
The use of expert systems in lithic analysis

*Roger GRACE**

RÉSUMÉ

Dans cet article, nous présentons l'emploi de systèmes experts pour l'analyse fonctionnelle, technologique et typologique des outils en pierre. Les systèmes experts sont des programmes informatiques qui « modélisent » le comportement des experts. Le savoir et le raisonnement d'un expert humain sont incorporés dans le programme informatique sous forme d'une série de règles formelles et de définitions précises des variables utilisées par l'expert pour son analyse. Ce genre de systèmes peut assimiler des données plus complexes que celles que le cerveau humain est capable de traiter, et il approche de l'intelligence artificielle. L'usage de ces systèmes experts donne des résultats plus précis dans l'interprétation de la fonction des outils en pierre. Dans les tests aveugles, ils ont produit de meilleurs résultats qu'un expert humain individuel. Étant donné que les programmes technologiques et typologiques sont régis par des règles formelles plutôt que par les caprices d'experts humains, les résultats en sont tout à fait cohérents, et l'on peut donc effectuer des comparaisons directes entre analyses différentes.

ABSTRACT

This paper presents the use of expert systems for the functional, technological and typological analysis of stone tools. Expert systems are computer programs that « model » the behavior of experts. The knowledge and reasoning of the human expert are incorporated into the computer program as a series of explicit rules and precise definitions of the variables used by the expert for analysis. Such a system can accommodate more complexity than the human mind is capable of handling, and it is on the threshold of Artificial Intelligence. The use of such expert systems produces more accurate results in interpreting the function of stone tools. In blind tests, better results have been achieved than by any individual human expert. As the technological and typological programs are governed by explicit rules, rather than the vagaries of human experts, the results produced are entirely consistent, and therefore direct comparisons can be made between different analyses.

Introduction

The need to correlate all the different variables involved in microwear analysis, including the

morphology of the tools and low power use-wear, such as macrofractures, is accepted by even the most enthusiastic proponents of distinctive microwear polishes. For example, in the paper by

Bamforth *et al.* (1990), it is stated that « the high-magnification approach relies largely, although not solely, on differences in the appearance of polishes... » (*ibid.* : 414), but « *all* (authors' italics) possible sources of information should be used to support an interpretation, including all varieties of microwear traces, overall tool size and shape and archaeological context » (*ibid.* : 415), and « ... successful interpretations of stone tools, uses depend on as many lines of evidence as possible and do not derive solely from the examination of polishes » (*ibid.* : 416). So that the concentration on the observation of the appearance of polishes has now been largely abandoned in modern microwear analysis. It is interesting to note that, when there is an apparent discrepancy between the appearance of a polish and other sources of information, the distinctive nature of the polish is rejected. As in the case of tool number 3 in a blind test, « the smooth, inflated character of the most developed polish on the edge might result from plants, but the edge damage and abrasion make this unlikely. This tool was probably used on wood. » (Bamforth *et al.*, 1990 : 417). So that the « edge damage » and « abrasion » take priority over the « distinctive » appearance of the polish, when correctly interpreting the worked material of this tool in the blind test.

Expert systems

The simultaneous examination of all these different sources of use-wear information in a consistent and coherent manner would be an advantage in obtaining more accurate results in microwear analysis. In the multi-dimensional method (Grace *et al.*, 1988), there are 33 interdependent variables, and an expert system has been developed in order to process this data ; « an expert system is a computer program which uses non-numerical domain-specific knowledge to solve problems with a competence comparable with that of human experts » (Doran, 1988).

The reason for using the expert system approach is that microwear analysis has been developed from the experience and expertise of practitioners. This has led to problems in the development of use-wear methodology because much of the

knowledge required for microwear analysis has been empirical and related to the specific research of the individual practitioner. This subjective and individual knowledge has then been transferred to completely different circumstances, without any understanding of the processes that are involved. Because knowledge has been acquired in this way, a major failing has been the lack of explicitness both in the nature of the data and in the reasoning behind the interpretation of that data, as the basic interpretive technique has been analogy. If use-wear on an archaeological tool matches that on an experimental tool, both sets of use-wear are assumed to have been derived from the same set of circumstances, without any explanation of why that should be, or whether the same set of use-wear attributes can arise out of different activities. That is, an archaeological tool was used for scraping wood because it has use-wear which looks like that on a tool that was experimentally used for scraping wood. Practitioners that have concentrated on polishes go even further by saying it is « wood polish » because it looks like polish experimentally produced by working wood, while they admit they cannot explain why wood polish should be any different from any other polish. The data is recorded in a non-systematic way mainly using vague descriptions. The blind test tool mentioned above is described as having edge damage and abrasion (Bamforth *et al.*, 1990 : 417), but edge damage and abrasion are not defined, and no values are placed on these variables. It is simply stated that the edge damage and abrasion do not look like those produced by contact with plants. This leaves the reader in no position to assess whether they agree with these statements about the data or the reasoning. The first major advantage of using an expert system for microwear analysis is the act of writing it.

« The process of developing an expert system has an indirect benefit also since the knowledge of human experts must be put into an explicit form for entering in the computer. Because the knowledge is then explicitly known instead of being implicit in the expert's mind, it can be examined for correctness, consistency and completeness. The knowledge may then have to be adjusted or re-examined, which improves the quality of the knowledge. » (Giarratano, Riley, 1989 : 5).

The *fast* expert system

Figure 1 : A illustrates the flow chart for the *FAST* (Functional Analysis of Stone Tools) expert system computer program. The first stage in the development of an expert system is to design the data base for storing the information in such a way that it can be easily accessed and input into the program. The Hypercard™ application used on Apple Macintosh™ computers is ideal for this, as its design is based on the idea of a card index file (hence Hypercard). The data card for the recording of the data is illustrated in figure 1 : B. Each data card of a used tool is linked to an outline drawing of that tool (fig. 1 : C). The data is automatically entered into the data cards by accessing a card for each variable that contains the values that the variable may take, and then « pressing » the appropriate button using the computer « mouse ». In the example of fracture types (fig. 1 : E), these are flakes, steps, snaps, flakes and snaps, flakes and steps, flute, burin, torsion, retouch, others (combination of fractures other than those mentioned) and absent. The definition and description of these fracture types are contained in a comprehensive manual that accompanies the expert system, and each variable and its respective values are described in Grace 1989. As a reminder, each variable card is linked to an example card (fig. 1 : D, for fracture types).

The data is then transferred into the *FAST* program. Each attribute, that is the value of each variable (e. g. edge angle of 50 degrees), is used to give an indication of motion or hardness of material, or both, according to a set of rules. For example, the variable edge angle is divided into ranges so that the value of the edge angle for a particular tool will fall within one of those ranges, giving the corresponding indication, i.e., if the edge angle = 42 degrees, this indicates « cutting or scraping a medium material » (as in the example of tool 33 in fig. 1). Note that the absence of a value for a variable can be diagnostic. The data in figure 1 : B shows the absence of rounding for tool 33, together with an edge angle of 42 degrees ; this indicates a « soft to medium material », because, if the worked material had been hard, then some rounding would have been expected on a 42 degree angled edge. Conversely, the value of a variable may be non-diagnostic. For example, there are microflakes on the ventral surface of tool 33, but, as flake

fractures can occur with almost any motion and with any worked material, the presence of these flakes is non-diagnostic. With retouched edges, the value « retouch » is entered because of the difficulties of separating use-wear fractures from retouch.

This process is repeated for each attribute. The program automatically assesses the attributes and enters the relevant indications into two cards, one of which contains information concerning macro-observations (use-wear seen by eye and with low magnification, fig. 1 : F), and the other card contains the indications derived from micro-observations (use-wear seen with high magnification, fig. 1 : G).

The syntax for these variable rules is very simple and takes the form of,

IF [condition] THEN PUT [indication].

For example, IF (edge angle < 30 degrees) THEN PUT (cutting soft material).

The rules may be more complex, involving 2 or more conditions to take account of the interaction between different variables.

For example ; IF (fractures are absent) AND (edge angle > 30 and < 60) THEN PUT (medium material).

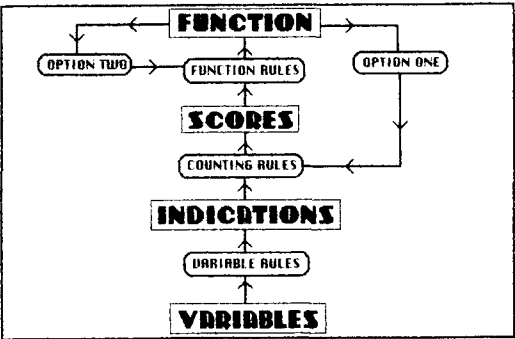
The parameters contained in these rules are derived from observations of experimental tools. The indications are then counted, again according to a set of rules.

For example,

EACH VARIABLE COUNTS AS TWO POINTS [except thickness, which has a maximum of 1]. This is because thickness only has two values (≤ 4 mm or > 4 mm) and is not very discriminatory and consequently less important. Therefore, it carries less « weight ».

IF EITHER SURFACE HAS TWO INDICATIONS, THEN EACH COUNTS 0.5 POINTS UNLESS OTHER SURFACE IS « retouch », « no polish » OR « no effect » THEN THEY COUNT ONE POINT EACH. If an indication contains two alternatives such as «SOFT/MEDIUM for microrounding (as in fig. 1 : G), then SOFT would receive 0.5 point, but doubled to 1 point because the other surface is retouched.

« NON-DIAGNOSTIC » COUNTS NO POINTS, is self-explanatory.

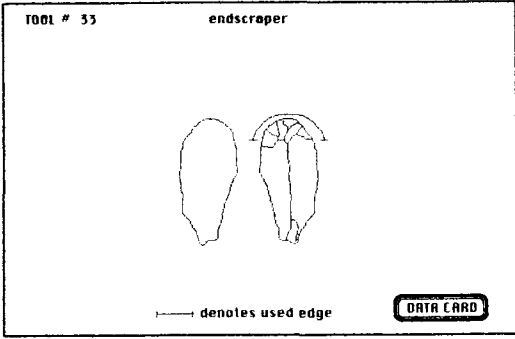


A

TOOL #	55	TYPE	endscraper	EDGE ANGLE	42
GRAINSIZE	fine			LENGTH	28
TOPOGRAPHY	flat			THICKNESS	6
TOPOGRAPHIC FEATURES	absent			PROFILE	0.56
				SHAPE	0.53
EDGE WEAR					
		macro	VENTRAL	macro	DORSAL
GLOSS	absent	absent	micro	retouch	micro
FRACTURES	absent	absent	<5	retouch	retouch
FRACTURE TYPE	absent	flakes	retouch	retouch	retouch
ROUNDING	absent	absent	retouch	retouch	retouch
MICROTOPOGRAPHY	flat		retouch		
DISTRIBUTION	continuous		retouch		
DISTRIBUTION TYPE	edge only even		retouch		
INVASIVENESS	<0.5		retouch		
LINEAR FEATURES	perpendicular		retouch		
STRIATIONS	perpendicular		retouch		
POLISH DEV.	C		C		

FAST

B

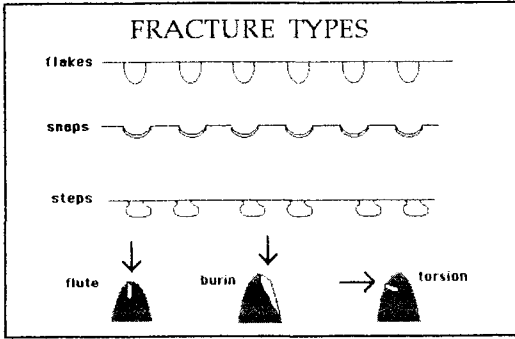


C

MICRO FRACTURE TYPE - DORSAL

FLAKES	FLUTE
STEPS	BURIN
SNAPS	TORSION
FLAKES & SNAPS	RETOUCH
FLAKES & STEPS	OTHERS
ABSENT	

D



E

MORPHOLOGY 33 endscraper

ANGLE	CUTTING/SCRAPING MEDIUM	
LENGTH	SCRAPING	
THICKNESS	SCRAPING	
PROFILE	SCRAPING	
SHAPE	SCRAPING	
VENTRAL MACRO DORSAL		
GLOSS	NON-DIAGNOSTIC	RETOUCH
FRACTURES	MEDIUM	RETOUCH
TYPES	NON-DIAGNOSTIC	RETOUCH
ROUNDING	SOFT/MEDIUM	RETOUCH
per percussion scraping 8 projectile		
MOTION whittling boring soft 1		
rotational piercing medium 5		
cutting 1 grooving hard 1		

F

MICRO 33 endscraper

FRACTURES	SOFT/MEDIUM	RETOUCH
TYPES	NON-DIAGNOSTIC	RETOUCH
ROUNDING	SOFT/MEDIUM	RETOUCH
TOPOGRAPHY	NO EFFECT	RETOUCH
DISTRIBUTION	NON-DIAGNOSTIC	RETOUCH
TYPE	NON-DIAGNOSTIC	RETOUCH
INVASIVENESS	SCRAPING	RETOUCH
LINEAR	SCRAPING	RETOUCH
POLISH DEVELOPMENT	SOFT or time [HARD]	SOFT or time [HARD]
per percussion scraping 4 projectile		
MOTION whittling boring soft 4		
rotational piercing medium 3		
cutting grooving hard 1		

G

MACRO 33 endscraper

PERCUSSIVE	0
WHITTLING	0
ROTATIONAL	0
SCRAPING	8
CUTTING	1
GROOVING	0
PROJECTILE	0
BORING	0
PIERCING	0
SOFT	1
MEDIUM	5
HARD	1

FUNCTION

TRANSFER

MOTION

SCRAPING

HARDNESS

SOFT/MEDIUM

MATERIAL

HIDE

H

Fig. 1. FAST expert system.

« GROOVING », « WHITTILING » and « PERCUSIVE » scores are doubled. This is because the attributes that indicate these motions are more diagnostic than others, and so this a method of weighing the variables.

The results of the counting rules are entered as SCORES into the interpretation card. In the example, this gives 12 indications of scraping, 1 of cutting, 5 of a soft material, 8 of a medium material and 1 of a hard material (fig. 1 : H). Then the function rules are applied. For example,

IF « cutting » ≤ 4 AND « scraping » > 8 AND
« grooving » ≤ 2 AND « whittling » ≤ 2
THEN PUT « SCRAPING »

IF « soft » ≥ 4 and ≤ 8 AND « medium » ≥ 0 and
 ≤ 2 AND « hard » = 0
THEN PUT « SOFT »

IF « soft » ≤ 6 AND « medium » ≥ 5 AND « hard »
 ≤ 4
THEN PUT « WOOD »

More complex rules involve combining motions with materials, and in certain cases also include morphological information concerning the tools.

IF « soft » ≥ 2 and ≤ 6 AND « medium » ≤ 8 AND
« hard » < 2 AND MOTION $\neq$ « whittling » OR
« boring/drilling » OR « grooving » OR « chopping/
adzing »
THEN PUT « HIDE »

This rule is constructed in this way because whittling, boring, drilling, grooving, chopping and adzing are motions unlikely to be used on hide.

IF « soft » = 0 AND « medium » ≥ 3 AND « hard »
 ≥ 8 AND MOTION $\neq$ « whittling » OR « cutting » OR
« piercing » OR « chopping/adzing » OR « grooving »
AND SUBTYPE $\neq$ « facet » (when referring to a
burin)
THEN PUT « STONE »

This rule is constructed in this way because whittling, cutting, chopping and adzing are unlikely motions to be used on stone, and grooving stone is more likely to be carried out with the burin « bit » rather than the « facet »

If the scores for motions and materials fall within the parameters in the program, then an interpretation will be made of motion, hardness of material and precise worked material. In the case of the example tool 33, the program gives SCRAPING a SOFT/MEDIUM material, probably HIDE (fig. 1 : H), which is correct, as tool 33 was an experimental tool used in a blind test (Grace *et al.*, 1988). If the scores do not fall within the parameters for motion, hardness or worked material, then the program gives « INSUFFICIENT DATA ». This will apply if there is insufficient use-wear on the tool to be diagnostic or if the use-wear is not consistent with a particular use. That is, it does not match the use-wear of tools in the reference collection of experimental tools from which the parameters were derived. This means the program can suggest a material that has not been studied by experimentation and so is not included in the program. Tool 44 used on cortex is an example (Grace, 1989).

Prior to the development of the expert system computer program, the interpretation of each attribute had to be done by assessing the information and the complex interrelationship between attributes in one's head, as it is where. *FAST* carries out this process automatically. This not only speeds up the process, but makes it completely consistent, as the same set of rules are applied each time. The 20 tools used in the last blind test carried out at the Institute (Grace *et al.*, 1988) were used to determine the parameters by which the rules were applied in order to make the functional interpretations. That is, the data that was recorded for that blind test was used as the training data for developing the program. The efficacy of the program is demonstrated by its achieving a result of 18 out of 20 correct interpretations of precise worked materials. The two tools that were not correctly identified were tool 38, for which the computer gave « insufficient data » (used on bark), and tool 44, which was designated « insufficient data » (this being used on cortex which was not programmed into the computer). The same scoring system as used in the blind test was applied ; therefore, to achieve a point, the precise worked material had to be identified. If the tool was used on antler, then only an answer of antler was awarded a point, not alternatives like bone/antler. This 90 % success rate is a significant increase on the result achieved by any of the analysts in the original blind test, the

maximum score achieved being 60 %. However, as the blind test data was used to develop the program, this high rate of success is misleading. The real test of the program is when a completely new set of data is used. The first 10 tools used in blind tests at the Institute (Newcomer *et al.*, 1986) were observed, and the data recorded, and then used to test the program. Of the 10 test tools, one was unused, and another was used as a projectile point that struck unknown material, leaving 8 precisely known materials that the tools were used on. Of these 8 tools, the precise worked material on which 6 of them had been used was identified by the program. The two not identified were tool 2, for which the computer gave « insufficient data » (actually used on shell), and tool 10, for which the computer gave « antler », but which was used on wood. In the original test, only two of these 8 were correctly identified. Though the function of these tools was known, this was a blind test as the computer did not have this information. Every time the *FAST* program is run constitutes a blind test.

The use of expert systems for functional analysis has improved the methodology in a number of ways :

1. Increased accuracy (table 1).
2. Reduction of the time required for analysis. In the original blind test (Newcomer *et al.*, 1986), each analyst had the tools for two weeks. The analysis of the same tools by *FAST* took 2 hours.
3. Increased consistency and standardization. The development of an expert system means that the observational techniques have to be systemized, and the rules provide a basis on which results can be assessed. Two analysts using the same program will obtain the same results.
4. The expertise gained over many years of research is made available to less experienced practitioners. One of the features of expert systems is that « the expert system may act as an intelligent tutor by letting the student run sample programs and explaining the system's reasoning. » (Giarratano, Riley, 1989 : 5). The *FAST* program is currently being used as a teaching program for learning use-wear analysis.

If the *FAST* results for the tools used in all blind tests at the Institute of archaeology (Newcomer *et al.*, 1986 ; Grace *et al.*, 1988) are combined, an estimation of the accuracy of *FAST* can be made.

	Motion	Hardness	Material
MACRO			
correct	97 %	66 %	28 %
insufficient data	0 %	31 %	44 %
wrong	3 %	3 %	28 %
MICRO			
correct	100 %	97 %	83 %
insufficient data	0 %	3 %	10 %
wrong	0 %	0 %	7 %
n = 29			

Table 1.

This means, at the level of motion and relative hardness, macrowear gives 66 % correct identifications, with only a 3 % error, the remainder being unidentifiable and therefore omitted from the calculation of functional configuration (see below). Microwear gives 97 % correct identifications, with a 0 % error of motion and hardness, but of course takes much longer, whereas macrowear can be applied to far larger samples. At the level of correct motion and precise worked material, macrowear only achieves 28 %, with a 28 % error. This low rate of success is to be expected when using only macro-use-wear information. Microwear gives 83 % correct identifications at the precise worked material level, with a 7 % error.

Whereas practitioners concentrating largely on polishes have now abandoned any attempt to separate identification of bone as opposed to antler, the *FAST* program still achieves this distinction. Of the 3 tools used on bone and the 5 tools used on antler, all were correctly identified. Three of the tools used on antler were used on soaked antler and, the program correctly identified 2 of these as being used on soaked antler. So, in terms of separating bone and antler, the *FAST* program achieves 100 % success with this sample, and can even separate soaked from dry antler in 4 out of 5 cases.

These figures compare favorably with those of the latest published blind test (Bamforth *et al.*, 1990), which, accepting the figures as published (*ibid.* : 425), achieve a success rate of 81 % for motion (as compared to 100 % for *FAST*) and 65 % for worked material (as compared to 83 % for *FAST*). If the same rigor of precision was applied to this test as is required of *FAST*, then these scores for the Bamforth *et al.* test would have to be re-assessed. For example, tool 11 was used for cutting fish ; the interpretation of cutting meat is regarded as correct on the grounds that « if we can accept that fish is

a type of meat (or at least a type of flesh), the interpretation... is essentially correct. » (Bamforth *et al.*, 1990 : 420). This answer would have received no points in a blind test used to test *FAST*. Also, the results from *FAST* on test tools 1-10 refute the claim that « the poor results in the Institute blind tests derive from attempts to interpret uninterpretable traces of use ... » (*ibid.* : 428). The tools are the same tools, the difference is the method, demonstrating that an expert system that incorporates all kinds of use-wear traces, of which polish is only one, increases « the sophistication of this method of analysis. », which Bamforth *et al.* call for (*ibid.* : 429).

The lithan expert system

A development of the use of expert systems is to integrate the results of functional analysis with typological and technological information. Towards this aim, a new expert system has been developed for the classification of the technology and typology of tools. This program is referred to

as *LITHAN* (LITHic Analysis of stone tools). This expert system follows the same procedures as *FAST*. Figure 2 : A illustrates the data card. Metrical attributes of the tools such as length, width and thickness are entered, and then non-metrical attributes are entered by accessing cards with the alternative values of each variable and « pressing » the appropriate button. For example, for the position of retouch; distal, left lateral, right lateral, proximal or dorsal ridge, in the case of crested tools (fig. 2 : B) Each of these cards is linked to another card that explains the values (fig. 2 : C).

Rules are then applied to interpret the blank type, knapping technology, hammer mode, amount of cortex, and the « type » of tool. Blanks can be blade, bladelet, flake, chip, fragment or chunk. Knapping technology can be blade, flake or Levallois. Hammer mode will be soft or hard, and cortex is broken down into 4 categories, dependent on the percentage of surface that is cortical (this information being useful in the reconstruction of reduction strategies). In the case of tool 33, this gives a non-cortical morphological flake that was made using a blade technology with soft hammer

TOOL # 33

TOOL length 39 width 29 thickness 6

mid-point width 29 mid-point thickness 6

PLATFORM width 45 thickness 2 type prepared

LATERAL EDGES parallel DORSAL RIDGES parallel

CORTX none

PERCUSSION no point no cone no marks

BUTT un-lipped

BULB diffuse

RETOUCH none

POSITION OF RETOUCH distal

RETOUCH TYPE use continuous uni-facial

EDGE FORM unretouched

END FORM round

LITHAN

A

POSITION OF RETOUCH

DISTAL

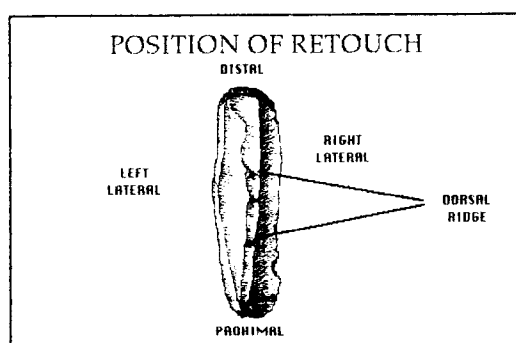
LEFT LATERAL

RIGHT LATERAL

PROXIMAL

DORSAL RIDGE

B



C

TOOL # 33

BLANK FLAKE

TECHNOLOGY TECHBLADE

HAMMERMODE SOFT HAMMER

CORTX NON-CORTICAL

TYPE

END SCRAPER

TRANSFER

D

Fig. 2. LITHAN experts system.

and is an endscraper (fig. 1 : C and fig. 2 : D). Often, there is insufficient data to identify such categories as knapping technology or hammer-mode, particularly when the tools are broken and the proximal end is missing. In such cases, they will be designated « indeterminate ».

Examples of rules :

BLANK TYPE : if length/width ratio > 2 and width < 12 mm. then put « BLADELET »

TECH TYPE : if platform Thickness < 5 and ButtType = « prepared » and Sides = « parallel » and Ridges = « parallel » then put « TECHBLADE »

HAMMERMODE : if percussion Cone = « no cone » and butt = « un-lipped » and bulb = « diffuse » then put « SOFT HAMMER »

TYPE : if diff (length - width) > 0 and distal Retouch = « DISTAL » then put « END SCRAPER »

General categories like endscraper are further subdivided by applying secondary rules :

1. if endForm = « ROUND » then put « END SCRAPER »
2. if endForm = « CARINATED » then put « CARINATED END SCRAPER »

The actual rules run to some 20 pages of programming in order to cover as many alternatives as possible. These rules are being constantly updated and expanded. The main advantage of the *LITHAN* program is consistency, in that anyone using the program will obtain the same results, eliminating some of the idiosyncrasies that often occur with individual typologists. Also, years of experience of a number of typologists are encapsulated in the program so that this accumulated experience is made available to the novice.

The *lithics* data base

The results from *FAST* and from *LITHAN* are then collated into a data base. That is the interpretations are automatically input into a *LITHICS* data base so that each item of debitage, both used and unused, has a card giving the tool's number, type, blank, technology, hammer mode, amount of cortex and, if used, an interpretation of the function of the tool,

both at the macro- and microlevel (fig. 3 : A). In the example of tool 33, the macrofunctional interpretation was of SCRAPING a MEDIUM material, with INSUFFICIENT DATA to identify the precise material ; the microfunctional interpretation is of SCRAPING a SOFT/MEDIUM material, most probably HIDE.

This data base can then be searched to obtain information and statistics. For example, the numbers of each blank type can be automatically generated (fig. 3 : B), and the number of used as opposed to unused tools (fig. 3 : C). Also, the type list is automatically generated and displayed (fig. 3 : D). These statistics and lists are extracted by simply « pressing » the appropriate button to activate the search programs. Then correlations between such things as typology and function can be made, or the kind of tools that were used correlated with blank types that are present in the assemblage etc. Also, functional typology can be automatically extracted.

Functional configuration

Functional interpretations, at the level of the 5 basic motions – cutting, scraping, rotational, percussive and projectiles –, and the 3 hardness categories – soft, medium and hard –, can be extracted (fig. 3 : E) and automatically produced as a graph representing the relative percentages of these functional types (fig. 3 : F). At this level of functional interpretation, a high level of accuracy can be achieved and often obtained by the use of macro-information only (table 1). This considerably speeds up the process of analysis. The resulting functional typology can be interpreted in terms of site function, rather than simply the function of individual tools, by comparing the functional configuration with models of particular kinds of sites (Grace, 1990).

For example, the results produced from applying these expert systems to the Mesolithic site of Thatcham in England and the extraction of the functional configuration from the data base (fig. 4 : A) lead to the interpretation that the site represents a home base (Grace, in press).

The functional configuration of the Thatcham sample has been compared with models of site function. Figure 4c is the functional configuration of a model « kill site » having a high incidence of

TOOL #

TYPE

TECHNO

functional data 

MACRO

MICRO

notes

A

LITHICS DATA BASE

TOOL # FIND

USE ? 10

TYPES ? 5

HAMMER ? 16

BLANK ? 7

TECH ? 3

CORTEN ? 2

FUNCTION ?

B

LITHICS DATA BASE

TOOL # FIND

USE ? 9

TYPES ? 31

HAMMER ? 2

BLANK ? 1

TECH ?

CORTEN ?

FUNCTION ?

C

TPOLOGY

sidescraper	1
backed blade	0
backed bladelet	2
backed flake	1
burin	3
burin spall	2
core	4
core fragment	1
core tablet	2
micro-burin	0
endscraper	0
retouched bladelet	0
piercer	2
TOTAL	25

D

THATCHAM 251

GRAPH SOFT MEDIUM HARD

CUTTING

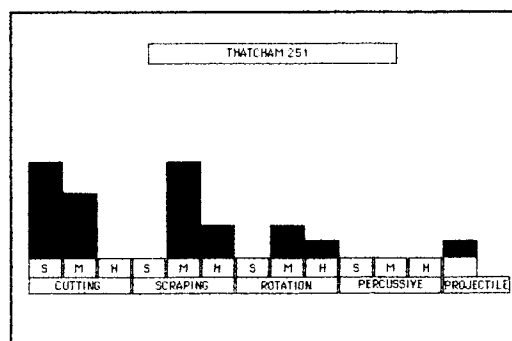
SCRAPING

ROTATIONAL

PERCUSSIVE

PROJECTILE MACRO MICRO

E



F

Fig. 3. LITHICS data base.

cutting (butchering) tools, percussive action on hard materials (joint separation) and projectile points. The model of a « home base » (fig. 4 : B) is derived from the experimental replication of a generalized tool kit where most activities are represented, the exception being percussion on soft materials, which is an unlikely activity. The results suggest that most activities are represented at Thatcham, giving an overall site function of a

« home base » (compare fig. 4 : A and see Grace, in press).

The histograms of « functional configuration » are based on calculating the percentage representation of each functional type in 5 % increments. This procedure exaggerates the representation of functional types having few units. For example, the 5 % « block » for projectile points in figure 4 : A represents only 1 projectile point. This

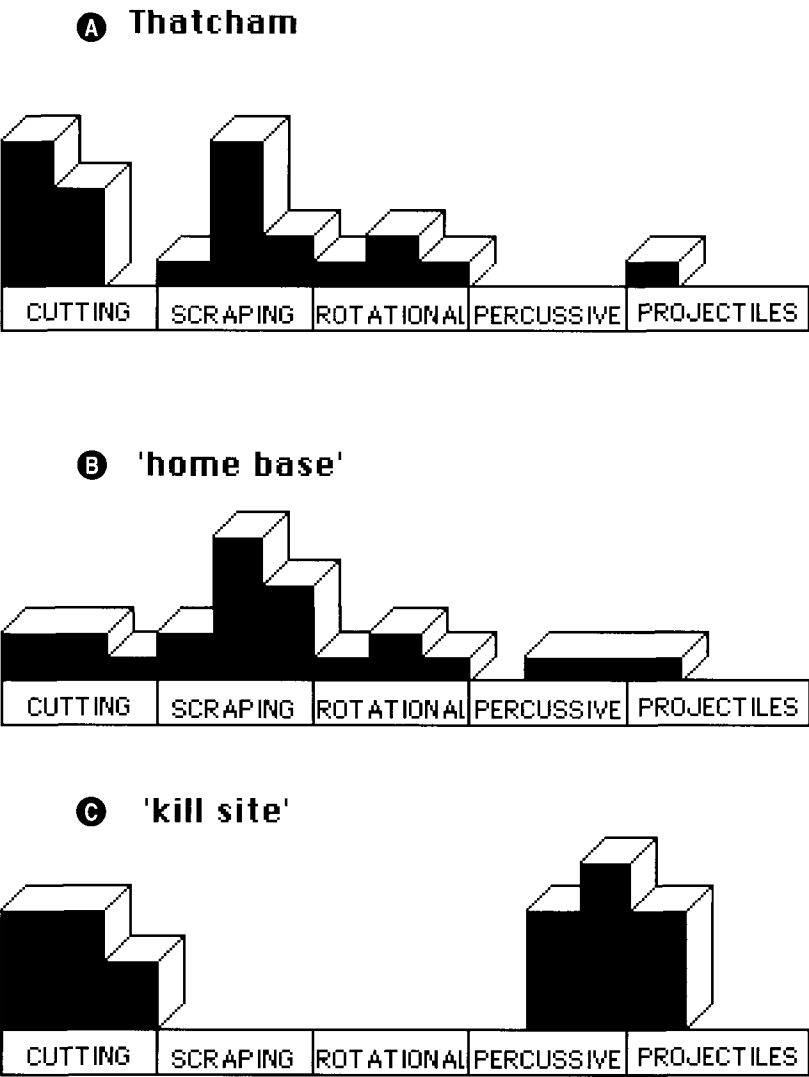


Fig. 4. Materials are in the order soft/medium/hard in each motion category.

procedure is adopted because the histograms are designed to illustrate the spread of activities rather than the absolute numbers or percentages. As illustrated in figure 5, the « shape » of the functional configuration of the histogram reflects the percentage representation of different uses.

Information such as which retouched tools were used and how they were used and how this relates to used unretouched tools, the relationship between blank type and function, the relationship between technology and function, etc., can be easily obtained from searching the data base. Having all this information available helps to understand the lithic assemblage not just in terms of function, but also of all the different aspects of

lithic technology that goes into the production of tools. This in turn helps to understand and reconstruct the process that lies behind the lithic assemblage.

Conclusions

Future developments of this integrated suite of expert systems will include spatial information, so that distributions of types (where the endscrapers are) or blanks (where the blades are) or particular activities (where the hide scrapers are) can be generated, or any combination of these different aspects of the lithic material. So, for example, the

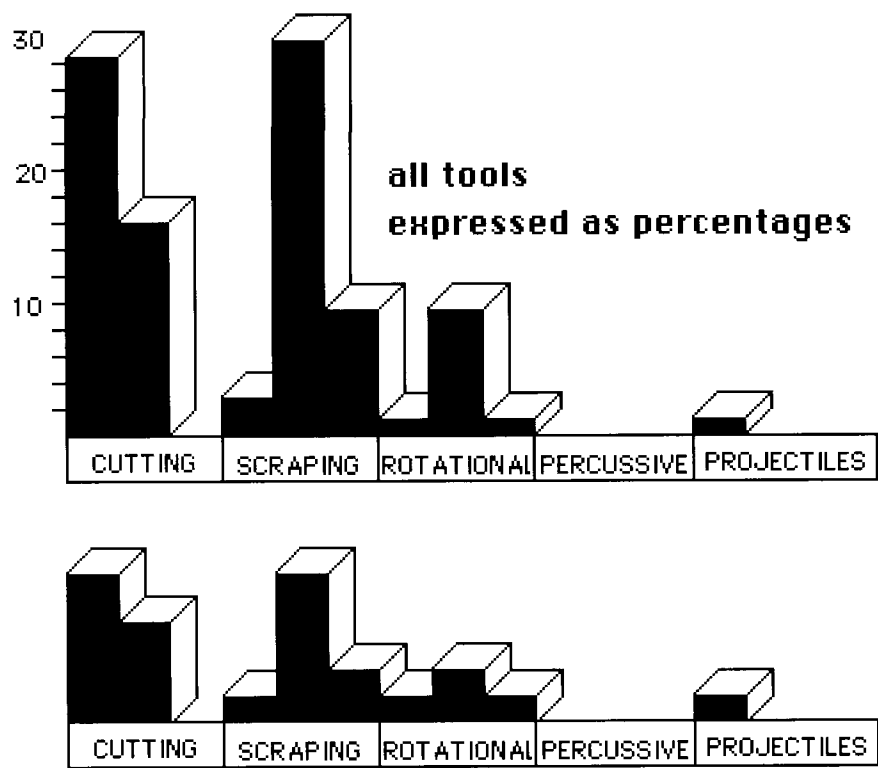


Fig. 5. Materials are in the order soft/medium/hard in each motion category.

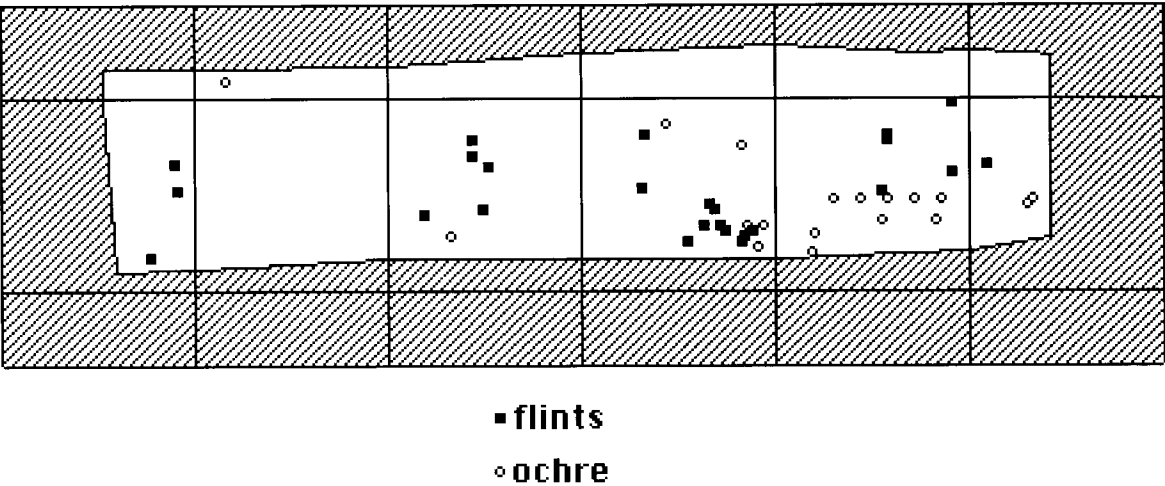


Fig. 6. Distribution of flints and ochre automatically generated from the data base.

locality of a cluster of blades, made into endscrapers and used for scraping hide, could be extracted from the data base and illustrated on a plan. This facility will make possible the recognition of activity areas within a site, not just activities concerned with processing various materials, but also flint knapping areas or « re-tooling » areas could be located. Non-lithic information can also be included. For example, figure 6 represents the spatial distribution of ochre and struck flints from an area from a Mesolithic site in England. The distribution of bone artifacts and any class of lithic artifacts can be generated in this way in order to investigate potential correlations.

The distribution of manufacturing areas, or non-lithic material, together with the location of

hide-scraping areas or bone- and antler-processing areas, for instance, would provide a more comprehensive archaeological context within which the whole picture of human activity at a site could be understood. This in turn would lead to the understanding of the cultural processes that lie behind site formation.

This paper is dedicated to the memory of Irene Levi-Sala. She will be missed as an archaeologist, but, more importantly, she will be remembered as a friend.

* University of Oslo, Institut for Arkeologi,
Kunsthistorie og Numismatikk, Frederiks Gate 3,
0164 Oslo 1, Norway.

Bibliography

- BAMFORTH (B. B.), BURNS (G. R.), WOODMAN (C.), 1990.— Ambiguous Use Traces and Blind Test Results : New Data. *Journal of Archaeological Science*, 17, p. 413-430.
- DORAN (J.), 1988.— Expert systems and archaeology : What lies ahead ? In : Ruggles, Rahtz (Ed.), *Computer and Quantitative Methods in Archaeology*. Oxford, BAR International Series, 446, p. 235-241.
- GIARRATANO (J.), RILEY (G.), 1989.— *Expert Systems : Principles and Programming*. PWS-KENT Publishing Company. Boston.
- GRACE (R.), ATAMAN (K.), FABREGAS (R.), HAGGREN (C. M. B.), 1988.— A multivariate approach to the functional analysis of stone tools. In : *Industries Lithiques : Tracéologie et Technologie*. Oxford, BAR International Series, 411, 2, p. 217-230.
- GRACE (R.), 1989.— *Interpreting the Function of Stone Tool : The quantification and computerisation of micro-wear analysis*. Oxford, BAR International Series, 474.
- GRACE (R.), 1990.— The limitations and applications of functional analysis. In : *The Interpretive Possibilities of Microwear Studies*. AUN 14, Societas Archaeologica Upsaliensis, Uppsala, Sweden.
- GRACE (R.), in press.— Use wear Analysis of the Mesolithic Site at Thatcham, England. To be published in the *Proceedings of the Prehistoric Society*.
- NEWCOMER (M. H.), GRACE (R.), UNGER-HAMILTON (R.), 1986.— Investigating microwear polishes with blind tests. *Journal of Archaeological Science*, 13, p. 203-217.