A Comparison of Seriation Methods using the Material from the Rhitsóna Cemetery, Boiotia, Central Greece

by

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Abstract

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using the Material from the Rhitsóna Cemetery, Boiotia, Central Greece.

Seven seriation methods were used to order the 86 graves from the cemetery at Rhitsóna, Boiotia, Central Greece in an attempt to obtain a chronological sequence. Most of these methods made use of matrices of similarity and distance coefficients. Three such coefficients were calculated using sets of 102 and 132 binary attributes which described the graves and their contents numerically. The sequences produced were evaluated on the basis of the arrangements of the coefficients in the matrices when the graves were placed in the suggested order as well as on their approximation of the true chronological order of the burials.

The results indicate that one of the basic assumptions used in most seriation methods may not always be true.

Résumé

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Etude des Methodes de Sériation utilisant le Matériel du Cimetière du Village de Rhitsóna, Béotie, Grèce Centrale

Dans le but d'obtenir une succession chronologique, sept differentes methodes de sériation ont été utilisées pour classifier les 86 tombes du cimetière de Rhitsóna, Béotie, Grèce Centrale. La plupart de ces methodes utilisent des matrices des mesures de similitude et de dissimilitude. Trois de ces mesures ont été calculés utilisant des groupes de 102 et 132 présences-absences qui décrivent les tombes et leurs contenus numériquement. Les successions obtenues furent évaluées sur bases de la disposition des mesures dans les matrices, les tombes étant placées dans l'ordre suggeré; ainsi que, approximativement l'ordre chronologique des enterrements.

Les résultats indiquent que la supposition de base utilisé dans la plupart des methodes de sériation pourrait ne pas être toujours justifiée.

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Introduction

Archaeological seriation may be defined as: "the task of arranging a set of comparable archaeological units, for example assemblages of artifacts, into a meaningful sequence solely on the basis of comparisons and contrasts between them" (Doran and Hodson 1975, p. 267). Usually in dealing with archaeological material, the analyst is looking for a sequence which is chronological. The comparisons and contrasts between units are made on the basis of the similarity or distance between them as represented numerically by similarity and distance coefficients.

Seriation is by no means a new technique in archaeological research. Towards the end of the last century, Sir William Flinders Petrie used a form of seriation which is called "sequence dating" in his study of 900 graves at Naqada in Egypt (Petrie 1899). The most important advance since Petrie came in the early 1950's with the publication of a new seriation algorithm by Brainerd and Robinson (Brainerd 1951; Robinson 1951), and nearly a decade later with descriptions of two computer programs for this algorithm (Ascher and Ascher 1963; Kuzara, Mead and Dixon 1966).

In recent years, several "rapid seration" algorithms have appeared in the literature. These are methods which are not supposed to require the use of a computer unless very large groups of units are being seriated. Some of these rapid methods were compared to the Brainerd-Robinson technique (Hole and Shaw 1967) in order to see whether they could duplicate the results obtained by the older method. In some ways, this study is a partial continuation of that begun by Hole and Shaw using, for the most part, algorithms for rapid seriation which have been published since their article. There are, however, differences.

To compare the similarity between units, Hole and Shaw used coefficients of agreement which depended on the relative frequencies of pottery styles within the deposits. For various reasons (see Section 4.1 below) it was decided, in this study, to use coefficients depending on the presence or absence of a set of attributes to calculate the similarity. In addition, these coefficients are calculated first using only the attributes describing the ceramic finds from the units and then using the attributes describing all the finds in order to attempt to determine the specific contribution made by the pottery which has, traditionally, been the main criterion used in dating most archaeological deposits.

The graves from the cemetery at Rhitsōna in Boiotia, Central Greece were chosen for this study for several reasons. This is one of the few systematically excavated cemeteries in Greece for which the results have been so completely published. Also, these graves have been dated independently using the pottery style and this sequence is readily available (Sparkes, 1967, pp. 128-130). A large sample of material is available from a single site, thus regional variation should not seriously affect the results. There are, of course, several imported objects which were found in the graves, and so there may be a small disturbance in the orderings obtained, but for the most part, the orderings should be chronological.

It should be remembered that this type of quantitative analysis of archaeological material should serve only as a guide to the writings of the history of a site or area. The methods described below should be used as time savers in the study of material and not as ways of obtaining a final chronological ordering of excavation units.

After a brief description of the site and the finds it produced, the attributes, the similarity and distance coefficients, and the seriation methods used in this analysis will be discussed. Following this the results obtained by using various combinations of attributes, coefficients and methods will be presented. Finally, these results will be compared and discussed.

Chapter 1 - The Site and Finds

1.1 Location, excavation and brief history of the site.

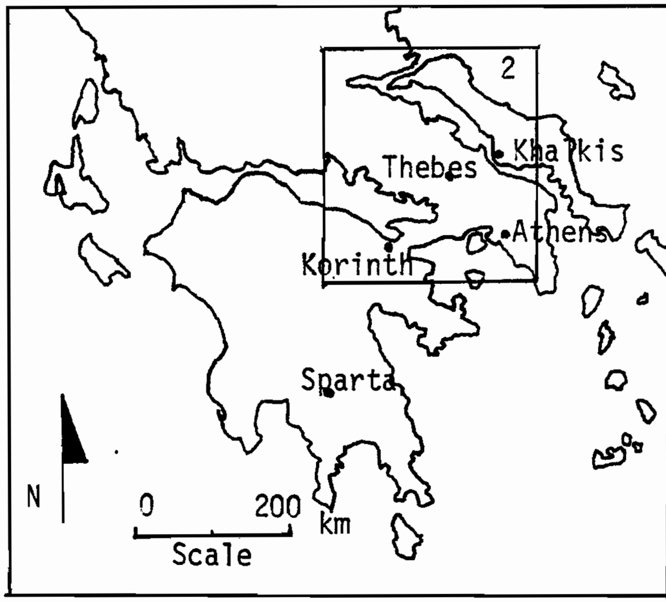
Rhitsóna is situated in eastern Boiotia about two thirds of the way along the road from Thebes to Khalkis in Euboia (see Maps 1-3). The modern road passes through the ancient site with the settlement on the west and the excavated cemetery on the east. Just to the north of the site, the road to Vathý branches off from the Thebes-Khalkis road.

The ancient site located near the modern hamlet of Rhitsóna is most probably that of Mykalessos. The position of Rhitsóna matches that given Mykalessos by several of the ancient authors (Thoukydides vii, 29, 2-4; Strab ix, 404; Pausanias i, 23; Pausanias ix, 19; Burrows and Ure 1907-8, pp. 232-242). Modern scholars seem to agree with the identification made by the excavators (Bakhuizen 1970, pp. 18-20; Fossey 1976, pp. 103-105).

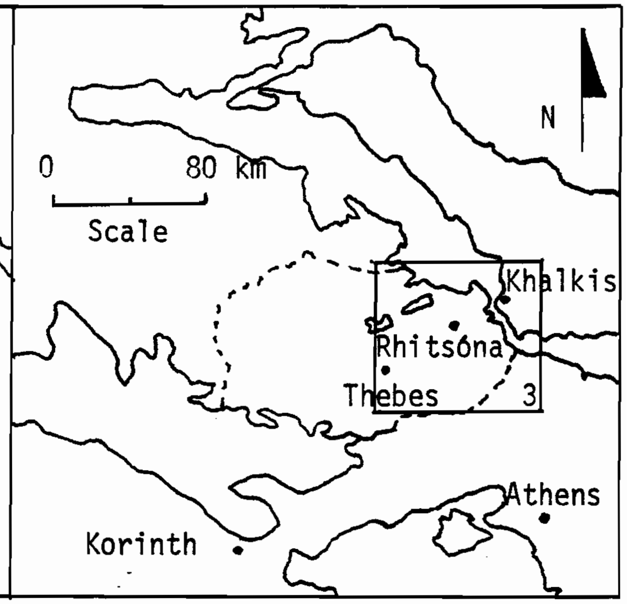
In the local ancient traditions, the name Mykalessos was given to this site because it was here that the cow which was leading Kadmos and his followers to Thebes lowed (Pausanias ix, 19).

Mykalessos may have had some prehistoric inhabitants as it is mentioned in Homer's Catalogue of Ships (<u>Iliad</u> ii, 498, Homer, <u>Hymn to Apollo</u> 222-4). Surface finds of sherds from the Early, Middle and Late Helladic periods (Fossey 1976, p. 102) also suggest some form of prehistoric occupation.

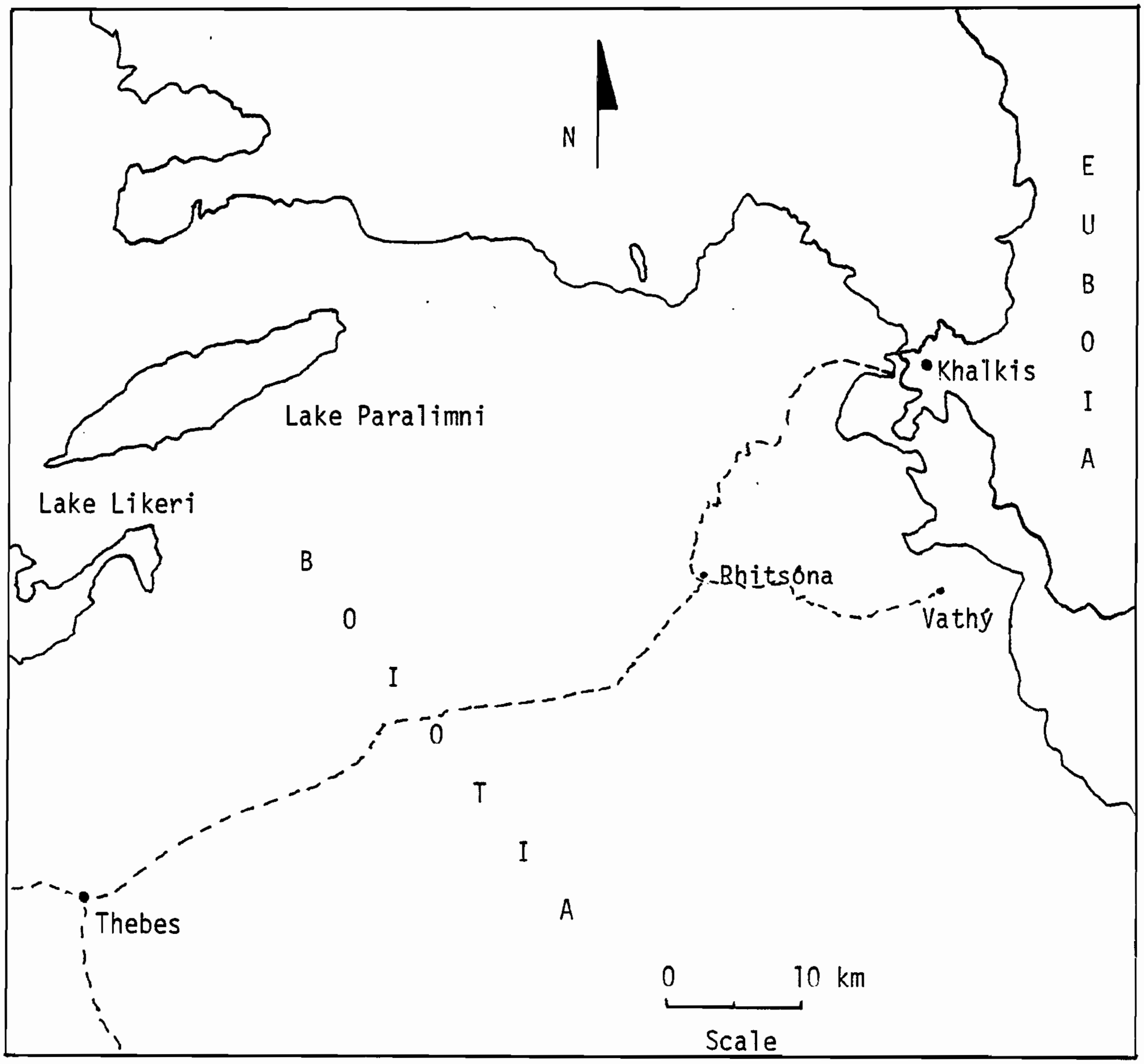
The position of the site, on two important communication routes, contributed greatly to its importance in antiquity



Map 1: Central and Southern Greece.



Map 2: Boiotia.



Map 3: North-East Boiotia.

(Burrows and Ure 1907-8, p. 236). The site flourished and minted its own money (Roesch 1965, p. 36) until the beginning of the fifth century BC when Athens defeated Khalkis. Rhitsóna had sided with Khalkis in this battle and declined in importance after it (Burrows and Ure,1907-8, p. 237). Rhitsóna, which had been an independent town and a member of the Boiotian League in its own right until this time, was probably annexed by Thebes. Its name does not appear in the list of League members after the re-organization by the Spartans in 457 BC (Bakhuizen 1970, pp. 150-51).

In 413 BC a group of Thrakian mercenaries, returning from a battle further south, attacked and captured Mýkalessos. By this time the town's walls had fallen, and the town, which was not expecting the attack (Thoukydides vii, 29) was captured. Almost the entire population was slain. The town was reoccupied from the early fourth century BC until as late as the second or third century AD.

The town itself, which has not been excavated, lies below modern fields which have been ploughed extensively. The cemetery is on a wooded ridge and has not been subject to the same treatment. It was excavated first by R.M. Burrows and P.N. Ure in 1907-8 and 1909, and in 1921-2 by P.N. Ure and A.D. Ure. These excavations (Burrows and Ure 1907-8, 1909; Ure 1912, 1913, 1915, 1927, 1934) uncovered graves ranging in date from Late Geometric (mid 8th cent. BC.) to Hellenistic or later (3rd - 2nd cents. BC.), some of which were very rich in finds. Their contents are briefly described in the remaining sections of this chapter.

The numbering system used for the graves, which does not correspond to their chronological order, but rather to the order of their discovery, contains some gaps. Some of the shafts which were originally given numbers in the sequence did not contain burials. To avoid confusion, the grave numbers were not changed for the publications (Ure, 1975b).

The material from the graves is presently in the archaeological museum in Thebes where a small selection of the numerous finds is on display. All information about the graves and finds from Rhitsóna used in this study comes from the catalogues in the publications. The material, which is in storage at the Thebes museum, was disturbed during the last war and subsequent rebuilding of the museum, and may have become mixed with finds from other excavations (Ure, 1975b). This would make physical examination of the actual finds a difficult and time-consuming process.

1.2 The Pottery.

The dating by an archaeologist of a deposit from almost any site in Greece depends to a great extent on the pottery it contains. Both the clay fabric and the style of decoration used on the surface of the pots changed considerably, even over relatively short time periods. Clay vessels break easily and are inexpensive. Thus a constant demand, which encourages changes in style, exists. For this reason, pottery can be used more often to obtain an accurate date for a deposit than almost and other type of find.

The graves excavated at Rhitsóna contained pottery dating from at least as early as the late Geometric period (9th and 8th centuries BC) and possibly the Protogeometric period (10th century BC), (Desborough 1952, pp. 294-5). The latest published pottery is Hellenistic (323-146 BC) in date. During the time spanned, many distinct pottery style were produced and appear in the Rhitsóna cemetery.

As the names imply, Protogeometric and Geometric pots are often decorated with geometric designs such as sets of concentric circles and semi-circles, triangles, diamonds and sets of bands. Occasionally, figured decoration was included on Geometric pieces, but no examples of this were found at Rhitsóna.

Grave 134 produced the only pot which is possibly Protogeometric. This is the pyxis 134.5 (Desborough 1952, pp. 195 and 318). The remaining pots from this grave, as well as those from grave 1 probably date from the Geometric period (Coldstress 1968, pp. 200 and 411). If 134.5 is Protogeometric, it is possibly an heirloom and is out of its true chronological context.

A ware usually known as 'Argive Monochrome' was present in several of the Rhitsóna graves. This is a pale, unpainted ware usually found in small jugs and conical oinochoai. It is occasionally decorated with incised or impressed zigzags or wavy lines. This ware is found in many places outside the Argolid, hence the quotation marks around the name. These other styles may have been local imitations of the

GRAVE / POTTERY STYLE	1	2	3	4	5	6	12	13	14	18	21	22	22A	26	30	31	33	34	36	40	46	49	50	51	52	55	56	57	59	60	61	66	67	68	75	76	80	82	85	86	87	88	89
PROTOGEOMETRIC																																											
GEOMETRIC	X																																										
ARG. MONOCHROME						X																																					
PROTOCORINTHIAN		X	X		?	X		?													X				?										X	X						X	X
CORINTHIAN			X	X	X		X	X	X	X	X			X		?				X		X	X	X													X	X	X	X	X		X
BOIOT. KYLIX S.					X		X			X		X	X	X		X			X	X	X	X	X	X													X	X	X				
BUCCHERO																																											
BLACK GLAZE			X		X		X			X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				X	X	X	X	X			
BLACK FIGURE		X	X		X		X			X		X	X	X	X	X	X		X		X	X	X	X	X	X		X		X	X					X	X	X	X	X			
RED FIGURE										X		X						X																									
WHITE GROUND																					X																						

GRAVE / POTTERY STYLE	90	91	92	93	95	96	97	99	101A	101B	102	103	104	107	108	110	111	112	113	114A	114B	115	120	121	123	125A	125B	125C	125D	125E	126	127	130	131	132	133	134	135	138	139	141	144	145
PROTOGEOMETRIC																																					?						
GEOMETRIC																																					X						
ARG. MONOCHROME																												X							X		X						X
PROTOCORINTHIAN	X	X		X				X																											X								
CORINTHIAN		X	X		X	X	X	X	X	X	X	X	X			X		X	X	X		X	X	X		X	X	X	X	X	X	X	X	X		X		X			X		X
BOIOT. KYLIX S.											X					X		X	X				X	X							X	X		X		X		X					
BUCCHERO		X	X					X		X																																	
BLACK GLAZE									X		X			X	X	X	X	X	X	X	X		X	X	X						X	X	X			X		X	X	X		X	
BLACK FIGURE				X							X				X	X		X	X	X	X		X	X	X						X	X	X	X		X		X		X		X	
RED FIGURE																																											
WHITE GROUND																																											

Table 1.1: Pottery styles found in the graves.

pottery which was produced either in the Argolid or at Korinth (Cook 1972, p. 23; Courbin 1966, pp. 31-32). The fabric dates from possibly as early as the eighth century BC and is found in contexts dated as late as the sixth.

At Rhitsóna, graves 6, 125C, 132, 134 and 145 contained 'Argive Monochrome' ware. All of these examples are jugs with either short or long necks. Some have impressed decoration (Ure 1934, pp. 18-19).

About the middle of the eighth century BC there was an increase in contact with the East which indirectly influenced the production and decoration of pottery (Cook 1972, p. 41). Since these innovations come from the Orient, the pottery produced at this time in Greece is called Orientalizing. It is characterized by a broader repertoire of decorative motifs and vase shapes than had previously been used. The decoration included human and animal figures and mythological creatures. Floral motifs such as the palmette and lotus were also introduced at this time. The figured decoration is executed more convincingly than previously giving less the appearance of stick figures. This style eventually developed into the black figure style.

Several types of Orientalizing pottery were found at Rhitsóna. The first of these is the Protocorinthian style which dates from about 725-640 BC (Cook 1972, pp. 46-55) and is found in a number of the graves (Table 1.1 and Ure 1934, pp. 19-21). The most common pot shape in this style from Rhitsóna is the aryballos, but a lekythos was also found. The painted decoration of these pots is mostly thin horizontal bands with rays or thicker bands at the bottom. Occasionally there are narrow zones of dots or running animals among the thin bands (Ure 1934, Pl. 3). Other decorative motifs may also appear. A detailed description of the style is given by Johansen (1923).

Local imitations of the Protocorinthian ware also appear (Ure 1934, pp. 21-2). These are jugs and bowls.

The Protocorinthian style developed through a transitional phase into the Corinthian style by about 625 BC. This style lasted until about 550 BC or later (Payne 1930, pp. 281-338). Corinthian pottery was found in a large number of the graves (Table 1.1). A detailed description of this pottery and the type of decoration used is given by Ure (1934, pp. 22-46) and Payne (1930 passim). In general, Corinthian pottery shows a devolution in decorative style over Protocorinthian. The emphasis is increasingly on speed of production and the decoration is sloppy, with elongated animals and large quantities of filling ornament (Cook 1972, pp. 55-62).

Corinthian pottery, as well as Protocorinthian, was decorated using incision for interior outlines of figures and added colour to emphasize details of the decoration. Purple, yellow and white are the colours most commonly added.

Another Orientalizing style found in the Rhitsóna graves is the Boiotian kylix style or the Bird Cup Group (Cook 1972, pp. 101-2). These are two- or four-handled cups some of which have a pedestal base. The decorative motifs used range from geometric zigzags and cross hatching to palmettes and birds.

The decoration is applied to the exterior and where birds have been included they are upside down. A detailed catalogue of examples from Rhitsóna is given by Ure (1927, pp. 12-20). The pots from this cemetery date between c. 550 and c. 500 BC.

One example of a style formerly known as Naukratis ware, but now known to have originated on the island of Khios (Cook 1972, p. 125) was found in grave 50. This is a chalice (Burrows and Ure 1909, pp. 332-334 and Pl. 25) which is dated to just after 550 BC by the excavators. It is a polychrome vase with two cocks depicted in the main decorative zone. This piece is probably an import (Burrows and Ure 1909, p. 133).

Several pots are in a fabric called bucchero by the excavators (Ure 1934, pp. 46-7). This indicates that they were fired in such a way as to make the clay gray or black throughout.

Black figure is a term that could be used to describe several of the pottery styles discussed above. However, the true black figure style was in fashion in most areas of Greece from about the middle of the sixth century BC until at least the middle of the fifth (Cook 1972, pp. 81-92). It is characterized by larger figured zones than those used on the preceding Orientalizing styles. Mythological scenes and scenes of everyday life are usually depicted on black figure pottery. In some cases, though, the pots are decorated with purely floral motifs.

The style is called black figure because the decoration is applied in clay-based paint to the surface of the pot.

After firing, the painted areas are black while the background remains in the colour of the clay. Details are still indicated by incision and added colours.

The most numerous black figure pots from Rhitsóna were kylikes, lekythoi and skyphoi. These come from a large number of the graves (Table 1.1) and have been classified and described in detail by the excavators (Ure 1927, pp. 39-73). These consist of imports from Attica and Euboia as well as local Boiotian black figure wares.

The hands of individual artists can sometimes be distinguished in black figure pottery. Many of the pots from Rhitsóna have been assigned to craftsmen or workshops (Beazley 1956, passim).

The red figure style is the opposite of black figure. The background is painted black while the figures decorating the surface of the pot are left in the original clay colour (usually red or pink). The use of incision decreases with most internal detail being indicated by painted lines. Incision is used to outline such things as black hair against the black background of the pot (Cook 1972, pp. 161-2). Added colour was also still used.

Red figure pottery was in fashion from the later sixth century BC until late in the fourth (Richter 1959, pp. 313-356). Some of the vase painters and workshops which had produced black figure pottery also made red figure and many new workshops opened.

Red figure pottery was found in only three graves at Rhitsóna. From grave 18 comes a kylix with the depiction of a nude figure carrying a tripod vessel in the internal central medallion. Grave 22 contained a kylix showing the back view of a seated figure on its interior and a skyphos with a satyr and an Amazon on the exterior. A small lekythos was found in grave 34. This last pot was decorated with a palmette on the front of the body. Certain of these pots have also been attributed to workshops (Beazley 1963, passim).

A style of pottery which was popular at the same time as red figure was white ground. This style, which was originally used on several pot shapes, became confined to the lekythos by about the middle of the fifth century BC (Cook 1972, p. 176). White ground pots were really red figure pots on which the background had been covered by a white slip.

Only grave 46 at Rhitsóna contained a white ground lekythos. This pot was decorated with one female figure, holding a fruit and a mirror, and palmette and lotus designs (Burrows and Ure 1909, p. 326 and Pl. 24).

By about the middle of the fifth century BC (Cook 1972, p. 186) a style of pottery known as black glaze ware had become popular. This ware is not really glazed but is covered with a lustrous coat of black paint. Sometimes lines or bands in purple are added.

The graves at Rhitsóna yielded large amounts of black glaze pottery which have been classified by the excavators (Ure 1913, pp. 4-19). Many of these were decorated by fluting or were done in imitation repoussé. That these pots had some value to their owners is illustrated by the fact that some had been repaired when the stem had broken off by the use of a lead rivet (Ure 1913, pp. 18-19).

Three of the graves (numbers 66, 67, 68) contained pottery from the Hellenistic period (323-146 BC). Numerous small flasks known as lacrymateria or unguentaria, plates, bowls, jugs, a lamp and various metal objects came from these graves (Ure 1913, pp. 55-57). The unguentaria are in green (or possibly gray) clay with white bands added as decoration. One has incision and several have a white rectangle on the middle of the body. The remaining pottery from these graves was usually undecorated though one plate had spirals and dots. The clay of these pots was usually reddish in colour.

1.3 Other finds.

Besides pottery, the Rhitsôna graves yielded large numbers of small finds, most of which were metal objects, terracotta figurines, glass vases and beads.

The metal objects were primarily of bronze and iron, although lead and silver ones were present (Ure 1934, p. 78). Many nails were found, some of which were attached to bronze plates as though they had been used to attach these to wooden coffins. Also found were strigils in bronze and iron. These were used to scrape oil and perspiration from the skin. Bronze fibulae, some with incised decoration, occured in a few of the graves. Other bronze objects included pins, needles, disks and finger rings of both the band and spiral types.

The figurines from the Rhitsóna graves exhibit a variety of forms. One from of human figurine was called the "pappas" because it had a head dress similar to that worn by a modern Greek priest. This type of figurine was probably meant to represent a goddess (Ure 1934, p. 52, note 2). Both standing and seated varieties were present.

Other human figurines were found, both male and female, in standing, seated and reclining positions. Some of these were draped and others were nude. The hair on some of the human figurines was represented by rows of raised dots or blobs of clay on the head. Human figurines like these and the "pappades" described above were common votive offerings at Boiotian sanctuaries and in Boiotian graves (Grace 1939; Goldman and Jones 1942).

Several of the figurines from this excavation were of forms between animal and human. Satyrs and selenoi fall into this category.

Figurines in animal forms were also numerous at Rhitsóna. Many horses were found, some with human or monkey riders and others without. Also found were cows, bears, pigs, rabbits, turtles, frogs and various types of birds. These animal figurines were also commonly used in Boiotian tombs (Grace 1939; Goldman and Jones 1942).

The terracottas, one in the form of an egg and the other in the form of a quince or an apple, were also found. A very detailed list and classification of the figurines has been published by Ure (1934, pp. 53-75).

Only four glass vases were found at Rhitsóna (Ure 1934, p. 76). There were three amphoriskoi and one alabastron. These vases were made using the "sand core" method of glass manufacture (Richter 1969, p. 384), and are perhaps imports to this site. Also of glass were some of the beads. Others were made of stone or a chalky paste. The beads were of various shapes and sizes (Ure 1934, pp. 76-77).

Several pieces of worked bone were found in two of the graves. These consisted of pieces of a bone strip with notches going right across the strip at frequent intervals and pieces of a second strip with triple grooves going across its width. These strips may have served a decorative purpose on wooden boxes.

1.4 List of graves with references, contents and dates.

The following is a list of the graves from Rhitsóna used in this study. Graves 15, 58, 74, 105, 117 and 136 were not included, either because their contents had been severely disturbed or because there was no pottery present.

The entry for each grave begins with a bibliography followed by a brief description of the pottery styles and small finds found in the grave. Next, the number of objects in the grave is given. This is broken down into categories of vases, figurines, metal objects and other types of finds where appropriate. In some cases, the numbers of objects mentioned in the description may not agree precisely with the numbers stated at the end of the entry. This is due to the fact that occasionally fragments of several finds were given a single find number and listed as a single find in the catalogue of the grave. Finally, the approximate date of the grave is given. The bibliography follows that of Sparkes (1967, pp. 128-130) with a few corrections and additions. A list of abbreviations used can be found at the beginning of the bibliography. The principal reference for each grave appears at the beginning of its bibliography. The dates are also those published by Sparkes. The dates are summarized in Table 5.1. The pottery styles found in each grave are summarized in Table 1.1.

1 <u>JHS</u> 30 (1910) pp. 341-2, figs. 5-6.
<u>Aryb</u>. p. 17f.
<u>GGP</u> p. 200 and 411.
An inhumation (?) accompanied by pottery with linear decorations dated to the Geometric period.
4 vases.
Mid 6th cent. BC.

2 <u>AE</u> 51 (1912) p. 119, fig. 21
An inhumation accompanied by Protocorinthian and black figure pottery.
There is also one head of a figurine.
4 vases, 1 figurine.
Late 6th - early 5th cent. BC.

3 <u>AE</u> 51 (1912) pp. 114-116, figs. 14-17.
<u>BGP</u> p. 15.
An inhumation accompanied by Protocorinthian, Corinthian, black figure and black glaze pottery.
60 vases.
Third quarter of the 6th cent. BC.

4 <u>JHS</u> 30 (1910) pp. 353-6, figs. 17-20.
An inhumation accompanied by Corinthian pottery, fragments of a bronze disc and three pieces of bronze spiral ring.
39 vases, 4 bronze finds.
c. 600 BC.

5 JHS 31 (1911) p. 75, fig. 4.
BGP p. 18.
AE 51 (1912) pp. 116-119, figs. 18-20.
VI and V Pls. 20 and 22.
Aryb. p. 58, fig. 8.
ABV p. 620, 83; 627, 5.
An inhumation accompanied by pottery of the Boiotian kylix style as well as Protocorinthian (?), Corinthian, black figure and black glaze pottery.
Also found was a figurine in human form.
34 vases, 1 figurine.
Late 6th cent. BC.

6 JHS 30 (1910) pp. 344-6, figs. 6 and 8.
FGS p. 7, 143-4.
VS p. 74 and 163.
An inhumation accompanied by "Argive Monochrome" and Protocorinthian pottery, fibulae and bronze spiral rings.
7 vases, 6 metal objects.
Late 8th cent. BC.

12 JHS 29 (1909) pp. 316-21, figs. 6-8.
BGP p. 17, Pl. 4.
AE 51 (1912) p. 114, figs. 12-13.
AE 54 (1915) p. 127, figs. 24-25.
VI and V Pls. 16 and 20-22.
ABV p. 214, 51; 468, 47; 581, 14; 622, under 115.
An inhumation accompanied by pottery of the Boiotian kylix style as well as Corinthian, black figure and black glaze pottery, and figurines and iron nails. The metal objects were listed as one find.
89 vases, 2 figurines, 1 metal find.
c. 500 BC.

13 JHS 30 (1910) pp. 346-9, figs. 9-12.
Aryb. Pl. 4.
NC p. 34; 274, 69; 291, 643.
VS p. 163.
An inhumation accompanied by Protocorinthian (?) and Corinthian pottery as well as pottery from the transitional period between the two. Also found were a bronze disc and an iron pin.
14 vases, 2 metal objects.
640-625 BC (or slightly later).

14 JHS 30 (1910) pp. 350-353, figs. 13-16.
Aryb. Pl. 9.
NC p. 57; 290, 567; 291, under 641.
An inhumation accompanied by Corinthian pottery.
29 vases.
Late 7th cent. BC.

18 BSA 14 (1907-8) pp. 287-298, figs, 8, 12, 17-21, Pls. 7-8, 13.
JHS 29 (1909) pp. 334-338, Pl. 26.
BGP p. 17, Pls. 2, 5-9.
AE 54 (1915) pp. 125-6, figs. 17-19.
VI and V Pls. 15-19, 21-22.
Stud. Ridge Pl. 2.
Aryb. Pls. 17-18.
NC p. 334, under 1517.
ABL p. 36; 109; 110; 187, note 2; 231, 9; 242, 17; 253, 10 and 14.
JHS 75 (1955) pp. 92-3, 14.
ABV p. 209, 3; 499, 35; 506, 2; 522, 1; 580, 1 and 5; 591, 2; 619, 54; 621, 103; 626, 1; 627, 3 and middle; 628, 4.
Para. p. 91, 12; 308 under Skyphoi.
BSA 68 (1973) p. 29.
An inhumation accompanied by pottery of the Boiotian kylix style, as well as Corinthian, black figure, black glaze and red figure pottery. There were also figurines in human and animal forms, lead rivets, iron fragments and worked bone.
255 vases, 12 figurines, 2 metal finds, 2 bone fragments.
c. 500 BC.

21 BSA 14 (1907-8) p. 298, fig. 22.
An inhumation accompanied by Corinthian pottery.
3 vases.
Early 5th cent. BC.

22 BSA 14 (1907-8) pp. 299-304, fig. 23, Pls. 13-14.
ARV^2 p. 140, 29; 381, 177.
A cremation (?) accompanied by pottery of the Boiotian kylix style as well as black glaze, black and red figure pottery. There are also two plastic vases.
10 vases.
500-480 BC.

22A BSA 14 (1907-8) pp. 299-300, 304-5.
The description of this grave is incomplete through no fault of the excavators. Work on grave 22 was interrupted by difficulties with the land owner. When it resumed, it was found that grave robbers had been at work. The remaining finds were excavated as 22A. The grave contained pottery of the Boiotian kylix style, black glaze and black figure pottery.
5+ vases.
Not dated by Sparkes, but should be 6th or very early 5th cent. BC.

26 BSA 14 (1907-8) pp. 281-287, figs. 12 and 16, Pls. 8, 11-12 and 15.
JHS 29 (1909) p. 309, note 5.
JHS 31 (1911) p. 81, fig. 10.
BGP pp. 16-17, Pls. 4 and 8-9.
VI and V Pls. 14, 16, 18, 21.
Aryb. p. 58, fig. 8, Pl. 17.
ABL p. 68, 108; 199.
ABV p. 467, 20; 471, 2; 491, 53; 617, 1-3; 623, 2.
NC p. 334, under 1517.
ASB p. 46.
An inhumation accompanied by pottery of the Boiotian kylix style as well as Corinthian, black figure and black glaze pottery. The grave also contained a small glass amphora, figurines in human and bird forms, fragments of iron which were possibly pieces of nails.
234 vases, 1 glass vase, 6 figurines, 4 metal finds.
510-500 BC.

30 BGP pp. 53-55, Pl. 17.
An inhumation accompanied by black glaze and black figure pottery and one figurine of a woman with a bird.
30 vases, 1 figurine.
Second half 4th cent. BC.

31 BSA 14 (1907-8) pp. 271-281, figs. 12 and 15, Pls. 7, 11-12 and 15.
JHS 29 (1909) p. 338, note 97.
JHS 31 (1911) p. 77, fig. 6, p. 79, figs. 8-9.
BGP pp. 15-16, Pls. 2-3, 5-6 and 8.
AE 51 (1912) pp. 109-110, figs. 2-3, p. 112, figs. 6-8 and note 1, p. 113, figs. 9-11, p. 114, figs. 12-13, Pls. 6, 2.
AE 54 (1915) p. 120, figs. 9-11, pp. 123-4, figs. 14-16.
VI and V p. 45, Pls. 6-7, 9, 14-15, 17-18, 19.
JHS 52 (1932) p. 62, II C 70, p. 65, III C 94 and 98.
Aryb, Pls. 14 and 18.
ABL p. 36; 68; 108; 201, 7; 204, 7.
NC p. 336, 1542.
JHS 75 (1955) pp. 90-91, 6; p. 91, 7.
ABV p. 209, 1-2; 471, 119-120 and 1; 496, 178; 619, 48; 625, middle; 626, 2.
Para. p. 84, 8; 91, 4; 94, under Skyphoi.
BSA 58 (1963) p. 18 and Pl. 2.
ASB pp. 45-7.

An inhumation accompanied by pottery of the Boiotan kylix style as well as Corinthian (?), black figure and black glaze pottery. There are also fragments of a glass vase and figurines in human and animal form, and iron nails.
360 vases, 1 glass vase, 13 figurines, 1 metal find.
c. 515 BC.

33 BGP pp. 52-53, Pl. 16.
An inhumation accompanied by black glaze and black figure pottery as well as fragments of an iron strigil.
50 vases, 1 metal find.
Early second half 4th cent. BC.

34 BGP pp. 50-52, Pl. 15.
VI and V Pl. 10.
An inhumation accompanied by black glaze and red figure pottery as well as two fragmentary iron strigils and one bronze needle which has been lost since the excavation.
45 vases, 3 metal finds.
Mid 4th cent. BC.

36 JHS 29 (1909) pp. 329-331, fig. 14.
BGP Pl. 9.
VI and V Pl. 10.
Aryb. Pl. 17.
An inhumation accompanied by pottery of the Boiotian kylix style as well as black figure and black glaze pottery. The grave also contained figurines in animal and human form, fragments of an iron nail or pin, fragments of a bronze fibula, bronze rings and yellow beads.
20 vases, 3 figurines, 3 metal finds, 2 beads.
Early 5th cent. BC.

40 JHS 29 (1909) pp. 310-316, figs. 1-5, 8.
BGP p. 13.
ASB p. 47.
An inhumation accompanied by pottery of the Boiotian kylix style as well as Corinthian and black glaze pottery. There were also figurines in human and animal form.
128 vases, 8 figurines.
Mid 6th cent. BC.

46 JHS 29 (1909) pp. 321-329, figs. 8-13, Pls. 23-24.
BGP p. 18.
AE 51 (1912) pp. 102-111, figs. 1, 4, 5, p. 115, fig. 15, Pls. 2, 6.

VI and V Pls. 15-16, 22.
ABL 112, δ; 141; 150, note 2; 259, 115.
ABV p. 530, 70; 546, 213 and 218; 547, 246; 560, 5131 571, 701 and 707.
ARV² p. 302, 10; 306, 7.
An inhumation accompanied by pottery of the Boiotian kylix style as well as Protocorinthian, black figure, black glaze and white ground pottery. Also found was a glass amphoriskos, figurines in bird and human form and iron and bronze nails.
56 vases, 1 glass vase, 2 figurines, 2 metal finds.
Early 5th cent. BC.

49 BSA 14 (1907-8) pp. 250-256, figs. 6 and 12, Pls. 9 and 15.
BGP pp. 13-14, Pls. 1 and 7.
AE 51 (1912) p. 114, figs. 12-13.
AE 54 (1915) pp. 116-117, figs. 1-3, pp. 118-119, figs. 4-5.
VI and V Pls. 13 and 17.
Aryb. fig. 8, Pls. 13, 14, 16.
ABL p. 3; 4, 2, 12, 17-18; 5; 10, note 3; 22; 28, note 2; 29; 34.
ABV p. 68, middle; 70, 2; 655, 11.
Para. p. 203, under class B, 2 and 3.
ASB pp. 40, 45.
An inhumation accompanied by pottery of the Boiotian kylix style as well as Corinthian, black figure and black glaze pottery. Also found were figurines in human and animal form, fragments of a silver phiale and fragments of iron nails.
420 vases, 25 figurines, 2 metal finds.
c. 560-550 BC.

50 BSA 14 (1907-8) pp. 257-264, figs. 7 and 9-12, Pl. 10.
JHS 29 (1909) pp. 332-334, fig. 15, Pl. 25.
BGP p. 14, Pls. 1 and 7.
AE 51 (1912) p. 113, figs. 10-11.
AE 54 (1915) p. 123, note 1.
VI and V Pls. 13 and 17.
Origin of Tyranny p. 115.
JHS 49 (1929) Pls. 12, 13, 16.
Aryb. p. 36, fig. 5, p. 38, fig. 6, Pls. 7, 9, 15, 16.
JHS 52 (1932) p. 56, I A 1.
ABL p. 4, 13-14; 5; 15, note 4; 16; 28, note 2; 36.
Studies Robinson Pl. 11 a-c.
ABV p. 30, 5 and 8; 655, 12.
NC p. 60 and note 4; 319, 1222; 320, 1265, 1289; 334 under 1517.

Para. p. 201, under class B, 1.
BSA 58 (1963) p. 18 and Pl. 2.
BSA 68 (1973) pp. 29-30 and Pls. 7-8.
ASB pp. 22, 40.
An inhumation accompaied by pottery of the Boiotian kylix style as well as Corinthian, black figure and black glaze pottery. Also present was Khiot ware. There were also figurines in human and animal forms and fragments of iron nails.
387 vases, 18 figurines, 1 metal find.
c. 560-550 BC.

51 BSA 14 (1907-8) pp. 265-270, figs. 13-14, Pls. 9 and 15.
BGP pp. 14-15, Pl. 7.
AE 51 (1912) p. 110, fig. 3, left, p. 113, figs. 10-11.
Stud. Ridgeway Pls. 1 and 2.
AE 54 (1915) p. 119, figs. 6-8, p. 123, figs. 12-13.
VI and V Pls. 13 and 17.
JHS 52 (1932) p. 56, I A 2, p. 57, I B 6.
Aryb. p. 58, fig. 8, Pls. 13 and 15.
ABL p. 36.
NC p. 60 and notes 2 and 5; 323, 1335; 334, under 1516 and 1517.
Para. p. 84, 12; p. 201, under class C, 1 and 2.
BSA 68 (1973) pp. 27-8 and Pl. 7.
ASB pp. 40, 45.
An inhumation accompanied by pottery of the Boiotian kylix style as well as Corinthian, black figure and black glaze pottery. Also found were figurines in human and animal forms and one nail head of an unspecified metal.
295 vases, 12 figurines, 1 metal object.
c. 540 BC.

52 BGP pp. 41-42, Pl. 10.
This grave was disturbed and the excavators are not sure that the objects listed come from it. It is an inhumation accompanied by Protocorinthian (?), black glaze and black figure pottery as well as one headless figurine in human form.
16 vases, 1 figurine.
First half 5th cent. BC. and c 400 BC (sic).

55 BGP pp. 49-50, Pl. 15.
An inhumation accompanied by black glaze and black figure pottery. Also found were two figurines in human form and fragments of a strigil.

15 vases, 2 figurines, 1 metal find.
Second half 5th cent. BC.

56 BGP pp. 48-49, Pl. 14.
An inhumation accompanied by black glaze pottery, a female figurine and fragments of a bronze needle. The needle has been lost since the excavation.
5 vases, 1 figurine, 1 metal find.
4th cent. BC.

57 BGP pp. 42-45, Pl. 11.
An inhumation accompanied by black figure and black glaze pottery as well as female figurines, glass beads, two bronze needles and lozenge-shaped pieces of white lead.
10 vases, 7 figurines, glass beads, 3 metal finds.
End of 5th cent. BC.

59 BGP pp. 46-47, Pls. 12 and 13. (see also pp. 45-46).
An inhumation accompanied by black glaze pottery as well as fragments of two iron strigils.
48 vases, 1 metal find.
Early 4th cent. BC.

60 BGP pp. 47-48, Pls. 12-13. (see also pp. 45-46).
An inhumation accompanied by black glaze and black figure pottery as well as fragments of three figurines in human form and fragments of several iron strigils.
43 vases, 3 figurines, 1 metal find.
First half 4th cent. BC.

61 BGP p. 41.
This is an undated group of fragments of black figure and black glaze pottery. There are also two fragments of figurines.
4 vases, 1 figurine.
Undated by Sparkes, but is later than 440 BC.

66 BGP pp. 55-56, Pl. 18.
An inhumation accompanied by unglazed pottery, a black glazed lamp and a bronze needle.
19 vases, 1 lamp, 1 metal object.
Mid 3rd cent. BC, or later.

67 <u>BGP</u> p. 56, Pl. 18.
An inhumation accompanied by only four lacrymateria (see fig. 2.1k) in green or gray clay with white bands.
4 vases.
Mid 3rd cent. BC, or later.

68 <u>BGP</u> pp. 56-57.
An inhumation accompanied by unglazed pottery and a bronze fragment.
2 vases, 1 metal object.
Mid 3rd cent. BC, or later.

75 <u>JHS</u> 30 (1910) pp. 342-344, figs. 6-7.
<u>FGS</u> p. 7, 142.
<u>VS</u> p. 88, 163.
An inhumation accompanied by Protocorinthian and unglazed pottery as well as two bronze fibulae, a bronze pin and three bronze spiral rings.
4 vases, 6 metal objects.
Late 8th cent. BC.

76 <u>BGP</u> pp. 40-41, Pl. 9.
<u>ABL</u> p. 136; 184; 189.
<u>ABV</u> p. 576, 6; 577, 24.
An inhumation accompanied by Protocorinthian, black figure and black glaze pottery as well as fragments of a lamp.
25 vases, 1 lamp.
Third quarter 5th cent. BC.

80 <u>VI and V</u> pp. 82-84 and 103, fig. 6, Pls. 1, 8-12, 14-16, 19, 21.
<u>Aryb</u>. Pls. 14, 18, 21.
<u>ABL</u> p. 55; 63; 107; 109; 163, note 2; 201, 3 and 9; 202, 21; 204, 6; 212, 148; 223, 43; 254.
<u>ABV</u> p. 469, 73; 488, 2; 492, under 76; 493, 105; 494, 121; 496, 163-4; 499, 29; 500, 61; 502, 114; 618, 38.
<u>Para</u>. p. 222, under The Painter of Munich 1874; 245.
An inhumation accompanied by pottery of the Boiotian kylix style as well as Corinthian, black figure and black glaze pottery. Also found were a glass bottle, figurines in human form, fragments of worked bone, fragments of silver possibly from a necklace, fragments of bronze and pieces of iron nails.
267 vases, 1 glass bottle, 1 bone find, 4 metal finds.
c. 500 BC.

82 VI and V p. 84, Pls. 18 and 22.
Aryb. Pl. 19.
ABL p. 144, note 3; 253, 17.
ABV p. 627, 7.
An inhumation accompanied by pottery of the Boiotian kylix style as well as Corinthian, black figure and black glaze pottery and one seated female figurine.
39 vases, 1 figurine.
Late 6th - early 5th cent. BC.

85 VI and V p. 85, Pls. 1 and 9.
An inhumation accompanied by pottery of the Boiotian kylix style as well as Corinthian, black figure and black glaze pottery.
45 vases.
Third quarter of 6th cent. BC.

86 Aryb. p. 83, Pls. 2, 4-13, 15-16, 21.
NC p. 60; 314, 1081-1083; 319, 1205, 1217, 1233; 320, 1244.
ABL p. 3, note 2; 4, 1.
ASB p. 25.
An inhumation accompanied by Corinthian, black figure and black glaze pottery as well as figurines in human and animal form and a bronze ring.
274 vases, 22 figurines, 1 metal object.
c. 580-570 BC.

87 Aryb. p. 83, Pls. 4, 5, 8, 21.
An inhumation accompanied by Corinthian pottery and one bronze ring.
28 vases, 1 metal object.
c. 600 BC.

88 Aryb. p. 83, Pls. 1 and 3.
VS p. 163.
(cf. FGS no. 145).
An inhumation accompanied by Protocorinthian pottery and two iron fibulae.
4 vases, 2 metal objects.
Late 8th cent. BC.

89 Aryb. pp. 83-84, Pls. 1, 4, 6.
An inhumation accompanied by Protocorinthian and Corinthian pottery and a white substance (see Ure 1934, p. 9).
9 vases, white substance.
Late 7th cent. BC.

90 Aryb. p. 84, Pls. 1 and 3.
An inhumation accompanied by one Protocorinthian lekythos.

1 vase.
Late 8th or early 7th cent. BC.

91 Aryb. p. 84, Pls. 3, 6, 8, 9, 21.
NC p. 56; 291, 633.
An inhumation accompanied by Protocorinthian, Corinthian and bucchero pottery as well as fragments of a bronze disc. The one Corinthian pot may be an intrusion.
30 vases, 1 metal object.
Late 7th cent. BC.

92 Aryb. p. 84, Pls. 1, 4, 5, 8, 9, 21.
An inhumation accompanied by Corinthian and bucchero pottery and a bronze ring.
17 vases, 1 metal object.
c. 600 BC.

93 Aryb. p. 22, note 2, p. 84.
This group of objects may not come from a grave. The group contains Protocorinthian and black figure pottery.
5 vases.
Mid 6th cent. BC.

95 Aryb. p. 85, Pls. 1, 8, 9, 21.
An inhumation accompanied by Corinthian pottery and five bronze rings.
54 vases, 5 metal objects.
c. 600 BC.

96 Aryb. p. 85, Pl. 1.
An inhumation accompanied by Corinthian pottery and two animal figurines.
7 vases, 2 figurines.
c. 570 BC.

97 Aryb. p. 85, Pls. 1, 4-6, 10, 12.
NC p. 57; 290, 568.
An inhumation accompanied by Corinthian pottery as well as a limestone alabastron.
13 vases, 1 limestone vase.
c. 650-600 BC, or later.

99 Aryb. pp.85-86, Pls. 3, 4, 6, 10, 17.
VS p. 17.
An inhumation accompanied by Protocorinthian, Corinthian and bucchero pottery as well as a figurine in animal form and an iron nail.
52 vases, 1 figurine, 1 metal object.
Early 6th cent. BC.

101A *Aryb*. p. 86, Pls. 2, 10, 12.
An inhumation accompanied by Corinthian and black glaze pottery.
5 vases.
c. 570 BC. (?)

101B *Aryb*. p. 86, fig. 1, Pls. 2, 7, 12, 15, 17, see also p. 89.
An inhumation accompanied by Corinthian and bucchero pottery and figurines in animal form.
37 vases, 4 figurines.
c. 590-580 BC.

102 *VI and V* pp. 92-93, 102, fig. 6, Pls. 1, 7-9, 11-12, 14, 17-20.
ABL p. 205, 6.
ABV p. 619, 52; 621, 94; 624-5, 1-9 and middle.
BSA 68 (1973) p. 29.
An inhumation accompanied by pottery of the Boiotian kylix style as well as Corinthian, black figure and black glaze pottery.
107 vases.
c. 520 BC.

103 *Aryb*. p. 86.
An inhumation accompanied by Corinthian pottery with possible intrusions of coarse pottery.
13 vases.
c. 550-525 BC.

104 *VI and V* pp. 86-87.
Aryb. Pl. 17.
An inhumation containing Corinthian pottery, figurines in human and bird forms and a pale blue substance embedded in the earth.
41 vases, 3 figurines, blue substance.
Mid 6th cent. BC.

107 *VI and V* p. 87, Pl. 25.
An inhumation accompanied by black glaze pottery and two figurines in human form.
7 vases, 2 figurines.
First half 4th cent. BC.

108 *VI and V* pp. 87-88.
Aryb. Pl. 20.
ABL p. 136.
ABV p. 566, 622.
An inhumation accompanied by black glaze and black figure pottery and a female figurine.

6 vases, 1 figurine.
Mid 5th cent. BC.

110 VI and V p. 88, 103, fig. 6, Pls. 6, 8, 13.
Aryb. Pls. 14-16.
Para. p. 201, under class B.
ASB p. 45.
An inhumation accompanied by pottery of the Boiotian kylix style as well as Corinthian, black glaze and black figure pottery. Also found were figurines in human, animal and bird form.
110 vases, 22 figurines.
Mid 6th cent. BC.

111 VI and V p. 89.
An inhumation accompanied by black glaze pottery and a bronze needle.
3 vases, 1 metal object.
Second half 5th cent. BC.

112 VI and V pp. 89-90, Pls. 2, 5-8, 12, 16, 19, 20.
Aryb. Pls. 14, 17, 19.
ABV p. 471, 1; 619, 47; 673.
NC p. 333, 1512.
ASB p. 46.
An inhumation accompanied by pottery of the Boiotian kylix style as well as Corinthian, black glaze and black figure pottery. Also found in this grave were figurines in animal and human form and fragments of large iron nails. The nails were listed as one find.
70 vases, 12 figurines, 1 metal find.
Late 6th cent. BC.

113 VI and V pp. 90-91, 103, fig. 6, Pls. 2, 11, 15.
ABL p. 585, 6.
An inhumation accompanied by pottery of the Boiotian kylix style as well as Corinthian, black glaze and black figure pottery.
57 vases.
Early 5th cent. BC.

114A VI and V p. 91, 103, fig. 6, Pls. 1, 10, 24.
Aryb. Pl. 20.
NC p. 334, under 1517.
An inhumation accompanied by Corinthian, black figure and black glaze pottery and one female figurine. For the Corinthian pot see Payne (1930, p. 334).
17 vases, 1 figurine.
c. 430-420 BC.

114B VI and V pp. 91-2, Pl. 25.
BSA 70 (1975) p. 270.
This group of vases, which may not have been a grave, contained black glaze and black figure pottery.
29 vases.
c. 400 BC.

115 VI and V p. 92, Pls. 7, 8, 10.
An inhumation accompanied by Corinthian and unglazed pottery.
52 vases.
c. 570 BC.

120 VI and V pp. 92-93, Pls. 2, 22.
ABV p. 628, 5.
An inhumation accompanied by pottery of the Boiotian kylix style as well as Corinthian, black glaze and black figure pottery. There was also one figurine in the shape of a horse.
52 vases, 1 figurine.
Late 6th cent. BC.

121 VI and V pp. 93-94, 103, fig. 6, Pls. 6-7, 9, 11-12.
Aryb. Pl. 19.
ABV p. 424, 7.
An inhumation accompanied by pottery of the Boiotian kylix style as well as Corinthian, black glaze and black figure pottery. Several figurines were also found.
34 vases, 5 figurines.
Late 6th - early 5th cent. BC.

123 VI and V p. 94, 103, fig. 6, Pls. 2, 10-11, 24.
An inhumation accompanied by black figure and black glaze pottery as well as bronze and iron strigils and iron nails.
34 vases, 5 metal objects.
c. 430-420 BC.

125A Aryb. pp. 86-87, figs. 2-3, Pls. 5 and 12.
An inhumation accompanied by Corinthian pottery and part of a bronze spiral ring.
17 vases, 1 metal object.
c. 600 BC.

125B Aryb. p. 87, figs. 2-3, Pls. 8-9.
An inhumation accompanied by Corinthian pottery.
7 vases.
c. 600 BC.

125C *Aryb*. p. 87, figs. 2-3, Pls. 3, 10, 13.
An inhumation accompanied by 'Argive Monochrome' and Corinthian pottery as well as figurines in human form, beads and bronze spiral rings. The rings were listed as one find.
13 vases, 2 figurines, 13 beads, 1 metal find.
c. 590-570 BC.

125D *Aryb*. p. 87, figs. 2-3, Pls. 13, 16.
An inhumation accompanied by Corinthian pottery and figurines in human and animal form.
4 vases, 2 figurines.
c. 590-580 BC.

125E *Aryb*. p. 87, figs. 2-3.
An inhumation accompanied by Corinthian pottery.
3 vases.
Early 6th cent. BC.

126 *VI and V* pp. 94-96, 103, fig. 6, Pls. 2, 4-8, 10-13.
Aryb. Pls. 14 and 17.
ABL p. 17, 8; 28, note 2.
ABV p. 461, 38.
NC p. 332, 1500; 334, under 1516.
BSA 70 (1975) p. 205.
An inhumation accompanied by pottery of the Boiotian kylix style as well as Corinthian, black glaze and black figure pottery. Also found were figurines in human form.
122 vases, 4 figurines.
c. 540-530 BC.

127 *VI and V* pp. 96-97, 103, fig. 6, Pls. 3, 9, 14.
ABV p. 471, 2.
An inhumation accompanied by pottery of the Boiotian kylix style as well as Corinthian, black figure and black glaze pottery. Also found were figurines in human and animal form.
60 vases, 4 figurines.
Late 6th cent. BC.

130 *VI and V* pp. 97-98, Pls. 3, 7-8, 10, 14-16, 20-21.
Aryb. p. 59, note 1, 71-72, Pl. 17.
ABL p. 68.
ABV p. 457, 21; 465, 28; 466, 1; 468, 48 and 53; 472, 3; 490, 31; 491, 45; 504, middle; 624, 7.

An inhumation accompanied by Corinthian, black glaze and black figure pottery as well as figurines in human and animal form and many fragments of iron nails. The nail fragments were listed as one find.
118 vases, 3 figurines, 1 metal find.
Late 6th cent. BC.

131 VI and V pp. 98-99, Pls. 2 and 15.
Aryb. Pls. 14 and 19.
An inhumation accompanied by pottery of the Boiotian kylix style as well as Corinthian and black figure pottery. Also found were figurines in human and bird form and bronze finger rings.
13 vases, 5 figurines, 2 metal finds.
Early 5th cent. BC.

132 Aryb. p. 88 and p. 13, fig. 4.
An inhumation accompanied by "Argive Monochrome" and Protocorinthian pottery.
9 vases.
c. 650-640 BC.

133 VI and V p. 99, 103, fig. 6, Pls. 3, 7, 11, 15, 18.
ABV p. 500, 45.
An inhumation accompanied by pottery of the Boiotian kylix style as well as Corinthian, black glaze and black figure pottery. This grave also contained figures in human and animal form and fragments of iron plates and nails. The metal objects were listed as a single find.
66 vases, 3 figurines, 1 metal find.
Late 6th cent. BC.

134 Aryb. p. 88, Pl. 3.
PGP p. 318.
GGP p. 200 and 411.
An inhumation accompanied by Geometric and 'Argive Monochrome' pottery with one piece which is possibly protogeometric in date.
5 vases.
Mid 8th cent. BC ?

135 VI and V p. 100, 103, fig. 6, Pls. 3, 9, 15, 21.
ABV p. 504, 13; 622, 115.
An inhumation accompanied by pottery of the Boiotian kylix style as well as Corinthian, black glaze and black figure pottery.
77 vases.
Late 6th cent. BC.

138 VI and V pp. 100-101, Pl. 3.
Aryb. p. 58, fig. 8, Pl. 20.
NC p. 334, under 1517.
An inhumation accompanied by black glaze pottery, figurines in human and bird form and a bronze needle.
7 vases, 8 figurines, 1 metal find.
Mid 5th cent. BC.

139 VI and V pp. 101-102, Pls. 10, 16, 22, 23, 25.
Aryb. Pl. 20.
ABV p. 566, 623.
BSA 70 (1975) p. 269.
An inhumation accompanied by black glaze and black figure pottery as well as figurines in human form, bronze and iron strigils and nails, and a bronze needle.
43 vases, 2 figurines, 11 metal finds.
c. 440-430 BC.

141 Aryb. p. 88, Pls. 5-6.
A cremation (?) accompanied by Corinthian pottery.
21 vases.
Late 7th cent. BC.

144 VI and V p. 102, Pl. 15.
An inhumation accompanied by black glaze and black figure pottery as well as fragments of an iron strigil and a burnt gray bead.
11 vases, 1 metal find, 1 bead.
c. 420-410 BC.

145 Aryb. p. 89, Pls. 2, 5, 7, 13, 15.
An inhumation accompanied by 'Argive Monochrome' and Corinthian pottery as well as figurines in human and animal form and a bronze spiral ring.
93 vases, 6 figurines, 1 metal object.
c. 580 BC.

Chapter 2 - Attributes

2.1 Types of attributes available.

A seriation of a group of objects or units will arrange them in an order based on the similarity between the objects. For large sets of units a computer is usually used to obtain this order, but even if the seriation is done by hand, it is necessary to have some way of comparing the objects being ordered and obtaining a numerical measure of the similarity between them. The traditional verbal descriptions which appear in catalogues of finds from excavations are not suitable for this type of analysis, so the information contained in them must be expressed in numerical form. Several ways of doing this are discussed below.

A verbal comparison of two objects usually consists of a list of similarities and differences with respect to a set of characteristics or attributes. The same type of approach is taken in seriation with the added requirement that the list of attributes must describe the set of objects as completely as possible. The attributes are designed in such a way that each object receives a "score" on each of them and these scores are compared to determine the degree of similarity between objects. Comparisons of objects will be discussed more fully in Chapter 3.

There are two distinct classes of attributes, one of which may be divided into two groups.

The first class consists of continuous attributes. These are measurements, such as height or weight, which can be made on a continuous scale. Continous attributes can be measured as accurately as allowed by the instruments used.

The second class is made up of attributes whose results fall into two or more distinct categories. These are called state attributes. As mentioned above, this class can be divided into two groups. The first consists of attributes such as the type of base on a pot for which more than two possible states exist. These are called multi-state attributes. The second group contains attributes with only two possible states. They are usually used to denote the presence or absence of the qualities they represent. Some examples of these are the presence or absence of decoration, or handles on pots. Two-state attributes are called binary attributes.

It is possible to express continuous and multi-state attributes as binary attributes. This property is useful as it is often difficult to calculate similarity between objects based on more than one attribute type.

Suppose a group of pots has been rated on a set of continuous attributes, one of which is the height of the pot. The results of the height attribute are shown in Table 2.1A. Suppose also that the analyst wishes to combine this infor-

Pot No.	Height (cm)
1	35.7
2	46.3
3	18.0
4	37.9
5	23.4
6	42.8
7	19.2
8	34.7
9	35.3
10	46.2

Table 2.1A: Heights in centimetres of a group of ten pots.

Pot No.	Height (state)
1	2
2	3
3	1
4	2
5	1
6	3
7	1
8	2
9	2
10	3

Table 2.1B: Heights of ten pots as indicated by attribute states.

mation with that contained in a set of multi-state attributes.

In order to be able to use most of the similarity coefficients available (Doran and Hodson 1975, p. 141), he would have to express the continuous height attribute as a multi-state attribute. This is accomplished by breaking the range of the continuous attribute into intervals of equal length. Each of these intervals becomes a state of the multi-state attribute replacing the continuous one. In the example, the smallest height is that of pot 3, and the range of heights can be broken into equal intervals starting with this value. For the purpose of illustration, an arbitrary interval of 10cm. was chosen. Smaller intervals result in more attribute states and more precision in the multi-state attribute. The state numbers and the height ranges which they represent are shown in Table 2.2. Since none of the pots has a height greater than 28cm., no further states are required. The state

State Number	Height Range
1	$18.0 \leq ht. < 28.0$
2	$28.0 \leq ht. < 38.0$
3	$38.0 \leq ht. < 48.0$

Table 2.2: Height of pot represented as a multi-state attribute.

of the height attribute for each pot in the example is shown in Table 2.1B.

Obviously it is not possible to reverse this process and convert a multi-state attribute to a continuous one. In our example, after the conversion, the exact height of the pot is no longer available. There has been a small loss of information which was necessary to bring the data into a form which is more compatible with the other information available.

The division of a multi-state attribute into a series of binary attributes is more easily accomplished. Each state of the multi-state attribute becomes a binary attribute. The two states of the binary attribute are used to show the presence (usually denoted by a 1) or absence (denoted by a 0) of the attribute in question. Suppose that the same 10 pots discussed above were rated on base type as a multi-state attribute according to the distribution shown in Table 2.3. The base type of each pot, as it would be shown for this attribute, is indicated in Table 2.4A. The base type as it

Base Type	State of Base Attribute
Flat	1
Straight ring	2
Flaring ring	3
Pedestal	4

Table 2.3: Base type represented as a multi-state attribute.

would be coded on a set of binary attributes is shown in Table 2.4B. The 1 in each row of Table 2.4B falls in the column for the base type pf the pot in that row. A zero appearing at the intersection of a row and a column indicates

Pot No.	State of Base Attribute
1	2
2	4
3	4
4	2
5	1
6	3
7	3
8	1
9	4
10	2

Table 2.4A: Base type of a set of ten pots as a multi-state attribute.

Pot No.	Flat	Straight Ring	Flaring Ring	Pedestal
1	0	1	0	0
2	0	0	0	1
3	0	0	0	1
4	0	1	0	0
5	1	0	0	0
6	0	0	1	0
7	0	0	1	0
8	1	0	0	0
9	0	0	0	1
10	0	1	0	0

Table 2.4B: Base type of a set of ten pots as a series of four binary attributes.

that the base type at the top of the column is absent from the pot whose number appears at the left end of its row. Of course, if more base types were present in the group of pots, more states would have to be added to the multi-state attribute and this would lengthen the series of binary attributes necessary.

It has been shown that continuous attributes can be converted to multi-state attributes and that the latter can be expressed as binary attributes. It follows that continuous attributes may be converted to binary through the use of multi-state.

Since binary attribute scores can be indicated by zeros and ones only, they can be manipulated by a computer much more efficiently than continuous or multi-state attributes. This becomes important when dealing with very large sets of data.

2.2 Attributes used in this analysis.

The quantity of objects found in the Rhitsōna cemetery varied considerably from grave to grave. The richest burial was number 49 which contained 447 objects, while grave 90 had only one. Since many of the tombs contained large numbers of finds, it has not been possible, in this re-examination, to give detailed descriptions of individual objects. With this limitation in mind, it was decided that a set of binary attributes which would describe the graves and their contents as completely as possible would be selected. The 132 attributes used have been broken into 7 categories. The attributes are listed below in their categories and those possessed by each grave are displayed in the tables referred to at the beginning of each section.

2.2.1 Grave types (see Table 2.5).

The first attributes which should be considered (numbers 1-6) concern the methods of construction of the graves.

1 Pithos burial:- The body and grave goods were placed in two large clay pithoi which were placed mouth-to-mouth and used as a coffin.

2 Stone-lined cist:- A rectangular shaft was dug in the ground and lined with stone slabs. The body and grave goods were placed inside and the top was covered with slabs.

3 Shaft grave:- A rectangular hole was dug in the ground in which the body and grave goods were placed. The hole was then filled in. Some, but not all of these graves (Ure 1927, p. 3) show evidence of having contained a wooden bier or coffin. This evidence was in the form of nails sometimes in metal plates. Since these may not have indicated the presence of a coffin in all the graves in which they were found, the attributes describing these are included with those for metal objects.

4 Tile grave:- The body and grave goods were placed in a shaft and covered with a flat ceramic tile. This type of construction was usually found with infant burials (Ure 1927, p. 4).

5 Gabled tile grave:- The body and finds were placed in a shaft and covered with tiles placed on edge so as to meet in a gable formation over the body.

6 Earth grave:- The body and grave goods were buried in an irregularly shaped hole with no coffin or other obvious means of protection.

2.2.2 Pot shapes (Table 2.6).

Attributes 7 to 41 describe the pottery which formed by far the greatest proportion of the finds from the Rhitsóna cemetery. The pot shapes varied greatly from one grave to

GRAVE / ATTRIBUTE	1	2	3	4	5	6	12	13	14	18	21	22	22A	26	30	31	33	34	36	40	46	49	50	51	52	55	56	57	59	60	61	66	67	68	75	76	80	82	85	86	87	88	89	90	91	92
1											1																																	1		
2								1							1		1	1							1	1	1	1	1	1		1	1	1								1				
3	1	1	1	1	1	1	1		1	1		1	1	1		1			1	1	1	1	1	1											1	1	1	1	1	1	1		1		1	1
4																																														
5																																														
6																															1															

GRAVE / ATTRIBUTE	93	95	96	97	99	101A	101B	102	103	104	107	108	110	111	112	113	114A	114B	115	120	121	123	125A	125B	125C	125D	125E	126	127	130	131	132	133	134	135	138	139	141	144	145
1			1			1	1																1	1	1	1	1					1								
2																																		1						
3		1		1	1			1	1	1			1		1	1			1	1		1						1	1	1			1		1		1	1	1	1
4																	1														1									
5											1	1		1							1															1				
6	1																	1																						

Table 2.5: Attributes 1-6 describing grave types.

another. The presence in each grave of any of the following pot shapes was recorded by a value of 1 for that attribute.

7 Ball aryballos (fig. 2.1a):- A small, round-bodied pot used for holding perfumes.

8 Flat-bottomed aryballos (fig. 2.1b):- This is similar to the ball aryballos but with the addition of a flat base.

9 Barrel-bodied aryballos (fig. 2.1c):- This shape is more ovoid than the ball aryballos and also has a base.

10 Ovoid aryballos (fig. 2.1d):- This is similar to the shape of number 11, but does not come to such a narrow base.

11 Piriform aryballos (fig. 2.1e):- This is taller than the ball aryballos and curves in to a very narrow base.

12 Bombylios (fig. 2.1f):- A taller, straight-sided vase with a broad lip and rounded base. This shape is also sometimes called an alabastron (Ure 1934, p. 16).

13 Amphora (fig. 2.1g):- A comparatively tall, closed shape with a fairly narrow neck and usually two vertical handles in the vicinity of the neck and shoulder or the belly of the pot. It was used for the storage of liquids.

14 Lekythos (fig. 2.1h):- A jug with a high, very narrow neck, and a tall body which tapers to the bottom before expanding suddenly to a wide base.

15 Oinochoe (fig. 2.1i):- A jug with a broad neck and a spout for pouring.

16 Jug (fig. 2.j):- A vessel for pouring which does not fit the description of number 14 and 15.

17 Lacrymaterion (fig. 2.1k):- Another type of small vase probably used for perfume. The shape is tall and thin with a swelling in the middle. These vases are sometimes called fuseiform unguentaria.

18 Amphoriskos (fig. 2.1l):- A small version of number 13.

19 Pyxis (fig. 2.1m):- A globular or straight-sided vase sometimes having a lid; in effect a ceramic box.

GRAVE / ATTRIBUTE	1	2	3	4	5	6	12	13	14	18	21	22	22A	26	30	31	33	34	36	40	46	49	50	51	52	55	56	57	59	60	61	66	67	68	75	76	80	82	85	86	87	88	89	90	91	92
7			1	1			1		1	1	1			1		1				1	1	1	1	1													1	1	1	1	1		1		1	1
8				1																1		1	1	1																1						1
9								1														1		1																						
10																																										1				
11																																											1	1	1	
12								1	1														1																	1			1			1
13			1							1	1																1										1									
14		1	1				1			1		1	1	1		1	1	1	1	1	1	1	1	1				1			1				1	1	1	1		1						
15	1			1						1		1				1	1				1																1									
16						1																				1			1			1			1		1			1						
17																																1	1	1												
18																							1																	1						
19			1	1						1										1				1				1																		
20															1								1																							
21																	1													1																
22		1	1				1			1		1	1	1		1			1		1	1	1	1												1	1	1								
23										1				1		1					1	1	1	1													1	1								
24																																														
25			1		1		1			1		1	1	1		1			1	1	1	1	1	1													1	1	1							
26			1				1			1		1				1	1			1	1	1		1	1	1		1	1	1							1	1								
27	1		1							1										1															1											
28							1			1				1		1					1	1	1	1							1					1	1	1								
29	1		1				1			1				1		1			1	1	1	1	1	1	1	1	1	1	1	1						1	1	1	1	1				1		
30															1			1																												
31							1			1					1		1	1	1		1		1			1										1	1									
32		1	1		1		1			1				1			1	1	1	1	1	1	1	1	1			1								1	1		1							
33			1			1	1			1		1		1	1	1	1	1	1	1	1	1	1	1	1			1	1	1	1					1	1	1	1							
34																							1																							
35																						1															1									
36								1	1																																					
37															1		1	1										1	1	1		1														
38	1					1				1											1				1				1					1			1			1						
39																																	1													
40															1													1																		
41																																1				1										

Table 2.6: Attributes 7-41 describing pot shapes.

GRAVE / ATTRIBUTE	93	95	96	97	99	101A	101B	102	103	104	107	108	110	111	112	113	114A	114B	115	120	121	123	125A	125B	125C	125D	125E	126	127	130	131	132	133	134	135	138	139	141	144	145
7	1	1	1	1	1	1	1	1	1	1			1		1	1			1	1			1	1	1	1	1	1	1	1					1			1		1
8			1										1						1									1										1		
9																																1								
10					1																																			
11																																1								
12		1		1	1		1																															1		
13																																								
14								1					1		1	1				1	1							1	1	1	1		1		1		1			
15				1																	1							1												
16								1									1								1							1		1						1
17																																								
18						1			1				1															1												
19																												1												
20																																								
21																																								
22								1							1	1			1	1	1								1	1	1		1		1					
23																																			1					
24						1	1																									1								
25								1					1		1	1				1	1							1	1		1		1		1					
26								1							1	1	1	1		1		1							1	1			1		1		1		1	
27							1	1		1											1							1		1					1					
28								1				1				1	1	1			1	1						1	1	1	1		1		1		1			
29								1		1			1		1	1				1	1	1						1	1	1			1		1		1		1	
30																																								
31												1				1	1					1											1				1			
32								1		1	1				1	1	1		1	1	1							1	1	1	1		1		1	1				
33								1			1	1	1		1	1		1	1	1	1	1						1	1	1	1		1	1	1	1	1			
34																				1																				
35															1	1																								
36																																								
37											1	1		1			1					1														1	1		1	
38								1	1		1												1					1					1	1						
39						1																																		
40																																								
41												1																												

Table 2.6 continued.

20 Spouted baby cup (fig. 2.1n):- A closed cup with a handle and a spout for feeding a baby or an invalid.

21 Askos (fig. 2.1o):- A low, irregularly shaped vessel with an arched handle and a neck.

22 Kothon (fig. 2.1p):- A low round vase with a deep rim.

23 Kothon-rimmed vase (fig. 2.1q):- These are vases with the same type of rim as number 22 but a different shape. Some have a high or low stem.

24 Pithos (fig. 2.1r):- A large vessel, usually with straight or slightly curved sides used for storage or burial. Pithoi used as coffins were not included in this category.

25 Boiotian kylix (fig. 2.1s):- A stemmed or unstemmed cup usually with four handles projecting horizontally from the lip. When there is a stem, it is thick. This shape is sometimes called the Boiotian bird kylix as the bird is one of the most common decorative elements used on this shape.

26 Kylix (fig. 2.1t):- A drinking cup with two handles and usually a tall, thin stem.

27 Cup (fig. 2.1u):- A shape which is similar to that of today's teacup. Usually, it has one handle, but examples with two have been found.

28 Kantharos with high handles and stem (fig. 2.1v):- A two-handled drinking cup having a stem. The handles rise above the level of the rim.

29 Kantharos with high handles and no stem (fig. 2.1w):- As number 28 but with a low base rather than a stem.

30 Kantharos with ring handles and stem (fig. 2.1x):- As number 28 but the handles do not rise above the rim.

31 Kantharos with ring handles and no stem (fig. 2.1y):- As number 30 but with a low base.

32 Miniature skyphos (fig. 2.1z):- A miniature version of number 33 usually used as a votive offering.

33 Skyphos (fig. 2.1aa):- A drinking cup with two handles which are usually horizontal and often a low ring base.

34 Chalice (fig. 2.1bb):- A high-stemmed cup with a deeper bowl than a kylix. The bowl is sometimes almost conical in shape.

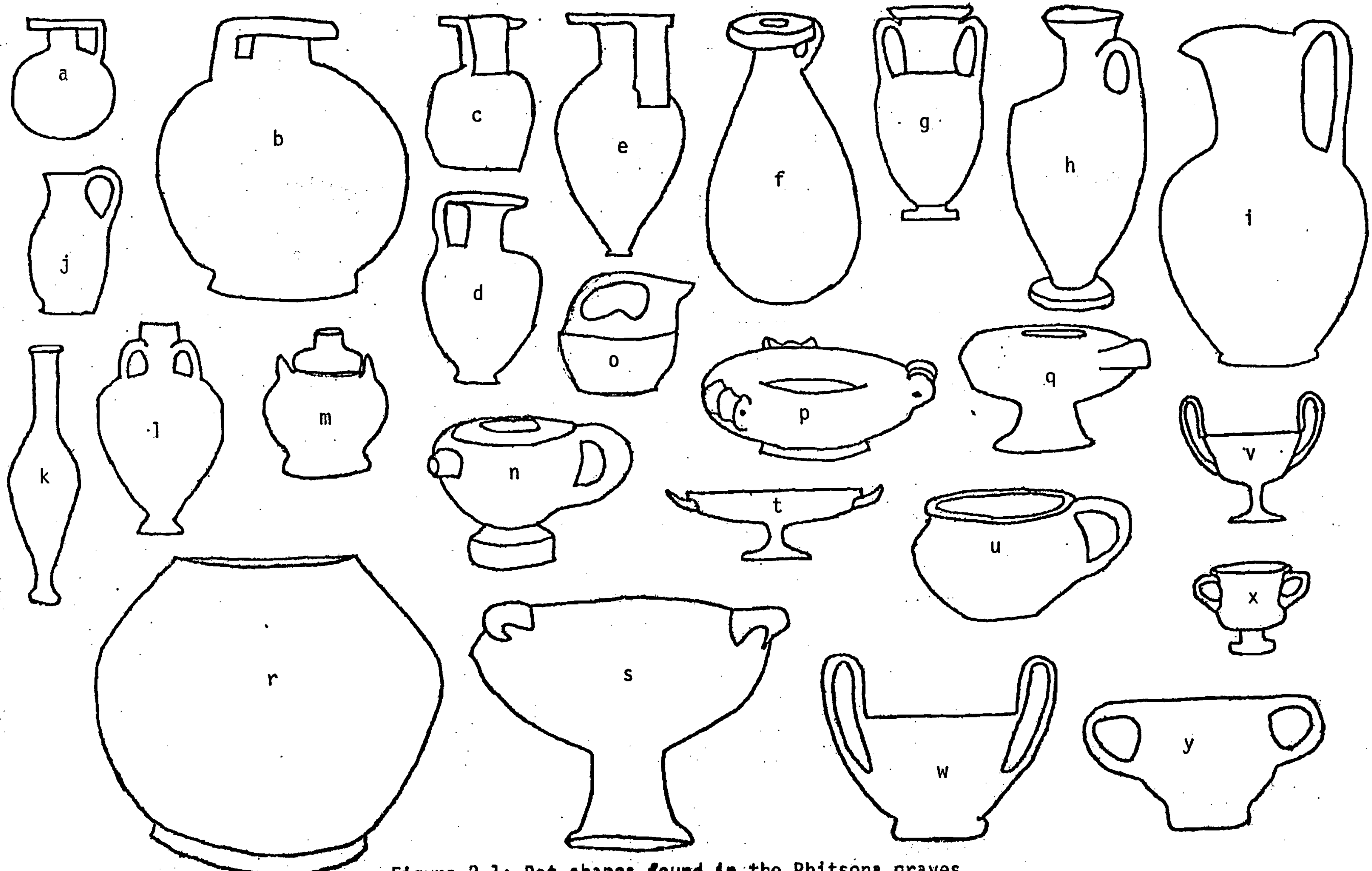


Figure 2.1: Pot shapes found in the Rhitsona graves.

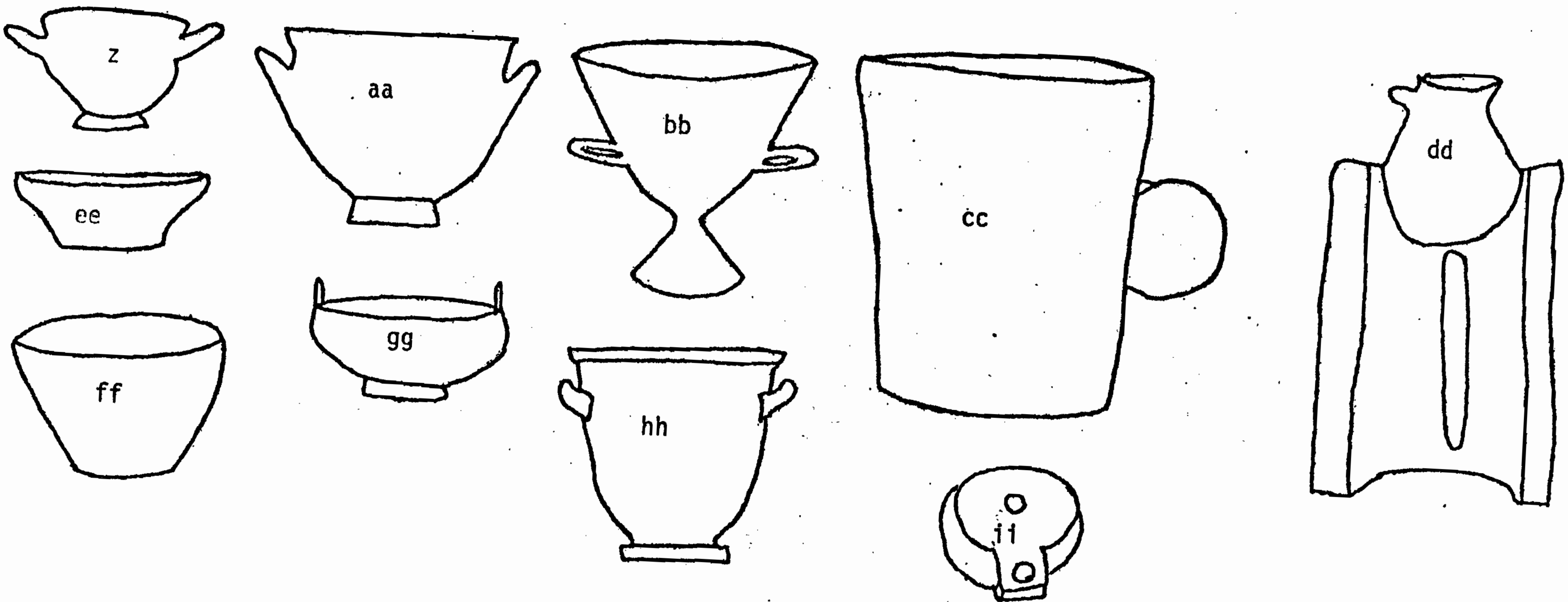


Figure 2.1 continued.

35 Tankard (fig. 2.1cc):- A one handled mug-shaped vase.

36 Tankard with support (fig. 2.1dd):- This is the same as number 35 with the addition of a cylindrical support with rectangular openings in it.

37 Saucer (fig. 2.1ee):- A shallow vessel with curving sides.

38 Bowl (fig. 2.1ff):- This is a handleless bowl.

39 Handled bowl (fig. 2.1gg):- The same as number 38 but with one or two handles.

40 Krater (fig. 2.1hh):- A broad mixing vessel with a base and usually two handles.

41 Lamp (fig. 2.1ii):- A small clay vessel which can be either open or closed. It has a spout which supports the wick and a body which can be filled with oil. The one example found at Rhitsóna is of the closed type.

2.2.3 Decorative techniques and structural decoration for pottery (Table 2.7).

Attributes 42 to 58 indicate the methods used to apply decoration to the surface of the pottery and the decoration which is added to the body of a pot. A value of 1 for an attribute in this section will indicate that some pot found in the grave has such decoration.

42-45 Added colour:- Sometimes coloured paint was used to highlight details of decoration on the surface of the pot. The colours used on the Rhitsóna pottery were: 42 white, 43 purple, 44 red, and 45 yellow.

46 Figures in silhouette:- The figures are painted on the clay ground of the pot with black or coloured paint.

47 Reserved figures:- The figures are left in clay ground and the background is painted.

48 Black glaze:- The entire surface of the pot is covered with a clay wash which has been baked to a lustrous finish. There is no figured decoration but there may be added colour.

49 Bucchero:- The pot is made of gray or black clay rather than one of the paler colours usually used.

GRAVE / ATTRIBUTE	1	2	3	4	5	6	12	13	14	18	21	22	22A	26	30	31	33	34	36	40	46	49	50	51	52	55	56	57	59	60	61	66	67	68	75	76	80	82	85	86	87	88	89	90	91	92
42				1			1			1				1		1			1		1	1	1	1				1				1	1	1			1	1	1	1	1					
43			1	1			1	1	1	1			1			1			1	1	1	1	1	1				1			1						1	1	1	1	1		1		1	
44				1	1		1	1	1	1				1		1	1			1	1	1		1				1	1	1							1	1	1						1	
45				1	1		1			1				1		1					1																1	1								
46		1	1	1	1		1		1	1		1	1	1	1	1	1		1		1	1	1	1	1	1		1	1	1	1					1	1	1	1	1	1		1		1	1
47										1		1						1																												
48			1	1			1			1		1		1		1						1		1	1			1	1								1	1	1							
49																																													1	1
50							1			1				1		1	1	1		1	1	1	1	1		1	1		1							1	1	1								
51							1			1				1		1			1		1		1														1	1		1						
52										1				1		1	1				1	1	1						1	1							1	1		1						
53															1	1					1			1													1									
54		1		1		1	1	1	1	1		1				1			1	1	1	1	1	1								1	1		1		1			1	1	1	1		1	
55						1											1						1						1	1																
56															1	1	1	1								1	1																			
57																1	1															1		1												
58														1																																

Table 2.7: Attributes 42-58 describing decorative techniques and structural decoration on the pottery.

GRAVE / ATTRIBUTE	93	95	96	97	99	1001A	1001B	1002	1003	1004	1007	1008	1010	1011	1012	1013	1014A	1014B	1015	1020	1021	1023	1025A	1025B	1025C	1025D	1025E	1026	1027	1030	1031	1032	1033	1034	1035	1038	1039	1041	1044	1045
42		1				1		1							1	1				1					1			1		1	1		1					1		1
43		1		1		1	1	1							1	1			1	1	1			1				1	1	1			1		1			1	1	
44								1							1								1	1					1		1				1			1		
45																													1		1		1		1					
46	1	1	1	1	1			1	1	1		1	1		1	1	1	1		1	1	1	1	1	1		1	1	1	1	1		1		1		1	1	1	1
47																																								
48							1	1			1	1	1	1	1	1	1			1									1	1					1	1	1			
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51																														1					1		1			
52								1				1			1					1		1								1					1		1			
53															1	1		1										1								1				
54		1	1	1	1		1	1				1				1			1				1	1			1	1	1			1	1					1		
55																																								
56																1		1										1												
57								1				1		1	1			1				1													1	1	1		1	
58																																			1					

Table 2.7 continued.

50 Handles with spurs (fig. 2.2a):- The handles, especially of kantharoi and skyphoi may have spur-like projections made of clay.

51 Handles with cross pieces (fig. 2.2b):- The larger vertical handles on some of the shapes sometimes have a bar of clay attached to the inner surface of the handle and the outer surface of the pot. This support is found part way down the handle.

52 Moulding:- An alteration of the shape of the pot while it is on the wheel or by impression into a mould.

53 Applied decoration:- This is decoration applied to the surface of the pot in clay. This type of decoration, also called plastic decoration, stands out from the pot's surface.

54 Incision:- Decoration is scatched into the surface of the pot before it is fired. This is done to outline figures or to provide details in the decoration.

55 Impressed decoration:- This is produced by pressing an object into the surface of a pot before it is fired to leave an impression.

56 Fluting:- The surface of the pot is decorated with vertical or horizontal fluting similar to that used on columns.

57 Groove:- One or more thin grooves are present on the surface of the pot.

58 "Imitation repoussé":- This is the excavator's terminology for a copy in clay of the repoussé work found on metal vessels. A more accurate description might be mould impression.

2.2.4 Decorative motifs (Table 2.8).

The figures or patterns described in attributes 59-102 were used as decorative motifs on the pottery from the graves. A value of 1 will indicate that at least one pot found in the grave was decorated with such a motif. The human and mythological figures used exhibit a great variety of forms so it was not possible to illustrate these in the figures. The vegetative and geometric motifs are illustrated.

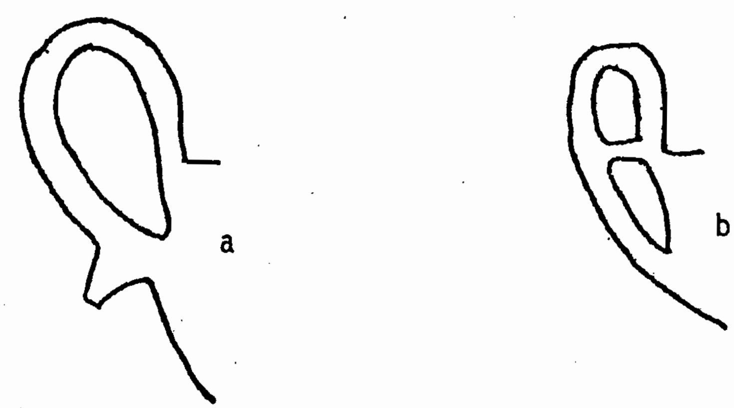

Figure 2.2: Illustrations of structural decoration on the pottery.

59 Human figures.

60 Sphinxes:- These were mythological beasts with the head of a man, or more usually a woman, and the body of a lion. Most also had wings.

61 Siren:- Mythological creatures which were half woman and half bird.

62 Satyr:- Another mythological animal which is part man and part goat or horse.

63 Maenads:- These are women clothed in skins and wearing wreaths of oak, ivy or fir. The maenad is a specific type of human figure which could be distinguished here because its presence was always noted by the excavators in the publications.

64 Animals:- Animals such as cattle and sheep which appear very infrequently on the Rhitsóna pottery.

65 Dolphins.

66 Birds.

67 Eyes.

68 Lotus buds or flowers (fig. 2.3a).

69 Leaves (fig. 2.3b).

70 Palmettes (fig. 2.3c).

71 Branches (fig. 2.3d).

72 Rosettes (fig. 2.3e).

73 Petals (fig. 2.3f).

74 Ivy leaves (fig. 2.3g).

75 Wreath on rim:- A wreath of ivy leaves around the rim of a pot.

76 Daisy pattern (fig. 2.3h).

77 Other floral ornament:- Floral designs which occur rarely on the Rhitsóna pottery.

78 Quatrefoil (fig. 2.3i).

79 Cinquefoil (fig. 2.3j).

80 Sixfoil (fig. 2.3k).

GRAVE / ATTRIBUTE	1	2	3	4	5	6	12	13	14	18	21	22	22A	26	30	31	33	34	36	40	46	49	50	51	52	55	56	57	59	60	61	66	67	68	75	76	80	82	85	86	87	88	89	90	91	92
59		1		1	1		1	1	1	1		1				1			1		1	1	1	1							1					1	1	1		1	1				1	1
60					1		1			1						1						1	1	1													1			1						
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62							1			1		1		1		1						1		1												1	1	1								
63										1				1		1					1			1												1	1	1								
64		1		1		1	1	1		1				1		1			1		1	1	1	1													1	1		1	1	1	1	1	1	
65										1						1																														
66							1	1	1	1				1		1					1	1	1	1																1		1	1		1	
67										1				1		1																					1	1								
68							1			1				1		1					1	1	1	1							1						1	1	1	1						
69		1	1		1		1							1							1	1								1							1	1								
70			1	1	1		1			1		1		1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1					1	1	1	1	1					1	
71							1			1				1		1			1		1	1															1									
72				1					1					1								1	1	1																1	1		1		1	
73					1		1		1	1	1	1		1		1					1																1	1		1						
74							1			1		1		1		1					1	1		1		1											1									
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79			1		1		1														1																1	1	1	1						
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90	1			1		1	1	1	1	1	1		1	1		1	1			1	1	1	1	1				1				1	1	1	1		1	1	1	1	1	1	1	1	1	1
91				1			1	1	1	1	1			1		1				1	1	1	1					1				1			1	1	1	1		1	1	1	1	1	1	1
92	1			1	1		1	1	1	1				1		1				1		1	1	1	1												1		1						1	1
93		1	1				1			1	1					1			1		1		1	1				1										1		1		1		1	1	
94				1		1	1	1	1	1	1			1		1				1	1	1	1	1	1				1	1					1		1			1		1			1	
95																1							1																							
96														1	1	1				1		1		1								1							1						1	
97					1	1	1		1	1		1		1		1				1	1	1	1	1													1	1								
98											1					1				1			1																	1						
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101					1		1		1	1				1		1				1	1	1	1	1													1	1	1	1						
102																	1					1																								

Table 2.8: Decorative motifs used on the pottery.

GRAVE / ATTRIBUTE	93	95	96	97	99	101A	101B	102	103	104	107	108	110	111	112	113	114A	114B	115	120	121	123	125A	125B	125C	125D	125E	126	127	130	131	132	133	134	135	138	139	141	144	145
59		1		1	1			1				1	1	1		1				1			1	1	1			1	1	1			1		1			1		1
60								1						1		1													1						1					
61			1	1	1			1							1								1																	1
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66	1	1		1	1			1							1												1		1									1		
67								1																																
68		1		1				1							1	1	1			1								1	1	1			1							
69								1	1		1				1						1							1	1	1			1							
70		1		1				1				1	1		1	1	1	1		1		1						1	1				1		1					
71																1														1					1					
72		1	1	1	1		1						1					1					1	1														1		1
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74								1									1		1										1	1										
75																		1																		1				
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77																		1																						
78	1	1	1		1	1	1	1	1	1					1	1			1				1	1	1	1		1												1
79	1						1	1	1							1				1						1		1	1	1					1					
80					1																																			1
81		1		1	1		1												1									1										1		
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90		1		1	1	1	1	1	1	1			1		1			1	1	1			1	1			1	1	1	1				1	1		1	1	1	1
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101				1				1		1			1		1	1	1		1									1	1	1						1				
102																																								

Table 2.8 continued.

81 Orange quarterings (fig. 2.31).

82 Cable pattern (fig. 2.3m).

83 Chevrons (fig. 2.3n).

84 Crosses (fig. 2.3o).

85 Herringbone (fig. 2.3p).

86 Hatching (fig. 2.3q).

87 Check (fig. 2.3r).

88 Tongue pattern (fig. 2.3s).

89 Wavy lines (fig. 2.3t).

90 Bands (fig. 2.3u).

91 Dots (fig. 2.3v).

92 Zigzags (fig. 2.3w).

93 Rays (fig. 2.3x).

94 Concentric circles (fig. 2.3y).

95 Concentric arcs of circles (fig. 2.3z).

96 Spiral (fig. 2.3aa).

97 Triangle (fig. 2.3bb).

98 Star (fig. 2.3cc).

99 Horseshoe (fig. 2.3dd).

100 Meander (fig. 2.3ee).

101 Band of short vertical lines (fig. 2.3ff).

102 Slanting lines (fig. 2.3gg).

2.5 Figurines (Table 2.9).

Attributes 103 to 118 describe the forms and methods of decoration of the figurines found in the Rhitsóna graves. A value of 1 indicates that the grave contained a figurine of the type described in the attribute. Most of these attributes are self-explanatory, so only a few are illustrated.

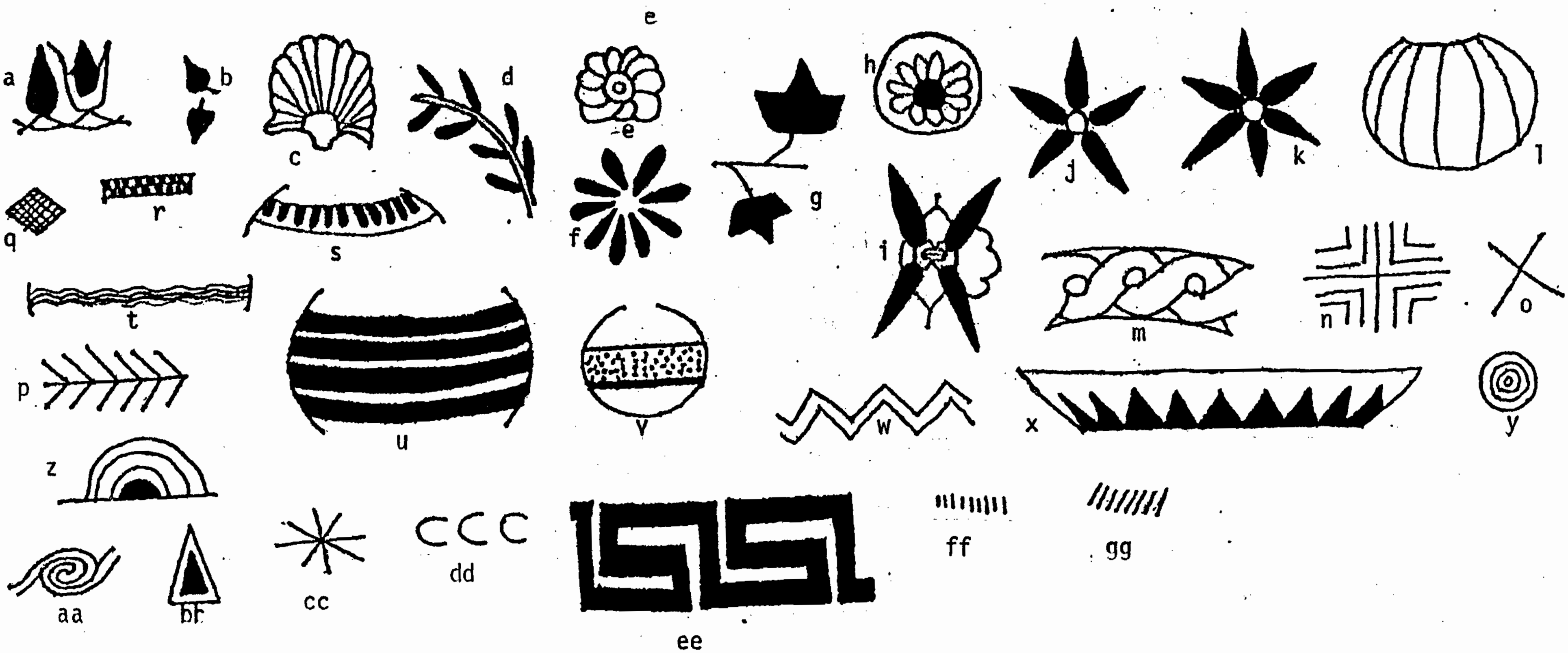

Figure 2.3: Decorative motifs used on the pottery.

103 People:- Used when it was impossible to determine the posture of the figurine as it was broken above the waist.

104 Seated people

105 Standing people.

106 Male

107 Female

108 Pappas with bird faces (fig. 2.4a):- This type of figurine has a head dress similar in form to that worn by the modern Greek priest or pappas. The face was quickly formed by pinching the clay, so it resembles that of a bird.

109 Pappas with human face (fig. 2.4b):- As number 108 but with a more carefully modelled face.

110 Horse with rider.

111 Horse without rider.

112 Other animals:- Animals other than horses which appeared in the graves.

113 Birds.

114 Hair of figurine in raised blobs of clay.

115 Use of red paint to decorate the figurine.

116 Use of white paint.

117 Use of yellow paint.

118 Use of black paint.

2.2.6 Metal objects (Table 2.10).

The following attributes, numbered 118 to 129, describe the metal objects found in the Rhitsóna graves as well as the metals they are made of and the ways in which they were decorated. A value of 1 indicates that the grave contained a metal object of the type described.

GRAVE / ATTRIBUTE	1	2	3	4	5	6	12	13	14	18	21	22	22A	26	30	31	33	34	36	40	46	49	50	51	52	55	56	57	59	60	61	66	67	68	75	76	80	82	85	86	87	88	89	90	91	92
103		1			1					1				1	1	1		1	1	1	1	1	1	1	1	1	1	1		1							1	1		1						
104																1																						1								
105					1					1				1	1	1		1	1	1		1	1	1	1	1	1	1		1							1			1						
106										1								1																												
107		1			1					1				1	1	1				1	1	1	1	1		1	1	1		1							1	1		1						
108																				1		1		1																1						
109					1					1				1		1				1		1	1	1													1									
110							1									1						1	1	1																1						
111							1									1				1		1	1	1																1						
112										1						1			1																											
113										1				1		1				1	1	1																								
114																		1										1		1																
115		1					1			1				1	1	1		1			1	1	1	1				1																		
116							1			1				1		1		1		1	1	1	1	1	1																					
117							1			1						1				1	1	1	1	1				1																		
118							1			1				1		1				1		1	1	1																						

Table 2.9: Attributes 103-118 describing the figurines from the graves.

GRAVE ATTRI- BUTE	93	95	96	97	99	101A	101B	102	103	104	107	108	110	111	112	113	114A	114B	115	120	121	123	125A	125B	125C	125D	125E	126	127	130	131	132	133	134	135	138	139	141	144	145
103										1	1	1	1		1		1				1				1	1	1	1	1	1	1		1			1	1			1
104											1	1									1							1					1			1				1
105										1	1		1		1		1								1	1	1	1	1	1	1					1	1			1
106											1				1																						1			
107										1		1	1		1		1								1	1	1	1	1	1	1		1			1				1
108																									1	1	1	1			1									1
109										1			1		1														1	1			1							1
110			1										1		1											1														1
111			1				1						1		1					1									1											
112					1		1								1															1										1
113										1			1		1															1	1									
114																																								
115																														1										
116																														1										
117																														1										
118			1																											1										

Table 2.9 continued.

119 Bronze disc.

120 Fibula (fig. 2.4c):- This is a brooch-like object of iron or bronze composed of a bow and a needle or pin which catches on a metal plate. It was probably used as a clothes-fastener, though large versions were produced, apparently for purely votive purposes.

121 Incision:- All types of decoration scratched into the surface of the metal.

122 Nails of either bronze or iron.

123 Pins.

124 Strigils of either bronze or iron:- This is an object with a handle from which a dull, curved blade protrudes. It was used to skim oil and perspiration from the skin.

125 Needles.

126 Bronze finger rings.

127 Spiral rings:- A finger ring in the shape of a tight spring, apparently also used as fasteners for braids of hair.

128 Silver objects:- These included a necklace and a phiale.

129 Lead objects:- These included rivets, lozenges and a bracelet.

2.2.7 Miscellaneous (Table 2.11).

This section lists three attributes, numbered 130 to 132, which did not fall into any of the other categories.

130 Glass vases:- These vases were made using the sand-core method of glass manufacture as glass blowing had not yet been discovered.

131 Beads of glass, paste or stone.

132 Worked pieces of bone.

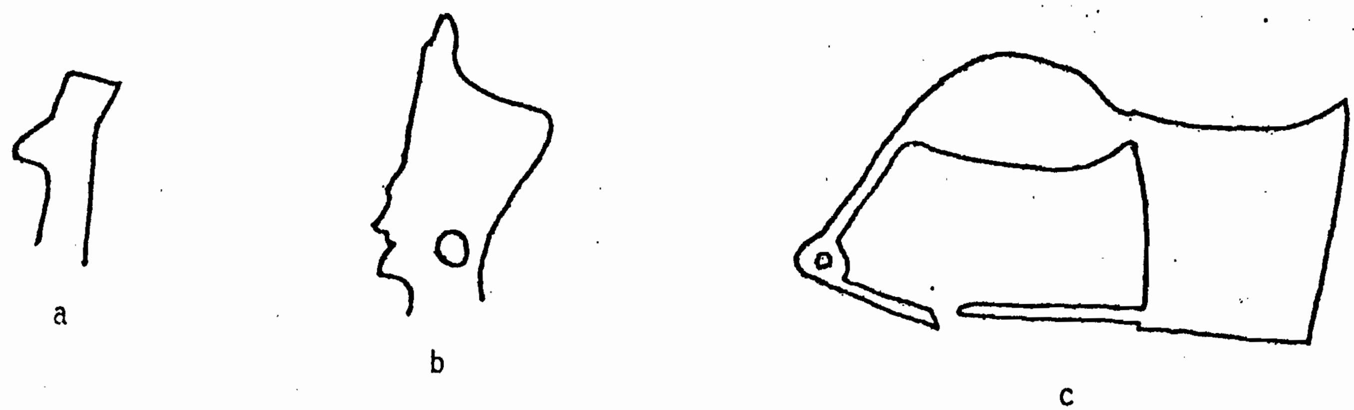

Figure 2.4: Illustrations of figurines and metal finds.

GRAVE / ATTRIBUTE	1	2	3	4	5	6	12	13	14	18	21	22	22A	26	30	31	33	34	36	40	46	49	50	51	52	55	56	57	59	60	61	66	67	68	75	76	80	82	85	86	87	88	89	90	91	92
119				1				1																													1									
120						1													1																1						1					
121						1																													1											
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126																			1																											
127				1		1																													1					1	1					1
128																						1															1									
129										1																		1																		

GRAVE / ATTRIBUTE	93	95	96	97	99	101A	101B	102	103	104	107	108	110	111	112	113	114A	114B	115	120	121	123	125A	125B	125C	125D	125E	126	127	130	131	132	133	134	135	138	139	141	144	145
119																																								
120																																								
121																																								
122					1										1							1								1			1				1			
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125														1																						1	1			
126																															1									
127		1																					1		1															1
128																																								
129																																					1			

Table 2.10: Attributes 119-129 describing the metal finds.

GRAVE / ATTRIBUTE	1	2	3	4	5	6	12	13	14	18	21	22	22A	26	30	31	33	34	36	40	46	49	50	51	52	55	56	57	59	60	61	66	67	68	75	76	80	82	85	86	87	88	89	90	91	92
130														1		1					1																1									
131																			1									1																		
132										1																											1									

GRAVE / ATTRIBUTE	93	95	96	97	99	101A	101B	102	103	104	107	108	110	111	112	113	114A	114B	115	120	121	123	125A	125B	125C	125D	125E	126	127	130	131	132	133	134	135	138	139	141	144	145
130																																								
131																									1												1		1	
132																																					1			

Table 2.11: Attributes 130-132 describing the miscellaneous finds from the graves.

Chapter 3 - Similarity and Distance Coefficients

After the objects to be seriated have been described as completely as possible using a set of attributes, it is necessary to have some way of comparing the attribute scores and obtaining a numerical measure of the similarity or distance between the objects. The meaning of the term "distance" will be discussed more fully below. Many methods of calculating numerical measures, or coefficients, of similarity and distance have been developed for use in analyzing biological material (Sneath and Sokal, 1973, p. 116ff), and can be applied to archaeological data as well. Most of these coefficients can be used with only certain of the attributes discussed in Chapter 2. Several coefficients which can be used with binary attributes are presented below.

Similarity and distance coefficients are calculated for each pair of objects being analyzed. In other words, in a set of N objects, each object will have N-1 values of the coefficient showing how similar it is to the N-1 other objects in the set.

The comparison of two objects splits the binary attributes describing them into four disjoint groups. These are summarized in Table 3.1. For convenience, the letters which

Object 1 / Object 2	Attributes possessed by object 1	Attributes not possessed by object 1
Attributes possessed by object 2	A= The number of attributes possessed by both objects	B= The number of attributes possessed by object 2 but not by object 1
Attributes not possessed by object 2	C= The number of attributes possessed by object 1 but not by object 2	D= The number of attributes possessed by neither object

Table 3.1: Binary attribute groups.

appear in the Table will be used in the descriptions which follow. The total number of attributes considered will be denoted by N. Thus N=A+B+C+D, since the four groups are pairwise disjoint.

The first similarity coefficient considered here is the simple matching coefficient and is denoted by S_{sm} (Sneath and Sokal, 1973, p. 132f). The simple matching coefficient is calculated by taking the ratio, (A+D)/N, of the number of attributes both objects possess (A) plus the number of attributs which both objects lack (D) to the total number of attributes (N). This coefficient, S_{sm}, gives the proportion of the total number of attributes for which both objects had identical scores. If the result obtained is multiplied by one hundred, a percentage of similarity is produced.

A problem arises with the use of the simple matching coefficient to calculate the similarity between two objects for which A+B+C is much less than N. The use of S_{sm} would produce a very high similarity for such pairs since D is large. This may or may not be desirable depending on what the analyst is trying to show and on the type of material with which he is working. At first glance, it might seem possible to solve this problem by eliminating D from the numerator of S_{sm} and calculate the quantity S_x=A/N. In practice, this creates other problems. The coefficient S_x depends on the number of attributes, A, possessed by both objects. If we were to calculate S_x for two objects possessing exactly the same twelve out of a total of twenty attributes, the result would be S_x=0.6. However, calculating S_x

for a pair of objects possessing the same eight out of twenty attributes produces $S_x=0.4$. Even though the objects in each pair are identical to each other as described by the given attributes, the values of S_x produced are different in the two cases, and they are not equal to 1.0 as they should be for any similarity coefficient used. Thus, S_x is not a satisfactory similarity coefficient and will not be used in this analysis.

To avoid the problems presented by S_x it is necessary to eliminate D from the denominator of the simple matching coefficient as well as from its numerator. The resulting coefficient, the next one to be discussed here, is called the <u>coefficient of Jaccard</u> (Sneath and Sokal, 1973, p. 131). It is usually denoted by S_j and is defined by $S_j=A/(A+B+C)$. The values of S_j vary, as do those of S_{sm}, from 0, indicating no similarity between the objects, to 1.0, indicating that the two objects are identical. The coefficient of Jaccard is not subject to the same problems as S_x, and produces better results than S_{sm} for pairs of objects with only a few attributes in common.

The remaining two coefficients are of a different type from those discussed above. They are called distance coefficients. Higher values of these coefficients indicate dissimilarity or a relatively large distance between objects, while lower values indicate greater similarity or a smaller distance between objects.

The first of these distance coefficients is the <u>Euclidian distance coefficient</u>, d, (Doran and Hodson, 1975, pp.

20-25 and 136-139). The formula is $d=\sqrt{B+C}$ for binary attributes. This formula is obtained from the formula for the distance d between two points (x_1,y_1) and (x_2,y_2) in the plane. The formula for this distance is $d=\sqrt{(x_2-x_1)^2+(y_2-y_1)^2}$ (see Figure 3.1).

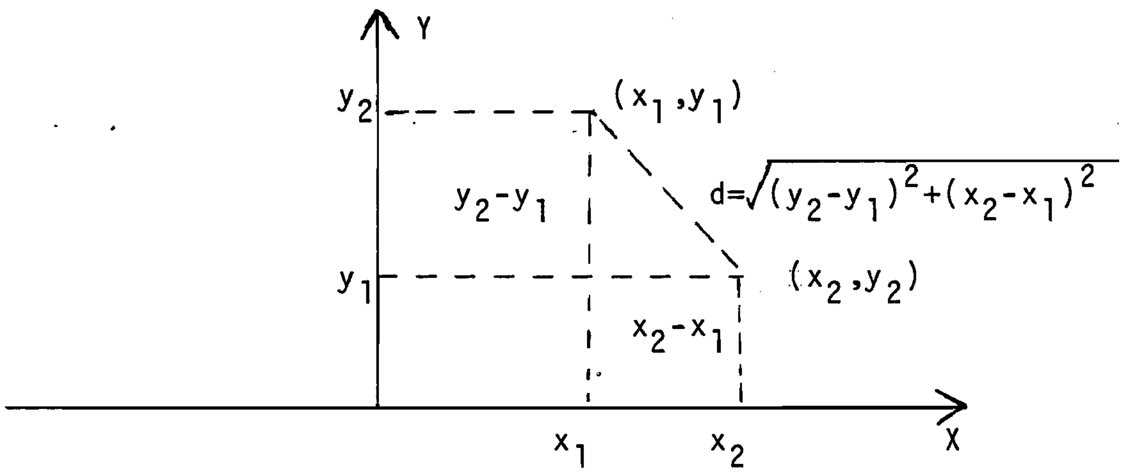


Figure 3.1: Distance between two points in the plane.

Of course, this formula is only for distance in two dimensions and is thus analogous to the case where objects are being compared on the basis of two attributes. An analysis involving many attributes must have one dimension for each of them. The co-ordinates for the i th object described by a set of N attributes would be given as $(x_{i1},x_{i2}, \ldots ,x_{iN})$. This would locate each object as a point in N-dimensional space. In this case, the simple formula for d given above becomes:

$$d=\sqrt{(x_{i1}-x_{j1})^2+(x_{i2}-x_{j2})^2+ \ldots + (x_{iN}-x_{jN})^2}$$

$$=\sqrt{\sum_{k=1}^{N} (x_{ik}-x_{jk})^2}$$

when calculating the distance between objects i and j. In the case where $x_{ik}=x_{jk}$, the difference is zero, so the only attributes which contribute to the distance are those for which the two objects have different scores. When using binary attributes, $d=\sqrt{B+C}$ as only the attributes in categories B and C (see Table 4.1 above) have different scores, and $(1-0)^2=(0-1)^2=1$.

The last coefficient we discuss is called the <u>squared Euclidean distance</u> and is usually denoted by d^2. The formula for binary attributes is $d^2=B+C$. This coefficient and the simple matching coefficient are linearly related to each other when only binary attributes are used. This means that if the squared Euclidean distance and the simple matching coefficient were calculated for all pairs in a set of objects, and the results plotted on an ordinary piece of graph paper using the values of the two coefficients as the co-ordinates for the point representing each pair, the points plotted would fall on a straight line. This linear relationship can also be expressed algebraically:

Since $N=A+B+C+D$

subtracting $d^2=B+C$

gives $N-d^2=A+B+C+D-(B+C)$

or $d^2=N-(A+D)$

$$=N-N.\frac{(A+D)}{N}$$

$$=N-NS_{sm}.$$

Therefore d^2 and S_{sm} are related linearly and identical orderings would result from their use. We will use S_{sm} in preference to d^2 here.

It should be noted that while the Euclidean distance is related to the simple matching coefficient, S_{sm}, as is the squared Euclidean distance, d, the relationship is not a linear one. The operation of taking the square root will greatly decrease the larger distances while hardly changing the smaller ones. The relationship between the simple matching coefficient and the two distance coefficients discussed here is only meaningful when using binary attributes. The distance coefficients can also be calculated using continuous attributes, but the simple matching coefficient cannot.

In this analysis, it was decided to use the simple matching coefficient, the coefficient of Jaccard and the Euclidean distance coefficient. The first two are the coefficients most commonly used in dealing with archaeological material (Doran and Hodson, 1975, pp.135-143), probably because they are easy to comprehend. The Euclidean distance coefficient has not been widely used on archaeological material, so it is included here.

Chapter 4 - The Seriation Methods

4.1 The Nature of Seriation.

Seriation consists of a group of procedures which will arrange a set of objects in a sequence or order. The basic goal of most of these procedures, which is not always attainable, is to place each unit between the two others to which it is most similar, thus constructing a linear arrangement of units. It is in the way in which this goal is achieved that the methods described later in this chapter differ.

Seriation of archaeological material is usually carried out with the hope of obtaining a relative chronological ordering of units. One end of the sequence produced can be taken to be earlier, and the units decrease in age as the other end of the ordering is approached. Seriation gives no information about the dates of the units or the intervals of time between two units in the sequence. For this reason, the result of this type of analysis is a relative rather than an absolute chronology.

The first seriation method to be published as such was that of Brainerd and Robinson (1951, pp. 293-313). Units were compared using a type of similarity coefficient, called an agreement coefficient, which depended on the proportions of similar material contained in the units being seriated rather than on the attributes displayed by the units. Virtually all seriation methods published since that of Brainerd and Robinson use this type of coefficient. Two units displaying similar proportions of finds are supposed to be close together in time. Seriation using this type of coefficient is called frequency seriation.

It may seem that frequency seriation presents a logical method for the ordering of a set of units, but recently some rather serious questions have been raised about it by McNutt (1973, pp. 45-60) who has shown that the results given by frequency seriation can be incorrect and misleading. His major objection is with the assumption that artifact types, as represented in archaeological deposits, are scarce in deposits contemporary with the beginning of their production and are found more frequently as their popularity increases and finally they occur less often as they are replaced by newer styles or artifact types. This assumption is basic to frequency seriation. McNutt shows that if a set of units is seriated in this way with respect to two artifact types or styles, the results cannot be chronologically correct. He then goes on to show how false orderings may be produced when more than two types are considered.

A more logical approach to the comparison of units seems to be offered by the complete description of the units using attributes and then comparing the attribute scores for each pair of objects using similarity or distance coefficients as described in chapters 3 and 4. The agreement coefficient used in frequency seriation is usually calculated primarily on the basis of percentages of pottery styles present in the unit. In some cases, the archaeologist must make _a priori_, arbitrary decisions about pots for which the decorative style may be assigned to more than one period. The use of attribute descriptions of the pottery attempts to eliminate this problem.

The variety and quantity of a certain type of object placed in some of the graves being used as units in this analysis may have depended on such things as the age and sex of the deceased, personal preference of the relatives, as well as the affluence of the family and mourners. The proportions of pottery styles in the graves which are close together in time might differ slightly for these reasons. This is another reason for not using frequency seriation in this study.

Even though most of the seriation methods used in this analysis were originally meant to order units on the basis of agreement coefficients, they can be used with similarity and distance coefficients as well. The methods order units on the basis of the similarity between them and so the logic of each method applies as long as the coefficient used expresses some form of similarity.

The coefficients are calculated from the table or matrix containing the attribute scores. This is called the raw data matrix. The coefficients themselves are stored in tabular form as similarity or distance matrices. Each row in such a matrix shows the similarity between one object being analysed and all the others. The similarity matrix will be square and symmetric.

The seriation methods attempt to order the objects in such a way that each one lies between the two it is most similar to. Ideally, the similarities with the other objects should decrease as one moves away in either direction along the ordering produced. If this ideal situation is realized, and the similarity matrix is arranged in the order given by the seriation method, the highest values will fall along the main diagonal (the one joining the upper left and lower right corners of the matrix), and the coefficients will decrease in size as one moves away from this diagonal both up and down the columns and along the rows to the right and left.

A matrix which has been arranged in this way is called a Robinson matrix or a matrix in Robinson form (Gelfand 1971, p. 193 and Robinson 1951, p. 309).

4.2 The concentration principle.

The concentration principle operates on the data in their most basic form by manipulating the entries in the raw data matrix without the use of similarity or distance coefficients. The raw data matrix shows the presence or absence of the attributes for each unit. In the raw data matrix, each row contains all the attribute scores for one unit. This method was first used by Petrie (1899, pp. 295-301) in his study of the graves at Naqada, in Egypt. Petrie called his method of seriation sequence dating. The present name is due to Kendall (1963, p. 659). A discussion of the method and specific analyses which make use of it can be found in Doran and Hodson (1975, pp. 276-279).

In brief, the method involves rearranging the rows of the raw data matrix so that the ones in each column fall in a single group with no zeros among them. In this way, the units possessing the same attributes are brought together in the raw data matrix. The assumption made is that for any unit, the attributes present reflect the styles in fashion at the time of its manufacture or deposition and that units which are close together in time will possess more of the same attributes than units which are not.

The goal of this analysis is the minimization of the sum of the distances between the first and the last 1 in each column of the raw data matrix. The first step in the algorithm is the calculation of the distance between the first and last 1 in each column. These distances are then summed. Any movement of rows in the raw data matrix is performed only if it will result in a reduction of this sum. Consider the raw data matrix in Figure 4.2.1, which shows the scores obtained by a set of six objects on a set of ten

1	0	0	1	0	1	0	1	0	1	0
2	1	0	0	1	1	0	1	1	0	1
3	0	0	1	0	0	1	0	0	1	0
4	1	0	0	0	1	0	1	1	0	1
5	1	1	0	1	0	0	0	0	0	1
6	0	0	1	0	1	1	0	0	1	0

Figure 4.2.1: Binary attribute scores for a set of 6 objects.

binary attributes. In the first column, the distance between the first and last one is 3 rows, in the second there is a single one so no contribution to the sum is made. In the third through the tenth columns the distances are: 5, 3, 5, 3, 3, 2, 5, 3. The sum of these distances together with that of the first column is 32.

The process of decreasing this sum begins in the first column. The only zero appearing among the ones is in row 3 so the second and third rows are interchanged giving the matrix shown in Figure 4.2.2. The sum of distances for this matrix is 29 which is an improvement over the last value, so

1	0	0	1	0	1	0	1	0	1	0
3	0	0	1	0	0	1	0	0	1	0
2	1	0	0	1	1	0	1	1	0	1
4	1	0	0	0	1	0	1	1	0	1
5	1	1	0	1	0	0	0	0	0	1
6	0	0	1	0	1	1	0	0	1	0

Figure 4.2.2: Matrix from Fig. 4.2.1 with second and third rows interchanged.

the new matrix is kept. The third column is the next in which zeros are found among the ones. The insertion of row 6 between rows 3 and 2 as illustrated in Figure 4.2.3 concentrates the ones in this column. After this has been done, the sum of the distances is 20 which is a considerable decrease.

The procedure described above continues through the

1	0	0	1	0	1	0	1	0	1	0
3	0	0	1	0	0	1	0	0	1	0
6	0	0	1	0	1	1	0	0	1	0
2	1	0	0	1	1	0	1	1	0	1
4	1	0	0	0	1	0	1	1	0	1
5	1	1	0	1	0	0	0	0	0	1

Figure 4.2.3: Matrix from Fig. 4.2.1 with the ones in

remaining columns. Then, because configurations of zeros and ones which may no longer exist may have prevented the movement of rows at the beginning of the analysis, the entire procedure is repeated. This is done until no further decreases in the summed distances result. In general, any movement downward of a row is allowed as long as it results in an improvement.

Finally, the unit names are printed in the order suggested by the results.

Since the order obtained using this algorithm gives the best solution for the input order used. This may not be the best arrangement possible so the input order was varied several times in an attempt to improve the sequence.

The program used for the concentration principle is listed in part 2 of the Appendix.

4.3 Gelfand's first method.

Gelfand's first method is one of the rapid seriation techniques mentioned in the Introduction above. In order to seriate a set of N objects using this method (Gelfand 1971, pp. 189-192), a list of the N-1 highest coefficients in the given similarity matrix which do not fall on the main diagonal, where all values are 1.0, is chosen subject to two conditions. These are: (i) N-2 subscripts, or object numbers appear exactly twice and 2 subscripts appear exactly once among the 2 (N-1) subscripts of the N-1 coefficients chosen, and (ii) all subscripts must "communicate". This second condition means that it must be possible, using the coefficients in the list, to form a linear sequence of all the units being seriated. Thus, no isolated loops may be formed by the selection of coefficients which do not "communicate". The method for obtaining this sequence will become clear in the following example.

Consider a set of six objects connected by some similarity coefficient as shown in Figure 4.3.1 below. In this case, N=6 and N-1=5. We must therefore select the five highest similarity coefficients from the matrix such that neither of the conditions given above is violated.

The highest coefficient in the matrix which does not fall on the main diagonal is 0.98, the one reflecting the similarity between objects 2 and 4. This will be denoted by (2,4). This is the first coefficient to be chosen and so does not violate either of the conditions (i) and (ii) given above. The second highest coefficient in the matrix is (1,5) =0.96 which can also be included as neither of the objects it refers to has appeared in the list. The third and fourth coefficients are (3,6)=0.95 and (1,2)=0.75 which are also

	1	2	3	4	5	6
1	1.00	0.75	0.65	0.70	0.96	0.70
2	0.75	1.00	0.52	0.98	0.74	0.60
3	0.65	0.52	1.00	0.48	0.64	0.95
4	0.70	0.98	0.48	1.00	0.72	0.58
5	0.96	0.74	0.64	0.72	1.00	0.69
6	0.70	0.60	0.95	0.58	0.69	1.00

Figure 4.3.1: Similarity matrix for a set of six objects.

admissible. The next four coefficients, (2,5), (4,5), (1,4) and (1,6) cannot be included. The subscript 2 already appears twice in the coefficient list, so the addition of (2,5) to the list would violate condition (i). The coefficients (1,4) and (1,6) cannot be included for the same reason. The inclusion of (4,5) would form a loop consisting of units 5, 1, 2 and 4, which would violate condition (ii). The next largest coefficient is (5,6)=0.69 which is the last coefficient to be added to the list, now containing five similarity coefficients.

The complete list of coefficients chosen is (2,4), (1,5), (3,6), (1,2) and (5,6). Subscripts 3 and 4 appear only once in this list and are taken to represent the endpoints of the sequence. If we begin with one of these, 3 for instance, and list the coefficients in the order in which they communicate, we will obtain the desired order of the units. We may note that the order of the subscripts within the brackets is unimportant because the matrix is symmetric. This means that, for any two objects n_1 and n_2, $(n_1,n_2)=(n_2,n_1)$. The sequence obtained is (3,6), (6,5), (5,1), (1,2), (2,4) so the order of the units is 3, 6, 5, 1, 2, 4.

In any purely mathematical seriation, no indication is given as to which end of the sequence may be earlier. This must be decided by the archaeologist after a physical examination of the units at the ends of the order produced.

A listing of the program used for this method may be found in section 3 of the Appendix.

4.4 Gelfand's second method.

Gelfand's second method (Gelfand 1971, pp. 192-194) is an attempt to seriate a group of units by arranging each row of the similarity matrix in Robinson form. This means that the highest value in the row appears near the centre with the other values decreasing towards the two ends. Once this has been done, the position occupied by each unit in each row is used to establish an overall ordering. The algorithm for this method uses a matrix containing the position of each unit in each row as well as the similarity matrix.

This method begins with the ordering of each row of the position matrix so that the unit on the main diagonal in that row is at the left end and the units towards the right are arranged in order of decreasing similarity with it. This is equivalent to arranging the coefficients in the corresponding row of the similarity matrix in descending order.

Consider the matrix shown in Figure 4.4.1. This matrix

	1	2	3	4	5	6
1	1.00	0.75	0.89	0.98	0.78	0.58
2	0.75	1.00	0.70	0.67	0.69	0.75
3	0.89	0.70	1.00	0.13	0.87	0.46
4	0.98	0.67	0.13	1.00	0.73	0.92
5	0.78	0.69	0.87	0.73	1.00	0.84
6	0.58	0.75	0.46	0.92	0.84	1.00

Figure 4.4.1: Similarity matrix for a set of six units.

gives rise to the position matrix shown in Figure 4.4.2 in which the coefficients in the rows have been arranged in descending order. In the first row of the similarity matrix,

	1	2	3	4	5	6
1	1	4	3	5	2	6
2	2	1	6	3	5	4
3	3	1	5	2	6	4
4	4	1	6	5	2	3
5	5	3	6	1	4	2
6	6	4	5	2	1	3

Figure 4.4.2: Position matrix with units in each row in descending order.

the highest coefficient occurred in the first position, second highest in the fourth position, etc. The other rows have been arranged similarly. In the second row there are two coefficients with the same value. Their order is unimportant at this stage of the analysis.

The second step is to arrange the rows of the similarity matrix in Robinson form. It is not necessary to move the first two units in the row as they are most similar to each other, so the first to be considered is the third. If the third unit is more similar to the second unit in the row than it is to the first, nothing is done. If, however, it is more similar to the first, it moves into the first position, displacing both the first and second units one position to the right, At this point, the first three units in the row have been ordered. The rest of the units, in turn, are moved to that end of the ordered portion of the row to which they are more similar.

In the first row, beginning in the third position, it

	1	2	3	4	5	6
1	2	5	3	1	4	6
2	4	6	2	1	3	5
3	4	6	5	3	1	2
4	3	5	6	4	1	2
5	2	6	5	3	1	4
6	2	5	6	4	1	3

Figure 4.4.3: Position matrix with rows arranged in Robinson form.

was found that object 3 was more similar to object 1 than to object 4. The similarities were obtained from Fig. 4.4.1 where (3,1)<(3,4). Object 3 was moved to the first position in the row with objects 1 and 4 moving one position to the right. The ordered portion of the row consisted of 3-1-4 at this stage. The next unit considered was number 5 which was found to be more similar to 3 than to 4. Similarly, 2 was more similar to 5 and 6 to 4 giving the order shown in Fig. 4.4.3 above.

If, in arranging a row in Robinson form, a unit is found to be equally similar to both ends of the portion of the row already ordered, its similarity with the units one position in from the ends is used.

Since the rows of the position matrix were ordered independently, the ends of the rows on each side of the matrix may not correspond and it may be necessary to "orientate" some of them by reversing the sequence of units in them. Each row is really an ordering of the units, and since the computer is incapable of deciding which end is earlier, it is possible that early units will be moved to the right end of some rows and the left end of others. Fig. 4.4.4 shows the position matrix with all rows oriented in the same

	1	2	3	4	5	6
1	2	5	3	1	4	6
2	5	3	1	2	6	4
3	2	1	3	5	6	4
4	3	5	6	4	1	2
5	2	6	5	3	1	4
6	3	1	4	6	5	2

Figure 4.4.4: Position matrix with all rows orientated in the same direction.

direction. In practice, row 1 was taken as the standard, For each other row, the units were reversed if less than half the numbers in the first half of the row matched those in the first half of row 1.

For each unit, the sum of the position number it occupies in each row of the ordered position matrix is calculated in the next step. This is a method of "averaging" the position of each unit in each row. Finally, these sums are arranged in decreasing order to give the final ordering of the units.

For our example, the summed position numbers for each unit as shown in Fig. 4.4.4 appear in Fig. 4.4.5. These

Unit number	1	2	3	4	5	6
Sum of position numbers	21	20	14	30	17	25

Figure 4.4.5: Sum of position numbers for each unit.

results arranged in descending order are shown in Fig. 4.4.6. Thus the final order of the units is: 4, 6, 1, 2, 5, 3.

Unit number	4	6	1	2	5	3
Sum of position number	30	25	21	20	17	14

Figure 4.4.6: Units arranged in final order.

As with any seriation method, no indication of which end of the ordering is earlier can be given until the units in question have been inspected. The "orientation" of the rows discussed above is not to determine the earlier end of the ordering but to ensure that the units at the ends of the rows correspond.

A listing of the program for Gelfand's second method can be found in section 4 of the Appendix.

4.5 The double link method.

The double link method (Renfrew and Sterud 1969, pp. 265-268) is a method of rapid seriation which can quite easily be done "by hand" for small samples; however, when dealing with more than about 30 units, the use of a computer is desirable. One analysis of the Rhitsóna graves can be done by hand in about four hours using this method.

The procedure for hand seriating using this method is quite simple. Starting with the similarity matrix, the two highest coefficinets in each column are circled. Each of the circled coefficients represents a link joining the two units to which it refers. Two coefficients are circled in each column in an attempt to order the units so that each one appears between the two to which it is most similar.

After the circling has been completed, a diagram showing all the links is constructed. The example illustrated in Figs. 4.5.1 and 4.5.2 shows these forst two steps of the analysis carried out on similarity matrix M.

	1	2	3	4	5	6
1	1.00	0.75	0.65	0.70	0.95	0.70
2	0.75	1.00	0.52	0.98	0.74	0.60
3	0.65	0.52	1.00	0.48	0.64	0.95
4	0.70	0.98	0.48	1.00	0.72	0.58
5	0.95	0.74	0.64	0.72	1.00	0.69
6	0.70	0.60	0.95	0.58	0.69	1.00

Figure 4.5.1: Similarity matrix M.

In the circling step, the numbers along the main diagonal are omitted as they do not reflect links between two distinct units. Also, if the highest number in a column

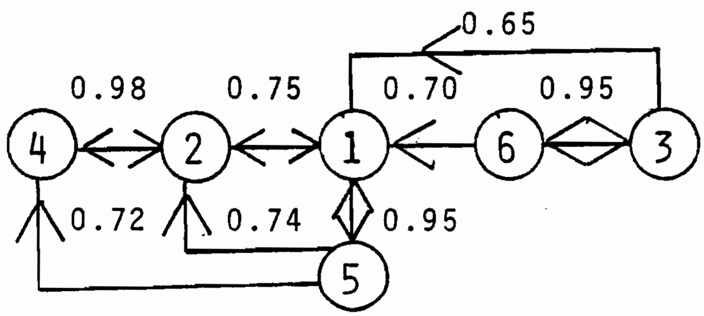


Fig. 4.5.2: Diagram showing links indicated by the circled coefficients.

appears more than once, it is circled as many times as it occurs. If it appears at least twice, the circling in the column is complete. If it appears once only, the second highest coefficient is located and circled as many times as it occurs. In some cases, this will result in more than two circled coefficients in a column.

In drawing the linkage diagram, each circled coefficient is shown as an arrow on a line connecting two units. The arrow points from the column unit to the row unit. Thus, the 0.75 in column 1 of Fig. 4.5.1 is shown as one of the arrows on the line connecting units 1 and 2 (the arrow pointing from the column unit, 1, to the row unit, 2) in Fig. 4.5.2. Since the corresponding coefficient in the second column is also circled, this line has two arrows.

The final stage of this type of analysis involves the simplification of the diagram produced in the second stage. All loops in the diagram are located and broken at the weakest link without regard to the direction of the arrow. In Fig. 4.5.2, units 1, 3 and 6 form a loop. The weakest link in this loop is the one with the lowest similarity attached to it, or the 0.65 joining units 1 and 3. This link is removed. Similarly, the other loops are located and broken one by one. The final result is shown in Fig. 4.5.3. The same final result is obtained regardless of the order in which the loops are considered.

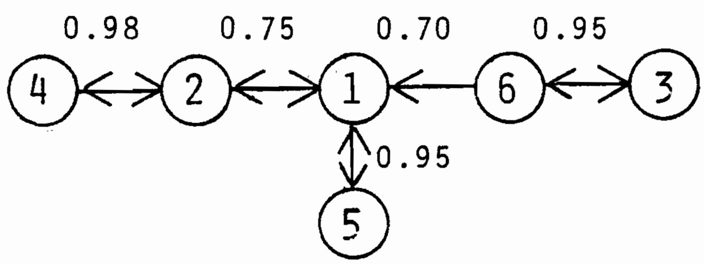


Fig. 4.5.3: Simplified linkage diagram for matrix M.

In breaking the loops, a link with one arrow is considered to be weaker than one with the same value but two arrows.

An efficient program for this method proceeds in a somewhat different way from the description given above. This is a modified version of Prim's algorithm for constructing a minimal spanning tree (Aho, Hopcroft and Ullman 1974, p. 223; Prim 1957, pp. 1389-1401). The final diagram is built up without allowing any loops to form. In this way, the rather time-comsuming process of having the computer search for loops is avoided.

The first step is equivalent to the circling step described above. All coefficients are eliminated from the similarity matrix except for the two highest in each column.

The second step resembles the construction of the linkage diagram. The highest coefficient remaining which corresponds to the highest circled coefficient, in the similarity matrix is located and all double links with this value are made. Following this, all single links with the same value are added. Next, the second highest coefficient is found and the links involving it are made. This procedure continues until all coefficients have been considered.

No link is added to the diagram if its addition would form a loop. Since the coefficients are considered in descending order of size and number of arrows, this is equivalent to leaving the weakest link out of each loop.

The resulting diagram is usually in the form of a straight line with branches. The longest path through the diagram may be taken to be the time axis with one end being earlier than the other and the units placed along it in their relative chronological order (see Fig. 4.5.3). The decision as to which end of the order is earlier must as always be made in the light of the material being seriated. The branches from the main sequence must be interpreted individually to determine the relation between the units in the branch and those in the main sequence.

The program used for the double link method is listed in section 5 of the Appendix.

4.6 The Descending Coefficient Method.

The descending coefficient method (Renfrew and Sterud 1969, pp. 268-270) is very similar to the double link method but can produce clearer results in some cases, expecially those where many links and loops would remain in the double link diagram.

The coefficients in the similarity matrix are considered in descending order until all objects have been linked, and groups of objects forming at high similarity values are isolated. Since it is possible for an object to appear in several of these groups, the final ordering is produced by overlapping them.

Consider the similarity matrix shown in Figure 4.6.1. The highest coefficient is 0.98 connecting objects 1 and 2. Further inspection reveals that both these objects are related to objects 4 and 6 by similarities greater than 0.98. These four objects form a group. Each of the objects in the group is connected to all the others by a similarity greater than 0.90. Although other objects, such as number 10, have

	1	2	3	4	5	6	7	8	9	10
1	1.00	0.98	0.52	0.92	0.47	0.97	0.95	0.26	0.96	0.92
2	0.98	1.00	0.63	0.93	0.85	0.95	0.35	0.72	0.15	0.78
3	0.52	0.63	1.00	0.61	0.94	0.73	0.92	0.91	0.96	0.63
4	0.92	0.93	0.61	1.00	0.54	0.90	0.69	0.22	0.82	0.46
5	0.47	0.85	0.94	0.54	1.00	0.37	0.91	0.96	0.94	0.32
6	0.97	0.95	0.73	0.90	0.37	1.00	0.28	0.67	0.75	0.52
7	0.95	0.35	0.92	0.69	0.91	0.28	1.00	0.90	0.92	0.94
8	0.26	0.72	0.91	0.22	0.96	0.67	0.90	1.00	0.95	0.45
9	0.96	0.15	0.96	0.82	0.94	0.75	0.92	0.95	1.00	0.95
10	0.92	0.78	0.63	0.46	0.32	0.52	0.94	0.45	0.95	1.00

Figure 4.6.1: Similarity matrix relating ten objects.

high similarities with certain members of the group, they cannot join because their similarities with other members are too low. Renfrew and Sterud suggest enclosing groups in a loop or Venn diagram (1969, p. 268-9). The Venn diagram for this group is shown as the left-most loop in Fig. 4.6.2.

Two other groups also form at similarities of 0,90 of higher. These consist of objects 1, 7, 9, 10 and 3, 5, 7, 8, 9 and are also shown in Fig. 4.6.2.

To construct the order we notice that in Figure 4.6.2 the left group and the central group have object 1 in common. Thus, they can be overlapped at object 1, since they both

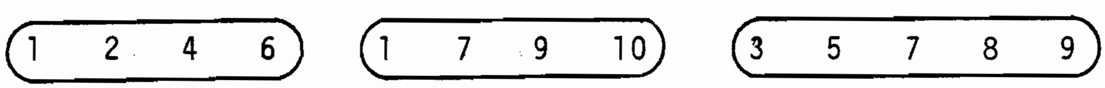


Figure 4.6.2: Groups formed by the descending coefficient method.

contain it. Similarly, the central group and the one on the right share objects 7 and 9 and can be overlapped using these two. The result is shown in Fig. 4.6.3.

The exact positions in the final ordering are specified only for objects 1 and 10 in this case. Objects 2, 4 and 6 can be interchanged with each other as can 7 and 9, as well as 3, 5, and 8. The method does not give any specific

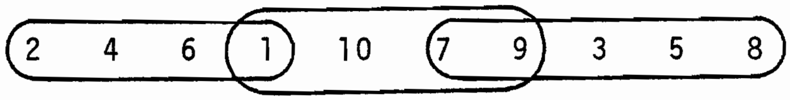


Figure 4.6.3: Final order of the objects from Fig. 4.6.1.

information about the order within any given group and this order cannot always de determined in the overlapping step. Some flexibility in the results is desirable as they should suggest rather than dictate the actual order of the objects.

It is very easy to perform this method by hand even for large numbers of objects. For this reason, the computer program for this method simply lists the coefficients in the similarity matrix in order of size. This program is listed in section 6 of the Appendix.

4.7 Contextual Analysis.

Contextual analysis (Dempsey and Baumhoff 1963, pp. 496-509) is a seriation method which attempts to place each unit in an order by considering its average similarity with the other units in the analysis. The goal is to create an order where each unit appears between the two others to which it is most similar and the similarity with the other objects decreases as one moves along the sequence, away from the unit, in either direction.

In the first stage of the contextual analysis, the set of objects to be seriated is split into two groups. This is accomplished by locating the row of the similarity matrix containing the maximum variation in similarity coefficients. The object represented by this row is taken to be the centre of one group. If there is a total n of objects in the analysis, the n/2 with the highest similarity to the chosen unit are placed in the first group and the remaining objects are left to the second. Since this division is made on the basis of only one unit, it is necessary to determine whether the groups created are consistent with the other data available. For each unit, the average similarities with its own group and with the other group are calculated. If an object's average similarity with its own group is greater than that with the other group, it stays where it is, otherwise it moves to the other group. When the units have been moved, the procedure of calculating the average similarities is repeated. This goes on until the groups become stable and no units move.

In the second stage of the analysis the units in the two groups are ordered. The production of a linear ordering of all the units is achieved by joining the two groups at the point where they are most similar. The units at the end points of the list should be very similar to their own groups and not similar to the other group. The units near the point where the two groups join should be only slightly more similar to their own group than they are to the other group.

For each unit, the difference between its average similarity with its own group and with the other group is obtained. In general, this difference should be small for units close to the centre of the ordering, and larger for units near the ends, so the units in the two groups are sorted in order of decreasing difference in similarity. The two groups are joined where the differences are smallest and the final ordering is produced.

As in all the other seriation methods, no indication of which end of the final ordering is earlier can be given.

A listing of the program for contextual analysis can be found in section 7 of the Appendix.

4.8 The Method of Brainerd and Robinson.

The Brainerd-Robinson technique (Brainerd 1951, pp. 301-313; Robinson 1951, pp. 293-301) was the first seriation method to be published as such. It was intended as a method of frequency seriation, but the reasoning applies when similarity and distance coefficients are used as well.

The Brainerd-Robinson method takes a matrix of similarity coefficients as input and re-orders the rows and columns to put the matrix into what is called Robinson form (Gelfand 1971, p. 194). Of course, it is not always possible for a matrix to be arranged so that it is precisely in Robinson form, and in this case, the algorithm should come as close as possible for the matrix concerned.

Since the original publication of the method, at least two descriptions of computer programs for arranging matrices in Robinson form have been published (Ascher and Ascher 1963, pp. 1045-1052; Kuzara, Mead and Dixon 1966, pp. 1442-1455). The first of these algorithms was not used in this analysis as the order of the objects in the final sequence depends on the order in which they were encountered by the program (Kuzara _et al_. 1966, p. 1444). This may also be true to a certain extent in the algorithms of Kuzara, _et al_., but in general, the results of this second algorithm are more reliable. If variations of the input order happen to produce different final orderings, various permutations of the data can be used to produce the best ordering available.

The problem with the second algorithm is that it is very expensive in terms of computer time for groups of objects of size greater than about twenty. For this reason, a clustering procedure was used as a preliminary step in this analysis to split the original set of objects into groups of similar objects. Once this was done, the objects in each cluster were seriated using the algorithm of Kuzara, _et al_. Next, one object from each cluster was selected and these were seriated using the same procedure. This gave the order of the clusters. Since the order of the objects in each cluster had already been determined, the final order of all objects could be constructed. The units in each cluster are arranged so that those on the left are more similar to the cluster on the left. The same is done for the cluster on the right.

As input, the clustering algorithm takes a "critical value", the names of the objects to be clustered and the similarity matrix relating these objects. The critical value is the lowest similarity at which clusters may form. This value is chosen so that the clusters produced contain a convenient number of objects. If the clusters formed are too large, seriation using the Brainerd-Robinson method is impractical. The maximum size for clusters should be ten to fifteen members. In some cases the critical value is found by trial and error, but in this case, the results of the Double Link Method were used to obtain it.

The first step in the clustering procedure is the identification of all the coefficients in the similarity matrix which are greater than or equal to the critical value. This is done by deleting all coefficients which are too small. Next, the first cluster is formed by listing the first object and all objects to which it is related by a similarity greater than or equal to the critical value. Any objects which are still outside the cluster but are related to at least one object within it by a similarity at least as high as the critical value are added. This continues until no further objects can be added to the first cluster. The second cluster is formed in the same way, using the next object which is not already part of the first. This procedure continues until all objects have been clustered.

The members of each cluster are then seriated using the Kuzara, Mead and Dixon algorithm for the Brainerd-Robinson method. This is a fairly long process. The goal is to find the ordering of the objects which will arrange the similarity matrix as close to Robinson form as possible. In order to judge the amount of deviation of a matrix from Robinson form, the amounts of any increases in similarity encountered while moving away from the main diagonal in any direction are summed. The larger this sum, the greater the deviation of the matrix from Robinson form.

The first step in the ordering is to interchange the first and second rows and columns of the similarity matrix. If the resulting matrix is "better" than the original (closer to Robinson form), it replaces it in the computer memory. The first row and column are then tried in the third position and the better of this matrix and the one in storage is kept. The procedure continues until the first row and column have been tried in all positions. The result of this is that the best position for the first object has been found.

Using the matrix in storage at this point, the same procedure is followed for the second row and column and all subsequent ones as well. After this has been done, the "best" ordering obtained to this point is in storage. This, however, may not be the best ordering possible as the movement of later rows and columns may make it possible to place earlier ones in positions which were unsuitable at the beginning of the ordering procedure. For this reason, the entire ordering procedure is repeated until no improvement in the results is obtained.

Kuzara, Mead and Dixon state (1966, p. 1446) that the input order of the data may have an effect on the ordering produced. They suggest using several different input orders to see whether the same results are consistently produced. In this analysis, only one other input order was used unless this produced a different final result. If this happened, several input orders were tied until the best final ordering of the data was obtained. This was the ordering which most closely approximated Robinson form in the similarity matrix.

When each of the clusters had been seriated, one member was selected from each, and the seriation procedure was repeated so that the order of the clusters could be determined. The member selected from each cluster was the one most similar to the other members of the cluster. This was the one with the highest average similarity to the other cluster members.

The seriation procedure for the objects selected was exactly the same as that described above for the ordering of each cluster.

When the ordering of the selected objects had been done, the final order of all the objects was constructed. The clusters were placed in the order indicated by the results of the preceding step. Each group was then oriented so that the end most similar to the cluster to its right was next to that cluster. The same was done for the left end.

The programs used for the method of Brainerd and Robinson are listed in section 8 of the Appendix.

Chapter 5 - Presentation of Results and Commentary

5.1 Introduction.

A total of six similarity and distance matrices was calculated for the Rhitsōna graves. The coefficients used were the simple matching coefficient, the coefficient of Jaccard and the Euclidean distance coefficient. Each of these three coefficients was calculated on two attribute sets.

Since the traditional method of dating graves uses the pottery found in each one, the attributes describing the ceramic finds only were used in the first calculations. The rest included all of the 132 attributes recorded. The purpose of this division of the attributes was to determine whether any refinement of the orderings produced could be obtained by using all the information about the graves rather than just the pottery.

In the case of the concentration principle which does not make use of any coefficient, only two orderings were produced. These are based on the same two attribute sets. For each of the other six methods of seriation, six sets of results were obtained.

In this chapter, the results are presented with general comments. Interpretation and comparison of these results appear in Chapter 6.

In order to facilitate visual comprehension of the results, the graves have been colour-coded according to the dates given by Sparkes (1967, pp. 128-130). The colours were chosen so that graves in earlier groups are green and

Group No.	Grave Nos.	Dates	Colour
1	1, 134	Mid 8th cent. BC.	
2	6, 75, 88, 90	Late 8th - early 7th cent.	
3	132, 13, 97, 14, 89, 91, 141	Second half 7th cent.	
4	4, 87, 92, 95, 125A, 125B	c. 600 BC	
5	99, 125C, 125D, 125E, 101A, 101B, 115, 96, 86, 145	Early 6th cent. BC.	
6	40, 49, 50, 93, 103, 104, 110, 51	Mid 6th cent. BC.	
7	126, 3, 85, 102, 31	Second half 6th cent.	
8	127, 5, 133, 130, 112, 26, 80, 12, 135, 120, 18	Late 6th cent. BC.	
9	121, 82, 2	Late 6th - early 5th cent.	
10	131, 22, 22A, 21, 113, 46, 36	Early 5th cent. BC.	
11	52	First half 5th cent.	
12	108, 138	Mid 5th cent. BC.	
13	76, 139	Third quarter 5th cent. BC.	
14	114A, 123, 144, 55, 111	Late 5th cent. BC.	
15	114B, 57, 59	End 5th cent. BC.	
16	60, 107, 34	First half-mid 4th cent.BC.	
17	33, 30	Second half 4th cent. BC.	
18	56	4th cent. BC.	
19	66, 67, 68	Mid 3rd cent. BC.	
20	61	Undated	

Table 5.1 Colour coding system for graves.

blue, with reds, yellows and browns used for later graves. Middle graves are purple. The one grave that was not dated by Sparkes is indicated in black. The complete coding system is explained in Table 5.1. In some cases, the groups may overlap in date and graves may be moved from one group to an adjacent one.

This table is reproduced as a fold-out at the end of the text for easy reference when examining the results.

The individual sets of results are presented in such a way that as many of the green graves as possible occur near the top end of the ordering.

5.2 Results of the Concentration Principle.

5.2.1a Results using ceramic attributes.

93 - 125E - 125D - 125C - 125B - 125A - 101A - 96 - 21 - 88 - 68 - 67 - 56 - 145 - 141 - 104 - 103 - 97 - 95 - 101B - 99 - 92 - 132 - 90 - 91 - 89 - 87 - 13 - 14 - 86 - 75 - 55 - 134 - 85 - 110 - 52 - 40 - 61 - 126 - 114B - 144 - 66 - 123 - 139 - 57 - 30 - 34 - 22A - 115 - 112 - 22 - 130 - 51 - 49 - 6 - 59 - 60 - 33 - 50 - 76 - 111 - 138 - 107 - 108 - 121 - 113 - 4 - 5 - 127 - 114A - 131 - 80 - 102 - 120 - 82 - 133 - 135 - 36 - 26 - 31 - 46 - 18 - 12 - 3 - 2 - 1.

5.2.1b Commentary

The majority of the green and blue graves appear towards the top end of the ordering with only a few below the central part. The graves from the purple groups are found towards the bottom end of the sequence with only grave 21 found above the centre. The later groups are found in the central part of the ordering and extend below the centre.

Most of the groups of graves are spread over large portions of the list. The only exception is group 12. The two graves from this group appear together below the centre.

5.2.2a Results using all attributes.

68 - 67 - 93 - 125E - 125D - 125C - 125B - 125A - 101A - 21 - 103 - 88 - 96 - 90 - 91 - 132 - 101B - 97 - 95 - 141 - 92 - 145 - 99 - 86 - 89 - 14 - 13 - 22A - 61 - 134 - 52 - 111 - 66 - 144 - 108 - 107 - 115 - 85 - 121 - 4 - 5 - 56 - 55 - 59 - 123 - 127 - 114B - 138 - 33 - 60 - 34 - 57 - 30 - 126 -

22 - 139 - 76 - 87 - 75 - 6 - 104 - 110 - 40 - 50 - 51 - 112 - 114A - 131 - 36 - 12 - 130 - 18 - 46 - 135 - 26 - 133 - 102 - 120 - 82 - 31 - 113 - 80 - 49 - 3 - 2 - 1.

5.2.2b Commentary.

The graves from the green groups appear mostly near the top end of the ordering. A few members of these groups do appear below the centre with grave 1 from the earliest group appearing at the bottom. The first of the blue groups can be found above the centre. Some of the members of the other blue groups also appear here, but most are in the bottom half of the list. The same is true of the graves from the purple groups. The later graves are found in the centre for the most part with a few of the latest graves appearing at the top end.

Only group 13 is well clustered in this sequence. The other groups are spread to a greater or lesser extent. Some of the groups such as number 10 are spread over almost all of the list, while others such as number 5 are confined to one half or the other.

5.3 Results of Gelfand's first method.

5.3.1a Results using the simple matching coefficient and ceramic attributes.

22 - 110 - 85 - 5 - 127 - 12 - 80 - 46 - 18 - 31 - 26 - 82 - 135 - 126 - 40 - 115 - 13 - 14 - 99 - 91 - 4 - 97 - 95 - 141 - 87 - 89 - 101B - 21 - 90 - 88 - 75 - 6 - 132 - 125E - 96 - 93 - 125D - 101A - 125C - 125B - 125A - 145 - 92 - 103 - 104 - 1 - 144 - 22A - 2 - 36 - 3 - 121 - 131 - 61 -

114B - 30 - 34 - 55 - 56 - 134 - 67 - 68 - 66 - 33 - 60 - 59 - 52 - 57 - 114A - 138 - 107 - 111 - 108 - 123 - 139 - 76 - 133 - 120 - 130 - 113 - 112 - 102 - 49 - 51 - 50 - 86.

5.3.1b Commentary

The graves have not been arranged in any type of chronological order by this combination of method, coefficient and attribute set. In the cases of groups 2, 3, 12, 13 and 19, the graves appear together or very close together. The other groups are spread over varying distances. Members of groups 5, 6, 7, 8 and 10 are found at both ends of the ordering.

In general, the later graves are found below the central part of the ordering with the very earliest two mixed among them and other early graves spread from the centre towards the top end of the ordering. Middle graves occur at the ends. There is a great deal of mixing between groups.

5.3.2a Results using the simple matching coefficient and all attributes.

13 - 4 - 145 - 125C - 125D - 125E - 132 - 75 - 6 - 66 - 68 - 67 - 134 - 1 - 103 - 93 - 88 - 90 - 21 - 101A - 125B - 125A - 92 - 95 - 87 - 141 - 89 - 97 - 14 - 91 - 99 - 101B - 96 - 114B - 33 - 60 - 59 - 52 - 107 - 138 - 111 - 56 - 55 - 114A - 108 - 30 - 34 - 57 - 139 - 36 - 131 - 133 - 113 - 135 - 82 - 26 - 130 - 112 - 102 - 126 - 40 - 110 - 22 - 76 - 123 - 144 - 22A - 61 - 2 - 121 - 3 - 120 - 85 - 115 - 104 - 5 - 127 - 12 - 46 - 80 - 18 - 31 - 49 - 51 - 50 - 86.

5.3.2b Commentary.

The majority of the later graves appear in the centre of this ordering, but there are some close to the upper end and approaching the lower end as well. Earlier graves all appear above the central section with some of the slightly later blue graves among them. The graves from the purple groups all appear below the centre. Groups 1 and 19 which contain the earliest and latest graves respectively are found beside each other near the upper end of the ordering.

Many of the groups are spread from one end to the other. This is true especially of those marked in blue. Other groups are spread over smaller sections of the list with only groups 1 and 19 having all their members together.

5.3.3a Results using the coefficient of Jaccard and ceramic attributes.

96 - 93 - 125D - 125E - 101A - 125C - 125B - 125A - 145 - 92 - 103 - 104 - 85 - 110 - 86 - 50 - 49 - 51 - 26 - 82 - 31 - 18 - 80 - 46 - 12 - 127 - 135 - 112 - 102 - 130 - 120 - 133 - 113 - 126 - 40 - 115 - 101B - 89 - 141 - 87 - 95 - 97 - 4 - 91 - 99 - 14 - 13 - 88 - 90 - 21 - 132 - 75 - 6 - 134 - 67 - 68 - 66 - 30 - 34 - 33 - 60 - 59 - 52 - 57 - 144 - 22A - 2 - 36 - 3 - 121 - 131 - 5 - 22 - 76 - 139 - 123 - 108 - 61 - 114B - 114A - 55 - 56 - 1 - 107 - 138 - 111.

5.3.3b Commentary.

The majority of the graves marked with green appear in the centre of the ordering with three of the earliest at the top end and one of the very earliest at the bottom. The blue and purple graves are mainly at the top end although some are found among and below the green groups. The later graves appear just below the centre and at the bottom end.

Only the graves of group 19 are found together, with those of the other groups usually spread over small sections of the ordering. Group 10 is scattered over most of the list.

5.3.4a Results using the coefficient of Jaccard and all attributes.

1 - 103 - 93 - 96 - 125D - 125E - 125C - 145 - 92 - 99 - 91 - 14 - 97 - 95 - 87 - 141 - 89 - 101B - 125B - 125A - 4 - 13 - 88 - 90 - 21 - 101A - 115 - 22A - 144 - 114B - 61 - 22 - 110 - 104 - 5 - 127 - 12 - 113 - 102 - 135 - 82 - 26 - 80 - 46 - 18 - 31 - 49 - 51 - 50 - 86 - 126 - 40 - 112 - 130 - 36 - 2 - 131 - 121 - 3 - 85 - 120 - 133 - 76 - 123 - 139 - 57 - 52 - 59 - 60 - 33 - 34 - 30 - 56 - 55 - 114A - 108 - 138 - 107 - 111 - 66 - 67 - 68 - 134 - 6 - 75 - 132.

5.3.4b Commentary.

The majority of the earliest graves occur near the top end of the ordering, however four of these are found at the extreme bottom end. A considerable number of the blue graves is found mixed with the green ones in the upper half. In the middle of the ordering, the mixture changes to purple with blue. A couple of the later yellow graves are found in this part of the list as well. The very bottom end of the list consists mostly of the later graves.

The members of all groups except number 19 are spread out in the ordering. The greatest scattering occurs in the blue groups.

5.3.5 Results using the Euclidean distance coefficient and ceramic attributes.

These results are exactly the same as those obtained using the simple matching coefficient and ceramic attributes.

5.3.6 Results using the Euclidean distance coefficient and all attributes.

These results are exactly the same as those obtained using the simple matching coefficient and all attributes.

5.4 Results of Gelfand's second method.

5.4.1a Results using the simple matching coefficient and ceramic attributes.

99 - 101B - 125A - 13 - 14 - 91 - 132 - 66 - 86 - 4 - 145 - 101A - 21 - 141 - 89 - 97 - 96 - 68 - 92 - 107 - 125B - 138 - 33 - 125D - 134 - 56 - 125C - 95 - 125E - 115 - 87 - 34 - 67 - 111 - 114B - 6 - 59 - 139 - 75 - 30 - 88 - 1 - 103 - 50 - 114A - 93 - 60 - 108 - 55 - 90 - 144 - 61 - 104 - 22A - 52 - 2 - 40 - 76 - 5 - 123 - 22 - 57 - 110 - 131 - 121 - 85 - 36 - 133 - 49 - 51 - 120 - 126 - 3 - 130 - 113 - 127 - 112 - 82 - 135 - 12 - 102 - 46 - 80 - 26 - 18 - 31.

5.4.1b Commentary.

The earlier, green grave groups are found for the most part in the upper part of the ordering with a few near the centre or just below. The lighter blue graves also appear in the upper part of the list. Darker blue and purple groups are mixed and in the lower part of the list with the exception of grave 21 which occurs near the upper end. The later groups of graves are all located in the central portion of the ordering with a couple of individual graves spreading out towards both ends.

The groups of graves are spread out to a great extent in this list. Even groups of different shades of the same colour do not usually appear together without the occurrence of graves from other colour groups among them.

5.4.2a Results using the simple matching coefficient and all attributes.

(51) - 26 - (31) - (112) - (12) - 115 - (80) - (46) - 97 - (18) - 141 - (49) - (95) - (87) - 91 - 14 - (92) - (125B) - (4) - 99 - (50) - (22A) - (61) - 89 - 145 - (2) - (103) - (82) - 1 - 101B - (40) - (133) - (67) - 90 - (68) - (102) - (93) - 75 - 96 - 125E - (125A) - 134 - (130) - 13 - (85) - 88 - 144 - (56) - 125C - (104) - 6 - (121) - (3) - (139) - 86 - (22) - 107 - 125D - 57 - (52) - (21) - 101A - 111 - (135) - (131) - (120) - (126) - (5) - 114B - 132 - (110) - 114A - (76) - 55 - 123 - 59 - (36) - (108) - (113) - (127) - (138) - (33) - (66) - (30) - 34 - 60.

5.4.2b Commentary.

The green groups of graves are spread from near the upper end of the ordering to below the centre with grave 132 appearing below the others near the lower end. Members of the blue and purple groups are spread over almost the whole list. The lowest part of the list does not, however, contain blue graves. The later graves appear to be confined mostly to the lower part of the ordering with only a few occurring at the centre and just above it.

Members of some of the groups appear close together in this list, but often a colour group will be split into two parts, or most of the graves in the group appear together with one or two at a great distance from the rest. This is the case with groups 4, 16 and 19. The remaining groups are spread out over the ordering.

5.4.3a Results using the coefficient of Jaccard and ceramic attributes.

21 - 96 - 132 - 125B - 125C - 101A - 125D - 101B - 13 - 90 - 88 - 125E - 1 - 92 - 75 - 145 - 103 - 6 - 141 - 87 - 104 - 89 - 125A - 93 - 99 - 144 - 67 - 115 - 22A - 95 - 68 - 4 - 86 - 134 - 97 - 121 - 40 - 14 - 66 - 130 - 91 - 85 - 61 - 76 - 120 - 12 - 113 - 126 - 131 - 2 - 112 - 56 - 3 - 55 - 60 - 57 - 127 - 110 - 5 - 114B - 108 - 82 - 133 - 49 - 50 - 31 - 22 - 51 - 102 - 34 - 26 - 135 - 33 - 52 - 59 - 114A - 139 - 46 - 18 - 80 - 30 - 36 - 107 - 123 - 138 - 111.

5.4.3b Commentary.

The earlier graves appear in the upper and middle parts of the ordering. The blue groups occur through most of the list with the lighter graves near the top end and going almost to the centre and the darker graves appearing mostly below the centre but with a few of these above the centre. Purple groups appear from just above the centre down to the lower end of the list. The later graves are for the most part below the centre with only a few at the middle or slightly above it.

Colour groups are not well defined in this ordering. The members of all groups are spread out over large parts of the list.

5.4.4a Results using the coefficient of Jaccard with all attributes.

134 - 21 - 67 - 103 - 101B - 125E - 13 - 125B - 75 - 89 - 92 - 1 - 141 - 88 - 68 - 101A - 87 - 6 - 91 - 132 - 125A - 4 - 97 - 125D - 14 - 95 - 66 - 90 - 125C - 99 - 120 - 22A - 115 - 111 - 86 - 114B - 104 - 85 - 12 - 93 - 96 - 102 - 126 - 3 - 113 - 135 - 145 - 108 - 110 - 144 - 40 - 50 - 127 - 138 - 51 - 107 - 36 - 80 - 46 - 133 - 49 - 112 - 2 - 31 - 18 - 52 - 26 - 130 - 82 - 123 - 76 - 5 - 139 - 59 - 121 - 30 - 114A - 33 - 61 - 22 - 34 - 131 - 57 - 55 - 60 - 56.

5.4.4b Commentary.

The earliest green graves all occur near the top end of the ordering. The blue groups are mixed with the green ones but extend into and even past the centre. For the most part the lighter blue graves are the ones mixed with the green ones and the darker groups appear nearer to the centre, but there are several exceptions to this. With only one exception the purple graves begin just above the centre and extend almost to the lower end of the ordering. The later graves are spread mostly from the centre to the lower end of the list with a few occurring above the centre as well.

In this list, some of the colour groups have their members appearing very close together. This is the case with groups 12, 13 and 17. In the cases of the other groups, numbers 4, 6 and 7 exhibit a certain amount of clustering with one or two individual graves at a distance from the main group. The rest are spread out through the list.

5.4.5 Results using the Euclidean distance coefficient and ceramic attributes.

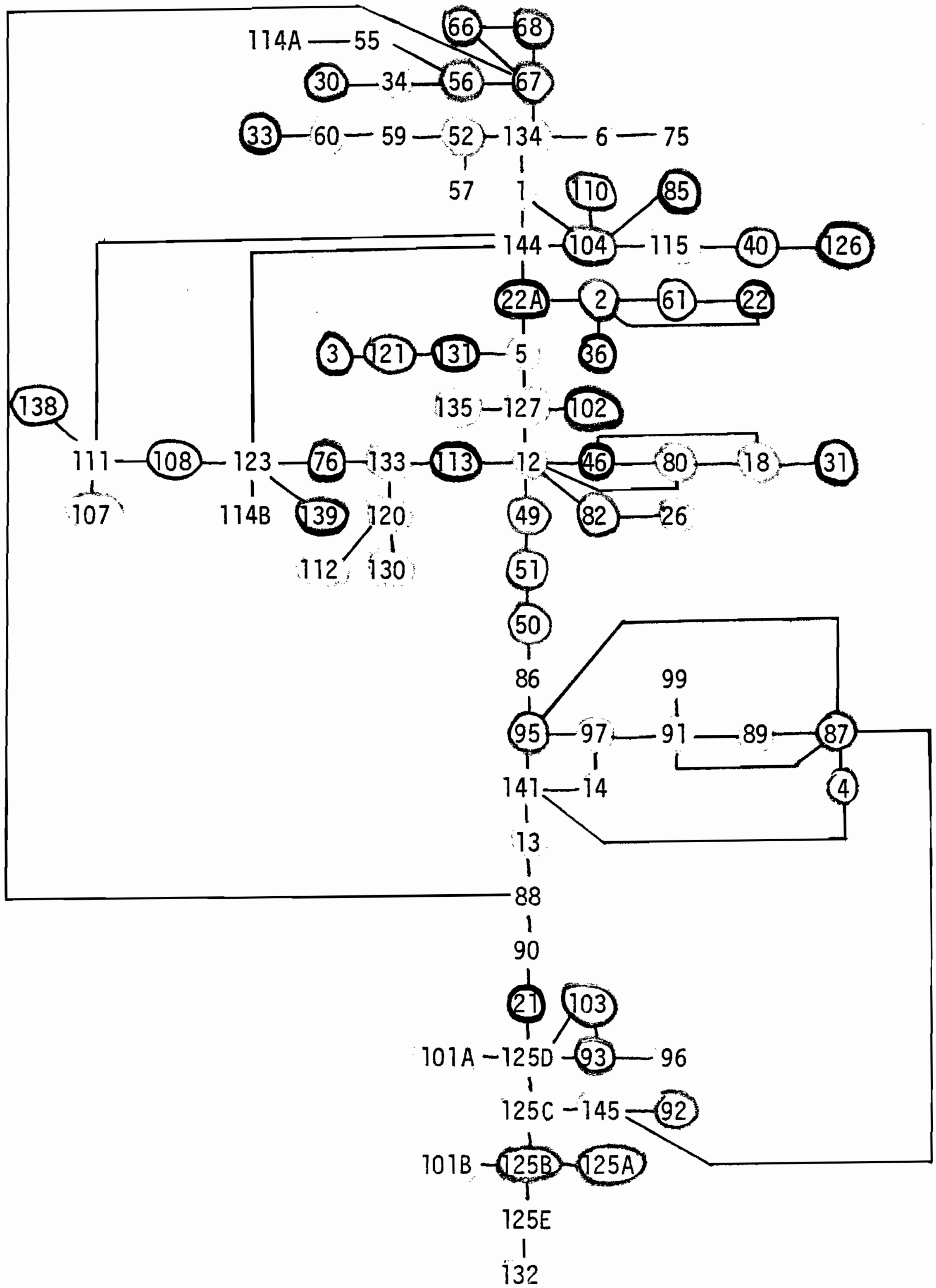
These results are exactly the same as those produced using the simple matching coefficient and ceramic attributes.

5.4.6 Results using the Euclidean distance coefficient and all attributes.

These results are exactly the same as those produced using the simple matching coefficient and all attributes.

5.5 Results of the Double Link Method.

5.5.1a Results using the simple matching coefficient and ceramic attributes.

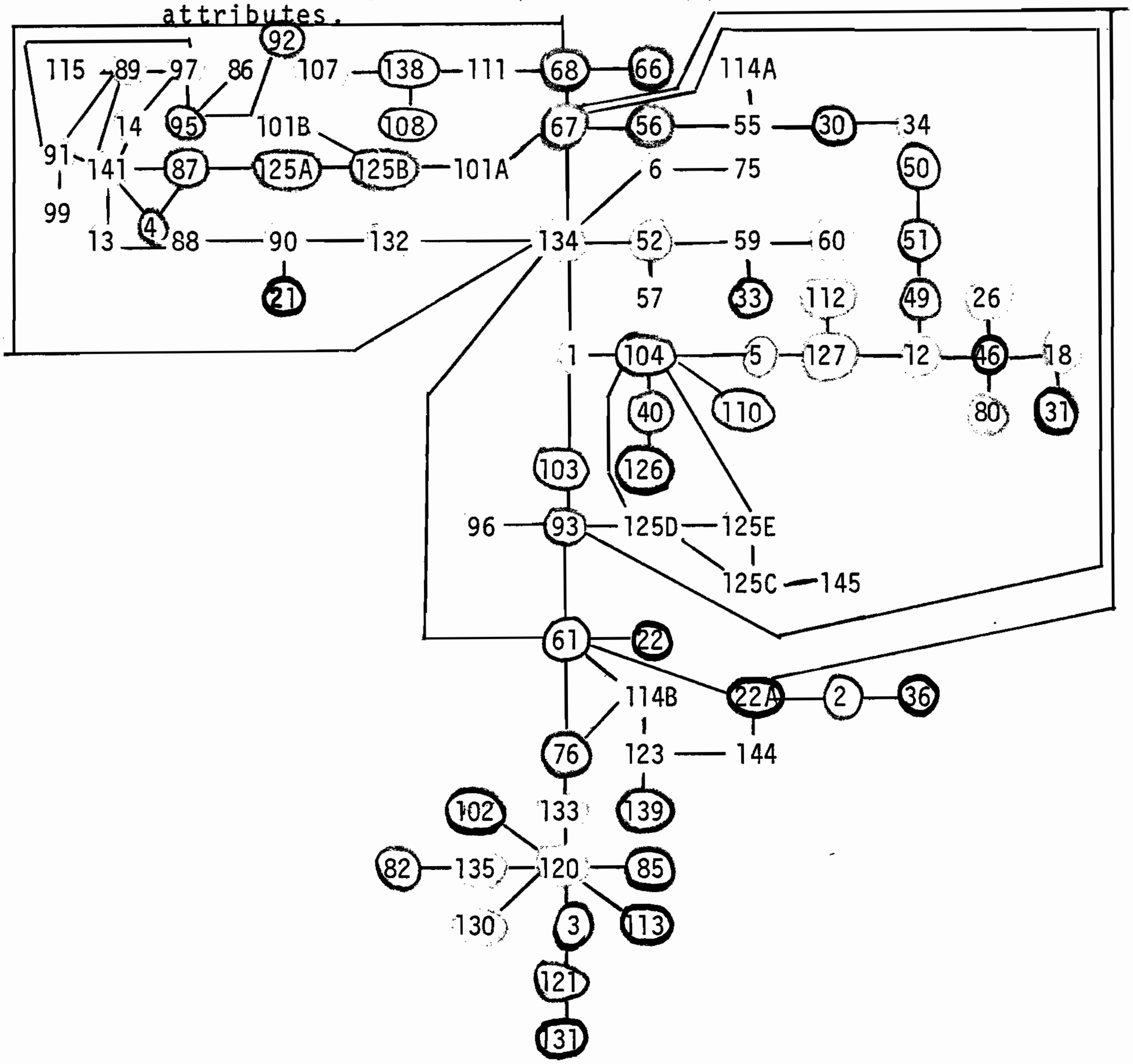


5.5.1b Commentary.

The green grave groups appear mostly at the bottom end of the ordering with only group 1 and two members of group 2 near the top. These four graves are linked to the other groups through grave 67. The lighter blue groups are mixed with the green groups and extend slightly above these. The purple graves appear towards the top end of the ordering with the darker blue graves among them. The later graves occur at the top of the ordering.

In general the members of the groups appear close together in the ordering produced. There are, however, certain exceptions, notably groups 5, 6, 7 and 16.

5.5.2a Results using the simple matching coefficient and all attributes.

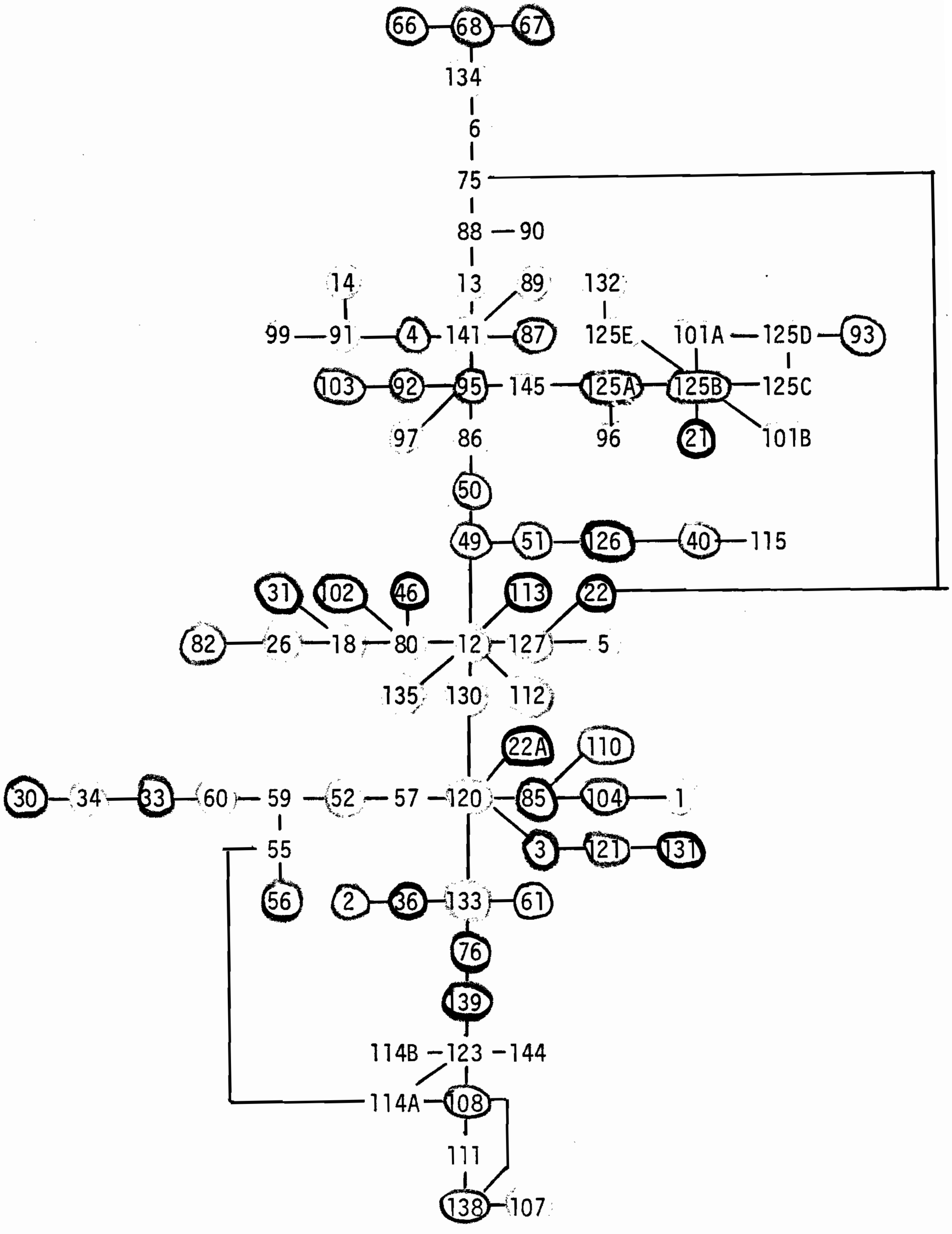


5.5.2b Commentary.

The green groups are found at the top of the ordering closely linked to the later graves. The blue and purple groups form the rest of the arrangement with a few of the later graves near the bottom end.

The majority of the groups are found with their members close together in the ordering. The exceptions are groups 5, 8, 9, 10, 11 and 18. In the case of group 8, there are two fairly cohesive clusters of graves separated by a number of graves from other groups. In some of the other groups, clusters of graves can be seen with just a few of the members found at a distance.

5.5.3a Results using the coefficient of Jaccard and ceramic attributes.

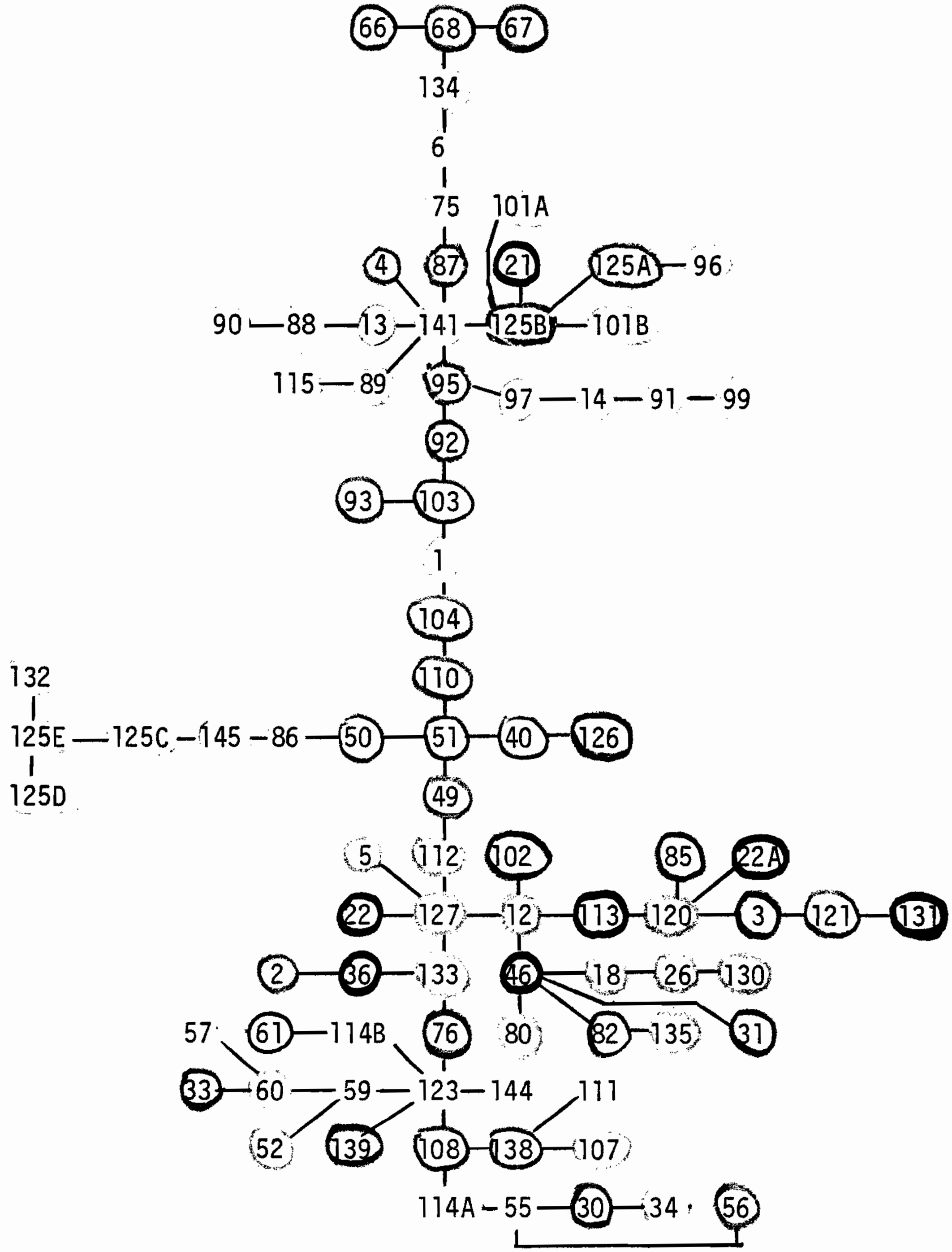


5.5.3b Commentary.

In this ordering, the green grave groups appear near the top of the sequence mixed with some of the blue graves towards the centre. The light blue graves are found with the green ones and the darker blue groups appear at the centre. The purple graves appear next, leading into most of the later grave groups. The latest group appears at the top end of the ordering.

The clustering of members of the groups is fairly good. Groups 5, 6, 7, 9 and 10 show the most spread.

5.5.4a Results using the coefficient of Jaccard and all attributes.



5.5.4b Commentary.

The majority of the green graves appear towards the top end of the ordering. Grave 1 is separated from the others by one blue grave and grave 132 is at a considerable distance from the rest. The light blue group is split with some graves appearing among the green ones and others with grave 132 near the central part of the sequence. Group 6 is confined to the central part of the ordering. The purple graves follow with the dark blue group mixed among them. Grave 21 is the only purple grave to appear at a distance from the others. The later graves with the exception of group 19 appear at the bottom end of the ordering. Group 19 is at the top end.

The groups in this ordering are usually found with their members fairly close together. The exceptions are groups 5, 8, 10, 16 and 17. In some cases, such as group 3, there is a cluster of members with one or more graves of the same group at a distance from it.

5.5.5 Results using the Euclidean distance coefficient and ceramic attributes.

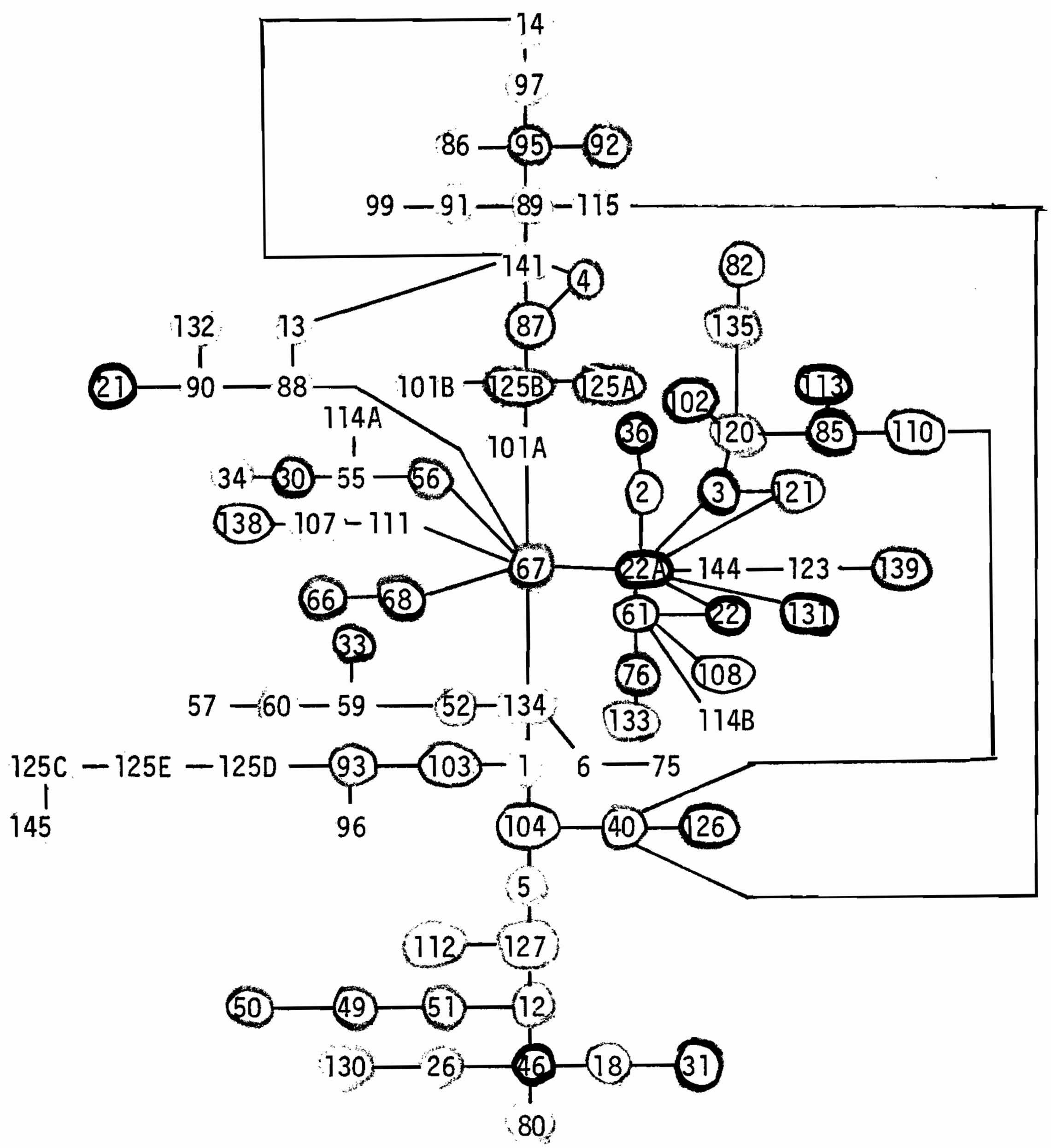
These results were exactly the same as those produced using the simple matching coefficient and ceramic attributes.

5.5.6 Results using the Euclidean distance coefficient and all attributes.

These results were axactly the same as those produced using the simple matching coefficient and all attributes.

5.6 Results of the Descending Coefficient Method.

5.6.1a Results using the simple matching coefficient and ceramic attributes.

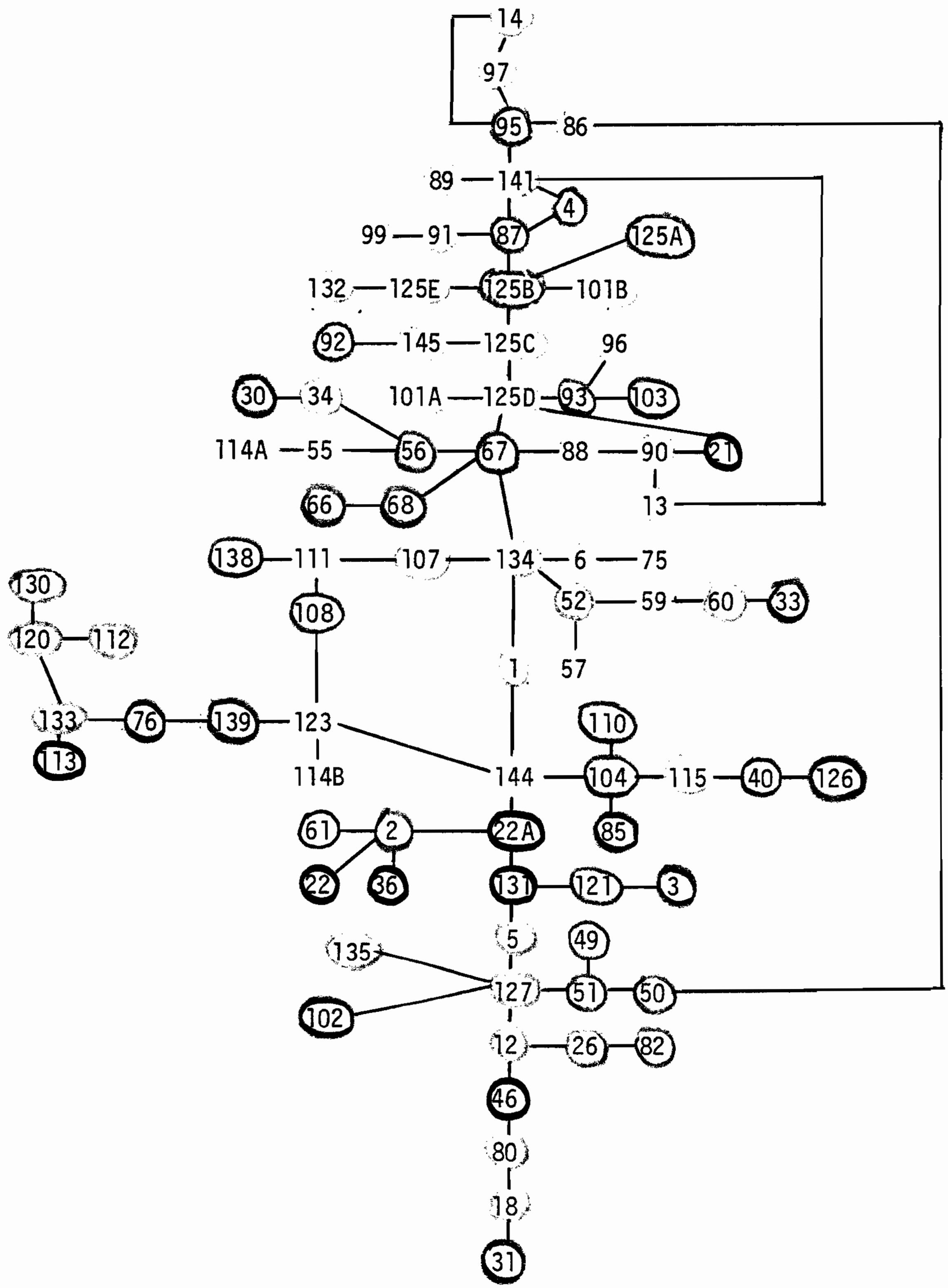


5.6.1b Commentary.

The green groups appear at the top end of the ordering with several near the centre connected through grave 67. Some of the lighter blue graves are mixed with the green ones at the top end, while others occur near the centre. The darker blue and purple graves appear in the centre and at the lower end. The later graves are all found at the centre.

Most of the groups in this ordering have their members fairly close together. The most glaring exceptions are groups 5, 7 and 10.

5.6.2a Results using the simple matching coefficient and all attributes.

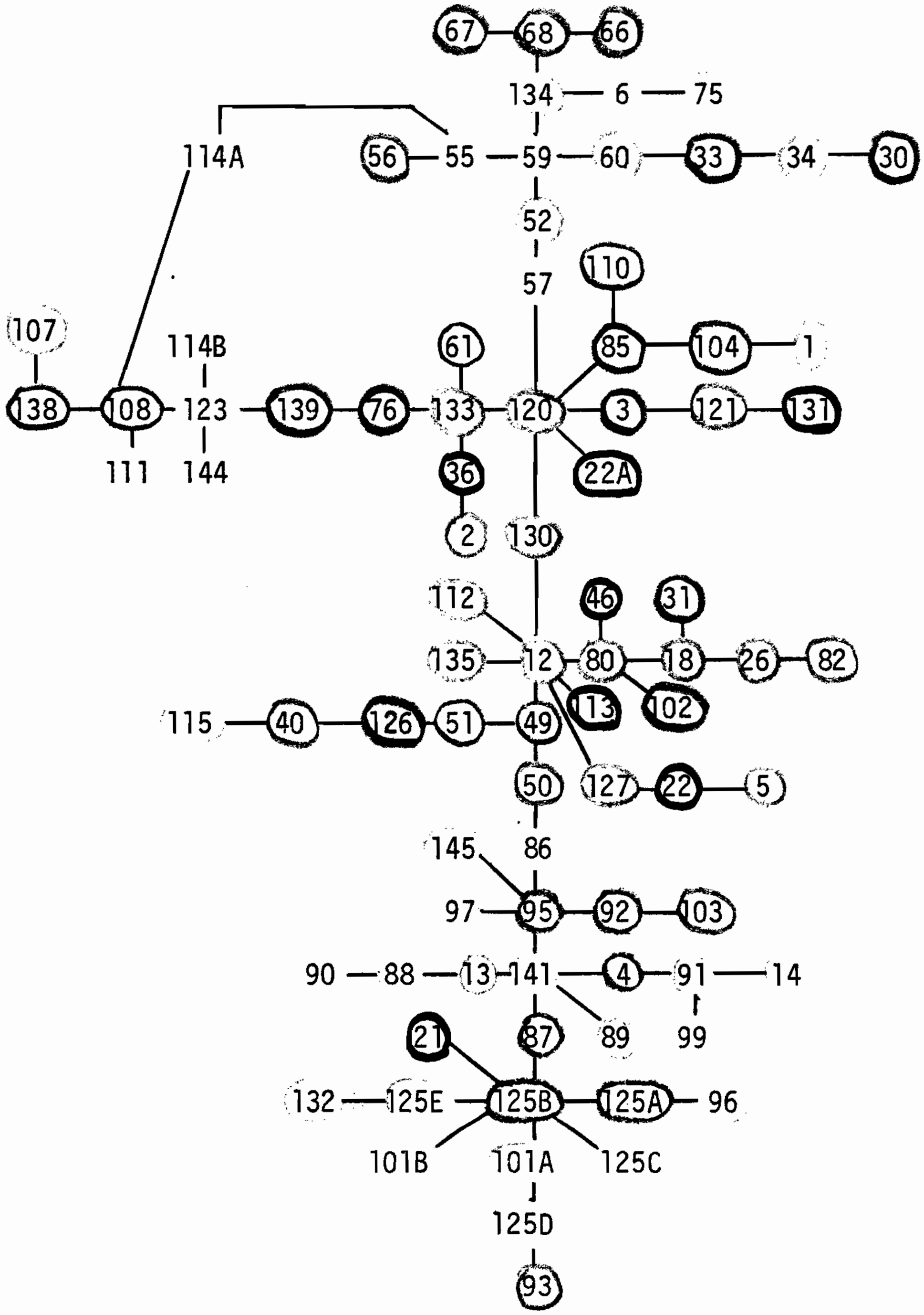


5.6.2b Commentary.

The green graves appear at the top end of the ordering and spread to the centre. Mixed among them are most of the lighter blue graves. The darker blue and purple graves are at the bottom end of the sequence and the later graves are found at the centre.

Most of the groups are very cohesive in this arrangement. Groups 7 and 10 are more spread out than the others.

5.6.3a Results using the coefficient and Jaccard and ceramic attributes.

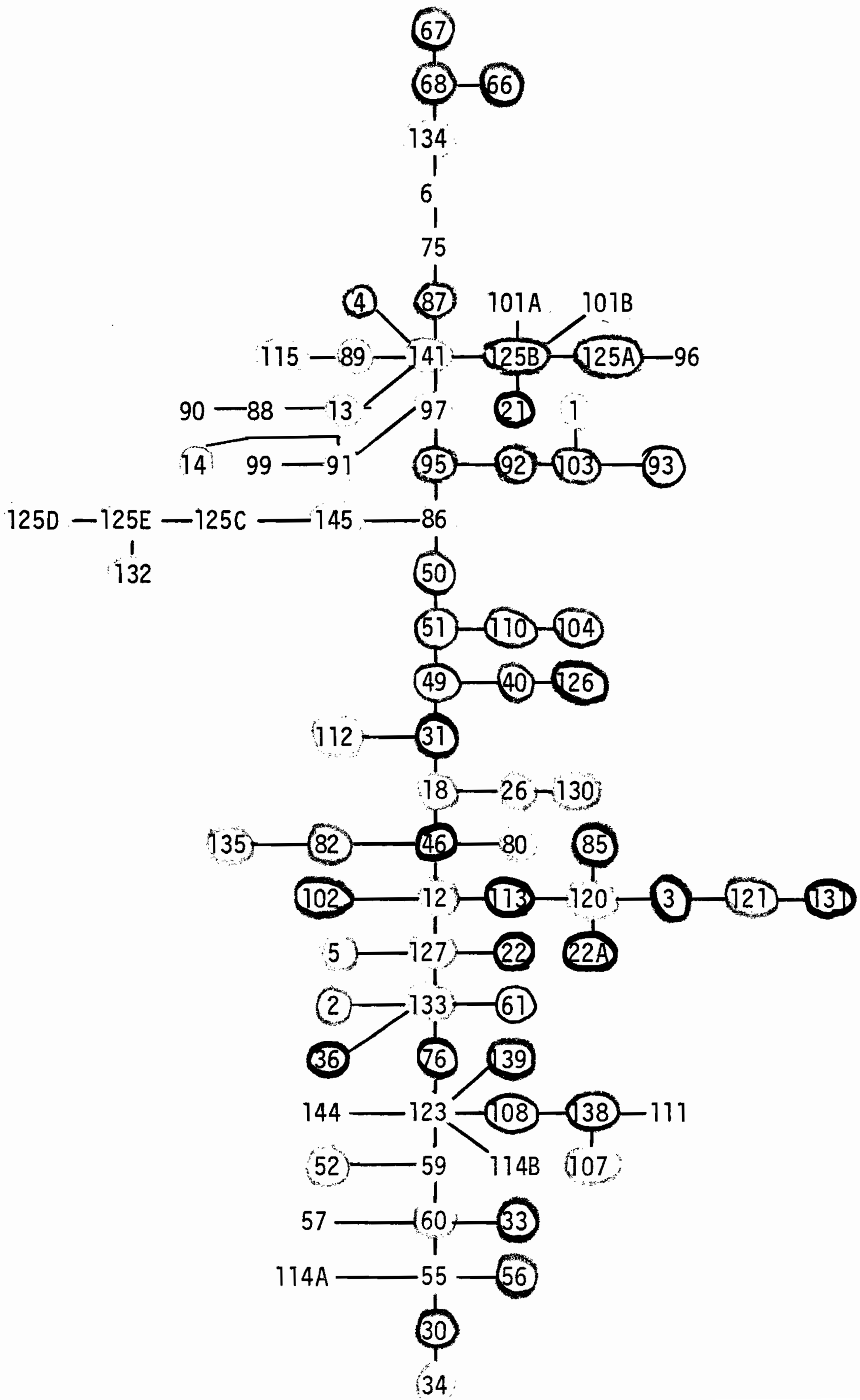


5.6.3b Commentary.

Most of the green graves appear at the bottom of the ordering with four of the earliest at the top. Most of the lighter blue graves appear at the bottom with the green graves. The darker blue and purple graves appear at the centre of the ordering with the later graves at the top.

Several of the groups are widely spread in this sequence. These include groups 2, 5, 6, 9 and 10. The other groups have their members relatively close together.

5.6.4a Results using the coefficient of Jaccard and all attributes.



5.6.4b Commentary.

The green graves appear mostly at the top end of the ordering. The light blue appear among them. Next come the darker blue and purple grave groups in the centre of the sequence with most of the later graves at the lower end. The latest graves appear at the top end of the ordering.

The majority of the groups are found with their members very close together in the ordering. Groups 1 and 10 show the greatest amount of dispersion.

5.6.5 Results using the Euclidean distance coefficient and ceramic attributes.

These results were exactly the same as those produced using the simple matching coefficient and ceramic attributes.

5.6.6 Results using the simple matching coefficient and all attributes.

These results were exactly the same as those produced using the simple matching coefficient and all attributes.

5.7 Results of Contextual Analysis.

5.7.1a Results using the simple matching coefficient and ceramic attributes.

67 - 134 - 125D - 68 - 56 - 111 - 66 - 132 - 30 - 125E - 107 - 101A - 90 - 125C - 93 - 96 - 88 - 34 - 144 - 21 - 1 - 138 - 55 - 125B - 92 - 101B - 75 - 125A - 103 - 145 - 60 - 114B - 22A - 52 - 104 - 89 - 87 - 13 - 108 - 6 - 61 - 2 - 59 - 33 - 123 - 114A - 141 - 99 - 95 - 115 - 57 - 131 - 97 - 121 - 91 - 139 - 76 - 14 - 4 - 22 - 5 - 110 - 36 - 3 - 85 - 120 - 40 - 133 - 86 - 130 - 113 - 126 - 112 - 127 - 135 - 50 - 82 - 102 - 51 - 26 - 12 - 49 - 46 - 80 - 31 - 18

5.7.1b Commentary.

The earlier graves are scattered from the top end of the ordering almost to the bottom. Among them are mixed virtually all of the latest graves. The purple groups are concentrated mainly at the bottom end of the ordering along with most of the darker blue graves. The light blue group is spread from one end of the list to the other.

Most of the individual colour groups are spread out over large parts of the list. The exceptions are groups 8, 13 and 19. Group 13 is together below the centre of the list while the other two are fairly well concentrated at the two ends.

5.7.2a Results using the simple matching coefficient and all attributes.

67 - 134 - 68 - 111 - 66 - 132 - 101A - 93 - 90 - 125D - 56 - 88 - 144 - 21 - 107 - 1 - 92 - 125C - 125E - 125B -

125A - 96 - 30 - 103 - 75 - 114B - 101B - 87 - 138 - 55 -
89 - 34 - 22A - 61 - 13 - 6 - 59 - 33 - 60 - 141 - 95 -
108 - 123 - 145 - 52 - 2 - 99 - 97 - 114A - 115 - 104 -
91 - 4 - 14 - 76 - 121 - 131 - 57 - 22 - 139 - 36 - 3 -
85 - 5 - 110 - 120 - 133 - 86 - 113 - 40 - 135 - 126 -
130 - 102 - 127 - 82 - 112 - 12 - 50 - 46 - 26 - 51 -
80 - 49 - 18 - 31

5.7.2b Commentary.

The green grave groups are spread out over much of the ordering. Among them appear many of the later groups as well, but some of these later graves appear closer to the bottom end. Purple graves are confined mainly to the lower end of the list, with a couple near the centre and even one above. The blue graves are fairly well distributed throughout the ordering.

Only groups 13 and 19 are moderately well defined in the list. Most of the others are widely spread out.

5.7.3a Results using the coefficient of Jaccard and ceramic attributes.

91 - 14 - 12 - 141 - 97 - 99 - 86 - 87 - 49 - 89 - 95 -
51 - 50 - 125B - 4 - 127 - 46 - 101B - 18 - 125A - 31 -
126 - 82 - 80 - 26 - 115 - 102 - 40 - 92 - 112 - 96 -
145 - 135 - 113 - 130 - 125E - 85 - 110 - 13 - 5 - 125C -
101A - 120 - 21 - 22A - 2 - 93 - 36 - 125D - 103 - 3 -
104 - 133 - 132 - 22 - 75 - 121 - 6 - 131 - 88 - 90 - 61 -
76 - 1 - 57 - 114B - 144 - 114A - 67 - 66 - 139 - 111 -
108 - 134 - 56 - 68 - 138 - 52 - 107 - 60 - 123 - 33 -
55 - 30 - 34 - 59.

5.7.3b Commentary.

The earlier two green groups are found on the lower side of the centre of the ordering with the later two mainly concentrated at the top end. Two members of group three do appear at and below the centre. The blue groups occur with the green ones at the top end of the list and spread down past the centre. Purple groups appear to be spread over most of the list with the lighter group mostly confined to the top part. The later graves are all found towards the bottom end of the ordering.

Groups 2, 12, 16 and 17 appear with their members fairly close together in the list. The other groups are spread over large distances.

5.7.4a Results using the coefficient of Jaccard and all attributes.

12 - 49 - 127 - 51 - 46 - 82 - 50 - 18 - 80 - 26 - 31 - 102 - 135 - 113 - 130 - 112 - 120 - 97 - 126 - 133 - 14 - 91 - 4 - 86 - 95 - 40 - 141 - 85 - 3 - 87 - 110 - 99 - 22 - 89 - 36 - 5 - 115 - 76 - 92 - 61 - 121 - 22A - 2 - 101B - 131 - 125A - 145 - 125B - 13 - 96 - 104 - 103 - 75 - 93 - 6 - 114B - 139 - 123 - 108 - 114A - 57 - 52 - 1 - 125C - 21 - 144 - 88 - 101A - 132 - 125E - 33 - 90 - 138 - 59 - 111 - 60 - 125D - 107 - 30 - 34 - 55 - 66 - 134 - 56 - 67 - 68

5.7.4b Commentary.

The green groups of graves are spread with the earlier two groups below the centre of the list and the later two above. The lighter blue group is spread out, but the darker blue groups are found in the upper part of the list for the most part. Most of the light purple graves are found in the top part of the list while the darker ones are more scattered. The majority of the later graves appear at the lower end, with a few near the centre and one above it.

Groups 16 and 19 are the only ones which are well defined in this list. None of the groups is found with all its members together.

5.7.5a Results using the Euclidean distance coefficient and ceramic attributes.

67 - 134 - 125D - 68 - 125E - 56 - 111 - 90 - 93 - 66 - 125C - 101A - 107 - 88 - 132 - 96 - 30 - 144 - 21 - 125B - 1 - 138 - 34 - 55 - 92 - 125A - 75 - 103 - 145 - 101B - 87 - 89 - 104 - 22A - 60 - 114B - 52 - 2 - 6 - 108 - 61 - 13 - 59 - 141 - 123 - 114A - 33 - 95 - 99 - 97 - 115 - 57 - 131 - 91 - 14 - 121 - 139 - 4 - 76 - 22 - 5 - 110 - 36 - 85 - 3 - 120 - 40 - 86 - 133 - 130 - 113 - 126 - 112 - 135 - 127 - 50 - 82 - 102 - 26 - 51 - 49 - 12 - 46 - 31 - 18 - 80

5.7.5b Commentary.

The green graves are spread over much of the list from below the centre to the top end. Among them are found all the later graves spread over the same area. The blue graves are found mostly at the bottom end of the list with some of the lighter ones spread towards the top. The light purple graves are all found at the lower end, but the darker ones spread from the bottom end to above the centre.

Groups 8 and 13 are the only ones which are moderately well defined in this ordering.

5.7.6a Results using the Euclidean distance coefficient and all attributes.

67 - 134 - 68 - 111 - 90 - 93 - 101A - 66 - 132 - 88 - 144 - 56 - 125D - 21 - 1 - 125B - 125E - 92 - 107 - 125A - 103 - 125C - 96 - 22A - 87 - 75 - 30 - 89 - 114B - 55 - 138 - 61 - 101B - 6 - 59 - 13 - 141 - 34 - 52 - 60 - 95 - 108 - 33 - 2 - 123 - 97 - 104 - 115 - 145 - 99 - 114A - 91 - 14 - 4 - 76 - 121 - 131 - 22 - 57 - 139 - 85 - 3 - 36 - 5 - 110 - 120 - 133 - 86 - 113 - 40 - 135 - 126 - 130 - 102 - 127 - 112 - 82 - 50 - 12 - 26 - 46 - 51 - 80 - 49 - 18 - 31

5.7.6b Commentary.

The green grave groups are found spread through the upper part of the list, with most of the later graves and some of the blue graves mixed among them. The lower section consists of the purple grave groups with most of the blue graves among them. The later graves are found spread from just below the centre of the list to the upper end.

None of the groups in this ordering is particularly well defined. Group 13 is the most compact, but there are four other graves between the two members of this group.

5.8 Results of the method of Brainerd and Robinson.

5.8.1a Results using the simple matching coefficient and ceramic attributes.

126 - 102 - 86 - 50 - 40 - 112 - 5 - 6 - 22 - 3 - 36 - 115 - 138 - 66 - 57 - 59 - 114A - 85 - 110 - 127 - 12 - 46 - 80 - 18 - 82 - 26 - 113 - 120 - 130 - 133 - 135 - 31 - 49 - 51 - 4 - 99 - 13 - 141 - 97 - 95 - 91 - 89 - 14 - 145 - 125A - 125B - 101B - 114B - 108 - 123 - 139 - 76 - 55 - 56 - 52 - 60 - 107 - 90 - 21 - 88 - 93 - 96 - 111 - 125C - 125D - 132 - 103 - 92 - 1 - 144 - 134 - 131 - 125E - 121 - 104 - 101A - 87 - 75 - 68 - 67 - 22A - 2 - 61 - 30 - 34 - 33

5.8.1b Commentary.

The earliest grave groups are spread throughout most of the ordering with a concentration just above the centre. The light blue graves are found in most parts of the sequence, but the darker blue and purple groups are mostly confined to the upper half. Most of the later graves appear in the centre with a few towards the ends.

In this ordering most of the groups are widely spread. Groups 1, 13 and 17 are the only ones which are found with their members close together in the list.

5.8.2a Results using the simple matching coefficient and all attributes.

92 - 99 - 97 - 91 - 4 - 14 - 13 - 125E - 125A - 125B - 95 - 87 - 141 - 89 - 66 - 68 - 67 - 88 - 90 - 93 - 101A -

111 - 134 - 1 - 103 - 21 - 22A - 144 - 56 - 107 - 138 - 108 - 145 - 125C - 125D - 30 - 114A - 55 - 52 - 59 - 60 - 57 - 34 - 115 - 101B - 96 - 132 - 104 - 61 - 22 - 2 - 6 - 75 - 76 - 121 - 3 - 120 - 85 - 127 - 12 - 26 - 18 - 31 - 46 - 80 - 82 - 130 - 102 - 5 - 33 - 114B - 123 - 139 - 50 - 51 - 49 - 135 - 113 - 133 - 36 - 131 - 110 - 40 - 126 - 86 - 112.

5.8.2b Commentary.

The green groups of graves are confined mainly to the upper part of the ordering with the majority of the light blue graves among them. The rest of the light blue graves along with the darker blue and purple ones are found in the bottom half of the list. The later graves appear mostly at or above the centre with just a few occurring below.

Most of the groups of graves are spread over considerable portions of this ordering. The exceptions are groups 1, 12 and 19.

5.8.3a Results using the coefficient of Jaccard and ceramic attributes.

132 - 21 - 90 - 88 - 22A - 61 - 22 - 5 - 92 - 103 - 104 - 1 - 107 - 138 - 111 - 55 - 56 - 6 - 75 - 115 - 125E - 96 - 86 - 110 - 145 - 125B - 125A - 89 - 87 - 141 - 4 - 99 - 97 - 95 - 91 - 14 - 13 - 101A - 125C - 101B - 125D - 93 - 114A - 144 - 114B - 76 - 108 - 123 - 139 - 134 - 66 - 68 - 67 - 34 - 30 - 33 - 52 - 59 - 60 - 26 - 31 - 18 - 46 - 49 - 50 - 51 - 80 - 126 - 40 - 2 - 36 - 57 - 131 - 121 -

3 - 135 - 120 - 133 - 130 - 82 - 127 - 12 - 113 - 112 - 102 - 85

5.8.3b Commentary.

Except for grave 134, all the green graves appear in the top half of the ordering. The light blue graves and some of the darker blue ones appear here as well. The rest of the dark blue graves appear with the majority of the purple graves in the bottom half of the list. The later graves are spread and appear in most parts of the sequence.

A few of the colour groups are found with their members fairly close together in this ordering. These are groups 13, 17 and 19. The rest are spread over large portions of the list.

5.8.4a Results using the coefficient of Jaccard and all attributes.

132 - 22A - 22 - 57 - 13 - 89 - 91 - 95 - 97 - 14 - 99 - 125B - 4 - 141 - 87 - 125A - 92 - 101B - 21 - 101A - 1 - 93 - 103 - 115 - 88 - 90 - 75 - 6 - 36 - 2 - 107 - 138 - 111 - 96 - 86 - 145 - 125C - 125E - 125D - 67 - 68 - 134 - 66 - 114B - 61 - 144 - 108 - 76 - 139 - 123 - 33 - 59 - 60 - 52 - 114A - 56 - 55 - 30 - 34 - 131 - 121 - 3 - 135 - 120 - 133 - 130 - 12 - 127 - 82 - 113 - 112 - 102 - 85 - 104 - 5 - 126 - 110 - 40 - 80 - 26 - 51 - 50 - 49 - 46 - 18 - 31

5.8.4b Commentary.

The green groups all occur in the upper half of the ordering. The light blue graves with a few of the darker ones are found among them. The darker blue graves and the majority of the purple graves appear in the bottom half of the list. Most of the later graves are found near the centre of the ordering but there are a few near the upper end.

The majority of the grave groups exhibit a lack of cohesiveness. The exceptions to this are groups 2, 13 and 19.

5.8.5 Results using the Euclidean distance coefficient and ceramic attributes.

These results were exactly the same as those produced using the simple matching coefficient and ceramic attributes.

5.8.6 Results using the Euclidean distance coefficient and all attributes.

These results were exactly the same as those produced using the simple matching coefficient and all attributes.

Chapter 6 - Discussion and Conclusions

6.1 Introduction.

Because seriation is a set of mathematical techniques, the results produced must be judged on the basis of the arrangements of the similarity and distance matrices relating the units as well as on the closeness with which the actual chronological ordering is approached.

A mathematical evaluation of the results can be obtained by arranging the similarity matrix in the order suggested by the ordering produced and calculating how closely this matrix approximates one in Robinson form. Two measures of closeness to Robinson form are used here. The number of decreases in similarity encountered as the main diagonal of the similarity matrix is approached both along the rows and columns can be counted. In a matrix which was arranged perfectly in Robinson form, there would be no such decreases. Another measure can be obtained by summing the amount of each decrease. Again, a matrix in Robinson form would show no decreases, so this total would be zero.

The colour groups distinguished in Chapter 5 can be used to design a coefficient which will show the spread of each group in the ordering. This will be called the clustering coefficient. Any group which extends over exactly as many spaces in the ordering as it has members should not contribute to this coefficient. In this way, only excess spread of the groups will be indicated. Thus for each group, the number of spaces it covers in the ordering is divided by the number of graves in the group. We then subtract 1.0 from this quotient.

The sum of these quotients over all the groups is taken to give the final value of the coefficient of clustering. In any sequence where the groups are all spread over the minimum possible space, the coefficient will be zero. Higher values will result when more spread is encountered.

In this chapter, all three of the measures discussed above will be given for the orderings for which they can be calculated. The results will be discussed and compared and, where possible, an interpretation will be presented. Finally, all the methods will be evaluated in the light of the results they produced.

6.2 Discussion of the results of the concentration principle.

Since the concentration principle does not make use of similarity or distance coefficients, only two sets of results were obtained by using it. These orderings are based on the two sets of attributes used to calculate each of the coefficents used with the other methods.

Neither of these two orderings approximates the chronological order of the graves with any degree of accuracy. As the clustering coefficients given in Table 6.2.1 indicate, the colour groups are so widely spread out that it would not be possible for the graves to appear in chronological order.

	Clustering coefficient
ceramic attributes	123.34
all attributes	124.00

Table 6.2.1: Values of clustering coeffieient for concentration principle.

The other two evaluation coefficients are obtained from the matrices of similarity and distance coefficients. In this case, these matrices were not used to obtain the orderings. The goal of this method is the clustering of the 1's in each column of the raw data matrix rather than the arrangement of the similarity matrix in Robinson form. To evaluate the method's degree of success in attaining this goal, the number of 1's in each column of the raw data matrix was counted and these numbers were totalled over all the columns in the matrix. For each ordering, the distance between the first and last 1 in each column of the rearranged raw data matrix was found and these distances were also totalled. A comparison of these numbers, which are given in Table 6.2.2, will indicate how well this clustering is done.

	Number of 1's	Distance between 1's
Ceramic attributes	1698	4842
All attributes	2005	6215

Table 6.2.2: Evaluation of clustering for concentration principle.

As the values in Table 6.2.2 show, the distance between 1's in the columns of the rearranged raw data matrix is roughly three times what it would be if the 1's were completely clustered. Part of this discrepancy is due to the fact that it is not possible to cluster the 1's in all the columns completely at the same time. In data matrices of the size used in this analysis, gaps in the 1's in at least some of the columns is inevitable.

Neither of the two orderings produced is better than the other. In both cases, there is some evidence of improvement over the order in which the graves were encountered by the program for the method. The green graves and the light blue ones which make up the earliest groups are found mixed with some of the later graves at one end of the ordering. The darker blue and purple graves are found at the opposite end and the majority of the later graves occur in the middle. This is a rather simplified description of the situation since some of the green graves occur among the later graves and at the bottom ends of the orderings and a few darker blue and purple graves appear near the top end. Some differentiation of very broad colour groups is achieved by this method, but no real indication of the chronological order is given.

6.3 Discussion of the results of Gelfand's first method.

None of the orderings produced by Gelfand's first method match the actual chronological sequence of the graves very closely. In the best cases, the tendency is towards the clustering together of graves of similar date, but even this is not consistently done. Some of the colour groups appear with all their members in one location in the ordering, others have a main cluster in one place with individual members of the group appearing elsewhere, and still other groups are spread from one end of the ordering to the other.

In the case using the simple matching coefficient with ceramic attributes, there is a considerable amount of mixing and there is no resemblance to the true chronological order. There is a tendency for the earlier graves to be found above the centre of the sequence, but the earliest are found among the later graves. Among the early groups are found graves from the blue groups, but some of these are also found at the bottom end of the ordering. The purple graves are found at the top and the bottom with only a few in the centre. The later graves are all just below the centre running towards the lower end, but the groups within the category are considerably mixed.

When all the attributes are used with S_{sm}, the clustering of the individual colour groups is better, but still not ideal. The earliest graves have been moved closer to the top end of the ordering, but with them have come the graves from the latest group. Many of the blue graves are mixed among the green, with the rest appearing at the bottom end of the sequence with the purple ones. The later graves again appear in the centre with a small number towards the lower end. Many of the graves have been moved considerably from their positions in the previous ordering, illustrating that the inclusion of the non-ceramic attributes, in this case, results in some small improvement of the ordering.

When using the coefficient of Jaccard with the ceramic attributes, the clustering is not as pronounced as previously. This time, the green grave groups appear near the centre of the ordering except for one near the top end and three near the bottom. Only one blue and one purple grave appear among the green ones. The blue and purple graves occur mostly near the bottom end with a few of these near the top. The later graves appear near the top but are split into two groups by the blue and purple ones. There is also one of the very earliest graves among them.

When the non-ceramic attributes are included, the results are more chaotic. The groups of graves are more widely spread. The two members of the earliest group appear at opposite ends of the sequence. The general tendency is for the green and light blue graves to appear near the top of the sequence followed by the darker blue and purple graves in the centre and the later graves near the bottom end. There is too much spread of the groups and mixing, though, for this to be considered a chronological sequence.

	Clustering coefficient	Number of increases	Total amount of increases
S_{sm} ceramic attributes	87.31	2959	113.543
S_{sm} all attributes	64.66	2956	94.119
S_j ceramic attributes	83.94	3094	150.668
S_j all attributes	113.54	3213	146.470

Table 6.3.1: Evaluation coefficients for Gelfand's first method.

The values of the three coefficients used to evaluate the results of Gelfand's first method given in Table 6.3.1 indicate that the use of the simple matching coefficient with all the attributes produces a slightly better ordering than the other combinations of attributes and coefficients. With respect to the arrangement of the similarity matrix, the results obtained using the simple matching coefficient are considerably better than those produced using the coefficient of Jaccard. The clustering coefficient shows a similar, although less marked, improvement.

The orderings produced with the Euclidean distance coefficient exactly duplicate those obtained using the simple matching coefficient. As mentioned above, the simple matching coefficient is linearly related to the squared Euclidean distance, and d is obtained from d^2 simply by taking the square root. This operation will not change the relative sizes of the coefficients. This means that if $d_1 < d_2$ then $\sqrt{d_1} < \sqrt{d_2}$. Since the coefficients are considered in order of size when using Gelfand's first method, the orderings produced with d and S_{sm} will be identical.

It must be concluded that none of the results of this method represent the true chronological order of the graves. From a mathematical point of view, the ordering produced using the simple matching coefficient with all the attributes is the best.

6.4 Discussion of Gelfand's second method.

The results of Gelfand's second method bear very little resemblance to the real chronological order of the graves. There is very little tendency towards the clustering of colour groups in the orderings produced.

When the simple matching coefficient is used, the results obtained using only the ceramic attributes are slightly better than those produced when all the attributes are taken into account. The green graves are spread from the top end of the sequence to below the centre. Mixed among them are the lighter blue graves. The darker blue and purple graves are mixed and extend from just above the centre to the bottom end. Grave 21 occurs near the top. The later graves are spread from the top end of the ordering to below the centre.

When all the attributes are used, the colour groups are more widely spread. The green, blue and purple graves appear virtually throughout the ordering. The later graves do occur above the centre, though most of them are confined to the lower half.

The results produced with the coefficient of Jaccard are slightly better than those discussed above. Both show the green graves towards the top end, but they are spread over a greater area when only the ceramic attributes are used. In both cases, the light blue graves are mixed with the green ones and when all the attributes are used, they continue below the green graves. The darker blue graves are spread over much of both the orderings. In both cases the purple graves are spread over the lower two thirds of the sequence as are the later graves. In the case where all the attributes are used, the latest group is found widely spread towards the top end. The ordering obtained using S_j with all the attributes seems to be the better of the two.

Since the orderings produced by Gelfand's second method depend only on the magnitude of the values of the similarity and distance coefficients used, it is not surprising to find that the results using the Euclidean distance coefficient are identical to those obtained using the simple matching coefficient.

The inclusion of the non-ceramic attributes resulted in radical changes in the orderings produced using both coefficients. In the case of S_{sm}, these attributes caused the ordering to deteriorate while the opposite is true of S_j. This is due to the nature of the two coefficients. The objects which did not possess very many of the non-ceramic attributes would appear very similar if S_{sm} were used. This is not true of S_j.

	Clustering coefficient	Number of increases	Total amount of increases
S_{sm} ceramic attributes	99.00	3016	164.268
S_{sm} all attributes	125.20	3334	252.088
S_j ceramic attributes	109.12	3444	342.222
S_j all attributes	88.09	3377	319.823

Table 6.4.1: Values of evaluation coefficients for Gelfand's second method.

The values of the three evaluation coefficients for the results obtained using Gelfand's second method are given in Table 6.4.1. Even though the ordering obtained when calculating S_{sm} on the ceramic attributes gives the similarity matrix most closely approximating Robinson form, it is not the best candidate for a chronological sequence. Visual inspection and the clustering coefficient reveal that the best ordering is the one obtained using the coefficient of Jaccard and all the attributes. Even here, however, the sequence is far from being ideal.

6.5 Discussion of the results of double link analysis.

The arrangements of graves produced using the simple matching coefficient with double link analysis do not approximate linear orderings. A number of loops could not be broken in these cases due to the presence of the lowest similarity on more than one link.

	Clustering coefficient
S_{sm} ceramic attributes	20.13
S_{sm} all attributes	18.31
S_j ceramic attributes	17.63
S_j all attributes	21.62

Table 6.5.1: Values of the clustering coefficient for results of the double link analysis.

The clustering coefficients for these two sets of results given in Table 6.5.1 show that the groups are more cohesive when all the attributes are considered. This is due to the greater number of unbroken loops which reduces the distance between group members. Only the clustering coefficients were calculated for the results discussed in this section. The other two coefficients can only be obtained if the units are arranged in a purely linear ordering. Forcing such an ordering on these results would defeat the purpose of this type of analysis.

Little useful information about the relative chronology of the graves can be obtained from the two arrangements produced using S_{sm}. This is because no endpoints for the ordering are obvious in the results. Also, the large number of unbroken loops conceals the actual sequence.

Orderings which are more linear result from the use of the coefficient of Jaccard. This is because in calculating the coefficient, the denominator of the ratio is variable and depends on the number of attributes possessed by both objects. This results in a greater variety of values for the coefficient and fewer ties in the similarity matrix. For the simple matching coefficient, the denominator is fixed and more ties result.

When the coefficient of Jaccard is used, the number of unbroken loops is generally reduced. The fact that the clustering coefficient calculated on the results obtained using the ceramic attributes only is smaller than either of the two discussed above is partly due to the fact that, usually, the members of any colour group are spread over a small area. This coefficient is larger when all the attributes are used. Visual inspection reveals that several groups are spread over larger areas than in the previous ordering. Also, the presence of only one small unbroken loop would tend to increase distances between group members, as this results in fewer paths connecting the two ends of the ordering.

In both cases, the latest group consisting of graves 66, 67 and 68 appears at the top end of the ordering closely linked to grave 134 of the earliest group. An examination of the contents of these four graves reveals that they all contain a limited variety of pot shapes which are decorated simply or not at all. For this reason the graves from the latest group are more similar to group 1 than to any other. The graves from the earliest group are split. When only the ceramic attributes are used grave 1 is connected to grave 134 through five later graves. It shares many pot shapes and decorative motifs with grave 104 and is linked to it in this arrangement. When all the attributes are considered, grave 1 has moved closer to the other green graves, but grave 104 has come with it.

The next group to appear in the ceramic ordering is number 2 which is completely linked together. When all the attributes are considered, this group is split and two of its members, numbers 88 and 90, appear on a side branch. Graves 6 and 75 contain metal objects and so does number 87 which is one of the graves between the two parts of this group. Graves 141 and 13 also appear on the branch with 88 and 90. Graves 141, 88 and 90 contained no metal. Number 13 did, but not the same types of objects as 6 and 75.

The remaining graves from groups 3 and 4, with the exception of number 132, are closely linked to number 141. Graves 96, 99, 101A, 101B and 115 from group 5 are found at the outer ends of the branches radiating from number 141. Grave 21 from group 10 is also found here linked to 125B. This is due to the fact that these two graves share a number of decorative motifs.

When only the ceramic attributes are used, the graves from groups 3 and 4 follow group 2. Among them are found the majority of graves from group 5 and, at the ends of side branches, even numbers 93 and 103 from group 6. Grave 21 is also attached to number 125B in this arrangement for the reason given above. Grave 115 from group 5 appears at the end of a chain which branches off a little further down the ordering. This is because it shares a number of the ceramic attributes with grave 40 from group 6. When the non-ceramic attributes are included, graves 86, 125C, 125D, 125E and 145 form part of a side branch which is separated from the remainder of group 5 by graves from group 6. The remaining group 6 graves, numbers 93 and 103, appear next to the earlier graves. These two do not contain any figurines. Grave 132 also appears with the group 5 graves which contained the figurines, even though it did not. Its position here is due to the similarity in the ceramic attributes. This can also be seen in the arrangement produced when only the ceramic attributes are used.

In the ceramic ordering, most of the graves from group 6 are found after the mixture of green and light blue graves. Number 126 appears among them because it shares many ceramic attributes with them. These graves are followed by those from group 8 which are completely together. From these radiate the graves from the surrounding groups. One chain of graves is connected through grave 120, but there is another link through grave 55 to the bottom end of the ordering.

The inclusion of the non-ceramic attributes tends to mix graves from group 8 more with those from groups 9 and 10, but the configuration is similar to that produced using only the ceramic attributes.

The later graves appear at the bottom end in both cases. There is a small amount of mixing, but the groups are fairly cohesive. As there is not much difference in the dates of these graves, and they all share a number of the same attributes, a certain amount of mixing is to be expected.

The results obtained using the coefficient of Jaccard are better than those produced using the simple matching coefficient with respect to obtaining a chronological placement of the graves. The inclusion of the non-ceramic attributes did not radically change the results obtained when either coefficient was used. The better sets of results do give orderings which approximate the true chronological sequence quite closely.

The orderings obtained using this method depend only on the relative sizes of the similarity coefficients, so it is not surprising that identical orderings resulted from the use of the simple matching coefficient and the Euclidean distance coefficient.

6.6 Discussion of the results of the descending coefficient method.

The use of the simple matching coefficient resulted in the formation of several loops in the diagram produced by the descending coefficient method. Most of these were eliminated when the coefficient of Jaccard was used because the similarities it produced were more varied.

	Clustering coefficient
S_{sm} ceramic attributes	20.76
S_{sm} all attributes	18.13
S_j ceramic attributes	20.87
S_j all attributes	17.79

Table 6.6.1: Values of clustering coefficient for the results of the descending coefficient method.

The values of the clustering coefficient shown in Table 6.6.1 indicate a slight improvement for both similarity coefficients when all the attributes are used.

Since the values of the similarity coefficients are considered in decreasing order of size in producing these arrangements of the graves, the Euclidean distance coefficients gave results identical to those produced using the simple matching coefficient.

The use of the simple matching coefficient produced two arrangements which are far from being chronological. In both cases, there is a central cluster of graves made up of the earliest and latest, and the other graves or branches which radiate from it. These branches are usually made up of graves of similar date. The loops in the diagram tend to relax this structure. As can be seen in the low values of the clustering coefficient, the colour groups are closely linked in these arrangements.

The two orderings produced using the coefficient of Jaccard appear to be quite different at first glance. When using only the ceramic attributes the graves from the latest group along with four of the very earliest graves appear at the same end of the ordering as the graves from groups 12 to 18. The graves from the other green groups along with the light blue graves appear at the opposite end with the darker blue and purple graves in the centre. With the exception of graves 1, 134, 6, and 75 this ordering is close to being chronological. The various colour groups are linked fairly well together.

The ordering produced using all the attributes is very similar to that obtained by using the double link method on the same data. This is also very close to being a chronological ordering.

Of the four sets of results produced using the descending coefficient method the last is the most satisfactory in giving a chronological ordering. The low value of the clustering coefficient shows that the colour groups are very closely linked. The other sets of results show a greater deviation from the real chronological order.

6.7 Discussion of the results of contextual analysis.

The orderings produced using the simple matching coefficient and contextual analysis are not chronological. In both cases, most of the colour groups are widely spread out. As the three evaluation coefficients shown in Table 6.7.1 demonstrate, a slight improvement results from the inclusion of the non-ceramic attributes. The colour groups are more cohesive and the arrangement of the similarity matrix is slightly closer to Robinson form. Even so, little chronological information can be obtained from this sequence.

	Clustering coefficient	Number of increases	Total amount of increases
S_{sm} ceramic attributes	108.59	3162	142.438
S_{sm} all attributes	99.60	3152	124.842
S_j ceramic attributes	64.30	3470	379.178
S_j all attributes	87.21	3414	273.060
d ceramic attributes	112.68	3137	1485.021
d all attributes	102.18	3254	1647.451

Table 6.7.1: Values of the evaluation coefficients for the results of contextual analysis.

Using the coefficient of Jaccard with only the ceramic attributes gives an ordering in which the colour groupings are more cohesive in some cases, but the deviation of the similarity matrix from Robinson form is increased. The inclusion of the non-ceramic attributes increases the spread of the colour groups but slightly improves the arrangement of the similarity matrix. When using the ceramic attributes, the later graves are found together at one end of the ordering, but the other groups are more widely spread and there is a considerable amount of mixing of their members. Thus, little information which would help in establishing a chronological sequence for the graves can be obtained from this ordering.

The Euclidean distance coefficient, when used with contextual analysis, produces results which are slightly different from those given by the simple matching coefficient. This is because the orderings are produced by considering average similarities rather than the magnitudes of individual similarities. The non-linear relationship between the simple matching coefficient and the Euclidean distance coefficient reduces large distances by a much greater proportion than small distances. The effect of this is to alter the order of the average similarities calculated during contextual analysis and change the final ordering produced. In this case, the changes are slight.

As is shown by the evaluation coefficients in Table 6.7.1, the colour groups are slightly more spread in the orderings obtained using the Euclidean distance coefficient than in the corresponding ones produced using the simple matching coefficient. The arrangement of the similarity matrix is slightly worse.

The use of contextual analysis gives orderings of little value in obtaining a chronological sequence. The best results were produced using the coefficient of Jaccard on the ceramic attributes, but even these were far from ideal.

6.8 Discussion of the results of the method of Brainerd and Robinson.

The four sets of results produced using the method of Brainerd and Robinson all show a large amount of deviation from the true chronological order of the graves. The evaluation coefficients given in Table 6.8.1 show that the inclusion of the non-ceramic attributes improves the clustering of the colour groups and the arrangement of the similarity matrices for both coefficients.

	Clustering coefficients	Number of increases	Total amount of increases
S_{sm} ceramic attributes	144.09	3254	146.827
S_{sm} all attributes	94.72	3080	123.815
S_j ceramic attributes	102.56	3342	202.435
S_j all attributes	86.93	3260	181.884

Table 6.8.1: Values of the evaluation coefficients for the results of the method of Brainerd and Robinson.

When using the simple matching coefficient with ceramic attributes there is a considerable spread of the colour groups. Several of the groups are found with their members in all parts of the sequence. The inclusion of the non-ceramic attributes does result in some improvement as stated above, but there is still a great deal of spread which can easily be seen. The arrangement of the similarity matrix is closer to Robinson form when all the attributes are used, but is still far from being ideal.

When the coefficient of Jaccard is used with the ceramic attributes, the results tend to be better. There is not as much spread in many of the colour groups as there was in the corresponding ordering produced with S_{sm}. The evaluation coefficients show that despite this, the arrangement of the similarity matrix deviates even further from Robinson form than before. The inclusion of the non-ceramic attributes results in a definite improvement, but not in a chronological ordering.

The method of Brainerd and Robinson arranges the similarity coefficients in order of their size, so the results produced using the Euclidean distance coefficient are the same as those obtained using the simple matching coefficient.

6.9 Conclusions.

In the orderings produced by all the seriation methods used in this analysis, several similarities in grave positions are evident.

The Hellenistic graves from group 19, numbers 66, 67 and 68, virtually always appear close to much earlier graves, and often with those from the first two groups which predate them by at least five hundred years. The attribute distributions for these graves are quite similar as they have decorative motifs and pot shapes in common. These include bands, jugs and bowls. This is the reason for their proximity in most of the orderings obtained.

The graves from group 10 which date to the early fifth cent. BC are widely dispersed in all the orderings produced. The distributions of the attribute scores for these graves vary considerably, even though they are all of similar date. This is especially true of the attributes describing pot shapes and decorative motifs. These differences cause these graves to appear to be more similar to graves from other groups than they are to each other, and they are spread through most of the orderings.

There can be little doubt that the results produced using the coefficient of Jaccard with the descending coefficient method and double link analysis were much closer to the true chronological sequence of the graves than any of the others. Several differences in approach exist between these two methods and the others used in this analysis. The most noticeable of these is that these two particular methods do not force the units into a purely linear ordering, while all the other methods do. Secondly, double link analysis and the descending coefficient method make use of only the higher values in the similarity matrix in establishing the order. With one exception, the other methods take all the coefficients in the similarity matrix into consideration in attempting to arrange it in Robinson form. The exception is Gelfand's first method.

For comparative purposes, the three evaluation coefficients used earlier in this chapter have been calculated for the graves in the order suggested by Sparkes (1967, pp. 128-130). These are presented in Table 6.9.1. It is obvious that this arrangement of the graves does not produce a similarity matrix in Robinson form. The clustering coefficients are all 0 because the colour groupings were obtained from this ordering of the graves. The other coefficients indicate that these arrangements of the similarity matrices are further from

Robinson form than those produced by many of the seriation methods employed. Thus, a method which operates on the assumption that something closely approximating the correct chronological sequence of the units will be obtained by arranging the similarity matrix in Robinson form will not produce the desired results when used on this data. However, a sequence approaching the chronological one is obviously obtainable from the data as the results of the two methods mentioned above indicate.

	Clustering coefficient	Number of increases	Total amount of increases
S_{sm} ceramic attributes	0	3298	213.866
S_{sm} all attributes	0	3404	201.203
S_j ceramic attributes	0	3213	243.311
S_j all attributes	0	3239	220.993
d ceramic attributes	0	3298	2117.841
d all attributes	0	3404	2329.140

Table 6.9.1: Evaluation coefficients calculated using the ordering suggested by Sparkes.

Of the methods in this study, only three, the descending coefficient method, double link analysis and Gelfand's first method, do not make use of all the values in the similarity matrix. Gelfand's first method restricts the final form of the ordering to a strictly linear arrangement, so the results it produces are not satisfactory. The other two methods, when used with the coefficient of Jaccard, give results which would aid in the dating of the graves by an archaeologist.

When using binary attributes, the simple matching coefficient and the Euclidean distance coefficient produced identical results in all except the case where contextual analysis was used. The reasons for this have been given above (sections 6.3 and 6.7) and result from the relationship between these two coefficients. The coefficient of Jaccard gave better results than the simple matching coefficient from the point of view of the clustering of the colour groups, but differences in similarity between units tended to be greater with this coefficient than with S_{sm}, so the similarity matrix was usually further from being in Robinson form as indicated by the total amount of increases. In this case, this is not an undesirable situation.

The inclusion of the non-ceramic attributes usually produced no significant improvement in the orderings obtained. The results were usually close to, or slightly worse than those produced using only the ceramic attributes. This indicates that the dating of deposits on the basis of pottery alone is a practice which can work.

For the graves used in this analysis, scored on the attributes listed in section 2.2 and compared using the similarity coefficients discussed in chapter 3, good results were obtained using the descending method and double link analysis. The orderings obtained using the other methods could possibly be improved by the first-hand examination of the material, but it can be seen that useful results can be produced using only the data available in the publications. It has been found that the arrangement of the similarity matrix in Robinson form, where possible, will not always produce the desired chronological sequence of units. This might also change after a detailed examination of the material from the graves.

Much work remains to be done in research on seriation. The comparison of methods, coefficients and attribute sets should be expanded and continued on other data sets. Also, comparisons with the results of other ordering techniques such as multidimensional scaling should be undertaken. It is only after a seriation method has been used on many data sets that its value in establishing a chronological order can be determined.

The results of this study appear to indicate that there is a place in archaeological research for at least some of the seriation methods used above, but that they must be refined further before they can be used independently.

Appendix - The Computer Programs

A.1 Introduction.

All the computer programs for the seriation methods described in Chapter 4 are listed in this Appendix. The programs were run on the MUSIC System (McGill University System for Interactive Computing) at McGill. This system presently runs on McGill's Amdahl V7, although until recently it ran on an IBM 370/158.

Most of the programs used were written in FORTRAN IV with the remainder being in ALGOL W. At the time when the programs were written, the ALGOL W compiler on MUSIC could not accomodate programs requiring large amounts of computer memory. MUSIC has since been altered so that this problem has been eliminated. This is the reason for the use of the two languages.

A.2 The program for the concentration principle.

```
/SYS REG=200
/LOAD FORTG1
          DIMENSION GR(86),K1(86),K2(86)
          INTEGER*2 IPT(86,132)
          LOGICAL IN(86,132)
C   INITIALIZE AND READ IN DATA
          READ5,M,N
5         FORMAT(2I3)
C   M=NUMBER OF UNITS
C   N=NUMBER OF ATTRIBUTES
          DO 15 I=1,M
          READ10,GR(I),(IPT(I,J),J=1,N)
10        FORMAT(A4,58I1,/,74I1)
          DO 14 K=1,N
          IF(IPT(I,K).EQ.1)GO TO 13
          IN(I,K)=.FALSE.
          GO TO 14
13        IN(I,K)=.TRUE.
14        CONTINUE
          K1(I)=I
          K2(I)=I
15        CONTINUE
C   K1 AND K2 CONTAIN ORDER OF UNITS
C   CALCULATE ISD=SUM OF DISTANCE BETWEEN FIRST AND
C   LAST 1 IN EACH ROW OF N
          ISD=0
          DO 35 I=1,N
          DO 30 J=1,M
          IF(.NOT.IN(J,I))GO TO 30
          L1=J
          K=M
20        IF(IN(K,I))GO TO 25
```

```
      K=K-1
      GO TO 20
   25 L2=K
      ISD=ISD+L2-L1
      GO TO 35
   30 CONTINUE
   35 CONTINUE
C  PRINT SUMMED DISTANCE
      PRINT40,ISD
   40 FORMAT('0','ORIGINAL DISTANCE= ',I10)
C  PERFORM ORDERING
C  FIND FIRST 1 IN ROW
      IC1=ISD
   45 DO 100 I=1,N
      DO 50 J=1,M
      IF(.NOT.IN(K1(J),I))GO TO 50
      L1=J
      GO TO 51
   50 CONTINUE
   51 L6=L1+1
C  FIND NEXT 1 IN ROW
      IT=L6
      L2=100
      DO 55 J=IT,M
      IF(.NOT.IN(K1(J),I))GO TO 55
      L2=J
      GO TO 56
   55 CONTINUE
      IF(L2.EQ.100)GO TO 68
   56 NO=L2-L1
      IF(NO.GT.1)GO TO 60
      L1=L1+1
      IF(L1.GE.M)GO TO 68
      GO TO 51
   60 KT=K1(L2)
      L6=L2
   61 K1(L2)=K1(L2-1)
      IF(L2-2.EQ.L1)GO TO 65
      L2=L2-1
      GO TO 61
   65 K1(L2-1)=KT
      L1=L1+1
      IF(L6.LT.M)GO TO 51
C  CALCULATE IC2=SUM OF DISTANCES
   68 IC2=0
      DO 85 I2=1,N
      DO 80 J2=1,M
      IF(.NOT.IN(K1(J2),I2))GO TO 80
      L3=J2
      K=M
   70 IF(IN(K1(K),I2))GO TO 75
      K=K-1
      GO TO 70
   75 L4=K
      IC2=IC2+L4-L3
      GO TO 85
   80 CONTINUE
   85 CONTINUE
C  COMPARE IC1 AND IC2
      IF(IC2.GT.IC1)GO TO 90
```

```
      K2(J2)=K1(J2)
90    CONTINUE
      GO TO 100
95    DO 96 J6=1,M
       K1(J6)=K2(J6)
96    CONTINUE
100   CONTINUE
C  COMPARE FINAL RESULT WITH LAST RESULT
      PRINT101,IC1
101   FORMAT('0','NEW DISTANCE= ',I10)
      IF(IC1.GE.ISD)GO TO 105
      ISD=IC1
      GO TO 45
C  PRINT FINAL ORDERING
105   DO 115 I=1,M
      PRINT110,GR(K2(I)),GR(K1(I))
110   FORMAT(' ',A4,5X,A4)
115   CONTINUE
      STOP
      END
```

A.3 The program for Gelfand's first method.

```
/LOAD FORTG1
C  DECLARATIONS
     DIMENSION GR(86),SIM(86,86),L1(86),L2(86),L3(86),L4(86),VAL(8
C  INITIALIZATIONS
     READ5,M
5    FORMAT(I3)
     DO 15 I=1,M
     READ10,GR(I),(SIM(I,J),J=1,M)
10   FORMAT(1X,A4,2X,12(F5.3,1X),8(/,5X,12(F5.3,1X)))
     L1(I)=0
     L2(I)=I
     L3(I)=0
     L4(I)=0
15   CONTINUE
     N=M-1
     K=0
     DO 20 I=1,M
     SIM(I,I)=0.0
20   CONTINUE
C  FIND HIGHEST VALUE IN SIM
25   XMAX=0.0
     DO 30 I=1,M
     DO 30 J=I,M
     IF(SIM(I,J).GT.XMAX)XMAX=SIM(I,J)
30   CONTINUE
     PRINT35,XMAX
35   FORMAT('OMAX. VALUE= ',F10.7)
     DO 75 I=1,M
     IF(L1(I).NE.2)GO TO 40
     DO 37 ML=I,M
     IF(SIM(I,ML).EQ.XMAX)SIM(I,ML)=0.0
37   CONTINUE
     GO TO 75
40   DO 70 J=I,M
     IF(SIM(I,J).NE.XMAX)GO TO 70
```

```
      IF((L1(J).EQ.2).OR.(L1(I).EQ.2))GO TO 60
      IF((L2(I).NE.I).AND.(L2(J).NE.J))GO TO 55
      IF(L1(I)+L1(J).NE.0)GO TO 45
      L1(I)=L1(I)+1
      L1(J)=L1(J)+1
      L2(I)=J
      L2(J)=I
      K=K+1
      L3(K)=I
      L4(K)=J
      VAL(K)=SIM(I,J)
      SIM(I,J)=0.0
      GO TO 70
45    IF(L1(I).EQ.0)GO TO 50
      L1(I)=L1(I)+1
      L1(J)=L1(J)+1
      L2(J)=L2(I)
      L2(L2(J))=J
      K=K+1
      L3(K)=I
      L4(K)=J
      VAL(K)=SIM(I,J)
      SIM(I,J)=0.0
      GO TO 70
50    L2(I)=L2(J)
      L2(L2(I))=I
      L1(I)=L1(I)+1
      L1(J)=L1(J)+1
      K=K+1
      L3(K)=I
      L4(K)=J
      VAL(K)=SIM(I,J)
      SIM(I,J)=0.0
      GO TO 70.
55    IF((L2(I).EQ.J).OR.(L2(J).EQ.I))GO TO 60
      L1(I)=L1(I)+1
      L1(J)=L1(J)+1
      MT=L2(I)
      L2(L2(I))=L2(J)
      L2(L2(J))=MT
      K=K+1
      L3(K)=I
      L4(K)=J
      VAL(K)=SIM(I,J)
      SIM(I,J)=0.0
      GO TO 70
60    PRINT65,GR(I),GR(J)
65    FORMAT(' ',2(A4,2X))
      SIM(I,J)=0.0
70    CONTINUE
75    CONTINUE
      IF(K.LT.N)GO TO 25
      DO 85 I=1,N
      PRINT80,GR(L3(I)),GR(L4(I)),VAL(I)
80    FORMAT(' ',A4,2X,A4,2X,F5.3)
85    CONTINUE
      STOP
      END
```

A.4 The program for Gelfand's second method.

```
/SYS REG=200
/LOAD FORTG1
      DIMENSION GR(86),SIM(86,86),IN(86,86),KT(86),NRD(86),
     *LIM(86),T(86),IS(86),KOUNT(86)
C   READ DATA
      READ5,M
5     FORMAT(I3)
      DO 15 I=1,M
      READ10,GR(I),(SIM(I,J),J=1,M)
10    FORMAT(1X,A4,2X,12(F5.3,1X),8(/,5X,12(F5.3,1X)))
15    CONTINUE
C   INITIALIZATION STAGE
      DO 25 I=1,M
      KT(I)=0
      KOUNT(I)=0
      LIM(I)=2
      IS(I)=I
      DO 20 J=1,M
      IN(I,J)=J
20    CONTINUE
25    CONTINUE
C   ARRANGE EACH ROW OF SIM IN DESCENDING ORDER
      DO 40 I=1,M
      JT=M-1
      DO 35 J=1,JT
      L=M-J
      DO 30 K=1,L
      IF(SIM(I,IN(I,K)).GE.SIM(I,IN(I,K+1)))GO TO 30
      IT=IN(I,K)
      IN(I,K)=IN(I,K+1)
      IN(I,K+1)=IT
30    CONTINUE
35    CONTINUE
40    CONTINUE
C   ARRANGE EACH ROW IN ROBINSON FORM
      DO 70 I=1,M
      DO 65 J=3,M
      KO=0
      X=SIM(IN(I,J),IN(I,1))-SIM(IN(I,J),IN(I,J-1))
45    IF(X.GT.0.0)GO TO 50
      IF(X.LT.0.0)GO TO 60
      KO=KO+1
      IF(KO.GT.J/2)GO TO 60
      X=SIM(IN(I,J),IN(I,1+KO))-SIM(IN(I,J),IN(I,J-KO-1))
      GO TO 45
50    IT=IN(I,J)
      LT=J
55    IN(I,LT)=IN(I,LT-1)
      LT=LT-1
      IF(LT.GT.1)GO TO 55
      IN(I,1)=IT
60    LIM(I)=LIM(I)+1
65    CONTINUE
70    CONTINUE
C   RESOLVE ANY TIES REMAINING IN EACH ROW
      DO 130 I=1,M
      DO 125 J=2,M
      IF(SIM(I,IN(I,J)).NE.SIM(I,IN(I,J-1)))GO TO 125
```

```
      L1=J-1
      L2=J
75    IF(SIM(I,IN(I,L2)).NE.SIM(I,IN(I,L2+1)))GO TO 80
      L2=L2+1
      GO TO 75
80    L3=L2+1
      LT=L3-L1
      LQ=0
      DO 85 K=1,LT
      NRD(K)=IN(I,L1+LQ)
      T(K)=SIM(I,IN(I,L1+LQ))
      LQ=LQ+1
85    CONTINUE
      IF(SIM(I,IN(I,L2)).GT.SIM(I,IN(I,L2+1)))GO TO 100
      DO 95 K=1,LT
      DO 90 L=2,LT
      IF(T(L).GE.T(L-1))GO TO 90
      TEMP=T(L)
      T(L)=T(L-1)
      T(L-1)=TEMP
      IT=NRD(L)
      NRD(L)=NRD(L-1)
      NRD(L-1)=IT
90    CONTINUE
95    CONTINUE
      GO TO 115
100   DO 110 K=1,LT
      DO 105 L=2,LT
      IF(T(L).LE.T(L-1))GO TO 105
      TEMP=T(L)
      T(L)=T(L-1)
      T(L-1)=TEMP
      IT=NRD(L)
      NRD(L)=NRD(L-1)
      NRD(L-1)=IT
105   CONTINUE
110   CONTINUE
115   LZ=0
      DO 120 K=L1,L2
      LZ=LZ+1
      IN(I,K)=NRD(LZ)
120   CONTINUE
125   CONTINUE
130   CONTINUE
C   ORIENTATE ROWS IN SAME DIRECTION
      N=M/2
      NO=N/2+1
      DO 155 I=1,M
      L=0
      DO 140 J=1,N
      DO 135 K=1,N
      IF(IN(I,J).NE.IN(I,K))GO TO 135
      L=L+1
      GO TO 140
135   CONTINUE
140   CONTINUE
      IF(L.GE.NO)GO TO 155
      DO 145 J=1,M
      NRD(J)=IN(I,J)
145   CONTINUE
```

```
      DO 150 J=1,M
      IN(I,J)=NRD(M-J+1)
150   CONTINUE
155   CONTINUE
C  SUM POSITIONS OF EACH UNIT IN EACH ROW
      DO 160 I=1,M
      DO 160 J=1,M
      KOUNT(IN(I,J))=KOUNT(IN(I,J))+J
160   CONTINUE
C  ORDER RESULTS
      N=M
      DO 170 I=1,M
      DO 165 J=2,N
      IF (KOUNT(J).GE.KOUNT(J-1))GO TO 165
      IT=KOUNT(J)
      KOUNT(J)=KOUNT(J-1)
      KOUNT(J-1)=IT
      IT=IS(J)
      IS(J)=IS(J-1)
      IS(J-1)=IT
165   CONTINUE
      N=N-1
170   CONTINUE
C  PRINT RESULTS
      DO 180 I=1,M
      PRINT175, GR(IS(I)),KOUNT(I)
175   FORMAT(' ',A4,1X,I5)
180   CONTINUE
      STOP
      END
```

A.5 The program for the double link method

```
/SYS REG=200
/LOAD WAT5
C  DIMENSION SUBSCRIPTED VARIABLES
      DIMENSION SIM(86,86),GR(86),LINK(86,86),L1(86),L2(86),L(
     *,XL(2,86)
C  READ IN DATA
      READ5,M
5     FORMAT(I3)
      DO 10 I=1,M
      READ15,GR(I),(SIM(I,J),J=1,M)
10    CONTINUE
15    FORMAT(1X,A4,2X,10(F6.3,1X),8(/,5X,10(F6.3,1X)))
C  INITIALIZATION OF ARRAYS
      DO 20 I=1,M
      L1(I)=0
      XL(1,I)=0.
      XL(2,I)=0.
      L2(I)=0
      L(I)=0
      SIM(I,I)=0.0
      DO 20 J=1,M
      LINK(I,J)=0
20    CONTINUE
C  FIND HIGHEST COEFFICIENT IN EACH ROW OF SIM
      DO 45 I=1,M
      AMAX=0.0
      BMAX=0.0
```

```
      DO 25 J=1,M
      IF(SIM(J,I).GT.AMAX)AMAX=SIM(J,I)
   25 CONTINUE
      XL(1,I)=AMAX
      K=0
      DO 30 J=1,M
      IF(SIM(J,I).EQ.AMAX)K=K+1
   30 CONTINUE
      IF(K.GE.2)GO TO 36
      DO 35 J=1,M
      IF((SIM(J,I).GT.BMAX).AND.(SIM(J,I).LT.AMAX))BMAX=SIM(J,
   35 CONTINUE
      XL(2,I)=BMAX
   36 DO 40 J=1,M
      IF((SIM(J,I).NE.AMAX).AND.(SIM(J,I).NE.BMAX))SIM(J,I)=0.
   40 CONTINUE
   45 CONTINUE
      DO 48 I=1,M
      PRINT46,GR(I)
   46 FORMAT(' ',A4)
      DO 48 J=1,M
      IF(SIM(J,I).EQ.0.0)GO TO 48
      PRINT47,GR(J),SIM(J,I)
   47 FORMAT(' ',A4,3X,F5.3)
   48 CONTINUE
C  FIND HIGHEST VALUE REMAINING IN SIM
   50 AMAX=0.0
      DO 55 I=1,2
      DO 55 J=I,M
      IF(XL(I,J).GT.AMAX)AMAX=XL(I,J)
   55 CONTINUE
C  RECORD ALL PERMISSIBLE DOUBLE LINKS
      DO 91 I=1,M
      IF((XL(1,I).NE.AMAX).AND.(XL(2,I).NE.AMAX))GO TO 91
      DO 90 J=1,M
      IF((SIM(I,J).NE.AMAX).OR.(SIM(J,I).NE.AMAX))GO TO 90
      IF(LINK(I,J).NE.0)GO TO 88
      LINK(I,J)=2
      LINK(J,I)=2
      L(I)=L(I)+1
      L(J)=L(J)+1
      SIM(I,J)=-SIM(I,J)
      SIM(J,I)=-SIM(J,I)
C  RECORD ALL INDIRECT CONNECTIONS RESULTING
      DO 65 K=1,M
      IF((LINK(I,K).EQ.0).AND.(LINK(J,K).EQ.0))GO TO 65
      IF((LINK(I,K).NE.0).AND.(LINK(J,K).NE.0))GO TO 65
      IF(LINK(I,K).EQ.0)GO TO 60
      LINK(J,K)=4
      LINK(K,J)=4
      SIM(K,J)=0.0
      SIM(J,K)=0.0
      GO TO 65
   60 LINK(I,K)=4
      LINK(K,I)=4
      SIM(I,K)=0.0
      SIM(K,I)=0.0
   65 CONTINUE
      KL=0
      KM=0
```

```
      DO 75 K=1,M
      IF(LINK(I,K).EQ.0)GO TO 70
      KL=KL+1
      L1(KL)=K
 70   IF(LINK(J,K).EQ.0)GO TO 75
      KM=KM+1
      L2(KM)=K
 75   CONTINUE
      DO 80 K1=1,KL
      DO 80 K2=K1,KL
      IF(LINK(L1(K1),L1(K2)).NE.0)GO TO 80
      LINK(L1(K1),L1(K2))=4
      LINK(L1(K2),L1(K1))=4
      SIM(L1(K1),L1(K2))=0.0
      SIM(L1(K2),L1(K1))=0.0
 80   CONTINUE
      DO 85 K1=1,KM
      DO 85 K2=K1,KM
      IF(LINK(L2(K1),L2(K2)).NE.0)GO TO 85
      LINK(L2(K1),L2(K2))=4
      LINK(L2(K2),L2(K1))=4
      SIM(L2(K1),L2(K2))=0.0
      SIM(L2(K2),L2(K1))=0.0
 85   CONTINUE
      GO TO 90
 88   SIM(I,J)=0.0
      SIM(J,I)=0.0
 90   CONTINUE
      IF(XL(1,I).EQ.AMAX)XL(1,I)=-XL(1,I)
      IF(XL(2,I).EQ.AMAX)XL(2,I)=-XL(2,I)
 91   CONTINUE
C  RECORD ALL SINGLE LINKS PERMITTED
      DO 131 I=1,M
      IF((XL(1,I).NE.-AMAX).AND.(XL(2,I).NE.-AMAX))GO TO 131
      DO 130 J=I,M
      IF((SIM(I,J).EQ.AMAX).OR.(SIM(J,I).EQ.AMAX))GO TO 95
      GO TO 130
 95   IF(LINK(I,J).NE.0)GO TO 128
      LINK(I,J)=1
      LINK(J,I)=1
      L(I)=L(I)+1
      L(J)=L(J)+1
      SIM(I,J)=-SIM(I,J)
      SIM(J,I)=-SIM(J,I)
C  RECORD ALL RESULTING INDIRECT CONNECTIONS
      DO 105 K=1,M
      IF((LINK(I,K).EQ.0).AND.(LINK(J,K).EQ.0))GO TO 105
      IF((LINK(I,K).NE.0).AND.(LINK(J,K).NE.0))GO TO 105
      IF(LINK(I,K).EQ.0)GO TO 100
      LINK(J,K)=4
      LINK(K,J)=4
      SIM(K,J)=0.0
      SIM(J,K)=0.0
      GO TO 105
 100  LINK(I,K)=4
      LINK(K,I)=4
      SIM(I,K)=0.0
      SIM(K,I)=0.0
 105  CONTINUE
      KL=0
```

```
           KM=0
           DO 115 K=1,M
           IF(LINK(I,K).EQ.0)GO TO 110
           KL=KL+1
           L1(KL)=K
     110   IF(LINK(J,K).EQ.0)GO TO 115
           KM=KM+1
           L2(KM)=K
     115   CONTINUE
           DO 120 K1=1,KL
           DO 120 K2=K1,KL
           IF(LINK(L1(K1),L1(K2)).NE.0)GO TO 120
           LINK(L1(K1),L1(K2))=4
           LINK(L1(K2),L1(K1))=4
           SIM(L1(K1),L1(K2))=0.0
           SIM(L1(K2),L1(K1))=0.0
     120   CONTINUE
           DO 125 K1=1,KM
           DO 125 K2=K1,KM
           IF(LINK(L2(K1),L2(K2)).NE.0)GO TO 125
           LINK(L2(K1),L2(K2))=4
           LINK(L2(K2),L2(K1))=4
           SIM(L2(K1),L2(K2))=0.0
           SIM(L2(K2),L2(K1))=0.0
     125   CONTINUE
           GO TO 130
     128   SIM(I,J)=0.0
           SIM(J,I)=0.0
     130   CONTINUE
     131   CONTINUE
           DO 135 I=1,M
           IF(L(I).EQ.0)GO TO 50
     135   CONTINUE
     C   PRINT LINKS FOR FINAL DIAGRAM
           DO 150 I=1,M
           PRINT140,GR(I)
     140   FORMAT('0',A4)
           DO 150 J=1,M
           IF(SIM(J,I).EQ.0.0)GO TO 150
           PRINT145,GR(J),-SIM(J,I)
     145   FORMAT(' ',A4,3X,F5.3)
     150   CONTINUE
           STOP
           END
```

A.6 The program for the descending coefficient method.

```
     /LOAD FORTG1
           DIMENSION GR(86),SIM(86,86),NO(86)
           READ3,M
     3     FORMAT(I3)
           DO 10 I=1,M
           NO(I)=0
           READ5,GR(I),(SIM(I,J),J=1,M)
     5     FORMAT(1X,A4,2X,12(F5.3,1X),8(/,4X,12(F5.3,1X)))
     10    CONTINUE
           DO 15 I=1,M
     15    SIM(I,I)=0.
           KON=M-1
     20    AMAX=0.
           DO 25 I=1,KON
```

```
      DO 25 J=I,M
      IF(SIM(I,J).LE.AMAX)GO TO 25
      AMAX=SIM(I,J)
      K1=I
      K2=J
25    CONTINUE
      PRINT30,GR(K1),GR(K2),AMAX
30    FORMAT(' ',A4,2X,'JOINS',2X,A4,2X,'AT',2X,F5.3)
      NO(K1)=NO(K1)+1
      NO(K2)=NO(K2)+1
      SIM(K1,K2)=0.
      DO 35 I=1,M
      IF(NO(I).LT.2)GO TO 20
35    CONTINUE
      STOP
      END
```

A.7 The program for contextual analysis.

```
/SYS REG=200
/INCLUDE ALGOLW
BEGIN
INTEGER I,M,A,B,FLAG,FLAG1,FLAG2; READON(M);
FLAG1:=0;FLAG2:=0;
BEGIN INTEGER C,D; REAL ARRAY AVGA,AVGB(1::M,1::2);
INTEGER ARRAY NO(1::M);
REAL ARRAY DIFF1,DIFF2(1::M);
REAL SUM,PHI;REAL ARRAY TEMP1,TEMP2(1::M); REAL MIN,MAX;
REAL ARRAY SIM(1::M,1::M); STRING(4) ARRAY GRAVE(1::M);
INTEGER ARRAY END1,END2(1::M); MIN:=1.0; C:=1;D:=1;
FOR I:=1 UNTIL M DO
BEGIN READON(GRAVE(I)); FOR J:=1 UNTIL M DO READON(SIM(I,J));
END;
FOR I:=1 UNTIL M DO BEGIN MAX:=0.;MIN:=1.0;
FOR J:=1 UNTIL I-1 DO BEGIN IF SIM(I,J)>MAX THEN MAX:=SIM(I,J);
IF SIM(I,J)<MIN THEN MIN:=SIM(I,J);END;FOR J:=I+1 UNTIL M DO
BEGIN IF SIM(I,J)>MAX THEN MAX:=SIM(I,J); IF SIM(I,J)<MIN THEN
MIN:=SIM(I,J); END;
DIFF1(I):=MAX-MIN; END;
MAX:=0.;
FOR I:=1 UNTIL M DO IF DIFF1(I)>MAX THEN BEGIN
MAX:=DIFF1(I);A:=I; END;
B:=TRUNCATE(M/2);
FOR I:=1 UNTIL M DO BEGIN DIFF1(I):=SIM(I,A);NO(I):=I; END;
FOR I :=M STEP -1 UNTIL 2 DO BEGIN FOR J:=1 UNTIL I-1 DO
BEGIN IF DIFF1(J)>DIFF1(J+1) THEN BEGIN PHI:=DIFF1(J);
DIFF1(J):=DIFF1(J+1);DIFF1(J+1):=PHI;A:=NO(J);NO(J):=NO(J+1);
NO(J+1):=A; END END END;
FOR I:=1 UNTIL B DO END1(I):=NO(I);
FOR I:=B+1 UNTIL M DO END2(I-B):=NO(I);
FOR I:=1 UNTIL M DO BEGIN DIFF1(I):=0.;DIFF2(I):=0.;
END; C:=B;D:=B;
LABEL: SUM:=0.0; FLAG:=0; FOR I:=1 UNTIL C DO BEGIN
FOR J:=1 UNTIL C DO SUM:=SUM+SIM(END1(I),END1(J));
AVGA(I,1):=SUM/C;SUM:=0.0;
FOR J:=1 UNTIL D DO SUM:=SUM+SIM(END1(I),END2(J));
AVGA(I,2):=SUM/D;SUM:=0.0;END;
FOR I:=1 UNTIL D DO BEGIN
FOR J:=1 UNTIL D DO SUM:=SUM+SIM(END2(I),END2(J));AVGB(I,1):=SUM/
SUM:=0.0;FOR J:=1 UNTIL C DO SUM:=SUM+SIM(END2(I),END1(J));
```

```
AVGB(I,2):=SUM/C;SUM:=0.; END;
WRITE("GROUP A"); FOR I:=1 UNTIL C DO WRITE(GRAVE(END1(I)),
AVGA(I,1),AVGA(I,2));
WRITE("GROUP B"); FOR I:=1 UNTIL D DO WRITE(GRAVE(END2(I)),
AVGB(I,1),AVGB(I,2));
FOR I:=1 UNTIL C DO BEGIN IF AVGA(I,2)>AVGA(I,1) THEN
BEGIN FLAG1:=FLAG1+1; TEMP1(FLAG1):=END1(I); END1(I):=0;
END END;
FOR I:=1 UNTIL D DO BEGIN IF AVGB(I,2)>AVGB(I,1) THEN
BEGIN FLAG2:=FLAG2+1; TEMP2(FLAG2):=END2(I);
END2(I):=0;END END;
LABA: IF END1(C)=0 THEN BEGIN C:=C-1; GOTO LABA; END;
I:=1; LAB2: IF END1(I)=0 THEN BEGIN
FOR J:=I UNTIL C-1 DO END1(J):=END1(J+1);
C:=C-1; GOTO LAB2; END ELSE BEGIN
I:=I+1; IF I<=C THEN GOTO LAB2; END;
FOR I:=1 UNTIL FLAG2 DO BEGIN END1(C+1):=TRUNCATE(TEMP2(I));C:=C+1;
END; LABB: IF END2(D)=0 THEN BEGIN D:=D-1; GOTO LABB; END;
I:=1; LAB3: IF END2(I)=0 THEN BEGIN
FOR J:=I UNTIL D-1 DO END2(J):=END2(J+1);
D:=D-1; GOTO LAB3; END ELSE BEGIN
I:=I+1; IF I <=D THEN GOTO LAB3; END;
FOR I:=1 UNTIL FLAG1 DO BEGIN END2(D+1)
:=TRUNCATE(TEMP1(I)); D:=D+1; END; IF FLAG1+FLAG2>0 THEN BEGIN
FLAG1:=0;FLAG2:=0; GOTO LABEL; END;
FLAG1:=0;FLAG2:=0;
FOR I:=1 UNTIL C DO DIFF1(I):=AVGA(I,1)-AVGA(I,2);
FOR I:=1 UNTIL D DO DIFF2(I):=AVGB(I,1)-AVGB(I,2);
FOR I:=C STEP -1 UNTIL 2 DO BEGIN
FOR J:=1 UNTIL I-1 DO BEGIN
IF DIFF1(J)>DIFF1(J+1) THEN BEGIN
A:=END1(J); END1(J):=END1(J+1);END1(J+1):=A;
PHI:=DIFF1(J);DIFF1(J):=DIFF1(J+1);DIFF1(J+1):=PHI;
END END END;
FOR I:=D STEP -1 UNTIL 2 DO BEGIN
FOR J:=1 UNTIL I-1 DO BEGIN
IF DIFF2(J)>DIFF2(J+1) THEN BEGIN
A:=END2(J);END2(J):=END2(J+1);END2(J+1):=A;
PHI:=DIFF2(J);DIFF2(J):=DIFF2(J+1); DIFF2(J+1):=PHI;
END END END;
WRITE(" GROUP 1 "); FOR I:=1 UNTIL C DO
WRITE(GRAVE(END1(I)),"    ",AVGA(I,1),"    ",AVGA(I,2),"    ",DIFF1(I));
WRITE(" GROUP 2 ");
FOR I:=1 UNTIL D DO WRITE(GRAVE(END2(I)),"    ",AVGB(I,1),"    ",AVGB(I
,"    ",DIFF2(I));
END END.
```

A.8 The programs for the method of Brainerd and Robinson.

A.8.1 The clustering program.

```
/INCLUDE ALGOLW
BEGIN INTEGER M; REAL CRIT; INTFIELDSIZE:=4; READON(M,CRIT); BEGIN
REAL ARRAY SIM(1::M,1::M);  STRING
ARRAY NAME(1::M);
FOR I:=1 UNTIL M DO  BEGIN READON(NAME(I)); FOR J:=1 UNTIL M DO
READON(SIM(I,J)); END;
FOR I:=1 UNTIL M DO BEGIN FOR J:=1 UNTIL M DO
SIM(I,J):= IF SIM(I,J)>=CRIT THEN 1. ELSE 0.; END;
BEGIN REAL ARRAY POINT(1::M); INTEGER I,K;
FOR J:=1 UNTIL M DO POINT(J):=1.; K:=0;
BEGIN FOR IN :=1 UNTIL M DO IF POINT(IN)=1. THEN
BEGIN K:=K+1; WRITE ("CLUSTER",K,":-",NAME(IN),",");
POINT(IN):=0.; FOR KIN:=1 UNTIL M DO
IF SIM(IN,KIN)+POINT(KIN)=2. THEN BEGIN WRITEON(NAME(KIN),",");
POINT(KIN):=0.; FOR JIN:=1 UNTIL M DO
IF SIM(KIN,JIN)+POINT(JIN)=2. THEN BEGIN WRITEON(NAME(JIN),",");
POINT(JIN):=0.; END END END END END END END.
```

A.8.2 The ordering program.

```
/SYS REG=200
/LOAD WAT5
C  ANALYSIS OF GRAVES BY COMPUTER
C  READ IN DATA
      DIMENSION SIM(86,86), B(21,21), C(21,21),GR(86),CG(20),IN(20,
      READ5, M, N
5     FORMAT(2I3)
      DO 10 I=1,M
      READ15,GR(I),(SIM(I,J),J=1,M)
10    CONTINUE
15    FORMAT(1X,A4,2X,12(F5.3,1X),8(/,5X,12(F5.3,1X)))
C  INITIALIZE IN
      DO 20 I=1,N
      READ25,CG(I)
20    CONTINUE
25    FORMAT(A4)
      DO 32 I=1,N
      DO 30 J=1,M
      IF(CG(I).NE.GR(J))GO TO 30
      IN(I)=J
      GO TO 32
30    CONTINUE
32    CONTINUE
C  INITIALIZE B AND C
      B(1,1)=0.
      M=N+1
      MC=N+1
      DO 35 I=2,M
      B(I,1)=CG(I-1)
      B(1,I)=CG(I-1)
      DO 35 J=2,M
      B(I,J)=SIM(IN(I-1),IN(J-1))
35    CONTINUE
      PRINT36
36    FORMAT(' ','SIMILARITY MATRIX')
      PRINT40,(B(1,I),I=1,MC)
40    FORMAT ('0', F5.3,1X, 20(A5,1X))
```

```
      DO 45 I=2,MC
45    PRINT 50, (B(I,J), J=1,MC)
50    FORMAT('0',A5,1X,20(F5.3,1X))
C     SERIATE SIMILARITY MATRIX
C     INITIALIZE MATRIX COEFFICIENTS
      ZB=0.
      ZC=0.
C     STORE COPY OF SIMILARITY MATRIX
      DO 53 I= 1,MC
      DO 53 J= 1,MC
53    C(I,J) = B(I,J)
      M=N
C     CALCULATE COEFFICIENT OF COPY OF SIMILARITY MATRIX
      DO 60 J=2,M
      DO 55 I=J,M
      IF(C(I,J).LT.C(I+1,J))ZC=ZC+C(I+1,J)-C(I,J)
55    CONTINUE
      DO 60 I=2,J
      IF (C(J,I). GT. C(J,I+1)) ZC=ZC+C(J,I)-C(J,I+1)
60    CONTINUE
C     MOVE ROW COLUMNS
      DO 95 K=2,M
      DO 90 I=2,M
      DO 65 J=1,MC
      W=B(J,I)
      B(J,I) = B(J,I+1)
65    B(J,I+1) = W
      DO 70 J=1,MC
      W=B(I,J)
      B(I,J)=B(I+1,J)
70    B(I+1,J) = W
C     CALCULATE COEFFICIENT FOR B
      DO 77 L1 = 2,M
      DO 77 L2 = L1,M
      IF (B(L2, L1). LT. B(L2+1,L1)) ZB=ZB + B(L2+1,L1)-B(L2,L1)
77    CONTINUE
      DO 76 IA=3,MC
      DO 76 JA = 3,IA
      IF (B(IA, JA). LT.B(IA, JA-1)) ZB=ZB+ B(IA, JA-1)-B(IA,JA)
76    CONTINUE
C     COMPARE COEFFICIENTS
      IF(ZB.GT.ZC)GO TO 90
      DO 85 IA=1,MC
      DO 85 JA=1,MC
85    C(IA, JA)=B(IA, JA)
      ZC=ZB
      PRINT40,(C(1,MA),MA=1,MC)
      DO 88 MA=2,MC
88    PRINT50,(C(MA,MB),MB=1,MC)
      PRINT 62, ZC
62    FORMAT('0','ZC=',F12.6)
      IF(ZC.EQ.0.) GO TO 100
90    ZB = 0.0
      DO 93 IA=1,MC
      DO 93 JA=1,MC
93    B(IA,JA)= C(IA,JA)
95    CONTINUE
100   PRINT 105
105   FORMAT ('1', ' SERIATED  SIMILARITY MATRIX')
      PRINT 40, (C(1,I), I=1,MC)
```

```
      DO 110 I=2,MC
110   PRINT50,(C(I,J),J=1,MC)
      STOP
      END
```

Abbreviations

ABL	Attic Black-Figure Lekythoi
ABV	Attic Black-Figure Vase-Painters
AE	ʼΑρχαιολογικὴ ʼΕφημερίς
ARV^2	Attic Red-Figure Vase-Painters Second Edition
Aryb.	Aryballoi and Figurines from Rhitsóna in Boeotia
ASB	Archaic Sculpture in Boeotia
BGP	Black Glaze Pottery from Rhitsóna in Boeotia
BSA	Annual of the British School at Athens
FGS	Frühe Griechischer Sagenbilder in Böotien
GGP	Greek Geometric Pottery
JHS	Journal of Hellenic Studies
NC	Necrocorinthia
Para.	Paralipomena
PGP	Protogeometric Pottery
RE	Real-Encyclopädie der Classischen Altertumswissenschaft
Studies Robinson	Studies Presented to D. M. Robinson
Stud. Ridge.	Essays and Studies Presented to William Ridgeway
VI and V	Sixth and Fifth Century Pottery from Rhitsóna
VS	Les Vases Sicyoniens

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Group No.	Grave Nos.	Dates	Colour
1	1, 134	Mid 8th cent. BC.	
2	6, 75, 88, 90	Late 8th-Early 7th cent. BC	
3	132, 13, 97, 14, 89, 91, 141	Second half 7th cent. BC.	
4	4, 87, 92, 95, 125A, 125B	c. 600 BC.	●
5	99, 125C, 125D, 125E, 101A, 101B, 115, 96, 86, 145	Early 6th cent. BC.	
6	40, 49, 50, 93, 103, 104, 110, 51	Mid 6th cent. BC.	●
7	126, 3, 85, 102, 31	Second half 6th cent. BC.	●
8	127, 5, 133, 130, 112, 26, 80, 12, 135, 120, 18	Late 6th cent. BC.	●
9	121, 82, 2	Late 6th-Early 5th cent. BC.	●
10	131, 22, 22A, 21, 113, 46, 36	Early 5th cent. BC.	●
11	52	First half 5th cent. BC.	●
12	108, 138	Mid 5th cent. BC.	●
13	76, 139	Third quarter 5th cent. BC.	●
14	114A, 123, 144, 55, 111	Late 5th cent. BC.	
15	114B, 57, 59	End 5th cent. BC.	
16	60, 107, 34	First half-Mid 4th cent. BC.	●
17	33, 30	Second half 4th cent. BC.	●
18	56	4th cent. BC.	●
19	66, 67, 68	Mid 3rd cent. BC.	●
20	61	Undated	●

Colour coding system for graves.