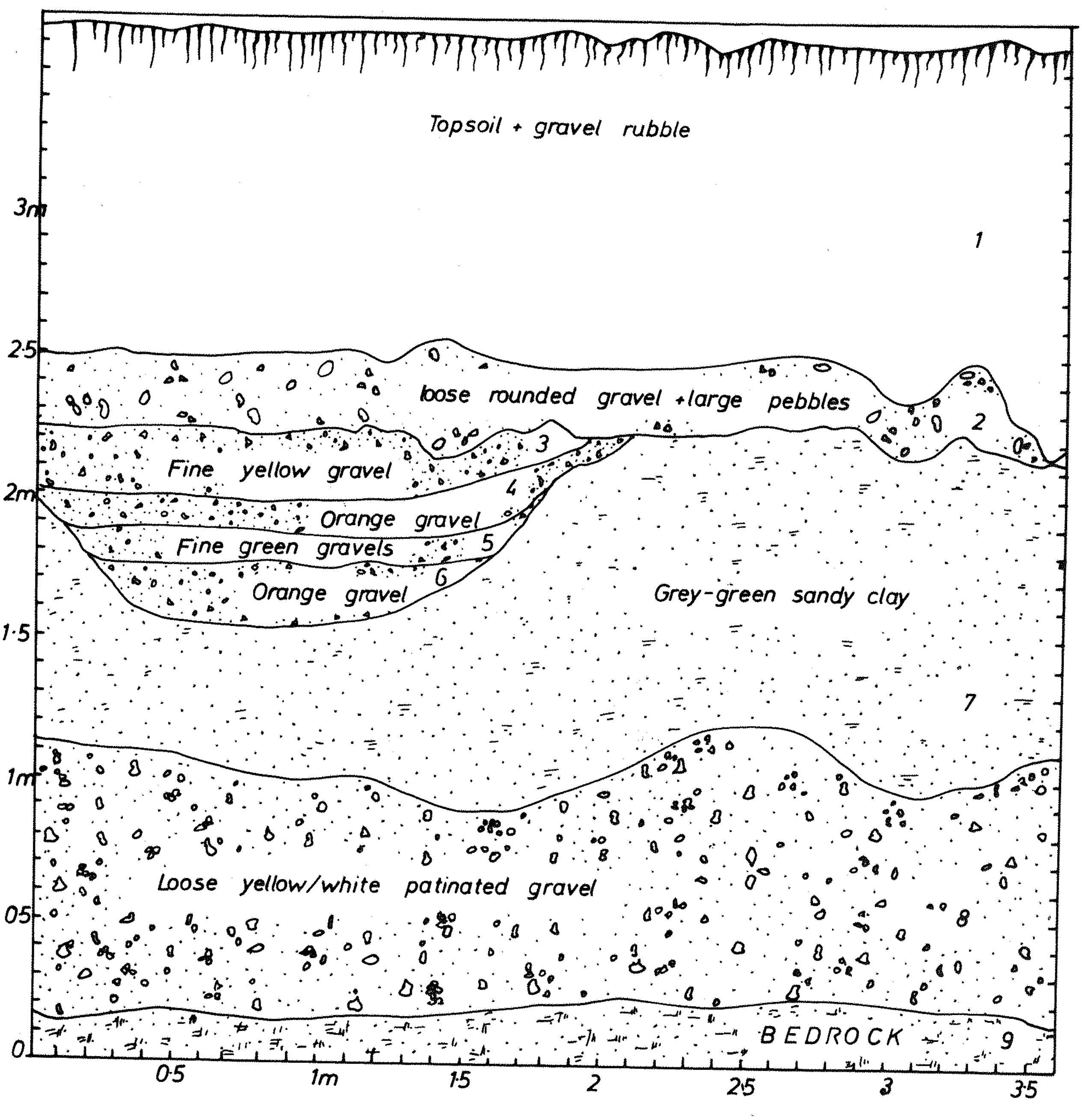


Fig. (38) Section 2, deposits along the east wall of the pit, Great Pan Farm.

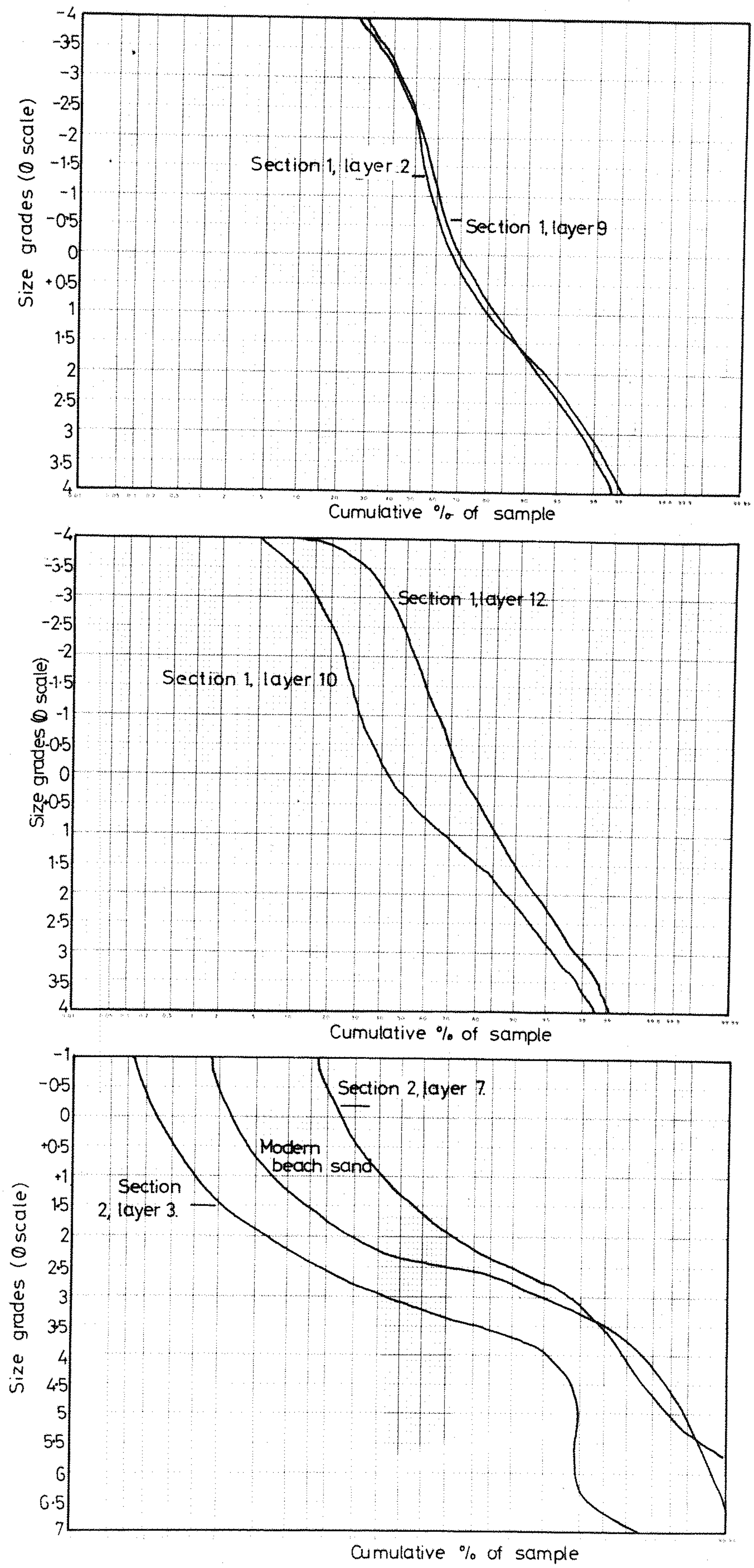


Fig. (40) Particle size distribution curves for samples from Section 1, Great Pan Farm.

beach sand could be the result of a temporary flooding of the lower coarse of the river, resulting in an accumulation of sand at this point. The inundation might only have been very short lived, but must have been the result of a rise in sea level to at least 16' (c.5m) above OD. In the measured sections the base of the sand lies at an average of 21.49' OD and this figure is likely to increase at the inaccessible extreme back of the deposit, (Fig. 35). No figures are available for the tidal range of the Medina estuary at Newport, but it is likely to be less than the 11' quoted for Cowes. A rise in sea level of perhaps 17-20' would then be required for the formation of the beach sand, within the range of the 7.5 m transgression. No firmer sedimentary evidence for this connection could be found, but the suggestion that the transgression responsible for this beach sand was the same as that responsible for the beach deposits on the mainland (p. 90) is strongly supported by the inclusion within both deposits of Mousterian of Acheulean Tradition industries, markedly similar in manufacturing technique and unlikely to be greatly separated in time.

The Implements

Poole (1924) records 140 implements, excluding roughouts, together with cores and at least 150 flakes. He estimated that about 1 implement was being found per 200 tons of gravel, even though the gravel was being dug by hand. By no means all of this collection has survived, and there is reason to believe that much of it was dispersed after Poole's death, its present location being unknown. However 110 implements, including both handaxes, flakes and retouched tools, are stored in Carisbrooke Castle museum and this assemblage was subjected to the analytical methods described above (p. 42-).

The total group

The composition of the assemblage is shown below (Table 28), and can be seen to include 46 handaxes, 2 of bout coupé form. There are 18

Levallois flakes, with no preferred butt type, and these tend to be rather large and flat, resembling the Bakers Hole form (Wymer 1968). The 37 retouched Mousterian tools include 6 single racloirs, 11 racloirs with bifacial retouch, probably used for chopping, 5 knives and some notched, denticulate and piercing tools. The general impression is of an all-purpose tool kit, with artifacts designed for a wide variety of uses. It is interesting to note that the assemblage also includes cores and manufacturing flakes.

The nature of the group suggests that it is a true assemblage rather than a random accumulation, indicating the presence of a working or occupation site. With the exception of one chert handaxe the artifacts are made of a speckled greenish-black flint, occasionally patinated yellow, and this is a direct contradiction to the composition of the matrix gravels (p.101). It seems likely that the makers of the assemblage deliberately selected the best material for their tools, since the flaking properties of flint are superior to those of chert, and this particular variety is, in addition, of attractive appearance.

The industry is of typical British Mousterian of Acheulean Tradition type, cruder than the Continental assemblages but still containing the typical backed knives and bout coupé handaxes. It has many features in common with the Warsash, Cams and Christchurch industries, but is especially remarkable for its small size, the handaxes seldom exceeding 10 cm in length. There seems reason from this and other characteristics of the group to support the theory advanced by Poole (1924) and Roe (1968) that there might be a chipping floor nearby. Roe (1968) summarises the main character of the industry and comments on the flakes, which he considers to be 'very much of the type generally associated with occupation sites'. He subjects 44 handaxes to his metrical analyses, and assigns them to the 'more pointed' variety of his 'Ovate Tradition'(Group 6). It is interesting to note that this is the same group which contained the Mousterian of Acheulean Tradition industries of Holybourne and Oldbury.

Since the find spots of each implement are recorded with very great accuracy by Poole (1924), the material coming from each individual sedimentary unit may be considered separately, before conclusions on the nature and unity of the 'assemblage' are drawn.

Table (28) Composition of the total artifact assemblage from Great Pan Farm

Type No.	Description	Total
1-2	Levallois flakes	18
4	retouched Levallois point	1
8	limace	6
9	single straight racloir	1
10	single convex racloir	3
15	double convex racloir	1
21	offset racloir	1
28	racloir with bifacial retouch	11
34	typical piercer	1
35	atypical piercer	1
36	typical backed knife	2
38	natural backed knife	3
41	Mousterian tranchet	1
42	notched tool	1
43	denticulate tool	1
56	rabot	2
65	divers	1
100	pointed triangular handaxe	3
102	sub triangular handaxe	9
107	cordiform handaxe	7
108	long cordiform handaxe	2
109	sub cordiform handaxe	1
111	discoidal handaxe	2
112	ovate handaxe	13
114	amygdaloidal handaxe	1
115	cleaver	1
116	flake cleaver	1
119	core	1
120	roughout	1
124	trimming flake	1
125	pointed triangular handaxe on flake	1
127	sub triangular handaxe on flake	4
132	bout coupé	2
135	long sub-cordiform handaxe on flake	2
137	ovate on flake	1
138	limande	1

Table (29) Summary statistics. Great Pan Farm assemblage

Layer	Number	Mean	Variance	Standard Deviation	Standard Error of mean	Skewness	Kurtosis
Abrasion							
Lower Yellow	43	10.74	104.05	10.20	1.55	3.13	12.65
Upper Yellow	17	9.52	66.88	8.17	1.98	2.06	2.06
Red	10	16.60	106.26	10.30	3.25	0.75	-0.74
Clay Band	10	8.80	83.51	9.13	2.88	1.81	2.64
Unlocated	30	8.90	39.50	6.28	1.11	1.39	2.80
Total	110	10.38	79.93	8.94	0.84	2.41	8.38
Weight							
Lower Yellow	43	160.27	12761.77	112.96	17.22	1.63	3.84
Upper Yellow	17	140.94	8476.30	92.06	22.32	0.94	0.70
Red	10	153.80	3450.40	58.74	18.57	0.36	-1.14
Clay Band	10	107.40	3033.60	55.07	17.41	1.35	1.83
Unlocated	30	117.54	3108.06	55.75	9.85	0.004	-0.84
Total	110	139.83	7862.07	88.66	8.37	1.73	5.51

Table (29) contd.

Layer	Number	Mean	Variance	Standard Deviation	Standard Error of mean	Skewness	Kurtosis
Length/breadth							
Lower Yellow	43	1.58	0.25	0.50	0.07	2.09	5.07
Upper Yellow	17	1.58	0.17	0.41	0.10	1.52	1.73
Red	10	1.66	0.44	0.66	0.21	1.43	1.35
Clay Band	10	1.44	0.03	0.19	0.06	0.13	2.21
Unprovenanced	30	1.52	0.13	0.36	0.06	2.29	5.83
Total	110	1.56	0.20	0.44	0.04	2.05	4.69
Breadth/ thickness							
Lower Yellow	43	2.44	0.55	0.74	0.11	0.77	0.38
Upper Yellow	17	2.41	0.51	0.71	0.17	1.23	2.11
Red	10	2.28	0.28	0.53	0.16	-0.10	0.01
Clay Band	10	2.44	0.22	0.47	0.15	1.46	3.31
Unprovenanced	30	2.53	0.73	0.85	0.15	2.85	11.60
Total	110	2.45	0.53	0.73	0.06	1.76	6.35

The Clay band

A total of 10 implements were available from the 'clay band', shown in Figs. 41 ~~and~~ . They consist mainly of very small ovate/sub triangular handaxes, often made of fresh, black, lustrous flint, or occasionally of mottled grey-yellow flint (Table 30). 80% of the tools are handaxes, the others including a typical proto-limace and a Levallois flake, with plain butt and some retouch. Four of the handaxes figured have been made on rather thick flakes, and all are neatly retouched, similar in manufacturing technique and showing some signs of having been used. They tend to be rather plano-convex in section (see Fig. 41). None of the implements exceeded 10 cm in length or weighed more than 150 gm. The abrasion measurements were variable, with a low mean average ridge width of 8.8 μm. There is a negative correlation coefficient between the length/breadth ratio and the abrasion (Fig. 42), with a value of -0.63, showing that the narrowest implements tend to have been the least abraded.

Table (30) Composition of the 'clay band' assemblage

Type No.	Description	Total
100-135	handaxes (varied shapes)	8
8	proto-limace	1
2	Levallois flake	1
		10

Table (31) Statistical summary parameters. 'Clay band' assemblage

Parameter	Mean	Variance	Standard Deviation	Standard Error of Mean	Skewness	Kurtosis
Abrasion	8.80	83.51	9.13	2.88	1.81	2.64
Length/breadth	1.44	0.03	0.19	0.06	0.13	2.21
Breadth/thick.	2.46	0.22	0.47	0.15	1.46	3.31
Weight	107.40	3033.60	55.07	17.41	1.35	1.83

Figure (41) Implements from the clay band

1. Handaxe. Type 100.
2. Handaxe. Type 135.
3. Handaxe. Type 127.
4. Handaxe. Type 135.
5. Handaxe. Type 102.
6. Handaxe. Type 107.
7. Limace. Type 8.
8. Handaxe. Type 112.
9. Levallois flake. Type 2.

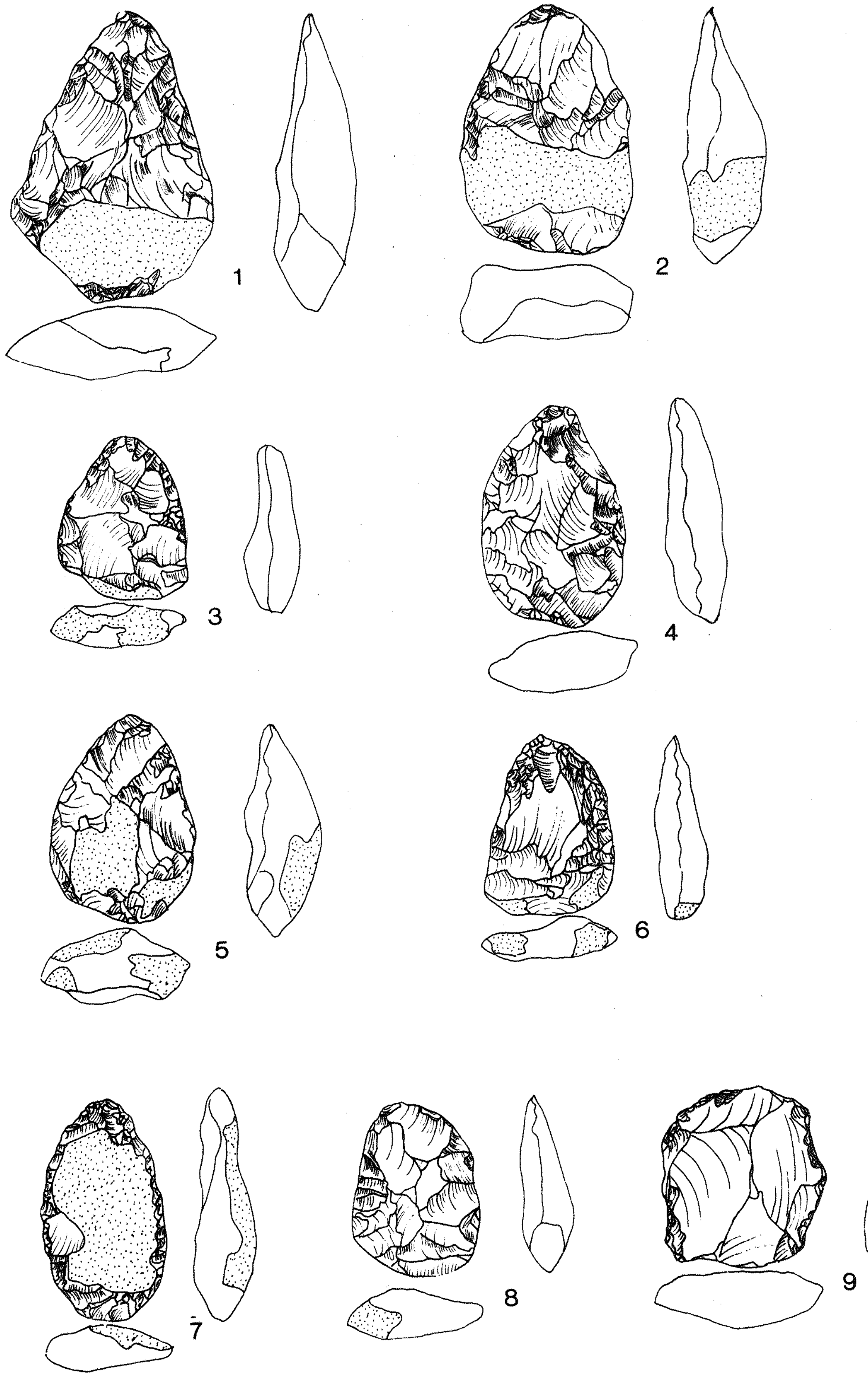
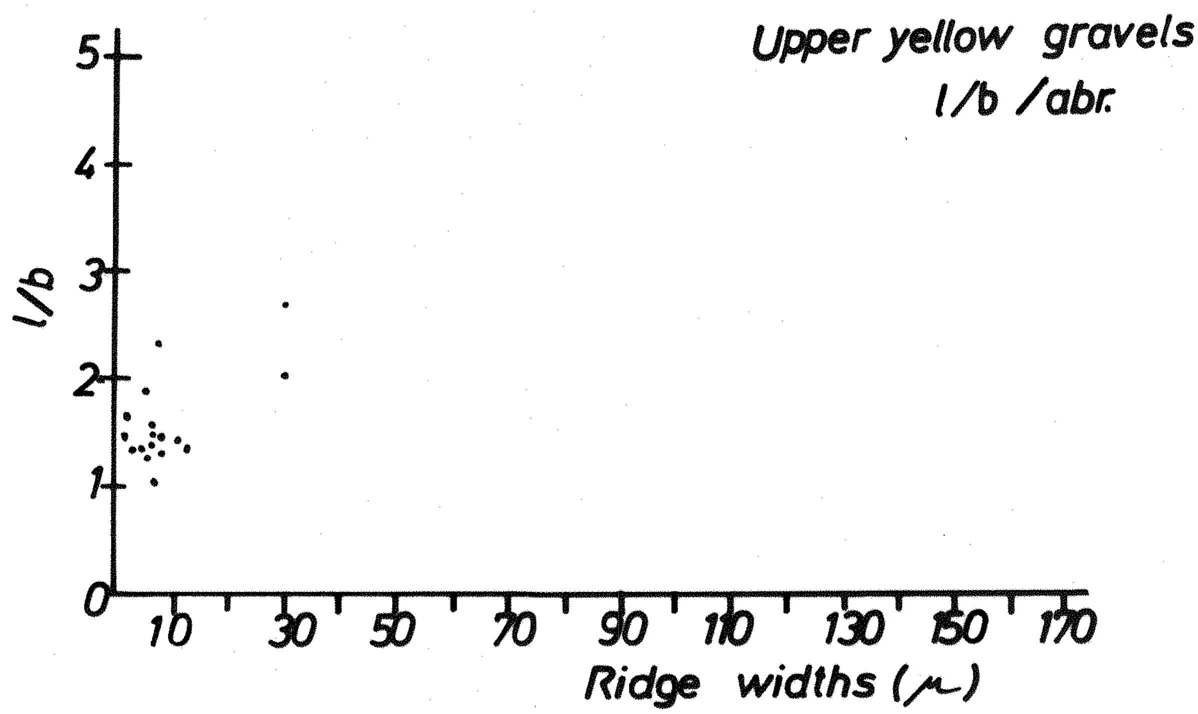


Fig. (41) Implements from the 'Clay Band', Great Pan Farm. (1/2)



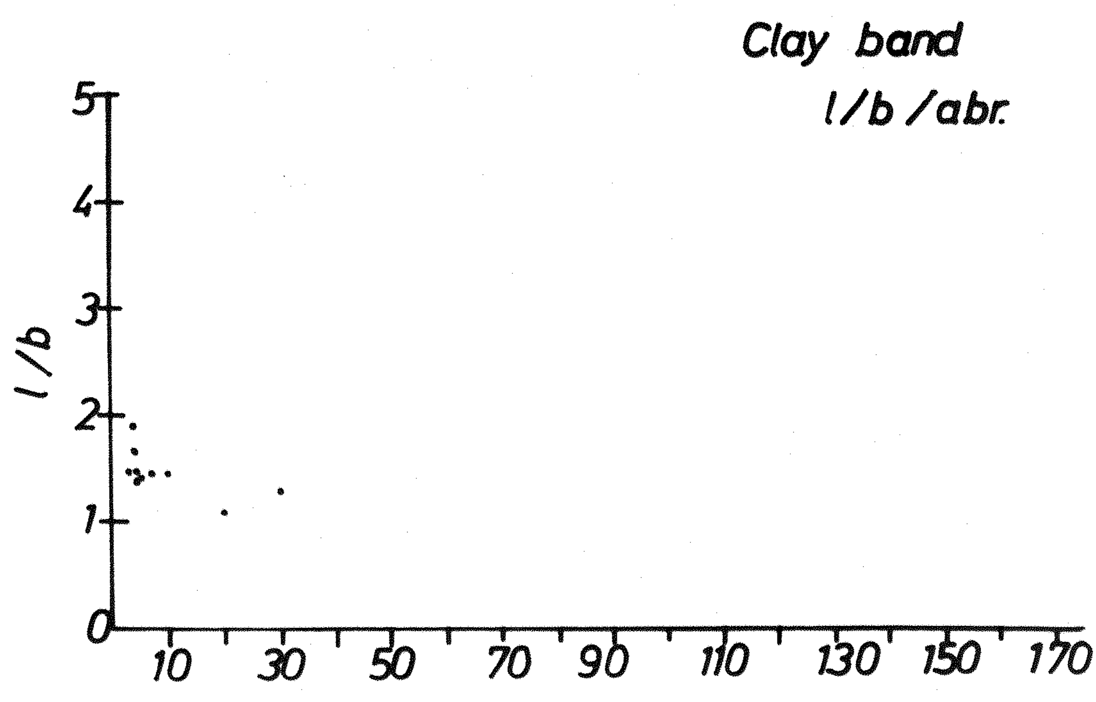


Fig. (42) Scatter diagrams, length/breadth ratio plotted against implement abrasion, implements from 'Upper Yellow' gravels, and 'Clay Band', Great Pan Farm.

Red gravels

These implements are more heavily abraded than those from other layers the mean ridge width being 16.69µm (Table 34), but this is possibly the result of heavy ferruginous staining. There is a negative correlation co-efficient between the length/breadth and breadth/thickness ratio (-0.64), showing the narrowest implements also to be the thinnest, as would be expected (Fig. 45). The red gravels as described by Poole (1924) are divided into 'upper' and 'lower' beds.

'Lower Red gravels'

This bed has yielded a mixed assemblage, including several crudely-made racloirs (Fig. 43 Nos. 3 - 6), one of which (No. 3) might also be classified as an end scraper. Two of the three handaxes present are sub-triangular, but none are made on flakes. One handaxe (Fig. 43), is so heavily encrusted with iron that it is unmeasurable.

Table (32) Composition of the 'Lower Red gravels' group

Description	Type No.	No. present
Handaxe	127	2
Handaxe	111	1
Levallois blade	1	1
Limace	8	1
Single convex racloir	10	1
Double convex racloir	15	1
Handaxe	107	1
		8 (Total)

Upper Red gravels

The only finds available for examination recorded from this bed are the two cordate handaxes shown in Fig. (44). These are remarkably similar in size, manufacturing technique and abrasion, both having a flat butt with a small patch of cortex. Their measurements are summarised on Table (34) together with those from the Lower Red Gravels.

Table (33)

Description	Type No.	No. present
Handaxe (cordate)	107	2

Table (34) Statistical summary parameters. Red gravel implements

Parameter	Mean	Variance	Standard Deviation	Standard Error of Mean	Skewness	Kurtosis
Abrasion (ridge width)	16.60	106.26	10.30	3.25	0.75	-0.74
Length/breadth	1.66	0.44	0.66	0.21	1.43	1.35
Breadth/thickness	2.28	0.28	0.53	0.16	-0.10	0.01
Weight (gm)	153.80	3450.40	58.74	18.57	0.36	-1.14

Fig. (43) Lower Red gravels

1. Handaxe. Type 127.
2. Handaxe. Type 127.
3. Racloir. Type 15.
4. Limace. Type 8.
5. Levallois blade. Type 1.
6. Single racloir. Type 10.
7. Handaxe. Type 111.
8. Handaxe. Type 107.

Fig. (44) Upper Red gravels

1. Handaxe. Type 107.
2. Handaxe. Type 107.

Fig. (43) Implements from the 'Lower Red' gravels, Great Pan Farm. (1/2)

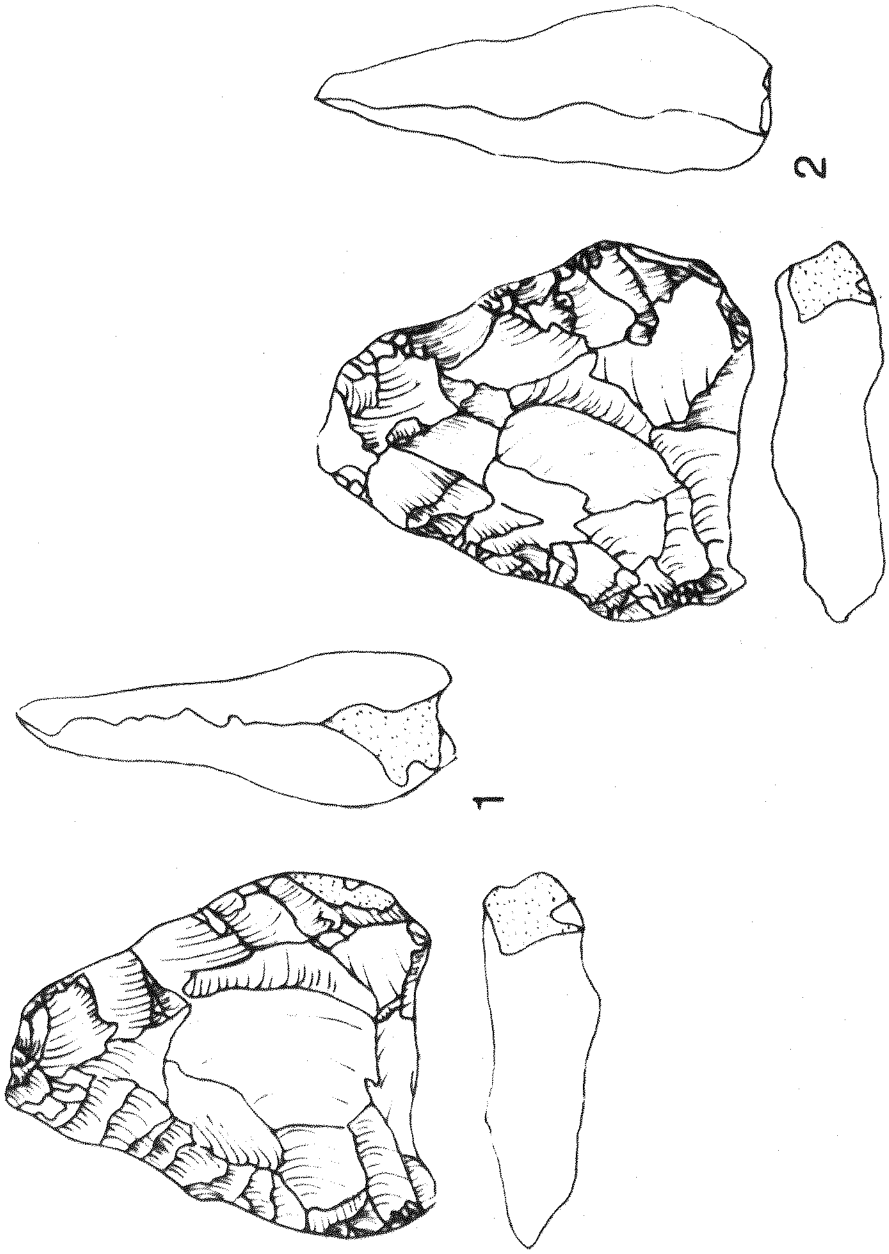
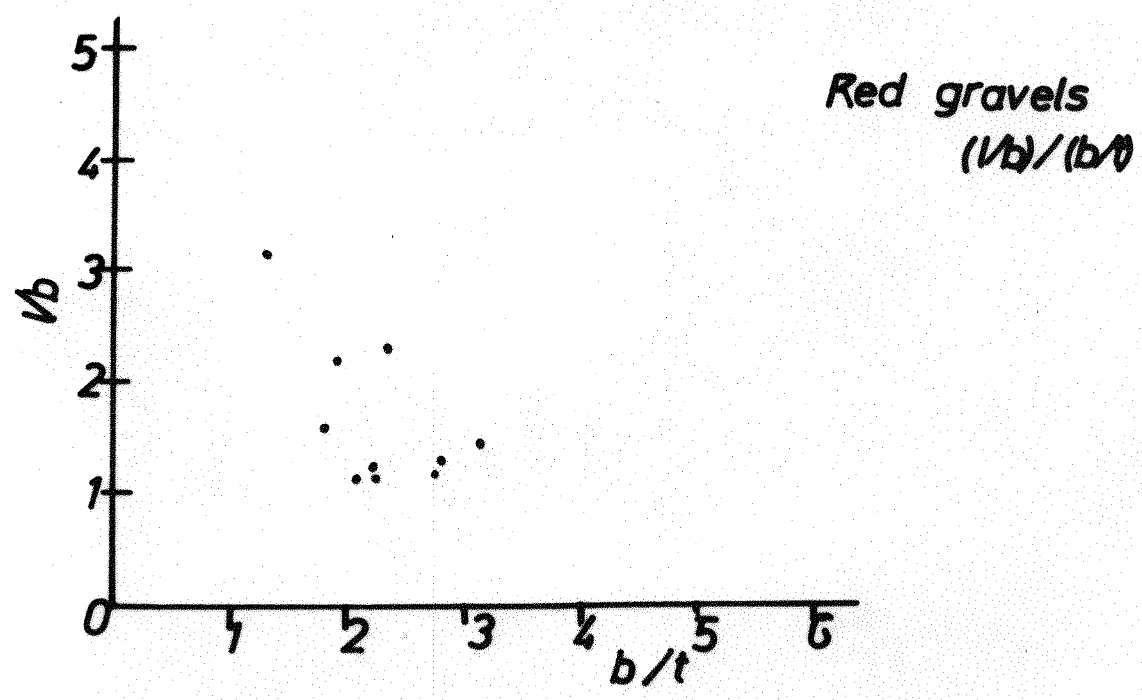


Fig. (44) Implements from the 'Upper Red' gravels, Great Pan Farm. (1/1)



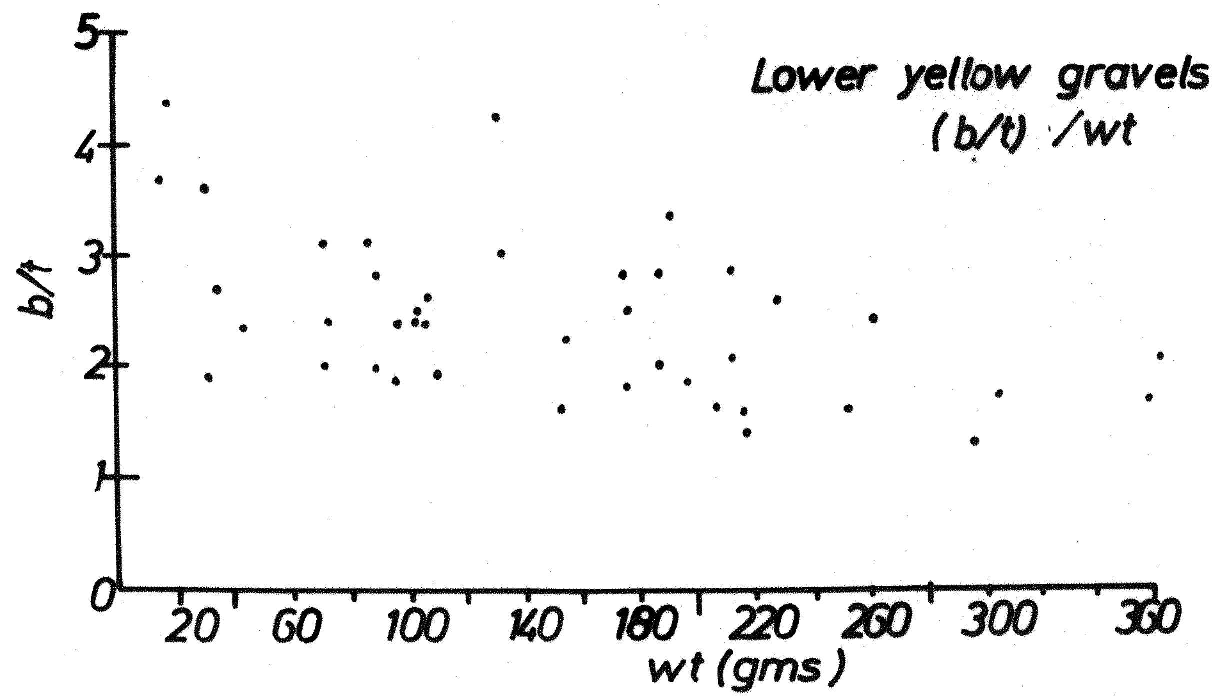


Fig. (45) Scatter diagrams, parameters from 'Red' and 'Lower Yellow' gravels, Great Pan Farm.

Fig. (46).

1. Thick Levallois flake, Type 1 (retouched). Clay Band.
2. Atypical single convex racloir. Type 10. Upper Yellow gravel.
3. Upper Palaeolithic type backed blade (unstratified)
4. Bout coupé handaxe. Type 132. Upper Yellow gravel.
5. Ovate handaxe. Type 112. Lower Yellow gravel.
6. Typical backed knife. Type 36. Lower Yellow gravel.
7. Atypical end-scraper. Type 31. Upper Yellow gravel.
8. Discoid handaxe. Type 111. Clay Band.

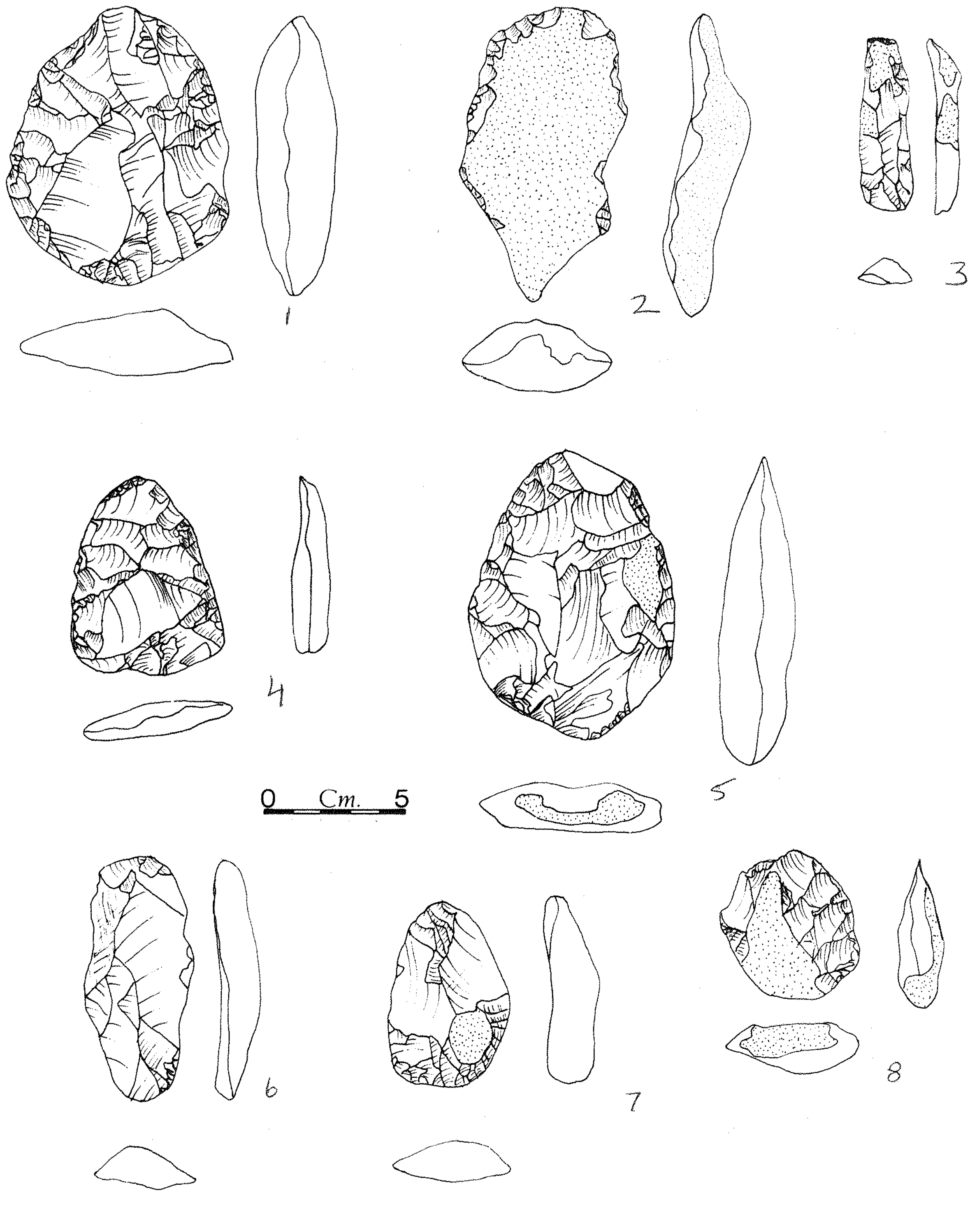


Fig. (46) Implements from various layers, Great Pan Farm.

Miscellaneous

The implement series recorded by Poole from Great Pan Farm, at present housed in the Carisbrooke Castle museum, contains a number of implements which are not recorded as stratified in any particular layer, and which generally bear a label saying either 'Great Pan Farm' or 'Pan Pit', occasionally supplemented by a section number. These are all included under this heading and do not differ in facies from the more accurately stratified material. Thirty implements are recorded (see Figs. 47-9). Inevitably this collection includes some of the finest Mousterian pieces, including a bout coupe handaxe, 3 natural-backed knives (Fig. 48 , 18-20), a piercer (Fig. 48, 10) and a number of 'segmental chopping tools'.

The group is abraded (mean ridge width 8.9μm), small and light in weight (mean weight 117 gms.). There is a negative correlation coefficient between breadth/thickness and weight, as for the Lower Yellow group, with a value of -0.42, showing that the thinnest implements are also the lightest in weight.

Table (35) Composition of the miscellaneous unprovenanced group

Type No.	Description	Total
1-2	Levallois flake	1
8	limace	2
34	typical piercer	1
28	racloir with bifacial retouch	4
38	natural backed knife	3
65	divers	1
102	sub triangular handaxe	4
107	cordiform handaxe	2
108	long cordiform handaxe	2
111	discoid handaxe	1
112	ovate handaxe	7
114	amygdaloidal handaxe	1
132	bout coupé	1
		30

Table (36) Statistical summary parameters. Unprovenanced miscellaneous material, Great Pan Farm.

Parameter	Mean	Variance	Standard Deviation	Standard Error of Mean	Skewness	Kurtosis
Abrasion (ridge width)	8.90	39.50	6.28	1.11	1.39	2.80
Length/breadth	1.52	0.13	0.36	0.06	2.29	5.83
Breadth/thickness	2.53	0.73	0.85	0.15	2.85	11.60
Weight	117.54	3108.06	55.75	9.85	0.004	-0.84

Miscellaneous

Fig. (47)

1. Handaxe. Type 112.

2. Handaxe. Type 132 (bout coupé)

3. Levallois flake. Type 1.

4. Retouched flake. Type 120.

5. Handaxe. Type 107.

6. Handaxe. Type 107.

Fig. (48)

7. Limace. Type 8.

8. Proto-limace. Type 8.

9. Levallois flake. Type 2.

10. Typical piercer. Type 34.

11. Upper palaeolithic backed blade, Type 65.

12. Racloir + bifcaial retouch (SCT) Type 28.

13. ditto.

14. Handaxe. Type 111.

15. Racloir + bifacial retouch (SCT) Type 28.

16. Levallois flake. Type 1.

17. Racloir with bifacial retouch (SCT) Type 28.

18-20 Natural-backed knives (Type 38).

Fig. (49) Miscellaneous

21. Handaxe. Type 112.

23. Handaxe. Type 112.

24. Handaxe. Type 112.

25. Handaxe. Type 168.

26. Handaxe. Type 108.

27. Handaxe. Type 112.

28. Handaxe. Type 112.

29. Handaxe. Type 102.

30. Handaxe. Type 111.

31. Handaxe. Type 102.

32. Handaxe. Type 102.

33. Handaxe. Type 112.

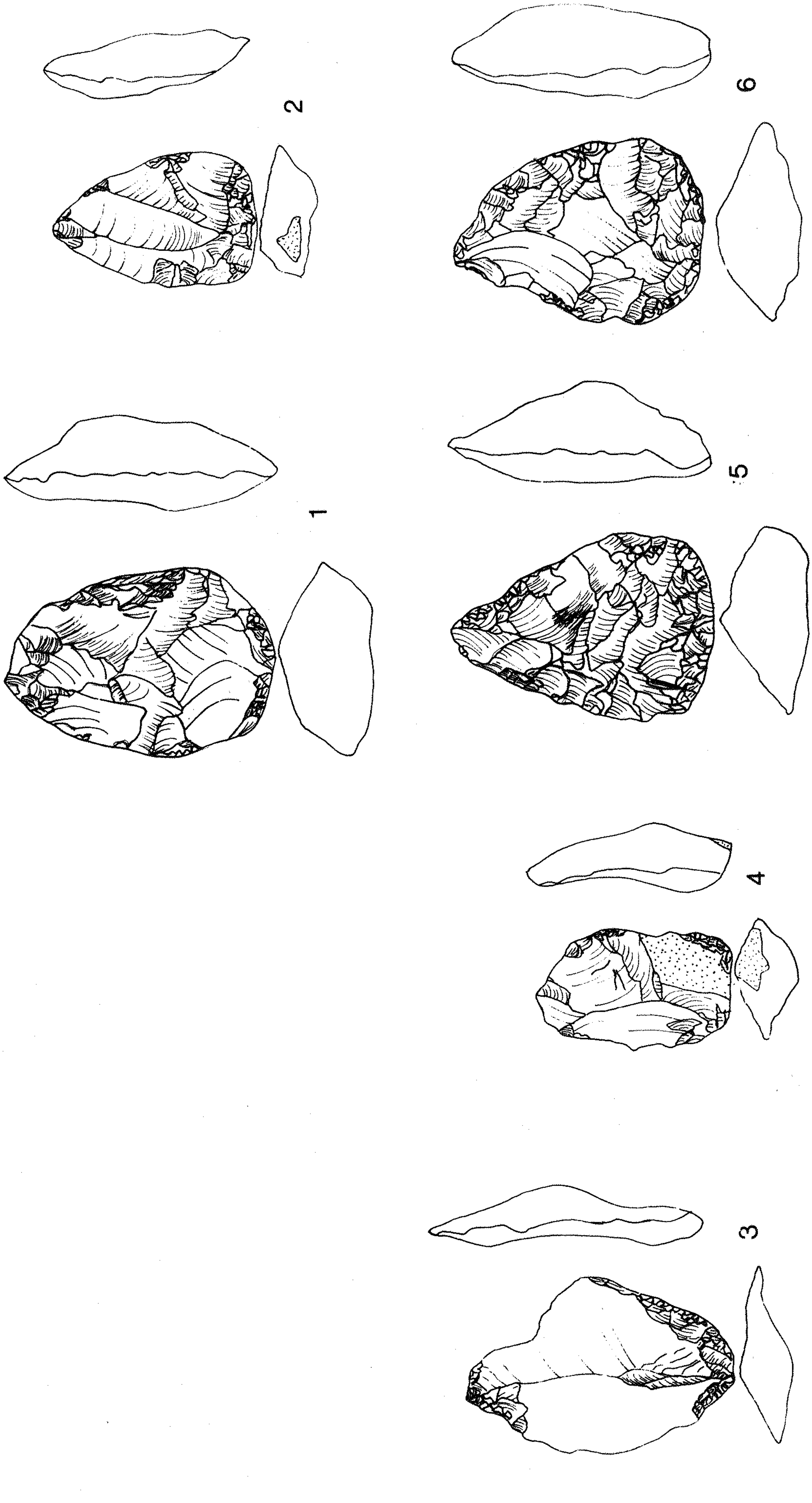


Fig. (47) Unprovenanced implements, Great Pan Farm. (1/2)

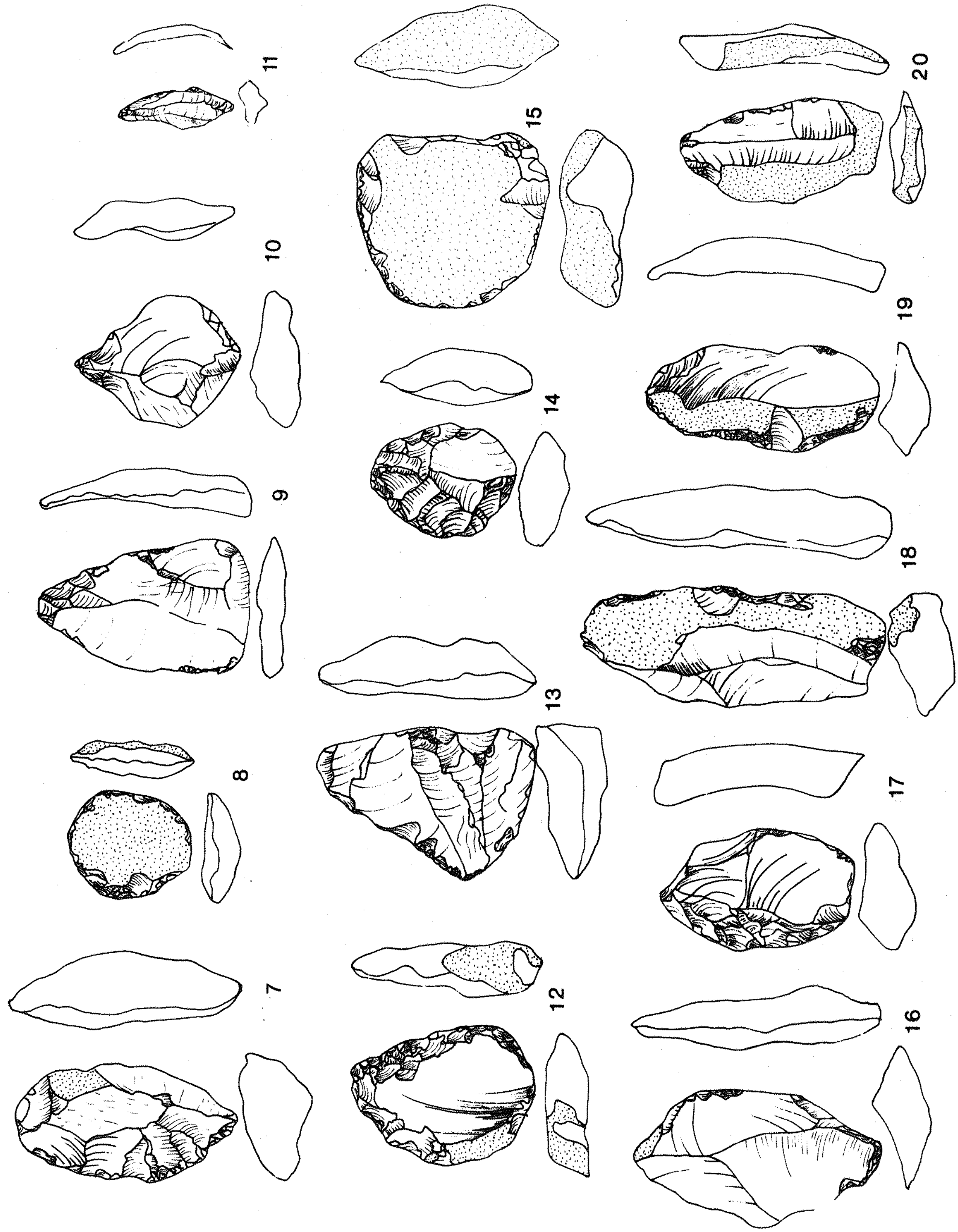


Fig. (48) Unprovenanced implements, Great Pan Farm cont'd. (½)

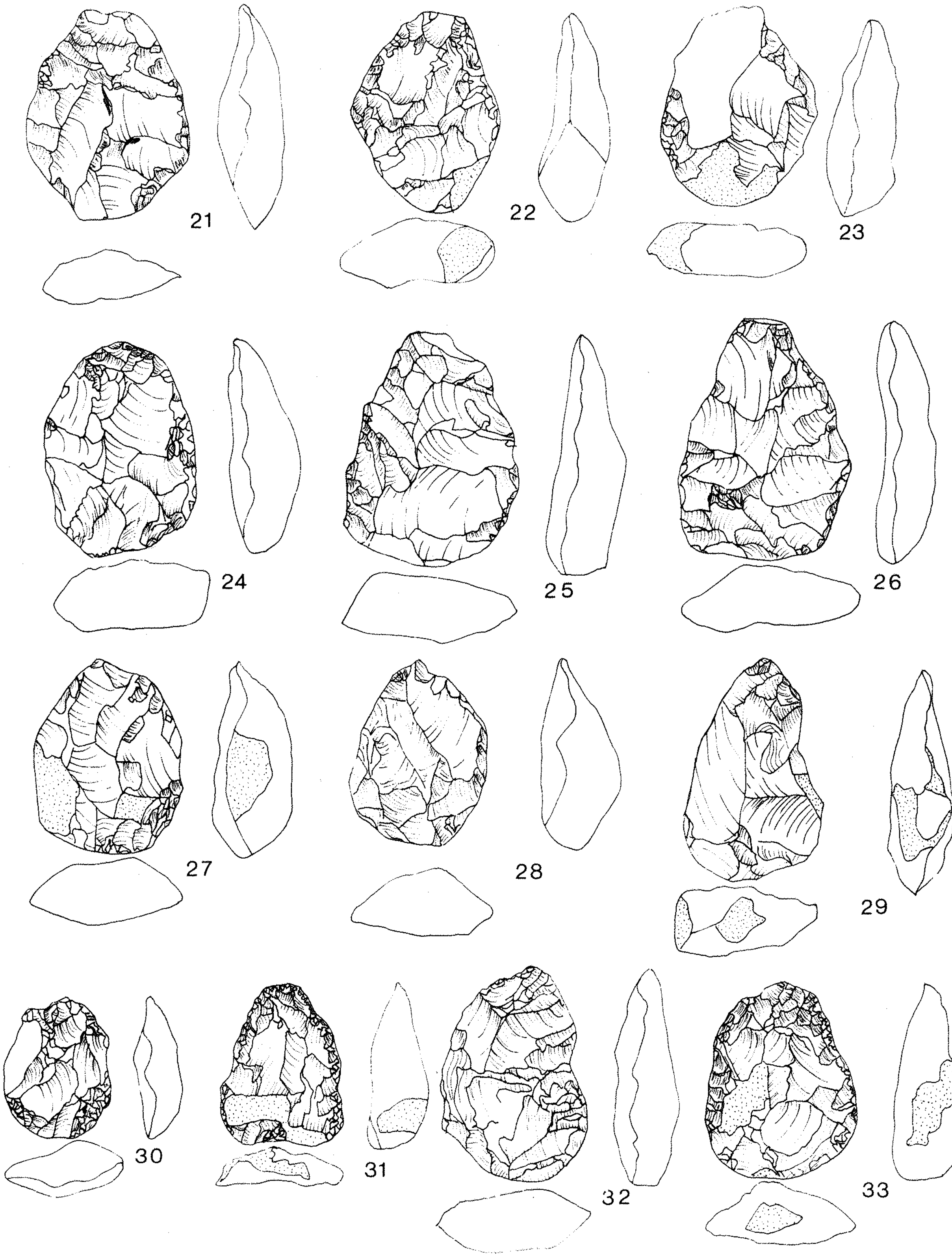
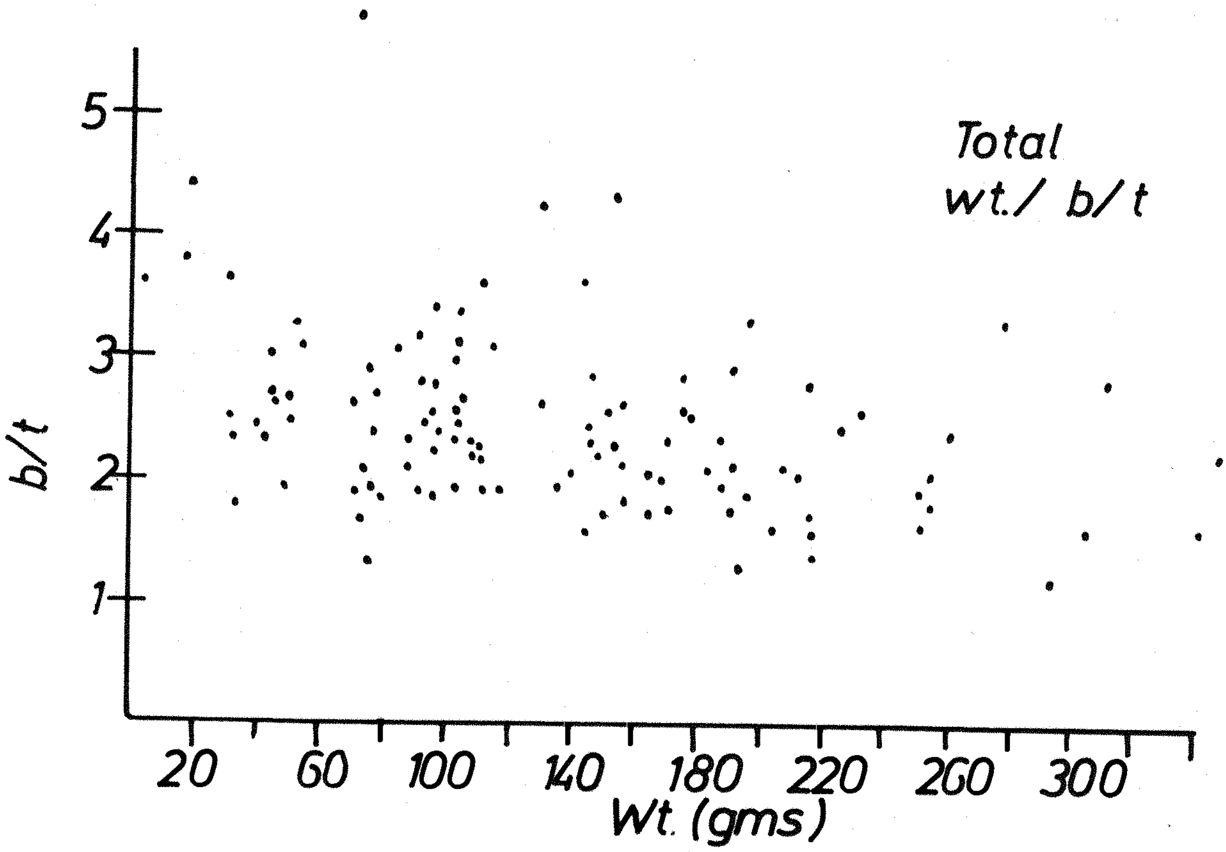


Fig. (49) Unprovenanced implements, Great Pan Farm cont'd. (1/2)



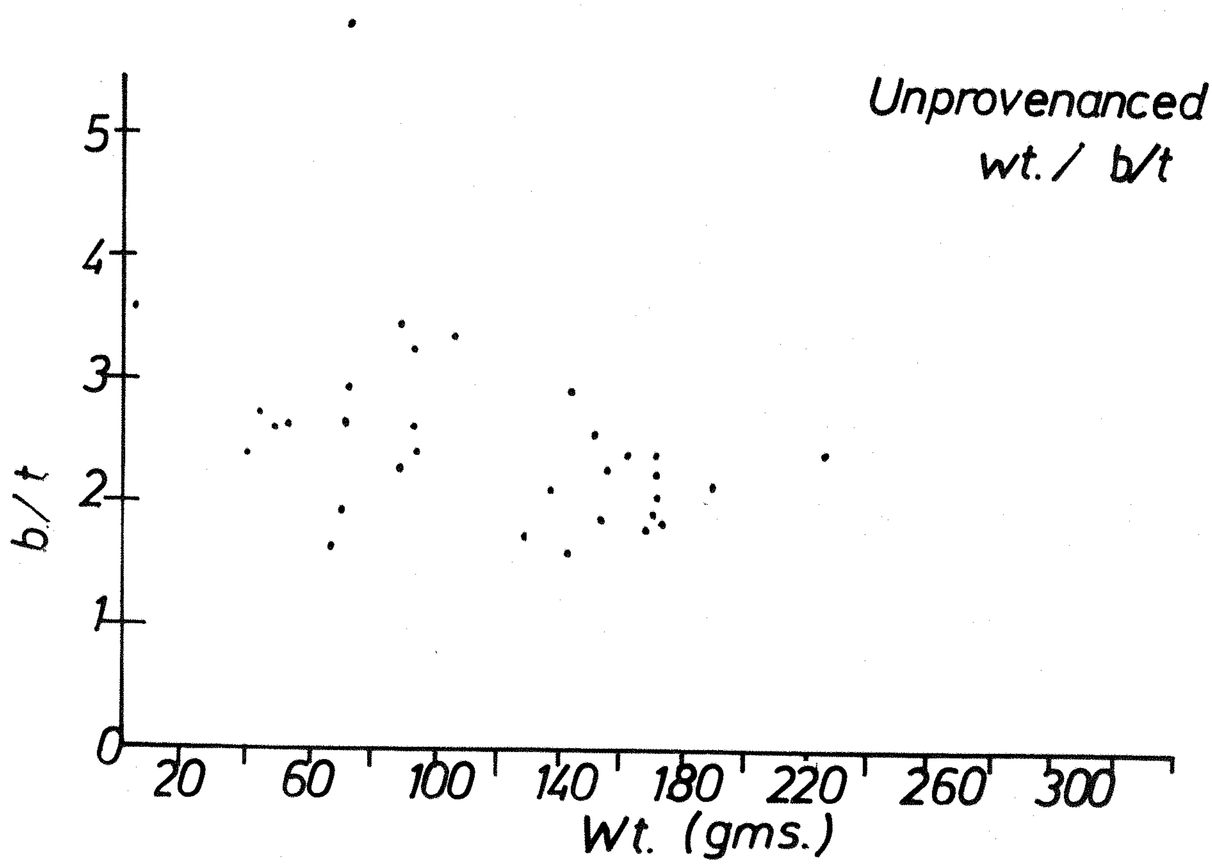


Fig. (50) Scatter diagrams, weight plotted against breadth/thickness ratio, implements from the total assemblage and from the unprovenanced material, Great Pan Farm.

<u>The 'Lower Yellow' gravels</u>

The assemblage from this bed is by far the largest recorded from the site. Forty-three implements were examined, 42 are shown in Figs. 51-4 these include 13 handaxes, 9 Levallois flakes, and other tools of Mousterian type. The handaxes tend to be small, none exceeding 13 cm in length, and light, only 1 being heavier than 350 grams. The handaxes are often made on flakes, several with the bulb of percussion still unworked, but they tend to have rather wavy edges, and are considerably thicker than is usual for handaxes found in a Mousterian assemblage. There are some very large Levallois flakes present and a number of rather thick racloirs of varied type. On the whole it would be true to say that the assemblage is much less refined than would be expected in the Mousterian of Acheulean tradition, but a number of features enable it to be classified under that heading. The abrasion index values of the tools are again variable, although there are a number which are comparatively unworn. Only 1 trimming flake was found, but the assemblage contains several of the thick racloirs which Wymer (1968) refers to as 'Segmental Chopping Tools', of wedge-shaped cross-section (Fig. 54 Nos. 25-27).

The mean of abrasion (ridge width) was low at 10.74 μm, indicating that the tools were rather fresh. The scatter diagrams (Fig. 45) showed a strong negative correlation co-efficient between weight and breadth/ thickness, indicating that the thinnest implements were also the lightest.

Table (37) Composition of the Lower Yellow gravel group

Type No.	Description	Total
1-2	Levallois flakes	10
8	limace	2
9	single straight racloir	1
10	single convex racloir	1
4	retouched Levallois point	1
21	offset racloir	1
28	racloir with bifacial retouch	6
35	atypical piercer	1
36	atypical backed knife	1
41	Mousterian tranchet	1
42	notched tool	1
43	denticulate	1
56	rabot	2
100	pointed triangular handaxe	1
102	sub triangular handaxe	3
109	sub cordiform handaxe	1
112	ovate handaxe	2
120	roughout	1
124	trimming flake	1
115	cleaver	1
116	flake cleaver	1
127	sub triangular handaxe on flake	1
137	ovate on flake	1
138	limande on flake	1
		43

Table (38) Statistical summary parameters. Lower Yellow gravels, Great Pan Farm

Parameters	Mean	Variance	Standard Deviation	Standard Error of Mean	Skewness	Kurtosis
Abrasion (ridge width)	10.74	104.05	10.20	1.55	3.13	12.65
Length/breadth	1.58	0.25	0.50	0.07	2.09	5.07
Breadth/thickness	2.44	0.55	0.74	0.11	0.77	0.38
Weight	160.27	12761.77	112.96	17.22	1.63	3.84

Lower Yellow gravels. Fig. (53)

1. Levallois flake. Type 2.

2. Levallois flake. Type 1.

3. Handaxe. Type 137.

4. Proto-limace. Type 8.

5. Handaxe. Type 102.

6. Handaxe. Type 109.

7. Handaxe. Type 116.

Lower Yellow gravels. Fig. (51)

8. Handaxe (roughout) Type 120.

9. Handaxe. Type 127.

10. Levallois flake. Type 2.

11. Single convex racloir (S.C.T.) Type 28.

12. Levallois flake. Type 2.

13. Single convex racloir (S.C.T.) Type 28.

14. Single straight racloir. Type 9.

15. Single convex racloir. Type 10.

16. Levallois flake. Type 1.

17. Trimming flake. Type 124.

18. Rabot. Type 56.

19. Proto-limace. Type 8.

Lower Yellow gravels. Fig. (54)

20. Handaxe. Type 112.

21. Mousterian tranchet. Type 41.

22. Handaxe. Type 100.

23. Cleaver. Type 115.

24. Single convex racloir. Type 28 (S.C.T.)

26. Single convex racloir. Type 28 (S.C.T.)

27. Single convex racloir. Type 28 (S.C.T.)

28.

29. Single thick Levallois flake. Type 2.

30. Handaxe. Type 100.

32. Denticulate. Type 43.

33. Levallois blade. Type 2.

34. Levallois blade + notch. Type 42.

Lower Yellow gravels. Fig. (52)

35. Handaxe. Type 102.

36. Handaxe. Type 102.

37. Levallois flake. Type 1.

38. Handaxe. Type 102.

39. Levallois flake. Type 1.

40. Rabot. Type 56.

41. Atypical piercer. Type 35.

42. Handaxe. Type 138.

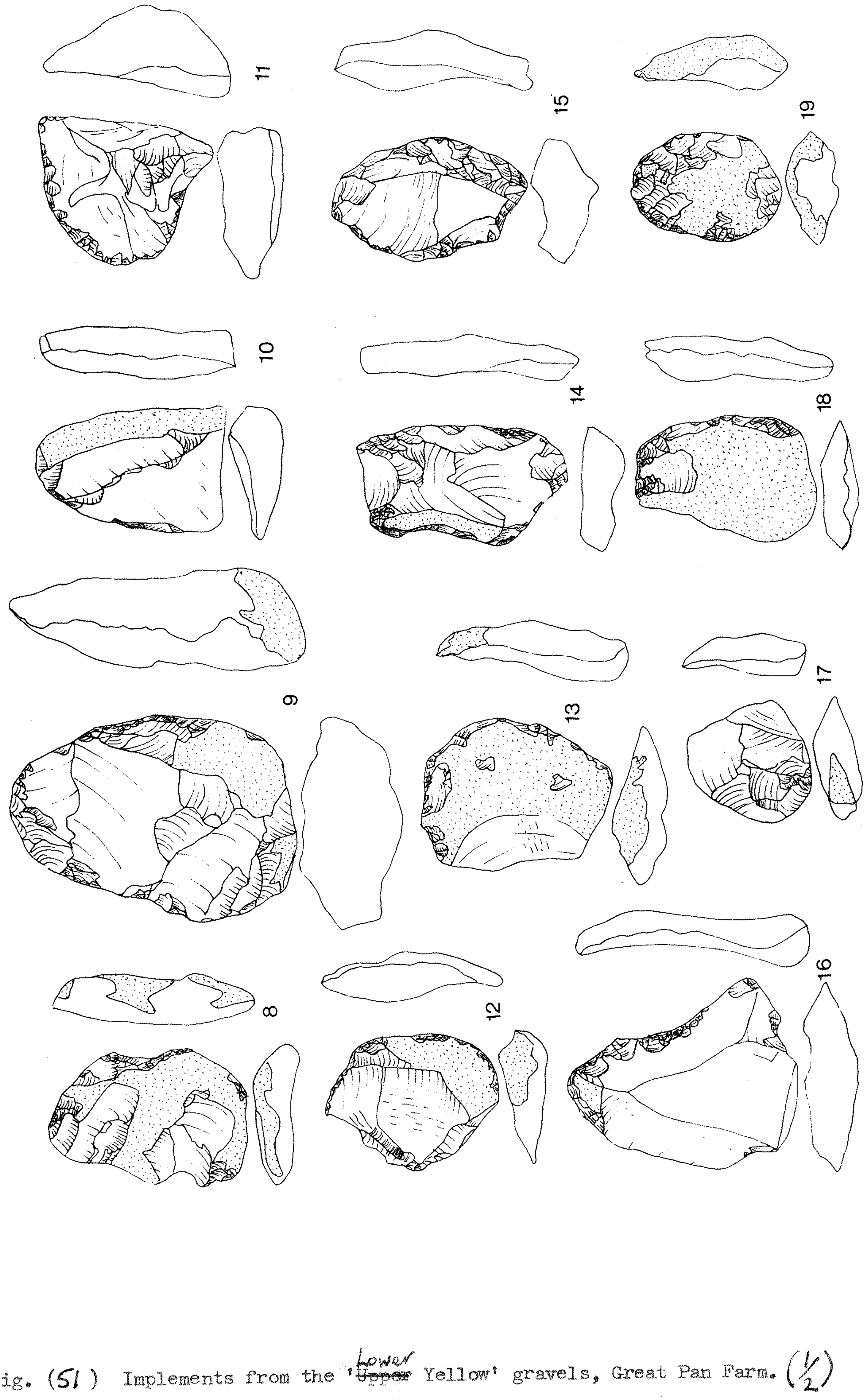


Fig. (51) Implements from the '~~Upper~~ Lower Yellow' gravels, Great Pan Farm. (1/2)

Lower

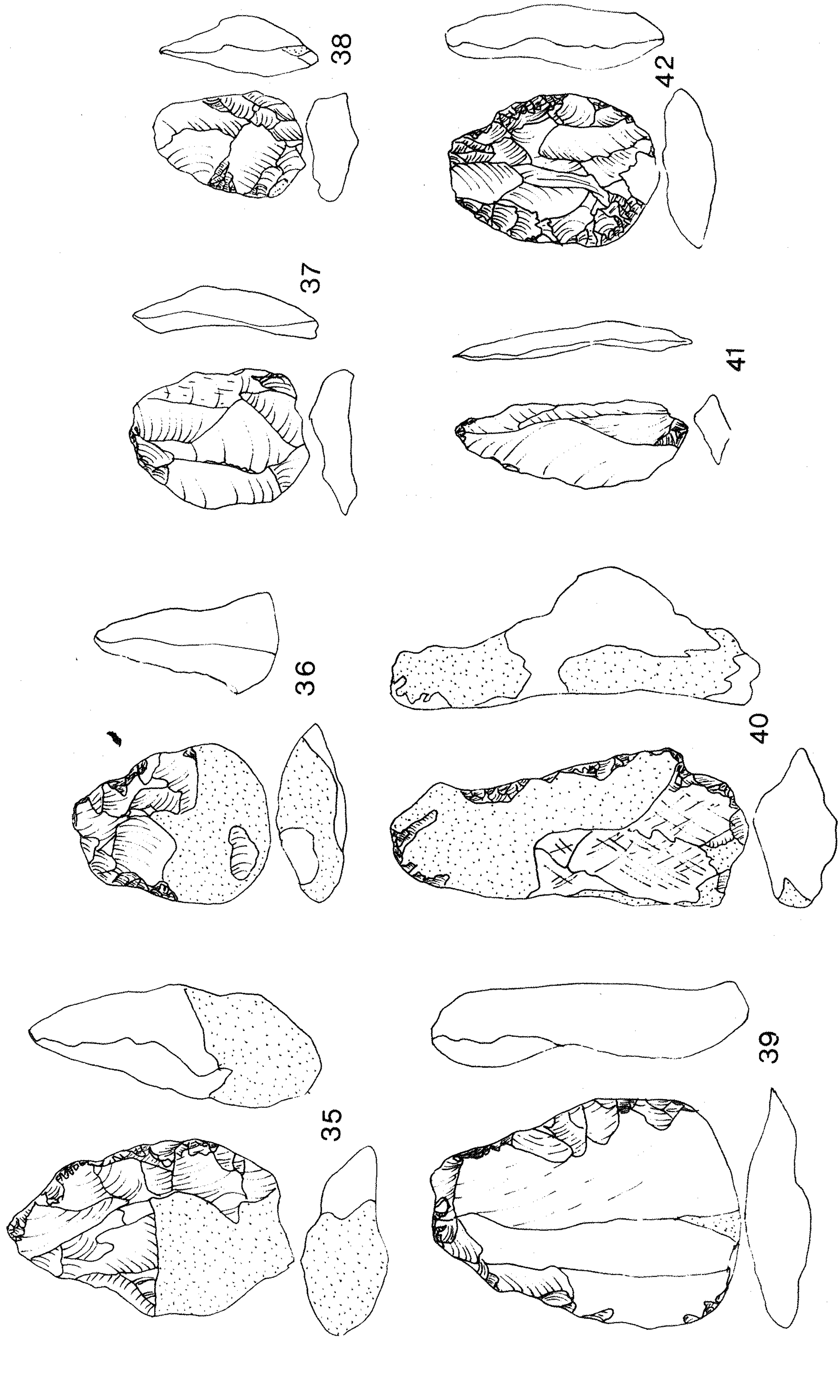


Fig. (52) Implements from the 'Lower Yellow' gravels, Great Pan Farm cont'd.

(½)

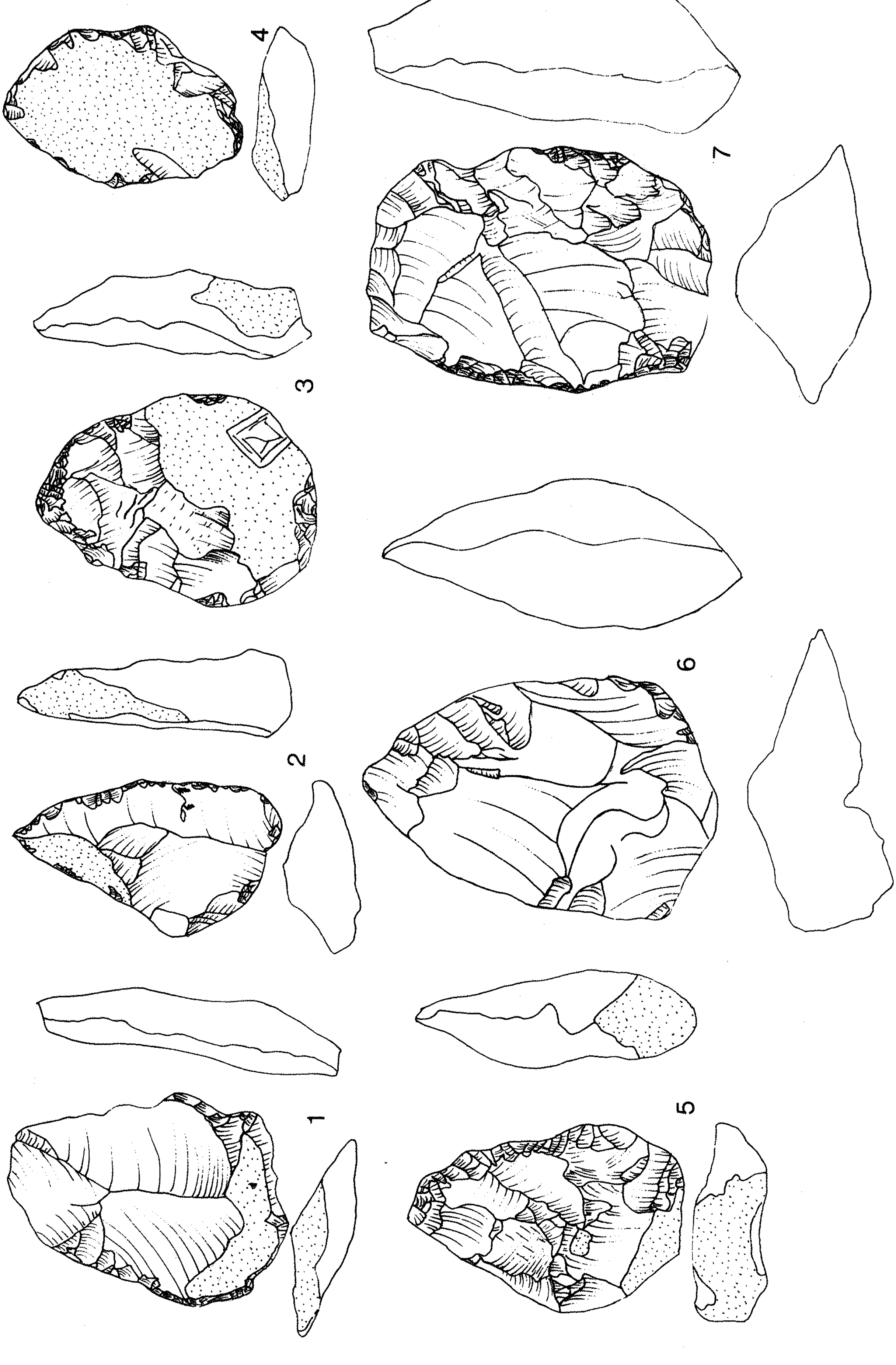


Fig. (53) Implements from the 'Lower Yellow' gravels, Great Pan Farm cont'd.

(1/2)

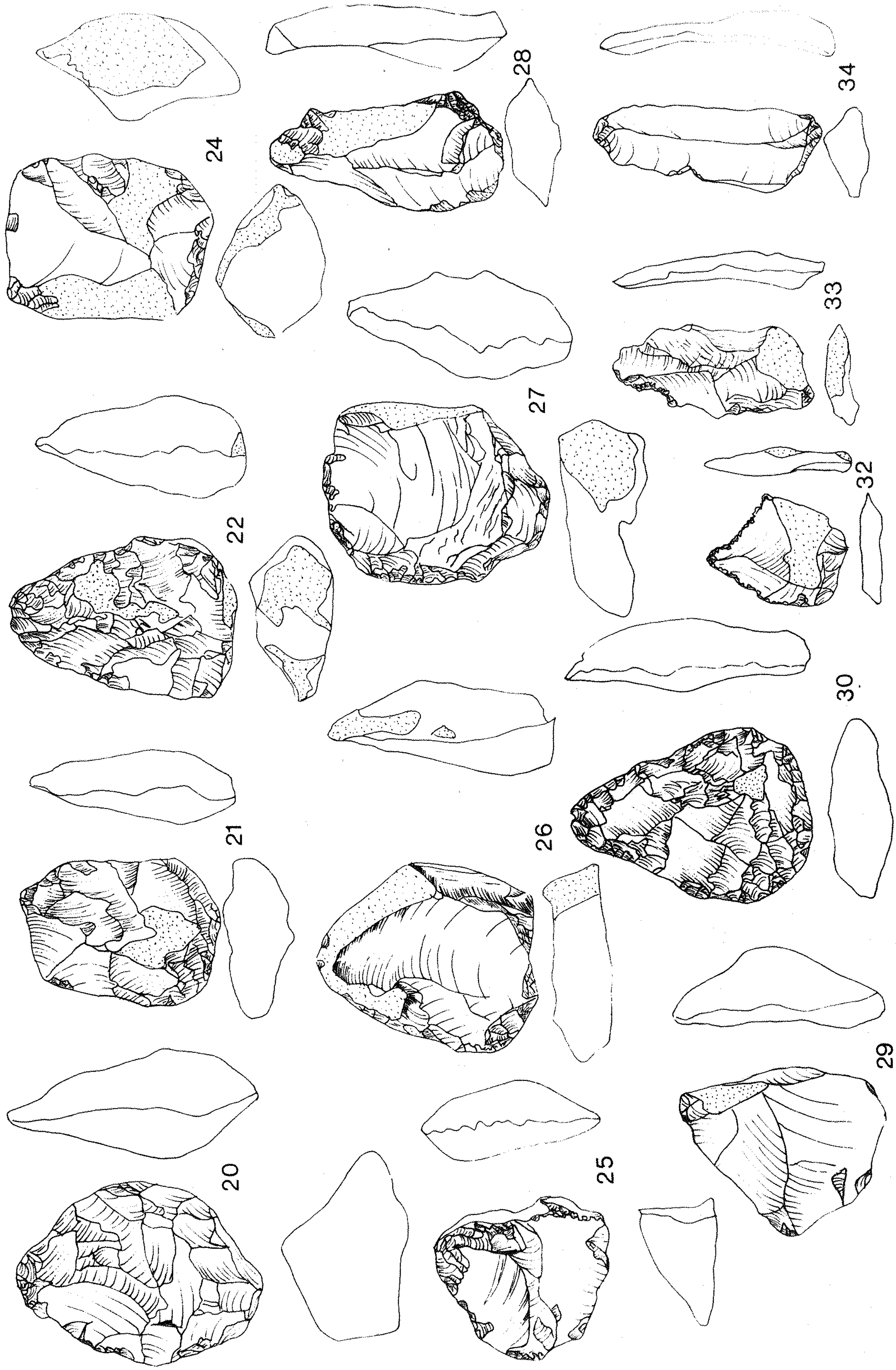


Fig. (54) Implements from the 'Lower Yellow' gravels, Great Pan Farm.

(1/2)

Upper Yellow gravels

Table (39) Composition of the Upper Yellow Gravel group

Type No.	Description	Total
1-2	Levallois flakes	3
10	single convex racloir	1
28	racloir with bifacial retouch	1
6	atypical backed knife	1
102	sub triangular handaxe	1
107	cordiform handaxe	1
112	ovate handaxe	3
119	tortoise core	1
125	pointed triangular handaxe on flake	1
132	bout coupe	3
137	ovate handaxe on flake	1
		17

This is again a varied assemblage, with 10 handaxes, 3 retouched tools and 3 Levallois flakes (Fig. 55). The backed knife is a typical Mousterian of Acheulean Tradition form. The handaxes tend to be small, often with rather irregular wavy edges, few of them made on flakes. None of the implements exceeded 13 cm in length. The degree of abrasion is variable, with a low mean ridge width of 9.52 µm. Scatter plots of the parameters measured showed a positive correlation coefficient between abrasion and length/breadth, showing that the thinnest tools were the lightest abraded, Table (40) and Fig. (42).

Table (39) Statistical summary parameters. Upper Yellow Gravel group, Great Pan Farm.

Parameter	Mean	Variance	Standard Deviation	Standard Error of Mean	Skewness	Kurtosis
Abrasion (ridge width)	9.52	66.88	8.17	1.98	2.06	3.65
Length/breadth	1.58	0.17	0.41	0.10	1.52	1.73
Breadth/thickness	2.41	0.51	0.71	0.17	1.23	2.11
Weight	140.94	8476.30	92.06	22.32	0.94	0.70

Fig. (55) <u>Upper Yellow gravels</u>

1. Handaxe. Type 125.
2. Handaxe. Type 102.
3. Backed knife. Type 36.
4. Handaxe. Type 112.
5. Bout coupé. Type 132.
6. Handaxe. Type 137.
7. Handaxe. Type 107.
8. Tortoise core. Type 119.
9. Handaxe. Type 132.

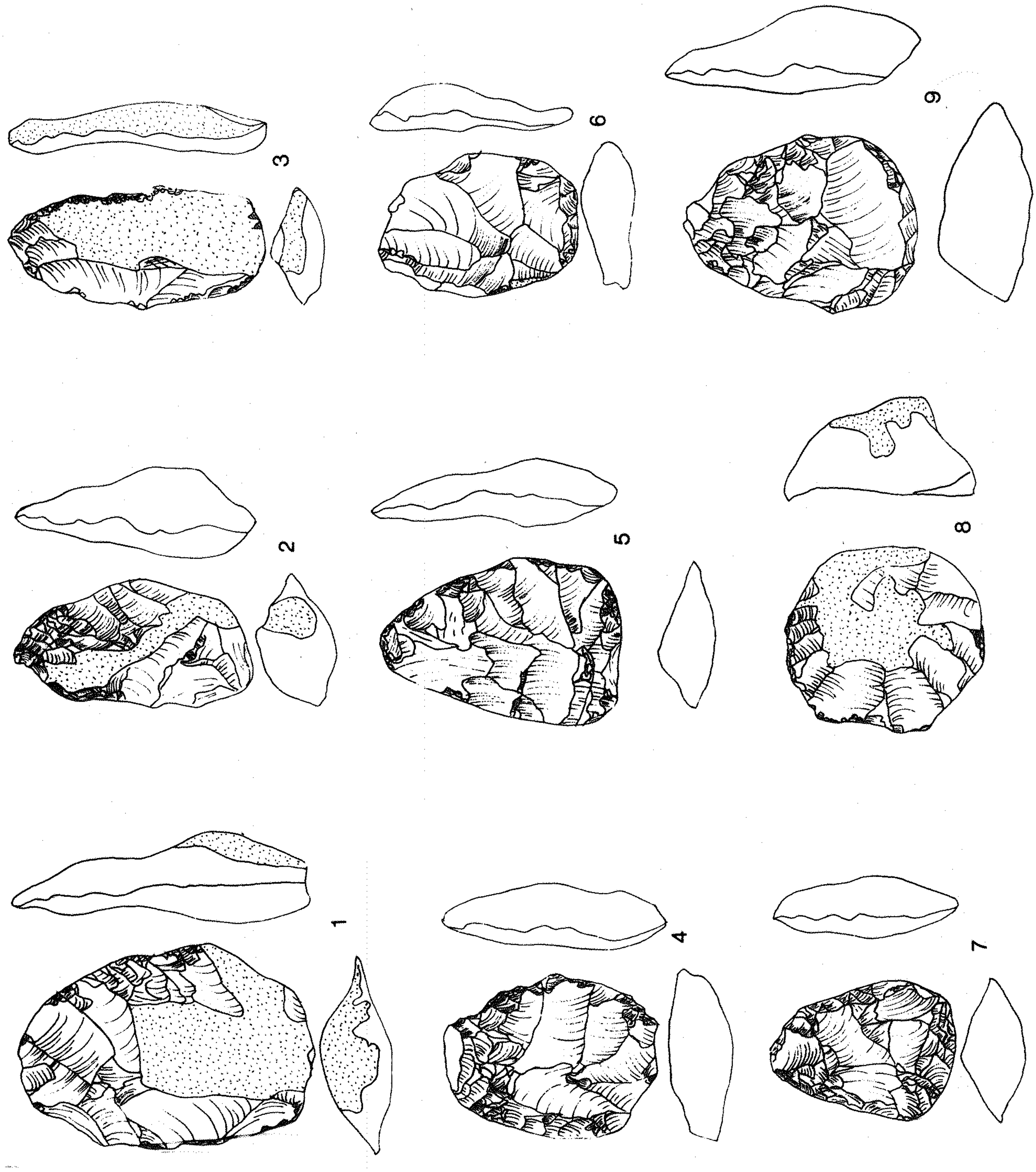


Fig. (55) Implements from the '~~Lower~~ Upper Yellow' gravels, Great Pan Farm cont'd.

upper

(1/2)

General remarks

It was important to determine whether the measured parameters of these subgroups differed significantly from the values obtained for the whole assemblage, and from eath other, since this is critical when considering the unity of the group. A Students 't' test was performed for each set of paramaters in every combination and for each group, utilising the computer program STUDENTS, run on Southamptoh University's ICL 1907 computer. It was found that certain pairs of values differed significantly, and these are listed below (Table 41), with their probability confidence levels.

Table (41). Results of the Students 't' test, Great Pan Farm implements

Parameter	Paired samples	Probability
Weight	Total/unprovenanced	0.90
	Total/Red Gravels	0.995
	Total/'clay band'	0.90
	Upper Yellow/unprovenanced	0.75
	Red Gravels/'clay band'	0.95
	Red Gravels/unprovenanced	0.95
Length/breadth	Total/'clay band'	0.75
	Red Gravels/'clay band'	0.75
	Lower Yellow/'clay band'	0.75
	Upper Yellow/'clay band'	0.75
	Red Gravels/unprovenanced	0.75
Breadth/thickness	Total/Red Gravels	0.75
	Unprovenanced/Red Gravels	0.75
Abrasion (ridge width)	Total/Red Gravels	0.975
	Total/unprovenanced	0.75
	Red Gravels/Lower Yellow	0.95
	Unprovenanced/Lower Yellow	0.75
	Red Gravels/Upper Yellow	0.95
	Red Gravels/unprovenanced	0.995

Implement weights

The results listed in Table (41) show that the weights of the implements recovered from the Red Gravels, the 'clay band' and the unprovenanced material differ significantly from the values obtained for the group as a whole, at a probability level greater than 0.90. In addition the weights of the Red Gravel implements differ significantly from those of the 'clay band', and from the unprovenanced material. This is a high degree of weight divergence in an assemblage, attributable principally to the fact that the groups contain material of widely differing facies, from comparatively heavy handaxes to very light flakes.

Length/breadth ratios

The length/breadth axial ratio measurements show less divergence than the weight values, although here again the 'clay band' group differs from all the other groups, with the exception of the unprovenanced material but including the total of all the implements. Red gravel implements again differ significantly from the unprovenanced material.

Breadth/Thickness ratios

This series of measurements shows little divergence, but again the Red Gravels differ from both the total and the unprovenanced groups.

Abrasion measurements

The abrasion measurements are slightly variable, with both the Red Gravels and the unprovenanced groups differing from the total. The Red Gravels also differ from the Lower Yellow, Upper Yellow and unprovenanced groups.

Conclusions

The size distribution for the groups can thus be seen to be fairly constant, with a low degree of divergence between the subgroups and the assemblage considered as a whole. The 'clay band' group stands out as being consistently narrower than the other groups, and the Red Gravel group as being consistently thicker. Weight values are variable, with three of the subgroups differing from the total, and divergences even between the subgroups, but this is unlikely to be especially significant for the reason stated above. The Red Gravel Group stands out as being significantly more abraded than the rest of the material, due to the contaminating effect of the heavy ferruginous staining which is apparent on most of the implements.

Although these results show that the sub groups form a far from homogeneous whole there seems to be little doubt that they may reasonably be taken together and grouped into a single assemblage. Bearing in mind the fact that the group sizes are small, possibly not representing the entire amount of material recovered, and that the selection of parameters to be measured is subjective the variation seen is not very great. However the study illustrates the folly of assuming the homogeneity of a group from visual impressions, and emphasises the fact that there may be wide degrees of divergence within a single true assemblage.

The implements were found stratified within a deposit of river gravel, with one intervening layer of beach sand. It is difficult to say how long the deposit took to form, and how this formation rate related to the implements. If Poole (1924) and Roe (1968) are right in their suggestions of a nearby occupation site, which seems likely from the nature of the assemblage, then this could have taken the form of a camp site or chipping floor very near to, or on, the gravel, with the implements being dropped and included in the deposit soon after they were made. Alternatively they could have been gradually washed into the gravels as it accumulated from a short distance away, a suggestion which would account for the slight but variable degree of wear. Although it has been previously stated that the time needed for the transgression resulting in the beach sand need not have been very great, it would certainly have been far longer than the time that a small hunting group would have been likely to stay in the area, and it therefore seems best to view the site as the accumulation of material derived from a very nearby occupation site, perhaps made by one or more visits of a small group of people. The products of this occupation were then gradually incorporated into the stratigraphy of the deposits as they accumulated.

4.14 Stone/Lepe (SU 458995)

Introduction

The remnant of the extensive gravel deposits at Stone and Lepe, on the coast of the Solent, east of the Beaulieu river, has been described by Reid (1893), West and Sparks (1960) and Everard (1954). Both the first two works were principally concerned with the fossiliferous estuarine clays which underlie the gravels at this point, and which are of vital importance for their chronology.

Description

The approximate extent of the gravel deposits is shown in Fig. (56), and the height and general appearance of the land in Fig. 57 . The general cross section, (Fig. 57), shows that the base of the deposits lies at approximately 0.5-1 OD, and that the present exposed cliff section varies from 4 to 4.5 m in height. The original height was probably much greater, since much of the deposit has been removed by erosion, and in places the extant dune remnant is less than 1m high. Occasionally the cliff is capped by dune sands. The highest part of the cliff is to be found at Lepe point, and the lowest at Stone point. The base of the section is generally obscured by cliff falls, but in places it can be seen that the gravels rest uncomformably on Barton sand.

The cross section (Fig. 57) shows that the deposit is a nearly horizontal segment of gravel, stretching back as far as Stone Farm, where it is separated from the higher gravels by a distinct bluff. The sloping area of the bluff probably obscures the cliff at the back of the deposits, the

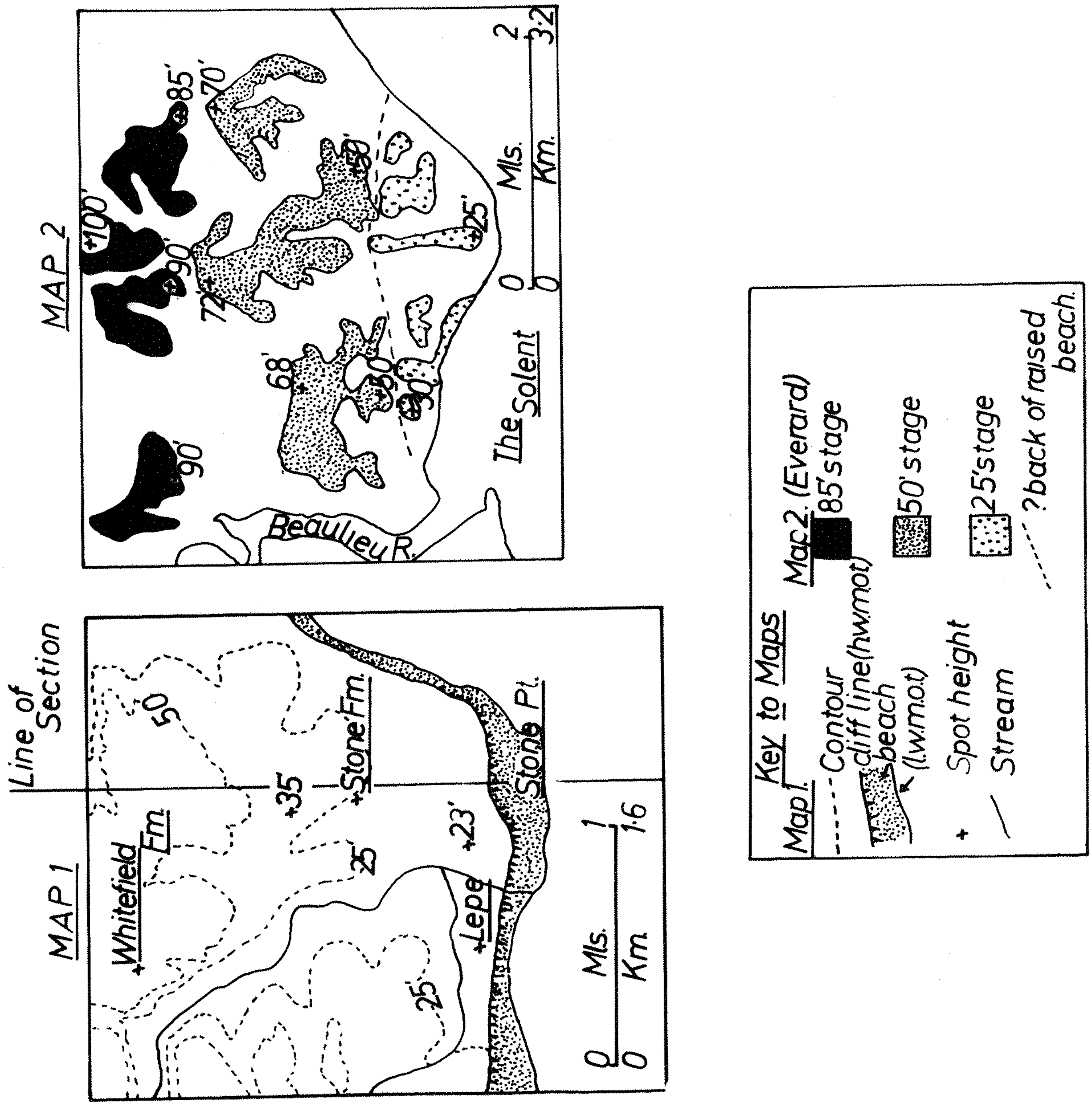


Fig. (56) Location and distribution of the deposits at Stone/Lepe.

(1) Location (2) Distribution of gravel, after Everard (1954).

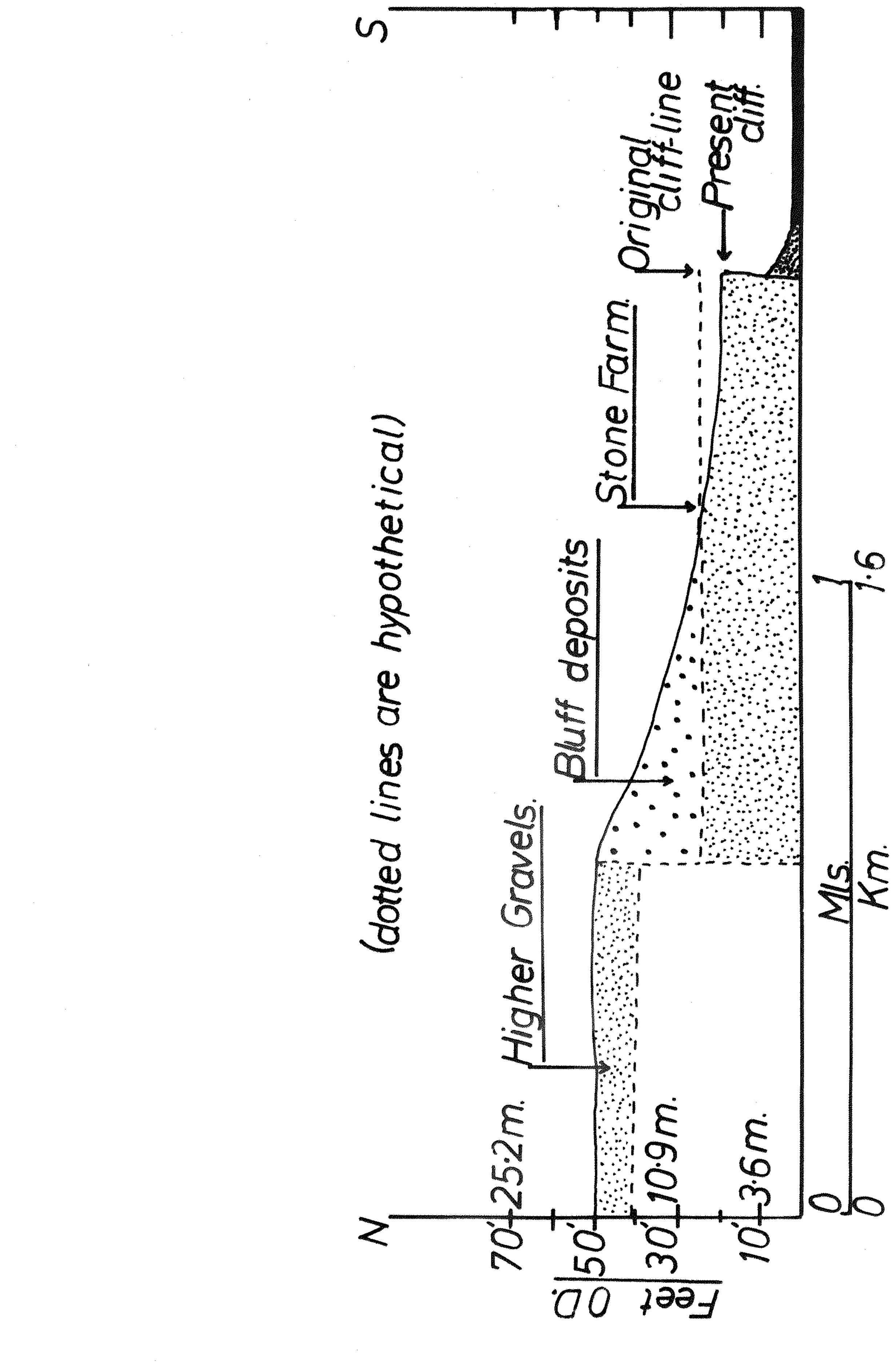


Fig. (57) Cross section through the deposits at Stone/Lepe.

surface of which is consistent at about 7.5m (25') O.D. The absence of marked horizontal gradient, and a buried cliff, are both indicative of a raised beach, and it seems likely from the topography that the feature is of marine origin. Everard (1954) also comments on this marked bluff.

Implements

Only one implement is reliably recorded from these deposits (Reid 1893), despite the fact that Roe (1968) lists two flakes, one retouched and one plain. Since the original drawing shows both sides of the flake with an ambiguous caption it is possible that the later record is a mis-interpretation. The implement figured by Reid (Reid 1893, p. 329), is a Levallois blade, possibly retouched, which he describes as having been found 'about 18" from the base of the gravel, where it was about 15' thick (Reid 1893, p. 328). He marks the actual position of the find on a photograph, which is here reproduced (Fig. 60). This shows that the blade is undoubtedly stratified within the deposits, in the level described in the present section (Fig. 61), as Bed 7. The writer has searched the exposure for further implements, but with no success.

The Gravels

Composition

As may be seen from the section (Fig. 61), the deposit is principally composed of angular and sub-angular shingle, evenly bedded and interspersed with beds and lenses of sand. The capping of 'brickearth' is porate, frequently heavily coated with salt, and often interspersed with small lenses of fine shingle, with a marked vertical alignment that shows the effect of cryoturbation. This cryoturbation is also most marked in the bed immediately below the 'brickearth' (Bed 3 of Fig. 61). The only other sedimentary structure present, apart from the evenly bedded sands of Bed 6, is the marked graded bedding of sand, shingle and cobbles, Bed 5.

Samples of the deposits were removed from Bed 2 ('brickearth'), Bed 6 (sand) and Bed 7 (shingle), for examination in the laboratory.

Analysis of the deposits

Bed 2, the 'brickearth'

This so called 'brickearth' appeared in the field to be a brown ~~sandy~~ deposit of sandy clay (Munsell colour 5YR3/4, dark reddish brown), heavily penetrated by recent rootlets.

Sieve and pipette analyses were carried out according to the procedures described above, the resulting particle size distribution curve being shown in Fig. 59. The textural parameters were calculated, and are summarised in Table (43). The sample consisted of about 93% sand, most of which was concentrated into the medium/fine grades. Only 11% of the sample was coarse sand, and only 4% mud, in this case almost pure silt. This result does not support the hypothesis that the 'brickearths' are a wind blown deposit consisting of weathered loess, which would contain a higher percentage of silt and clay. Indeed the low skewness value (0.058) and high fine sand percentages are indicative of a fairly dynamic environment of deposition, allied to a beach sediment, although the proportion of fine sand suggests that wind played an important part in the formation of the deposit. It is difficult to determine the precise environment of deposition, but it seems likely that this was a fine sand, possibly originally derived from beach sand, which has been heavily weathered 'in situ' so that it has developed some characteristics resembling the parabraunerdes described by Swanson (1968, p. 88). The sample was decalcified, highly ferruginous and remarkably similar in composition to the 'brickearth' overlying the same raised beach at Christchurch (Fig. 65).

Bed 6. The stratified sand lens

This bed consisted of almost pure sand (Munsell colour 2.5Y7/2, light grey) with a few small white-patinated pebbles. The sample analysed, (Table 43) consisted of 85% sand, with less than 1% mud and 14% fine gravel. The stratified sand lens had a skewness value of -0.284, which may be taken to indicate that it was formed under marine conditions. Many writers have asserted that negative skewness values indicate that the sediment was laid down under moderate or strong water flow, as on beaches, littoral zones or tidal inlets, and that this feature may be attributable to the winnowing action of a current which removes the finer material. Negative skewness is extremely rare in river sediments, or in those laid down under dune or estuarine condition (Duane 1964, Fuller 1962), Steers 1968, Inman 1949, Inman 1952).

A modern beach sand, from the same area, was analysed for purposes of comparison. It also showed a negative skewness and its principal characteristics, shown in Curve 2, Fig. (59) and Table (43), are almost identical to those of the stratified sand. The ancient sample probably had a larger wind-blown component, since the modern sample was taken on the foreshore. It seems probable that the ancient sand might have come from the back of the beach, nearer the dunes.

Bed 7. <u>The shingle</u>

1258 gms. of the basal shingle were analysed, since this is the bed which contained the implement recorded by Reid (1893). The roundness and sphericity of the particles were examined, in addition to a sieve analysis. The particle size distribution showed that the sample was principally composed of fine shingle (82%), with less than 18% of sand, (Table 43). The shingle was uncompacted and not interleaved with sand lenses, and rested unconformably on Tertiary sands. Some even bedding was observed. The positive skewness (0.544) of the deposit makes it unlikely that it is the product of marine action.

Analysis of the roundness of the component particles showed that this was varied, but not high, the sample mean lying at 0.36 (sub-angular), with a standard deviation of 0.116. The range of the sphericity measurements was much greater, as can be seen from the histograms (Fig. 58), from 0.71-0.91. The mean of sphericity was 0.80, and the skewness value of roundness was higher than that for sphericity, indicating that the pebbles

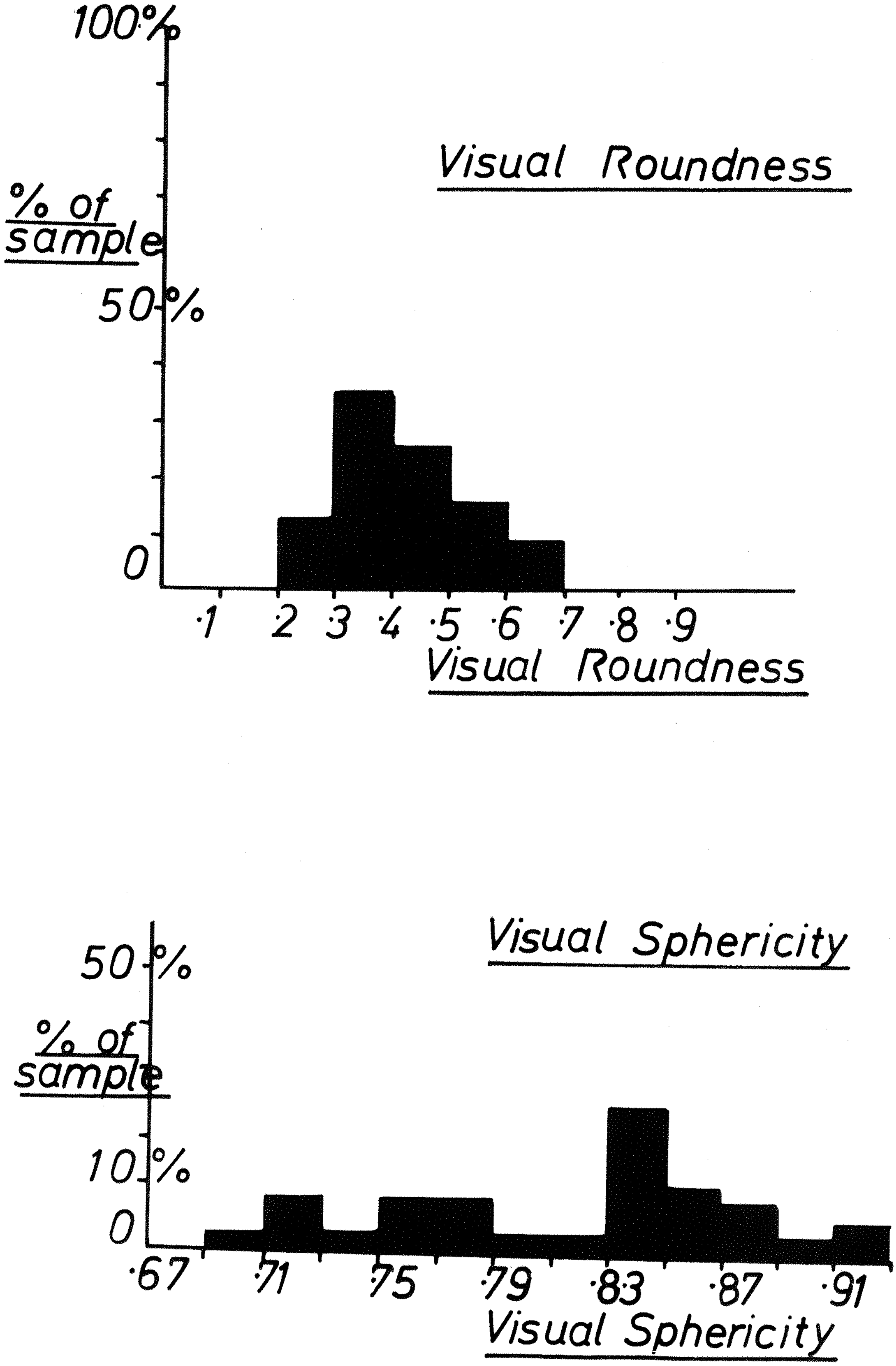


Fig. (58) Histograms of the roundness and sphericity value of pebbles from the shingle (Bed 7), at Stone/Lepe.

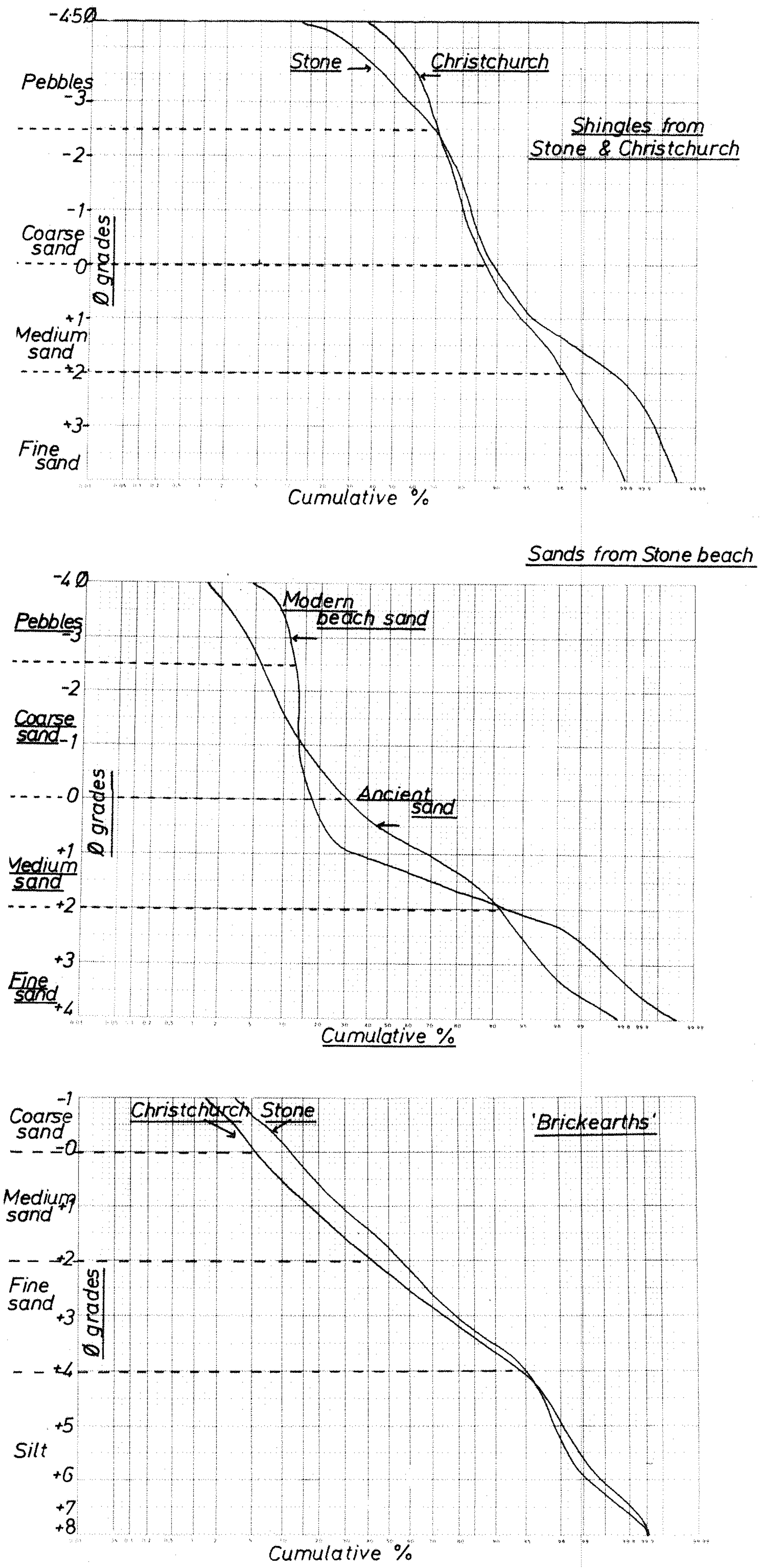


Fig. (59) Particle size distribution curves for samples from Stone/Lepe.

tended to be quite spherical, but angular.

The positive skewness of the grain size distribution, together with the angularity of the shingle, indicates that this deposit was not formed under marine conditions. ~~A clear contrast can be seen with the undoubted marine shingle of Bembridge (p.).~~ The environment of deposition of this deposit is therefore different from that of the sands of Bed 4.

Table (42) Measurements of Roundness and Sphericity, Stone /Lepe shingles

Parameter	Mean	Standard Deviation	Standard Error of Mean	Skewness	Kurtosis
Roundness	0.36	0.013	0.116	0.526	-0.354
Sphericity	0.80	0.003	0.060	-0.301	-0.986

Remarks on stratigraphy

The presence of a clear case of graded bedding in Bed 6 (Fig. 61) is interesting, since this is generally thought to be the result of an intermittent or pulsating sediment supply ~~(Beulig 1936)~~. This phenomenon is frequently present in beach deposits, indeed if a 'beach cusp' were sectioned (Sparks 1968) a very similar result would be obtained. This bed also contained some of the largest cobbles found in the section, with a markedly higher degree of roundness and sphericity than the shingle above them, giving the whole feature a distinctively 'marine' appearance. The difficulty of detecting the environment of deposition of the brickearth has already been mentioned, but again it seems possible that the bulk of its fine sand could have been ultimately derived from a marine deposit.

In summary, therefore, it seems that the initial depositional phase, resulting in the shingle of Bed 7, is not typically marine, although it is capped by deposits clearly formed by marine or tidal estuarine action. The topmost deposits (Beds 2 and 3) have been much modified by cryoturbation, an indication of a phase of severely cold climate since their deposition.

Fig. 1.—*Section in the sea-cliff, near Stone (Hampshire).* From a photograph.

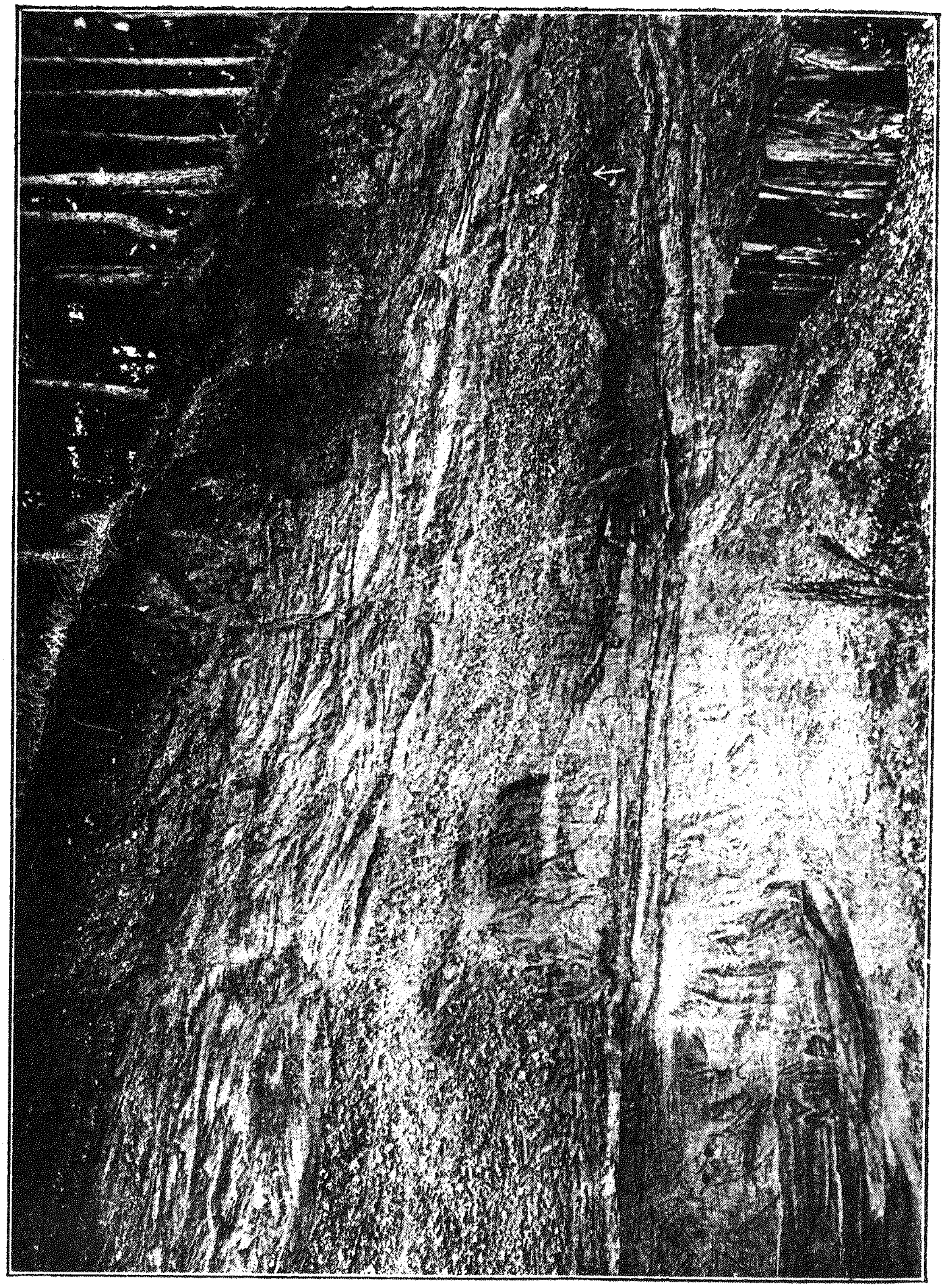


Fig. (60) Section through the cliffs at Stone, with the position of the implement find marked by a white arrow (bottom right), from Reid (1893, p. 328).

Affinities and Chronology

Everard (1954) considers that these deposits form part of his so-called 25' stage, indeed the only remnant of that stage present in the New Forest area. The western edge of this fragment has a height of about 30' O.D., and there is a 15' bluff reaching up to the 50' stage. Despite the horizontal nature of the remnant Everard does not include it as a 'horizontal segment', simply because he does not recognise any of these between the 10-15' stage, and the 50-70' stage, a surprising conclusion in view of the evidence from other area (Everard 1952 p. 97). However, as can be seen from the figures, the longitudinal gradient of the original terrace before denudation must have been very slight, and its perceptible gradient at the present day seems largely attributable to a false effect produced by erosion of the seaward side. There seems to be little difficulty in classing the original terrace as horizontal. In Everard's opinion the horizontal segments cannot be equated with true raised beaches, since their gravels are too angular, and he considers that they largely consist of solifluxion gravels, reworked by marine action in the limited fetch of the Solent. This hypothesis would not be inconsistent with the results obtained from analysis of the present section, the gravel and shingle of which are certainly not typically beach deposits. However the sands must have been formed under tidal or estuarine conditions, but their source of supply would in any case have differed from the shingles. There is no evidence at all to suggest that these might be river deposits, and one could reasonably describe the deposits as those of an atypical raised beach.

Chronology

It seems likely that the beach segment in question would have been formed in a transgressive sea, in a location where there was a great deal of gravel available for re-working. It seems probable that the Wight/Purbeck ridge had been breached by this date, if not long before, since had

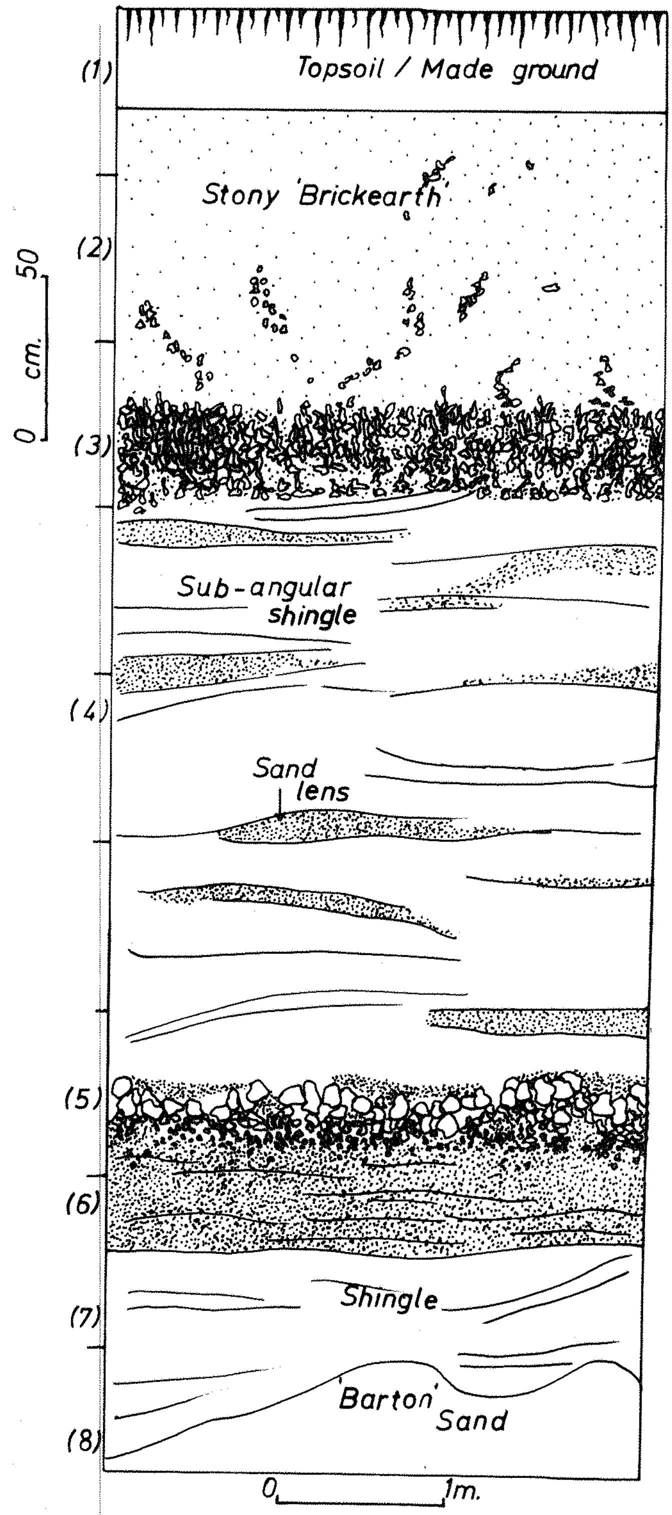


Fig. (61) Section through the deposits at Stone/Lepe. (vertical scale twice the horizontal).

this not been the case the environment of deposition of the deposits would have been more characteristically estuarine. The raised beach is demonstrably later than the estuarine clays that are beneath it, which have been assigned by West and Sparks (1960) to Zone (f) of the Ipswichian interglacial, as at Bobbitshole and Selsey. The deposits seem to belong to a later phase of Zone (f) than Selsey (see p. 168).

The marine transgression forming the beach must therefore be placed some time after the end of Zone (f), and there are other indications of a rapid rise in sea level at about this period. Von der Brelie (1954) working from Continental evidence, considers that the main regressive zone lies in Zone (i).

This fragment of the raised beach can therefore be assigned to the late Ipswichian (Eemian) 7.5m raised beach complex, both on stratigraphic and chronological grounds.

Table (43) Characteristics of the Stone/Lepe deposits.

						Folk statistics				
Bed No.	Description	Total weight sampled	% sand	% gravel	% mud	Mean	Standard Deviation	Variance	Skewness	Kurtosis
2	'Brickearth'	194.168	92.951	3.028	4.021	1.78	1.460	2.130	0.058	0.889
6	Stratified sand	503.200	85.211	14.418	0.371	0.431	1.427	2.036	-0.284	1.750
7	Shingle	1258.070	17.902	82.058	0.040	-2.837	1.866	3.480	0.544	1.251
	Modern beach sand	556.390	86.051	13.924	0.025	1.191	1.277	1.631	-0.412	4.946

4.15 Christchurch

The Bournemouth and Christchurch area of Hampshire has produced many thousands of implements (Roe 1968), and the terrace sequence and sites have been the subject of a number of papers, notably those of Bury (1923), Green (1946, 1947, ~~1949~~), Calkin and Green (1949) and Sealy (1955). The youngest and lowest terrace features of the area are the Christchurch terrace and the Muscliff delta, or Muscliff terrace (Calkin and Green 1949), with surface heights from 20-40'OD.

Calkin and Green (1949) produced a detailed account of the distribution and stratigraphy of these two features, together with the implement finds made from them. Their distribution map is shown in Fig. (63).

The so-called Muscliff delta seems to have been related to a sea level at least 30' above the present, since it has a surface height of 41'OD, although the outer surface slopes down to 32'OD (Fig. 64). It has the form of a typical bay delta, as the result of fluviatile aggradation near the tide head in the drowned valleys of the Stour and the Avon. Present beds of growing bay deltas show that they form up to the high water mark of the spring tides, and that the depth of deposit may be very great. The Muscliff delta gravels have a thickness of over 50' in places, and are reported from 41'OD to -15'OD. The mode of formation of a bay delta differs from that of a river terrace, since it grows outwards in a fanlike shape (Miller 1883), attaining a thickness limited only by the depth of water available.

Parts of the Muscliff delta have been replaced by a terrace gravel with a surface height of 18-27'OD, which Calkin and Green (1949) consider was formed after the retreat of the sea from the level to which it had risen during the formation of the delta. This 'Christchurch terrace' (Fig. 63) is found below the formation of the delta, below a bluff at about 23'OD, which separates it from the Muscliff delta (Fig. 63). The Muscliff delta and Christchurch terrace appear to have formed either by a single transgressive episode or two episodes closely related in time ~~(p.)~~.

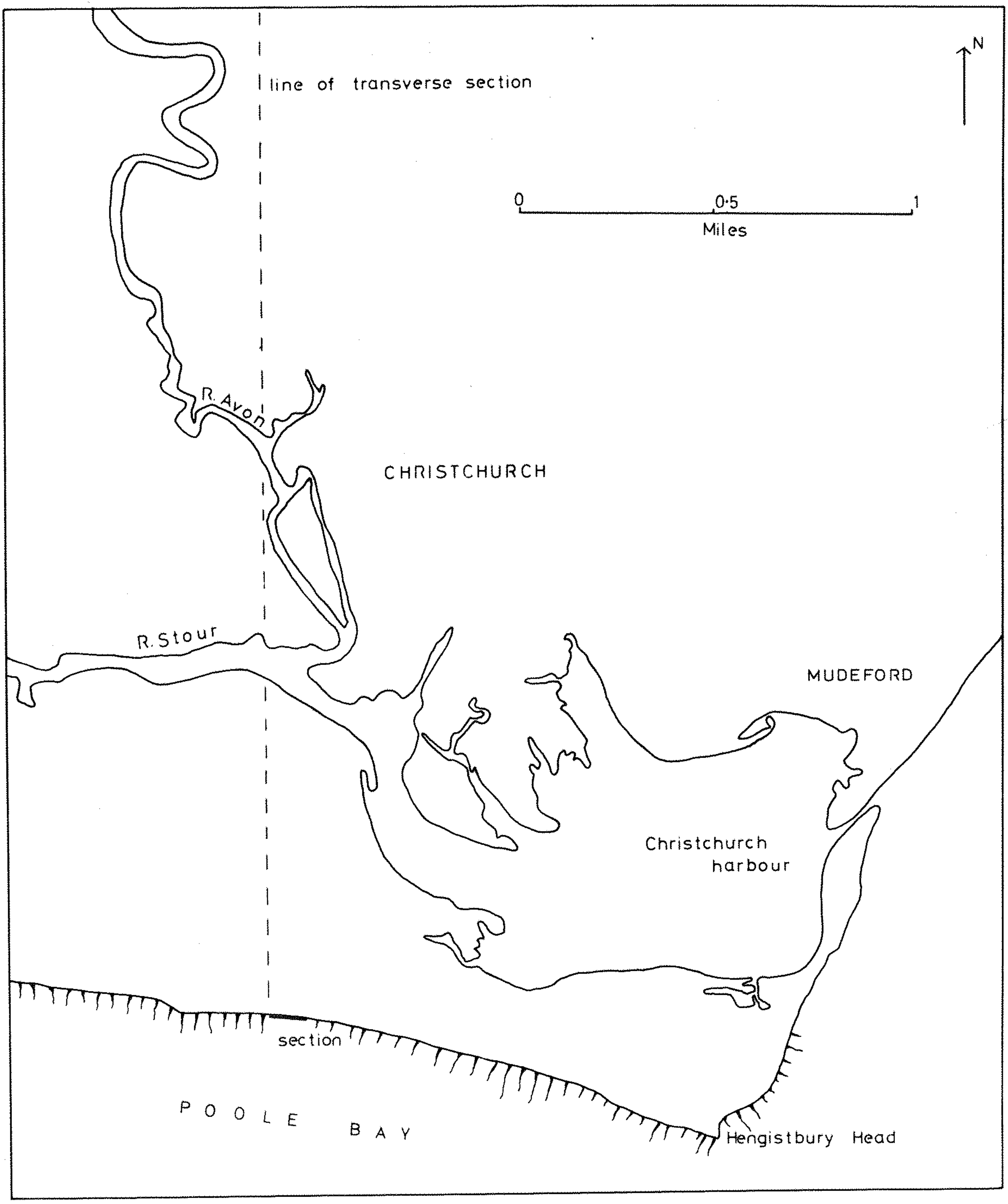


Fig. (62) Map of the Christchurch area, showing location of the measured section.

The distributions of these features, according to Calkin and Green (1949) are shown in Fig. (63), although they considered that the Christchurch terrace was fluviatile, and the present study shows that at least the coastal stretch, is of marine origin. The various fragments thought by them to belong to the Christchurch terrace become the floodplain of the Stour and Avon at 34'OD, but it is possible that they are distinct from the coastal fragment which may be considered as a raised beach. Since no exposures of the inland sections are to be found it is impossible to make a categorical statement concerning their relationship to the coastal fragment, but the implement finds from the inland Christchurch terrace are similar both in type and their fresh condition to those from the coastal segment, making a similar environment of deposition rather likely. However the tidal conditions in this part of Poole Bay at the time of the formation of the deposit are likely to have been complex, and the exact stratigraphic relationship of the Muscliff delta and the Christchurch terrace is unlikely to be straightforward. It is possible that the inland segments may be the result of mixed environments of deposition, and in any case they probably consist largely of gravels redeposited from the Muscliff delta, cut by the Christchurch terrace.

The rise in sea level which was responsible both for the drowning of the river valleys, and thus for the formation of the bay delta, and afterwards for the aggradation leading to the formation of the raised beach segment seems to have been Ipswichian in date, and related to the 7.5m transgression. The raised beach episode is certainly of this date, as is shown by the archaeological material found within it, and the close relationship of Christchurch terrace artifacts with types, including bout coupé axes, found stratified within the Muscliff gravels suggests that the two are indeed closely related in time and not the product of two separate inundations.

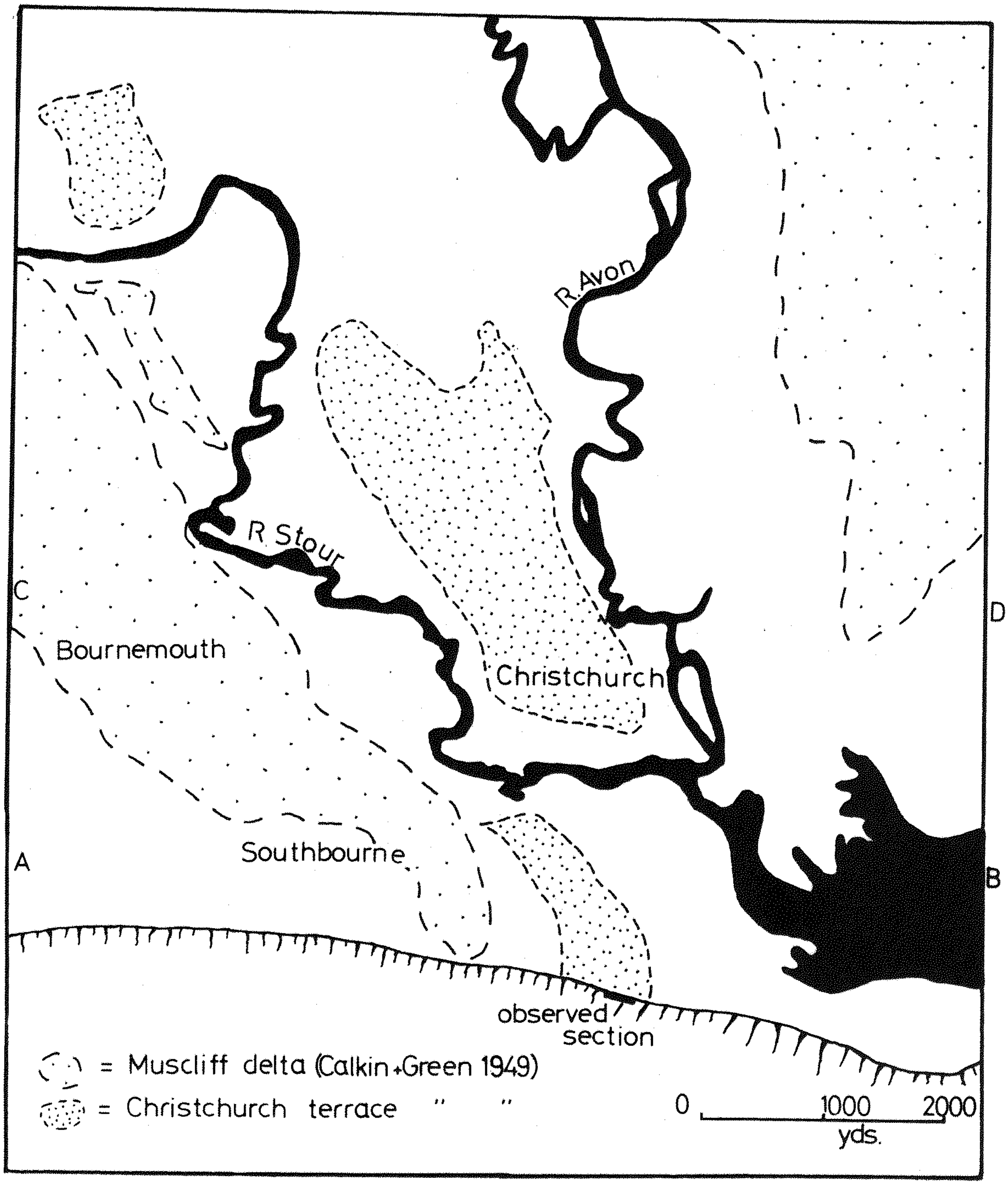


Fig. (63) Terrace deposits of the Christchurch area, after Calkin and Green (1949).

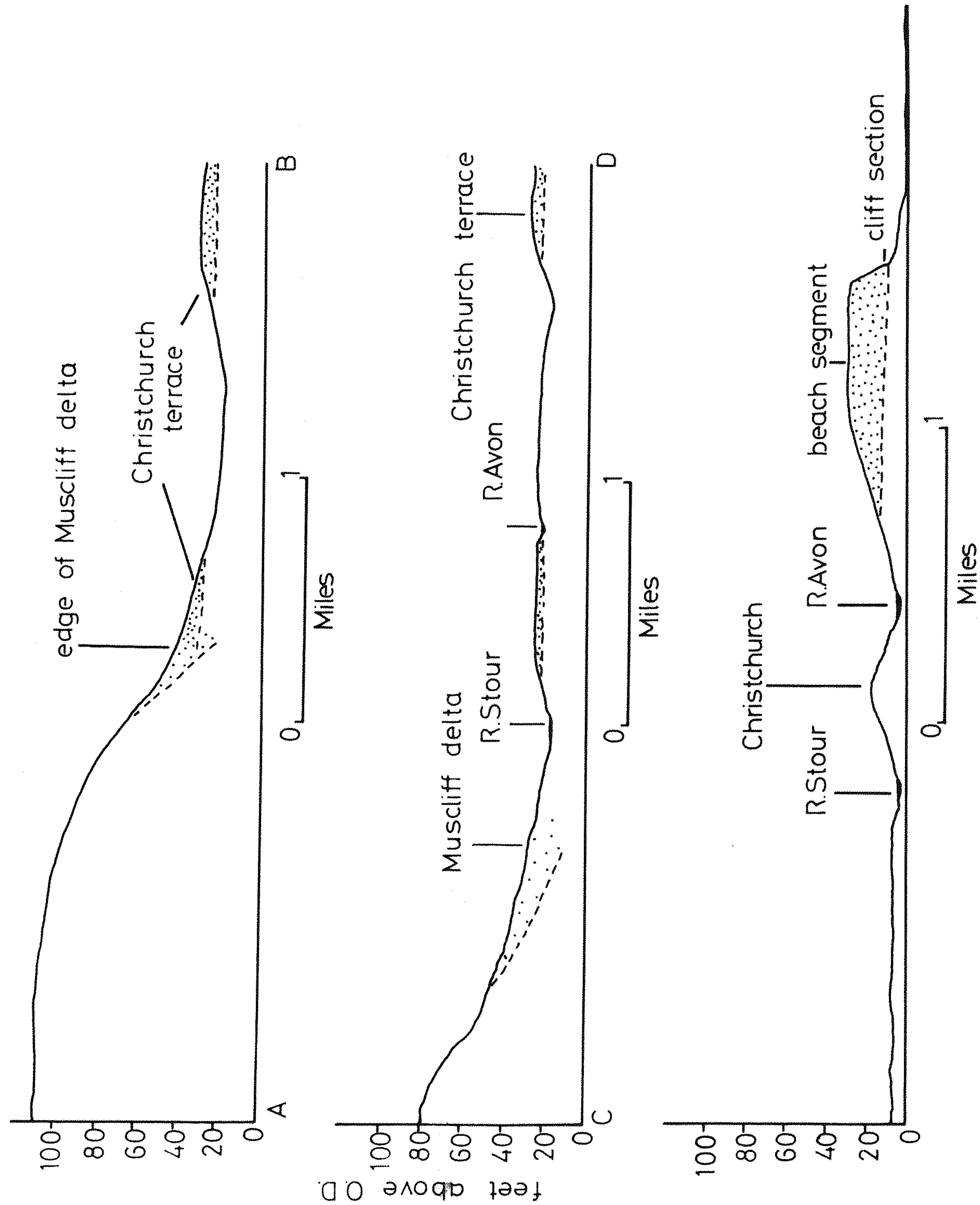


Fig. (64) Transverse sections of the deposits at the Christchurch area. (a) west/east section C/D across Fig. (63). (2) west/east section along A/B, across Fig. (63). (3) Transverse section along dotted line N/S across Fig. (62).

The Section

The height of the coastal segment exposed in the cliff (Fig.65) drops from around 25-39' to the level of the present beach, the surface height sloping away to the north, towards the flood plain of the Stour, and rising to the east, to Hengistbury Head, and to the west to the higher terrace levels of Bournemouth. A fine section through the deposits could be seen on the coast between Southbourne and Hengistbury Head (Fig.62), although it is now partially obscured. The deposit consists of over 3m of ~~shingles and~~ gravels including lenses of sand, and is capped firstly by 'brickearth' and then by a modern blown dune sand. The deposits rest conformably on Tertiary sands (Fig.65).

Towards the base of the section lenses of very coarse gravels may be found (Beds 4 and 6), which include a number of large black pebbles re-deposited from the Eocene beds. These are heavily rounded (R= 0.8 or 0.9), with high sphericity values, and often bearing signs of marine action. Well-rounded flint cobbles are also found. The Eocene pebbles, derived from the local Tertiary sediments, only occur in the gravel fraction of the deposits, and no smaller particles could be found by an examination of the sand faction with a binocular microscope.

The section was measured and drawn, and sediment samples taken from each layer. The modern dune sand (layer 7) was also sampled to compare its composition with the stratified sand. Fig. (66) shows the particle size distribution for the gravel (Bed 4) and the shingle (Bed 3). Both deposits are rather coarse grained, over 30% of the particles in layer 4 being larger than -6Ø ~~(mm)~~, mostly Eocene pebbles. The mean size of the material in layer 3 is 3.176Ø (Table 44), and that of layer 4 is -5.139Ø. Both samples contain over 80% of gravel and less than 0.3% mud (clay and silt). Both were poorly sorted and strongly fine skewed, but layer 3 was mesokurtic whilst layer 4 was very leptokurtic, a distortion attributable to the large amount of very coarse material found in the latter sample. Both gravels

CHRISTCHURCH

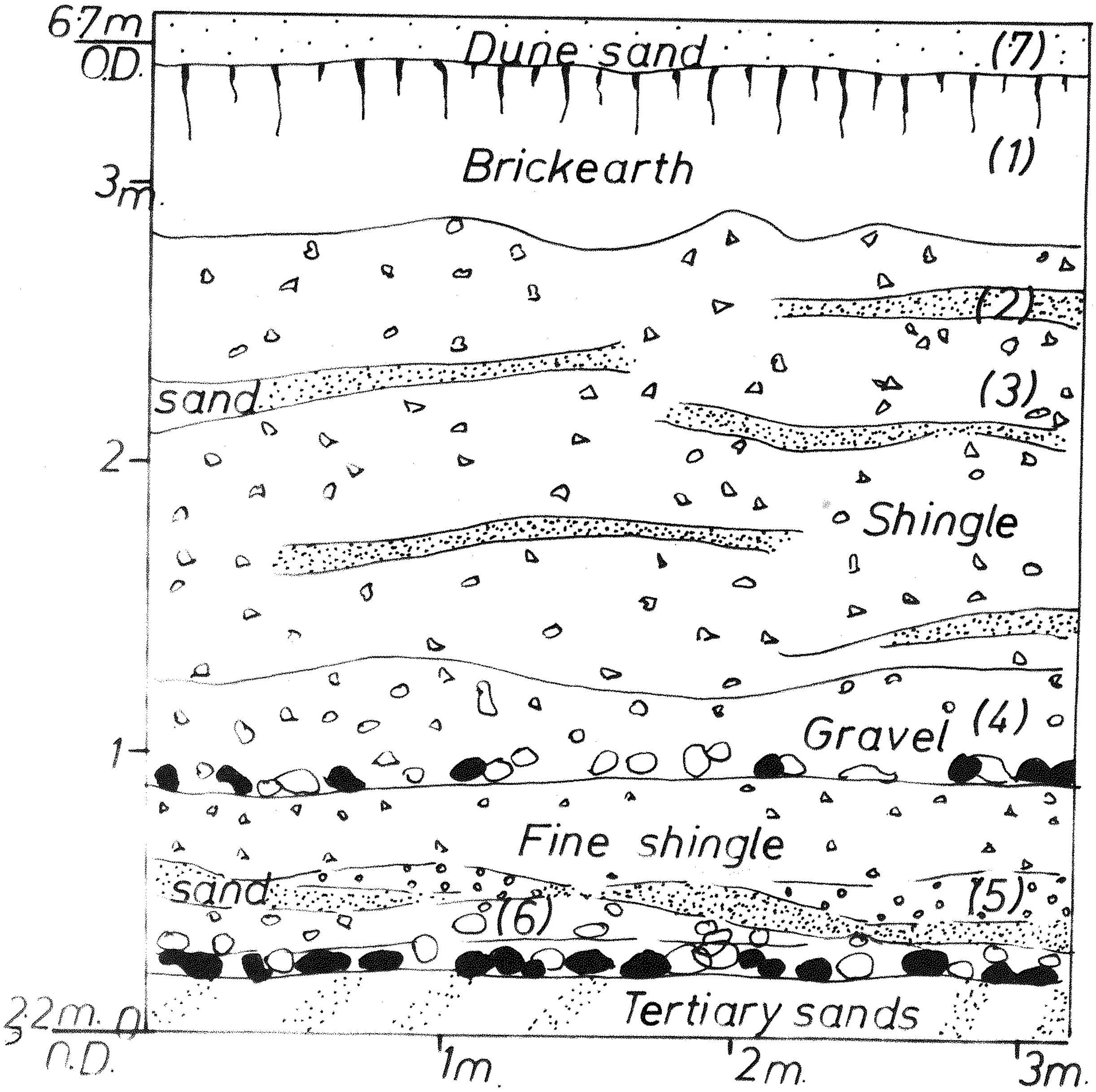


Fig. (65) Coastal section through the Christchurch deposits.

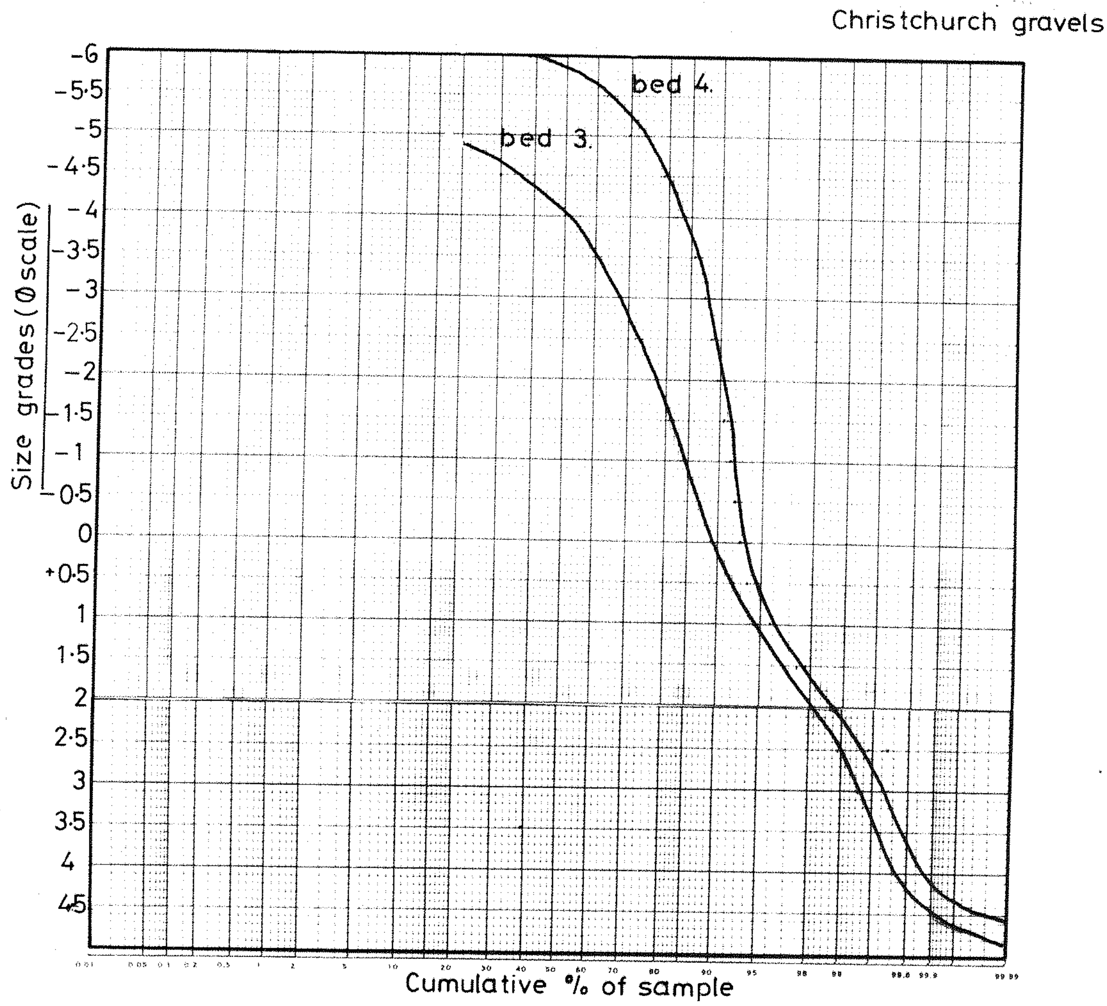
Table (44) Characteristics of the Christchurch deposits

Sample	Description	% gravel	% sand	% mud	Mean	Standard Deviation	Variance	Skewness	Kurtosis
Dune Sand	sand	0.002	99.947	0.051	1.538	0.475	0.225	0.324	0.881
Brickearth (bed 1)	slightly gravelly sand	1.464	94.982	3.553 silt=3.438 clay=0.085	2.112	1.197	1.433	-0.081	1.038
Layer 3	gravel	81.587	18.120	0.293	-3.176	1.952	3.812	0.716	0.950
Sand in Layer 3	slightly gravelly sand	0.853	98.980	0.168	1.480	0.514	0.264	0.254	1.212
Layer 4	gravel	91.338	8.536	0.126	-5.139	1.689	2.854	0.683	2.002

are felt to have been deposited in a high energy environment, and are thus likely to be marine in origin, although the raw material could have originally been derived in part from fluviatile terrace gravels at higher levels.

Fig. (66) shows the particle size distribution curves for the stratified sand lens from Bed 3, together with the results for the capping dune sand and the 'brickearth'. The stratified sand lens consists almost entirely of sand, (98.98%), with less than 1% of mud. It was positively skewed, quite well sorted and leptokurtic, with a mean size of 1.488∅. The dune sand was also moderately well sorted and almost entirely composed of sand (99.94%). The particle size distribution curves show the marked similarity between the two samples, the principal difference occurring near the top of the curve, occasioned by the 0.85% of gravel present in the stratified sand. Since the arithmetic probability paper on which the curves are drawn expands the 'tails' of the distribution this small difference is exaggerated. The similarity between the samples, together with the good sorting, positive skewness and an examination of the surface characteristics of the sand grains suggests that the stratified sand has an environment of deposition similar to that of the dune sand, and it seems likely that it was formed by aeolian action towards the back of the raised beach. A strong contrast exists between the particle size composition of the dune sand and of beach sands, for example those shown in Fig. (40).

The particle size distribution of the brickearth is shown in Fig. (66). This was a brown sandy deposit, Munsell colour 7.5Y5/7 (brown), not very well compacted and with a pH value of 8.1. Sieve and pipette analysis showed that the deposit consisted mainly of sand (94.98%) with an appreciable amount of mud (3.55%). This is similar to the 'brickearth' already described from Stone, further along the coast (Fig. 59). The deposit was negatively skewed and rather poorly sorted, which would



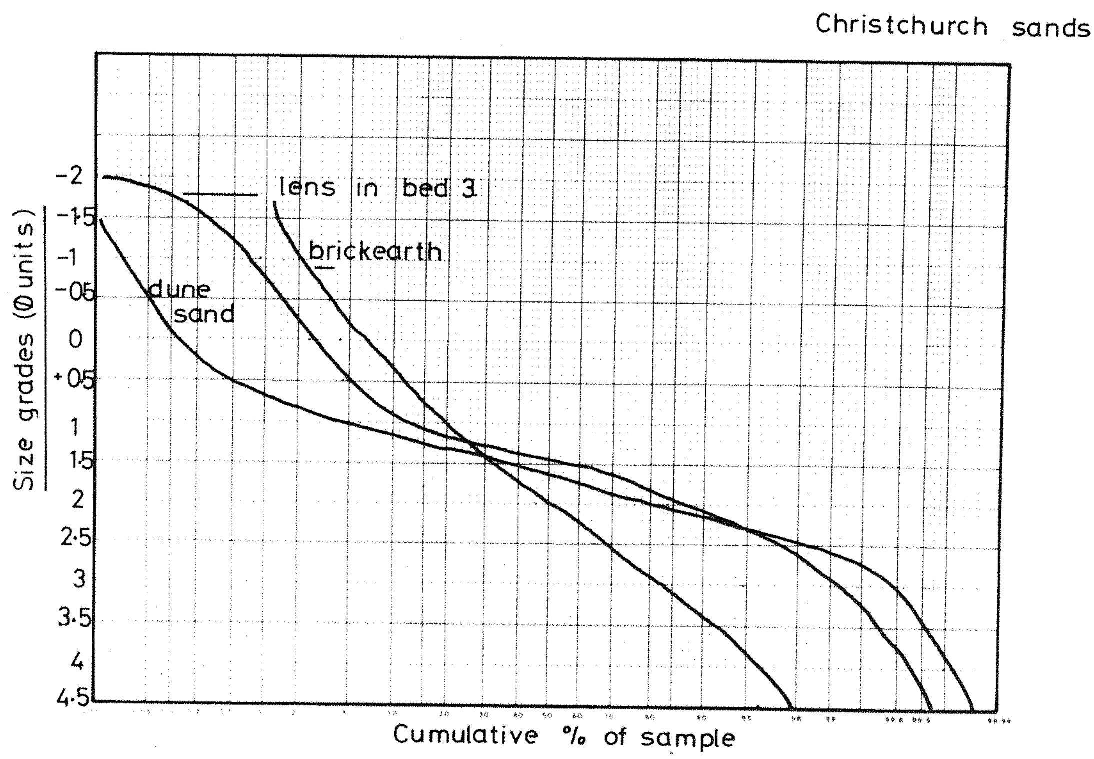


Fig. (66) Particle size distribution curves for samples from Christchurch deposits.

normally indicate a marine origin, but this is contradicted by the presence of fine material such as the clays and silts. It is suggested that the 'brickearth' had indeed been originally derived from beach sand, which had possibly been blown onto the top of the raised beach segment after the retreat of the sea. This deposit had then been weathered 'in situ', and decalcified, resulting in its present characteristics. There seems little doubt from the results presented above that this exposure shows deposits which are the remains of a raised beach segment, rather than a fluviatile aggradation.

The Implements

Both the Muscliff and Christchurch terraces have yielded a number of implements of Mousterian of Acheulean Tradition facies. Since the two formations are likely to be similar in age it seems reasonable to consider these finds together. There is no question of an 'assemblage' or a 'site' being present, but only a number of the finds in a very fresh condition, suggests that they are likely to be largely contemporary with the deposits.

Calkin and Green (1949) record a total of 16 implements from the Muscliff delta, of which only 9 are now traceable, and 8 from the Christchurch terrace, of which only 1 can now be found. In addition they report 8 other implements which came from these deposits but which are not precisely located, 1 of which can now be found, and which is marked 'Christchurch Terrace'.

The composition of this group is shown in Table (45). The bout coupé axe from the Christchurch terrace and the double racloir are drawn in Fig. (67), together with some implements from the Muscliff delta. The whole group is remarkable for the 4 superb bout coupé axes, three of which are shown in Fig. (67). Fig. (67) no. (1) is a particularly interesting specimen, made on a flake of attractive black flint, with an abrasion index value of 0, indicating that it is virtually in 'mint' condition. Fig. (67) no. (2) is a more triangular bout coupé with a flat cross section, and no. (4) is a bout coupé axe of very small size, reminiscent of some of the specimens from Great Pan Farm (p.107). The implements found also included a fresh Levallois flake, a roughout and a core. Since the number of finds was so small and there was no grounds for postulating an assemblage, it was not thought that the usual linear regression analysis of the measured variables was likely to produce any valid results. However a simpler analysis of the group showed that 50% of the implements were very lightly abraded (index values less than 2), although 2 specimens were quite heavily abraded. The mean weight of the implements was 222.61 gms, and they tended to be rather small in size and thin in section.

Conclusions

The inclusion of lenses of dune sand within the deposit on the coastal exposure suggest that the observed section originally was well to the back of the beach. The hydrological situation in the area at the time of the deposition of this fragment seems to have been extremely complicated. It is impossible to estimate the former height of the back of the beach, but it is suggested, on the grounds of the included implements and the clear relationship between these deposits and those of Stone, that this may be a beach fragment produced by the 7.5m transgression. If this is so then Muscliff delta, including implements of related type, is unlikely to have formed at a very different time and may quite possibly have been deposited during the same transgressive phrase.

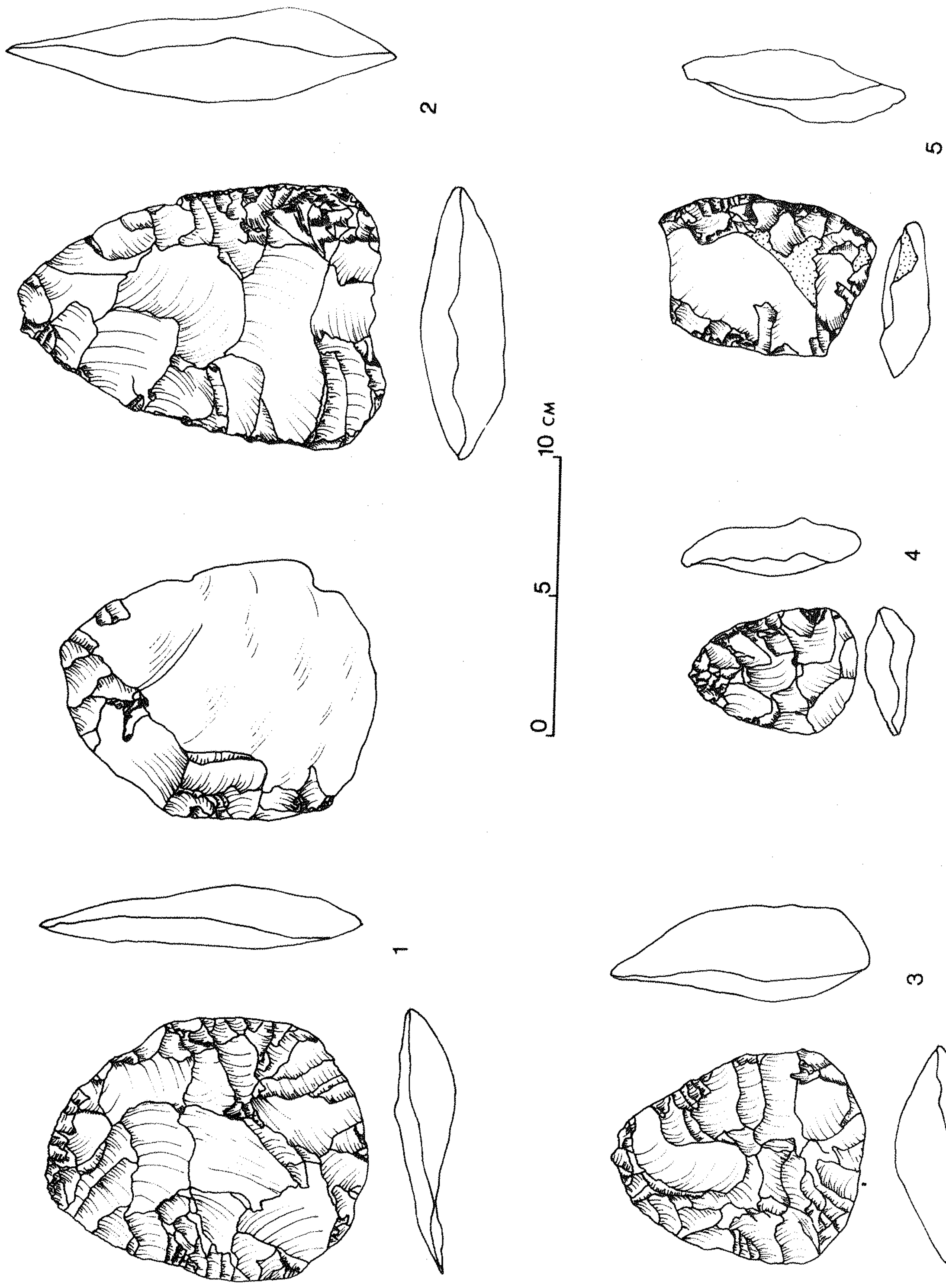


Fig. (67) Implements from the Christchurch and Muscliff terraces.

Table (45) Implements from the Muscliff delta and Christchurch terrace

Type No.	Description	No. found	Formation
1	Levallois flake	1	Muscliff delta
15	double convex racloir	1	Christchurch terrace
119	core	1	Muscliff delta
120	roughout	1	Muscliff delta
125	pointed triangular handaxe	2	Muscliff delta
130	lanceolate handaxe	1	Muscliff delta
132	bout coupé handaxe	3	Muscliff delta
		1	Christchurch terrace
		11	

4.21 Fisherton (near Salisbury, Wilts. SU 138302)

Introduction

The first reference to the extensive 'brickearth' deposits at Fisherton (sometimes referred to as Fisherton Anger), comes in the work of Charles Lyell (1826). He describes the deposit as 'varying in thickness from 10-20', divided into laminae, occasionally separated by layers of fine sand or small flints', and appearing to be a 'tranquil sedimentary deposit from water' (Lyell 1826).

Much work was done on these deposits in the 1890's, especially by Dr. H.P. Blackmore, creator of the Blackmore museum in Salisbury. He noted that the 'brickearth' formed a low terrace alongside the R. Wily or Wylye (Fig. 68), between Salisbury and Wilton, rising 30-40' above the present flood-plain. The deposits were being extensively quarried at this time, and several writers record that they attained a depth of nearly 10 m (30') in the quarries at 'Hardings and Bakers pits' (now untraceable). The base of the 'brickearths' (sometimes also referred to as clays) frequently rested on a layer of light-coloured marls, full of land and fresh water shells, and the deposit appeared to dip markedly towards the south. (Blackmore 1897, Cunnington 1858, Evans 1872, 1864, Lyell 1833, Prestwich 1855, Reid 1903, Stevens 1870). The geological survey mark the 'brickearths' on the geological maps, but no work has been done on the deposits in this century. The area has now been almost completely built over, and it is doubtful whether any of the 'brickearths' are left. Indeed Reid, in the Geological Survey Memoir of 1903, stated that 'so much of the brickearth has been worked out that many of the sections are obscure' and was forced to quote a section given by Prestwich (1855), over 50 years earlier.

This lack of extant sections is most disappointing, since the deposits yielded one of the most important collections of Pleistocene faunal and molluscan material found in the south of England, accompanied by artifacts

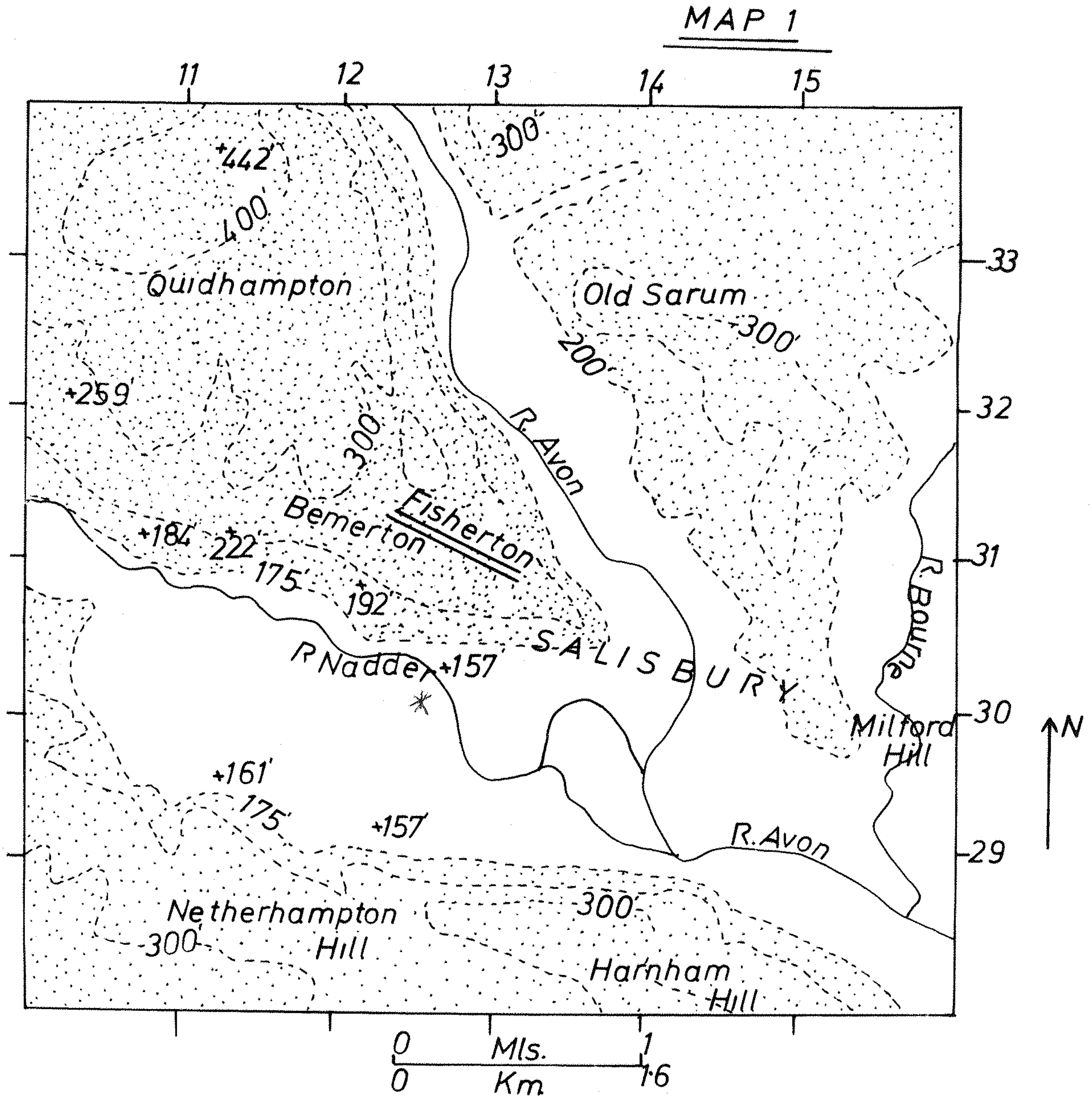


Fig. (68) Topography of the Fisherton area.

* Nadder/Wily

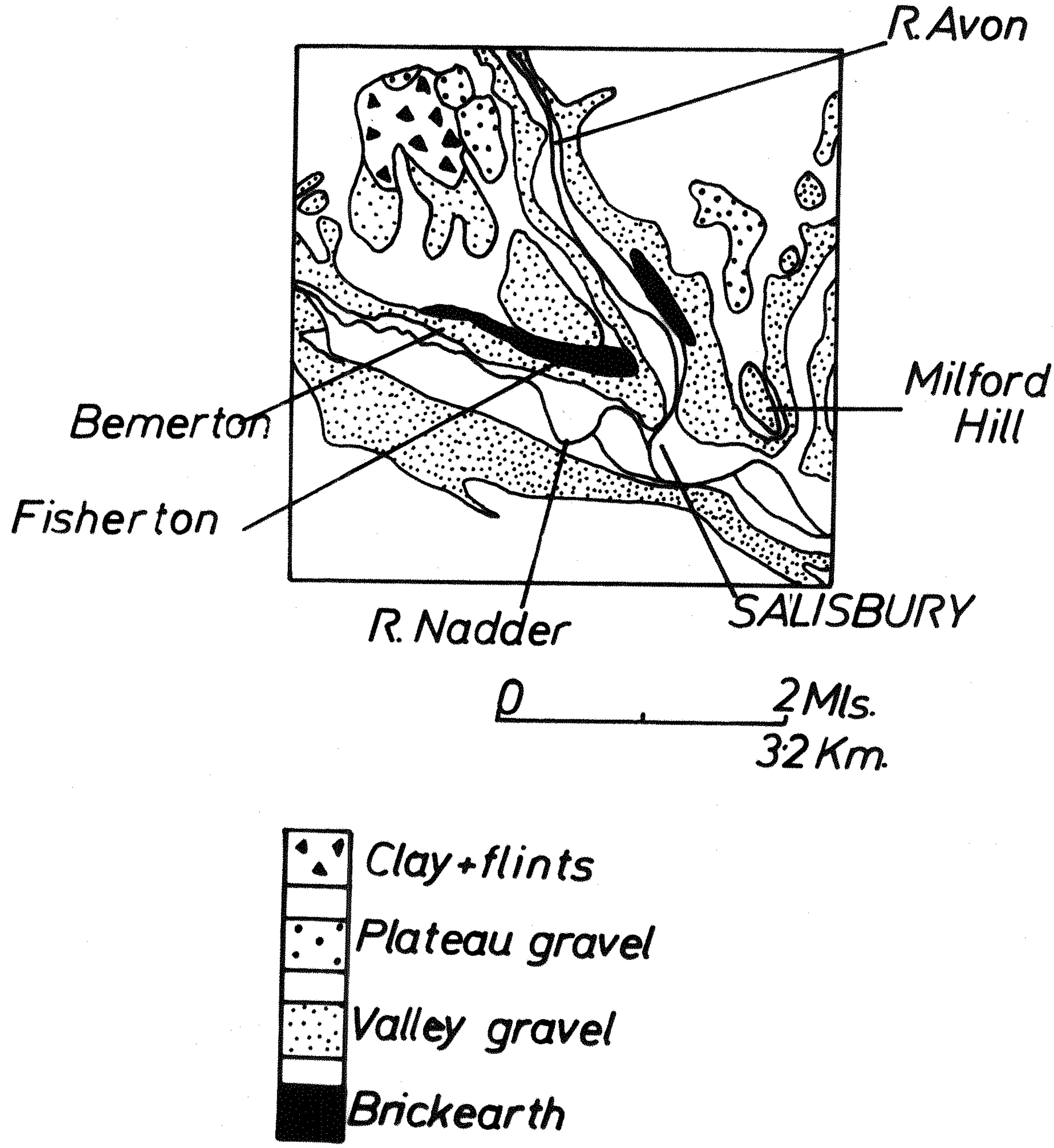


Fig. (69) Drift deposits of the Salisbury area.

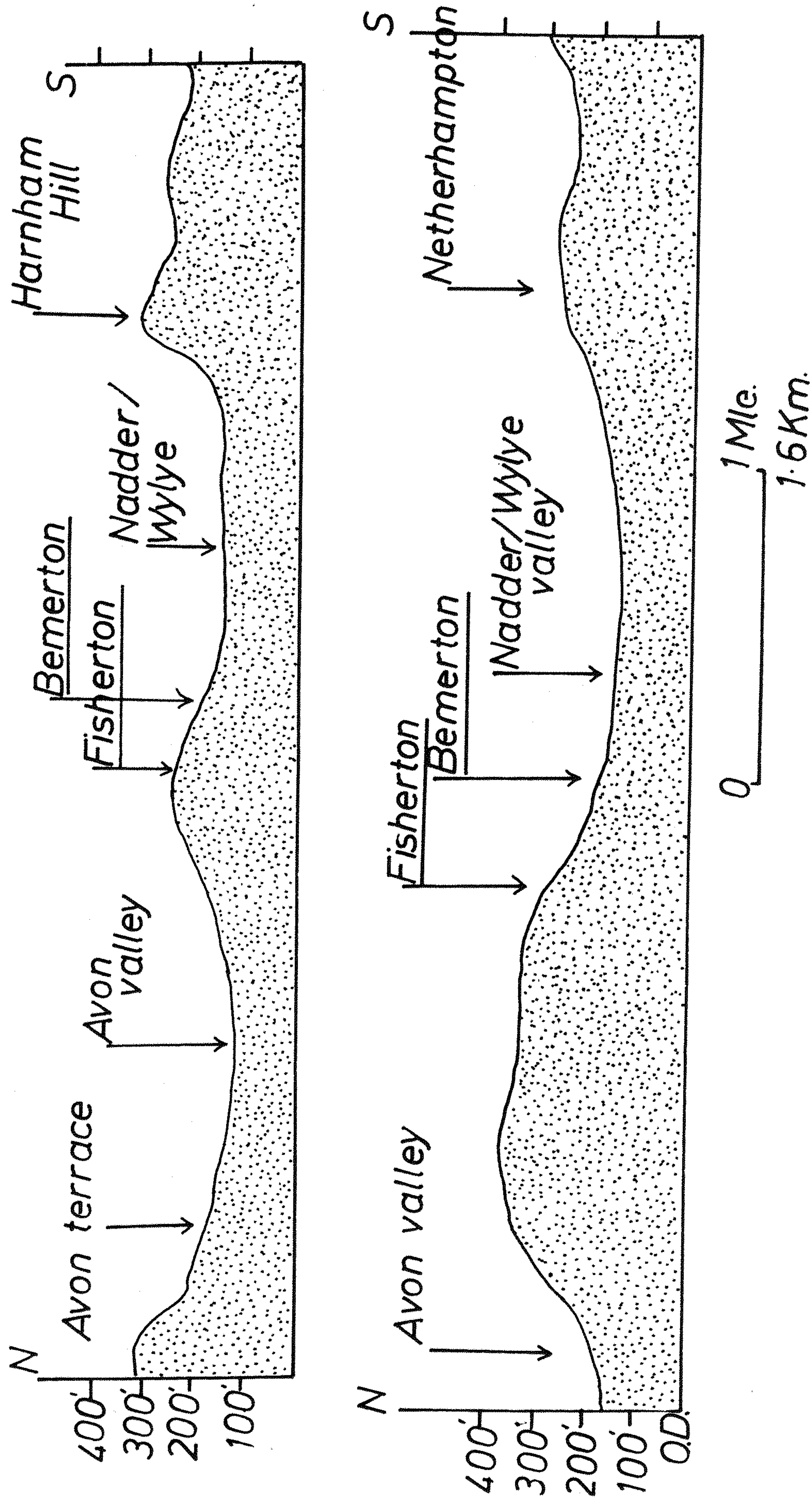


Fig. (70) Cross sections of the Fisherton area.

(1) along ~~northing~~ easting 13, Fig. (68)

(2) along ~~northing~~ easting 12, Fig. (68)

stratified within the 'brickearths'. Additionally frustrating is the fact that the term 'brickearth' was used by 19th century authors to describe any sort of material suitable for the manufacture of bricks (see p. 78), and is not a reliable indicator of the composition or environment of deposition of the deposit.

Although the area is built over (see Fig. 68) a fortuitous gas pipeline trench at Grid, Ref. SU124310 (see map) showed that at this point there was neither gravel nor brickearth on top of the chalk bedrock, although either would have been expected from the Geological survey map. Just below this height (see section 1 Fig. 70), the 175' Bemerton terrace is still a marked topographical feature. Local residents could give no indication of an area where the deposit might still be sampled, and the other small outcrop (2 miles away on the other side of the valley) was in a similar case. One is therefore forced to rely on the descriptions and sections of earlier workers.

Sections through the deposits

Two drawn sections through the brickearth are preserved, one from the so-called 'Blackmore Locked Notebook' in the library of Salisbury Museum. The writer is indebted to the Curator, Mr. H. Shortt, for permission to consult it. It is the most accurate record of all Dr. Blackmore's observations, kept in the form of a diary. The other is compiled from ~~an earlier~~ description by Reid (1903).

Section 1

This section, compiled from work done in the 1890's, is reproduced in Fig. (71), from p.3 of the 'locked notebook'. The caption states that there is a marked thinning out of the beds on the north (uphill) side, and that some become only 1-1½" thick. Blackmore mentions that a little further south than the end of the section the brickearth becomes 8' thick, well over the depth shown in the figure.

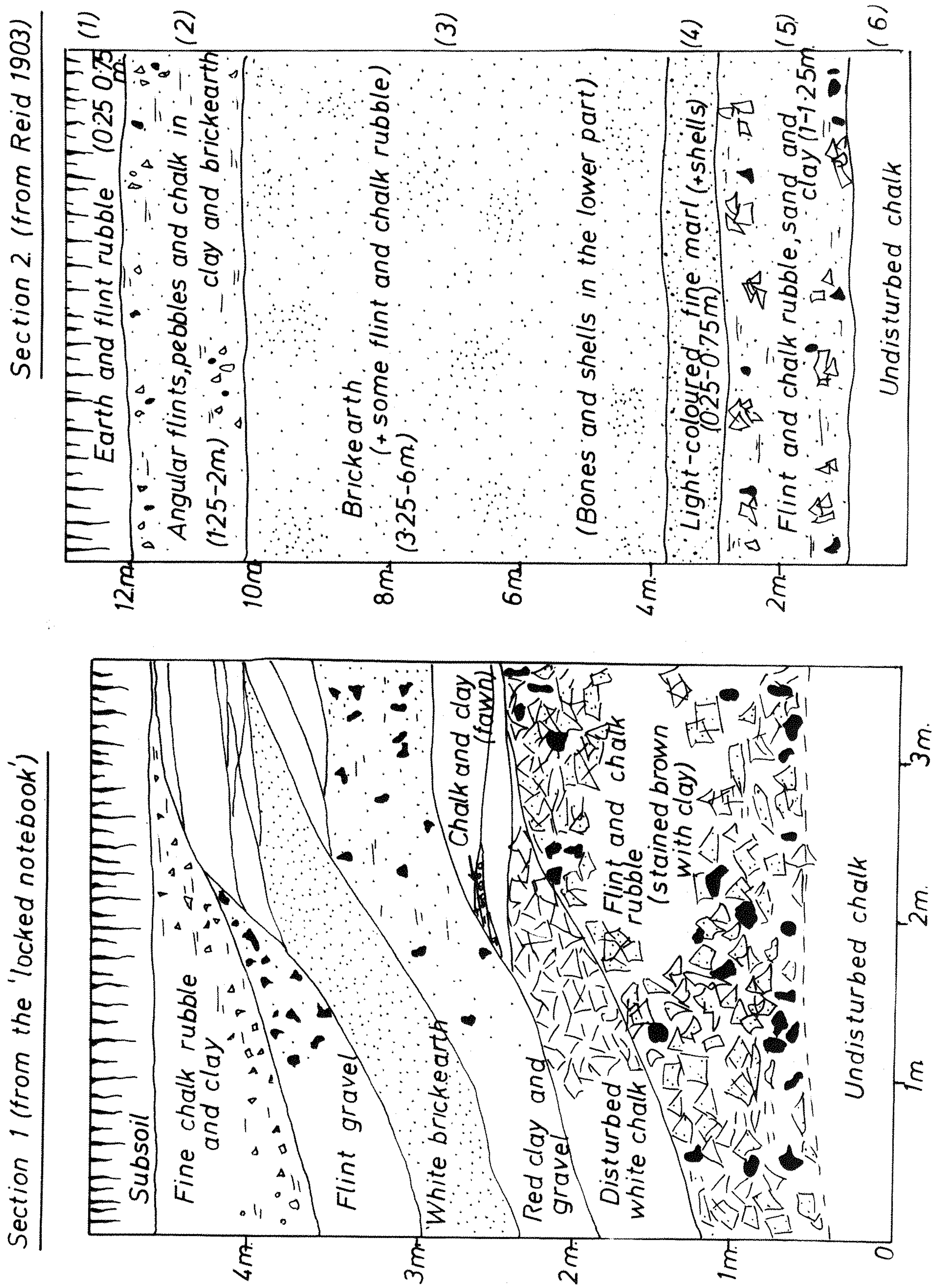


Fig. (71) Sections through the Fisherton deposits.

(1) from the Blackmore 'locked notebook'

(2) after Reid (1903)

It appears from the section that the deposit at this point was composed largely of soliflucted material. The present slope of the Fisherton hill-side (Fig. 70) is approximately 1 in 17, amply sufficient for solifluxion, and it is possible that it might originally have been steeper. Beds 2,3 6 and 7 and 9 of Fig. (71) seem to be either soliflucted material and/or coombe rock, differing in composition with the relative amounts of chalk, gravels and clays available, and probably with the climate at the time of formation of the deposit. The white 'brickearth' of Bed 4 is presumably a leached horizon, and the 'red clay and gravel' underneath it represents the illuviation zone of the same deposit. The 'brickearth' must therefore have been subjected to a considerable period of weathering, and was then capped by the solifluxion deposits of Beds 2 and 3, which were probably formed under severe climatic conditions.

Section 2.

This section was drawn by Reid (1903) on the basis of data in Prestwich (1855). The section is taken at 'Hardings brickyard', where the deposit is supposed to attain maximum thickness. Again there appears to be a capping of soliflucted material (Beds 1 and 2) over the brickearth, to the considerable maximum depth of nearly 3m. The 'brickearth' depth here exceeded 5-6m., and is underlain by the 'light-coloured marl' already mentioned. The basal deposits of Bed 5 again appear to be coombe rock. Reid mentions the extensive faunal and molluscan remains, stating that the latter are much more numerous in the marl than in the brickearth. It is possible that this marl might be a chalk meltwater deposit.

Conclusion from the sections

Swanson (1970, p. 59), discusses the 'brickearths' of the New Forest in considerable detail, and casts doubt on the previously accepted theory that many of them are of aolian origin. He finds only three locations where the 'brickearths' can be considered as weathered loesses. In the case of Fisherton the great depth of the deposit, and its height above sea level, indicate that aolian origin is most likely, as does the position of the deposit in the lee side of a hill. Whatever the origin it has obviously been heavily weathered in situ, and the greater thickness downslope may be accounted for by simple topography. It seems worth noting that, if the deposit was indeed a weathered loess, the rate of loess accumulation is not rapid, only 2.4 cm per 1000 years according to McBurney (1971). Other hypotheses, including the one of fluviatile origin favoured by early writers, or the possibility of the deposit being a fluvioglacial spring meltwater deposit, cannot really be discussed without examination of an actual section. Should the deposit be of primarily loessic nature it seems likely to have been deposited under cool, rather than temperate conditions. The extensive weathering that it appears to have undergone would have needed temperate conditions, but the capping of solifluxion deposits and coombe rock indicate at least one cold period after the deposition of the 'brickearth'.

Implements

Only two implements were recorded from this 'brickearth', neither of which can at present be traced. Evans (Fig. 72) illustrates one specimen, a bout coupé with a very flat cross-section, finely worked, probably with a soft hammer. This drawing is reproduced (enlarged) in Fig. (72). The tool is described as being in a sharp condition, with marks of use on one edge, and having a white 'porcellaneous' lustre. Evans records another, identical implement from the same location, although the second tool was apparently in too fragmentary a condition to survive. The figured specimen was found in association with bones of mammoth (Mammuthus primigenius B.) The fragmentary condition of the second specimen, probably due to frost, and the white lustre of the first lend support to the hypothesis that the 'brickearth' in which they were found was formed under cold conditions. The association between these two bout coupé handaxes and the plentiful faunal remains about to be described, is vital to the chronology of the

Wessex area. The only other location within 100 miles where this occurs is the assemblage from the Hyaena Den (Somerset). Since the bout coupé form was apparently manufactured only during a comparatively short period of time during the ~~Middle/Late~~ Upper Pleistocene it should thus be possible to postulate a date for the deposit both on typological and faunal grounds.

The fauna

Extensive faunal remains listed in Table (46), have been recovered from the 'brickearth'. Lyell (1826) states that although the bones are very decomposed they do not appear to be rolled, and that they occur only in the 'brickearth' and not in the surrounding gravel. Blackmore (in the 'locked notebook'), who was responsible for most of the finds, notes that the bones were found at various levels in the deposit, but that they were most abundant a few feet from its base, especially on the hillsides. The bones seem generally to have been much broken, although the state of preservation seems to vary from species to species, and this is likely to be a function of the lengthbof time that the bones were exposed to the air, before incorporation into the deposit. The lowest 'brickearths' seem to have produced few mammalian remains, but included mammoth, horse and rhinoceros, whilst the higher deposits (for example the section at Hardings pit, where the brickearth was 30' deep) yielded plentiful horse, ox and deer, but little elephant or rhinoceros (Evans 1894).

Remarks on the fauna

Souslik (C. Citellus erythrogenoides)

This small rodent, originally described by Evans (1894) as 'about the size of a squirrel', was found in large numbers in the 'brickearths'. An original estimate of at least 13 individuals, many with teeth still remaining in the sockets, was later increased to over 50. The 'locked notebook' of Dr. Blackmore states that 'at one point in the brickearths of Fisherton the teeth and bones of the pouched marmot (= souslik) occur in great abundance. In some instances the entire skeleton has been discovered with

Table (46) Fauna from the 'brickearths' at Fisherton (compiled from Blackmore 1896, Cunnington 1858, and the 'locked notebook' Modern terminology from Kurtén, (1968).

Common name	Species name	Original identification	Notes
CARNIVORA			
Cave hyaena	C.Crocuta G.	Hyaena spelea	last molar
Cave lion	F.Leo spelea G.	Felis spelea	canine
Wolf	Canis lupus L.	Canis lupus	
Fox	Vulpes vulpes L.	Canis vulpes	2 frags & impressions.
PROBOSCIDEA			
Mammoth	Mammuthus primigenius B.	Elephas primigenius	? complete skeleton
PERISSODACTYLA			
Woolly rhinoceros	Coelodonta antiquitatis B.	Rhinoceros tichorinus	
Horse	Equus sp.	Equus(caballus,fossilis & plicidens)	
Wild ass	E.hydruntinus R.	Asinus fossilis	
ARTIODACTYLA			
Pig	Sus scrofa L.	Sus scrofa	calcis frag of young animal.
Red deer	Cervus elaphus L.	Cervus elaphus	
Reindeer	Rangifer tarandus B.	Cervus tarandus	
Musk ox	Ovibos moschatus L.	Ovibus moschatus	
Steppe wisent	Bison priscus Bo.	Bison priscus	
Bison	Bison minor L.	Bison minor	
Aurochs	Bos primigenius L.	Bos primigenius	
LAGOMORPHA			
Varying hare	Lepus timidus L.	Lepus timidus	
RODENTIA			
Souslik	C.Citellus erythrogenoides	Spermophilus superciliosus	
Vole	Arvicola terrestris/amphibius	Arvicola ratticeps & agrestis	
Lemming	Lemmus lemmus	Lemmus norwegicus	
Arctic lemming	Dicrostonyx torquatus	Lemmus groenlandicus	
AVES			
Goose	Anser palustris	Anser palustris	
Duck	Anas boschas	Anas boschas	bone with fox teeth impressions.

the bones articulated and undisturbed, showing that the little animals had perished while rolled up in the usual attitude of hibernation'. The species was originally identified by Falconer, from Mendip fossils in the Williams collection, as Spermophilus erythrogenoides, and by Professor Kamp as S.superciliosus (Blackmore 1867). The souslik is a small burrowing animal, not found in Britain today, but common in certain types of Pleistocene deposits.

Lemming

Two distinct species of lemming are recorded, both of which were again found in large numbers. The presence of lemming in a deposit is generally indicative of severe climatic conditions, especially when the bones of a small colony, still in the natural position, leave no doubt of the fact that they are contemporary with the deposit.

Cave hyaena (Crocuta spelaea).

It is rare, but not unknown, to find this species in open air deposits.

Canis

The wolf (Canis lupus) has great climatic tolerance, and can live in virtually any environment from tundra to semi-desert. The fox (V. vulpes) is not so tolerant, since it is not found on actual tundra, but prefers forest or steppe environments. It is possible that the arctic fox (Alopex lagopus) was mis-identified here.

Horse

Several distinct species of horse have been recorded but it is almost impossible to correlate them with modern terminology. Kurtén (1968) considers that few of these distinctions will turn out to be valid. The occurrence of horse in the Ipswichian interglacial is rare, except at the extreme beginning and end. It is absent from the climatic optimum.

Bovids

Bison priscus prefers open ground and woodland, but may be associated with a steppe environment. Bos primigenius prefers grassland and open woodland, but the musk ox (Ovibos moschatus) is well adjusted for arctic tundra, and is often found in faunas dominated by reindeer.

Deer

There are additional contradictions in other species of Artiodactyla. The reindeer (R.tarandus) has no environmental preference for a severe climate, making seasonal migrations between tundra and forest, whilst the red deer (Cervus elaphus) lives in temperate forest.

Both the mammoth (M. primigenius) and the woolly rhinoceros (Coelodonta antiquitatis) will thrive in severe arctic tundra, and Lyell (1826) says that 'at one point there is reason to believe that the entire skeleton of an elephant might have been preserved'. This must have been mammoth since it is the only elephant species recorded. The pig or boar (Sus scrofa) is common in temperate forest assemblages, or those from interglacials. The record of wild ass (Asinus fossilis) is probably a species of horse (E. hydruntinus) which has donkey-like teeth. The presence of the varying hare (Lepus timidus) is again indicative of boreal or arctic tundra. Since no numbers are given it is impossible to estimate the relative proportions of the different species, but the assemblage appears to be dominated by steppe-tundra species, adapted for severe conditions, with an admixture of temperate woodland animals. From the remarks quoted previously (p.144) it seems that there was some stratification, with a 'cold' fauna at the top of the hill, and a warm fauna at the bottom. It is impossible to say whether the fauna was mixed or contaminated, although this does not seem likely.

Molluscan assemblages

The molluscan species (listed in Table 47), fall into three groups, land, marsh and freshwater, although there are some species which can live in combination of the two. The mollusca were recovered both from the marl, underlying the 'brickearth', as well as from the 'brickearth' itself.

Almost all the land species could occur in marshes, although this would not be their usual habitat. Pupilla, although today a xerophile, was a marsh species during the colder phases of the Pleistocene (J. Evans, 1972, personal communication). The fauna is therefore a mixed one, combining species from several habitats, ultimately laid down in fresh water (Evans 1972) and the land element indicates damp, marshy conditions in a generally open landscape.

Molluscan climate and chronology.

This fauna is of a type generally associated with interstadial climatic conditions. Many species, for example, 3,4,5,8,10,12,13,19,20,22,23,26 on Table (47) are characteristic of the late Weichselian/Devensian in Britain, as at Cherhill and Beckhampton (Evans 1965). A second group (2,16,6,11) are not found in the late Devensian, but occur in earlier interstadials, and, even more likely, at the end of the Ipswichian/Eemian interglacial, extending into the cool Pinus zone (h-i) (Sparks 1964, Evans in Wainwright 1972).

(The writer is indebted to Dr. J. Evans for his invaluable help and remarks on the morphology and environmental preferences of the mollusca).

General Chronology of the deposits

The environment of deposition of the deposits is questionable. Some indications would suggest that it is likely to have been a weathered loess, and others, notably the molluscan fauna, suggest fluviatile conditions. In both sections the 'brickearths' are capped by solifluxion deposits and coombe rock, indicating at least one period of intense cold after their formation. Should the basal deposits of Section (1) be coombe rock then there was another very cold interglacial episode before the deposition of the brickearth, unless both deposits belong to the same phase, which is possible. The maximum depth of 'brickearth' recorded here is 30' (10 m) McBurney (1972) notes that the loess deposits of La Cotte (see p.172) accumulated at a rate of some 24 cm. per 1000 years, to a total depth of

Table (47) Mollusca from Fisherton
(Compiled from Evans 18~~64~~69, Prestwich and Brown 1855. Modern terminology from Ellis 1951.)

Original name	Correct name	Environmental preference
1 Acme/Acicula lineata	Acicula fusca (Montagu)	Land
2 ? C. tridentatum	Carychium minimum (Müller)	Land
3 Zua lubrica	Cochliopa lubrica (Müller)	Land
Zua subcylindrica	" " "	Land
4 Pupa muscorum/marginata	Pupilla muscorum (Linné)	Land
5 Helix arbustorum	Arianta arbustorum (Linné)	Land
6 Helix nemoralis	Cepea nemoralis (Linné)	Land
7 Helix rufescens	Hygromia striolata (Pfeiffer)	Land
Helicella sp.	" "	
8 Helix hispida	Hygromia hispida (Linné)	Land
9 Helix hispida var. concinna	Hygromia hispida va. concinna (Jeffreys)	Land
10 Helix pygmaea	Punctum pygmaeum (Drapernaud)	Land
11 Zonites rotundatus	Discus rotundatus (Müller)	Land
12 Helix ~~fluva~~ fulva	Euconolus fulvus (Müller)	Land
Zonites ~~fluvus~~ fulvus	" "	Land
13 Helix radiatulus	Retinella radiatulus (Alder)	Land
Zonites radiatulus	" "	Land
14 Helix pulchella	Vallonia pulchella (Müller)	Marsh/land
15 Limax agrestis	Agriolimax agrestis (Linné)	Marsh/land
16 Catinella arenaria	Succinia oblonga (Drapernaud) ?	Marsh
17 Succinia putris	Succinia putris (Linné)	Marsh
18 Succinia elegans/gracilis	Succinia sarsi (Esmark)	Marsh
19 Lymnaeus trunulata	Lymnaea trunculata (Müller) X	Fresh water/ marsh
20 Lymnaea palustris	Lymnaea palustris (Müller)	"
21 Planorbis spirorbis	Planorbis leucostoma (Millet)	"
22 Pisidium fontinale	Pisidium casertanum (Poli)	"
23 Pisidium obtusale	Pisidium obtusale (Lamark)	"
24 Valvata piscinalis	Valvata piscinalis (Müller)	Freshwater
25 Bithynia tentactulata	Bithynia tentaculata (Linné)	"
26 Lymnaeus pereger	Lymnaea peregra (Müller)	"
Limnea limosa	" "	"
27 Planorbis carinatus	Planorbis carinatus (Müller)	"
28 Ancylastrum fluviatile	Ancylus fluviatilis (Müller)	"
29 Pisidium amnicium	Pisidium amnicium (Müller)	"
30 ? Pisidium pusillum	Pisidium nitidum (Jenyns)	"
31 Pisidium pulchellum (Pisidium pulchellus)	Pisidium pulchellum ([illegible])	"

12m. These figures agree very well with those obtained from excavations at Molodova, in the Ukraine (Russia) where the excavator calculated a deposition rate of 23cm/1000 years. Both these sets of figures have been obtained by calibration with C 14 and Pa/Th dates. Should the Fisherton 'brickearths' be weathered loesses then their great depth is by no means unique, and it is possible that they may have accumulated over a considerable time, since McBurney estimates that the period of active loess formation during the Wurm might have lasted 50-60,000 years. This might also account for the apparent change in the fauna.

The occurrence of both steppe and tundra forms of mammalia seems at first to be contradictory, but it is possible that such a mixture might occur at the extreme end or the very beginning of an interglacial, particularly the last (Ipswichian/Eemian) interglacial. The molluscan evidence suggests that the site belongs in the cool Pinus (h-i) zone of the Ipswichian, which would be in excellent agreement with the faunal evidence. The occurrence of a 'cold' fauna at the base of the deposits, and then a warm fauna at the top is not incompatible with this hypothesis, since the hillslope conditions makes such a stratigraphic condition impossible to explain without the help of extant sections. It is possible that we might have a mixed environment, or reversed stratigraphy, or that the 'warm' fauna survived into the early ~~Weichselian~~ Devensian, to be deposited during a period of slight temperature amelioration. There is evidence to suggest that the bout coupé handaxes were contemporary within the fauna, and since these forms are confined to a narrow period of time, a date for the deposits at the extreme end of the Ipswichian transition to ~~Weichselian~~ Devensian would be in perfect agreement with the fact that so many bout coupé handaxes are stratified within the late Ipswichian raised beach deposits. It is worth noting in passing that the 'terminus post quem' for the exposure of the raised beach at Stone (p. 130) is Zone f of the Ipswichian, which again would give excellent agreement. The presence of evidence for at least one period of cold climate after the deposition of the 'brickearths' again supports the

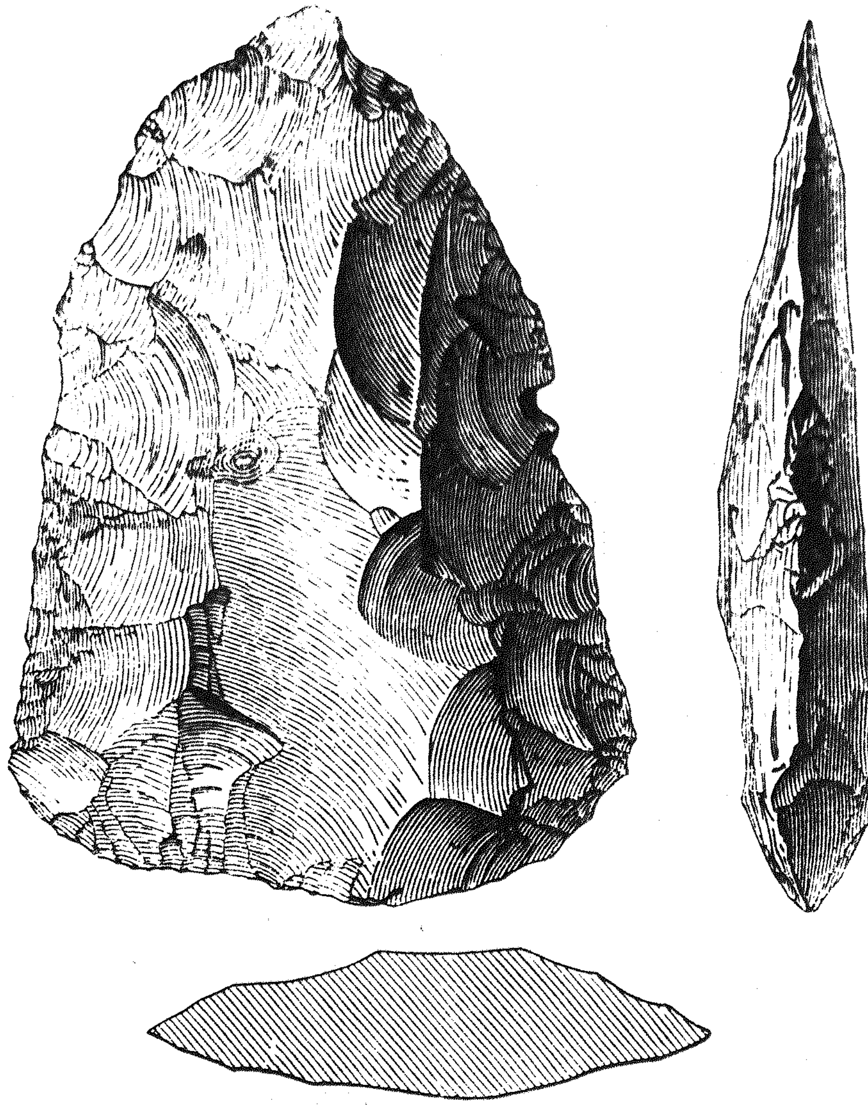


Fig. 471.—Fisherton. $\frac{1}{2}$

Fig. (72) Bout coupé handaxe from Fisherton. Original length c. 12 cm. From Evans (1897, p. 630, Fig. 471).

hypothesis, but a categorical statement cannot be made without examination of the deposits, should an exposure be revealed at a later date.

4.22 The Basingstoke 'surface finds'

Introduction

The Basingstoke area of N. Hampshire is remarkable for a series of surface finds of Lower and Middle Palaeolithic material, in association with clay-with-flints. These were found as the result of detailed field work by Messrs. Ellaway, Rainbow and Willis, earlier in this century. (Ellaway and Willis 1922, Willis 1946). The total of implement finds probably exceeds several thousand, and they occur in concentrations of variable size, widely scattered over the area. This concentration is, however, more a reflection of the careful field-work of the searchers, and their area of operation, rather than of any archaeological factors. The 'sites' marked on the map seldom consist only of implements of one particular period, and frequently tools from Lower Palaeolithic to late Bronze age in type may be found in association.

The area is featured in this survey since at least one site, Holybourne, shows a concentration of Mousterian and Levallois material, in conditions that suggest this is more than a random accumulation.

Clay-with-flints

The high chalk downlands of the Hampshire Basin are frequently covered by this irregular patchy deposit, which was described by Willis (1946) as a 'variable and puzzling formation', the origin of which has never been successfully established. It consists of a stiff brown clay, containing variable amounts of flint, which are frequently covered with a thick white patina. It is unstratified, and appears to attain its maximum thickness at the greatest elevations. The boundaries of the deposit are indefinite, and the geological maps very inaccurate in this respect. The clays are often associated with thin spreads of deep reddish-brown gravel, heavily frost-fractured. Many of the early Geological Survey memoirs describe

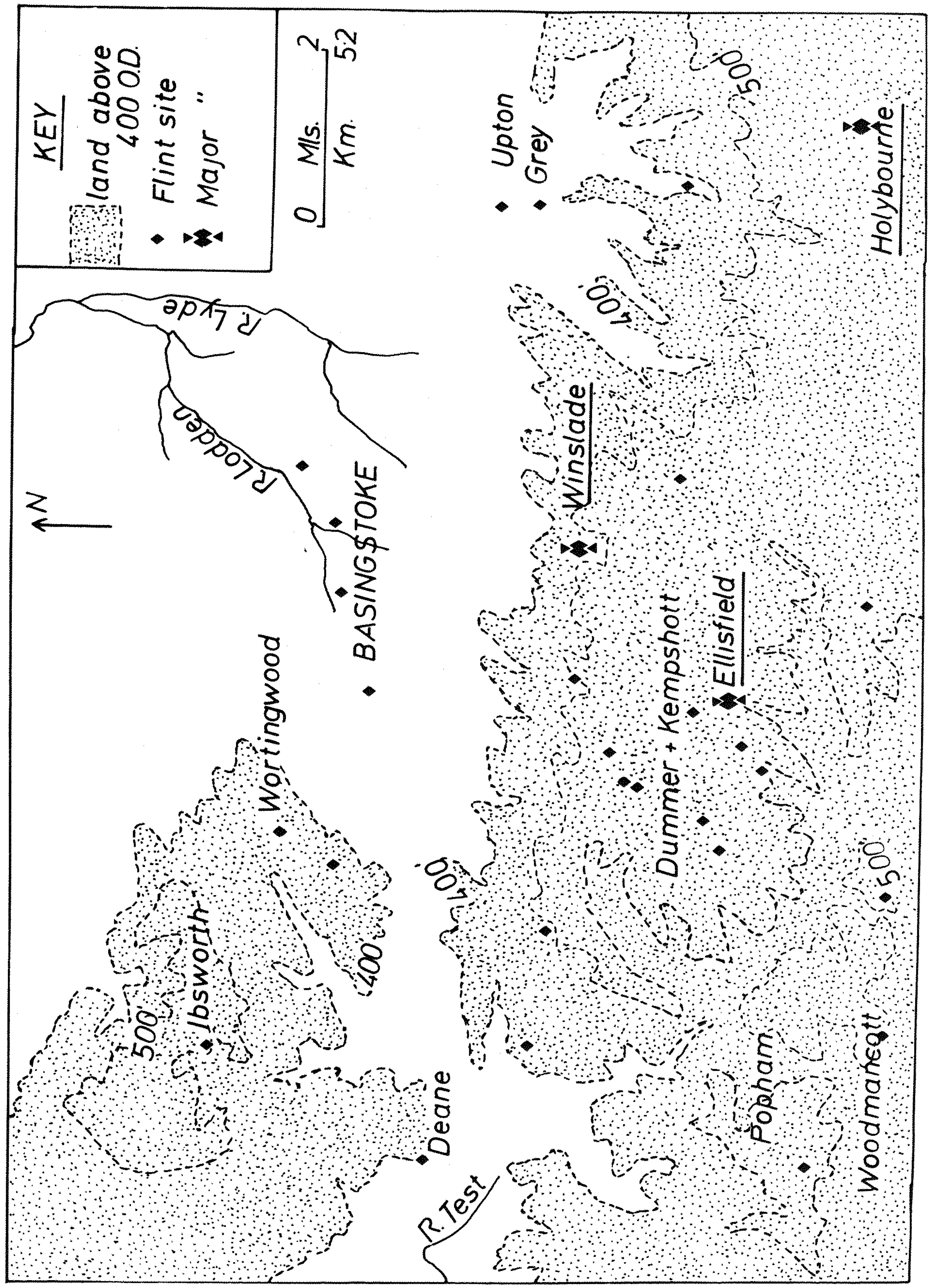


Fig. (73) Topography of the Basingstoke area with location of find spots.

this deposit (for example Reid, 1903) and attempt to explain its origin. Bury (1910), notes that it is frequently associated with the Pliocene peneplains at 700-900'OD., while Wooldridge and Linton (19) believe it to be a sub-aerial deposit which accumulated, at least in part, during a prolonged period of weathering. Small (1972) notes its extreme complexity, and comments on the fact that it appears to contain material of different ages. He agrees with the general verdict that it was formally much more extensive, and that it has been much dissected by the formation of later Quaternary river valleys. Kellaway (1971 p. 31) suggests that this extensive dissection took place during the 'Anglian' (Lowestoftian) glaciation, possibly as a direct result of fluviglacial processes. However Green (1973) has demonstrated that there is no evidence for the presence of an ice sheet in this area, although this does not preclude the possibility that the dissection did take place during this period, as the result of periglacial, not fluviglacial, processes. If this is the case then the prolonged period of weathering suggested by Wooldridge and Linton must date to at least as early as the 'Cromerian', and to have taken place under a climatic regime that does not appear to have been repeated later in the Pleistocene. The deposit was much modified by cryoturbation and solifluxion at a later date, and material from it is included in the 'Plateau' and 'Valley' gravels.

The Basingstoke area

The chalk downland approximately 8-10 miles to the east, west and south of Basingstoke (see Fig.73), varies from 3-700'O.D., and has a high concentration of clay-with-flints (see Fig.74). The area lies at the extreme edge of the chalk anticline, where it dips under the soft Tertiary rocks of the London basin to the north. The chalk formation present is the soft Upper Chalk, which contains a high percentage of flint and is easily weathered. No clay-with-flints occurs on the Tertiaries, although they are partially covered with plateau and valley gravel and brickearth. This

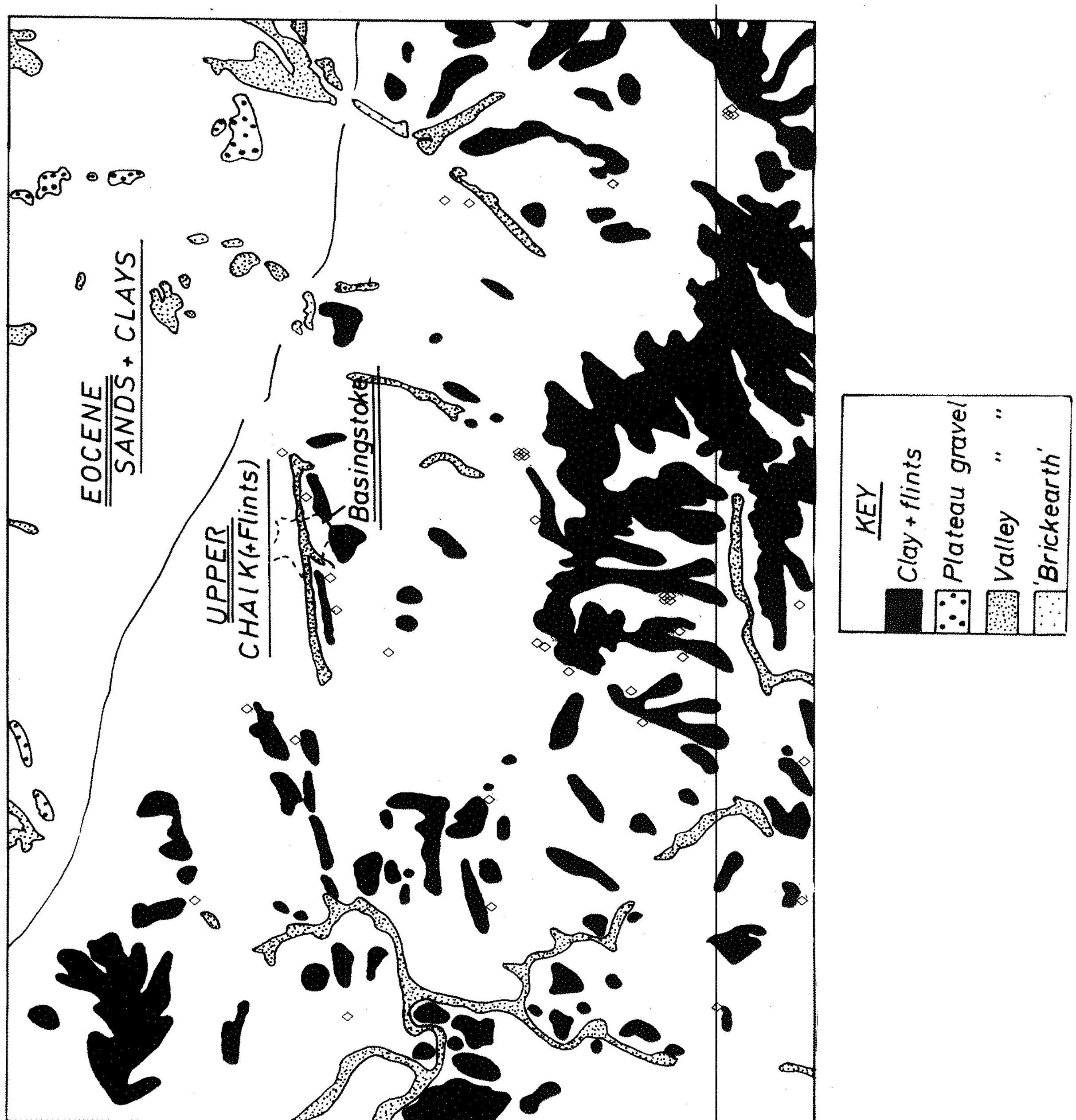


Fig. (74) Drift deposits of the Basingstoke area, find spots marked as white lozenges.

distribution lends support to the theory that the clay-with-flints is a chalk weathering product.

Implements

The majority of the implements bear no signs of water rolling, but are very heavily weathered. The weathering patina is in some cases so heavy that it has completely penetrated the tool, not leaving the usual grey core in the centre and resulting in an implement of harsh granular texture (Willis 1946 p. 255), often with a white 'chalky' appearance, and extensive frost-cracks. Table (48) presents a summary of the approximate amounts of material recovered from each site, but it is probably inaccurate. The first section is compiled from information kept in the files of the Hampshire County Museum at Winchester, where the majority of the collections are now lodged, together with notes and papers left by the original workers. Roe (1968) endeavoured to isolate the Palaeolithic material from this mass, and his results are shown in the second half of the table. The frequent discrepancies between the two are due to the admixture of Neolithic, Mesolithic and later material in the original records.

There are five major concentrations of Palaeolithic material, Holybourne, Dummer, Ellisfield, Winslade and Worting, but the material included under these headings is not necessarily derived from one location, but is generally a composite total accumulated from stray surface finds in that locality. Only at Holybourne is there evidence to suggest the presence of a true 'site'. A pilot study was therefore undertaken on Holybourne, and two of the other major sites, to see whether a full detailed study of all the material was likely to yield any significant archaeological results.

Holybourne (and Yarnhams) SU 208960

The location of this site is marked on Fig. (73), and can be seen to occur at over 700'O.D., at the edge of the clay-with-flints. Roe (1968) lists about 24 handaxes and at least 50 flakes from this area, and the earlier Museum catalogue 'at least 75 implements (including handaxes) and

Table (48) Surface finds from the Basingstoke area

Catalogue in County Museum, Winchester | Roe (1968)

Site Name	Grid Ref.	'O.D.	Implements	Handaxes Total	roughouts	cores	Flakes ret.	unret.	odds	cores	Levallois flakes
Winslade (+Swallick and White Hill)	SU 638478	600'	'89 + flakes'	37+	1+	3+	10+	13+	-	-	-
Holybourne(+Yarnhams)	SU 208960	730'	'73 + flakes'	24	-	-	50		-	-	-
Ellisfield (total)	SU 628457	600'	'20 + flakes and core'	8	1	3	14	94	4	1	-
Dummer (total) (= D. +Kempshott)	SU 588460	660'	17	9	1	1	3	3	-	1	-
Worting (total)	SU 605518	430'	11	12	-	-	10	61	2	1	3
Bidden Water	Not located	?420'	8	-	-	-	-	-	-	-	-
Budds Hill	"	420'	2	-	-	-	-	-	-	-	-
Woodmancote	SU 570430	420'	7	1	-	-	-	-	-	-	-
Audwell	Not located	?	5	-	-	-	-	-	-	-	-
Broadley	"	?	5	-	-	-	-	-	-	-	-
Popham (total)	SU 556439	590'	5	-	-	2	18	19	-	-	-
Deane (total)	SU 567489	460'	4	8	-	-	3	1	-	-	-
Ford Farm	Not located	?	4	-	-	-	-	-	-	-	-
Southam	"	?	4	-	-	-	-	-	-	-	-
Willocks hill	"	300'	3	-	-	-	-	-	-	-	-
Bottledown	"	?	2	-	-	-	-	-	-	-	-
Burley Lane, Ashe	"	?	2	-	-	-	-	-	-	-	-
Farleigh Wallop	SU 623468	600'	1	-	-	-	5+	8+	1	-	-
Hannington	?	660'	2	-	-	-	-	-	-	-	-
Humbly Grove(2nd site)	?	?	1 core 1 'side scraper of Mousterian type	-	-	-	-	-	-	-	-
Humbly Grove	?	410'	3-4 flakes	-	-	-	-	-	-	-	-

flakes'. By no means all of this material is readily available, there is no modern catalogue and no precise find-spots are recorded. Roe (1968) considered that the group from Holybourne may just be classed as an assemblage and states '....only at Holybourne could a group of handaxes suitable for metrical analysis be obtained, it is small, but just worth using'. He notes the fact that the material was more localised than any of the other sites, but was not concerned with the flake material, except for a passing reference to the presence of handaxe trimming flakes, which he considered as additional evidence for the presence of an assemblage.

The material from this site is all very heavily weathered, some of the handaxes being virtually unclassifiable for this reason. A small sample was examined, the composition of which is shown below.

Table (49)

Type No.	Description	No. examined
9	Single convex racloir	2
123	Retouched flakes	2
122	Unretouched flakes	1
1-2	Levallois flakes	1
(varied)	Handaxes	13
162	Bout coupé handaxe	1
		20 (total)

The handaxes were generally of a refined Acheulean type, and included a perfectly typical bout coupé, in mint condition, together with other Mousterian forms such as two single convex racloirs. Roe (1968) has described the material in detail. The degree of weathering varied, even in this small sample, and superficial examination of the rest of the material showed that this was always the case. The Mousterian axes and flakes were much less heavily weathered than some of the other axes, and Roe presumably chose these for his measurements. The group cannot be

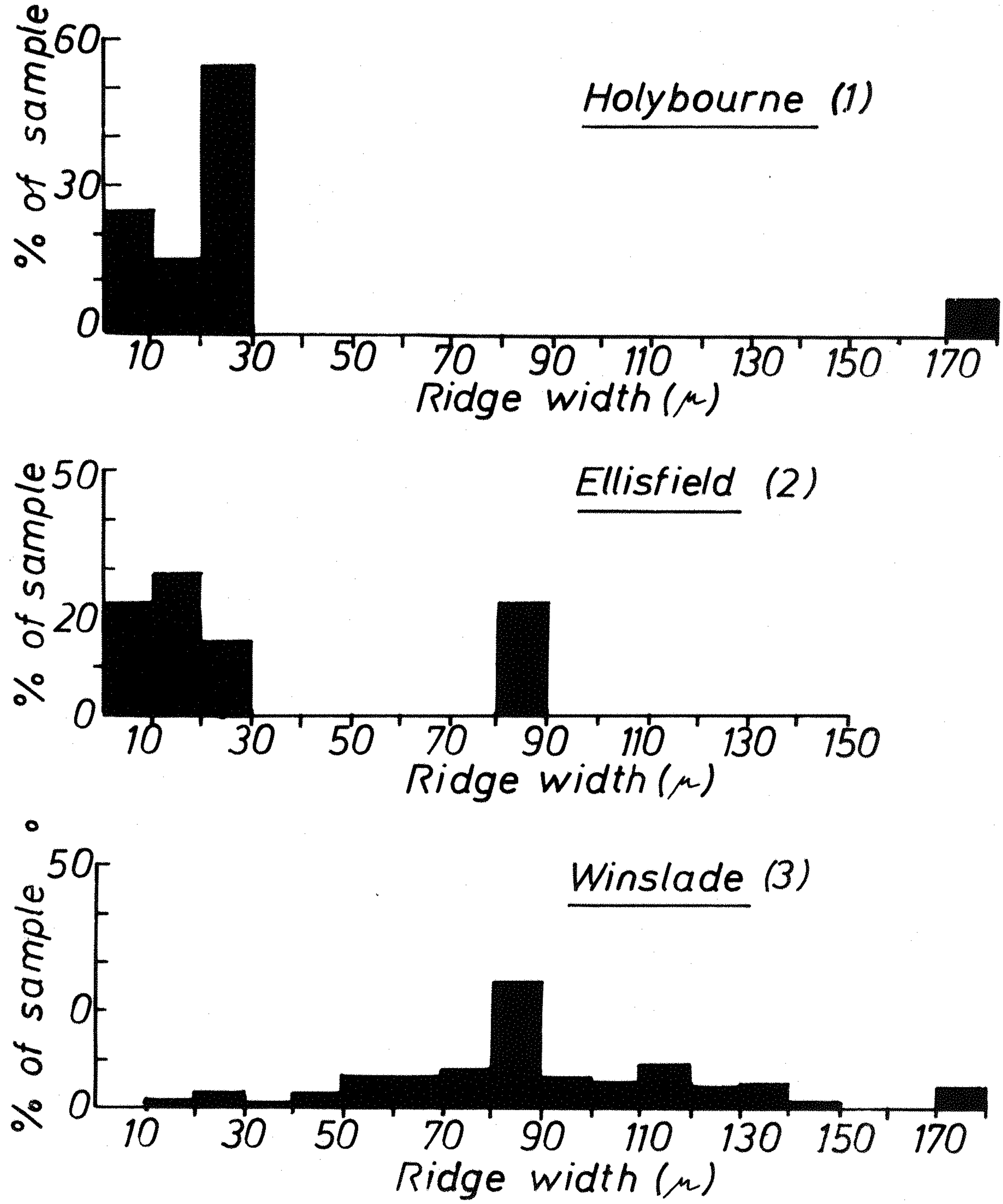


Fig. (75) Histograms of ridge widths for implements from three Basingstoke sites.

considered as uncontaminated. The abrasion index of the above-listed artifacts was measured, although in this case it was measuring the degree of weathering, rather than the degree of stream rolling. The mean ridge width was found to be 28.4µm, with a standard deviation of 40.5, due to the marked bimodality which is shown clearly in the histogram (Fig.76). Further statistical work on such a small sample is quite invalid, but this serves to illustrate the point that the sample is far from being unified.

Roe measured 19 of the handaxes, and considered that they fell into his Group 6 (the 'more pointed' variety of his Ovate Tradition). This is the same group to which the Mousterian of Acheulean Tradition industries of Great Pan Farm and Oldbury were assigned, both of which also contain the bout coupé form. All the sites included in this group are considered as late in the Acheulean, or Mousterian.

This evidence suggests that the Holybourne site does indeed represent a collection of material that is typologically related, but it is difficult to see how a precise assemblage could be defined, as this would involve a subjective selection of the less weathered material. Many of the Mousterian forms present here recur in the industries associated with the 7.5m raised beach (see p.56), and the location of this site is not dissimilar to that of Bleak Down, on the Isle of Wight, where a similar concentration of material was observed. Both sites plausibly represent a ~~baief~~ brief visit to the hilltops by hunters, probably in the early Devensian (Weichselian).

Ellisfield

A sample of material from this site was examined for purposes of comparison. The evidence for the existence of a true 'site' is even more tenuous than at Holybourne, and the material more heavily weathered. The group examined included handaxes of every facies from early Acheulean to Mousterian, none having any trace of rolling. The site occurs at 600' O.D., again on the edge of the clay-with-flints.

Table (50)

Type No.	Description	No. examined
10	Single convex racloir	2
31	end scraper	1
123	retouched flake	1
1-2	Levallois blade/flake	3
119	tortoise core	1
(varied)	Handaxes	8
122	unretouched flakes	41
124	waste flakes	4
		61 (total)

Some of the weathered handaxes could have been of any type, and the shapes seem to be variable. Patination varied from deep chalky white to dark reddish brown. The Levallois and Mousterian material was again the least heavily weathered, which gives a bimodal abrasion measurement similar to Holybourne. The mean ridge width was 36.4µm, with a standard deviation of 29.6. The implements were found scattered over a wide area, and there is no evidence for the presence of an assemblage.

Winslade (SU 638478)

This location, at about the same altitude as Ellisfield, is reputed to have yielded an even higher concentration of material, but scattered over a very wide area.

The pilot sample examined was more heavily weathered than either of the previous sites, and included material of every conceivable type, patination and condition. The flakes, of all kinds, tended to have the typical chalky white patina, whilst the handaxes were frequently heavily iron-stained and had often nearly disintegrated from the effect of frost. Mean ridge width was much greater than at the other sites, at 81.7µm (standard deviation 44.0) and this broad spectrum of results can be seen on the histogram (Fig. 76). There is no evidence to suppose that this is anything more than a random accumulation of material.

Table (51)

Type No.	Description	No. examined
9	Single straight racloir	1
1-2	Levallois flakes/blades	9
123	retouched flakes	1
122	unretouched flakes	88
124	trimming flakes	1
(varied)	handaxes	15
		115 (total)

Conclusions

The material recorded from this area consists of a series of random accumulations of artifacts, which tend to occur in concentrations at the edges of the clay-with-flints, and which are presumably derived from it by weathering. The contents of these concentrations are unrelated typologically, and differ widely in their degree of weathering. Examples of material from the minor sites support these generalisations, and the artifacts from Ellisfield and Winslade are so mixed as to be archaeologically useless. The 'sites' seem to be the result of the random inclusion of humanly-worked material into the clay-with-flints, and the equally random weathering-out of this material.

The presence of fresher Mousterian and Levallois material in some of the concentrations is interesting, and at Holybourne there is evidence to suggest that this may constitute an assemblage. None of the sites have any evidence for working floors. It can therefore be concluded that the statement made by Roe (1968) that Holybourne deserves the status of a archaeological site can be tentatively supported by an examination of the weathering of the artifacts, but that precise definition of an assemblage is likely to be subjective. None of the other sites are likely to yield any archaeological information of value.

4.23 Bleak Down (Isle of Wight) SZ 512817

Introduction

The geology and implement finds from this site have been described by Poole (1932), in the only published reference. The site consists of a gravel-capped spur of Lower Greensand, at an altitude of 278' O.D. (160' above the height of the River Yar), see Fig. (76). The gravel is mapped as 'plateau gravel' by the Geological survey, and was worked extensively by hand in the 1920's, leading to the finding of a large number of implements.

The deposits

No extant section of the gravel survives, and comments upon the stratigraphy must therefore be based on published material. Poole (1932) divides the gravel into two main spreads, the northern lower one being derived presumably mainly by solifluxion from the higher southern one. He refers to these as the 'Higher' and 'Lower' terraces.

Higher Terrace

Fig. (76) from Poole (1932,p.31 diag.3), presents his opinion of the structure of this deposit. It seems to consist of a core of 'earlier' gravels, now extensively denuded, containing 'Chellean' and 'St. Acheul 1' handaxes, often worn and patinated. The gravel is based on Lower Greensand, and is interleaved with beds of sand and clay. The deposit of this gravel ('A') is followed by a further gravel ('B'), containing the same sort of implements, but with the addition of 'St. Acheul II' material, a fine, unworn ovate of which is illustrated by Poole (Poole 1932 plate 3 Fig. 12). The next deposits, described as 'pockets of a pale gray clay', is formed in hollows in the initial gravel ('A'), which may be up to 50' in length. It seems possible that these represent the filling of meltwater hollows, formed

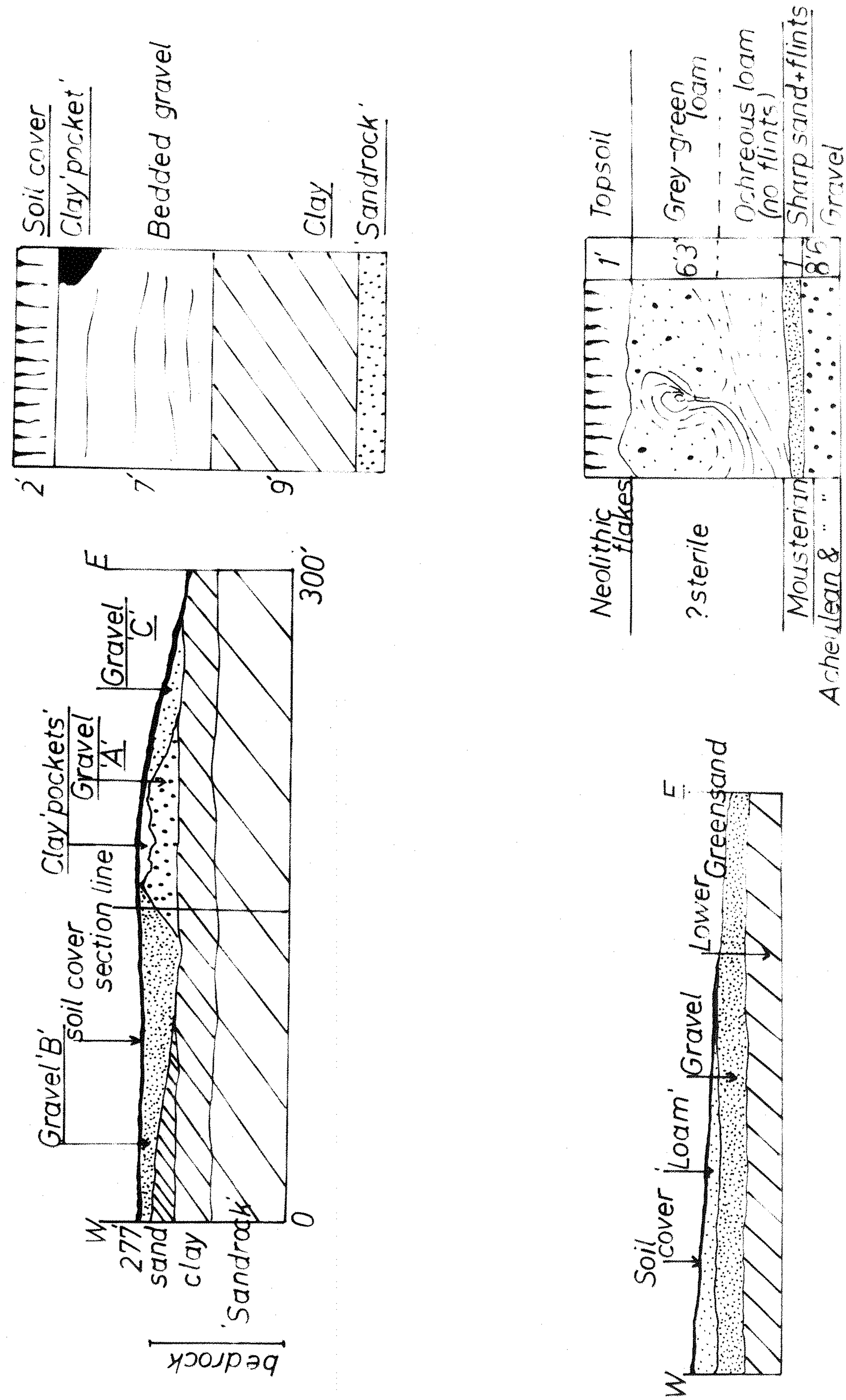


Fig. (76) Terrace structure and deposits at Bleak Down, after Poole (1932)

(1) Sections of the 'Higher' terrace, after Poole (1932, p. 31)

(2) Sections of the 'Lower' terrace, after Poole (1932, p. 37)

under severe climatic conditions, since their filling is stated to be fine-grained, although variable in colour and composition. They contained the remains of an unworn Mousterian industry. The final deposit of the area is another gravel ('C'), which seems from the description to be a composite bed composed of soliflucted material derived from all the previous deposits, including the clay pockets.

Without a section little stratigraphic information of value can be gained from this description. Several periods of gravel deposition and human presence are certainly indicated, but the environment of deposition of the gravel is unknown. The presence of Middle Palaeolithic material in a deposit that seems likely to have formed under severe, perhaps periglacial, conditions is interesting, and this must certainly have been succeeded by another period of cold climate, to form the solifluxion gravel ('C').

Lower Gravels

Fig. (76) shows Poole's section and diagram of his 'Lower Terrace' (from Poole 1932 p. 37) which has a base level at 236' O.D. These gravels seem mainly to have been soliflucted from the upper terrace, and consisted generally of an amorphous mass of sands and gravel, except at the base where Poole mentions some current bedding. The presence of large cobbles up to 20" x 12" is interesting. Implements occurred at all levels in the gravel, mixed 'St. Acheuel I and II, and Le Moustier'. This mixture is again indicative of a solifluction deposit, and it is interesting to note that the composition of these 'Lower terrace gravels' is probably very similar to that of the solifluxion gravel ('C') of the upper terrace, and possibly of similar date. The section of these lower gravels (Fig. 76) has several notable features. The gravel appears to be covered by a 'brickearth', of unknown composition, which overlies a sandy deposit containing Mousterian tools. It is unfortunate that the loose usage of the term 'brickearth' negates the possibility of using it as a factor of diagnostic of environment, but the high altitude makes it possible, indeed probable, that it would have a large aolian component. Should this be so it would again indicate severe conditions. There is a definite cryoturbation feature within these brickearths, and a separation into a topmost 'gray-green loam', indicative of extensive weathering, and a basal ochreous zone with flints. The exposed situation would favour leaching and other soil-forming processes in such deposits.

Implements

The gravel workings on this site, described above, have yielded a considerable number of implements, and Roe (1968) records a total of 84 artifacts from the various deposits. This includes 75 handaxes, mainly from locations described as 'Cotton's pit' and 'Vectis Stone Co. pit', now untraceable. Poole (1932) figures a fine series of Mousterian artifacts, and comments on their patination, abrasion and exact location. However the other implements, mostly housed in the Carisbrooke Castle Museum and very varied in type and other features are generally labelled 'gravel ('A'), ('B'), or ('C'), and seldom exactly located, which renders them virtually useless. There is, however, a very great range of types, varying from the earliest Acheulian to advanced soft-hammered late Acheulean material. The Mousterian series occurs in the clay pockets in the gravel ('A'), and in the deposits immediately succeeding them.

Mousterian implements

The writer has examined the material from this site, and considers, in agreement with Poole, that some 13 of the implements (all precisely located) constitute an assemblage, and are related both typologically and stratigraphically. There are also similarities in patination and manufacturing technique. The assemblage is noted in Table (15), and its contents analysed in Table (52). It can be seen that of the 12 tools 8 are axes, 2 are retouched flake tools of Mousterian type, and 1 is a tortoise core. No bout coupe axes are present, although this might have been expected, and the implements tend to be of a pointed ovate rather than a cordiform.

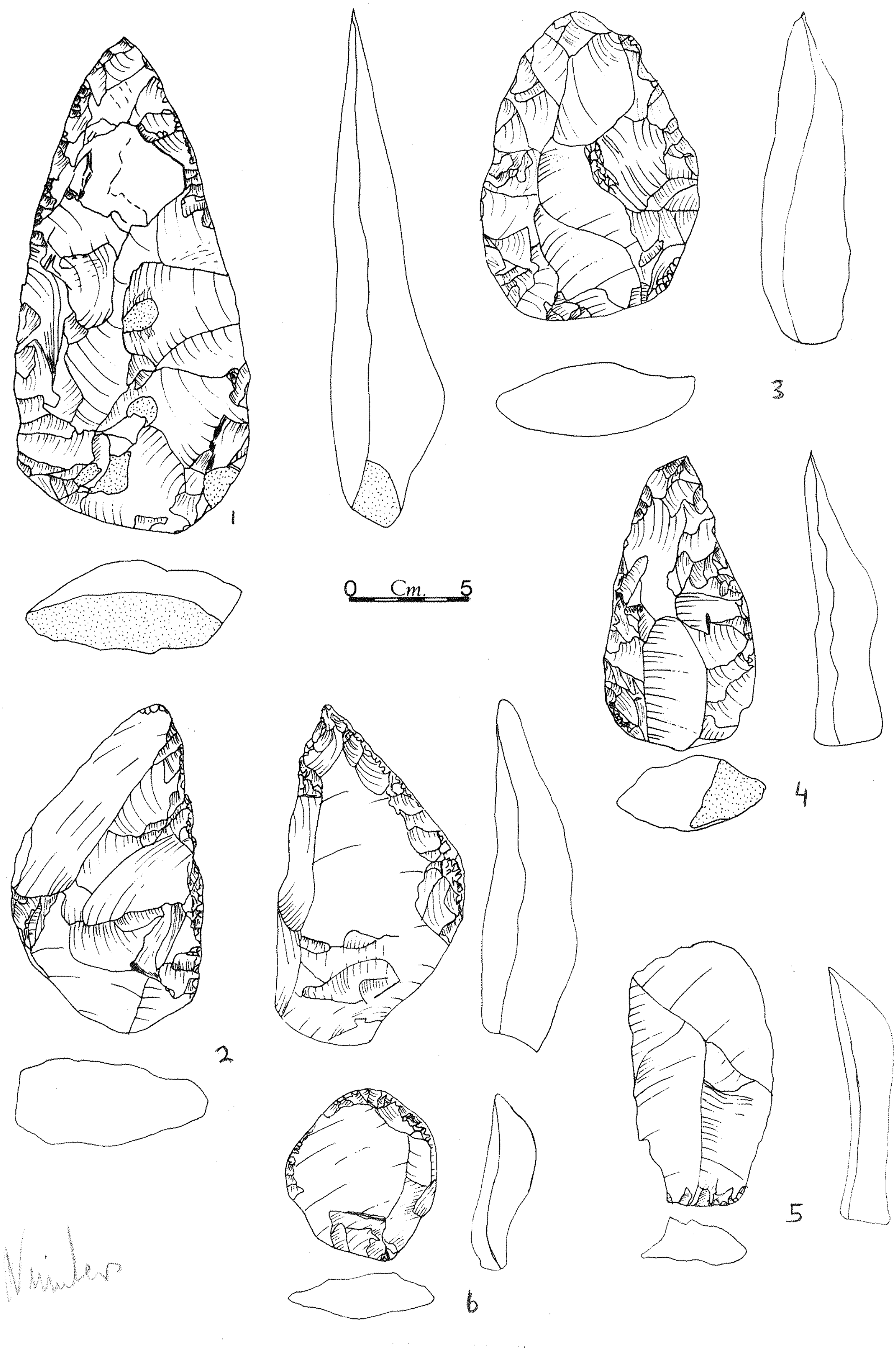


Fig. (77) Mousterian implements from Bleak Down, including handaxes (1 and 4), a Faustkeilblatter (2), a Levallois flake (5) and a single convex racloir (6).

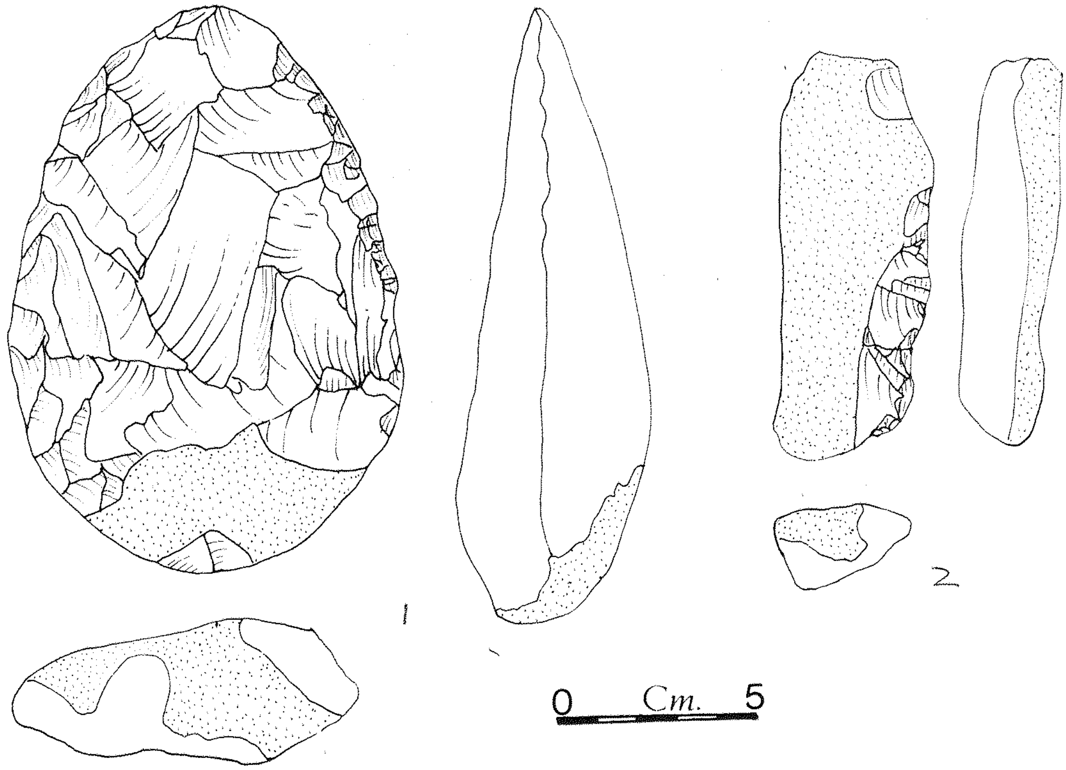


Fig. (78) Mousterian implements from Bleak Down, including an ovate handaxe (7) and a single straight racloir (8).

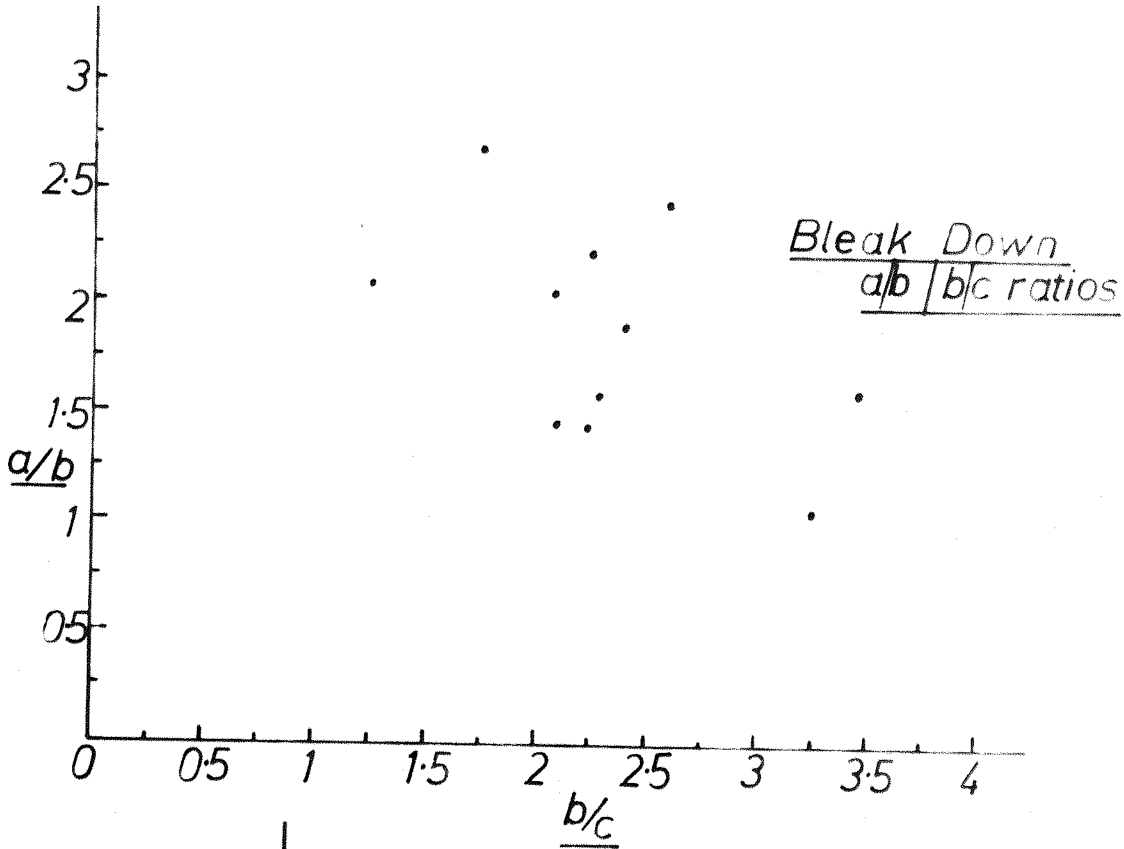
shape. Some of the implements show signs of frost action, and the formation of a weathering layer (as at Holybourne, p.153), but the largest implements, for example Fig. (77) Nos. 1+2, are in mint condition with an abrasion index value of 0, indicating that they are probably contemporary with the deposit in which they were found. The variation in index value of the other members of the assemblage is attributable to weathering, not to transport. The presence of a tortoise core, Levallois flakes and Mousterian implements associated with pointed handaxes is rather irregular, but occurs at the Mousterian of Acheulean Tradition site of La Cotte de St. Brelade (see p. 64), indeed the fine lanceolate handaxe (Fig. 79 no. 1) and the 'Faustkeilblatter' (Fig. 79 No. 3), may be exactly paralleled at La Cotte.

Fig. (79) shows scatter diagrams of the measured parameters of the tools, plotting the axial ratios (a/b and b/c) against each other, and then weight against degree of abrasion ~~(see p.)~~. Table (52) below, shows a summary of the statistical properties of these measurements, and Table (15) presents a tool-by-tool breakdown.

Table (52) Statistics on implement parameters, Bleak Down

Parameter	Mean	Variance	Standard Deviation	Standard Error of Mean	Skewness	Kurtosis
Abrasion	10.58	27.53	11.293	3.260	1.153	0.030
a/b ratio	1.76	0.28	0.532	1.153	0.230	-1.077
b/c ratio	2.27	0.33	0.578	0.167	0.244	0.462
Weight	309	44590	211.164	60.957	0.588	-0.833

It will be seen from these figures that the implements as a whole tend to be large, and heavy, a useful comparison may be made with the statistics of the Great Pan Farm assemblage (p.109). Abrasion values are extremely variable (for reasons stated above). The sample is far too small for any significant tests of correlation or regression between the parameters,



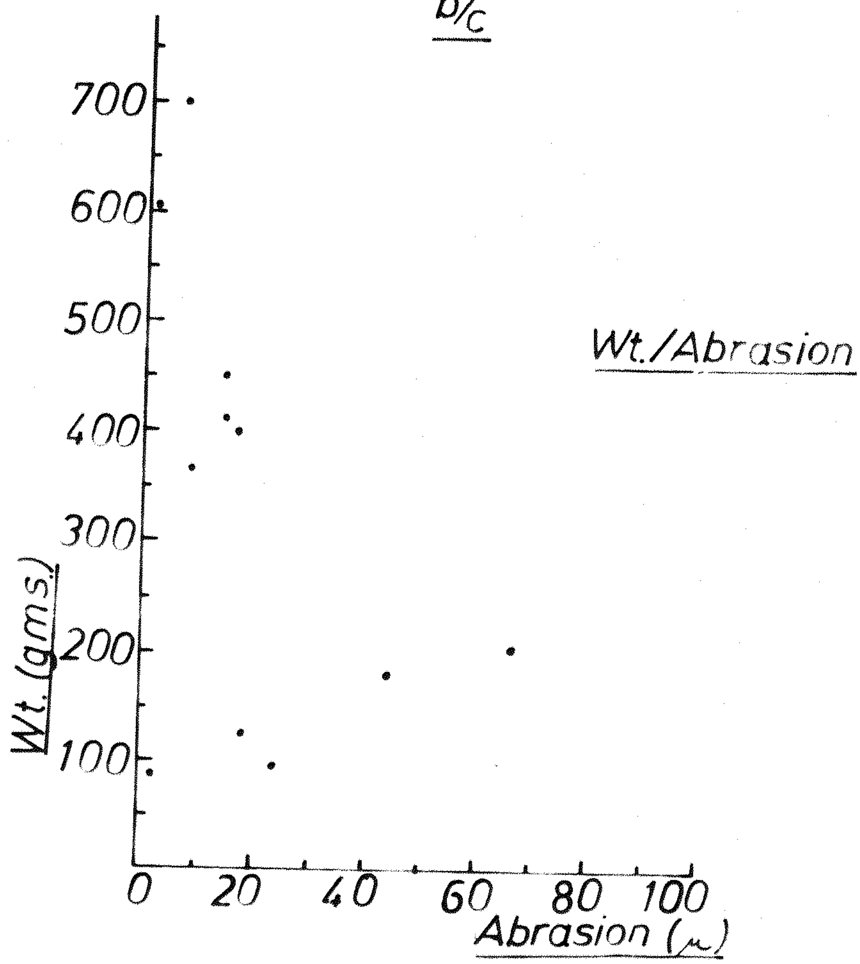


Fig. (79) Scatter diagrams, axial ratios and weight/abrasion plots for implements from Bleak Down.

although an attempt showed a mild negative correlation between a/b and b/c on the diagram (Fig. 79). In non-statistical terms the assemblage can be described as lightly abraded (75% having an Index value of less than 1) and composed of a variety of different implement shapes, with a marked tendency to thickness and heaviness.

Typological affinities

The only other Mousterian site on the Isle of Wight, Great Pan Farm, bears no typological relationship to Bleak Down. These implements are much larger, and totally different in manufacturing technique, and the Great Pan Farm axes tend to be cordate or bout coupé types, with little trace of frost action. If this assemblage from Bleak Down is a true one, then the abrasion measurements are very varied, but the same thing occurs at Holybourne (p. 156). The assemblage possesses some puzzling typological features, and bears no resemblance to any of the 'raised beach' industries. It would be easier to say that it was a false assemblage produced by random accumulation of stray finds, but this is inconsistent with the available stratigraphic evidence. Certainly if the group is accepted as Mousterian, as it should be from the presence of a perfectly typical tortoise core, Levallois flakes and racloirs, and as Mousterian of Acheulean Tradition, from the handaxes, it is very atypical, and possibly reflects cultural contact between Mousterian and Acheulean groups. It is impossible to date the site stratigraphically, since it plausibly represents very temporary occupation of the hilltop, but its situation is very similar to that of Holybourne. The presence of at least one cold period after the deposition of the industry is indicated, and it is therefore unlikely to postdate early Devensian (Weichselian). The occurrence of a typical 'Faustkeilblatter' may suggest cultural overlap in the Final Acheulean/Micoquian/Early M.A.T. horizon at the beginning of the Weichselian, but the assemblage is far too small to be diagnostic.

Section 5. Chronology + conclusions.

5.1.

It is important, when considering the chronology of these southern British site industries, to relate them to other British and Continental sites and assemblages. The Continental Mousterian succession has been the subject of much recent work (Mellars, 1969), which makes it possible to compare the characteristics of the classic French sites with those of the less well documented English examples.

The origins of the Mousterian of Acheulean Tradition are complex and obscure, but Bordes (1973) believes that both the M.A.T. and the Micoquian represent a continuation of the Acheulean during the later Pleistocene. The relationship between the two traditions is uncertain, although they are probably the end of two distinct branches of the Acheulean. Certainly many Acheulean features are to be seen in the Hampshire Mousterian of Acheulean Tradition industries. Mellars (1973, personal communication) emphasised the fact that since relatively little is known about what happened in human terms in pre-Devensian times the possibility of a Wolstonian date for these industries cannot be ruled out on purely typological grounds, although the stratigraphy and fauna make it extremely unlikely. The bout coupé handaxe seems only to have been manufactured during a comparatively short period of time at the end of the Ipswichian and during the early Devensian in Britain, and during late Last Interglacial and early Wurmian times on the Continent. However, roughly cordiform handaxes are known from all phases of the Acheulean, but the precise form and high degree of refinement seen in the bout coupé does not seem to have been achieved at earlier dates. The Levallois technique is not particularly important in British Mousterian of Acheulean Tradition, although it used to be considered the type fossil of the Mousterian complex. It is, however, often important in some of the Late Middle Acheulean industries and is present at Bakers Hole and Northfleet (Thames valley) during the Wolstonian, and at Ebbsfleet, Crayford and Iver (Thames valley) during the Ipswichian (Wymer 1968).

The poverty and crudeness of the British Mousterian of Acheulean Tradition makes it difficult to obtain a reliable date by typological analogy. Collins (1972, personal communication) accepts the British M.A.T. as an entity, commenting on the inadequacy of the assemblages. The M.A.T. industries considered in this study are especially crude, with cross-sections thicker than any implements from the other British or Continental sites. Since this crudeness is shared by all the southern English sites, together with certain other manufacturing characteristics, it suggests the possibility of a distinct culture province. An alternative explanation might be that the sites represent the result of the activities of a group of people over a comparatively short period of time, or over a slightly longer period of time with a marked lack of innovation and great conservatism in tool making traditions. The industries are distinctive and the assemblages discussed above are typologically related to each other, whilst still forming a part of the general north west European Mousterian of Acheulean Tradition group. They are, however, far from being identical to their Continental parallels, This emphasises the importance of the bout coupé handaxe, since it is virtually the only artifact type which is so distinctive that any amount of provinciality is unable to disguise its essential character.

The division of the Mousterian of Acheulean Tradition into the two subgroups (A and B) has already been discussed. On the Continent these two variants seem to have been made at different periods, the earlier (type A) at the beginning of the Wurm, at the base of the Younger loess in France, and the later (Type B) close to the end of the Mousterian period, in the late Wurm 11 (40-30,00 BP), which is the 'classic' M.A.T. phase in Perigord. Bordes considers that this type B always succeeds the Wurm 1/2 (Brørup) interstadial, and that it develops into the Perigordian at about the time of the Wurm 2/3 (Göttweig) interstadial.

Collins (1970) replaces this bipartite division with a single seriation line, envisaging the Mousterian of Acheulean Tradition as starting with the basal loessic site of Le Tillet (Bordes 1954), early in Wurm 1 at 78,000BP, and finishing with La Rochelle (Delporte 1963) much later, at around 40-35,000BP. He defines a 'Paxton' group of M.A.T. in Britain, with bout coupé handaxes, which would include the Hampshire sites together with the 'cafe au lait' series from Le Tillet, and date to very early in the Wurm 1, close to the interglacial boundary. Since Le Tillet is the only Continental site on this seriation line with the bout coupé handaxe this supports the theory that the British M.A.T. sites where this form is plentiful must be of similar date. Both Le Tillet and the southern British sites would predate Oldbury, La Cotte de St. Brelade, Bois du Rocher and Grainfollet, which Collins considers must belong to nearer the middle of the M.A.T. trend line. Mellars (1968) stresses the fact that the early 'open sites' (such as Le Tillet) are typologically very distinct from the later 'classic' Perigordian M.A.T., as well as being separated by a considerable time gap. The bout coupé handaxe is occasionally to be found at these later sites, such as Pech de l'Azé (Bordes 1955), but in a poorly made and atypical form. The southern British M.A.T. sites seem to be related to the earlier (type A) variant of the M.A.T. which provides additional evidence for a date preceding the Wurm 1/2 interstadial.

There are a number of parallels between the southern English sites and the Balve 4 and Karstein groups of the Central European M.A.T. described by Bosinski (1960). The natural backed knives, single convex racloirs and large unretouched Levallois flakes appear in the later, Balve 4, group, thought to date to ' a temperate oscillation at the end of the early Wurm' (Bosinski 1960), although the long blades with irregular patchy retouch and small thick handaxes are more common in the earlier, Karstein, group, probably dating from Wurm 1. The Achenheim 4 sites, typologically between Karstein and Balve 4, also yielded implements which are in many ways similar to the British material, although better refined. In Germany there is a definite cultural overlap between the Micoquian and the early M.A.T., a suggestion which has already been made for southern England (p. 89). These typological parallels seem to support the theory that the southern English industries predate the Wurm 1/2 interstadial.

The presence of the bout coupé handaxe, which is made on the Continent early in the Wurm, the survival of the tradition of making pointed handaxes and the possible admixture of Micoquian forms all tend to suggest that the southern British industries are likely, on typological grounds, to have been made early in the Wurm, preceding the Wurm 1/2 interstadial. Confirmation of this suggestion must now be sought from stratigraphic context and associated faunas.

5.2. Stratigraphic dating of the 7.5m raised beach

The implement assemblages from Warsash and Cams are stratified within the deposits of the 7.5m raised beach, and there are strong reasons for correlating the observed sections at Christchurch and Great Pan Farm with the same transgressive episode. The minor sites of Bleak Down, Holybourne and Fisherton, contain implements typologically related to the littoral industries, although they are in completely different localities, on hill-tops instead of near the sea. It is clearly important to obtain an idea of the chronology of the 7.5m raised beach, to date its included implement assemblages and thus provide a basis for the chronology of the Mousterian of Acheulean Tradition in southern England.

Much evidence exists for dating the formation of the 7.5m raised beach to a period of high sea level during the Ipswichian (Riss/Wurm) interglacial. The beach is found at the cave site of La Cotte de St. Brelade at a height of 8m OD, at a location unlikely to have been disturbed by local tectonic movement, and at numerous other sites on the coasts of north western Europe and the Mediterranean. Zeuner (1959), who made a comprehensive study of the deposits, named the beach the 'Late Monastirian', and considered that it was Ipswichian (Riss/Wurm interglacial) in date.

The beach is dated in other parts of the world to about 100,00-80,000 BP, by Th/U readings, ~~and warm water isotopic 016/018 temperatures~~. Although pessimistic about some of the large scale sea level correlations proposed by Zeuner, West (1971) agreed that the Late Monastirian episode is Ipswichian in date, and that the higher, 35m beach (ApSimon and Shackley, forthcoming) is to be correlated with the Hoxnian interglacial.

The deposits of this same Late Monastirian transgression area also found in Normandy, where the Normannien 2 shingle beach is of this date. This 'Lower Normannien' beach occurs at a height approximately 4-5m above the highest spring tides, and there is also an 'Upper Normannien' beach some 8-3m above it. The brickearth which caps the 7.5m beach at Selsey (England) (West and Sparks 1960) seems to be contemporary with the loess capping the Normannien beach, with the loessic 'heads' of Wurm 1, and with some phrases of the coombe rock in Sussex. At La Cotte de St. Brelade the Late Monastirian beach is capped by Wurmian head, which contained the Mousterian of Acheulean Tradition assemblage. Most workers regard both the Normannien beaches as last interglacial in date, although Guilcher (1974) discussed the case for a penultimate interglacial date for the higher beach. Recently it was suggested that the lower beach belonged to a Wurmian interstadial, but there is no conclusive evidence in Brittany or Normandy to suggest high interstadial sea level during the 40,000 years, and archaeological evidence from other parts of France supports a last interglacial date. Recognition of the same transgressive phase in other parts of the Continent, such as the Netherlands or Germany, is more difficult, since the areas have been downwarped, but there seems to be some evidence for correlation on palynological grounds, (von der Brelei 1954), Sindowski 1958). West and Sparks comment that the central part of the English Channel seems to have been relatively stable during the Ipswichian so that there is no difficulty in correlating the British and Normandy exposures.

West and Sparks (1960) describe occurrences of the 7.5m beach in the Solent area, introducing the important point that most of the localities where the beach has been recognised are not near its former shore line, which is to be found at Black Rock, Brighton. Smith (1936) recorded a maximum elevation of 38' OD for the top of the shingle of the beach at this site, and 29.5' OD for its base. West considers that the maximum height of wave action during the formation of the beach was probably 40'OD, about 4' above the high spring tide level. This gives a mean sea level for the beach of 25' (7.5m) OD, which is in agreement with the figures arrived at by Zeuner (1959). The idea has been put forward by Everard (1954) that the reduced 'fetch' in the Solent may have been responsible for marine resorting of gravels moved down by solifluction into a pseudo raised beach which may account for some of the anomalies noted in the composition of the beach gravels at Warsash. The varied tidal conditions and the fact that the same portion of the raised beach is not exposed at every site also accounts for minor discrepancies in height.

During the first half of the Ipswichian, in the mixed-oak zone, brackish water indications in the flora at Ilford (West et al 1964) suggest that the sea had reached a maximum of roughly 4m above OD at that date. The rock platforms and cliffs described by Charlesworth (1957, p. 1251), and the possible tidal laminations at Little Thurrock and Purfleet (Hollin 1974) are a result of this transgression. By the middle of the interglacial, deposits at 1m at Trafalgar Square (Franks 1960) suggest that the sea had fallen away from its early maximum, but in the second half of the interglacial aggredation occurred in the Thames estuary to about +5m at West Thurrock and +8m at Aveley. This aggredation is probably related to the raised beach deposits occurring at 7.5m OD in the south of England, including those described in this study. Hodgson (1964) argues against the 17m sea level being represented in the area and Hollin (1974) considers that the March gravels (Baden Powell 1934) and the 17m beach of Portland and

Bembridge (Arkell 1947), form part of the same trangression. This is as yet unconfirmed by archaeological evidence.

On the eastern seaboard of North America, especially in Bermuda and south Carolina, there is a series of deposits which have been attributed to a last interglacial still-stand of +16m, which may have occurred late in the period (Hollin 1972). However it is conceivable that this may be of much earlier date, perhaps Hoxnian or even intra Wolstonian. It is therefore possible that the sea may have risen to above the height indicated by the 7.5m beach in the last interglacial, possibly achieving a height of 17m towards the extreme end of the episode. However if this is so it is perhaps surprising that fragments of the 17m beach are not more common. Hodgson (1964) could find no trace of such deposits in Sussex, in an area where the 7.5m beach is well exposed, and if the 17m transgression were to postdate the 7.5m sea level rise it is difficult to explain why the earlier deposits were not severely denuded. Little archaeological material can be traced from the 17m beach, and that surviving includes Acheulean handaxes.

It is clear, therefore, that there are ample grounds for assigning the formation of the 7.5m raised beach to the last (Ipswichian) interglacial. Evidence points to this transgression as having been rather late in the interglacial, although a sea level of nearly the same height may have already been reached near the beginning, the sea subsequently falling again. It is difficult to determine the exact relationship of the 7.5m and 17m transgressions, as opinion is divided not only on whether the latter level is actually a distinct phase, but also on whether it belongs to the penultimate or final interglacial. West and Sparks (1960) discuss palynological evidence associated with the 7.5m transgression, and it seems difficult to envisage a higher sea level succeeding the Late Monastirian one. The capping materials of head and other solifluxion deposits, attributable to Wurm (Devensian) 1 make it most unlikely that the 7.5m beach could have been formed after the Ipswichian.

5.3. Dating of the Mousterian of Acheulean Tradition Industries from their faunal associations

Examination of the general correlation table (Table 16) will show that the faunas definitely associated with the M.A.T. industries in Britain have a number of points in common. Those from Kents Cavern and Oldbury are both alike, as are the faunas recovered from Fisherton and Oldbury. The occurrence of Arvicola at La Cotte de St. Brelade is interesting, as it is found in the Middle Pleistocene (~~Wolstonian~~) faunas of Greys and Ilford in the Thames valley, which are associated with Levallois industries of Ipswichian date, and it then disappears from the faunal record until the Ightham horizon (Marr 1916).

Mellars (1971) notes that the faunas associated with the typical M.A.T. horizons of Perigord consist of bovids or red deer, but at La Cotte reindeer is as important as auroch, and the indications are of very cold conditions. This is supported by a consideration of the position of the La Cotte cave, and the fact that it would only be accessible to man and to the larger mammals at periods when sea level was substantially lower than at the present time.

The other M.A.T. faunas are also generally cold in type, but with a sufficient admixture of more thermophilous animals to enable a mixed, steppe tundra with woodland type of environment to be postulated, rather than a strictly arctic biotype which would be associated with a full glacial period. It would be true to say that both Kents Cavern and Oldbury have faunas which could fit into an environment at the transition between glacial and interglacial conditions, evidence from the first site pointing to a date seen after the beginning of the Wurm, and from the latter to a date connected with the Wurm 1/2 (Brørup) interstadial.

The fauna from Fisherton (p.145) is complex, and it is interesting to note that the mollusca indicate the type of conditions present at the extreme end of the Ipswichian, extending into the cold Pinus zone (h–i) (Evans 1972).

The mammalian fauna principally consists of animals adapted to cool tundra but includes some 'steppe' forms. A date at the end of the Ipswichian for Fisherton would be in excellent agreement with the Ipswichian date postulated for the industries associated with the 7.5m beach. Kents Cavern and the Hyaena Den seem to have been occupied during the Wurm 1, not actually at the glacial maximum, which would accord well with the evidence of the implements. It seems reasonable to postulate a later date for Oldbury, probably related to the Wurm 1/2 interglacial interstadial, the M.A.T. industry from that site being later in the seriation trend of Collins (1970) than the assemblages from the 7.5m beach.

5.4 General Chronology and Conclusion

The inclusion of the Mousterian of Acheulean Tradition industries within deposits stratigraphically dated to the late Ipswichian indicates that the M.A.T. tradition in Britain began earlier than was generally supposed. Fig. (18) illustrates the markedly littoral distribution of the sites, which is paralleled to a lesser extent on the Continent. The occurrence of typologically related material away from the coast may indicate that the makers of the industry had a hunting range extending into upland areas, the limits of which are marked by the distribution of stray bout coupé axes. It would, however, be unreasonable to place too great an emphasis on this littoral distribution, since the chances of an industry surviving within the deposits of a raised beach are considerably greater than if the same industry had been scattered on the downlands, which have been subjected to almost continuous ploughing for the last four thousand years.

At La Cotte de St. Brelade (Jersey) the Mousterian of Acheulan Tradition must post date the Ipswichian, since the industry is stratified above the deposits of the 7.5m beach, within 'head' dating to Wurm 1. There appears to have been a cultural hiatus on the island between the Acheulean industries of Rissian times and the Mousterian of the Wurm, probably attributable to the higher sea levels of the Ipswichian. The re-occupation of the island during a period of low sea level during the Wurm would mean that the Mousterian of Acheulean Tradition industry of La Cotte is later in date than those mainland industries associated with the 7.5m beach. It is interesting to note that the La Cotte M.A.T. is the only British Mousterian assemblage actually associated with the remains of Homo sapiens neanderthalensis (McBurney 1971). Zeuner (1959) states that there is evidence of a low sea level (to -70mOD) during Wurm 1, and to -30mOD in Wurm 3. The Wurm 2 period does not, however, seem to have been so cold, so that by the eustatic theory the amount of water locked up in the ice caps would not have been so great, and the fall in sea level correspondingly less intense. Sea level seems likely to have fallen gradually at the beginning of Wurm 1, and it would have been possible for man to have crossed to England, or to the Channel Islands, at this period. The Mousterian of Acheulean Tradition assemblages of Kents Cavern and La Cotte are probably a result of this movement. However the sites associated with the bout coupé axe (Collins 'Paxton' group, including the 7.5m beach industries) are Ipswichian in date, although it is difficult to see how their makers could have reached Britain during the interglacial. Several hypotheses could be contrived to account for the association between the Mousterian of Acheulean Tradition industries with the bout coupé axe and the 7.5m (Ipswichian beach).

(a) That there was a land bridge between Britain and the Continent at the time of the formation of the 7.5m beach.

(b) That the 7.5m beach post dates the Wurm 1 low sea level.

(c) That the raised beach Mousterian of Acheulean Tradition industries are not truly stratified within the beach, but come from on top of it and possibly postdate its formation.

(d) That there was a period of low sea level during the Ipswichian which had the effect of temporarily exposing part of the Continental shelf and enabling hunters to cross over to Britain.

(e) That the M.A.T. variant present in the 7.5m beach is an 'in situ' development of the Acheulean, and unrelated to the Continental M.A.T.

(f) That the makers of the M.A.T. industry had boats.

There is certainly no evidence for the presence of a land bridge between Britain the Continent at the time of the formation of the beach, which is found at both sides of the English Channel. The dimensions of the Channel in Ipswichian times were similar to those which it reached during the post glacial. Nor is there any evidence to suggest that the makers of the industry might have had seaworthy boats, but this is always a remote possibility.

Several authorities (p.168) have refuted the suggestion that the 7.5m beach was formed during the Wurm 1/2 interstadial. The 3m beach, Zeuner's 'Epi-Monastirian' is manifestly younger than the period of solifluxion which followed the deposition of the 7.5m (Late Monastirian) beach at Gibraltar, and was presumably formed during the high sea level of the Wurm 1/2 interstadial. This 3m sea level was, however, attained again during the post-glacial.

No evidence exists to support the contention that the M.A.T. industries are not truly stratified within the 7.5m beach. As far as the writer is aware there are no Mousterian artifacts reliably associated with the deposits of 'brickearth' and 'head' which cap the beach on the mainland, although they certainly occur on Jersey. Every indication from reliable authorities (e.g. Evans 1872) and from personal finds supports the inclusion of the artifacts <u>within</u> the beach deposits. Much of the material is very fresh and it is therefore unlikely that it was incorporated at the earliest stages of the beach formation, since this would have caused heavy marine abrasion. It is possible that the implements were dropped on the beach during the latest stages of its formation, perhaps even after the sea level had begun to recede, but there is no stratigraphic evidence to support this. Certainly the low degree of abrasion seen on the artifacts indicates that they received little rolling whilst actually contained in the matrix deposits.

It is quite possible, and indeed likely, that there were several brief cold periods within the Ipswichian interglacial, and one at least is definitely recorded with an age of about 89,000 BP in the Camp Century Greenland ice core (Johnsen et al 1972). There is tentative evidence for this cold period from the filling of the Alveston bone fissure (Gloucestershire), where a brief period of scree formation might date from this time (Taylor and Shackley 1973, Appendix). Since the 7.5m beach is elsewhere dated to 80,000 BP (Emeliani 1964) it is possible that the makers of the industry could have crossed to Britain during this brief cold period. This same episode could have been responsible for the low level deposits at the Trafalgar Square site, and it certainly seems to have preceded the sea level rise leading to the deposition of the 7.5m beach (Hollin 1974).

The industries stratified within the beach, and those typologically associated with them are thus likely to represent a development of the tool making traditions brought to Britain by hunters coming from the Continent during this period. This would account both for the atypical nature of the assemblages and the presence of Micoquian and Final Acheulean forms, since it is reasonable to suppose that southern England already supported a small population of hunters still using the earlier tool forms. This cultural overlap has already been suggested for some of the north European sites. The relationships between the British assemblages and their Continental equivalents are close enough to dismiss the hypothesis that the British material could represent an 'in situ' development of the Late Acheulean.

The earlier variety of M.A.T., with the bout coupé handaxe, ceased being made in France at some time during the Wurm. The Mousterian industries included in the first weathering horizons of the loess (Younger loess 1/2, corresponding to Wurm 1/2 interstadial) appear to be a poor variety of Typical Mousterian. They never include bout coupé handaxes, and handaxes of any form are rare and poorly made. It is therefore unlikely that the British Mousterian of Acheulean Tradition could postdate the Wurm 1/2 of of the first Devensian interstadial.

Bordes (1959) suggested that during the periods of loess deposition the areas were unlikely to be heavily inhabited. It is interesting to note that the implement assemblages from the loess sequence come principally from the extreme base (as at Le Tillet) where the climate would have been milder, or from the weathering horizons. Britain and north France could not have been occupied intensively during Wurm 1 (Mellars 1971) although the Mousterian industry stratified within 'head' deposits at La Cotte indicate at least the sporadic presence of hunting groups.

During the Wurm 1 the handaxe making Mousterian tradition survives to the south, rather than the north, of the classic Perigordian area, in the Iberian Peninsula and western Africa. The tradition re-emerges in southern France in Wurm 2, which was warmer but climatically unstable. The faunas associated with the British Mousterian of Acheulean Tradition do not indicate full glacial conditions, and frequently have a strong 'steppe' component. This suggests that they come from just before, or just after, the maximum cold.

Collins (1970) considers that the site of Oldbury is late in the British Mousterian of Acheulean Tradition, probably near the first Devensian interstadial (Wurm 1/2). This would account for the mixture of biotypes observed in the fauna, which include some forest-dwelling mammals. The faunas of Kents Cavern and the Hyaena Den seem to belong to the beginning of the Devensian, suggesting that these sites are earlier than Oldbury, but later than the 7.5m beach assemblages. The scatter of bout coupé axes and isolated sites seems to date to early Devensian times, before the first interstadial (Wurm 1/2). Since the bout coupé axe is found in the 7.5m beach industries the stray finds seem more likely to have been made towards the beginning of the Devensian rather than the ehd. It has already been suggested that the site of Fisherton, which includes bout coupé axes, dates to the extreme end of the Ipswichian or the very beginning of the Devensian, which indicates that the makers of the coastal Mousterian of Acheulean Tradition industries were already hunting some distance away from the coast. It seems likely that the Mousterian of Acheulean Tradition industries of southern England may have been made over a cultural period of quite long duration, lasting from the end of the Ipswichian until the first Devensian interstadial (Wurm 1/2). The Mousterian of Acheulean Tradition industries associated with the 7.5m beach form the first group of a culture tradition which represents a development of the final Acheulean. The makers of this industry probably first arrived in Britain during a period of low sea level during the Ipswichian, and either survived or sporadically returned during the early part of the succeeding Devensian glaciation.

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