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Statistical analysis of the lithic furniture of the Ifri Ouberrid site in Ain Elleuh in the Moroccan Central Middle Atlas

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Abstract— *The archeological potential of the central Medium Atlas is characterized by its richness and its diversity. The lithic furniture discovered in the site of Ifri Ouberrid is very significant and its exploration requires a powerful statistical tool allowing to simultaneously process all the quantities of objects collected in the various abductions. The Principal Component Analysis – A.C.P. is the most favorable and necessary method to fully understand and refine the work of archeologists.*
Keywords— Archaeological potential, Lithic furniture, Multivarious analysis, Principal Components analysis, Site Ifri Ouberrid.

I. INTRODUCTION

The cave of Ifri Ouberrid is located in the municipality of Aïn Elleuh, about 15km as the crow flies at the south of the city of Azrou. It's formed of two caves which pierce a cliff in oolithique limestone. The main cave measures 6m of breadth at the entrance on a height of 2,30m and about 10 meters deep.

Excavations carried out in the main cave have allowed to reveal anthropogenic deposits that extend to a depth of about 1,80 m. Their analysis has identified 7 stratigraphic units that contain two important human's occupations: the first would go back to the early Neolithic and would be dated 6846 ± 56 cal. BP and the second would be of epipaleolithic age and would be located around 8222-8416 cal. BP. These two levels of occupation have delivered important quantities of lithic industry with a clear dominance of debitage products and nuclei attesting to intense debitage on the site itself.

II. METHOD AND ANALYSIS

The total number of lithic furniture collected in the Ifri Ouberrid site is 4051 pieces. All the archaeological levels have delivered, although in a visibly unequal way, objects in rather significant quantities. The table below gives the distribution of the lithic industry by removal:

Removal	Shards	Blades	Lamellas	Nucleus	Debris& splinters	Tools	Total
1	122	16	28	226	583	13	988
2	136	22	25	111	346	9	649
3	112	36	34	167	366	8	723
4	71	35	33	63	160	1	363
5	101	42	61	43	210	5	462
6	82	31	31	84	241	5	474
7	38	31	27	14	139	3	252
8	14	5	10	2	51	1	83
9	14	4	0	4	26	0	48
10	0	0	0	2	7	0	9
Total	690	222	249	716	2129	45	4051

We know how to analyze each of these six variables separately, either by drawing a graph or by calculating numerical summaries. We also know that we can look at the links between two variables (for example shards and lamellas), either by making a graph of the cloud of dots type, or by calculating their linear correlation coefficient, or by carrying out the regression of one on the other.

However, how to study six variables simultaneously, if only by making a graph ?

The difficulty comes from the fact that the individuals (the removals) are no longer represented in a plane, space of dimension 2, but in a space of dimension 6 (each removal being characterized by the 6 objects detected). The objective of the Principal Component Analysis (A.C.P) is to return to a reduced dimension space by distorting the reality as little as possible. It is therefore necessary to obtain the most relevant summary of the initial data.

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We present below some results of the A.C.P. performed with SPSS software on this data. This will help to realize the possibilities of the method. The results have been limited to two decimals, although software programs generally provide much more, but they are rarely useful.

III. PRELIMINARY RESULTS

The software first provides the average, standard deviation, minimum and maximum of each variable. It is therefore, for the moment, univariate studies.

Basic statistics

Variable	Average	Standard deviation	Minimum	Maximum
Shards	69,00	49,57	0,00	136,00
Blades	22,20	15,12	0,00	42,00
Lamellas	24,90	18,15	0,00	61,00
Nucleus	71,60	76,82	2,00	226,00
Debris & splinters	212,90	179,72	7,00	583,00
Tools	4,50	4,37	0,00	13,00

Let us note the great heterogeneity of the six considered variables: different orders of magnitude for averages, standard deviations, minima and maxima.

The following table is the correlation matrix. It gives the linear correlation coefficients of the variables taken two by two. It is a succession of bivariate analyzes, constituting a first step towards multivariate analysis.

Correlation coefficients

Variables	Shards	Blades	Lamellas	Nucleus	Debris & splinters	Tools
Shards	1,00	0,62	0,69*	0,82**	0,88**	0,87**
Blades	0,62	1,00	0,91**	0,31	0,38	0,32
Lamellas	0,69*	0,91**	1,00	0,37	0,48	0,45
Nucleus	0,82**	0,31	0,37	1,00	0,96**	0,92**
Debris & splinters	0,88**	0,38	0,48	0,96**	1,00	0,97**
Tools	0,87**	0,32	0,45	0,92**	0,97**	1,00

* The correlation is significant at the 0,05 level (bilateral).

** The correlation is significant at the 0,01 level (bilateral).

Note that all linear correlations are positive, which means that all variables vary, on average, in the same direction. Some correlations are very strong (0,97 and 0,96), other are averages (0,69 and 0,62), others are rather weak (0,32 and 0,31).

Let's continue the examination of the outputs of this analysis by studying the matrix of variances-covariances, matrix of the same nature as that of the correlations. The diagonal of this matrix gives the variances of the six variables considered (it should be noted that at the level of calculations, it is more convenient to manipulate the variance than the standard deviation, for this reason, in many statistical methods, such as the A.C.P, the variance is used to take into account the dispersion of a quantitative variable).

Matrix of variances-covariances

Variables	Shards	Blades	Lamellas	Nucleus	Debris&splinters	Tools
Shards	2457,33	470,11	628,33	3143,11	7885,00	190,55
Blades	470,11	228,84	251,02	361,08	1045,68	21,44
Lamellas	628,33	251,02	329,43	517,40	1581,10	36,05
Nucleus	3143,11	361,08	517,40	5901,60	13374,40	310,33
Debris & splinters	7885,00	1045,68	1581,10	13374,40	32302,76	769,27
Tools	190,55	21,44	36,05	310,33	769,27	19,16

The eigenvalues below are those of the variances-covariances matrix.

Eigen values ; explained values

Factors	Eigenvalues	Variance Percentage	Cumulated Percentage
1	4,40	73,33	73,43
2	1,35	22,50	95,83
3	0,12	2,00	97,83
4	0,08	1,33	99,16
5	0,04	0,67	99,83
6	0,01	0,17	100,00
Total	6,00	100,00	-----

Each row of the table above corresponds to a virtual variable (the factors) whose eigenvalue column provides the variance (each eigenvalue represents the variance of the corresponding factor). The percentage of variance column is the percentage variance of each row relative to the total. The cumulative percentage column represents the sum of these percentages.

Let's add now the variances of the 6 initial variables (diagonal of the variances-covariances matrix):

2457,33 + 228,84 + 329,43 + 5901,60 + 32302,76 + 19,16 = 41239,12

The total dispersion of the abductions considered in dimension 6 is thus equal to 41239,12.

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Let's add otherwise the 6 eigenvalues obtained:
4,40 + 1,35 + 0,12 + 0,08 + 0,04 + 0,01 = 6,00
The cloud of points in dimension 6 is not the same and its global dispersion has changed a lot. The first two factors alone account for almost the entire dispersion of the cloud, which allows to neglect the other 4.
As a result, the 2-dimensional charts summarize almost exactly the actual configuration of the data in dimension 6: the goal (relevant summary of the small-scale data) is therefore achieved.

IV. RESULTS ON THE VARIABLES

The fundamental result concerning the variables is the table of correlations variables factors. It is these correlations that will allow to make sense of the factors and interpret them.

Factors	F1	F2
Shards	0,97	0,02
Blades	0,65	0,73
Lamellas	0,73	0,65
Nucleus	0,89	-0,39
Debris&splinters	0,94	-0,31
Tools	0,92	-0,35

First of all, the two columns of this table allow to realize the graph of the variables given by the following figure. But these two columns also make it possible to give a meaning to the factors and thus to the axes of the graphs.

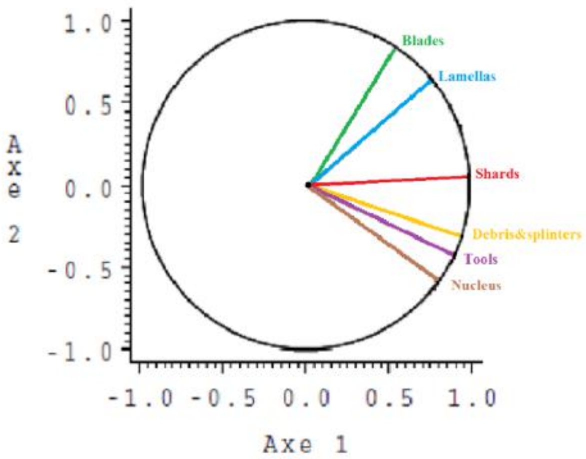

Fig. 1: Representation of the variables

Thus, we see that the first factor is correlated positively, and quite strongly, with each of the 6 initial variables: the higher the removal, the greater the quantity of lithic furniture is significant on axis 1; conversely, the deeper it is, the lower the quantity; the axis 1 represents, in some ways, the overall result for all 6 types of objects considered compared to the abductions made.
As regards axis 2, it opposes, on the one hand, shards, blades and lamellas (positive correlations), on the other hand, nucleus, debris and splinters and tools (negative correlations). It is therefore an axis of opposition between these two types of objects. This interpretation can be specified with graphs and tables relating to abductions. We present them below.
Note that the presentation quality of each type of object is relevant. Debris and splinters are represented at 99,10%.

V. RESULTS ON THE ABDUCTIONS

The table given below gives the results of the A.C.P. on removals.

Removals	Weight	Factor1	Factor2	Average
Removal 1	0,10	220,12	-18,89	164,66
Removal 2	0,10	126,44	12,59	108,16
Removal 3	0,10	133,44	-8,33	120,50
Removal 4	0,10	53,53	8,56	60,50
Removal 5	0,10	66,65	27,46	77,00
Removal 6	0,10	84,98	6,62	79,00
Removal 7	0,10	45,14	15,30	42,00
Removal 8	0,10	17,27	6,18	13,83
Removal 9	0,10	9,35	3,30	8,00
Removal 10	0,10	2,72	-0,35	1,50

It should be noted that each removal represents 1 element out of 10, hence a weight or a weighting of 1/10 = 0,10, which is provided by the first column of the table.
The following 2 columns provide the coordinates of the removals, on the first two axes (the factors) and thus allowed to draw up the abductions graph. The latter makes it possible to specify the meaning of the axes, therefore of the factors.

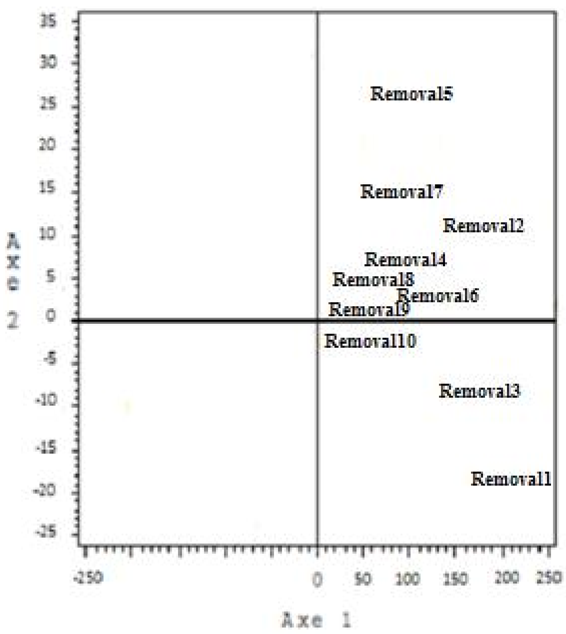

Fig. 2: Representation of the abductions

We confirm that as well as the first axis represents the overall result of the removals: if we take their score on axis 1, we obtain the same ranking as if we take their

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overall average. Moreover, the highest removal on the graph, the one with the highest coordinate on axis 2, is the removal 5 which the results are the most contrasting in favor of debris and splinters and shards. This is exactly the opposite for removal 1 where 583 debris and splinters were obtained, 226 nucleus and 122 shards, but small quantities of tools, blades and lamellas. It should be noted that the removal 10 has a score close to 0 on the axis 2 because the quantity of objects obtained is very homogeneous for each type of object.

VI. CONCLUSION

The contributions of the variance removals according to the axes 1 and 2 (remember that we use the variance here to measure the dispersion) are given by the general contributions, ie the dispersion in dimension 6 (it is what is called the inertia of the cloud of abductions, the notion of inertia generalizes that of variance in any dimension, the variance always being relative to a single variable). These contributions are provided in percentages and make it possible to locate the most important removals at each axis (or the cloud in dimension 6). They are generally used to refine the interpretation of the results of the analysis.

The first removal represents nearly 94% of the variance: it is preponderant in the definition of the axis 1, in contrast, the contribution of the removal 10 is almost null. Finally, concerning the quality of the representation, the removal 1 is represented at 100%: its representation is then very good.

REFERENCES

[1] A. Baccini (2010). “Statistique descriptive multidimensionnelle”. Institut de Mathématiques de Toulouse - UMR CNRS 5219.

[2] A. Mikdad, F. Nekkal, M. Nami, C. Zielhofer et F. Amani (2012). Recherches sur le peuplement humain et l'évolution paléoenvironnementale durant le Pléistocène et l'Holocène au Moyen Atlas central: résultats préliminaires. Bulletin d'archéologie marocaine (ISSN: 0068-4015), dépôt légal: 20/1956, tome 22, p.53-71.

[3] IBM SPSS Statistics 20.

[4] R. Chenorkian (1975). Atlas préhistorique du Maroc, Mémoire de maitrise, Aix.

[5] R. Hajila (2013). “La statistique: La partie cachée du patrimoine culturel. Cours et exercices corrigés”. Tome 1 (ISBN: 978-9954-32-626-8), n° du dépôt légal: 2013 MO 2792.

[6] R. Hajila (2016-2017). “Statistique descriptive multidimensionnelle: L'analyse en composantes principales”, séminaires pour les filières: Histoire et Archéologie de l'Occident Méditerranéen, Muséographie et Archéologie préhistorique, unpublished yet.

[7] R. Hajila (2011-2012). “L'analyse en composantes principales”, séminaires pour la filière: Archéologie préhistorique, unpublished yet.