A COMPUTER ANALYSIS OF IONIC CAPITALS

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1. INTRODUCTION

The purpose of this paper is a deductive statistical study of a given set of Ionic capitals. It is an obvious and legitimate question to ask: why a deductive analysis rather than an inductive one, which is desirable for any thereoretical investigation.

We must state from the beginning that the starting point of this study is the corpus of data measurements on Ionic capitals gathered by Dinu Theodorescu [1]. This collection contains numerical information on 82 actual Ionic capitals described by 75 variables referring to spatial composition and details of sculptural style.

The application of an inductive statistics requires a detailed knowledge of the distributional qualities of the populations to which we apply the inferences and a complete control of the formation of the samples from which we infer. None of these requirements are met in our case, and more fundamentally we have no possibility to observe the entire population of existing Ionic capitals and carefully define how our sample was extracted in a way that makes it possible to use meaningful inference statistics.

In a deductive analysis we have no a priori assumptions that we cannot control. We have at our disposal a definite system of archaeological objects described by a definite set of variables. All restrictions and limitations refer only to the data and this leaves us in full control to use statistical methods properly.

Faced with a tremendous quantity of numerical data, we try to extract only the "important" information necessary for further analysis and interpretation of the structure and evolution of Ionic capitals in a large geographical area.

There is also an immediate reason that makes such an analysis necessary. Four Ionic capitals originating from Histria, that had been in archaeological storage for some time, have been investigated recently. Another Histrian capital had already been investigated by Dinu Theodorescu and included in the data corpus supporting this study.

Theodorescu's study is based on a method known as the graphical matrix method that has been worked out and developed by J. Bertin [2]. For a brief discussion on the method, a clearer definition of the terms is needed. The question is how to classify a collection of items (where item means something very general) starting from a given number of characteristics (variables). In the best of situations, these variables can be codified numerically in an unambiguous way, so that a matrix is obtained including on each row a given item, and on each column the answer for that item to a given question from among the variables. Of course, should the codification of the variables be changed, the matrix we obtain is altogether different. However, it is hoped that, in most cases, the relevant correlations between items can be preserved from which a consistent classification or perhaps a relevant structure in the item system as a whole should be deduced. In archaeology, the purpose is mainly a straightforward seriation of the items in terms of a continuity parameter which is commonly associated with the chronology (or evolution) of the item system. In the case of a presence / absence matrix or of abundance matrix, a thorough mathematical theory of seriation and a significant number of algorithms leading to a satisfactory solution of the problem are available [3].

In principle, any such algorithm introduces a special type of distance between items and an atimonotonic function of that distance known as similarity. Using some typical techniques into the details of which we shall not go right now, the similarity matrix is converted to a Robinson configuration which is the final result of the algorithm.

[1] D. Theodorescu, *Le chapiteau ionique grec, essai monographique*, Génève, 1980.

[2] J. Bertin, *Sémiologie graphique*, Paris, 1973.

[3] *Mathematics in the Archaeological and Historical Sciences*. (eds. F. R. Hodson, D.G. Kendall and P. Tăutu), Edinburgh. See e.g. Kendall's paper, p. 215.

DACIA, N. S., tome XXXIV, Bucarest, 1990, p. 77–110

The technique employed by Theodorescu ranges within this latter class of methods. It is worth nothing that all matrices cannot be brought to a perfect Robinson shape. For archaeological purposes, an approximate solution of the problem still have some merit.

In view of the current influence of widespread computer use, the mere seriation of a collection of archaeological items is no longer satisfactory. At present, some extremely sophisticated techniques such as correspondence analysis (CA), principal components (PCA), principal coordinates (PCO), multidimensional scaling (MDS), all of which range within a broader class known as Factor Analysis (FA), have become available to archaeology and are applied to a variety of archaeological problems. Another method, called nonmetric multidimensional scaling (NMDS), that does not fall into FA class, but produces practically the same kind of output information is also in current use.

Unfortunately, in classical architecture, only one case [4] of partial application of such methods has been reported so far, namely A.-M. Collombier's PCA investigation on the same data corpus.

What we intend to do below is use the whole mathematical arsenal available for a statistical investigation on Ionic capitals. The results obtained by Theodorescu and Collombier shall be regarded both as a guide and as a further check of our main conclusions.

2. THE DATA

Theodorescu's collection consists of 82 actual Ionic capitals that have been collected uniformly from four large traditional geographic areas as follows : 22 from Asia Minor (AM), 21 from Aegean (E), 29 from Continental Greece (C) and 10 from Western Greece (GO). From a chronological viewpoint, their distribution is asymmetrical as 73 of them date back from a period earlier than 330 B. C. while only 9 of them come from a later period. So, we are dealing with a capital sample that can be regarded as representative for a rather long time span from archaism to classicism.

To describe these 82 capitals 75 variables have been used that fall into two distinct sets : (a) the so-called "quantitative" set consists of 25 ratios referring to 14 basic dimensions that define the volumetric composition of a capital ; these variables are sufficient for the schematic characterization of any capital ; (b) the further 50 variables (the "qualitative" or "style" set) refer to sculptural details, thus giving a full architectural picture of the capital.

Unfortunately, a complete description including all 75 variables is not available for every capital. Some of the variables could not be observed due to the poor state of the items, and others have been lost because they have not been reported. Even though some mathematical procedures can be used to reconstitute the missing variables, we thought such operation might have been too assuming for our case, so we have had to do without 12 items (2—3 ; 10—11 ; 16 ; 24 ; 35—36 ; 47—48 ; 53 ; and 61). It is a quite important loss in view of the overall number, small as it is. The remaining items have been renumbered from 1 to 70.

Out of the 25 "quantitative" variables, we have kept along only 17, as we decided to give up all ratios that included abacus elements. According to Collombier, the abacus is not a relevant element in the structure of Ionic capital. Variable no. 8 i.e. the stress transmission angle (α), has been replaced by the tangent of that angle which is a strictly monotonic function. We left trivially correlated variables out of question. For instance, it is obvious that $A = E + D + D$ (using Theodorescu's denotations, see Fig. 1a).

Moreover, we took upon ourselves to correct some little printing errors in the original table (e.g. A/L cannot be 0.328 with item Kavala 42) and a few values have been updated [5].

In exchange, we thought it most useful that a new variable, G/A be introduced, taking into account the relevance of that ratio for the general composition of the main front of the capital. Four further capitals from Histria [6], two from Priene and one from Labranda [7] have been added to the original 70, so a final list of 77 Ionic capitals has been obtained (see Table 1).

[4] A.—M. Collombier, Revue Archéologique, 1983, 1, p. 79—96.

[5] Data for Erechteum (no. 50) and Halicarnassus (no. 11) taken from W. Hoepfner, Bathron, Beitrage zur Architektur und verwandten Künsten, Saarbrucker Studien zur Archäologie and Alten Geschichte, 3, 1988, p. 227. and W. Hoepfner, E.—L. Schwandner, *Haus und Stadt im Klassischen Griechenland*, München, 1986, p. 161—166.

[6] The data for Histrian capitals no. 71, 72, 73 have been published elsewhere (see infra note 26—27). The data (in centimetres) for capital no. 74 are : $A = 74.3$; $B = 53.8$; $C = 54.$; $C' = 59.$; $B = 58.8$; $F = 50.$; $H = 56.2$; $E = 30.3$; $L = 16.4$; $M = 3.2$; $K = 6.8$; $J = 9.6$; $I = 13.$; $G = 23.6$; $D = 22.$; the volute dimensions represent a reconstitution attempt.

[7] The new introduced capitals are from Priene and Labranda ; data taken from W. Hoepfner, E.—L. Schwandner, *op. cit.*, loc. cit.

To avoid size effects, all "quantitative" variables have been rescaled in a simple manner, following a suggestion by Collombier, so that only their ranks have been retained for analysis. Also, the "style" set of variables will be discussed in a subsequent paragraph.

3. CORRESPONDENCE ANALYSIS OF QUANTITATIVE VARIABLES

As suggested by Bolviken et al.[8] and an entire series of Scandinavian archaeologists [9], the method of correspondence analysis seems to be one of the most promising tools for analysing archaeological data of abundance or presence/absence type. We do not intend to describe the method in details, however some features of this method are to be emphasized.

Correspondence analysis belongs to the large group of data reduction methods. The original imput matrix X is transformed by a rather complex scaling procedure into a matrix A, and then the eigenmodes of the overlap matrix A^t A and AA^t are found by standard techniques. A very nice feature of this method is the symmetrical treatment of units and variables, which can be analysed together in the same low-dimensional space spanned by very first eigenvectors.

Let X be the input matrix with rows corresponding to units and columns corresponding to variables. The CA method defines average profiles, the expected unit profile (EUP), and the expected variable profile (EVP) in terms of column marginals and row marginals, respectively. The method draws a "plane" (a low dimensional variety) through EUP in the direction of the maximal variation of points and the reduced material can be obtained as projections of points onto this plane. According to Bolviken, there are three main properties of these plots : (a) the total variation of the data can be divided into contributions from each principal axis and consequently each plot can be judged on its percentage contribution to the total ; (b) variables contribute with a certain amount to the explanation of each axis and this reveals their importance ; (c) the relative positions of units and variables in the plots can be used for cluster identification or seriation effects.

The latter property is of a great importance for the analysis of a real archaeological situation. Other methods such as MDS and PCA may also be used to reveal both clustering and seriation. However, PCA requires data with normal distribution and MDS uses a questionable ingredient, the similarity coefficient. With CA we have another method to analyse the structure of the data and the results of all these methods can be correlated together to draw some meaningful conclusions.

Fig. 1 presents the plot of the first two principal axes from CA. These axes account for 39.6% and 25.9% respectively, from the total variation of the data. The third axis contributes with 11%, giving a total explanation of about 77 %, so that a discussion based on the first three axes seems to be satisfactory.

A direct examination of the unit distribution in Fig. 1 evidences a complicated combination of seriation, expressed by the general V-shaped form and strong clustering effects. The same is true for variables in Fig. 2.

Clustering effects are most prominent. Although the division into clusters of units is quite clear, we have considered it necessary to introduce a precise method to obtain not only the cluster composition, but also the form of cluster, degree of homogeneity, center, radius, satellites, outliers, etc. For this reason, we introduce a one-body density, a function of two variables, defined as follows :

Let (xi, yi), i = 1, 2, ... N be the coordinates of N points in a plane, then the number of points per unit area in an arbitrary point (x, y) is :

$$\rho(x, y) = A \sum_{i=1}^{N} \exp\{-a*[(x-xi)**2+(y-yi)**2)]\}$$

where a is a parameter and A the normalisation constant, obtained (for fixed a) from the condition :

$$\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} \rho(x, y)\ dx\ dy = N$$

Parameter a is free and reflects the degree of geometrical correlation we want to introduce. For large values of this parameter we obtain a homogeneous density and for small ones, the

[8] E. Bolviken et al., World Archeology, 14, 1982, 1. p. 41.

[9] *Multivariate Archaeology. Numerical Approaches in Scandinavian Archaeology*, A. Archus, 1988.

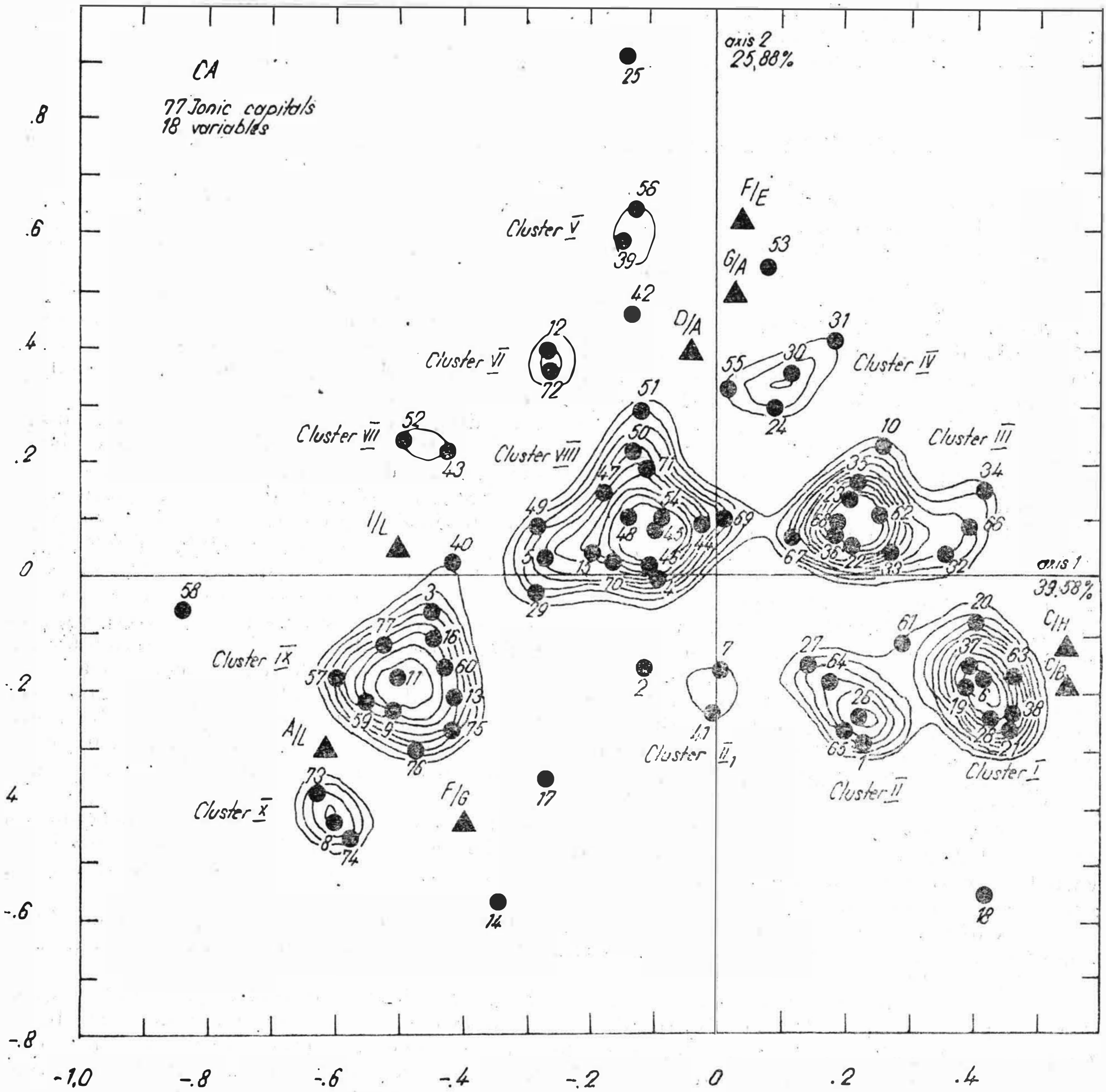

Fig. 1. — Plot of first two principal axes from C.A. Distribution of units and some important variables.

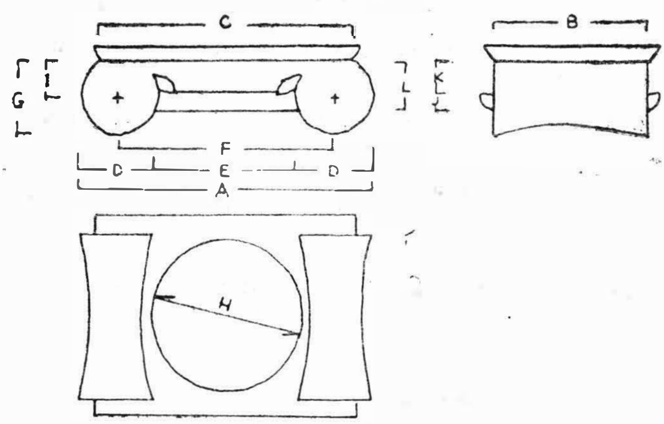

Fig. 1a. — Design of Ionic capital and the main dimensions (as denoted by D. Theodorescu)

Table 1

Numerical values of the quantitative variables; the old numbering (D. Th) and the new one (M. M—C)

D.TH.	M.M-C	A/B	C/B	F/B	C/A	A/H	C/H	F/H	tg a	D/A	F/E	F/G	A/L	K/L	J/L	I/L	G/D	θ_1/θ_2	G/A
EPH 1	1	2.775	1.785	1.830	0.643	2.170	1.395	1.430	0.374	0.297	1.625	1.940	4.040	0.627	0.372	0.762	1.142	1.165	0.339
EPH 4	2	1.681	1.176	1.079	0.699	1.667	1.164	1.067	0.258	0.306	1.676	1.838	3.820	0.578	0.422	0.751	1.140	1.124	0.349
EPH 5	3	1.565	1.083	1.042	0.693	1.500	1.040	1.000	0.111	0.306	1.718	1.920	4.500	0.625	0.375	1.000	1.132	1.218	0.346
EPH 6	4	1.800	1.200	1.167	0.683	1.982	1.350	1.175	0.455	0.344	1.925	1.550	4.770	0.634	0.366	1.012	1.115	1.118	0.383
EPH 7	5	1.580	1.095	1.005	0.695	1.455	1.010	0.928	0.122	0.323	1.820	1.725	3.680	0.555	0.445	0.756	1.140	1.150	0.368
DID 8	6	2.500	2.000	1.530	0.800	2.300	1.910	1.440	0.753	0.332	1.800	1.560	3.930	0.626	0.394	0.663	1.125	1.156	0.384
DID 9	7	2.050	1.453	1.340	0.708	1.842	1.305	1.203	0.384	0.299	1.620	1.885	4.115	0.679	0.310	0.836	1.161	1.165	0.348
DID 12	8	1.420	1.040	0.925	0.765	1.430	1.050	0.980	0.203	0.280	1.580	2.180	5.750	0.520	0.480	1.000	1.127	1.122	0.314
DID 13	9	1.500	1.030	0.990	0.685	1.490	1.020	0.980	0.167	0.304	1.680	1.920	5.200	0.458	0.542	1.000	1.128	1.155	0.351
HAL 14	10	1.940	1.522	1.067	0.785	2.338	1.835	1.287	0.566	0.389	2.450	1.235	3.200	0.545	0.455	0.792	1.145	1.187	0.461
HAL 15	11	1.494	1.000	0.993	0.669	1.495	1.001	0.994	0.131	0.288	1.575	1.989	4.612	0.645	0.322	0.903	1.156	1.127	0.333
XAN 17	12	1.570	0.990	0.890	0.630	1.740	1.100	0.990	0.203	0.370	2.180	1.385	3.760	0.634	0.372	0.887	1.150	1.242	0.426
PRI 18	13	1.500	1.000	0.998	0.666	1.621	1.080	1.080	0.070	0.300	1.666	1.940	4.630	0.545	0.456	0.875	1.127	1.140	0.338
PRI 19	14	1.640	1.128	1.180	0.687	1.639	1.125	1.177	0.258	0.258	1.487	2.475	5.080	0.528	0.470	0.815	1.130	1.147	0.292
SAR 20	15	1.570	1.050	1.000	0.668	1.610	1.090	1.038	0.167	0.325	1.817	1.688	3.750	0.510	0.390	0.802	1.161	1.143	0.363
MAG 21	16	1.512	1.000	0.994	0.677	1.537	1.080	1.005	0.176	0.302	1.660	1.880	4.680	0.610	0.390	0.950	1.155	1.154	0.349
PER 22	17	1.632	1.190	1.115	0.730	1.632	1.192	0.885	0.344	0.288	1.582	2.100	4.520	0.520	0.480	0.815	1.137	1.145	0.327
DELP 23	18	2.640	2.200	1.890	0.835	2.540	2.120	1.820	0.932	0.248	1.420	2.420	4.270	0.400	0.600	0.730	1.195	1.173	0.296
DEL 25	19	2.180	1.610	1.350	0.744	2.580	1.860	1.600	0.767	0.340	1.950	1.600	3.800	0.410	0.590	0.800	1.135	1.093	0.386
DEL 26	20	2.740	2.000	1.610	0.735	2.840	2.040	1.670	0.624	0.326	1.790	1.430	3.300	0.565	0.435	0.823	1.260	1.223	0.411
DEL 27	21	1.750	1.540	1.100	0.860	2.430	2.180	1.560	0.726	0.328	1.830	1.790	3.140	0.400	0.600	0.640	1.075	1.132	0.353
DEL 28	22	2.090	1.350	1.210	0.645	2.650	1.710	1.610	0.509	0.375	1.950	1.490	3.820	0.630	0.370	0.855	1.175	1.168	0.405
DEL 29	23	2.150	1.560	1.320	0.725	2.060	1.500	1.270	0.434	0.360	2.190	1.490	3.580	0.635	0.250	0.850	1.150	1.135	0.414
DEL 30	24	2.000	1.360	1.250	0.645	1.940	1.250	1.125	0.237	0.382	2.460	1.350	3.800	0.485	0.300	0.950	1.132	1.103	0.432
DEL 31	25	1.730	0.920	0.960	0.530	1.800	0.950	1.000	-0.040	0.410	3.050	1.130	3.100	0.485	0.250	0.930	1.200	1.172	0.492
SAM 32	26	2.150	1.765	1.450	0.822	1.990	1.635	1.340	0.589	0.302	1.705	1.940	3.700	0.570	0.430	0.747	1.150	1.186	0.347
SAM 33	27	2.120	1.140	1.320	0.565	2.120	1.410	1.320	0.389	0.328	1.850	1.680	3.900	0.370	0.520	0.890	1.129	1.113	0.370
CHI 34	28	2.600	1.745	1.690	0.670	2.620	1.755	1.705	0.531	0.314	1.750	1.855	3.660	0.640	0.360	0.716	1.115	1.108	0.350
LES 37	29	1.666	1.065	1.040	0.640	1.640	1.050	1.030	0.194	0.314	1.845	1.745	4.300	0.575	0.425	0.857	1.145	1.152	0.360
THA 38	30	2.030	1.315	1.150	0.633	2.030	1.315	1.150	0.258	0.381	2.400	1.251	3.250	0.636	0.364	0.855	1.189	1.126	0.453
THA 39	31	2.142	1.285	1.190	0.600	2.360	1.420	1.310	0.240	0.380	2.330	1.110	2.670	0.600	0.400	0.810	1.315	1.202	0.499
THA 40	32	2.780	1.890	1.700	0.680	2.100	1.430	1.290	0.383	0.359	2.175	1.395	3.110	0.505	0.495	0.834	1.220	1.130	0.438
SAL 41	33	2.300	1.675	1.325	0.713	2.620	1.910	1.515	0.713	0.364	2.120	1.395	4.080	0.710	0.290	0.935	1.130	1.152	0.411
KAV 42	34	2.430	1.730	1.365	0.773	2.930	2.160	1.633	0.637	0.383	2.400	1.253	3.280	0.705	0.265	0.835	1.170	1.161	0.448
HIS 43	35	2.138	1.620	1.230	0.712	2.200	1.668	1.270	0.434	0.374	2.285	1.385	3.380	0.698	0.402	0.756	1.113	1.182	0.416
ATH 44	36	2.110	1.590	1.175	0.785	1.940	1.520	1.125	0.455	0.365	2.160	1.380	3.450	0.480	0.520	0.880	1.148	1.131	0.419
ATH 45	37	1.885	1.315	1.170	0.700	2.710	1.890	1.680	0.509	0.315	1.680	1.660	3.080	0.485	0.515	0.654	1.187	1.148	0.374
ATH 46	38	2.580	1.830	1.590	0.708	2.950	2.050	1.820	0.700	0.315	1.600	1.660	3.600	0.460	0.540	0.828	1.170	1.156	0.369
ATH 49	39	1.530	1.000	0.893	[illegible]	1.710	1.120	1.000	0.122	0.375	2.390	1.360	3.520	0.516	0.241	0.828	1.148	1.163	0.431
ATH 50	40	1.560	0.970	0.995	0.520	1.500	0.932	0.855	-0.05	0.309	1.658	1.805	3.700	0.600	0.400	0.754	1.145	1.183	0.353
ATH 51	41	1.740	1.235	1.125	0.710	1.825	1.232	1.182	0.354	0.298	1.608	1.970	4.130	0.500	0.250	0.757	1.104	1.142	0.329
ATH 52	42	1.525	1.088	0.950	0.554	1.675	1.095	0.978	0.122	0.371	2.260	1.460	3.510	0.492	0.242	0.810	1.080	1.151	0.400
ATH 54	43	1.530	1.070	0.928	0.670	1.545	1.030	0.912	0.140	0.338	1.820	1.545	4.180	0.690	0.310	0.955	1.130	1.218	0.382
ATH 55	44	1.810	1.245	1.082	0.680	1.845	1.270	1.092	0.315	0.342	1.885	1.532	4.240	0.475	0.270	0.883	1.132	1.159	0.387
ATH 56	45	1.820	1.137	1.110	0.625	1.785	1.115	1.090	0.212	0.332	1.815	1.580	3.900	0.565	0.342	0.830	1.170	1.129	0.388
ATH 57	46	1.660	1.200	1.044	0.682	1.790	1.220	1.140	0.315	0.315	1.720	1.740	3.770	0.675	0.286	0.777	1.162	1.175	0.366
ATH 58	47	1.660	1.100	1.048	0.680	1.800	1.220	1.125	0.277	0.324	1.775	1.565	3.850	0.636	0.295	0.940	1.235	1.193	0.400
ATH 59	48	1.660	1.060	1.050	0.638	1.835	1.180	1.150	0.240	0.317	1.730	1.627	3.660	0.555	0.300	0.915	1.230	1.162	0.390
ATH 60	49	1.680	1.133	1.025	0.676	1.680	1.133	1.027	0.185	0.320	1.705	1.617	4.030	0.665	0.335	0.950	1.183	1.200	0.379
ATH 62	50	1.635	1.175	0.980	0.724	1.730	1.250	1.035	0.296	0.331	1.770	1.510	3.590	0.630	0.200	0.863	1.200	1.224	0.397
ATH 63	51	1.597	1.130	0.915	0.706	1.740	1.250	1.010	0.258	0.352	1.950	1.450	3.670	0.580	0.228	0.864	1.142	1.168	0.402
ATH 64	52	1.475	0.97	0.88	0.634	1.463	0.96	0.875	0.212	0.34	1.70	1.535	4.18	0.70	0.30	0.965	1.15	1.153	0.391
ERE 65	53	1.63	1.255	0.695	0.77	1.71	1.33	0.34	0.305	0.41	3.04	1.165	2.89	0.51	0.49	0.775	1.11	1.132	0.455
MAR 66	54	1.63	1.093	1.015	0.62	1.91	1.28	1.19	0.363	0.329	1.86	1.59	3.79	0.64	0.37	0.905	1.19	1.119	0.391
DELP 67	55	1.67	1.022	0.96	0.612	1.95	1.22	1.095	0.230	0.363	2.12	1.345	3.48	0.495	0.375	0.775	1.138	1.13	0.419
CAP 68	56	1.535	0.983	0.882	0.645	1.72	[illegible]	1.0	0.105	0.389	2.6	1.3	3.22	0.535	0.32	0.805	1.142	1.176	0.444
OLY 69	57	1.5	1.0	0.94	0.67	1.54	[illegible]	0.945	0.185	0.315	1.71	1.8	5.8	0.55	0.45	1.1	1.112	1.126	0.350
OLY 70	58	1.24	0.92	0.825	0.74	1.24	0.915	0.825	0.061	0.295	1.618	2.02	5.2	0.75	0.25	1.0	1.118	1.192	0.330
OLY 71	59	1.61	1.06	1.125	0.566	1.45	0.97	1.015	0.078	0.278	1.58	2.20	4.6	0.666	0.334	1.13	1.14	1.172	0.317
OLY 72	60	1.48	1.01	0.975	0.685	1.55	1.06	1.025	0.167	0.30	1.65	1.95	4.65	0.64	0.36	0.85	1.122	1.153	0.337
MAR 73	61	2.05	1.755	1.29	0.854	2.15	1.84	1.348	0.649	0.322	1.76	1.68	3.37	0.6	0.4	0.755	1.16	1.195	0.374
PAE 74	62	2.32	1.65	1.37	0.707	2.23	1.585	1.32	0.404	0.356	2.04	1.44	3.12	0.653	0.347	0.817	1.155	1.203	0.411
GEL 75	63	2.30	1.82	1.43	0.79	2.32	1.83	1.435	0.455	0.328	1.82	1.643	2.99	0.455	0.5	0.645	1.147	1.152	0.376
SYR 76	64	1.685	1.61	1.13	0.955	[illegible]	1.72	1.15	0.687	0.297	1.75	1.94	3.64	0.64	0.24	0.72	1.162	1.15	0.345
LOC 77	65	1.60	1.53	1.08	0.955	1.72	1.64	1.15	0.6	0.29	1.595	1.965	3.25	0.613	0.307	0.613	1.172	1.133	0.340
SEL 78	66	1.675	1.617	0.998	0.995	1.99	1.99	1.183	0.661	0.35	1.99	1.455	2.71	0.595	0.27	0.604	1.161	1.163	0.406
SEL 79	67	1.49	1.285	0.91	0.862	1.63	1.405	0.995	0.296	0.326	1.755	1.665	2.88	0.586	0.265	0.595	1.127	1.106	0.367
SEL 80	68	1.605	1.428	0.95	0.887	1.783	1.565	1.03	0.477	0.334	1.79	1.528	2.862	0.582	0.324	0.643	1.158	1.184	0.395
SEL 81	69	1.7	1.16	1.058	0.683	1.775	1.195	1.092	[illegible]	0.322	1.75	1.63	2.99	0.602	0.398	0.628	1.185	1.196	0.382
SEL 82	70	1.55	1.0	0.963	0.648	1.59	1.095	1.05	[illegible]	0.298	1.545	1.73	3.1	0.632	0.378	0.646	1.212	1.19	0.361
HIS C40	71	1.623	1.052	1.002	0.648	[illegible]	1.137	1.083	[illegible]	0.333	1.852	1.540	3.44	0.648	0.352	0.804	1.202	1.149	0.400
HIS A111	72	1.594	1.0	0.972	0.627	1.642	1.03	1.002	0.034	[illegible]	1.906	1.511	3.471	0.717	0.277	0.814	1.187	1.135	0.404
HIS C34	73	1.367	0.985	0.904	0.720	1.374	[illegible]	0.908	0.162	0.303	1.580	1.894	4.990	0.442	0.553	1.000	1.004	1.142	0.304
HIS C0	74	1.381	1.000	0.929	0.727	1.322	0.960	0.303	0.061	0.296	1.650	2.118	4.530	0.414	0.585	0.792	1 072	1.127	0.317
PRIENE	75	1.531	1.000	1.015	0.653	1.573	1.027	1.043	0.176	0.200	1.562	1.960	4.713	0.554	0.445	0.856	1.127	1.130	0.338
PRIENE	76	1.508	1.000	1.000	[illegible]	1.576	1.045	[illegible]	0.149	0.290	1.606	1.968	4.906	0.514	0.485	0.906	1.147	1.124	0.333
LABR	77	1.500	1.000	1.000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.566	1.969	4.650	0.676	0.323	0.945	1.178	1.200	0.338

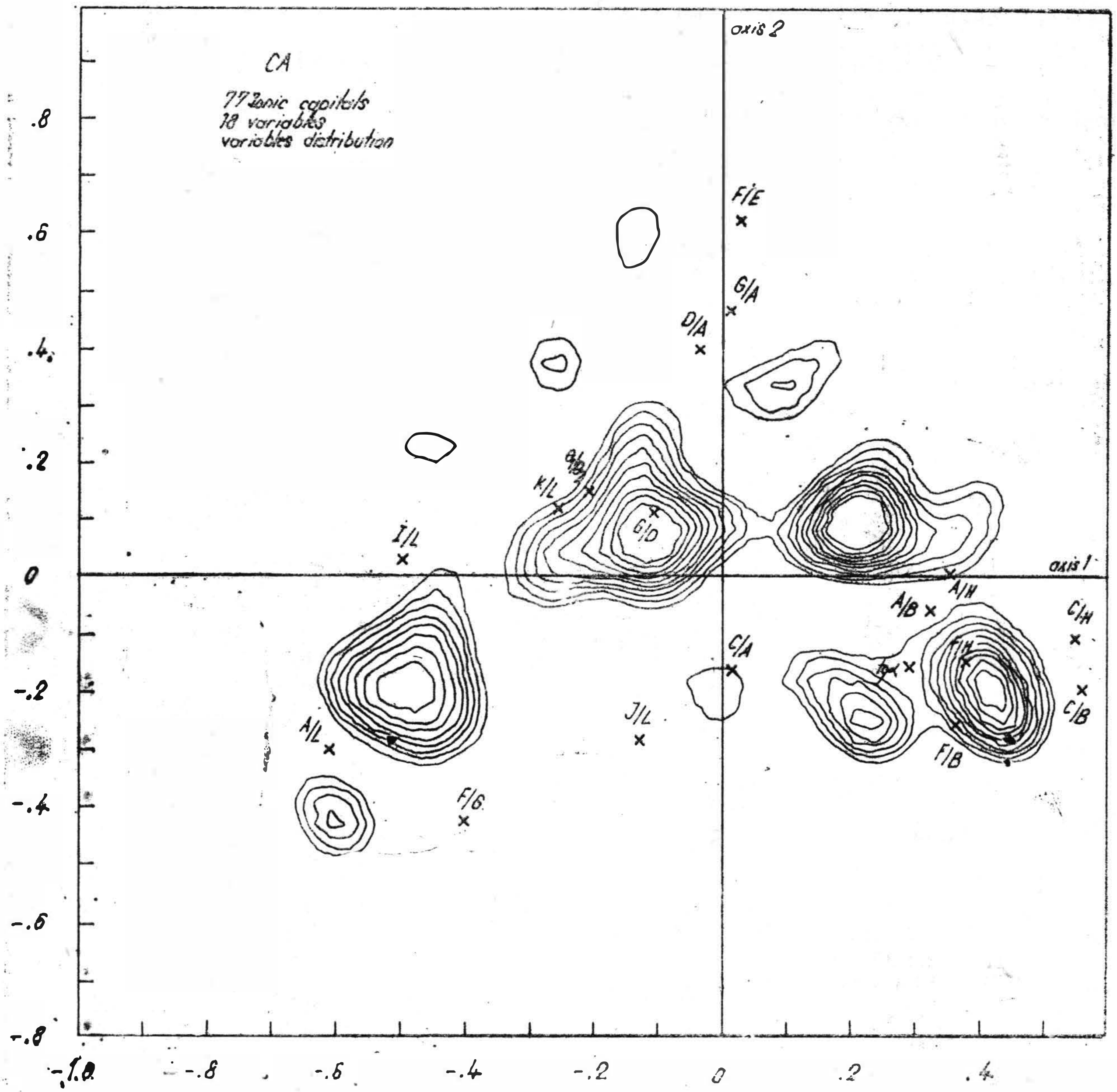

Fig. 2. — Plot of first two principal axes from CA. Distribution of variables.

density takes significant values only in the strict vicinity of the points. By moving parameter a between these extremes, we obtain a dynamic picture of cluster formation. In Fig. 1, with an optimal choice of parameter a (of the order of ~ 0.05) the density function is presented as contour plots, revealing all characteristics mentioned above. In Fig. 3 we have a 3-dimensional picture of the density function, stressing the complexity of the cluster identification problem.

The CA plot of the first principal axes can also be used for solving the seriation problem. However, the first axis accounts for only 40% from the total variation of the data and for this reason we expect some difficulties. The units and variables were seriated according to their first CA coordinate. By coding the variables into three "colours" (open signature for low values, hatched signature for medium values and heavy signature for high values) we obtain the pattern from Fig. 4. This figure also gives full information on the numbering, the source and time classification of the Ionic capitals according to Dinu Theodorescu (on the right hand) and the new numbering utilized throughout this paper (on the left hand),. The first impression created by this figure is that of an approximate Robinson matrix with black (heavy) signatures (i.e. high values of the variables) located on the main diagonal. Going from top to bottom, we also observe a clear time effect in this matrix : hellenistic capitals at the top, classical in the middle and archaic at the bottom. We shall return to this problem later.

The contribution by which variables accounted for eah axes can be extracted from Fig. 5. This diagram suggests that only few variables contribute esscentially to the explanation of the first principal three axes. This is especially true for axis 2 and 3, where groups of about four variables cover 70% and 78% of the total, respectively. The explanation for the first axis seems to be shared by a large group of variables, as the four most prominent contributors, namely A/L, I/L, C/H, C/B only account for 58%. This aspect probably explains the pattern in Fig. 4 which is entirely based on projections of units and variables onto the first CA axis.

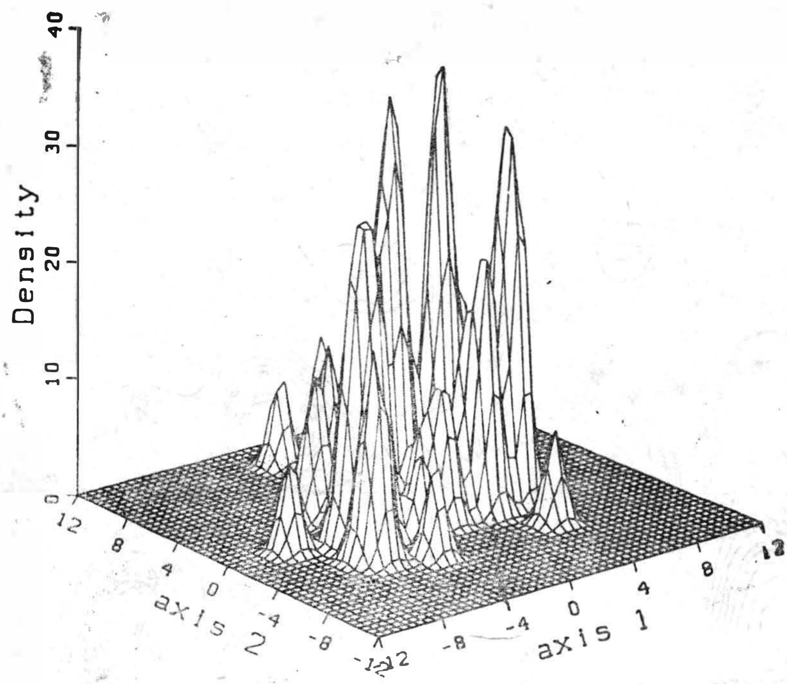

Fig. 3. — 3-dimensional plot of point density distribution of fig. 1.

4. COMPARISON OF CA WITH OTHER METHODS

As a first check, we compare the CA results with similar plots given by other data reduction methods : MDS, PCA and NMDS. Amathematical description of these methods is beside the scope of this paper. The reader may consult for example the paper of Mardia et al [10].

Multidimensional scaling constructs a configuration of N points in Euclidean space using information on distances between the N items. However, the distances need not be based on Euclidean definition and can represent many types of dissimilarities between the items. In some cases, only similarities are available, but these can be converted into distances by a standard transformation. In our case, the Ionic capitals are observable as $N = 77$ points in a 18-dimensional space. Certainly, many of these dimensions are redundant and any distance matrix based on these coordinates will be non-Euclidean.

Bearing in mind this observation, we have performed two MDS calculations : one based on Euclidean distance (Fig. 6) and another based on chi-square distance (Fig. 7). Both figures present the plot of the first two principal axes, suitably reflected to fit the configuration produced by CA. We point out in these figures the main clusters defined by CA.

Concerning Fig. 6 we observe a good enough similarity with Fig. 1. The first CA axis and first MDS axis are strongly correlated, so a seriation based on MDS gives similar results as those in Fig. 4. The outliers, namely capitals 14, 17, 18, 25 and 58 are clearly separated from the bulk. Nevertheless, the Euclidean MDS plot is much more agglomerated, with clusters that are less well separated. The internal structure of each cluster is significantly changed. For example, the capitals 67 and 68, members of CA cluster III are shifted strongly towards cluster VIII ; cluster II is virtually divided into two subclusters. The only cluster which gets consolidated in its structure is cluster IX, with Hellenistic components. We shall resume all of these problems in a subsequent paragraph.

In the plot of Fig. 7, the MDS is performed with chi-square distances as dissimilarities. This plot fits the CA result perfectly, as both methods are based on the same type of correlation between items. A single difference concerns the outliers 14, 18, 25 and 58 which are shifted much strongly from the rest.

The main objective of all data reduction methods is the determination of a minimum set of independent variables, necessary to account for the redundant set of observed variables. PCA is ideally suited to deal with this problem, when the redundancy of the observed variables is

[10] K.V. Mardia, J.T. Kent, J.M. Bibby, *Multivariate Analysis*, London, N. Y. 1979.

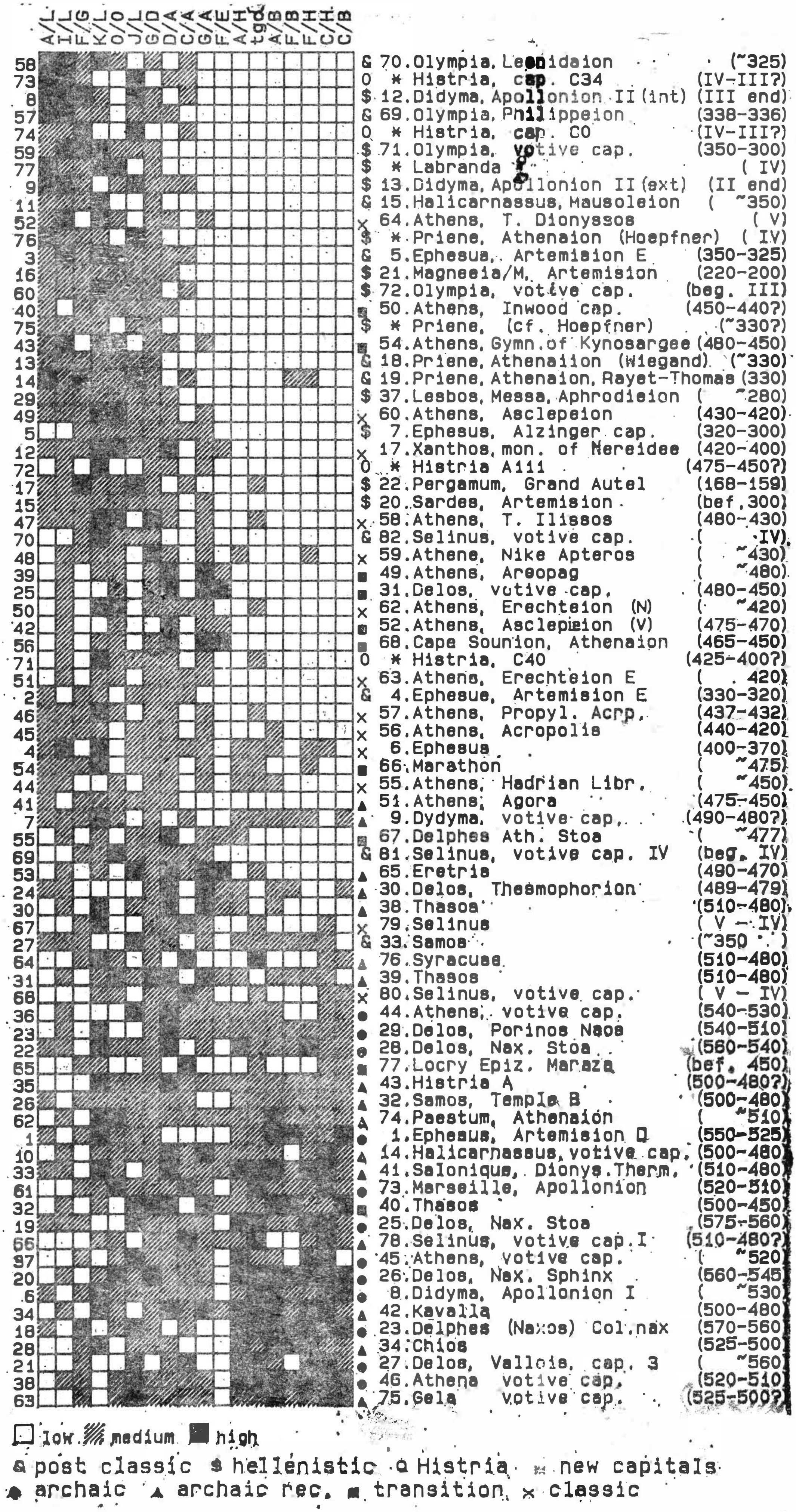

Fig. 4. — CA seriation of units and variables (for explanation see the te[xt]

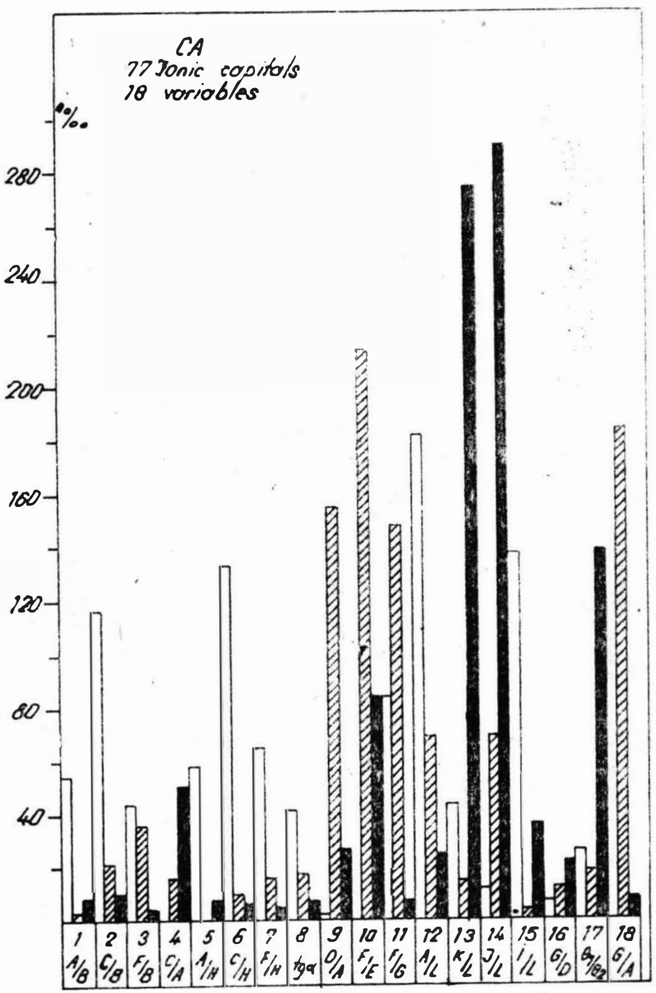

Fig. 5. — Contribution per variable accounted for CA first three axes.

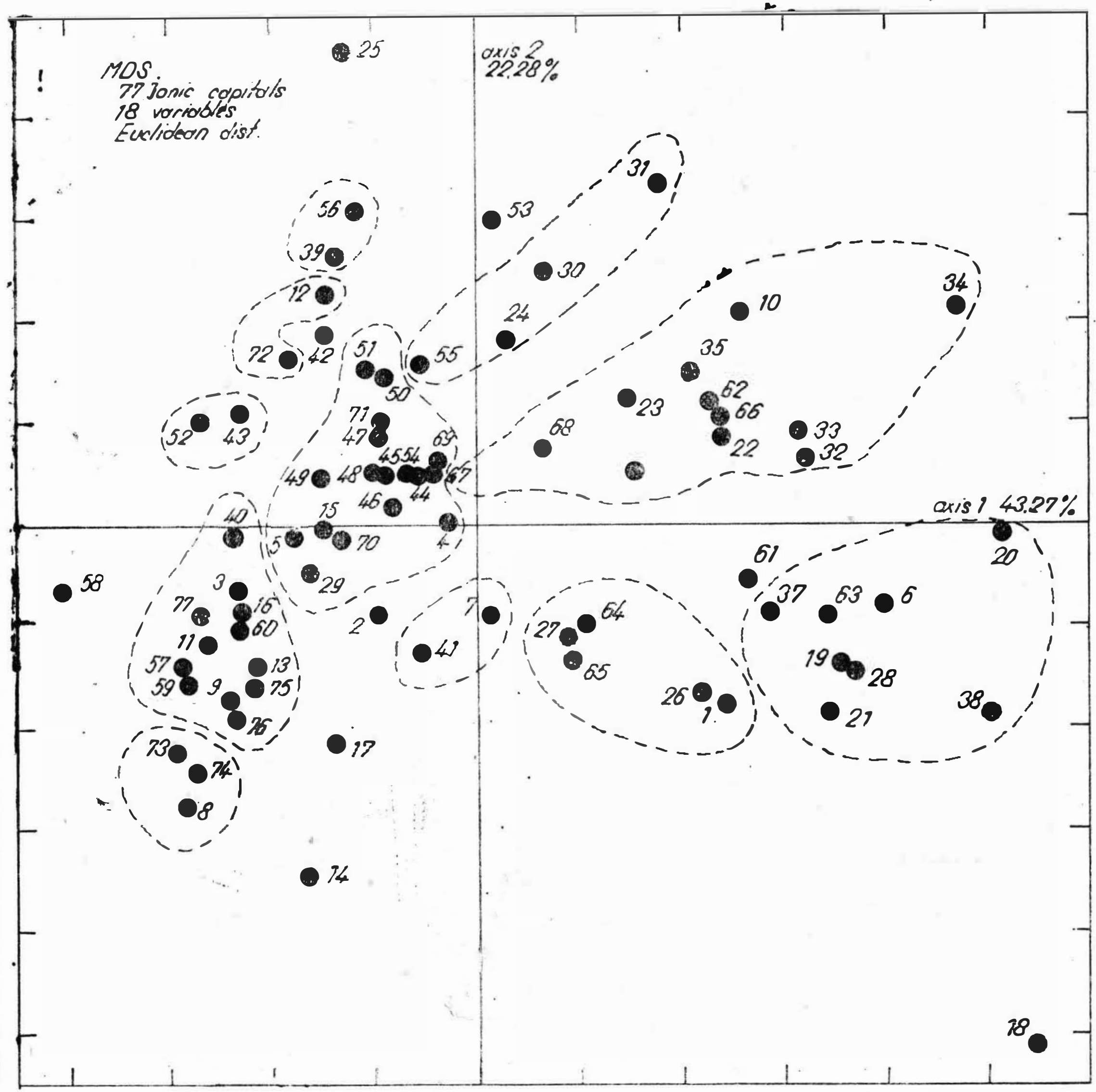

Fig. 6. — Plot of first two principal axes from MDS with Euclidean distance.

attributable to their linear dependence on a smaller set of underlying variables. As pointed out by Collombier, some of the variables are trivially correlated : A = E + D + D. Another example is L = J + K. But for many variables this dependence is severely nonlinear. In such cases PCA

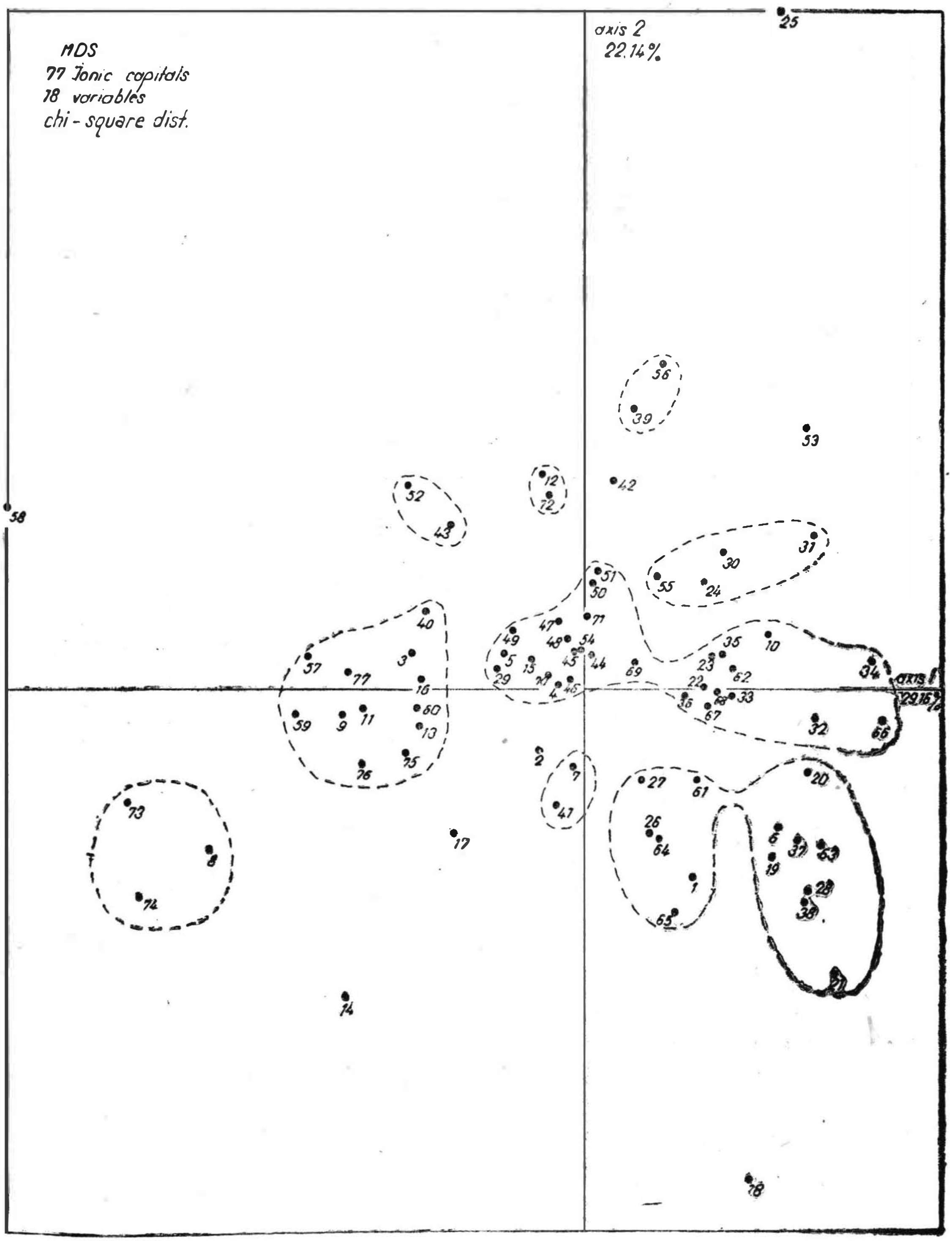

Fig. 7. — Plot of first two principal axes from MDS with chi-square distance.

fails to reduce the observed variables to an optimal representation and the number of the observed dimensions will greatly exceed the true degree of freedom contained in the data. Furthermore, PCA can be used safely only with data for which the covariance and correlation concepts are meaningful, that is for normally distributed variables. For a complete discussion of this problem the reader is urged to consult Madsen's contribution in Multivariate Archaeology (see note 9).

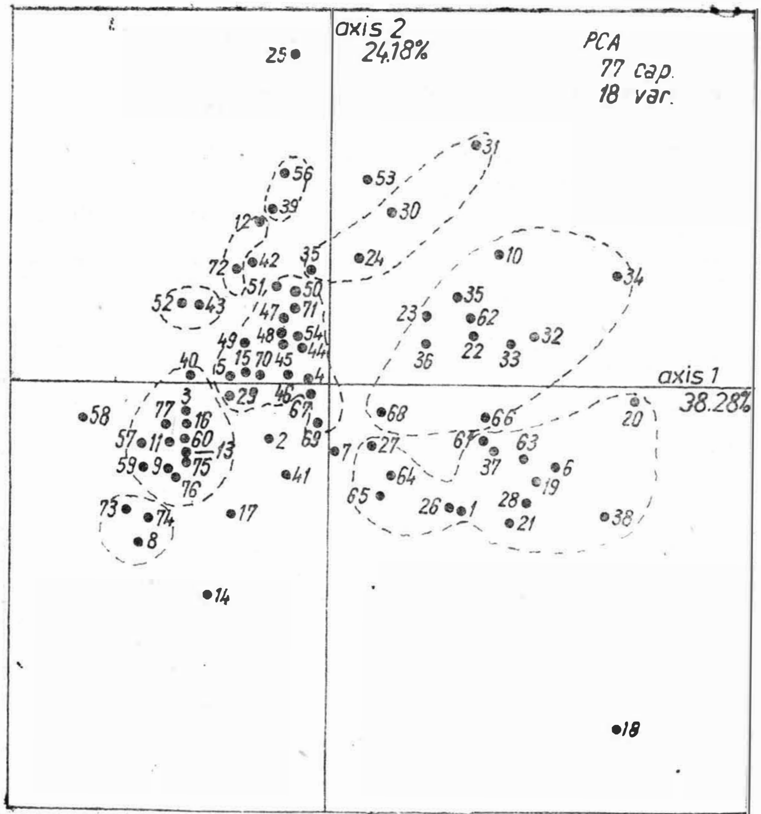

Fig. 8. — Plot of first two principal axes from PCA (units).

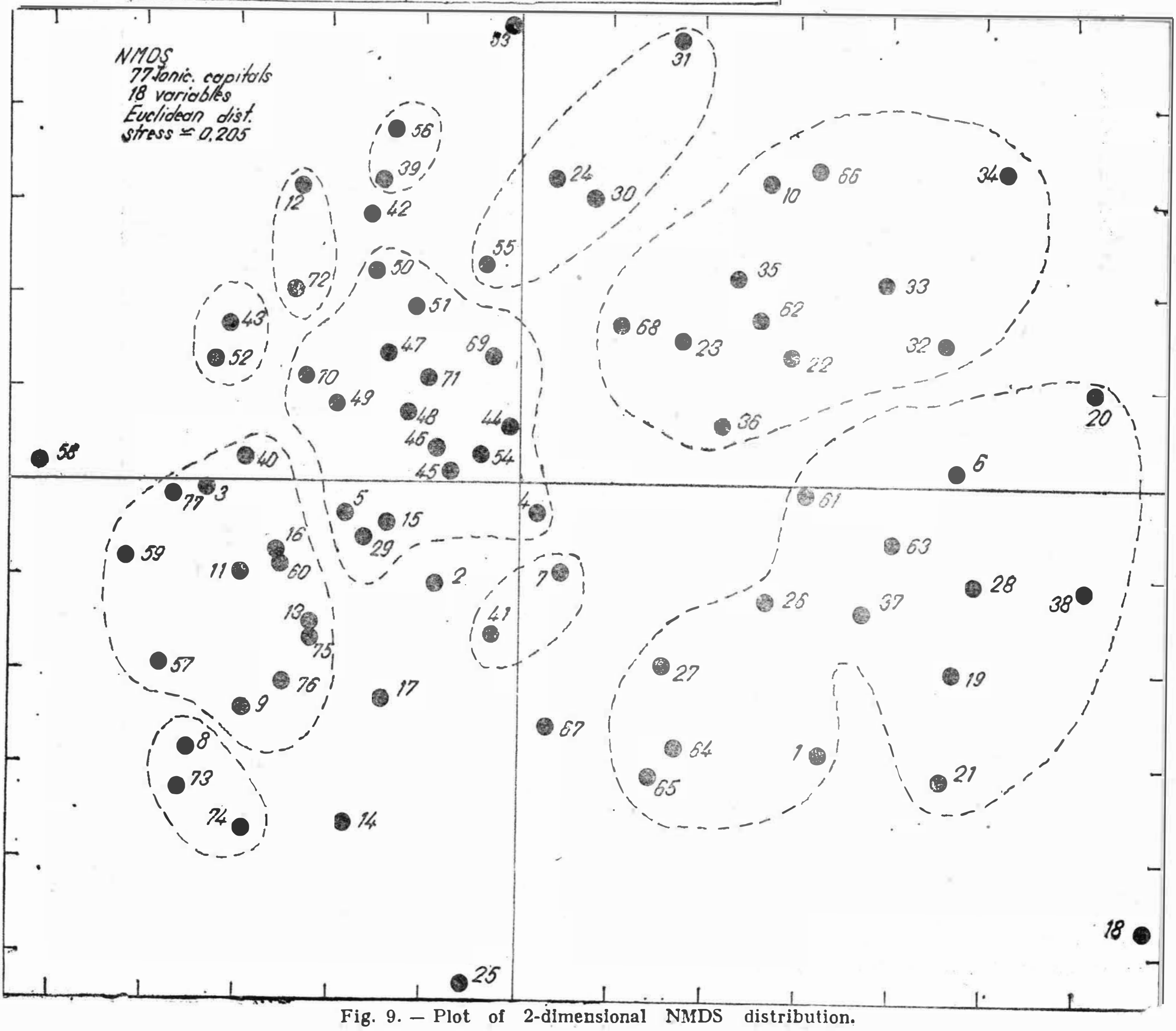

Fig. 9. — Plot of 2-dimensional NMDS distribution.

The PCA plot in Fig. 8 is quite similar to the MDS plot with Euclidean distance as dissimilarity. It is not a surprise that MDS and PCA both give the same results, because these methods are completely equivalent in this context (see note 10).

The last method we turn to for checking CA results is the nonmetric multidimensional scaling (NMDS). In Fig. 9 we present a two-dimensional plot obtained with a program [11] which follows closely the algorithm of Sheppard and Carol [12] and Kruskal [13].

One important question connected with the NMDS problem is true dimensionality of the space in which we want to produce a configuration of points. For a direct comparison with other results, we decided to choose from the very beginning a two-dimensional solution, which is not too far from the real situation, as suggested by all other methods. In spite of a high stress (due to an incomplete convergence process this is 0.205), close to the upper limit of acceptance, the plot in Fig. 9 confirms once more the CA configuration. A single observation is to be made here : capital 67, which raises frequent problems, is completely ejected from cluster III.

Combining the results from all these methods, we have at this moment a comprehensive image of the cluster structure of the Ionic capital distribution. The almost perfect fit between configurations given by CA, MDS, PCA and NMDS can be taken as a strong argument for the usefulness of the criteria chosen to define the Ionic capital.

Also, one of our main objectives, the classification of Histrian capitals, can be firmly established in the main stream of Greek Ionic capital.

5. THE DYNAMICS OF IONIC CAPITAL — A CHRONOLOGICAL SURVEY

One of the most important problems in archaeology is the chronology. In our case, there is no question to establish a chronology for Ionic capitals. Our task is only to compare the existing chronology with the classification given by correspondence analysis [14].

It has been pointed out in a preceding paragraph that the seriation can profitably be solved by CA and the single axis which parametrize the data reflects time intervals between items. This fact was suggested by Fig. 4, where units and variables were seriated acording to their projections onto the first CA axis. Going from top to bottom, we penetrate deeply into the history of Ionic capitals. Another argument is offered by the diagram of Fig. 10, where the coordinates of units onto first CA axis are directly correlated with their time coordinate. Due to some ambiguity in the dating of capitals, these appear as intervals (error bars) with a specific sign in the middle. The sign corresponds to the conventional partition of the evolution of Ionic capitals in the period 570—100 B.C. (see the insert in Fig. 10).

Of course, we cannot expect all points to be located on a smooth curve. This would only be possible for a small-stepped quasi-continuous evolution in time and space of the Ionic capital. However, as it is well known, the situation is quite different. There were a number of periods more or less clearly delimited (in time), that were particularly rich in architectural ideas and came up some rather definite structures of the Ionic capital. The passage from one period to another was more often than not an abrupt one. A rather long series of factors such as geographic diffusion, sheer reproduction, imitations, comebacks, developments in geometry and number theory, various social factors have led to time fluctuations, including considerable ones. This is particularly true for that part of the diagram in Fig. 10 that corresponds to Hellenism where the time correlation of the first CA axis is manifestly lost. We should also bear in mind that some links might be missing from the chain of capitals we are investigating. Last but not least, we must recall that the first CA axis is but responsible for 40% of the overall data variation.

A much more consistent picture of the time evolution of Ionic capitals is obtained by matching the two-axis CA distribution to the time coordinate, as shown in figs. 11 and 12. These figures prove an obvious correlation of the three main CA axes, particularly of the first two ones, and the time coordinate.

A careful analysis of fig. 11 reveals that the V-shape of the CA distribution is associated with time arrow, and the cluster structure of the distribution illustrates a distinct separation of the periods, i.e. archaic-transition-classical-Hellenistic Clusters I and III (archaic), VIII (classical) and IX (post classical and Hellenistic) are the most homogeneous of them all. Transition capitals raise some interesting problems. As they are evidence of a boiling period of search for new solutions,

[11] Computer program designed by F. Cârstoiu.

[12] R.N. Sheppard, J.D. Carol, *Multivariate Analysis*, London, 1966.

[13] J.B. Kruskal, *Psychometrika*, 29, 1964, p. 1—27, 5 —129.

[14] For the chronology of the Histrian capitals nos. 35 (500—480 B.C.), 71 (425—400 B.C.) 2 (after 475 B.C.) and 73 (IV—III centuries B.C.) see note no. 18, 26, 27. The dating of capital no. 74 established in thispaper.

they do not gather into a well defined group on the CA diagram, but rather occupy a diffuse area in quadrant I—II. Their position with respect to the center of diagram, as well as their relative positions suggest considerable fluctuations in the variables governing the 2nd axis (see Fig. 5). Transition capitals may incidentally appear incorporated on the outskirts of some clusters (e.g. nos. 65, 32) or gravitating like satellites (e.g. nos. 41, 43).

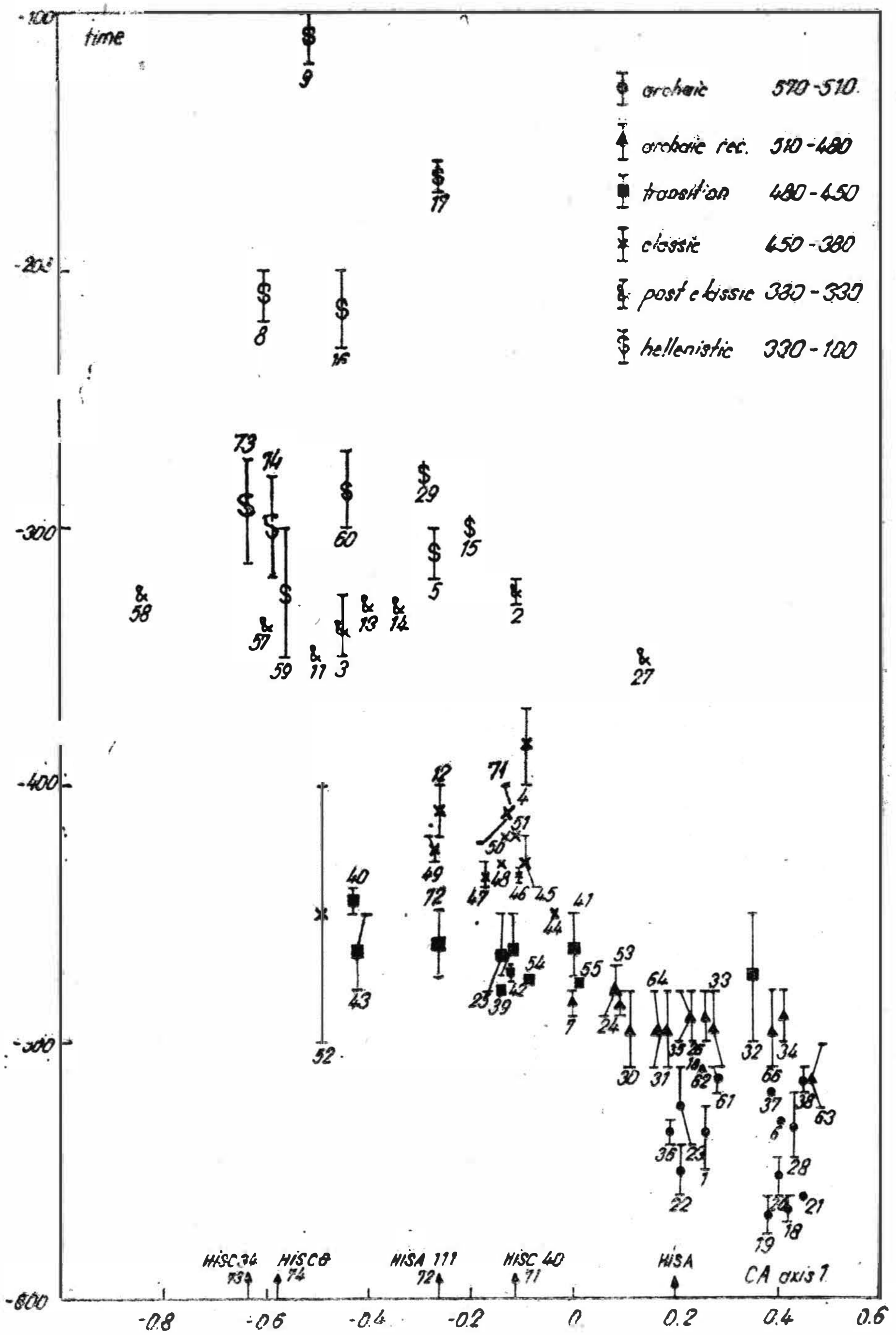

Fig. 10. — Time-scale correlation of first CA axis.

The diagram in Fig. 12 does not bring forth substantial news regarding the time distribution of Ionic capitals, whereas it shows a lower separation ability of the variables that govern the 3rd CA axis. Nevertheless, a marked group of capitals pertaining to one same period is quite evident, so the cluster structure resulting from the first two axes is proved stable.

Further information can be derived from Fig. 13 in which the geographic and the CA distributions are compared. A quite consistent picture is obtained that underscores the definite

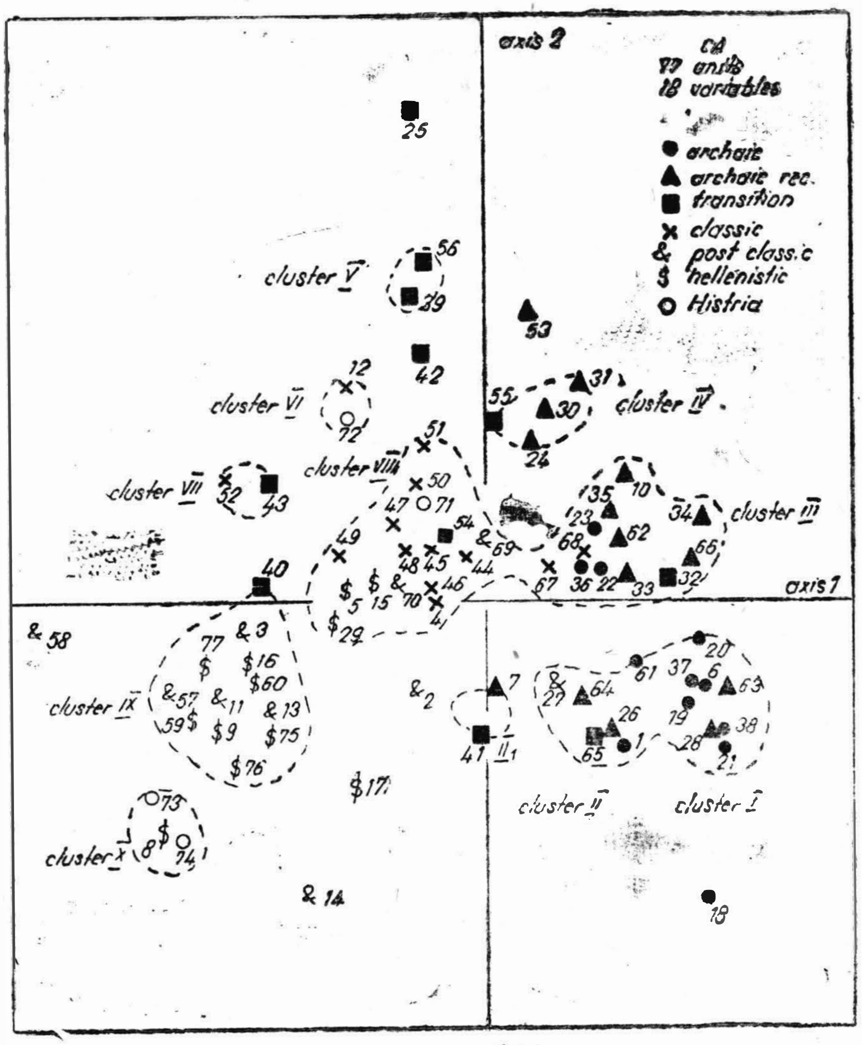

Fig. 11. — Time structure of CA distribution, axes 1 and 2.

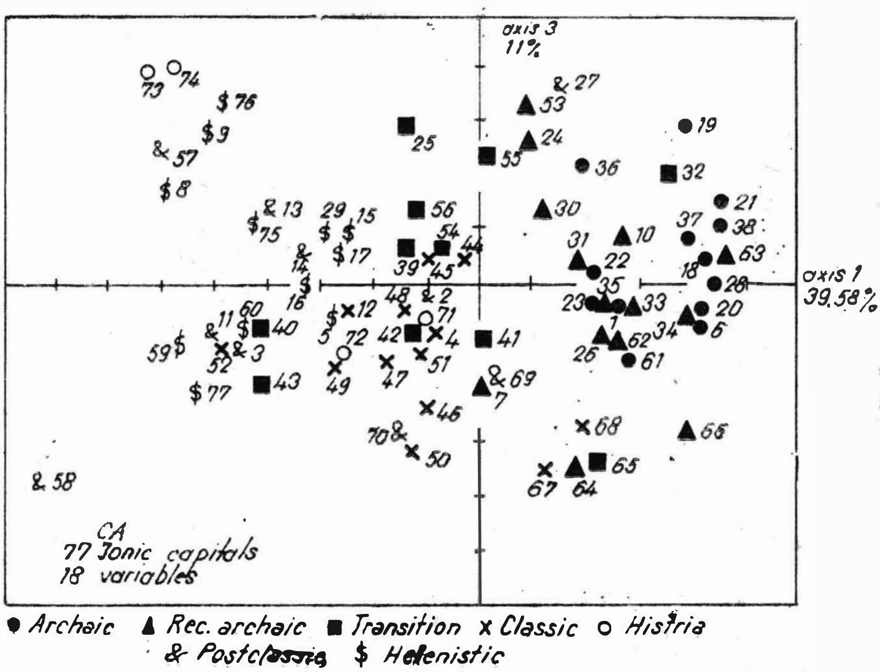

Fig. 12. — Time structure of CA distribution, axes 1 and 3.

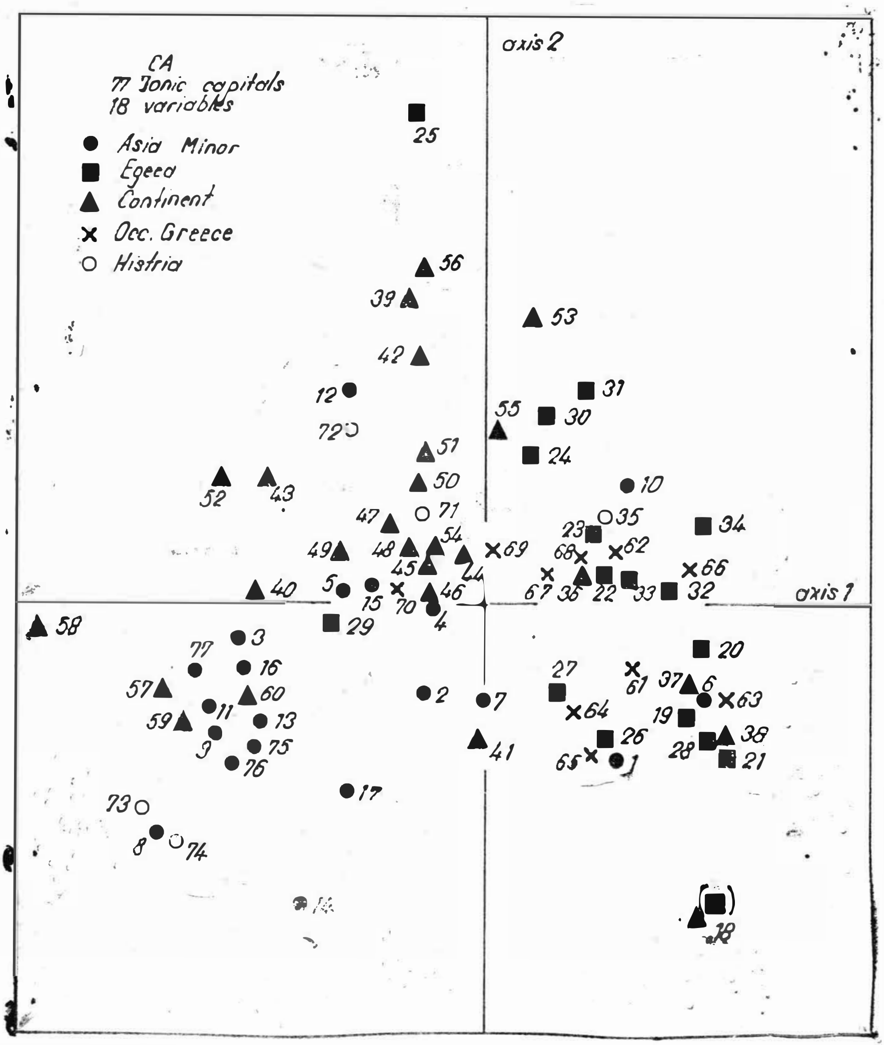

Fig. 13. — Geographical distribution of Ionic capitals.

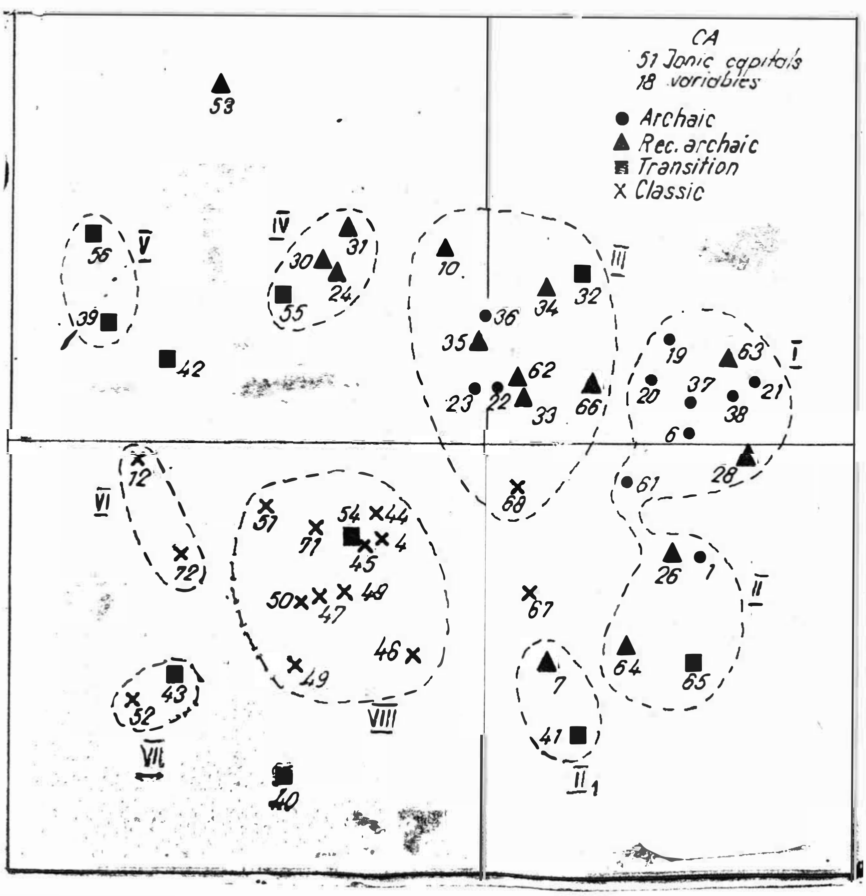

Fig. 14. — CA plot (axes 1 and 2) of period archaic-classic.

importance of the geographic factor for the stability of the cluster structure of our Ionic capital system, some regional predilections for a certain style of Ionic capital design, and also some instances of a subordonation of the design by regional traditions.

To establish a final cluster composition two major tests have been performed. The first such test (Fig. 14) referred to stability and consisted in ruling out a considerable number of capitals in a quite brutal manner as it seems. First, we eliminated outlier capitals (81, 25, 58) that largely influence the first two CA axes by the extreme values of a great many variables. Second, we got rid of recent capitals (post classical and Hellenistic capitals). We thus confine ourselves to a shorter time period in which the ranges of the variables undergo a less dramatic evolution. Surprisingly, the typical V-shape is lost, suggesting that the subsystem can no longer be ordered in terms of one sole parameter that varies permanently. The cluster structure however is left unchanged as far as cluster identity and their internal structure are concerned. A major characteristic of the distribution in Fig. 14 is a more uniform and balanced location of the clusters with respect to the center of the diagram (EUP).

An interpretation problem concerns the diagram location of the couple of clusters I and II, wherein cluster II is placed beneath cluster I, so its position on time axis appears unnatural. This may suggest the distinction of archaic from late archaic is merely formal one.

As the last test to check up the composition of CA-identified clusters, we have performed two cluster analyses using the UPGMA algorithm of Sneath et al [15]. The resulting diagrams, Figs. 15 and 16 are based on similarity coefficients that were defined in terms of the Euclidean inter-unit distance and the chi-square distance, respectively. More on this topic is to be found below.

6. COMPOSITION ANALYSIS

We will now refer to the specific items that make up the clusters resulting from the above procedures and to this aim we will resume our discussion starting from Figs. 1—16. Since an exhaustive discussion on all of correlation, as they have been revealed by our methods, does not fit into economy of our study, we will turn to such correlations that are of general nature. Furthermore, we will focus our attention on the Histrian items, hoping that the results of previous studies will receive some improvements. We will begin with quadrant IV and follow the natural order of time evolution.

Quadrant IV

In this quadrant three clusters can be noticed. Cluster I only brings together archaic capitals. The chronological sequence is headed by the Delos capital no. 19 (the Naxian Oikos, 575—560 B.C.) which also takes a central location in the cluster, followed by other Delos items, nos. 21 ($\pm$ 560 B.C.) and 20 (the Naxian Sphinx, 560—545 B.C.). Next in the chronological chain comes capital no. 6 from Didyma ($\sim$ 530) and after it capital no. 28 from Chios (525—500 B.C.). The sequence is closed by two Athenian "votives", nos. 37 ($\pm$ 520 B.C.) and 38 (520—510 B.C.) and capital no. 63 from Gela (525—500 B.C.). Items from the Aegean area and Asia Minor appear to prevail (Fig. 13) with Delian capitals nos. 19, 20 and 21 acting as focuses whose influence extends to both Attica and Western Greece. We also note capital no. 20 (the Naxian Sphinx) as having an eccentric position within the cluster. The UPGMA methods (Figs. 15 and 16) can be used to complete certain observations regarding the direct correlations between items of that group. We will dwell on the votive capitals, in view of peculiar character of being nonconstructive. The Athenian votive no. 37 appears to be in direct correlation with nos. 21 and 19, which may lend some support to the assumption that Athenian capital should originate, in point of composition, from an evolutive chain in which the Delian items from the Naxian Oikos and the "engraved" capital play an essential role. This might be true even though the Athenian votive exhibits as will be said below — a peculiarity that makes it distinct from the rest. Besides, Fig. 16 shows a high degree of correlation between the votive no. 37 and the other Athenian votive, no. 38, all the more so that they are relatively contemporary to each other. The latter (no. 38) also appears in direct correlation with no. 20 (Fig. 15), thus emphasizing the importance of the Delian-Cycladic center as a source of Ionic influence upon the continental area.

[15] P.H.A. Sneath, R.R. Sokal, *Numerical Taxonomy*, San Francisco, 1973.

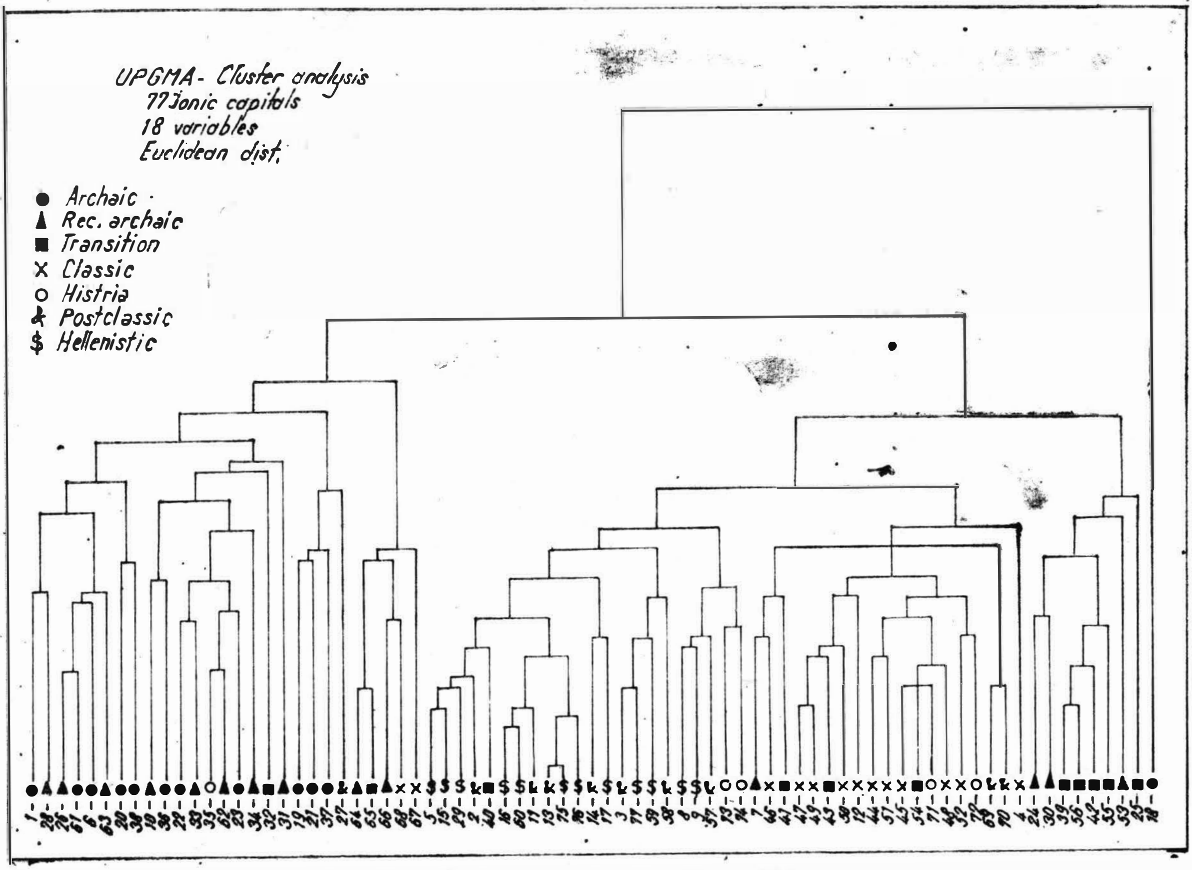

Fig. 15. — Cluster analysis, Euclidean distances.

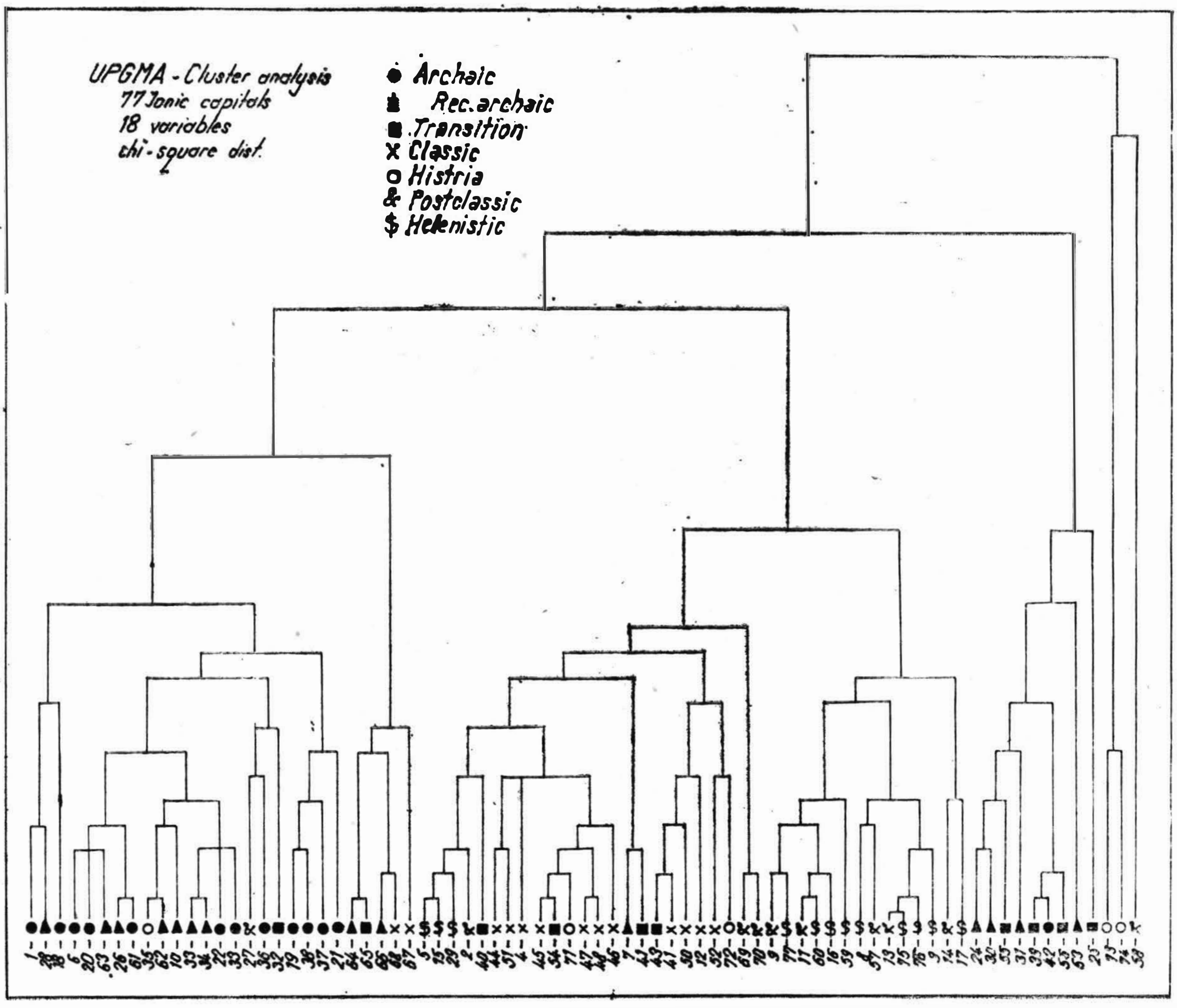

Fig. 16. — Cluster analysis, chi-square distances.

The last "votive" in the cluster, capital no. 63 from Gela appears to be closely correlated with nos. 6, 26 and 61, i.e. Didyma, Samos and Marseille, respectively. If we admit the dates as such, we could confine ourselves to setressing once again the interdependence of centers in the Western Greece (herein Marseille and Gela) and those in the Aegean — Asia Minor area (Didyma, Samos). While taking no final decision on a potential chronological reassessment, it can be noticed that a correlation of the three methods would perhaps suggest the following time sequence. So, the leading position could be ascribed to capital no. 6 (Didyma) located at the center of cluster I, followed by nos. 63 (Gela), 61 (Marseille) and 26 (Samos). The current dating would not be contradicted for we may either place capital no. 63 as definitely closer to 525 B.C. and no. 61 (Marseille) as clearly subsequent to the former, or else accept a of capitals from the Asia Minor — Aegean area and Western area (Fig. 13). Excepting capital no. 27 (Samos), the chronological sequence is shared by archaic period represented by The Ephesus capital no. 1 (550—525 B.C.) and a transition period, the exponent of which is the item no. 65 (Locri/Maraza) dating from "before 450". The interdependence of the A observe the correlation of nos. 64, 65, 66, 67, 68 from this viewpoint, we find two items rivaling for the "model" of capitals from the Asia Minor—Aegean area and Western area (Fig. 13). Excepting capital no. 27 (Samos), the chronological sequence is shared by archaic period represented by the Ephesus capital no. 1 (550—525 B.C.) and a transition period, the exponent of which is the item no. 65 (Locri/Maraza) dating from "before 450". The interdependence of the Asia Minor, Aegean and Western centers is emphasized once again.

Figures 15 and 16 document a close relation between the head of series, no. 1 (Ephesus) and capital no. 26 (Samos) dating from the late archaic period. We may interpret this relation as a dependence of the Samos type on the Ephesus one, which is also confirmed by the MDS method (Fig. 6) and cannot be contradicted by NMDS (Fig. 9). From among the Western capitals in cluster II, no 64. (Syracuse) and no. 65 (Locri) (Figs. 15 and 16) appear to be in direct correlation to each other. In view of the latter's position in the cluster, in close proximity to nos.1 (Ephesus) and 26 (Samos), and the intergroup correlations mentioned earlier, one could draw further conclusions — besides the compositional "dependence" of the Western capitals on the Aegean — Asia Minor ones — and possibly review the chronology of capital no. 65, though not in contradiction with its original dating. It is thus possible that the Locri/Maraza capital should move upwards on the time axis, and be dated in the late archaic. It is worth noticing that, on account of Figs. 15 and 16, capital no. 65 appears to be correlated to three more Western capitals — which seems quite natural — only the latter three belong to a different cluster. They ar two votives from Selinus (510—480 B.C. and Vth—IVth) nos. 66 and 67 and another votive (also V—IV) at the Palermo museum, no. 68. If we observe the correlation of nos. 64, 65, 66, 67, 68 from this viewpoint, we find two items rivaling for the "model" for the votive part in this series. These are no. 64 (Syracuse) and no. 66 (Selinus) and it is not impossible that they should mark a source of inspiration which might have had its "launching platform" in Ephesus (no. 1), then overlain by Attic influences.

A particular problem is raised in cluster II by the position of item no. 27 (Samos), dated in the late classical period (±350 B.C.) and thus appearing as a chronological exception in the cluster's population.

In Figs. 15, 16, the direct correlations revealed by the investigation method point to a high proximity of nos. 19, 21, 37 (according to Fig. 15) and nos. 36, 32 (Fig. 16). Thus, this correlation refers to two Delian items (from the Naxian Oikos and the "engraved" capital), one Athenian votive (± 520 B.C.) and another Athenian votive (540—530 B.C.), and finally a Thasian capital (500—450 B.C.). In conclusion, the position of no. 27 in cluster II may be interpreted in two ways: either it should be dated considerably earlier in accordance with the chronologic characteristics of the cluster (the other correlations mentioned strengthen this assumption); or it belongs indeed to sequence ±350 B.C., thus illustrating the re-use of earlier archaic-like procedures. Such experiment-does not appear unnatural in the known framework of an Ionic revival in the geographic areas of Asia Minor and Aegean origin in the IVth century B.C. Account taken of the composition features expressed by the important variables (to be discussed below), this latter interpretation appears to be more correct.

As to the small cluster II-1, it consists of items nos. 7 and 41: a late archaic votive capital from Didyma (490—480 B.C.) and another capital discovered in the Athens agroa (475—450 B.C.), respectively. Their affinity revealed by CA means has been contradicted by neither MDS (Fig. 6) nor NMDS (Fig. 9). Figs. 15, 16 give clear evidence of their direct correlation, which hence can be interpreted as a dependence of Athenian model on the Asia Minor type of composition (no. 7).

The 3-cluster distribution described above is clearly supported by the composition features resulting from the analysis of the main variables (Figs. 1, 2, 4 and 5).

Thus, the population of cluster I is characterized (at a general level) by :

(a) an oblong plane (the C/B ratio is maximum in four items and medium to high in other four items). An exception is the Athenian capital no. 37, that is actually an illustration of the Attic contribution to the Ionic evolution by introducing a square plane (C/B minimum) ;

(b) a thin shaft (C/H is minimum in eight items and medium for one) ;

(c) medium volutes (D/S and G/A have medium values in every case ; the two minimum values for G/A are also quite close to the medium ones) ;

(d) high central body (on the face) (A/L is minimum in seven cases and medium in two cases) ;

(e) the volute eyes line is placed above the line of lower surface (I/L is minimum in six items and medium in another one) ;

(f) the shape of volutes mark a slight elongating tendency in the vertical direction. This feature is apparent from the F/G ratio (minimum in seven cases and medium in two), as correlated with F/E (minimum in every case) and G/A (medium values mostly). Volute-spacing is maximum in comparison with center spacing (F/E is minimum).

Cluster II is characterized by :

(a) a medium-oblong plane (the C/B ratio is medium in three items and maximum in one case, the Ephesian head of series, no. 1). The exception is the Samos capital no. 27 whose plane is square (C/B is minimum), thus evincing an Attic influence.

(b) average shaft (C/H is medium in every case).

(c) small volutes (G/A is minimum in four cases ; D/A minimum in three) with a slight trend towards medium values in the case of Samos capital no. 26 (minimum G/A, but medium D/A). Again the Samos capital no. 27 is an exception by its medium values for both G/A and D/A.

(d) the central body illustrates the passage from maximum height to medium massiveness (A/L is minimum in two cases and medium in three other ones)

(e) the eyes line is determined by the I/L ratio which is minimum in four cases and medium in capital no. 27.

(f) volute spacing is maximum (minimum F/E) ; except for capital no 27 that shows a front compacting trend (medium F/E) ; this corresponds to a significant departure from the oblong shape (by correlation of a medium F/G with medium D/A and G/A).

Cluster II-1.

(a) a medium oblong plane tending to a square shape (C/B is medium in capital no. 7 and minimum in the Athenian capital no. 41)

(b) a thick shaft (C/H is minimum in both cases)

(c) small volutes (D/A and G/A are minimum in no. 7 ; with no. 41, G/A is minimum and D/A tends to medium)

(d) central body of average height (medium A/L)

(e) the eyes line is high in case no. 7 and slightly lowered in the case of no. 41 (I/L is minimum and medium, respectively)

(f) maximum volute spacing in comparison with center spacing ; the elongation of the volutes is significantly decreased (F/G is medium in both cases, and correlated with a minimum G/A)

In the quadrant in question one should note the downright isolated position of capital no. 18 (the Naxian Column) from Delphi. This distancing from every cluster is confirmed by all methods. The only hint of correlation is revealed in Fig. 16, where no. 18 appears directly related to Asia Minor capitals no. 1 (Ephesus) and 28 (Chios)[16].

Quadrant I

The population of cluster III corresponds to a chronological sequence that is generally defined by archaic and particularly late archaic dating. The only exceptions are two votive capitals from Selinus, nos. 67 and 68, both generously dated in the Vth—IVth centuries B.C. Capital no 22 from Delos (560—540 B.C.) can be regarded as head of this chronological series. It is followed closely by no. 23 (Pôrinos Naos, 540—510 B.C.). Besides, they have a central place in the

[16] Capital no. 18 has been associated to the Cycladic capitals and the Naxian votives from Delos. Its oblong plane and thin shaft would support such association (P. Amandry, *La Colonne des Naxiens et le portique des Athéniens*. Fouilles de Delphes, II, Paris, 1953 ; R. Martin. BCH, Supplément I, Études deliennes, 1972, p. 371—398 ; Anne-Marie Collombier, *op. cit.*, p. 93) In this study, capital no. 18 appears definitely distinguished from the above, as evidenced by variables of axis 2. One further variable on axis 1 (I/L) is emphasizing this distinction.

cluster, along with the Athenian votive no. 36 (540—530 B.C.) [17]. The importance of the Cycladic-Aegean centre as a focus of irradiation towards the mainland and Western Greece is emphasized again (Fig. 13). Neither MDS nor NMDS contradict this fact; moreover, direct correlations are observed in Figs. 15 and 16. First, both these dendrograms confirm the existence of a close correlation between nos. 22 and 23. Together, these two Delian capitals are correlated, in their turn, with no. 33 (Salonic, 510—480 B.C.), no. 62 (Paestum, ± 510), no. 34 (Kavalla, 500—480 B.C.) and finally no. 35, that represents the late Histrian archaic [18]. The Histrian capital thus turns out to originate in the Delian models and quite close to the Western capital no. 62. A chronological analysis of these capitals together with the position of no. 35 in cluster III and the correlation degrees expressed in Figs. 15, 16 allow us to assume the Histrian capital is chronologically closer to 500 B.C. rather than 480 B.C.

The Athenian votive no. 36 (540—530 B.C.), appears to be directly correlated to no. 10 (Halicarnassus, 500—480 B.C.) and no. 32 (Thasos, 500—450 B.C.). Hence, it is not unlikely that the latter should be dated with quite a good accuracy during the late archaic (500—480 B.C.) [19].

It is possible that the subseries mentioned might represent a composition model "irradiation" after two different directions from the same original focus (nos. 22 and 23). The second "chain" (starting from the Athenian votive no. 36, while having the same original Delian "peak")[20] could in fact express a prevailingly votive line (illustrated by nos 36 and 10; the Thasian item no. 32 is an exception) that would perhaps lead to the Western votive group, as will be seen below.

The very close correlation of nos. 36 and 10, as shown in Figs. 15, 16 would thus be perfectly justified. It is these very values resulting from their non-constructive character that justify the separation from the first "chain", since the main variables of the cluster as taken individually do not manage to distinguish them from each other (Figs. 4, 5).

Capitals nos. 67 and 68 (two votives from Selinus) differ more clearly in their main values from the rest of the cluster (Fig. 4). The direct correlations expressed by Figs. 15, 16 bear evidence of their proximity to no. 66, another votive from Selinus. So a Western votive group having its chronological "peak" in no. 66 (510—480 B.C.)[21], definitely stands out. Through no. 66 the composition pattern of group can be traced back to the same focus of Cycladic-Aegean origin.

Capitals nos. 68 and 67 seem to bear witness of Attic influences. With no. 68, it is especially its position within the cluster, quite close to the Athenian votive no. 36 that is significant in this respect. As to capital no. 67 it exhibits most evidently a square plane concept [22]. Anyway, it appears located on the extreme left of the group (Figs. 1, 11) thus nearing the classic capital group. The MDS method (Fig. 6) actually ascribes it to that group, while NMDS, (Fig.9) locates it between the cluster II and II-1 which is probably due to its square plane that is the only element that may relate it to the Athenian item no. 41. The Western subgroup could thus end the votive subseries of this big cluster. Its Athenian "peak" no. 36 can be regarded as correlated indirectly to the Western group, since in Figs. 15 and 16, the Asia Minor votive no. 10 (which is directly related to no. 36) forms a "bridge" to the votive group 66, 67, 68 through capital no. 62 (Paestum). On the other hand, as a result of these relations one might come to consider shifting capitals nos. 68 and 67 to an earlier chronological sequence (Vth century B.C.).

As far as the main variables are concerned, the prevailing features of cluster III are as follows:

(a) a medium oblong plane (10 items, one maximum oblong plane and one square plane).

(b) medium thick shaft (8 items, plus four more thin-shaft items).

(c) large volutes (8 items, while three more capitals tend to medium volutes — medium D/A and G/A, but minimum F/G — and one single item, no 67, clearly revealing medium volutes.

(d) a central body of maximum height (while medium values are only found in two items).

(e) the volute eyes line is in an medium position (except for four items in a maximum position).

(f) medium volute spacing as compared to the inter eyes distance (except for three items showing maximum spacing).

[17] The population of cluster III (excepting nos. 67 and 68) includes the series first determined by R. Martin, i.e. Delos no. 22 and 23, Paestum no. 62, Athens no. 36, Salonic no. 33, Thasos no. 32, Kavalla no. 34, Halicarnassus no 10, Histria no. 35, Selinus no. 66 (R. Martin, REA, 61, 1959, p. 1—15; idem BCH, 96, 1972, p. 303 ff; see also A.—M. Collombier, *op. cit.*, p. 92, Fig. 5, and p. 93—94, that reconfirms it fully without further additions.

[18] For the dating of this capital, see D. Theodorescu, Dacia, N.S., 1968, p. 261—264.

[19] It is interesting to notice that votive capitals (except for nos. 36 and 68) are generally located on outskirts of the cluster (e.g. nos. 10, 66, 67), as "satellites" around the central group.

[20] A correlation of capital no. 36 with the Delian focus could be suggested by Fig. 16, via capital no. 10 which can be correlated in its turn with nos. 62 and 35.

[21] Their relation to other Western items, the votive from Syracuse no. 64 and capital no. 65 from Locri, has been mentioned before.

[22] D. Theodorescu, *Le chapiteau ionique grec*, passim.

Cluster IV brings together a less abundant series consisting of Thasian capitals nos. 30 and 31 (both dated in 510—480 B.C.), no. 24 (Delos, 489—479 B.C.) and no. 55 (Delphi, ± 477 B.C.). The importance of the Aegean area remains high, however the continental influence marked by the Attic square plane gets pervasive. It is only the Delian capital through its slightly oblong plane that still bears witness of Aegean inertia. The group character is confirmed by its close seriation as proved by correlations shown in Fig. 16. Apart from reconfirming the direct correlations of nos. 24 and 30, Fig. 15 also reveals connections with the population in cluster III and that of the next cluster (V), evidencing the intermediate transition character of the cluster IV opposite to the composition type expressed by the clusters III and V. The MDS and NMDS reassert this conclusion. The general composition type can be described as follows :

(a) square plane excepting no. 24 of medium oblong plane
(b) thick shaft (excepting no 31 of medium shaft)
(c) large volutes
(d) maximum height of the central body (except for no. 24 of medium massiveness)
(e) the volute eyes line in medium position
(f) medium volute spacing as compared to the distance between their centers.

Capital no. 53 (Eretria, 490—470 B. C.), appears isolated from cluster IV. As far as the main variables are concerned, it differs from the cluster population by a maximum spacing of the volutes. Its correlations (Figs. 15, 16) as a whole define it as an intermediate type between the clusters IV and V. Its position according to MDS and NMDS does not contradict this interpretation, while its position in CA (Fig. 14) and PCA distribution (Fig. 8) further supports it [23]. Even though its peculiar character as compared to the neighbouring capital populations has to be emphasized.

Quadrant II

The cluster V consisting of two capitals, i.e. no. 39 (Athens, 480 B.C.) and no 56 (Cape Sunion, 475—450 B.C.), brings together the satellite no 42 (Athens 475—470) an all continental group. This distinction of the group from cluster IV capitals is emphasised by direct correlations as shown in Figs. 15 and 16. However, the possibility for defining a continental series is revelated correlations between this group and the two capitals from Delphi (no. 55) and Eretria (no. 53). So the continental series appears defined by the chronological "peaks" no. 53 (Eretria, 490—475 B.C.) and no. 39 (Athens, 480 B.C.), followed by no. 55, 42 (Athens, 475—470 B.C.) and no. 56 (Cape Sunion, 477—450 B.C.). As for the values of the main variables, we notice that the population of cluster V belongs to a group following the same composition type as that of cluster IV (including no 53). So all these capitals (clusters IV and V including no. 53) pertain to the same large group of composition, where a continental subseries can be distinguished. The clearcut separation of cluster V (Figs. 1, 11) with respect to IV can also express a particularity of composition since, among others, the continental group (nos. 39, 42, 56) clearly exhibits a tendency to a lower height of the echinus in the front (J/L is minimum), whereas the height of a remains medium (J/L is medium) in group IV [24]. At the same time however, it is worth mentioning that the separation is also an expression of the time anteriority of cluster IV (510—480 B.C.) as compared with series V (480—450 B.C.). The "intermediate" position of capital no. 53 from Eretria (490—470 B.C.) is also relevant from this point of view. On the other hand, it cannot be ruled out that the isolate position of no. 53 should express in this context a reconsideration of the composition of the Ionic capital due to a highly original architectural outlook.

Votive no. 25 (Delos, 480—450 B.C.), similarly to votive no. 18 in quadrant IV, appears completely driven to a margin, even though it generally presents the same characteristics of the main variables as subgroups V and IV do. It belongs essentially to the big composition group (series IV, V) earlier described, which is confirmed by correlations in Figs. 15, 16. Still, there are distant correlations as it is evidenced by its isolated place in Fig. 1.

Cluster VI appears for the time being to consist of no more than two items, i.e. no. 12 (Xanthos, 410—400 B.C.) and no. 72 (Histria, later than 475 B.C.). Comparing its characteristics to those of cluster V described above, some important similarities are found such as the square plane and the thick shaft. As to the volutes, they have maximum largeness in cluster V, but

[23] As far as the front side appearance is concerned, capital no. 53 (Eretria) is different, for instance, from group IV by its very high echinus (J/L max.) as compared to the medium one prevailing in that group (see Fig. 4).

[24] In terms of the echinus contribution to the front side, capital no. 53 (Eretria) is also correlated with a mainland Athenian capital (no. 36) in cluster III the J/L value of which is also maximum.

they decrease to medium values with capitals nos. 12 and 72. Likewise, volute spacing tends to increase in cluster V (F/E from maximum to medium) and decrease in cluster VI (F/E from minimum to medium).

In Figs. (1, 11) the Histrian capital no. 72 is seen to be quite close to the classical capital from the Neried Monument in Xanthos. The same proximity is also suggesting indirectly in Fig. 15. Both Figs. 15 and 16 prove an indirect correlation between the Histrian capital and the large group of Attic capitals, beginning with item nos. 50, 49, 43, 48, etc., including Histrian capital no. 71. We also notice (Figs. 15, 16) a direct correlation between no. 72 and the classical Athenian item no. 52. According to the CA method (Figs. 1, 14), the latter is found to form the small cluster VII, along with no. 43 (Athens, 480—450 B.C.). Examining the main variables (Fig. 4) one may regard group VI (nos. 12 and 72) as an "intermediary" between the clusters V and VII.

These, the slight tendency toward medium volutes, which is typical of cluster V appears as a definite fact in cluster VII (nos. 52, 43), just as the volute spacing grows downright maximum in the same cluster VII. In a similar way, the cluster VI tendency toward a medium height of the central body turns to a definitely medium central body in cluaster VII, while volute eyes line turns from medium in VI to maximum in VII. All the groups (V, VI, VII) share a number of characteristics, i.e. square plane, thick shaft, low echinus. So, all in all, it appears that group VI can be regarded as a "bridge" from V to VII. Intergroup correlations, as shown in Figs. 15, 16, are in support of such interpretation and of an evolution of the latter groups (VI, VII) towards a classical structure which is evident in cluster VIII.

That series in which outline such experiments that will finally result in a classical structure proceeds chronologically as follows : no. 39 (Athens, ±480 B.C.), no. 56 (Cape Sunion, 475—450 B.C.) and 42 (Athens, ±475 B.C.), no. 43 (Athens, 480—450 B.C.), no. 72 (Histria, 475—450 B.C.), no 52 (Athens, Vth century B.C.) and no. 12 (Xanthos, 420—400 B.C.).

In the above, the Attic center is seen to hold both a predominant part in the classicizing evolution and a large power of irradiation into the Asia Minor area (evidenced here by the capital of the Nereid Monument at Xanthos).

Examining such correlations that describe large groups, as shown in Figs. 15, 16, we can fill up the chronologic continental chain with older capital such as Athenian items no. 36 (540—530 B.C.), no 37 (±520 B.C.) and no. 38 (520—510 B.C.). In this way, the continental series reveals its origin in the Cycladic-Aegean model expressed by no. 22 (Delos, the Naxian Stoa). As a result, the first great continental chain starts from an irradiation focus, no. 22 and proceeds with nos. 36, 37, 38, 53, 55, 39, 56, 42, 43, 72 and 52 [25]. One can see in this chain a type of time development of continental composition schemes that will result in the flourishing period of Attic classicism. The particular features of this evolution are clearly expressed by the appropriate variables in Fig. 4. This sequence is not uniform however, as far as composition evolution is concerned. There is evidence of at least two uncommon moments.

The first such moment is suggested particularly by the capital from Eretria (no. 53) and even by the Athenian Stoa capital from Delphi (no. 55), suggesting that the chronologic bridge within the series ending with no. 38 and then resuming with no. 39, is marked by unexpected interferences.

The second important moment is evidenced by Histrian item no. 72 [26] and by a capital from the Athenian temple of Dionysos Thermaios (no. 52) that both reveal an interference from a different chain that we will dub the Marathon sequence as we describe it below.

Cluster VIII is definitely dominated by classical Athenian capitals. Of a particular importance is the place of capital no. 54 from the Marathon Memorial, which is the oldest (± 475 B.C.) in the cluster. According to it, one can assume the composition scheme of capital no. 54 already included the main characteristics that would lead to the most representative capitals of Athenian Classicism. Internal vicinities in the cluster as well as relations within the Attic population as suggested in Figs. 15, 16 point to a significant degree of correlation with the classic Athenian capitals no. 44 (Hadr. Libr. ±450 B.C.), no 45 (440—420 B.C., no. 48 (Nike Apteros, ±430 B.C.), nos. 50 and 51 (both from the Erechteum) no. 47 (I. Ilissos, 440—430 B.C.), no. 49 (Asklepieion, 430—420 B.C.), no. 46 (Propylaea, 437—432 B.C.) and no. 47. In Fig. 14 illustrating the application of CA but to the items ranging from the archaic to the classic structure, marked correlations can be seen again, while relative distances (from the "focus", no. 54, seem to express relative levels of chronology. To describe the chronologic continental chain, whose nodal point in composition evo-

[25] A chronological assessment of this time sequence as a function of its position in Fig. 1 might suggest to reduce the dating period for the Eretria capital to 490—480 B.C.

[26] M. Mărgineanu — Cârstoiu, in *Histria, Eine Griechenstadt an der Rumänische Schwarzmeerküste ; Xenia, Konstanzer Althistorische Vorträge und Forschung*, Konstanz 25, 1990, p. 103—111.

lution is the Marathon capital (expressing a qualitative "leap" as compared to relatively contemporary capitals from the first continental sequence earlier described), we have to note the large number of correlations in Figs. 15, 16. Thus, to complete the "Marathon chain" one can take into account the Athenian capital no. 41. It appears in Figs. 15, 16, and confirmed by MDS, NMDS and particularly CA (Figs. 1, 14), in direct connection with the Asia Minor item no. 7, a late archaic votive from Didyma. Hence, this no. 7 can be regarded as the source "pattern" of the continental series in which the Marathon capital plays such an important role. Of course, in the general frame work, one can consider formally that no. 7 bears witness of archaic influences from the Cycladic-Aegean center. However, both capitals, nos. 22 and 19 are very far away and in quite distinct clusters, and the system of correlations (Figs. 15, 16) emphasize that distinction.

Abiding by the information from the above statistic methods, we will have to confine ourselves to the idea of an irradiation "focus" in Didyma (no. 7). However, we cannot rule out the possibility that the Ephesian item (no. 1) from Artemision "D" should hint to a potential bridge to another item, perhaps older, missing from the present statistics. (Anyway, an Asia Minor source can be considered). Such suppositions will not be subject to further research until the number of items in the statistics is efficiently completed.

Now back to cluster VIII (figs. 1, 10), we notice that the "Marathon chain" leading to the acme of Athenian classicism also has direct scions in the Asia Minor — Aegean area. The late classic capital no. 4 from Ephesus (400—370 B.C.) follows close on Athenian models, so an even tighter dating about 400 B.C. might come in for discussion. The Hellenistic capitals no. 5 (Ephesus, 320—300 B.C.), no. 15 (Sardes) and no. 29 (Lesbos, $\pm$ 280 B.C.) revive some similar composition schemes into a later epoch. The irradiation of Attic classicism reaches as far as the Western area through votives nos. 69 and 70 from Selinus. It is worth mentioning that the Selinus votives together with the Hellenistic eastern capitals have marginal positions in cluster VIII. (The continental capitals of first ("less perfect") chain also have eccentric positions in Fig. 14, which may support the assumed distinction of two continental series).

The classic Histrian capital no. 71 [27] appears in cluster VIII at little distance from nos. 47 (T. Ilissos) and 48 (Nike Apteros), and especially the Erechteum capital no. 50 (Northern Portico). Such considerable proximity to the composition type of no. 50 further strengthens an earlier hypothesis of ours[28] concerning some particular connections between the composition techniques that are apparent on both the Erechteion capital and the Histrian one. The positions of the two Histrian capitals nos. 71 and 72 can illustrate the actuality of a quality "leap" from no. 72 to no. 71. We were describing in the same earlies study a possible procedure of transforming a composition scheme which is "less perfect", as expressed by no. 72, into another more elaborate one in no. 71 (where the values of the main ratios are extremely close to the "golden number"). So, the Histrian series begins with no. 35, takes up a classical Attic influence, illustrated by no. 72, the structure of which gets through another transformation, in fact a decisive leap that brings, in no. 71, the Histrian form quite close to that of classic Athenian capital.

One also finds in Fig. 14 some useful information on the Western Selinus capitals nos. 67 and 68. Their intermediate location between the archaic — transition group and the compact classic zone is a good evidence of an archaic prone inertia amidst classical trends. The composition particularities illustrating this fact are seen in Fig. 4.

The location of capital no. 40 ("Inwood") in Figs. 1, 11, 13, 14, hints some particularities that have to be strong enough to make it eccentric to the classical "Marathon chain", and also to its part as an intermediary between the continental classicism and the subsequent (post—classical and Hellenistic) ages. So, Figs. 15, 16 reveal strong correlations between no. 40 and no. 2 (Ephesus, Artemision "E", 330—320 B.C.), no. 5 (Ephesus, 320—300 B.C.), no. 29 (Lesbos, $\sim$ 280 B.C.) and no. 15 (Sardes, $\pm$ 300 B.C.). According to the indirect correlations in Figs. 15, 16, the "Inwood" capital seems to be related rather to the first continental chain (the eccentric one) still similarly to the Histrian item no. 72, it also shows evidence of interferences by the "Marathon chain" [29]. The "Inwood" capital appears as a link between the Attic classicism and the population of cluster IX in which the Hellenistic capitals prevail.

Cluster VIII appears to be quite homogeneous in its main variables :

(a) square plane (all items)
(b) thick shaft (all items)
(c) medium volutes (all items)

[27] *Ibidem*, p. 111—114; idem, Dacia, N.S., 28, 1984, p. 157—180.

[28] Ibidem, passim.

[29] D. Theodorescu has estimated the Marathon capital as the oldest Attic link of the series leading to the "classic triad" (Ilyssos, Nike Apteros, Propyleae). He claims the starting point of this chain is the Naxian Stoa prototype from Delos (no. 22) (see D. Theodorescu, *op. cit.*, p. 127).

(d) central body height from maximum (eight items) to minimum (seven items)
(e) volute eyes line, expressed by I/L, generally in medium position
(f) maximum volute spacing as against inter-center distance (F/E is minimum in all items).

Quadrant III

Cluster IX brings together a number of postclassic and Hellenistic capitals (Figs. 1, 11). This chronological group is also well illustrated in Figs. 15, 16, where correlations with items eccentric to the group, but still pertaining to the same chronologic sequence, are present too.

Capital no. 11 from the Mausoleum of Halicarnassus lies at the center of cluster which is an indication of the role as a chronological "peak" and a potential focus radiating influences on a chain pertaining prevailingly to Asia Minor. This focus role might also be suggested by Figs. 15, 16 where no. 11 appears sufficiently correlated to both the post-classical capitals from Priene (nos. 13, 75 and 76) and Hellenistic ones from Olympia (no. 80) and Magnesia (no. 16).

Since the Hellenistic population in the statistics is not large enough, we will not try a detailed study on intergroup correlations [30]. We only notice the eccentric singular positions held by capitals no. 14 (Priene), no. 17 (Pergamum) and no 58. (Olympia, Leonidaion) with respect to cluster IX. Their participation in clusters whose populations cannot be determined in this study is to be assumed.

Cluster X consists now of Histrian capitals nos. 73, 31 (C34, IVth—IIIrd c.B.C.) and 74 (CO), and of the Hellenistic item no. 8 from Didyma (Apollonion II). Figs. 15, 16 on the whole suggest a relative correlation between the Histrian capitals and also some more or less distant connections with the post-classic capitals from Olympia (no. 57, Philippeion, 338—336 B.C.) and perhaps even no. 58 (Leonidaion, ±325 B.C.)

As a result of these considerations, which are of course only preliminary, we believe the Histrian no. 74 could be dated about the IVth—IIIrd centuries B.C.

As far as the main variables are concerned, the population of the post-classic-Hellenistic clusters dominated by Asia Minor items illustrates the following characteristics, as expected :

(a) square plane
(b) thick shaft
(c) small volutes
(d) central body height alternating from medium to maximum
(e) volute eyes line in proximity to the line of lower surface and even coinciding to it in some items (e.g. nos. 73, 58, 9, 3).
(f) maximum volute spacing as against inter-center distance.

7. ANALYSIS OF STYLISTIC VARIABLES

As mentioned in paragraph 2, Dinu Theodorescu describes the Ionic capital by means of 50 stylistic variables of presence/absence type, to complete the architectural image of the capital. We do not want to insist here on the correctness of the definition of these variables, though some of them are in evident contradiction with the very nature of a presence/absence type. Note also that some variables cannot be of much help, as the answer is "yes" for more than half of the capitals. The main question is now to manage together the two systems of variables, account being taken of their different nature. Remember that the quantitative variable system was scaled in a simple manner, so only the rank variable was retained for analysis. This rank ranges between 0 and N—1, where N is the total number of items, that is 77 in our case. It is impossible to avoid size effects when we join the two systems. This fact is clearly demonstrated in Fig. 18, where we have performed a CA of 18 quantitative variables and some 40 stylistic variables. The image that emerges is practically unchanged in comparison with Fig. 1, demonstrating a dominant size effect of quantitative variables. For this reason, we decided to treat the stylistic system of variables separately by performing a CA based on a selected subsystem of 40 variables (Fig. 17) and a cluster analysis (UPGMA algorithm) based on Jaccards, Yules, Phi and simple matching similarity coefficients (Figs. 19—22). For the sake of completeness we have also performed a seriation based on row and column marginals ordering (Fig. 23). (This algorithm, as generalised by F. Cârstoiu for the abundance type matrix is presented in Appendix 1 of the paper of R. Harhoiu, "Chronologische Fragen der Völkewanderungszeit in Rumänien" , this issue).

[30] A more comprehensive statistic analysis of Hellenistic capitals is in progress.

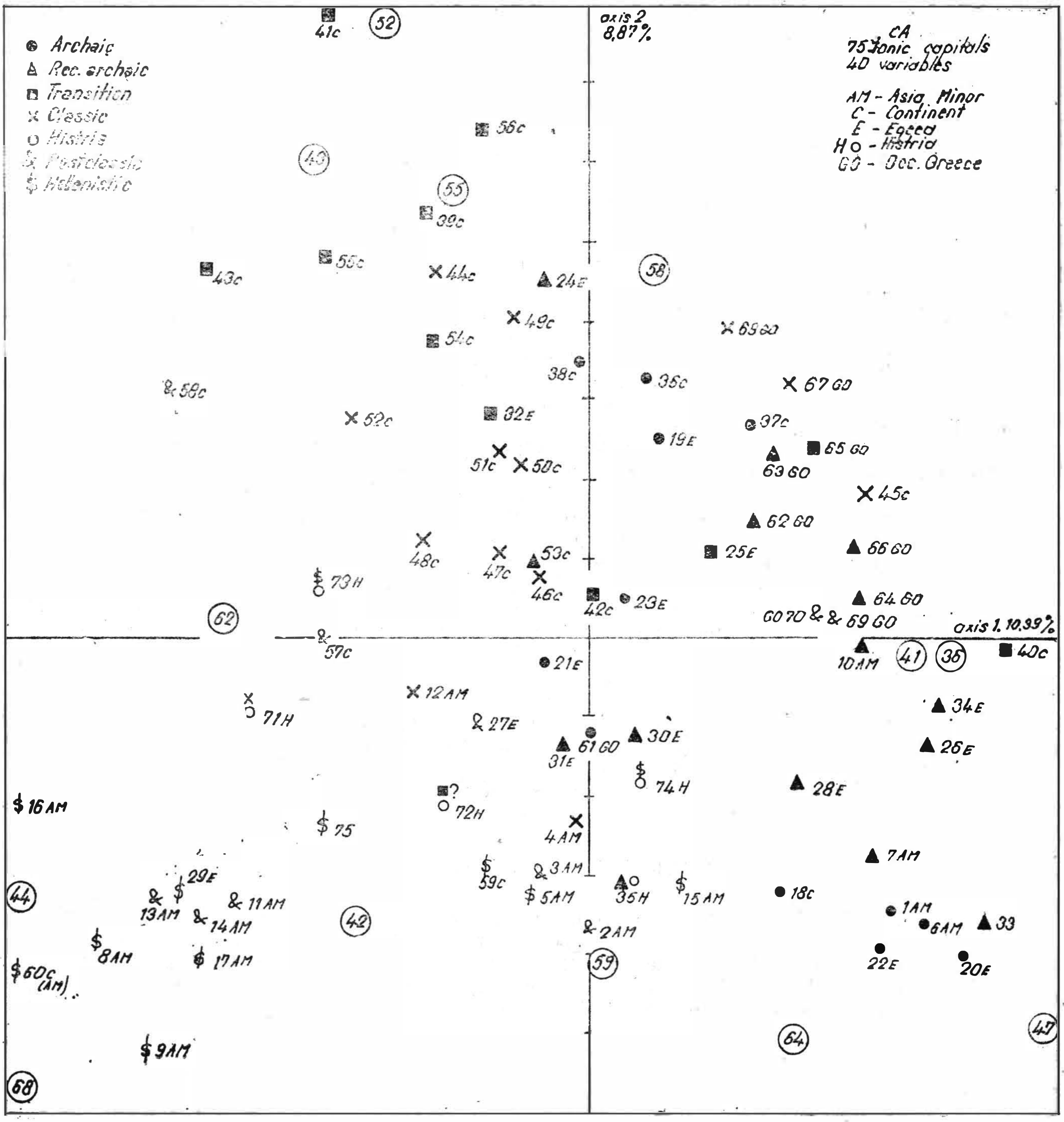

Fig. 17. — CA plot of 75 Ionic capital's 40 stylistic variables.

If we compare Figs. 1 and 17 we came easily to the conclusion that style cannot perturb the chronologic groups resulting from an analysis of composition features only. So, the composition is more relevant for the time evolution of Ionic capital physiognomy.

CA and cluster analysis conducted in terms of sole stylistic variables reveal an organization in which regional particularities carry the major weight. Still, on the whole, a distribution after the direction of chronologic evolution can be noticed. The CA however does not result in clusters, but rather in a somewhat diffuse picture in which, but for a few exceptions, the chronology can be observed on quadrants rather in terms of compact clusters. Such chronologic distribution is non-linear, revealing the persistence from one period to another, even within relative groups,

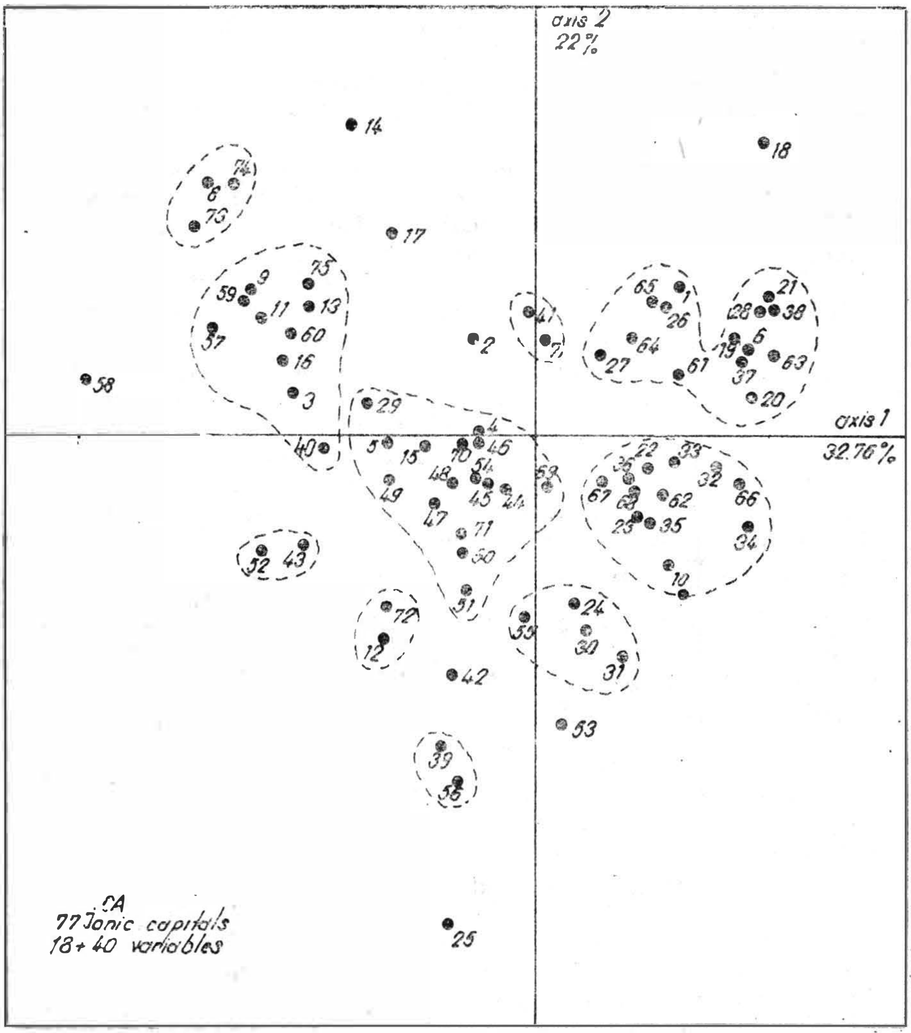

Fig. 18. — CA plot of 75 Ionic capitals ; 40 (stylistic) and 18 (composition) variables.

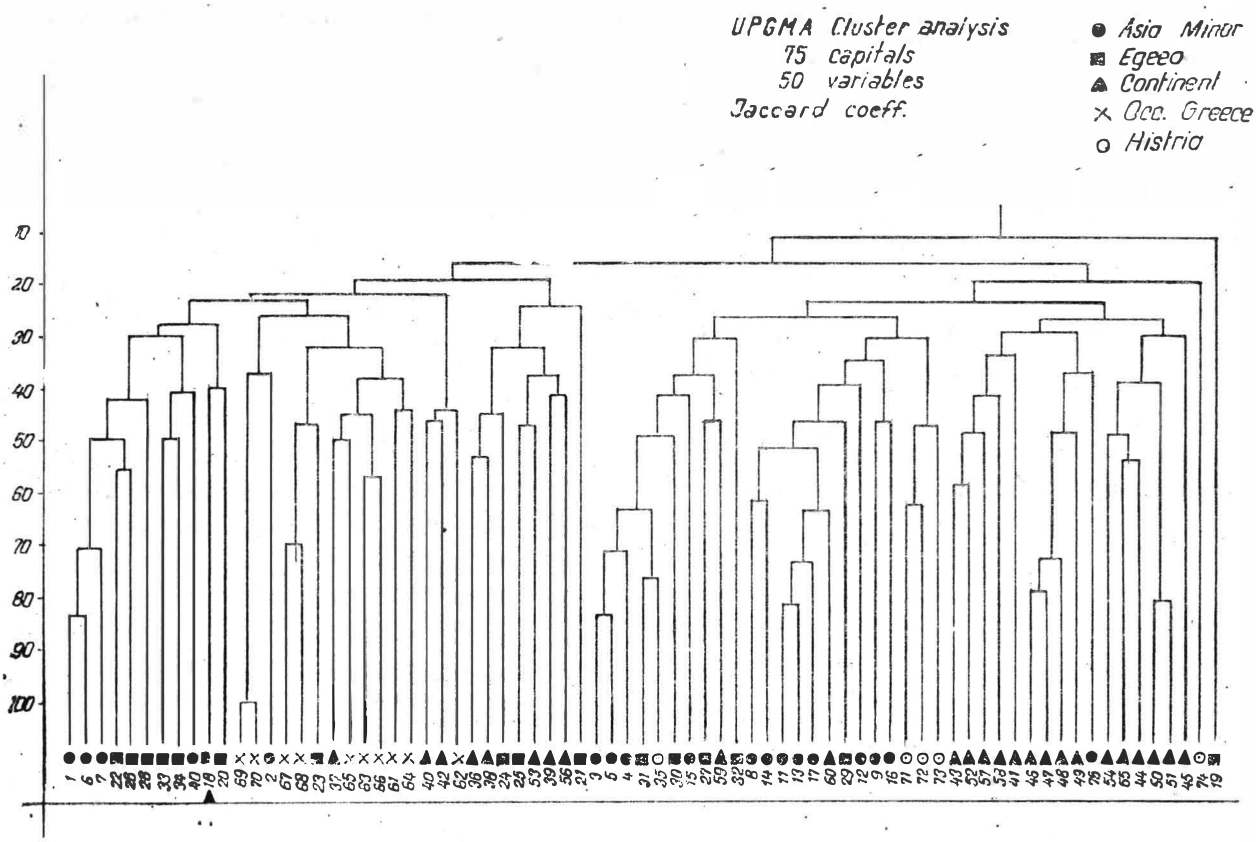

Fig. 19. — Cluster analysis, Jaccard similarity coefficient.

of certain style characteristics and pointing thus to their inertia as they can be either kept on or revived at different times.

Such inertia that can be noticed in correlation groups expressed by cluster analysis (Figs. 19—22) and even CA (Fig. 17) actually suggest the strong persistence of some regional characteristics.

From the CA in Fig. 17 one notices that the archaic and late archaic are prevailing in quadrant IV. Two of the capitals pertain to the Hellenistic age, suggesting that certain regional archaic-like characteristics are revived during Hellenism. (As a matter of fact, capital no. 15 (Saides) and perhaps capital no. 2 (Ephesus) are associated to the Asia Minor focus ; the Histrian capital no. 74 itself proves the persistence of some style features originating from Asia Minor, namely from the old Milesian colony). The archaic capital no. 61 (Marseille) likewise bears witness of an irradiation from the eastern focus to the West.

Hence, it is the Cycladic-Aegean-Asia Minor center that governs the style characteristics of the populations in quadrant IV. The simultaneous presence of the two Histrian capitals, i.e. no. 74 [31] mentioned above and a later archaic capital (no. 35), suggests, besides what we have said above through the time persistence at Histria of these dominant features of Asia Minor origin, that something we may call a "Histrian school" actually existed in that continental center. So, a style that had been acquired during the archaic period via the direct natural influence from Asia Minor (we once again recall that Histria was a Milesian colony) has generally preserved its particularities well off. They overlapped with some composition developments that have supported in time — as we have pointed out above — Attic influences [32].

We note the CA location (Fig. 17) of the "Inwood" capital no. 40, which we regard as relevant for the source of its own individual style features subject to influences from the Cycladic—Aegean—Asia Minor areas, and for its relations (even though less illustrative) to the Western population group, including influences from the same geographic areas.

Whereas the population of quadrant IV appears dominated by the Cycladic — Aegean — Asia Minor area, that of quadrant I is governed by Western Greece. Nevertheless, two archaic Aegean capitals are present here suggesting an irradiation from the Cycladic—Aegean center to the West.

Also included in that vast group are archaic Athenian capitals no. 36 and 37. From the chronological viewpoint, their dependence on the Aegean items nos. 19 and 25 may be considered. Back to the "Inwood" capital, one can say that its location in CA (Fig. 17) makes it possible that it be sort of a "bridge" from the Cycladic — Aegean Asia Minor area to the western area.

It is the archaic and transition periods that prevail in this quadrant, and the corresponding style are transmited as far as to the classic Western population (nos. 65, 67, 68) and even to the Athenian capital no. 45.

Quadrant II, that illustrates significantly a tendency to Attic classicism, is defined chronologically somewhere between the transition period and classicism.

By its position in CA (Fig. 17), the Delian capital no. 24 (Thesmophorion, transition period) appears as a "bridge" between the quadrant I and the Attic capitals. The sole archaic item in the group, Athenian votive no. 38, is associated to the same context. Capital no. 32 (Thasos) also appears stylistically closer to the continental group. Once again the Marathon capital no. 54 holds a important position within this large group. The Histrian capital no. 73 appears related from a stylistic view point to the Attic group while it is still quite near to the border of the next quadrant.

Quadrant III is dominated geographically by the Asia Minor area, and chronologically by the post-classical and Hellenistic aspect. The classical capital from the Nereid Monument at Xanthos as well as Histria capitals nos. 71 and 72 are related stylistically to the Asia Minor focus.

We will now try to discriminate between stylistic groups (or series) using the results of UPGMA methods (Figs. 19—22) which prove very effective to this aim.

A first series of correlations (most likely pointing to a stylistic series) seems to have as chronologic "peaks" the capitals no. 18 (the Naxian Column), and no 20 (the Naxian Sphinx). They are both strictly correlated to each other, thus suggesting that their typical patterns are also most similar to each other. Two subseries each of them closely connected to one of these patterns can be observed.

[31] M. Mărgineanu-Cârstoiu, Xenia, 25, 1990, p. 117—123. The data of capital no. 74 are mentioned in note 6. As to no. 73, even though it be a Roman replica (a possibility that has been mentioned in that study), the location of the composition type it replicates in the IVth—IIIrd cc. still holds.

[32] On the presumed existence of a "Histrian school" as far back as the Vth century B.C., see M. Mărgineanu—Cârstoiu, *op. cit.*, p. 113.

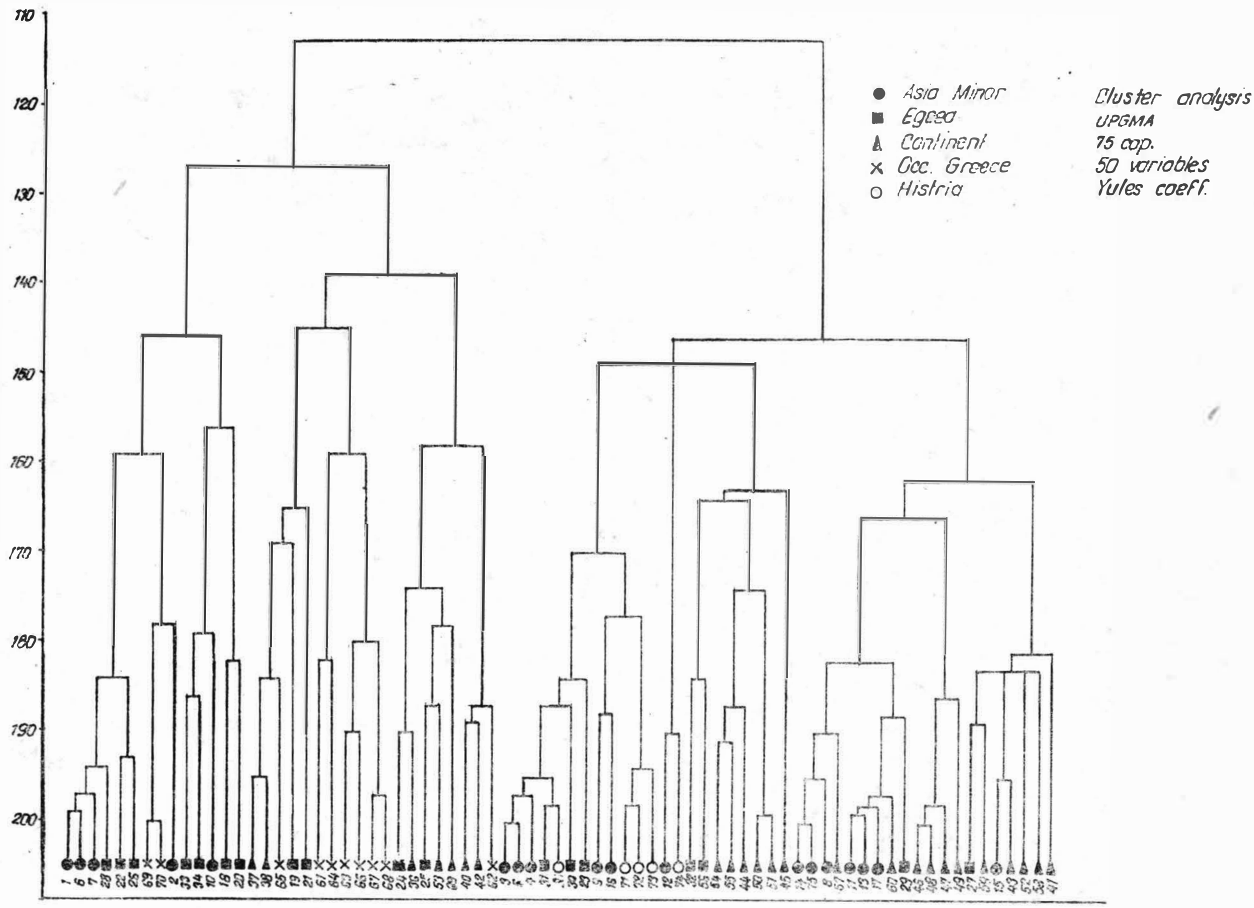

Fig. 20. — Cluster analysis, Yules similarity coefficient.

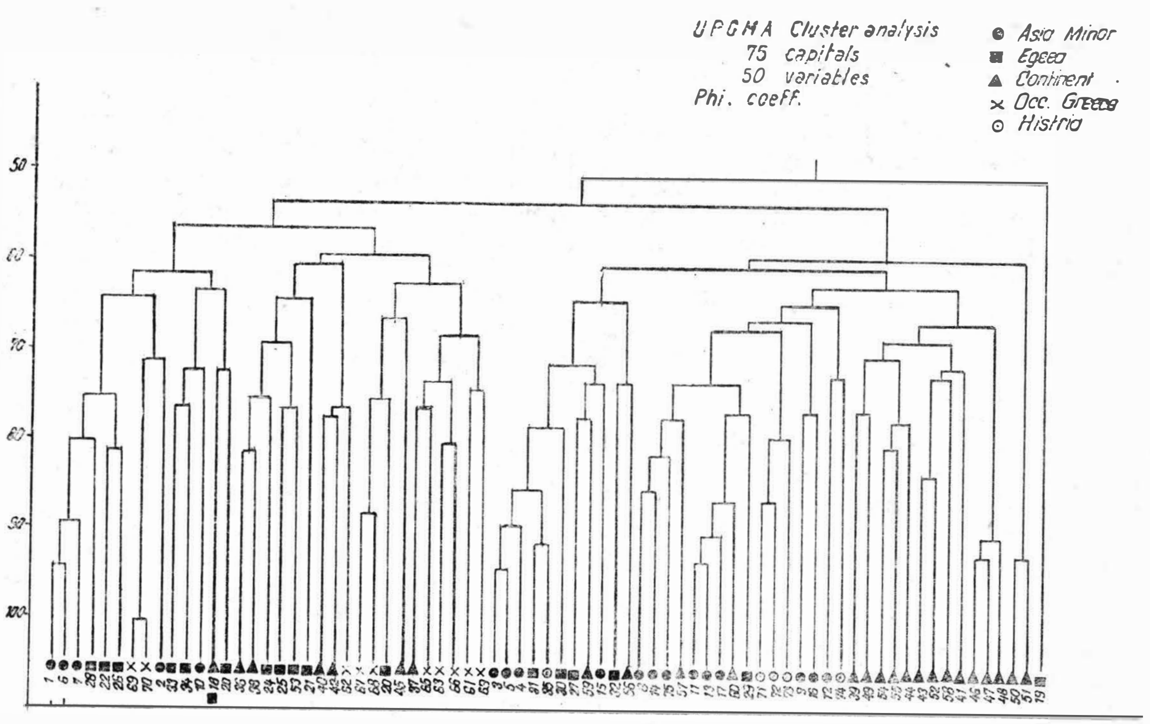

Fig. 21. — Cluster analysis, Phi coefficient.

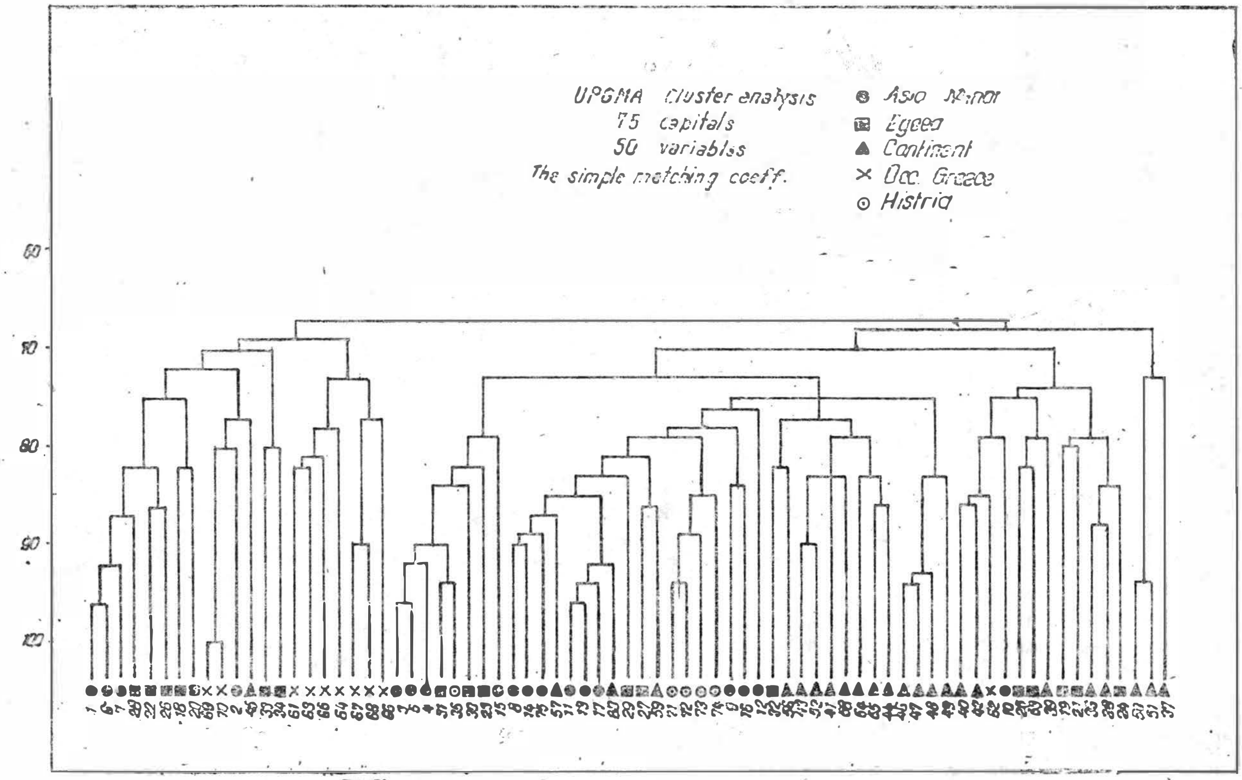

Fig. 22. — Cluster analysis, the simple matching similarity coefficient.

The first subgroup, that is associated to no. 18, has the Delian capital no. 22 (the Naxian Stoa) as a "peak" from wich further five capitals derive : no. 1 from Ephesus, nos. 6 and 7 from Didyma, no. 8 from Chios, and no. 26 from Samos.

The second subseries includes some late archaic capitals from Salonic (no. 33), Kawalla (no. 34), and Halicarnassus (no. 10), as well as the postclassical capital no. 2 from Ephesus. It is interesting to note that in CA (Fig. 17), the second subseries is distributed as a chain surrounding eccentrically the population of the first subgroup.

Of utmost eccentricity is the position of the "Inwood" capital (no. 40) that appears closely correlated with no. 62 (Paestum) and no. 42 (Athens). Together they make up a small stylistic group as is suggested by Figs. 19—22 which also reveal a potential correlation with capital no. 10 from Halicarnassus. Thus, our earlier observations on no. 40 are furthermore enriched and rounded off with a picture of the irradiation of Eastern influences to Attica. In Fig. 17 this "Inwood" group appears in connection with both the previous group included in quadrant IV and with the distinct group of Western capitals. Intergroup correlations uncovered by UPGMA method (Figs. 19—22) associate indirectly the "Inwood" group to the following subgroups in quadrant I :

(a) the Western group consisting of capitals nos. 61, 63, 64, 65, 66, 67, 68, correlated with the archaic Athenian item no. 37 and the classic Athenian item no. 45. So this group is subject to influences from the large group of quadrant IV.

(b) the "Eretria" group consisting of no. 53 (Eretria), no. 25 (Delos, a votive), no 39 (Athens) in direct correlation to one another. This stylistic subseries rounded off according to the correlations and described in chronologic order, reveals a distant focus in the Delian capitals from Naxian Oikos (no. 19) and the "engraved" capital) (no. 36), correlated to each other and followed by capitals no. 53 (Eretria), no . 24 (Delos), no. 39 (Athens) and no. 25 (Delos).

Comparing the CA ordering of composition variables (Fig. 1) with intergroup and the CA ordering in terms of style (Fig. 16, 17), it can be noticed that, whereas the original (distant) sources of influences are generally the same, the stylistic correlations are transmitted outside the composition clusters too. For instance, capitals no. 10, 34, 33 in cluster III (Fig. 1) are stylistically correlated with no. 20 of cluster I , no. 2 (isolated in quadrant III), nos. 69 and 70 of cluster VIII. In the same way, capitals nos. 1, 6, 28, 26 pertaining to the same composition cluster I and same stylistic group (Figs. 1, 16, 17) are correlated stylistically with no. 22 of cluster III, and, even no. 18 (which appears isolated from composition viewpoint as it seen in Fig. 1).

The capital from Eretria (no. 53) is once again significant : in Fig. 1 it is located in intermediate position between the clusters IV and V, while in point of style appears correlated with elements of these clusters through numbers 24 and 39, respectively. Of course, where the stylistic correlations define a number of groups coinciding to compositional groups, the series (or subseries) thus established can be regarded as the most complex and decisive for the general evolution of Ionic formula of style and composition. The "Inwood" capital (no. 40) remains an exception, account being taken of its position in Fig. 1 and its direct stylistic correlations with no. 62 (cluster III) and no. 42. In a general view, it may be assumed to pertain to a composition chain, we have formally called "the less perfect" one.

Before we move over to the next quadrant, we will have to review the capitals in quadrant IV that have been left out of the correlation so far. It is the case of the late archaic capital no. 30 from Thasos. Figs. 19—22 reveal its close stylistic correlation with the late archaic Histrian capital no. 35. This couple is correlated in its turn with Ephesian capitals no. 4 (classical), no. 3 (post-classical) and no. 5 (Hellenistic).

It is also, though more distantly, related to the subgroup consisting of the post-classical capital no. 27 from Samos and the Hellenistic nos. 59 and 15 (Olympia and Sardes, respectively). The other Thasos capital no. 32. also exhibits a correlation, even though weaker, with that group. We notice that the Delian archaic item no. 23 (Porinos Naos) seems to be the chronologic "peak" of that stylistic series. The Thasian group (whose stylistic features have their distant origin in the center expressed by Delos no. 23) can be assumed to suggest an important interference of a somewhat distinct character (a "Thasian school" perhaps) that will have influenced the Histrian archaic style illustrated by no. 35. The features of the Thasian group will then have spread through subsequent epochs down to Hellenism across the Asia Minor area (Ephesus, Sardes), the Aegean (Samos) and even mainland (Olympia) areas. The importance of the Thasos center in the Ionic development gets clearer now, account taken that the group of nos. 30 and 31 exhibits a complex unitary structure preserving its strong lasting correlation from both viewpoints of composition and of style.

So, two different trends (both starting from the same distant Delian source) have made their contribution in the formation of the Histrian archaic capital (no. 35) : as far as composition is concerned it depends mostly on such pattern as developed at Salonic (no. 33), Kavalla (no. 34) and Paestum (no. 62), which in their turn originate in the Delian focus no. 22; from the stylistic viewpoint, the Histrian capital bears witness of a direct Thasian influence, via nos. 30 and 31 that descend stylistically, in their turn, from the Delian capital no. 23 (Porinos Naos). It is worth noting that, whereas no. 22 (Naxian Stoa) and no. 23 are closely correlated to each other as to their composition, each of them appears to be the source of a distinct stylistic chains. As for Naxian Oikos, as we have already seen, it is indebted to an older pattern illustrated by capital no. 18, the Naxian Column. The other Delos capital no. 20 (the Naxian Sphinx), event though correlated — however distantly — to no. 20 (each of them part of a different composition cluster), appears as if it might have been a third Delian "peak" of a distinct stylistic sequence, as we have mentioned earlier. The manifold creative power of the Cycladic — Aegean center and its role in the original formation of Ionic capitals are clearly suggested by statistic methods in this study.

Several distinct stylistic subgroups are apparent within the great Attic group in quadrant II. According to UPGMA results (Figs. 19—22), all these subgroups appear correlated to each other at a distant level, suggesting actually a large continental series, quite distinct from former ones and revealing the creative role of Attic in the Ionic evolution.

The first stylistic group in this large series is formed by direct correlation and includes, the capital from the Athenian Stoa in Delphi (no. 55), the capital from the Marathon Memorial (no. 54) and another one from Hadrian's Library (no. 44). The peculiar character of no. 55 appears less clearcut now : whereas its composition pattern ranks it closer to the "less perfect" chain from a stylistic point of view it now seems more closely related to the At ic pattern illustrated by the Marathon capital and Hadrian's Library one. Another stylistic group begins with Athenian item no. 43 (Kynosarges Gymnasium), continues with the Athenian classic no. 41 and ends up with the post-classic item (no. 58) from the Leonidaion in Olympia.

The next group defines unequivocally the classic Athenian triad including no. 46 (Propyleae), no. 47 (the Temple on Ilissos), and no. 48 (Nike Apteros). Certainly quite close to it is the classic capital from the Asklepieion (no. 49).

The last group consists of two Erechteum capitals (nos. 50 and 51) that appear indirectly correlated with the "Marathon group". Besides, a number of more distant correlations with both capital no. 45 and the archaic Athenian capital no. 37 are visible in Figs. 19—22. This latter correlation with no. 37 might point both ito some distant stylistic echoes of Eastern origin and to something we may call the Attic "ring" (no. 37) of propagation of these influences to the Erechteum items.

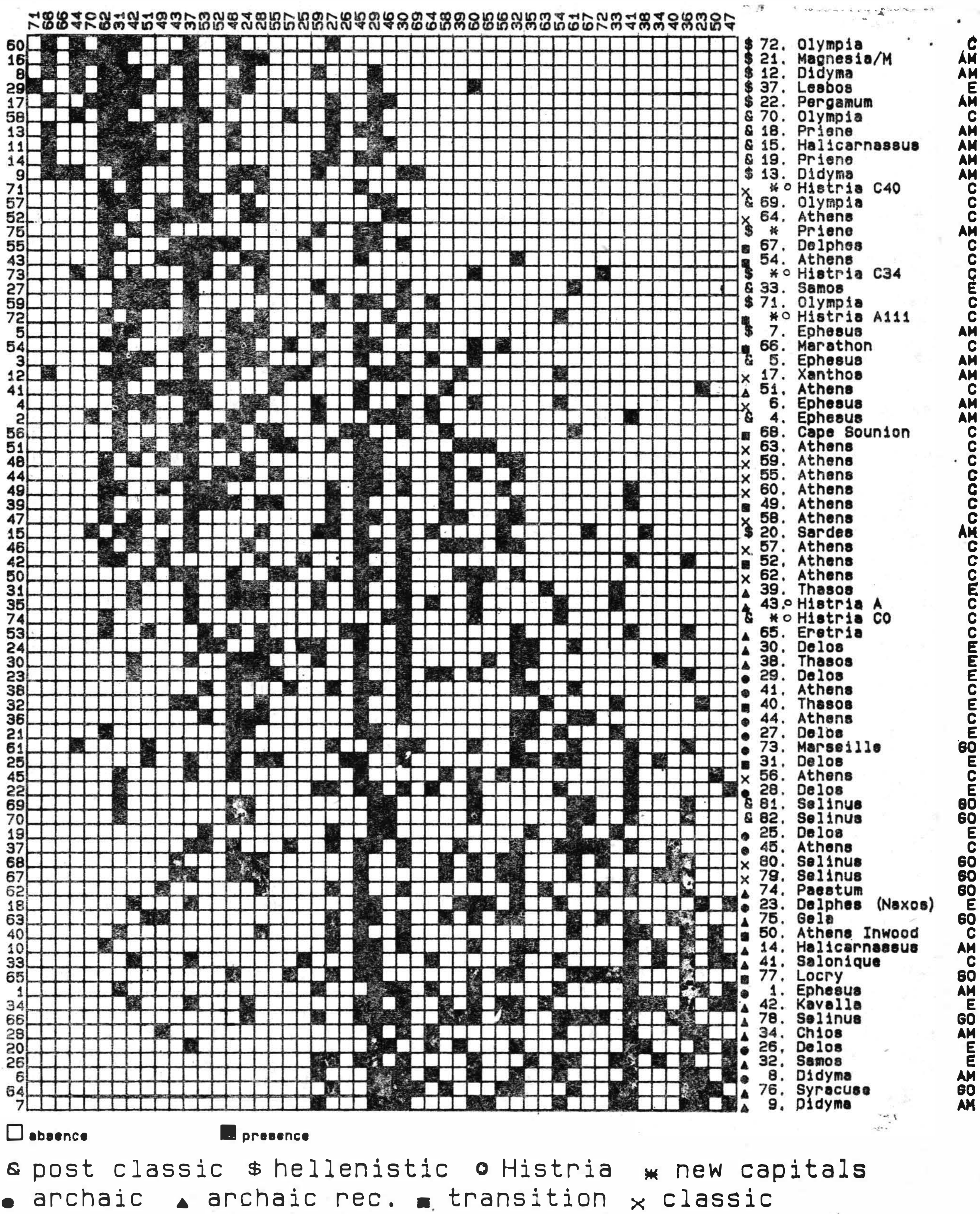

Fig. 23. — Computer seriation of 75 Ionic capitals, 50 stylistic variables.

In Figs. 19—22, Histrian capitals nos. 71, 72, 73 turn up as a small distinct group with the connections between no. 71 and no. 72 obviously closer than others. Their presence in CA (Fig. 17) in a zone of Asia Minor prevalence, reveals that the stylistic features of Asia Minor origin predominate with these Histrian capitals. So, on the whole, the so-called "Histrian school" appears to be characterized by an Attic trend in point of composition development, and a prevailing Asia Minor orientation in style.

Group correlations as suggested by Figs. 19—22 give specific evidence of this considerable proximity to the Eastern style. Such pieces of evidence are the relations of the Histrian group with other groups consisting of Eastern, Asia Minor and (sporadically) — Aegean capitals. From among these we mention the group including nos. 9 and 16 (the Hellenisti capitals from Didyma and Magnesia, respectively) and another (mainly Hellenistic) one consisting of nos. 11, 13, 17, 60, 29, etc.

Histrian capital no. 74 appears correlated to the other Histrian capitals. Together they make up something that we dare define as an illustration of a local Histrian school (Fig. 22). Figs. 19—22 also suggest a rather direct influence of the capital from the Nereid Monument at Xanthos (no. 12) upon the Histrian capital no. 74. A general view of this correlation system together with the CA picture (Fig. 1) both stress the definite importance of the stylistic pattern expressed by capital no. 12 for the evolution of Histrian style.

The chronologic peak of the Histrian sequence thus configurated is the late archaic capital no. 35. The stylistic group where it belongs appears linked by distant connections both to the Attic group and to another group consisting of remaining Histrian capitals. As a conclusion one may say the Histiian-developed style is subject to at least two significant iradiations : the first comes from Thasos, and another one, later than the first, from Xanthos. Attic type interferences, whether secondary ones, are not to be neglected.

Now we are left with the postclassic and Hellenistic capitals in quadrant III, divided into several groups suggested by the cluster analysis (Figs. 19—22) :

(a) A group of sole Asia Minor origin beginning with the votive from Halicarnassus (no. 11), followed by the postclassical item no. 13 (Priene), no. 17 (Pergamum), no. 60 (a Ptolemaic votive from Olympia) and no. 29 (Lesbos) ·,

(b) A group consisting of the postclassic capitals nos. 14 and 75 (Priene), capital no. 57 from the Olympian Philippeion, and the Hellenistic capital from the Didyma (no. 8);

Definition of variables by D Theodorescu				variable nr. fig. by D. Th.
plane	scheme		square	23
			hexagonal	24
			octagonal	25
			decagonal	26
			rectangle	27
	lower surface		prolonged up to baluster	28
			echinus under baluster	29
			baluster with same contour	30
	plateau		correspond with connection of volutes	31
			enlarged by added piece	32
			enlarged by changing of volutes line	33
facade	volutes		differend profile on faces	34
		canal	flat disc	35
			convex	36
			concave	37
			with decoration	38
			double astragal	39
			courved under plateau	40
		astragal	rond simple profile	41
			boarded rond profile	42
			flat profile	43
			absent above the echinus	44
			courved above the echinus	45
			straight above the echinus	46
		eye	absent	47
			flat or hollowed	48
			convex	49
			with rosette decoration	50
			with added piece	51
	echinus		profile lesbiancyma	52
			without carved decoration	53
			even decoration elements	54
	"coussinet"		well differentiated piece	55
			reduced between echinus and astragal	56
	palms		absents	57
			situated on "coussinet"	58
baluster	inclined (plane of volute) faces			59
	start line : straight at plateau level			60
	volume	cylindrical	simple, without profile	61
			with simple or fluted "baltaeus"	62
		fluted	three flutes	63
			four flutes	64
			more than four flutes	65
		bell	with or without decoration	66
	decoration	scales	on the baluster	67
			on the baltaeus	68
		vegetale	on the baluster	69
			on the baltaeus	70
			on the flutes	71
shaft	partially added at capital			72

Fig. 24. — The definition of stylistic variables (by D. Theodorescu).

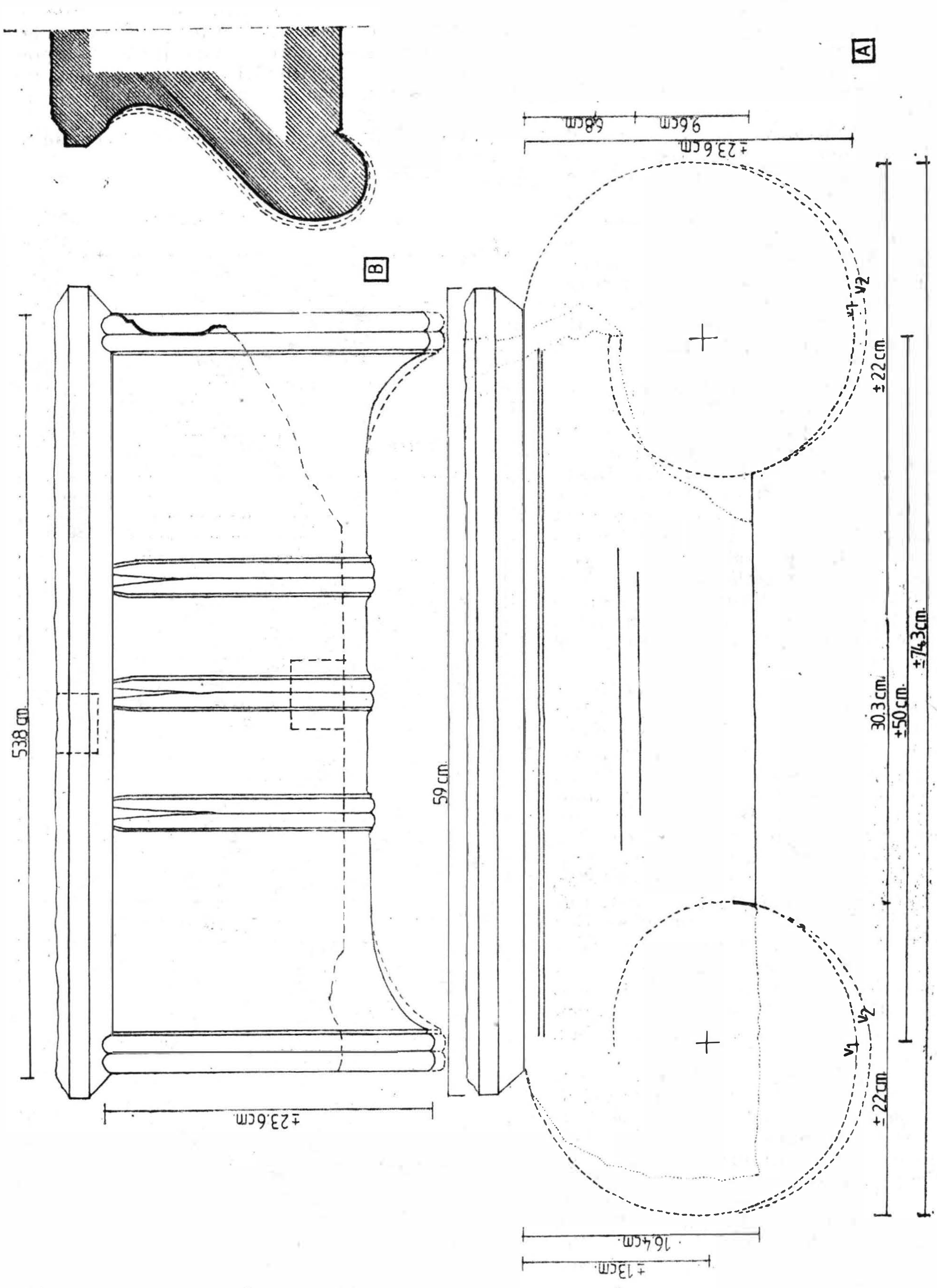

Fig. 25. — Capital no. 74; A : main front, B : lateral front.

(c) A larger group (nos. 31, 30, 35, 4, 3, 5, 27, 59, 15), related to the quadrant IV (Fig. 17) earlier discussed ; in this group now we only overscore the direct correlations that reveal, on one hand, the subgroup of Ephesian capitals with the classical no. 4 as chronologic peak followed by a post-classical capital (no. 3) and a Hellenistic one (no. 5) and, on the other hand, a subgroup with its chronologic peak in no. 27 (Samos) and including besides a Hellenistic votive from Olympia (no. 59) and another Hellenistic capital from Sardes (no. 15) ;

(d) a Hellenistic group consisting of no. 9 (Didyma) and no. 16 (Magnesia/M) and correlated with the Histrian group, as we have pointed out above.

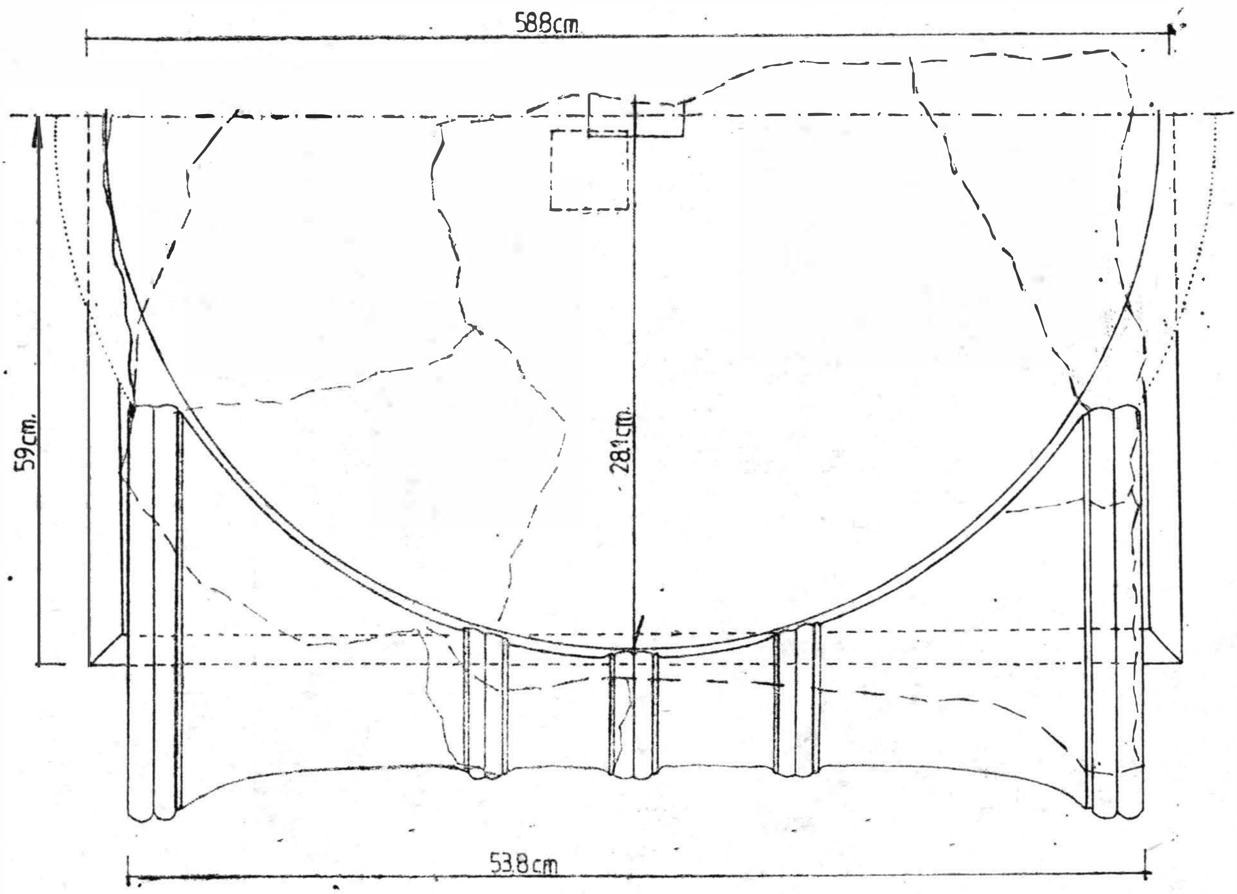

Fig. 26. — Capital no. 74 : plan.

Of course, there are among all these stylistic groups or series a number of overlappings (as revealed by cluster analysis) that also account for their somewhat diffuse distribution in CA (Fig. 17). The stylistic variables in terms of which the correlations described above can be determined and the aspects expressing intergroup irradiation can be seen in Fig. 23. The table, which is an illustration of a simple seriation method, describes on whole both the large stylistic groups distinguished earlier and the possibilities for reassessing some of the interpretations that have been outlined so far.

★

The purpose of this study has not been to bring forth some surprising novelty on the Ionic capital, but rather to underscore the capacity statistical methods have to dig out fundamental information on the account of which research on the Ionic evolution could be circumscribed in a more complex range of topics. From this viewpoint, we hope our study to be one step forward in the direction opened by D. Theodorescu and A.—M Collombier. The main difficulty (besides the lack of a complete description in many a case, which D. Theodorescu had already had to cope with) arose from that a number high enough of pictures and mappings of the capitals in our statistics were unavailable to us due to a quite limited access to references we have had so far. That is what barred us from a deeper approach, including a classification of the issues and a discussion in terms of style and composition at the same time. Some of our interpretations in this paper are likely to illustrate the drawback much to our regret [33].

[33] I am indebted to prof. Stig Welinder (Uppsala) for his granting me permission to use the STAR computer program. I also owe many thanks to dr. F. Cârstoiu (Inst. of Atomic Physics, Bucharest) for the design of several computer programs and his mathematical supervision of the paper. I also thank dr. M. Dincă (Inst. of Atomic Physics) for the computer processing of Figs. 4 and 23 and Table I.