Application of a new method of typometric study to Paleolithic handaxes

Eduardo Ramil_Rego[1-2], Ana Jesús López_Díaz[3], Alberto Ramil_Rego[4], Santiago Pozo_Antonio[5]

[1] *MUPAV, Museo de Prehistoria e Arqueoloxía de Vilalba, Rúa Dr. Domingo Goas,2, E-27800 Vilalba, Lugo (Spain), director@museovilalba.org.*
[2] *Dpto. de Historia, Universidad de León. C. Vegazana, E-24071, León (Spain), eramr@unileon.es.*
[3] *Escola Politécnica Superior, Universidade da Coruña, Rúa Mendizábal, s/n, E-15403 Ferrol (Spain), ana.xesus.lopez@udc.es.*
[4] *Escola Politécnica Superior, Universidade da Coruña, Rúa Mendizábal, s/n, E-15403 Ferrol (Spain), aramil@cdf.udc.es.*
[5] *E.T.S. Ingenieros de Minas, Universidade de Vigo, Rúa Maxwel, s/n E-36310 Vigo, Spain, ipozo@uvigo.es*

Abstract – **The studies about handaxes have been centred on analysing their shapes under a typometric perspective. The Borders's method, the most widely used worldwide, does not allow an appropriate study of the volumetric features of stone tools, since it presents subjective categories based on the visual recognition of the characteristics of an assemblage composed of 200 individuals. We propose a new method to analyse the metrological composition of a series of hand axes and to mathematically analyse the proximity or distance among different series. This paper presents the application of this methodology in order to study various series of handaxes dated from the Middle Acheulean, coming from Europe, Africa and Asia, in order to analyse their internal structures and to carry out comparative studies among them. The analyses confirm, in general terms, the chronocultural adscription of the series and the determinism in the metric of some extremely tough raw materials.**

I. INTRODUCTION

In this paper, it is presented a method of handaxes typometric analysis based on the calculation of 10 indices established from the stone tools front and side views. These indices focus on the relation between pairs of metric parameters in order to determine the general features of the tools, as well as those of their specific areas. These rates determine the volumetric characteristics of handaxes one by one, while they allow to establish the structure of a given series and to determine morphological types. This method allows to make comparisons among different series based on data from different series of tools.

This method has been applied to different series of handaxes from Europe, Africa and Asia in order to validate its usefulness in regards to a chronocultural use. The results obtained are highly positive, which will enable its application to other series from different parts of the world in order to increase the knowledge about these tools and their structuring within the series from the Lower and Middle Palaeolithic.

II. STATE OF THE ART

Since almost 100 years ago, the studies about handaxes have been focused on their morphotypological aspects [1]. In the 1960s, the first methods for their metric analysis were established. The best known of them is the one designed by Bordes [2], which is commonly used with the modifications proposed by Balout [3]. At the same time, Roe [4] created a similar system, which was perfected by McPherron [5]. At present, both systems have not a widespread use because of their limited objectives and their poor typometric characterisation of the handaxes. Therefore, they have not allowed either to properly structure the sets or to establish a comparison method for different sets.

III. DESCRIPTION OF THE METHOD

The method is based on the calculation of 10 indices which operate by relating two metric parameters. In order to define the method, the metric characteristics identified by the Anglo-Saxon [4,5] are assumed and a new one is added: the length or height of the point with the greatest thickness, L_3, (Fig. 1). The convergence on the tip and on the base, seeing them both frontally and laterally, is highlighted, since they are key elements in shaping the handaxes and, so far, have not been fully studied. Moreover, other parameters which are traditionally mentioned but not quantified, such as the bilateral dissymmetry and the fluctuation of the lateral edge, are quantified.

frontal view   side view
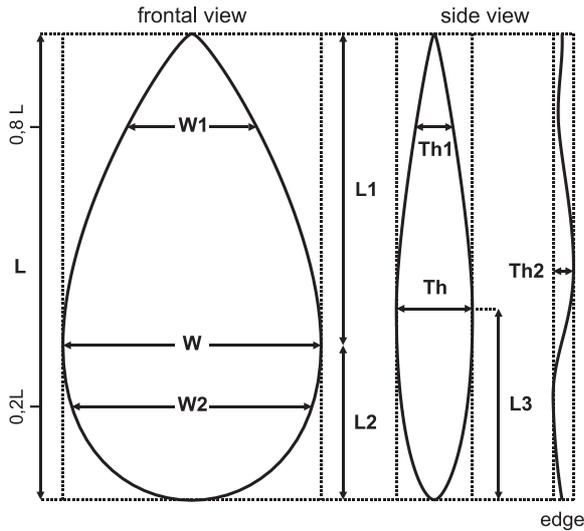
L	Maximum length	L1	Tip length
L2	Base length	L3	Basolateral length
W	Maximun width	W1	0,8L width
W2	0,2L width		
Th	Thickness	Th1	0,8L thickenss
Th2	Edge thickness		

Fig. 1. Metric handaxes.

Table 1. Typometric indices.

#	Name	Definition
1	Distal elongation	$Ad = L_1/L$
2	Distal prominence	$Pd = L_1/(2A)$
3	Distal convergence	$Cd = 1 - A_1/A$
4	Distal robustness	$Rd = E_1/E$
5	Global elongation	$Ag = A/L$
6	Global robustness	$Rg = E/A$
7	Global dimension	$Dg = L/3$
8	Basal prominence	$Pb = L_2/(2A)$
9	Basal convergence	$Cb = 1 - A_2/A$
10	Basolateral prominence	$Pbl = L_3/L$

A typological classification is established based on a hierarchy of the indexes, in which a greater importance is given to the distal elongation *Ad*, followed by the distal prominence *Pd* and the distal convergence *Cd*. The types are established from these three parameters, while their subtypes are related to the global robustness.

The data provided by the indices series can be used not only for the typological classification of each handaxe but also for the observation of the typometric structure of a set of handaxes. In order to do that, a graph which contains all the values of their indices in box plot format is established and it also allows to include several sets to observe their similarities.

The method has been created to study the Acheulean site of Louselas, located on the Atlantic coast of Spain [6], where it has been determined a set with a predominance of ovate handaxes, followed by the lanceolate ones and, to a lesser extent, by other formal groups. The series shows a great internal coherence, which is represented by the low amplitudes of the indices at an interquartile level, except for the distal robustness indices and the fluctuation of the edge, which show a greater amplitude.

The data available in the "Acheulian biface database" [7] have been used in order to make a comparison among other series and the indices have been calculated according to our method. Both in the graph of box plot and in the mathematical analysis made, a greater proximity is shown between the Louselas series and the ones from Warren Hill (England) and Sidi Abderrahman-STIC (Morocco), all of them assigned to an intermediate stage of the Acheulean, while other series from Europe, Africa and Asia assigned to earlier and later stages are more distant.

Table 2. Number of handaxes select for the study.

Name		number
Warren Hill abraded	WHA	176
Warren Hill lightly abraded	WHB	133
Sidi Abderrahman STIC	SAS	104
Sidi Abderrahman "cunette"	SAC	145
Tabun Cave level E	TAE	160
Louselas	LOU	93

IV.   RESULTS

A null hypothesis analysis was done in order to check the ability of each index to separate the six different series. The number of series pairs with a probability of null hypothesis below 5% for each index is shown in Table 3. Note that the total number of pairs is 15, so the first three indices (*Ad, Cd, Pd*) are close to this number. The index that provides the greatest value is *Dg*.

To stablish the proximity of the different series based on the values of the indices a multivariate analysis MANOVA has been performed. Maximizing the separation between the six groups defined in table 2, five canonical variables were obtained. Using these canonical variables is possible to determine the distance between the pairs of groups (table 4) and use them to construct a dendrogram (Fig. 2). It is noted that WHA, WHB, SAC and TAE have a closer proximity while LOU and SAS are the furthest away from the other groups.

Table 3. Number of series pairs with a probability of null hypothesis below 5% for each index.

Indices	pairs
Dg	14
Pd, Rd	13
Cd	12
Rg	11
Ad, Ag, Pbl	10
Pb, Cb	8

Table 4. Distance between series pairs obtained with the canonical variables of MANOVA analysis.

	WHA	WHB	SAS	SAC	TAE	LOU
WHA	0	0.67	11.62	1.75	3.86	8.57
WHB	0.67	0	16.37	3.54	4.70	11.62
SAS	11.61	16.37	0	5.87	11.41	7.35
SAC	1.75	3.54	5.87	0	2.18	5.65
TAE	3.86	4.70	11.41	2.18	0	7.89
LOU	8.57	11.62	7.35	5.65	7.89	0

Another possibility is to compare the series by setting typological groups. Following the 23 types proposed in [6], which are determined by the values of Ad, Pd and Cd, the relative frequency histograms for each type were obtained. The cumulative probability plots are shown in Fig. 4. The comparison of these curves was performed using the linear correlation coefficient which results are shown in Table 5. In this case the values close to 1 shows greater proximity between sets.

In this case the hierarchical clustering was performed taken as distance between the groups one minus the linear correlation coefficient. The corresponding dendrogram is shown in Fig. 5. Here are the most similar series are WHA and WHB followed by SAC, TAE and LOU. The series that is further away from others is SAS.

Table 5. Linear correlation coefficient of cumulative probability curves of Fig. 4.

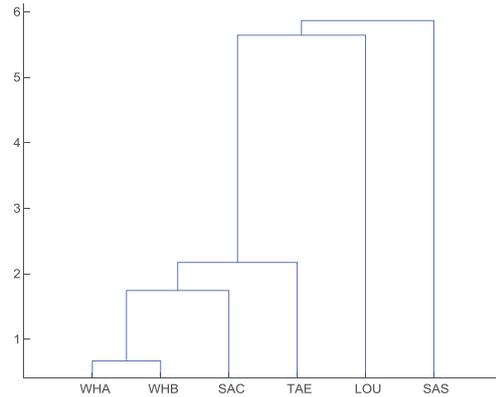|	WHA	WHB	SAS	SAC	TAE	LOU
WHA	1	0.998	0.819	0.947	0.933	0.968
WHB	0.998	1	0.792	0.932	0.916	0.954
SAS	0.819	0.792	1	0.943	0.967	0.931
SAC	0.947	0.932	0.943	1	0.992	0.99
TAE	0.933	0.916	0.967	0.992	1	0.989
LOU	0.968	0.954	0.931	0.99	0.989	1

Fig. 2. Dendrogram showing the hierarchical clustering between series of handaxes obtained with the canonical variables.
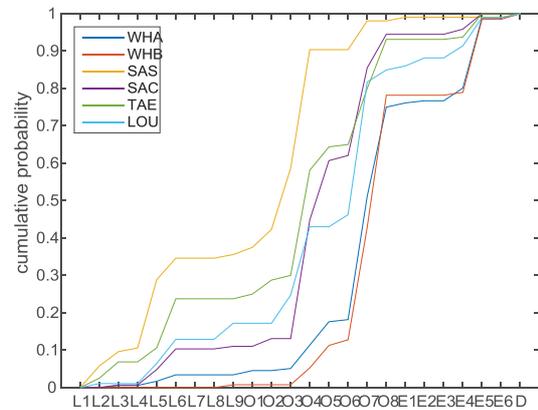

Fig. 3. Cumulative probability distributions corresponding to the typological groups (L = lanceolate, O = oval, E = elliptical).
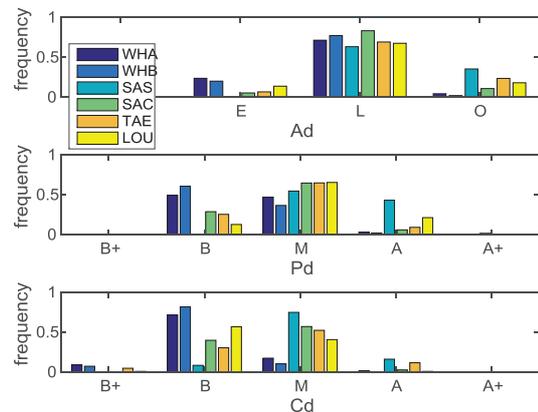

Fig. 4. Histograms of variables Ad, Cd and Pd used in the definition of typological groups (B = low, M = mediun, A = high.
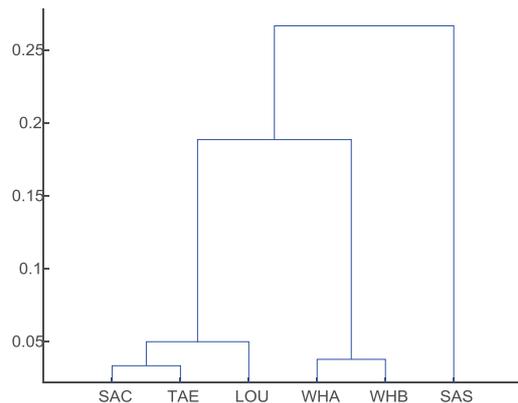
Fig. 5. Hierarchical clustering between series of handaxes obtained with the the linear correlation coefficient of cumulative probability histograms of typological groups.

V. CONCLUSIONS

An easy implementation-methodology to analyse the metrological composition of a series of handaxes and to mathematically analyse the proximity among different series were carried out in this research.

The methodology is based on the easy measuring of different metric parameters assuring the expansion of the method. The first approach was the vectorization of the frontal view and two lateral views of every handaxe and then operate using CAD utilities, with pinpoint accuracy.

The method can be applied to paleolithic handaxes and other similar tools, using the indices values to establish different typological classification systems.

The new typometric system can be applied in different places, facilitating the data exchange among different locations with handaxes and enabling the comparative analyses of series of handaxes in order to determine their variability according to chronological and/or cultural aspects.

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