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ATTRIBUTES OF OLDOWAN AND LOWER ACHEULEAN TOOLS: 'TRADITION' AND DESIGN IN THE EARLY LOWER PALEOLITHIC*

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Abstract

Attribute data have been collected on Oldowan and Lower Acheulean tools—choppers and scrapers—from a series of sites in sub-Saharan Africa. The data were collected with a view toward shedding light on (1) taxonomic relationships among the occurrences, (2) the typology of the varieties of tools in question (as well as more general aspects of the typology of early Lower Paleolithic artefacts), and (3) broad principles of design. The major analytical approach involved scanning the data for statistically significant differences in mean values for attributes between classes, between taxonomic entities, and between classes of raw material. Included among the more important results of the study are proposed revisions of the existing taxonomy, such as the inclusion of the Lower Acheulean in the Oldowan Industrial Complex and the recognition of the importance of size as a design criterion for the choppers and scrapers.

Introduction

The earliest known stone tool industries are confined to a few sites in sub-Saharan Africa—principally, the Koobi Fora sites from East Rudolph (Kenya), the Peninj sites near Lake Natron (Tanzania), Beds I and II at Olduvai Gorge (Tanzania), and two of the Transvaal (South Africa) Australopithecine sites: Sterkfontein and Swartkrans. For a more extensive discussion of the age of these sites, I refer the reader to Bower (1973 *passim*), Isaac (1972a), and Vrba (1975); here, I shall simply note that the industries are most securely dated at Olduvai, where they lie in a range between about 1,0 and 1,8 m.y., and Peninj, where the sites are dated to approximately 0,9–1,6 m.y. The Koobi Fora sites have been dated to about 2,6 m.y. (Isaac *op. cit.*), but this date is being re-evaluated and may ultimately be adjusted upward by several hundred thousand years (Curtis 1975).

The South African sites have so far proven resistant to attempts at radiometric dating and problematic with respect to faunal dating. On the basis of the latter, it seems likely that the complete sedimentary column at each site may embrace a very long time-span—at Sterkfontein, from at least 2,0 to 0,5 m.y., and at Swartkrans, from about 1,8 m.y. to near the end of the Middle Pleistocene. While many of the artefacts from these sites derive from the early sediments, some may represent stratigraphically higher levels.

Despite the very primitive stage of lithiculture represented by the industries in question, they contain much morphological variability, ranging from crude bifaces through massive core tools (choppers, scrapers, polyhedrons, etc.) to small and sometimes rather delicately finished flake tools. Within this

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range, it is possible to recognize a series of recurring forms, presumably reflecting a conceptual basis (however vague) in the mind of the flint knapper. The typology devised by Mary Leakey (1967, 1971: 4–8) essentially involves the recognition of such forms—without, of course, implying any necessary connection between types and the conceptual images of the toolmaker.

However, as Isaac (1972a: 395; see also Leakey 1967: 420) has suggested, there is much apparently *ad hoc* variability in the assemblages in question, such that many (if not most) of the types grade imperceptibly into others, and it is often difficult to assign a given specimen to a particular type. For instance, there is an end chopper illustrated by Leakey (1971: 54) at the top of the page which, judging from the drawing, might be difficult to distinguish from heavy duty scrapers. This raises the possibility that, whatever design criteria entered into the conception and manufacture of the tools, they may have been expressed in rather general terms, such as 'a bulky tool with a cutting edge', or 'a small tool with a pointed end', and so forth. If such was the case, the construction of a traditional typological system may well involve selecting more or less fortuitous 'concentrations' of forms as types out of an essentially randomly varying set of tools. Many of the resulting types would, of course, be of little or no value in comparative studies.

Isaac (1974) has introduced an alternative analytical framework, which seeks to avoid some of these pitfalls; it is essentially inductive and is based on the concept of 'morphological fields'—i.e. very broadly defined formal categories that are mutually exclusive, such as 'large, bifacial' and 'small, unifacial' fields. Having identified the range of fields represented in an assemblage, one can scan each field for modalities of shape and/or size. Such modalities, constituting subdivisions of the morphological field, would be broadly comparable to traditional types and would serve the same purposes as the latter; however, they would be based largely on properties inherent in the material, thus reducing the rather large dose of subjectivity which inevitably enters into traditional typologies. Moreover, the modalities might be expected to reveal at least part of the design system involved in the production of the tools more directly and more securely than could a traditional typology.

In addition to establishing a typology, Leakey (1971: 269–74) has also elaborated a taxonomy and classified occurrences from the various sites (*loc. cit.* and 1970; see also Isaac 1967 and 1969). In terms of the systematics generally in use for the Paleolithic of sub-Saharan Africa (Clark *et al.*, 1966), two major taxa (industrial complexes) are involved—the Acheulean and the Oldowan. These contain the following subdivisions (see Tables 1, 2, 4 and 5):



TABLE 1. Sites* ranked on chopper attributes.

	15	14	5	13	4	12	9	1	3	11	10	16	17	8	2	6	7
End Scars .	\bar{x}	1,2	1,0	0,88	0,87	0,86	0,78	0,77	0,75	0,73	0,70	0,67	0,67	0,60	0,54	0,50	0,50
	s	0,80	0,71	0,66	0,92	0,66	0,70	0,83	0,96	0,71	0,78	0,67	0,86	0,82	0,72	0,67	0,72
	V	67	71	75	106	77	90	107	128	95	107	96	127	123	120	123	144
Scar Total	\bar{x}	6,0	5,9	5,8	5,3	5,0	4,8	4,8	4,7	4,7	4,5	4,4	4,4	4,3	4,3	4,0	3,9
	s	2,0	2,1	1,5	2,0	1,9	1,6	1,5	1,7	1,8	2,5	1,7	1,5	1,9	1,2	1,2	1,4
	V	33	36	26	38	38	33	31	36	38	56	39	34	43	28	28	36
Axis . . .	$\bar{x}\ddagger$	17	14	16	6	12	7	15	5	2	8	11	4	10	13	3	9
	s	83	77	75	71	71	69	68	68	67	66	65	65	63	61	58	58
	V	23	21	23	14	22	19	16	12	14	14	18	14	15	23	16	18
Max-dim† .	$\bar{x}\ddagger$	17	16	14	6	15	12	4	7	5	8	3	2	10	11	13	9
	s	107	98	93	87	86	85	83	82	82	81	81	80	78	77	77	74
	V	14	27	17	15	15	23	13	23	13	14	16	15	13	18	23	23
Chord . . .	$\bar{x}\ddagger$	13	28	18	17	17	15	28	16	18	20	19	17	23	30	31	41
	s	17	3	14	1	13	2	16	12	4	5	11	10	9	6	7	15
	V	72	68	61	60	58	58	57	55	53	53	52	52	52	51	50	50
Chord/axis†	\bar{x}	21	22	21	32	19	15	23	21	12	16	14	21	19	23	20	21
	s	30	32	35	52	33	27	41	38	23	30	28	24	41	37	46	40
	V	3	1	13	9	2	11	17	10	4	14	5	12	16	15	8	6
Chord/axis†	\bar{x}	1,18	1,04	1,02	0,89	0,87	0,86	0,86	0,85	0,84	0,82	0,80	0,79	0,78	0,76	0,73	0,73
	s	0,22	0,10	0,31	0,20	0,20	0,31	0,14	0,16	0,16	0,26	0,25	0,22	0,24	0,36	0,31	0,26
	V	19	10	30	22	23	36	16	19	19	32	31	28	31	47	42	36

- * Sites: 1. Koobi Fora, lower unit: FxJj1, FxJj10, GiJi3 (N=4).
 2. DK1 (N=22).
 3. FLK I (N=8).
 4. FLK NNI (N=14).
 5. FLK North, 1-6 (N=32).
 6. HWK East, 1 (N=24).
 7. HWK East, 2 (N=8).
 8. HWK East, 3-5 (N=30).
 9. FLK North, sandy cong. (N=13).
 10. MNK II, skull (N=10).
 11. FC II West (N=26).
 12. SHK Annexe (N=14).
 13. TK II (N=15).
 14. EF-HR (N=9).
 15. Sterkfontein (N=30).
 16. Swartkrans (N=21).
 17. Peninj, MHS + RHS (N=6)

† Prob. of F ratio < 0,05; LSD valid for 95% confidence interval.

‡ Values for \bar{x} in mm.

- Acheulean Industrial Complex
 - Upper Acheulean Industry
 - Lower Acheulean Industry
- Developed Oldowan Industry
 - Developed Oldowan A Phase
 - Developed Oldowan B Phase
- Oldowan Industrial Complex
 - Oldowan Industry

Of these taxa (represented in slightly paraphrased form without, I believe, altering the substance of Leakey's presentation), only the Upper Acheulean is not included among the occurrences in question.

The most important diagnostic distinction between the Acheulean and Oldowan complexes lies in the rate of occurrence of bifaces, which account for at least 40% of the shaped tools in the Acheulean and fewer than 40% in the Oldowan. This distinction serves diagnostically only in differentiating Lower Acheulean industries from those of the Oldowan Complex, for there are numerous examples of Upper Acheulean occurrences with few or no bifaces (cf. Clark 1970: 96-100; Isaac & Isaac 1975: 22). However, the problems inherent in this ambiguity lie beyond the scope of this paper, and I am informed by Mary Leakey that the criteria for classification of the Acheulean are, in any case, being revised.

Within the Acheulean Complex, the Lower and Upper industries differ largely in terms of the relatively irregular shape of the bifaces in the former and their deeper, more invasive flake scars. In the Oldowan Complex, the Developed Oldowan is distinguished from the Oldowan Industry by exhibiting a greater variety of types—notably through the addition of such forms as bifaces, awls and *outils*

TABLE 2. Industries* ranked on chopper attributes.

	4	5	3	1	2	
End Scars .	\bar{x}	0,98	0,87	0,78	0,70	0,63
	s	0,86	0,74	0,79	0,69	0,72
	V	88	85	101	99	114
Scar Total .	\bar{x}	5,1	5,0	4,7	4,4	4,2
	s	2,0	1,6	1,6	1,7	2,1
	V	39	32	34	39	50
Axis† . . .	\bar{x}	5	4	1	3	2
	s	79	71	67	66	64
	V	21	19	14	20	16
Max-dim† .	\bar{x}	27	27	21	31	25
	s	5	4	1	2	3
	V	99	91	82	80	9
Chord† . . .	\bar{x}	17	22	15	21	18
	s	17	24	18	26	23
	V	5	1	3	4	2
Chord/axis .	\bar{x}	66	55	55	53	49
	s	21	17	17	22	21
	V	32	31	32	41	43
Chord/axis .	\bar{x}	3	1	5	4	2
	s	0,89	0,84	0,83	0,77	0,77
	V	0,30	0,24	0,22	0,31	0,28

- * Industries:
 1. Bed I Oldowan: sites 1-6 (see Table 1), 10 (N=114).
 2. Dev. Old. A: sites 7-9 (N=51).
 3. Dev. Old. B: sites 11-13 (N=55).
 4. S. African 'Oldowan': sites 15, 16 (N=51).
 5. Lower Acheul.: sites 14, 17 (N=15).

† Prob. of F ratio < 0,05; LSD valid for 95% confidence interval.

TABLE 3. Materials* ranked on chopper attributes.

		2	1
End Scars	\bar{x}	0,81	0,76
	s	0,78	0,75
	V	95	99
Scars†	\bar{x}	5,4	4,5
	s	2,0	1,8
	V	37	40
Axis	\bar{x}	68	64
	s	17	21
	V	25	33
Max-dim	\bar{x}	84	81
	s	18	22
	V	22	22
Chord	\bar{x}	59	53
	s	20	19
	V	35	36
Chord/axis†	\bar{x}	0,97	0,80
	s	0,30	0,27
	V	31	34

* Materials:

1. Quartz < 50%; sites (see Table 1) 1, 2, 4-11, 14-17 (N = 249).
2. Quartz > 50%; sites 3, 12, 13 (N = 37).

† Differences significant at 0,05 level.

écaillés. The A and B phases of the Developed Oldowan are much alike, except that the former lacks bifaces.

Broadly speaking, the industries represent a chronological succession: from earliest to most recent, (1) Oldowan, (2) Developed Oldowan A and (3) Developed Oldowan B plus Lower Acheulean; however, at Olduvai *all* of the industries are more or less contemporary—i.e. they are all present in Bed II above the Lemuta Member (Bower 1973: 78-80). Attempts to explain this astonishing taxonomic diversity at such an early stage in the evolution of lithic technology have included the possibility of intrusion of cultures that originated elsewhere (Leakey 1967, 1971: 272), the suggestion that a 'quantum jump' in technology occurred in one or two of the cultures involved but not in the others (Isaac 1969), and the idea that the industries are merely activity variants of one another (Clark 1970: 85 ff.). So far, none of these explanations has been amply tested against data; in any case, the whole issue rests on *acceptance* of the taxonomic assessment. On both logical and empirical grounds (i.e. the whole historical trajectory of stone tool technology, which involves progressive differentiation of industries), it seems rather improbable; one would expect homogeneity. Whatever the case may be, it seems clear, as Mary Leakey has implied (1971: 278-81), that the classification of tools and distribution of taxa may be of some use in helping to unravel complex problems in hominid phylogeny.

In this paper, I shall report the results of an attribute study aimed largely at some of the issues sketched above. In particular, I hope to shed some light on the relationship between 'morphological fields' and traditional typologies, and also on their relative merits in dealing with early Lower Paleolithic occurrences. In addition, I shall attempt to assess the taxonomic interpretation of the Oldowan and Lower Acheulean materials. Beyond these more or less parochial concerns, I shall explore certain aspects of design—particularly those related to design specificity and the standardization of product (cf. Isaac 1972a: 393-5)—which are not only intrinsically interesting but may have been crucially involved in basic processes of sociocultural evolution.

Methods

I have collected data on two classes of tools that are abundantly and ubiquitously represented in the Oldowan and Lower Acheulean occurrences: choppers and scrapers. In the case of the choppers, I have used a restricted version of the type definition (Bower 1973: 135-6) in order to confine the sample to 'classic' choppers; thus, only specimens exhibiting all of the definitive attributes of the type were included, and all borderline tools were excluded. However, the scraper class was very broadly defined, ignoring the typological distinction between heavy- and light-duty scrapers, as well as finer typological distinctions among the light-duty scrapers (Leakey 1971: 6-7). Thus, the scraper sample approximately represents a morphological field—tools with a flat base defined in part by a steeply flaked edge. My reasons for defining one class of tools much more restrictively than the other are directly related to the aims of the study and will become apparent in subsequent discussion.

The inventories of sites composing the chopper and scraper samples are indicated in Tables 1 and 4, respectively. All artefacts that fit the definition for each class were included in the appropriate sample—with the exception of a few pieces that had been removed for casting. Logistical limitations made it impossible to include the entire inventory of excavated sites from Olduvai in the data samples, but the sites that are included span the stratigraphy of Beds I and II and embrace all of the industries recognized by Leakey. Since the scraper class was broadly defined, it included very large numbers of specimens at many of the sites; thus, in the time available for data collection (about three months of part-time work in 1971 and three weeks of full-time effort in 1974), fewer sites could be included in the scraper sample than in the chopper sample. The former consists of 245 specimens and the latter of 288—though, for technical reasons, two of the choppers had to be excluded from most of the analytical procedures.

Data were collected on a series of both qualitative and quantitative attributes in each of the samples. The chopper attributes (see Tables 1, 7 and 8) consisted of:

1. Qualitative attributes

- (a) edge shape (although data were collected on 15 states of the attribute, determined by the

TABLE 4. Sites* ranked on scraper attributes.

		12	9	11	8	2	4	10	5	3	7	1	6
SAX†	$\bar{x} \ddagger$	62	60	59	54	49	48	47	45	44	44	36	34
	s	23	26	24	24	18	14	12	32	20	25	10	11
	V	37	43	41	44	37	29	26	71	45	52	28	32
		11	9	8	12	10	2	4	5	7	3	1	6
SBX†	$\bar{x} \ddagger$	62	55	48	48	48	45	45	45	37	36	36	32
	s	29	22	25	26	21	19	18	36	24	18	13	14
	V	47	40	52	54	44	42	40	80	65	50	36	44
		12	11	9	8	10	2	4	5	3	7	1	6
Length†	$\bar{x} \ddagger$	75	75	72	63	59	58	58	53	52	50	43	40
	s	18	30	26	25	21	20	18	39	20	28	12	14
	V	24	40	36	40	36	34	31	74	38	56	28	35
		9	11	8	12	4	2	10	3	1	5	7	6
T Max†	$\bar{x} \ddagger$	52	50	46	41	39	38	34	32	29	25	22	20
	s	25	23	22	30	21	24	23	21	13	26	15	16
	V	48	46	48	73	54	63	68	66	45	104	68	80
		9	8	11	2	1	10	5	12	3	7	4	6
Edge L†	$\bar{x} \ddagger$	111	107	106	91	90	86	84	82	80	69	69	49
	s	64	68	50	50	38	52	68	42	55	33	43	?
	V	58	64	47	55	42	60	81	51	69	48	62	45
		11	9	8	12	2	10	4	5	7	3	1	6
Circum.†	$\bar{x} \ddagger$	217	200	179	175	166	164	160	152	135	134	122	112
	s	88	71	78	69	61	55	50	118	78	65	32	39
	V	41	36	44	39	37	34	31	78	58	48	26	35
		1	9	8	6	7	11	2	3	5	4	10	12
Scars	\bar{x}	6,5	5,9	5,7	5,6	5,4	5,2	5,1	5,1	5,0	4,7	4,7	4,0
	s	2,2	2,5	2,4	3,1	2,2	1,6	2,0	2,0	1,4	2,0	2,0	1,4
	V	34	42	42	55	41	31	39	39	28	43	43	35
		11	1	9	2	10	4	6	5	8	7	3	12
SBX/SAX	\bar{x}	1,06	1,04	1,03	0,96	0,96	0,95	0,95	0,93	0,89	0,86	0,86	0,74
	s	0,30	0,34	0,48	0,30	0,22	0,34	0,27	0,27	0,27	0,24	0,34	0,26
	V	28	33	47	31	23	36	28	29	30	28	40	35
		1	3	8	7	5	2	9	10	12	11	6	4
Edge L/Circum.	\bar{x}	0,73	0,67	0,58	0,57	0,56	0,55	0,55	0,51	0,49	0,48	0,46	0,43
	s	0,23	0,70	0,20	0,26	0,12	0,23	0,24	0,25	0,25	0,14	0,22	0,18
	V	32	104	34	46	21	42	44	49	51	29	48	42
		11	8	9	1	4	2	3	10	12	6	7	5
T Max/Length†	\bar{x}	0,74	0,74	0,73	0,70	0,65	0,63	0,62	0,53	0,50	0,47	0,44	0,43
	s	0,45	0,16	0,29	0,28	0,32	0,29	0,33	0,23	0,30	0,26	0,16	0,25
	V	61	22	40	40	49	46	53	43	60	55	36	58

* Sites:

1. Koobi Fora, lower unit: FxJj1, FxJj10, GiJj3 (N=18).
2. DKI (N=32).
3. FLK I (N=32).
4. FLK North, 1-6 (N=27).
5. FLK NNI (N=4).
6. HWK East, all levels (N=17).
7. TK II (N=31).
8. Sterkfontein (N=36).
9. Swartkrans (N=26).
10. EF-HR (N=6).
11. RHS (N=12).
12. MHS (N=4).

† Prob. of F ratio < 0,05; LSD valid for 95% confidence interval.

‡ Values for \bar{x} in mm.

combination of elevation and plan view of the cutting edge, the elevation alone has proven more informative, so only the five states related to elevation are reported here: concave, convex, pointed, denticulate, straight, irregular).

2. Quantitative attributes

(a) scar ratio (combination of flake scar counts on opposite sides of the cutting edge)

- (b) scar total (sum of scar counts from attribute (a) above)
- (c) end scars (scars truncating the cutting edge)
- (d) working axis (the distance between the midpoint of the cutting edge and the butt of the piece)
- (e) maximum dimension, or Maxdim
- (f) chord (straight line distance between the ends of the cutting edge)
- (g) chord/axis (approximate breadth/length ratio of the piece).

TABLE 5. Industries* ranked on scraper attributes.

		4	5	1	3	2
SAX† . . .	\bar{x}	56	56	45	44	36
	s	25	21	18	25	13
	V	45	38	40	57	36
SBX† . . .	\bar{x}	56	51	41	37	34
	s	26	24	19	24	16
	V	46	47	46	65	47
Length† . . .	\bar{x}	70	67	54	50	44
	s	26	26	20	28	17
	V	37	39	37	56	39
T Max† . . .	\bar{x}	49	44	35	23	22
	s	23	24	21	18	15
	V	47	55	60	78	68
Edge L† . . .	\bar{x}	109	96	82	69	54
	s	66	48	49	33	28
	V	61	50	60	48	52
Circum.† . . .	\bar{x}	195	188	148	135	123
	s	78	75	60	78	46
	V	40	40	41	58	37
Scars . . .	\bar{x}	5,8	5,4	5,4	5,2	4,9
	s	2,4	3,9	2,2	2,1	1,7
	V	41	72	41	40	35
SBX/SAX . . .	\bar{x}	0,98	0,98	0,95	0,94	0,86
	s	0,26	0,29	0,38	0,33	0,24
	V	27	30	40	35	28
Edge L/Circum. . .	\bar{x}	0,58	0,57	0,56	0,49	0,47
	s	0,42	0,26	0,21	0,19	0,27
	V	72	46	38	39	57
T Max/Length† . . .	\bar{x}	0,73	0,64	0,64	0,50	0,44
	s	0,26	0,38	0,31	0,23	0,16
	V	36	59	48	46	36

* Industries:

1. Bed I Oldowan: sites 1-5 (see Table 4) (N=113).
2. Dev. Oldowan A: site 6 (N=17).
3. Dev. Oldowan B: site 7 (N=31).
4. South African 'Oldowan': sites 8, 9 (N=62).
5. Lower Acheul.: sites 10-12 (N=22).

† Prob. of F ratio < 0,05; LSD valid for 95% confidence interval.

A more exhaustive definition of the chopper attributes is available in Bower (1973: 136-8).

The scraper attributes (see Tables 4 and 9) consisted of:

1. *Qualitative attributes*

- (a) edge shape (edge of the scraper base, as seen with the base oriented in the horizontal plane and facing up).

2. *Quantitative attributes*

- (a) scraper A axis, or SAX (maximum dimension of the scraper base *parallel* to the retouched edge; cf. Isaac 1974)

- (b) scraper B axis, or SBX (maximum dimension of the scraper base *perpendicular* to the retouched edge; cf. Isaac op. cit.)
- (c) length (maximum dimension of the scraper base)
- (d) thickness, or T Max (maximum dimension of the piece perpendicular to the scraper base)
- (e) edge length, or Edge L (length of the retouched portion around the perimeter of the scraper base)
- (f) circumference, or Circum. (total circumference of the scraper base)
- (g) scars (number of primary flake scars adjoining the scraper base)
- (h) SBX/SAX (an index of the direction of elongation of the scraper base; values higher than unity \approx endscrapers)
- (i) edge length/circumference (an index of the extent to which the scraper base has been modified)
- (j) thickness/length (a ratio aimed at distinguishing between 'high-backed' and 'low-backed' tools).

Data on raw materials were also collected in both the chopper and scraper samples in terms of a simple, binary distinction: quartz and non-quartz (Tables 3 and 6). Although limitations of logistics and technical competence precluded collecting more detailed information on raw materials, I believe the present data are useful, since the fracture properties of quartz are much less regular than those of most other rock types in the samples.

In earlier attempts to analyse the chopper data (Bower 1973: 86-116), I have relied heavily upon graphic interpretation. Here, however, the analysis is basically statistical, and graphs enter the process only in connection with a limited range of purposes. The data for each sample have been collated by sites, industries and raw materials; elementary statistics—mean, standard deviation and coefficient of variability

($V = \frac{100s}{x}$)—have been computed for each collation

and also for the two complete samples (Table 12).

In addition, an analytical technique called LSD (Least Significant Differences) from the Statistical Package for the Social Sciences (Nie *et al.* 1970) has been used to identify differences significant at the 0,05 level in mean values of attributes between pairs of sites, pairs of industries, and the single pair of raw material categories. The LSD programme first ranks all 'groups' (e.g. sites, industries, etc.) on a given attribute and then compares mean values between pairs of 'groups' starting at the high end of the range. When a significant difference is found, all lower values in the range are, of course, also recognized as significant, and the process is iterated starting with the second highest group in the range, and so on. The results of the LSD analysis are displayed in Tables 1-6, 10, and 11. It is important to note that the LSD distinctions are significant *only* if the probability of the F ratio (abbreviated to 'F prob' in Tables 10 and 11) does *not* exceed the chosen level of significance in the present analysis (0,05). To put it another way, no significant differences exist among 'groups' whose probability of the F ratio for a given attribute is greater than 0,05.

Review of the Data

Comparison of Sites. Turning first to the site-by-site data arrays (Tables 1, 4, 7, 8, and 9), two important generalizations may be drawn. One is that nearly all of the attributes which are likely functions of the overall size of the piece (choppers: Maxdim; scrapers: SAX, SBX, Length, T Max, Circum.) discriminate among the sites. Furthermore, the rank order of sites on size-related attributes shows remarkably close parallels among attributes for a given class of tools and even to some degree across tool classes. This suggests that all of these attributes may, in fact, be measuring a single variable, namely, overall size; however, as I shall later show, there are indications that, at least in the case of scrapers, one size-related attribute (T Max) may be of particular importance.

TABLE 6. Materials* ranked on scraper attributes.

		I	2
SAX	\bar{x}	51	46
	s	22	20
	V	43	43
SBX†	\bar{x}	47	39
	s	22	21
	V	47	54
Length†	\bar{x}	61	53
	s	24	23
	V	39	43
T Max†	\bar{x}	42	30
	s	23	20
	V	55	67
Edge L†	\bar{x}	97	74
	s	56	45
	V	58	61
Circum.†	\bar{x}	171	142
	s	71	68
	V	42	48
Scars	\bar{x}	5,5	5,0
	s	2,4	2,0
	V	44	40
SBX/SAX	\bar{x}	0,97	0,89
	s	0,33	0,30
	V	34	34
Edge L/Circum.	\bar{x}	0,56	0,56
	s	0,23	0,45
	V	41	80
T Max/Length†	\bar{x}	0,68	0,56
	s	0,29	0,29
	V	43	52

* Materials:

1. Quartz < 50%; sites (see Table 4) 1, 2, 6, 8-12 (N=151).
2. Quartz > 50%; sites 3-5, 7 (N=94).

† Differences significant at 0,05 level.

The Peninj sites (MHS and RHS) and Swartkrans consistently appear at the top of the range, while TK II and Koobi Fora have consistently low values, and the rest of the sites tend to oscillate around mid-range values. The LSD matrices for the site-by-site comparison have not been included here because they differentiate only among sites near the extremes of the range of values for given attributes and thus have failed to generate stratigraphically or culturally meaningful clusters of sites.

Another key generalization is that, almost without exception, attributes related to *shape* or *manufacturing technique* (choppers: End Flakes, Scar Total, Scar Ratios; scrapers: Scars, SAX/SBX, Edge L/Circum.) are relatively stable—i.e. they do not discriminate among the sites. The only important exceptions are the edge shape distributions (Tables 8 and 9). Among the choppers, HWK East (level 2) seems to represent the only major departure from an otherwise monotonous distribution pattern, although Sterkfontein and Swartkrans also differ slightly from the general edge shape distribution pattern and closely resemble one another. It may be of consequence that the faunal debris at HWK East (level 2) is dominated by very large animals—proboscidian and rhino remains (Leakey 1971: 94). Unfortunately, the data for FLK North (levels 1-6) were aggregated, so it is not possible to compare the proboscidian site level (6) with HWK East (2). As for the scraper edge shapes, the Koobi Fora sites, FLK NNI, and site MHS from Peninj seem to differ moderately from the otherwise fairly stable distribution pattern; however, the samples from FLK NNI and MHS are exceedingly small, so the percentages are of questionable significance.

Although the chopper scar ratios (Table 7) exhibit considerable variability, it is not such as to group the sites into obvious clusters; furthermore, the distribution of scar ratios follows a general pattern from which none of the sites depart markedly. This general pattern deserves further comment: at all of the sites, the majority of the choppers (usually at least 75% and never less than 60%) have scar ratios in the 1:1, 1:2, 2:2, 2:3, 3:3, and 3:4 classes combined; at most sites, the combined 2:3 and 3:3 ratios are dominant. Apparently, a more or less symmetrical distribution of flake scars about the cutting edge was preferred, which tends to support Leakey's (1971: 269) argument that the choppers are, in fact, tools and not cores. Were they cores, one would expect a high incidence of imbalanced scar ratios—that is, pieces from which a few flakes had been struck to create a platform and many other flakes detached from the edge of the platform.

Comparison of Industries. Turning next to the collation of attribute data by industries (Tables 2, 5, 10 and 11), the same general pattern observed in the site-by-site collation is again evident: the attributes of size discriminate significantly (at the 0,05 level) among 'groups', but the attributes related to shape and manufacturing technique do not. In the case of size-related attributes, the Lower Acheulean industry is most often at the high end of the range, followed closely—and sometimes surpassed—by the South African Oldowan industry. In terms of statistically significant distinctions, two clusters are more or less

TABLE 7. Relative frequencies (%) of chopper scar ratios.*

Site†	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	N		
1			25,0					25,0					50,0									4	
2	4,5	22,7		4,5			18,2	27,3				4,5	9,1	4,5		4,5						22	
3	12,5						25,0	12,5	12,5				25,0					12,5				8	
4	14,3		14,3				21,4	28,6				7,1					14,3					14	
5	9,4	12,5	3,1				18,8	25,0	9,4			3,1	15,6			3,1						32	
6	16,7	16,7	8,3				33,3	16,7					4,2			4,2						24	
7			37,5				25,0	12,5	12,5				12,5									8	
8	23,3	13,3					16,7	23,3				6,7	6,7	6,7		3,3						30	
9		30,8	30,8					15,4	7,7			15,4										13	
10		20,0					50,0	20,0					10,0									10	
11	11,5	15,4	3,8				11,5	15,4				23,1	7,7			7,7	3,8					26	
12	21,4	14,3						35,7	7,1			14,3	7,1									14	
13		6,7	13,3				6,7	20,0	13,3			13,3	13,3					6,7			6,7	15	
14		33,3						33,3	11,1			11,1	11,1									9	
15	26,7	26,7			3,3		13,3	10,0				3,3	6,7		10,0						4,8	4,8	21
16	23,8	9,5	9,5		4,8		23,8	9,5				33,3	33,3									6	
17	16,7						16,7																

Scar ratios:

1 = 1:1	4 = 1:4	7 = 2:2	10 = 2:5	13 = 3:4	16 = 4:4	19 = 5:5
2 = 1:2	5 = 1:5	8 = 2:3	11 = 2:6	14 = 3:5	17 = 4:5	20 = 5:6
3 = 1:3	6 = 1:6	9 = 2:4	12 = 3:3	15 = 3:6	18 = 4:6	

† See Table 1 for site key.

consistently segregated by these data: the Lower Acheulean and South African industries, on the one hand, and the Oldowan and Developed Oldowan on the other. The attributes appearing in Tables 10 and 11 are the only ones in the respective tool classes whose probability value for the F ratio is low enough to validate the LSD analysis. It is particularly noteworthy that essentially parallel results were obtained using two different classes of tools, each of which was defined in terms of quite different conceptual frameworks: traditional typology and morphological fields.

Raw Material. Tables 3 and 6 display the results of the LSD analysis with the data collated by raw material categories. What emerges here with respect to the choppers is that the quartz-dominated assemblages have significantly higher scar totals and chord/axis ratios. The first of these results militates against earlier observations (Isaac 1972b; see also Bower 1973: 133) to the effect that the number of flake scars on core tools increases over time. Although the data are not strictly comparable, since Isaac's results refer to the total number of scars on a tool, not just those intersecting the 'cutting edge', the possibility that the sites involved in his analysis (Koobi Fora lower member, and DK I) are broadly contemporary can no longer be discounted (see Introduction). Moreover, the scraper scar totals for Koobi Fora (Table 4) are also at the high end of the range, though the value does not differ significantly at the 0,05 level from those of other sites. In any event, since the present analysis shows a significant difference in chopper scar totals about the edge *only* when the data are collated by raw materials (cf. Tables 1 & 2), at least this aspect of the intensity of flake removal seems to be unambiguously controlled by raw material.

The results concerning the chord/axis ratio are broadly consistent with the site-by-site LSD analysis (not shown here), in which the only segregation that

occurred involved the Koobi Fora sites, FLK I and TK II, on the one hand, and all levels at HWK East, on the other hand. Of the first three 'groups', only the Koobi Fora sites are *not* quartz dominated, while a substantial number of the tools from HWK East, especially in levels 3-5, are made of chert (cf. Leakey 1971: 264). These results also militate against an earlier suggestion of mine (Bower 1973: 103 & 114-15) that there might be a time-dependent trend toward more elongated choppers in the relevant assemblages. It now seems reasonably clear that the degree of elongation is largely a function of raw material.

Turning to the scrapers, the data imply that size-related attributes are controlled by raw material—in fact, that the non-quartz-dominated assemblages contain tools that are larger, on the average, than those in quartz-dominated assemblages. Here, of course, is ambiguity since the size of tools also varies significantly by industry (Table 5). Although the industries that are segregated at the high end of the range—the Lower Acheulean and South African Oldowan—contain a predominance of non-quartz scrapers, there are major differences between the raw materials of these two 'groups'. Furthermore, the site-by-site data on raw material reveal that no clear correlation exists between raw material and size of the piece (see Table 4). Indeed, some of the non-quartz-dominated sites (e.g. Koobi Fora) exhibit very low values for size-related attributes—not only among the scrapers but even among the choppers. I regard the effect of raw material on the size of scrapers as an open question—one which more detail on raw material might help to resolve.

In closing the review of data on raw material, it should be noted that, unlike the choppers, the scraper scar counts do *not* seem to vary with raw material—nor, for that matter, do they vary however the data

TABLE 8. Relative frequencies (%) of chopper edge shapes.*

Site†	cx	cv	s	d	p	N
1 . . .	75,0			25,0		4
2 . . .	63,6		22,7	4,5	9,0	22
3 . . .	75,0	12,5	12,5			8
4 . . .	50,0	7,1	36,6	7,1		14
5 . . .	53,1	3,1	25,0		18,8	32
6 . . .	33,3	8,3	33,4	16,7	8,3	24
7 . . .	12,5	12,5	12,5	37,5	25,0	8
8 . . .	46,7	3,3	40,0	10,0		30
9 . . .	53,9	7,7	30,8	7,7		13
10 . . .	70,0		10,0	20,0		10
11 . . .	50,0	3,8	30,7	3,8	11,5	26
12 . . .	49,9		42,8	7,1		14
13 . . .	73,4		13,3	6,7	6,7	15
14 . . .	44,4		11,1	33,3	11,1	9
15 . . .	20,0	13,3	30,0	20,0	16,6	30
16 . . .	28,6	9,5	33,3	23,9	4,8	21
17 . . .	50,0		33,3	16,7		6

* cx = convex s = straight p = pointed
 cv = concave d = denticulate

† See Table 1 for site key.

are collated. The stability of the scraper scar count is particularly interesting—though difficult to interpret—in view of the fact that the scraper class is so very broadly defined, including a great deal of morphological and metrical variability. It seems that the choppers and the scrapers differ markedly in terms of design principles related to flake removal about an edge. In the choppers, the number of flakes removed is 'allowed' to vary with raw material, while the distribution of flakes is relatively fixed; in the scrapers, the number of flakes is relatively fixed despite variations in raw material and size of the piece.

Modalities. The frequency distribution polygons in Figures 1-6 display modalities within size-related attributes of each of the tool classes, while those in Figures 7-9 deal with other attributes deemed important for reasons that will soon become apparent. On a very general level, it seems that there is a marked difference between the curves for the chopper attributes and those for the scraper attributes. The former are essentially unimodal and more or less 'bell-shaped', while the latter are at least weakly multimodal and tend to be skewed to the left. This distinction is also reflected in Table 12, where coefficients of variability (V) for size-related attributes (those expressed in mm, excepting Edge Length) are considerably higher for scrapers than for choppers.

Since the LSD analysis reveals that size is an important variable among both choppers and scrapers, I have attempted to determine whether any particular aspect(s) of size might contribute more than others toward the variability. In the case of the choppers, Table 1 (see also the F ratio probability Table 10) suggests that maximum dimension was 'allowed' to vary more than any other size-related attribute.

In the case of the scrapers, T Max (Fig. 6) seems to exhibit more pronounced modalities than any of the other size-related attributes; this is supported by Table 13, which, though a rather crude assessment of relative variability, shows a much larger total variance for T Max than any of the other variables. ('Average Axis' in Table 13 was determined by averaging the mean values for SAX and SBX at each site. While this procedure is statistically questionable, it is probably not unreasonable in the present circumstances, since the values for the two attributes generally differ little.) Furthermore, the data on T Max/Length suggest that absolute as compared

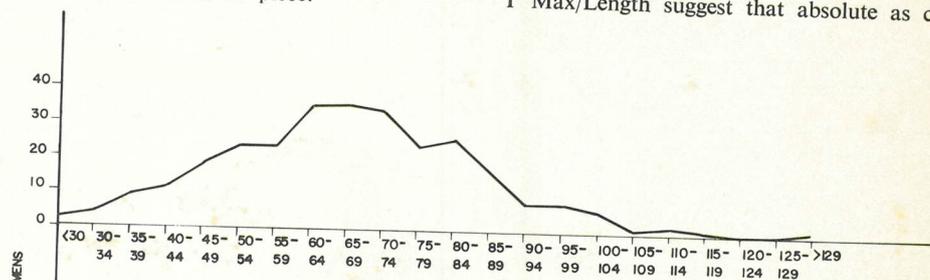


Fig. 1. Chopper axis.

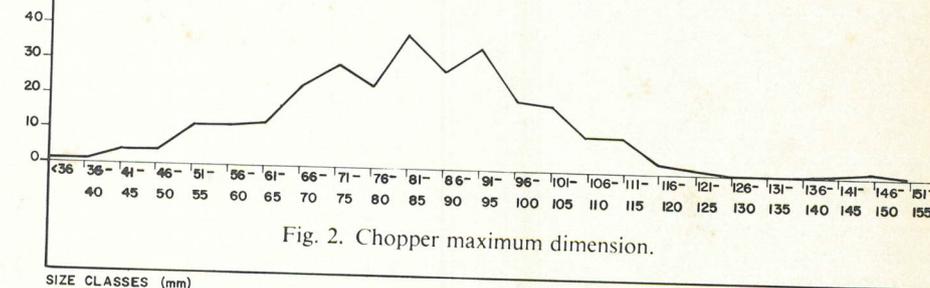


Fig. 2. Chopper maximum dimension.

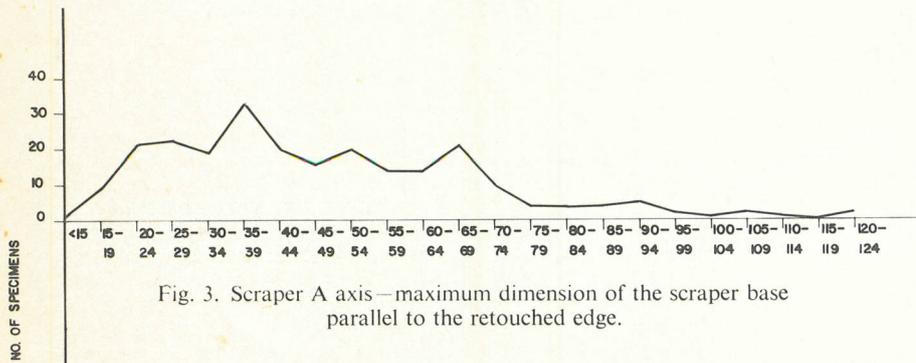


Fig. 3. Scrapper A axis—maximum dimension of the scraper base parallel to the retouched edge.

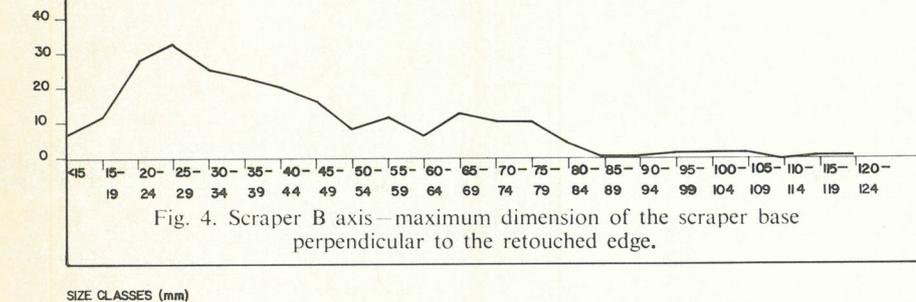


Fig. 4. Scrapper B axis—maximum dimension of the scraper base perpendicular to the retouched edge.

SIZE CLASSES (mm)

with relative thickness is of greater consequence. Unfortunately, the data on T Max/Average Axis were not available at the time of the LSD analysis, and for technical reasons it is impossible to run them now; however, a comparison of Figures 7 and 8 suggests that this variable might prove a more useful

measure of relative thickness since Figure 8 seems to contain more clearly delineated modalities.

Figure 9 represents an attempt to assess variability in the overall size of the scraper; the 'Mean Diameter' is broadly comparable to Leakey's (1971: 4) attribute of the same name and is computed as follows:

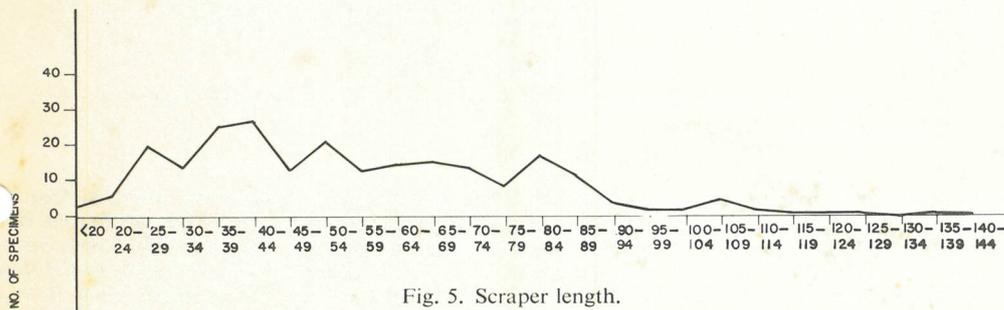


Fig. 5. Scrapper length.

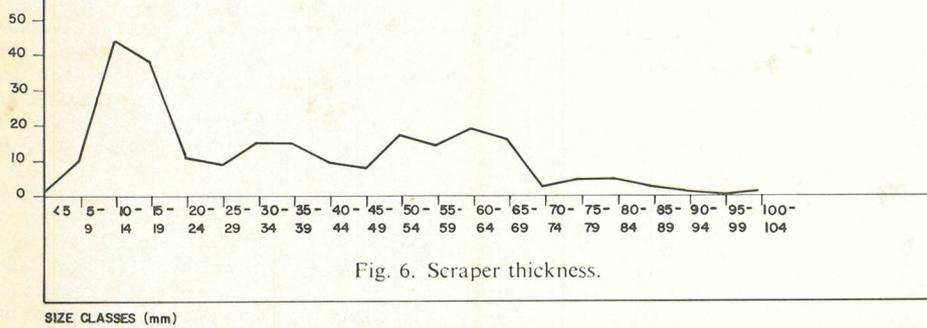


Fig. 6. Scrapper thickness.

SIZE CLASSES (mm)

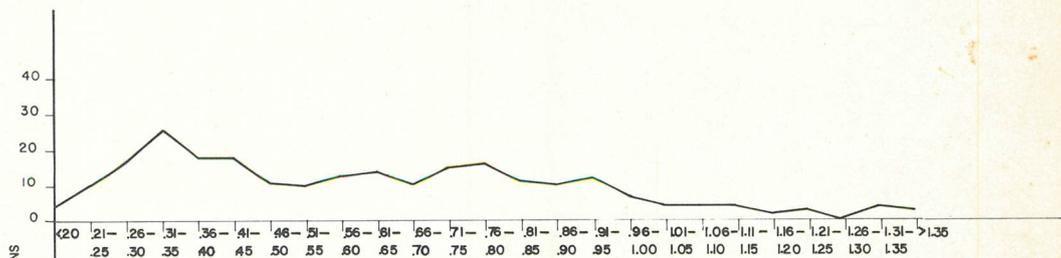


Fig. 7. Scraper thickness/length ratio.

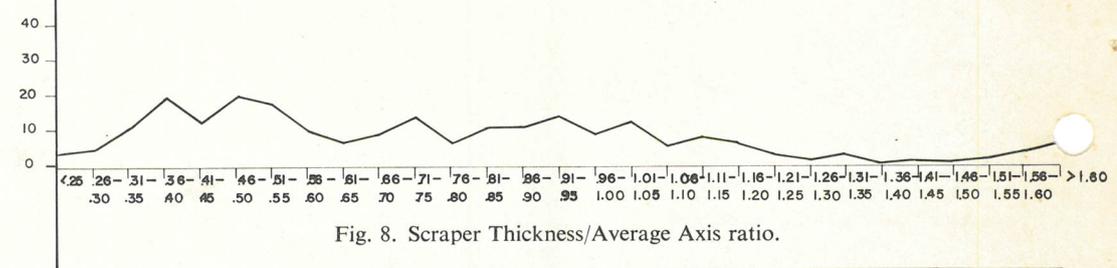


Fig. 8. Scraper Thickness/Average Axis ratio.

SIZE CLASSES (mm)

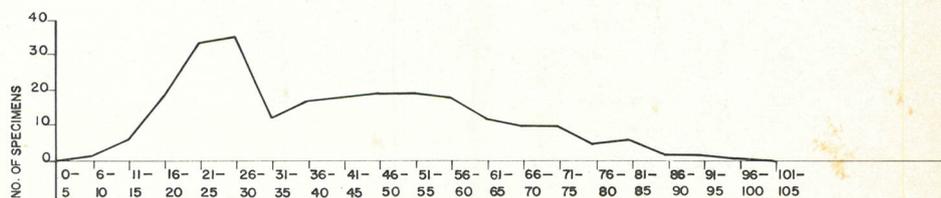


Fig. 9. Scraper mean diameter.

SIZE CLASSES (mm)

$(T \text{ Max} + \text{SAX} + \text{SBX}) \times 3$. Leakey has used this attribute as a criterion for distinguishing between heavy-duty (> 50 mm) and light-duty (< 50 mm) tools—not just scrapers, but all tools. However, the data in Figure 9 do not support this distinction so far as scrapers are concerned; indeed, to the extent that there is any major trough in the curve, it occurs at 31–35 mm and suggests that the latter value would be a better ‘threshold’ between heavy- and light-duty scrapers.

Summary and Conclusions

We may now return to the issues posed at the outset of the paper, beginning with a comparison between the typological approach and that based on the concept of ‘morphological fields’. Unfortunately, the present data offer a rather ambivalent perspective on this issue. On the one hand, the evidence for relatively limited variability among the choppers (e.g. low coefficients of variability on attributes that

are independent of shape, and unimodal frequency distribution curves for the same attributes) rather strongly suggest that the intuitively based type—in this case, a very restrictive one—does reflect design criteria for the tools. On the other hand, there are data from the scrapers (especially, but also the choppers) which imply that, beyond certain very broad formal criteria, morphological distinctions are more or less irrelevant, while metrical ones are crucial; size, in other words, apparently mattered much more than shape in designing discrete kinds of tools within a broad morphological field. Interestingly enough, Stiles *et al.* (1974) have developed a parallel demonstration of the importance of size as a design criterion in the chert flake assemblage at HWK East (levels 3 and 4). This suggests that, while the typological approach is not without merit for comparative studies of early Lower Paleolithic tools, the types recognized need to be carefully assessed against criteria of the sort that can come from the analysis

TABLE 9. Relative frequencies (%) of scraper edge shapes.*

Site†	cx	cv	n	p	d	s	ir	N
1 . .	16,7		50,0	11,1			22,2	18
2 . .	40,6	3,1	31,3	3,1	3,1	3,1	15,6	32
3 . .	56,3	6,3	12,6	6,3		6,3	12,5	32
4 . .	44,4	7,4	25,9				14,8	27
5 . .	25,0	75,0						4
6 . .	47,1	11,8	5,9	11,8		11,8	11,8	17
7 . .	35,5	6,5	29,1	6,5		9,7	12,9	31
8 . .	30,6	2,8	25,0	5,6	8,3		27,8	36
9 . .	42,3	11,5	19,2			15,4	11,5	26
10 . .	33,3		33,3			16,7	16,7	6
11 . .	66,7		16,6			8,3	8,3	12
12 . .	25,0	25,0			25,0	25,0		4

* cx = convex p = pointed s = straight
 cv = concave d = denticulate ir = irregular
 n = nosed
 † See Table 4 for site key.

TABLE 11. Scraper LSD analysis.

SAX (F prob. = 0,001) Industries*†					SBX (F prob. = 0,001)				
4	5	1	3	2	5	4	1	3	2
4	—	×	×	×	5	—	×	×	×
5	—	×	×	×	4	—	×	×	×
1	—	—	—	—	1	—	—	—	—
3	—	—	—	—	3	—	—	—	—
2	—	—	—	—	2	—	—	—	—

Length (F prob. = 0,001)					T Max (F prob. = 0,000)				
5	4	1	3	2	4	5	1	2	3
5	—	×	×	×	4	—	×	×	×
4	—	×	×	×	5	—	×	×	×
1	—	—	—	—	1	—	—	—	—
3	—	—	—	—	2	—	—	—	—
2	—	—	—	—	3	—	—	—	—

Edge L (F prob. = 0,001)					Circum. (F prob. = 0,000)				
4	5	1	3	2	5	4	1	3	2
4	—	×	×	×	5	—	×	×	×
5	—	×	×	×	4	—	×	×	×
1	—	—	—	—	1	—	—	—	—
3	—	—	—	—	3	—	—	—	—
2	—	—	—	—	2	—	—	—	—

T Max/Length (F prob. = 0,000)				
4	5	1	2	3
4	—	×	×	×
5	—	—	—	×
1	—	—	—	×
2	—	—	—	—
3	—	—	—	—

* See Table 5.
 † × = significant difference (0,05 level).

TABLE 10. Chopper LSD analysis.

Chord (F prob. = 0,047) Industries*†					
5	1	3	4	2	
4	—	×	×	×	×
1	—	—	—	—	—
3	—	—	—	—	—
5	—	—	—	—	—
2	—	—	—	—	—

Axis (F prob. = 0,017)					
5	4	1	3	2	
4	—	—	×	×	×
5	—	—	—	—	×
1	—	—	—	—	—
3	—	—	—	—	—
2	—	—	—	—	—

Maxdim (F prob. = 0,000)					
5	4	1	2	3	
4	—	—	×	×	×
5	—	—	×	×	×
1	—	—	—	—	—
2	—	—	—	—	—
3	—	—	—	—	—

* See Table 2.
 † × = significant difference (0,05 level).

TABLE 12. Quantitative chopper and scraper attributes.

Chopper Attributes N = 288			
	\bar{x}	s	V
End flakes	0,76	0,75	99
Scar total	4,6	1,8	40
Axis*	68	17	26
Max. dim.*	84	19	22
Chord*	54	19	36
Chord/axis	0,82	0,28	34

Scraper Attributes N = 245			
SAX*	48	21	44
SBX*	44	22	50
Length*	57	24	42
Max. thickness*	36	23	63
Edge length*	86	53	62
Circum.*	158	71	45
Scars	5,4	2,2	42
SBX/SAX	0,94	0,32	34
Edge length/circum.	0,56	0,33	59
Thickness/length	0,62	0,30	48

* Values for \bar{x} in mm.

TABLE 13. Variability in scraper attributes.

Site	Circ. ($\bar{x}=158$)			T Max ($\bar{x}=36$)			Length ($\bar{x}=57$)			Axis ($\bar{x}=46$)‡			T Max/Length ($\bar{x}=0,62$)		
	\bar{x}	d*	% d†	\bar{x}	d	% d	\bar{x}	d	% d	\bar{x}	d	% d	\bar{x}	d	% d
Koobi Fora	122	36	22,8	29	7	19,4	43	14	24,6	36	10	21,7	0,70	0,08	12,9
DKI	166	8	5,1	38	2	5,5	58	1	1,8	47	1	2,2	0,63	0,01	1,6
FLK I	134	24	15,2	32	4	11,1	52	5	8,8	40	6	13,0	0,62	0,00	0,0
FLK North	160	2	1,3	39	3	8,3	58	1	1,8	47	1	2,2	0,65	0,03	4,8
FLK NNI	152	6	3,8	25	11	30,5	53	4	7,0	45	1	2,2	0,43	0,19	30,6
HWK East	112	46	29,1	20	16	44,4	40	17	29,8	33	13	28,3	0,47	0,15	24,2
TK II	135	23	14,5	22	14	38,9	50	7	12,3	41	5	10,9	0,44	0,18	29,0
Sts	179	21	13,3	46	10	27,8	63	6	10,5	51	5	10,9	0,74	0,12	19,3
Sk	200	42	26,6	52	16	44,4	72	15	26,3	57	11	23,9	0,73	0,11	17,7
EF-HR	164	6	3,8	34	2	5,5	59	2	3,5	47	1	2,2	0,53	0,09	14,5
RHS	217	59	37,3	50	14	38,9	75	18	31,6	61	15	32,6	0,74	0,12	19,3
MHS	175	17	10,7	41	5	13,9	75	18	31,6	55	9	19,6	0,50	0,12	19,3
Totals		183,5		288,6			189,6			169,7			19,3		

* Difference (regardless of sign) between \bar{x} for site and \bar{x} for whole sample on a given attribute.

† d expressed as a percentage of \bar{x} for the whole sample.

‡ Average value of the SAX and SBX.

of morphological fields. Given the crudity of the artefacts, it is doubtful whether analyses of the sort illustrated by Sackett (1966) would prove relevant in this connection, and the present study may provide a more useful model.

Turning to the taxonomic issues outlined earlier, it seems clear that one cannot conceptualize 'tradition' in the early Lower Paleolithic in the same way one does in more evolved industries, i.e. as formal properties of tools that are initiated and maintained by social processes (cf. Isaac 1972a: 400-1). Nevertheless, a modified concept of 'tradition' is surely involved in the broad kinds of typological and metrical similarities and differences at which this study is aimed. One envisions a common social matrix to account for the similarities manifested and a major social schism for differences among contemporary artefact occurrences. Perhaps what is shared between the two ways of conceptualizing 'tradition' is the idea of common social matrix, while the major difference lies in there being no necessary connotation of sustained social interaction in early Lower Paleolithic traditions. It certainly does not seem necessary to invoke sustained social interaction in order to account for the very gross kinds of formal and metrical continuities that exist among physically discrete assemblages of early Lower Paleolithic tools.

In so far as one can speak of 'traditions' in early industries, it seems to me that the data at hand suggest overriding continuities in both the scrapers and the choppers, with minor discontinuities separating the Lower Acheulean and South African sites from all of the others—and perhaps also from each other. Among the more impressive evidence for continuity is the fact that virtually all of the attributes related to shape and/or manufacturing technique are relatively stable in both classes of tool; especially

noteworthy in this connection are the persistent edge shape distributions for both the choppers and the scrapers. Even in the size-related attributes of the scrapers, some sites representing both Oldowan and Lower Acheulean occurrences (DK I, FLK I, FLK North, and EF-HR; see Tables 4 and 13) are generally very close to the mean values for the whole sample—and, of course, to one another.

However, the size-related attributes discriminate rather consistently in both classes of tools between the Lower Acheulean and South African sites, on the one hand, and the Oldowan, on the other. Moreover, Leakey (1971: 270 & ff.) has shown that the Lower Acheulean bifaces differ from those of the Developed Oldowan in having more consistent mean diameters, somewhat lower and less varied values for breadth (length and thickness/length ratios, and smaller numbers of flake scars, averaging 9,7 for the Lower Acheulean, 18 for site SHK, and 16,5 for site B1, both of which are Developed Oldowan occurrences (see also Isaac 1967). In addition, Isaac (1969) has argued that the capacity to strike large flakes (maximum diameter greater than 10 cm) is an innovation of the Lower Acheulean.

There is some evidence for a distinction between the South African sites (which also contain small numbers of bifaces (Leakey 1970)) and all others in the chopper edge shapes (Table 8). Differences between the Developed Oldowan and Oldowan Industries, as well as internal differences in the Developed Oldowan (A and B phases), have been discussed in the Introduction.

In summary, it would seem that, while certain persistent features link all of the sites in this study, the Lower Acheulean and South African sites stand apart at one level, while the Bed I Oldowan, Developed Oldowan A, and Developed Oldowan B

differ from one another at a lower level. Only the differences between the Bed I Oldowan and Developed Oldowan and between the two phases of the Developed Oldowan seem to be time dependent, although there is some degree of chronological overlap among these entities; the age of the South African material is, as I have earlier indicated, very insecure, and the Lower Acheulean substantially overlaps the Developed Oldowan. There is some evidence in the present data for geographic distinctions: in addition to the unique properties of the South African material noted above, there are indications in Tables 8, 9, and 13 that the Koobi Fora sites may differ slightly from all of the others.

A reasonable taxonomic interpretation of these relationships would be:

Industrial Complex	Oldowan
Industry	Oldowan
Phase	Bed I Oldowan Developed Oldowan A Developed Oldowan B
Industry	Oldowan of Acheulean Tradition (= Lower Acheulean)
Industry (tentative)	Krugersdorp (= South African) Oldowan

The major differences between this scheme and Leakey's (see Introduction) lie in distinguishing the South African materials from the Developed Oldowan and in including the Lower Acheulean in the Oldowan Industrial Complex. The assignment of the South African material must, however, remain tentative until an adequate sample of tools has been excavated under controls appropriate to what is now known of the stratigraphy of the sites. The reassignment of the Lower Acheulean material implies that, rather than being an intrusive element (Leakey 1971: 269), the industry is likely to have been evolved out of local 'traditions'.

There is little I can add to what has already been said about design criteria and standardization in the Oldowan Complex. In summary, it appears that:

- (1) discrete forms seem to have been conceptualized out of broad, morphological fields, and individual tools fairly closely patterned on them despite variation in size;
- (2) despite the rather amorphous appearance of many of the tools, certain rather detailed features, such as the edge shapes of both choppers and scrapers and the scar ratios of choppers, seem to have been design foci;
- (3) in the choppers, raw material was 'allowed' to control the number of flakes detached, while the number of flakes removed from scrapers was relatively invariant, differences in size and raw material notwithstanding; and
- (4) perhaps the most crucial design feature was overall size of the piece.

In connection with the last observation, I regret not having collected data on volume, but this is the wisdom of hindsight. I also suspect that more detailed data on rock types might prove rewarding. There is undoubtedly a large reservoir of as yet untapped information locked in the Oldowan tools.

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