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PROCEDURE AND FORM IN A LOWER PALAEOLITHIC INDUSTRY : STONEWORKING AT KILOMBE, KENYA

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Human culture has developed gradually from primitive beginnings, but this does not mean that archaeological evidence from early times should be designated as crude without appropriate examination of the evidence. With millions of years of cultural hindsight, we may tend to see cultural evidence as more simple than it truly is. Most of the early industries in Europe which belong to the Acheulean tend to reinforce the 'simple' image, for the use of flint nodules as raw material stresses the concept of core-tools, and in the past at least, conditions of recovery haven often minimised the importance of flakes and flake tools. In Africa, the occurrence of raw materials such as lavas in the form of boulders and cobbles encouraged other methods of working, including the systematic detaching of large flakes to make bifaces (Goodwin, 1929; Isaac, 1969), and certain sites allow the relationships between procedure and form to be studied in detail. The site of Kilombe is offered as an example in this paper, to show that pattern and process were sophisticated as much as a million years ago.

MENTAL ABILITIES IN STONEWORKING

It can be argued that an essential part of culture is the 'imposition of arbitrary form' (Holloway, 1969). This implies both *process* (related events extended through time) and the *creation of particular shapes*. Thus, as recent technological studies stress (e.g. Cahen & Karlin, 1980; Roche, 1980), we see even in the simplest industries, operational chains. These are strings of individual planned actions, with the caracteristic that each is subordinated to an ultimate goal, but that each step is also evaluated individually with reference to the results already achieved, and those desired. This requires the brain to integrate information from various events and hypothetical events separated in time, and in this process visual imaging seems indispensable. Craik (1943) was among the first to stress the simulating powers of the brain which allow complex human activities of this nature. Some authors have used ordinary computer-type algorithms to simulate the output of stone industries (e.g. Johnson 1978). Useful as these are, the elementary 'yes/no' switching involved means that only a fraction of the decisions occurring can be represented, and these with great simplification. Such models do not encompass the visual imaging (embracing internal representation of both data and procedure) characteristic of the stoneworking process. Some recent artificial intelligence studies do, however, approach the nature of stone-working decisions much more closely (for example, the procedural representations in Sacerdoti (1977). Since stone tool-making is one of the first carefully controlled processes which can be studied, and the process can be broken down into individual 'strikes', stone tool studies may form a good testing ground for artificial intelligence approaches, provided that adequate documentation can be assembled.

The word 'template' is used in this study (cf. Deetz, 1967). This is a short-hand for specifying internal representation of any precise information about external form to be imposed. I recognise that the word 'template' sounds too hard or solid, and that procedure and form are not tryly separable, but these terms are all useful as working concepts.

THE KILOMBE SITES

Kilombe is an Acheulean site complex (Bishop, 1978; Gowlett, 1978, 1980) believed to be over 700,000 years old on the basis of the reversed magnetisation of the sediments (Dagley *et al.*, 1978). This dating is consistent with the evidence of pig teeth among the fragmentary faunal remains, which suggest an age in the range 0.4 - 1.0 Myr (J.M. Harris, pers. comm.). The archaeological sites lie on the western flank of the Rift Valley, 30 km north-west of Nakuru in Kenya. The material from the sites has general similarities with Olorgesailie, about 150 km further south (Isaac, 1977), and also with sites in Olduvai Bed IV (Leakey, 1975).

Few Lower Pleistocene sites are extensive enough to allow the study of large samples from different points within a single horizon. At the Kilombe Main Site (GqJh 1), artefacts are stratified in tuffs and palaeosols, but the vast majority belong to a single extensive horizon, which can be followed along a front of more than 200 metres.

PROCEDURAL TEMPLATE

As the Main Horizon at Kilombe covers an area which may amount to 14,000 sq. m, and by weight the material is made up largely of bifaces and cobbles, which are distributed at a density of up to 40 kg/10 sq. m, the site provides a basis for looking at a very large output, and assessing patterns and process. The first point is that in most of the area, a consistent pattern is maintained, in which bifaces are predominant, accounting for c. 58 - 64 % of the shaped tools. Cores, including the large cores necessary for the production of biface blanks, are very rare at Kilombe, so it is apparent that not all the stages of artefact manufacture are present. The site thus provides evidence on a massive scale of 'ruptured process', with a hiatus for transport intervening between geographically separated stages of manufacture (fig. 1). At Kilombe the transport distances may have been relatively short, since most of the artefacts are made of a phonolite lava which occurs locally. This compares with the situation at La Kamoa, where evidence suggests transport for about 1.5 km (Cahen 1975), but as at Olorgesailie and Olduvai, some artefacts were transported much further, probably more than 10 km (cf. Isaac, 1977; Leakey, 1971).

There is sufficient uniformity on the Kilombe Main Horizon to show that the artefact makers were guided by routines, or set plans. In consequence, generalised diagrams can be made of the processes determining the production of an Acheulean industry. These procedural diagrams are in effect 'time maps' for some workings of early human minds (figs. 1 & 2). The procedural template of fig. 2, composed to fit Kilombe, would seem to fit most East African Acheulean industries, but there are certainly variations from site to site.

As represented here, the output is that of conventional typological classes such as 'chopper' or 'discoid' (cf. Leakey, 1971 : 4, 6). We do not know that these are true 'types', but there is no doubt that the typological list does reflect a structured field of variation. As similar fields of variation occur regularly on many sites, there was evidently careful control, regardless of our present day labelling.

MORPHOLOGICAL TEMPLATES

Morphological studies of large samples of artefacts by metrical techniques can tell us how successfully form was imposed. It is sometimes suggested that there is no 'mental template' of form, but that 'function' is the key factor. Function is a strong constraint, but it is always possible to use different tools to do the same job. Even though the form of a class of tools may be determined by function, it is difficult to argue that this particular form is rediscovered by experience in the case of each individual artefact.

The examples from Kilombe given here relate only to the bifaces, though other artefacts also exhibit intriguing design regularities.

1. CORRELATIONS

The very high correlations between basic dimensions (Length, Breadth, Thickness) are remarkably similar for different parts of the site (table I). These alone suffice to show the sophistication of the industry, for there are many thousands of bifaces at Kilombe, and it is reasonable to assume that they were made by numbers of individuals. Although modern knappers can reproduce bifaces, the problem of getting two individuals to produce series with the same proportions - or high dimensional correlations - has

Sample	Specimens	Breadth/length Ratio			Thickness/Breadth Ratio			Correlations	
		Mean		s.d.	Mean		s.d.	B & L	T & B
EH	105	0.62	±	0.08	0.47	±	0.12	0.83	0.46
AH	27	0.62	±	0.09	0.45	±	0.11	0.93	0.54
AC/AD	115	0.60	±	0.07	0.48	±	0.09	0.80	0.48
EL/EHS	61	0.61	±	0.07	0.45	±	0.09	0.86	0.51
Z	16	0.61	±	0.05	0.55	±	0.12	0.85	0.58

Sample	Specimens	Length			Breadth			Thickness		
		Mean		s.d.	Mean		s.d.	Mean		s.d.
EH	105	152	±	30	94	±	18	43	±	10
AH	27	144	±	43	87	±	20	38	±	8
AC/AD	115	152	±	31	89	±	14	42	±	9
EL/EHS	61	140	±	27	84	±	14	37	±	8
Z	16	165	±	25	101	±	16	56	±	15

Table I. Biface ratios, correlations, and basic measurements from different parts of the main Kilombe site. Dimensions in millimetres. EH and AH are excavated samples; other samples were collected on surface within 15m of Main Horizon exposures.

not yet been tackled. Correlations between Length and Breadth are consistently the highest at Kilombe and elsewhere. This seems to reflect both the primary design target, and the greater technical difficulty of controlling thickness.

2. PROPORTIONS

The high correlations are remarkable enough, but they also allow the study of the early human sense of geometrical proportions. For any two dimensions, lines can be fitted to the points by the method given by Kermack and Haldane (1950), in which the slope of the *reduced major axis* is determined by the ratio of the two standard deviations. None of the Kilombe bifaces was made shorter than c. 8 cm, but the projected lines consistently pass so close to the origins of the axes as to demonstrate an evolved and precise sense of geometrical proportions : in effect, a precursor of mathematical abilities (fig. 3). Most remarkable of all is that the fitted lines, and mean values closely match the proportion of 'Golden Section' (c. 0.62 : more precisely 0.6185/1) favoured in classifical art and architecture, il all of the Kilombe samples (Gowlett, in prep.).

3. SUBGROUPS WITHIN THE SERIES

The bifaces have been treated as a single category in the analyses above, though in conventional typological terms they include subgroups such as 'hand-axes' and 'cleavers' (the latter separable through having a transverse or semi-transverse axe-like edge). Isaac (1977) remarked that hand-axes and cleavers appear to intergrade at Olorgesailie, through intermediate 'chisel-ended' forms. At Kilombe any separate design forms within the bifaces *must* conform to a single overall design standard, or the dimensional correlations would be much lower. Nevertheless, Wishart's mode analyses was employed to test for serparate groups within the material (Wishart 1969). Seven or in some cases eight continuous measured variables were used in the analyses. In the results, hand-axes and cleavers could not be picked out as separate natural clusters, but for two samples from different parts of the site, groups of 'large' bifaces and 'small' bifaces were distinguished in each case. These echo, in some sense, the parallel Acheulean and Developed Oldowan B recognized by Leakey at Olduvai (Leakey 1971, 1975). The full implications of this must be discussed elsewhere, but these results emphasiste the dangers of relying too heavily on conventional typological classification, and demonstrate that early archaeological material can possess design regularities which are not immediately apparent.

CONCLUSIONS

The evidence from Kilombe helps to demonstrate that much information about early psychological, as well as practical, abilities, is preserved within Palaeolithic stone industries. Much of this information only emerges when artefacts are studied in series. The execution of plans through extended periods of time clearly demands mental concentration. It is a vital aspect of early human behaviour, and a prime subject for further study and documentation. As the separation of procedural and morphological 'templates' is essentially an arbitrary one, plainly one of the outstanding characteristics of the early human mind was the ability to integrate these various factors.

The fact that the abilities of imposing form on stone artefacts were so highly developed approaching one million years ago emphasises the need to consider whether in the rapid technological changes of the last 100,000 years, we are seeing merely refinements of these abilities, or entirely new developments.

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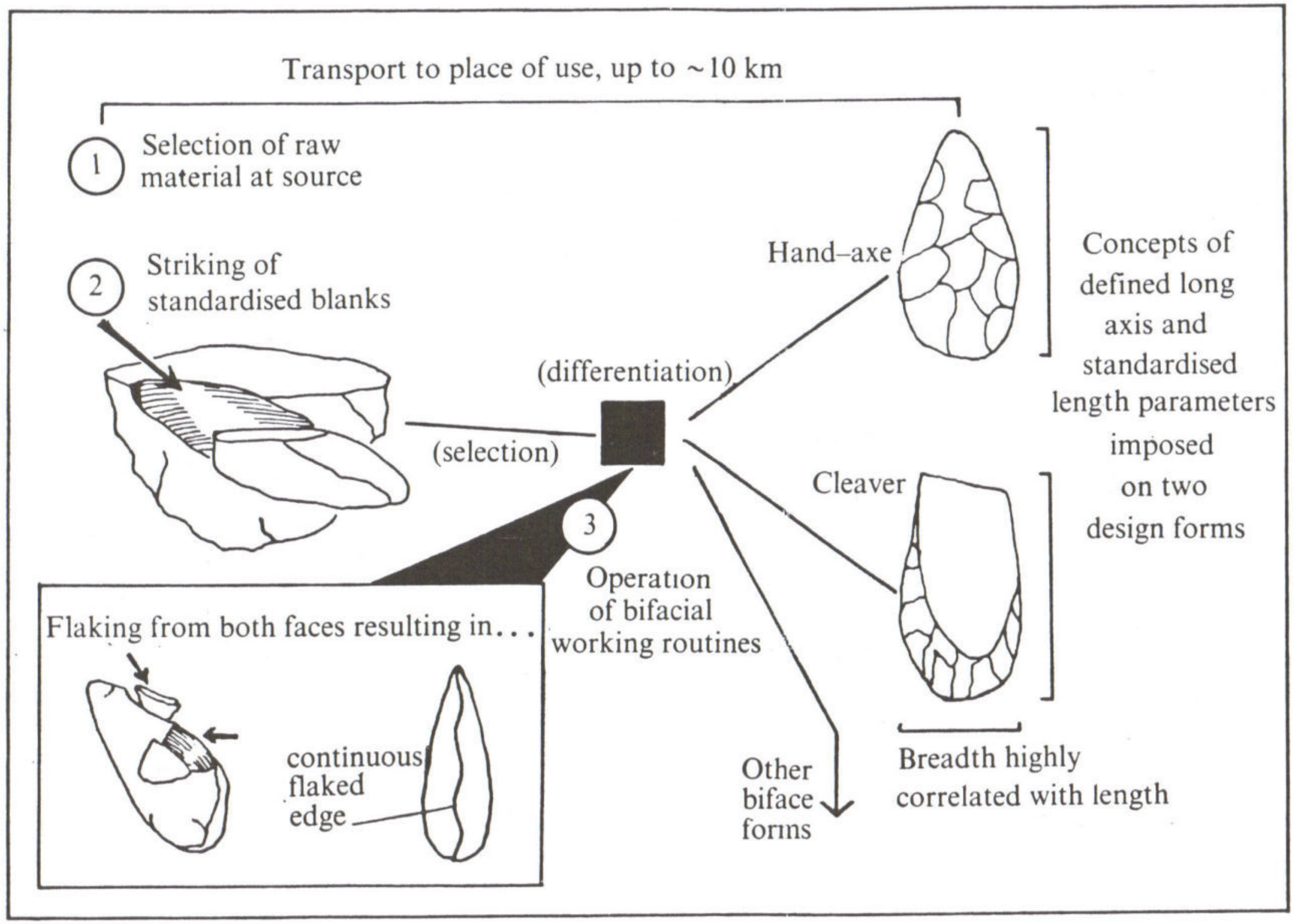

Fig. 1. A diagram illustrating some of the various planned steps underlying the production of bifaces on East African Acheulean sites such as Kilombe.

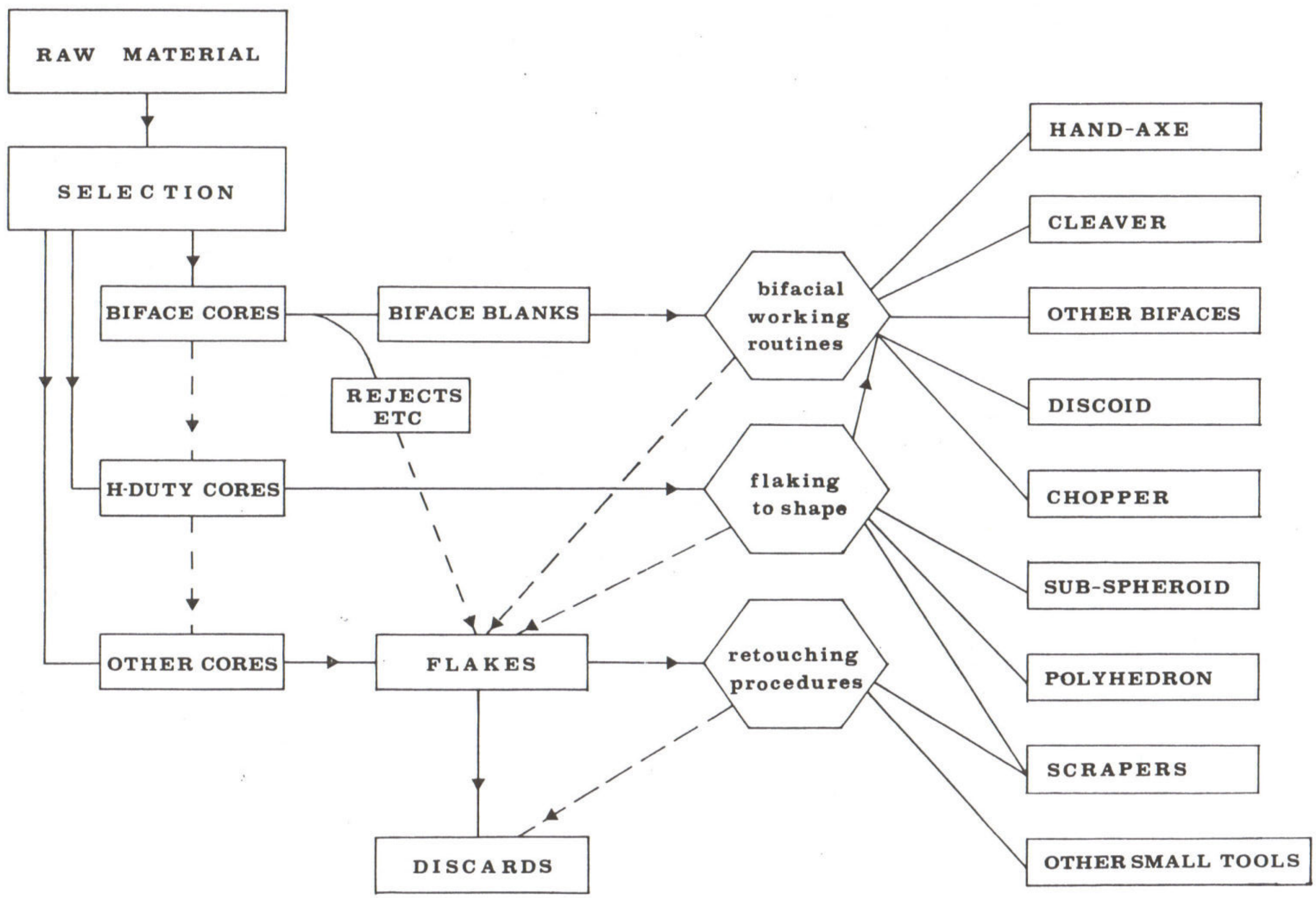

Fig. 2. A procedural diagram for the production of an East African Acheulean industry of the late Lower Pleistocene/early Middle Pleistocene.

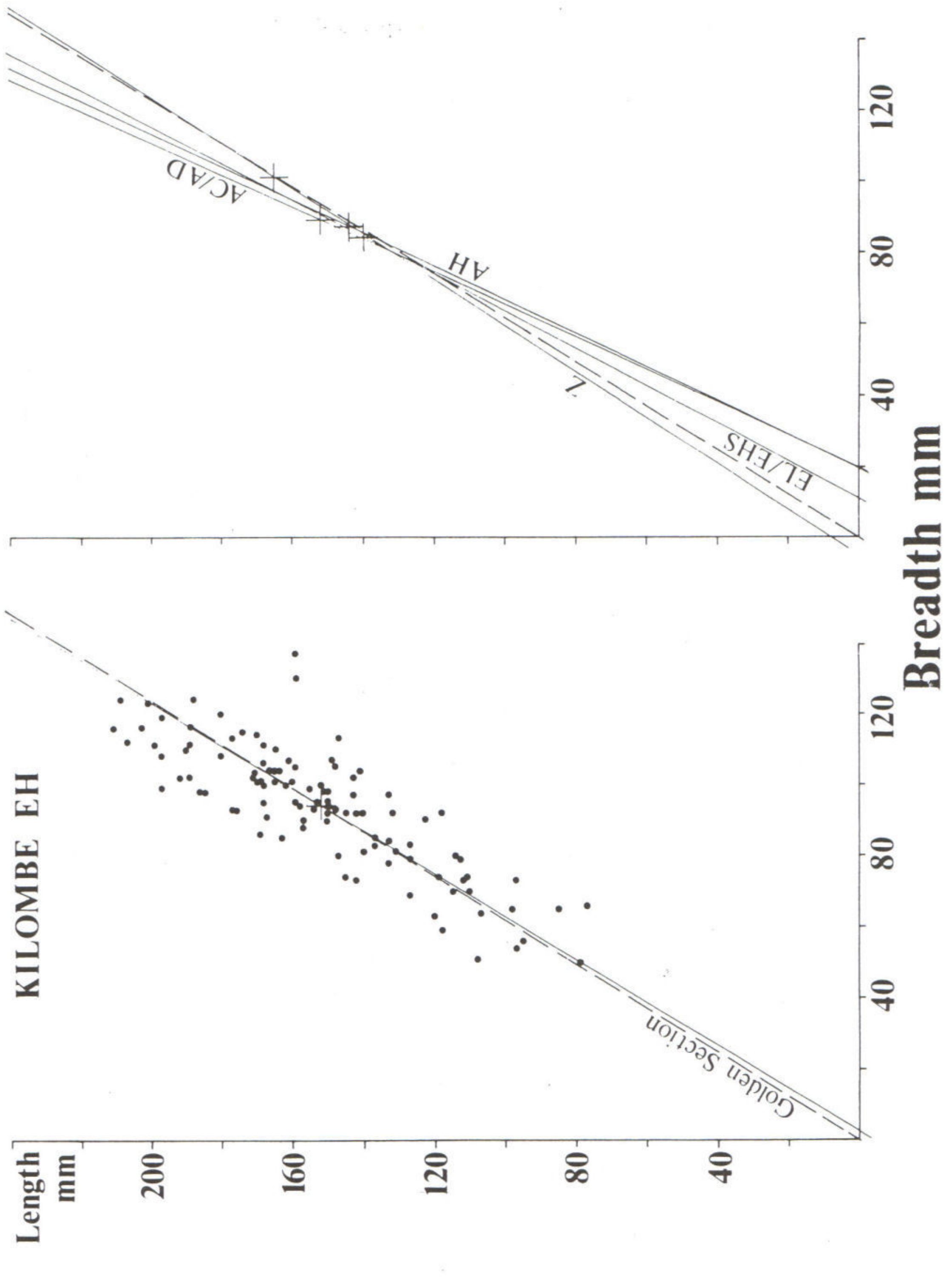

Fig. 3. Left : scatter diagram for breadth and length of bifaces from EH excavation on the Kilombe Main Site. Solid line : reduced major axis; dashed line : ratio of Golden Section. Right : fitted lines for other samples from the Kilombe Main Site. Crosses indicate sample means.