√

BNL 28105

Excavations at Seibal
Department of Peten, Guatemala

ANALYSES OF FINE PASTE CERAMICS

Edited By

Jeremy A. Sabloff

with

contributions by

Ronald L. Bishop
Garman Harbottle
Robert L. Rands
Jeremy A. Sabloff
Edward V. Sayre

Research carried out under the auspices of the United States Department of Energy under contract no. DE-AC02-76CH00016.

Peabody Museum Memoir
Volume 15, Number 2,

2b

ANALYSES OF FINE PASTE CERAMICS

CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER ONE

Introduction:

A Brief Informal History of the Brookhaven Fine Paste Ceramics Project

by
Jeremy A. Sabloff

The Brookhaven Fine Paste Ceramics Project has spanned a 20-year period under the direction of Edward V. Sayre, Garman Harbottle and their many associates in the Department of Chemistry, Brookhaven National Laboratory. Under the auspices of the U. S. Atomic Energy Commission, these scientists have spent a huge amount of time collaborating with archaeologists in the study of Fine Paste ceramics.

The Brookhaven Laboratories first began their work with Fine Paste pottery in 1956 when Dr. Linton Satterthwaite of the University of Pennsylvania gave them some sherds from the great Classic Maya site of Piedras Negras in the southern Maya lowlands and from the highland Guatemala site of Kixpek (see Figure 1 for the location of all the archaeological sites mentioned in this monograph). Dr. Sayre and his colleagues wished to test the newly developed technique of neutron activation, and the temperless pottery of Southern Mesoamerica which appeared just prior to the collapse of Classic Maya civilization. Their analyses pointed to an identity between the Fine Orange pottery from Piedras Negras and Kixpek. Moreover, it indicated that the Piedras Negras Fine Orange differed from utilitarian pottery found at that site. Sayre and his co-authors concluded (Sayre, Murrenhoff, and Weick 1958:iii):

> A group of Mayan sherds from Guatemala included pieces typical of the Mayan city of Piedras Negras and some typical of a special "fine orange" ware produced in the distant Guatemalan highlands. Examples of "fine orange" ware found at Piedras Negras were to be compared to both . . . All the Mayan "fine orange" ware found at Piedras Negras more closely resembled in composition as well as in style its prototype from the mountains than the typical ware of that city, and hence probably had been transported from the mountains to the city. Thus it was demonstrated that the data obtained might indicate provenance and reveal routes of ancient commerce.

In the late 1950's, Gordon R. Willey initiated the Peabody Museum's Rio Pasion archaeological project at Altar de Sacrificios. Work at this important site was followed by investigations at the equally significant site of Seibal. Both sites revealed relatively large quantities of Fine Paste ceramics, which figured prominently in the ceramic analyses and interpretations of R.E.W. Adams (1971) and J. A. Sabloff (1975) at Altar and Seibal, respectively. There were strong indications, based in part on the previous work of R.E. Smith (1958) and Heinrich Berlin (1956), that the Gulf Coast region of modern-day Tabasco and Campeche might be the source area for much of the Fine Paste pottery found at the Pasion sites. Moreover, there were clear indications that the introduction of these ceramics at various southern Maya lowland sites might be related to the whole question of the collapse of Classic Maya civilization.

It was with some surprise, therefore, that Sabloff read in an article in Science by Rainey and Ralph (1966: 1491) that

> The Brookhaven National Laboratory has used neutron-activation analysis to demonstrate, with pottery from Italy and from Central America, that a detailed analysis of elements contained in the clays makes it possible to determine the source of the materials and perhaps the region of manufacture. For example, the fine orange ware found at Piedras Negras in the lowlands of Guatemala has been proved to have been fabricated from deposits located in the highlands.

He discussed this finding with G. R. Willey and R. E. Smith and in June, 1966, Willey wrote to Edward Sayre at the Brookhaven Laboratory. Willey noted:

> Since 1958 I have been excavating in Maya archaeological sites in the southern Peten. We have found numerous large quantities of Fine Orange at Altar de Sacrificios which is located at the junction of the Salinas and Pasion rivers in the southwestern Peten. More recently, we have found fine paste wares at Seibal in the southern central Peten. As you may know, these

wares appear rather suddenly in Maya sites at the end of the Classic period (ca. A.D. 800-900). We are very much interested in pinning down the point of origin and difussion of these wares. I am still unconvinced that they do originate in the Highlands. For one thing they are found in their largest known quantities in the Tabasco Lowlands well downstream from us. In any event, it is an important problem for us in Maya archaeology.

We have a very large sample of Fine Orange from Altar de Sacrificios and a substantial sample from Seibal is now being shipped up from Guatemala. Could we interest you in coming to our aid on this?

Sayre responded:

> The possibility of making a detailed technical study of Mayan Fine Orange is most interesting to me. The small study undertaken in cooperation with Professor Satterthwaite some years ago, of course, did little more than establish that compositional investigation was a promising method for this material. What would now seem most worthwhile would be a comprehensive investigation of this pottery type.

Within six months, the Fine Paste Project was fully underway:

In early 1967, Dr. L.-H. Chan, a post-doctoral fellow at Brookhaven, began the first neutron activation analyses of pottery from Seibal, Altar de Sacrificios, and other Mayan sites. The original aims of these analyses, as stated in a letter from Sabloff to Chan, included the following:

1. was the Altar (Y) Fine Orange pottery made at one place or a number of places? Sherds from Seibal, Altar de Sacrificios, and several other sites (collections of which are located in the Peabody Museum) could be tested and the results compared with the data which you already have from Piedras Negras and Kixpek.
2. was the pottery of the different Fine Orange Groups (X,Y, and Z) made at the same place?
3. is there any difference between the fancy burial pottery (widespread) and the utilitarian pottery (Rio Pasion area only) in source, composition, etc."

The Sayre-Chan work resulted in a paper presented at the 1968

American Chemical Society Symposium on Archaeological Chemistry. This report subsequently was published in Brill, editor, Science and Archaeology (1971) along with an accompanying commentary by Sabloff on the archaeological implications of the Sayre-Chan study.

The preliminary results of the Brookhaven-Peabody collaboration were so intriguing, as regards the potential source connections among Fine Paste sherds, that it was decided to continue the Fine Paste analyses. As it was noted in the final Seibal ceramic report (Sabloff 1975: 242):

> For more than half a dozen years, the Seibal Archaeological Project and the Brookhaven National Laboratory have cooperated in a pioneering study of the Fine Paste ceramics of Southern Mesoamerica. The study was initiated for the purpose of testing a wide variety of assumptions which had been made by archaeologists about this pottery. In relation to Seibal and Altar de Sacrificios, we were particularly interested in discovering if all the pottery was traded in or if some of it, especially the so-called utilitarian pottery of Altar de Sacrificios, was locally manufactured. The initial results of the Brookhaven analysis indicated that virgually all the "Y" or Altar group Fine Orange pottery was made in one place. Furthermore, although this location probably was not at either Seibal or Altar de Sacrificio, it may have been somewhere along the Usumacinta drainage. In addition, the Altar Group material could be analytically separated from the Silho ("X") and Balancan ("Z") group pottery.
>
> We were sufficiently excited and encouraged by these results to continue and to widen the original study.

With the departure of Chan from Brookhaven, new associates of Sayre such as P. Meijers and later Rafael Abascal joined the project. Additional sherds from Maya sites were sent to Brookhaven over the next several years in order to expand the original study. Moreover, in 1969, three important events occurred which had a profound effect on the Brookhaven Fine Paste Project. First, while Sayre went off to Egypt on leave, Garman Harbottle of the Department of Chemistry at

Brookhaven agreed to take over the Fine Paste analyses. Harbottle's continuing enthusiasm for the project was in no small measure responsible for its success. Second, Robert Rands of Southern Illinois University became interested in the project and agreed to send Fine Paste materials, which already had undergone petrographic analyses to Brookhaven for study. It thus became possible to fruitfully combine the results of neutron activation and petrographic analyses in the Fine Paste study. Third, initial soil samples from the Usumacinta drainage were sent to Brookhaven through the cooperation of Edward Sisson so that it became possible to begin the search for potential source locations for Fine Paste pottery.

In addition, through the cooperation of Michael Coe, John Paddock, and George Cowgill, samples of fine, temperless pottery from San Lorenzo in Tabasco, Lambityeco in Oaxaca, and Teotihuacan in Central Mexico were submitted to Brookhaven for comparative analyses.

In 1975, Harbottle and Sayre published the interim results of the "Brookhaven-Peabody phase" of the Fine Paste study in an article entitled "Current Status of Examination of Sherds of Fine Paste Ceramics from Altar de Sacrificios and Seibal and their Comparison with other Maya Fine Paste Ceramics." But several years before this publication, the focus of the Brookhaven study had begun to shift. Since the early 1970's, the collaboration between Brookhaven and Southern Illinois University has grown in importance. The analysis of a wide variety of Fine Paste sherds from the Palenque region, as well as clay samples, has considerably broadened the base of the initial study. The petrographic analyses of Rands and his associates also have given the Fine Paste study a new dimension by providing complementary data and allowing better and finer divisions of similar Fine

Paste sherds than was previously possible. With the entrance of Ronald L. Bishop of Southern Illinois University in the project, the "Breokhaven-SIU phase" has proceeded rapidly and has recently been completed.

The papers in this volume represent the culmination of two decades of research. They indicate the great potential of analytical studies of archaeological ceramics and the value of close cooperation between scientists and archaeologists to the benefit of the research and scientific goals of both parties.

CHAPTER TWO

Chemical and Mathematical Procedures Employed in the Mayan Fine Paste Ceramics Project

by

Ronald L. Bishop,
Garman Harbottle, and
Edward V. Sayre

A → The Chemical Analysis of Mayan Fine-paste Ceramics

B → Introduction

It is interesting that the first chemical analyses of archaeological material, which were carried out by Klaproth (Caley 1962) in 1790, were concerned with a technical point: the means by which the colors of red, green, and blue glass tesserae, from a mosaic in the Villa of Tiberius at Capri, were produced. A century later, Richards at Harvard (Richards 1895) analyzed classic Greek pottery, but with an entirely different aim, the same one that will be our concern in this paper, namely, the determination of probable provenience. "At the request of Mr. Edward Robinson, of the Boston Museum of Fine Arts, several analyses of ancient Athenian pottery were recently made at this laboratory...the interest of these analyses was mainly archaeological, turning upon the identity of the source of these remains with that of others found in other cities,..." and finally "The variations in the relative amounts are singularly small, the range being not nearly so large as that given by Brougniart, in his 'Traite des Arts Ceramiques'. Hence, it is possible, that all of these specimens, which were picked up in the city of Athens itself, were the product of a local pottery." Almost hidden in Richards' statement is an assumption that has elsewhere been called the "Provenience Postulate" (Weigand et al. 1977) namely, that in many instances there will exist differences in chemical composition between pottery from different sources that will exceed, in some recognizable way, the differences observed within pottery from a given source. This postulate is at the root of all studies involving provenience attribution <u>via</u> chemical analysis: the first part of this section will deal with the measurement of these chemical composition differences, and the second, with the mathematical and statistical procedures for "recognizing" them.

In 1955 studies on the analysis of ancient pottery <u>via</u> neutron activation (abbreviation, NAA) were begun at Brookhaven National Laboratory. The first samples of Mesoamerican ceramics were supplied by Professor L. Satterthwaite and included "Fine Orange" ware (Sayre et al. 1958). This may properly be taken as the starting-point of the research path which terminates, at least for the time being, in the present ~~paper.~~ volume. Significant milestones on this path were the initiation of collaboration with G. Willey and J. Sabloff at Harvard University-The Peabody Museum, then with R. Rands at Southern Illinois University, and the generous assistance of J. Paddock in Oaxaca, P. Krotser in Vera Cruz and M. Coe at Yale. Publications thus far include the <u>Papers of the Fourth Symposium on Archaeological Chemistry of the American Chemical Society</u> (September, 1968) published under the editorship of Brill (1971), the Peabody Museum Memoir of 1975 (Sabloff 1975) containing an interim report, in the appendix, by Harbottle and Sayre, and the paper delivered at the XLI Congreso de Americanistas (Rands et al. 1975) which is a very short summary of the Mayan Fine Paste Studies, touching on the present work. The present volume should be considered as superceding all these previous studies, at least insofar as the analyses of Fine Orance ware are concerned (see Table 1 for a complete summary of the composition of all the samples analyzed in this study; the CPRU's are discussed in Chapter 3).

B →

Sampling of Archaeological Ceramics

In his Ph.D. thesis, Bishop (1975) has considered an archaeological ceramic as a kind of "special sedimentary product", and he and Rands will, in Chapter 3 below, discuss the geochemical, petrographic and sedimentological implications of this view in the context of the Fine Paste wares. The procedures to be adopted in the sampling of Fine Orange wares are also very much dependent upon these same considerations.

If we think of the content or percentage of a particular chemical element, let us say iron, in clay from a bed which has been repeatedly used for the preparation of a certain type of pottery, then it is clear that different samples of the clay, and hence different samples of pottery, would show, even if analyzed exactly, a natural "spread". We can express that spread mathematically as a variance, σ_N^2, where σ_N is the standard deviation of the exact percent iron measurements in the assumed infinite population of clay or ceramic samples. Note that we imply that iron is neither gained nor lost during the fabrication, firing and burial period of an archaeological ceramic specimen: although this is probably true for most elements, it may not be for all, as will be discussed below.

The statistical parameters that will define the properties of a particular group of ceramic specimens, in terms of which group membership will be defined, are the centroid of the group and the group variance about this centroid. For individual elements the analytically determined total variances, S_T^2, will be greater than the measured natural variance of the group itself, S_N^2, by the sum of the additional variances, S_S^2 and S_A^2, added respectively by the errors in the sampling and the analyses of individual specimens. That is

$$S_T^2 = S_N^2 + S_S^2 + S_A^2 \quad .$$

Thus if the measured S_T^2 is reasonably to represent the natural S_N^2, the variance of sampling, S_S^2, and of analysis, S_A^2, must be kept within reasonably low limits. The combined errors of sampling and analysis can be inferred from the reproducibility of sets of multiplet analyses of samples taken from the same objects, and the analytical error itself determined by multiplet runs of samples of carefully homogenized materials. Within limits the analytical error can be reduced to an arbitrarily determined amount through refinement of the analytical procedure and the sampling error is similarly subject to reduction through in effect using greater fractions of the individual specimens in each sample. It is very important, however, that both sources of error be taken into account and reduced to acceptable limits through appropriate control of sampling and analytical techniques.

The question "To what degree will the pottery from a given source be consistent in composition?" involves both the geochemical distributions mentioned above and the anthropological tradition of pottery-making. If the potter was making tempered wares, then pottery analysis by any technique necessarily reflects the elemental contents of the temper as well as the clay. Some tempers, notably quartz sand (silica), have low specific contents of trace elements, and tend to act merely as diluents. Organic tempers such as straw or cattail fluff would be expected to burn out on firing, leaving behind their mineral ash, which one would guess would not seriously perturb the analytical data relationships between clay and ceramic. On the other hand, tempers such as volcanic ash contain enough different elements to contribute materially to the overall composition (cf. Rice 1978; Arnold et al. 1978). In any case, the possibility of forming archaeologically viable groups of tempered sherds on the basis of their chemical compositions rests on the conservatism of pottery-making societies: the potters tend to obtain temper and clay by following traditional patterns and to mix them according to pragmatic recipes or proportions handed down in their societies. Such seems to have been the case in the highly-tempered "Thin Orange" ware associated with classic Teotihuacan: we have recently completed a chemical study of this trade ware (Sayre and Harbottle nd.; Abascal-M 1974): suffice it to say here that although the "core" group of Thin Orange was somewhat more diffuse (chemically speaking) than fine-paste groups we have studied, it was nonetheless sufficiently cohesive to allow it to be differentiated from all other pottery of Mesoamerica, and especially from (presumed) local imitations. Another case in point concerns the mica-tempered amphorae of Marseilles (Fillieres 1978). Here, although the ware is highly-tempered, the body of 95 analyses form an astonishingly cohesive group, reflecting either an exact ceramic technology, or the fortunate occurrence of a remarkably homogeneous naturally-tempered clay.

In the present work we are, fortunately, dealing with fine-paste, i.e. not deliberately tempered, wares. There is good reason to expect that the compositon of this pottery will relate closely to that of the clay out of which it was formed, and also that small samples of these sherds will be representative of them. We have noticed, for example, that whereas in the case of <u>tempered</u> "Thin Orange", it was necessary to grind up and mix two to three grams of each sample and from this withdraw a representative specimen of 40 mg for analysis (Abascal-M 1974; Harbottle et al. 1976), in the case of Fine Orange, small repetitive samples taken from a single sherd agreed very well. In fact, in one case we analyzed a single 6-mg sample drilled from a Fine Orange sherd and found that its analysis agreed well with a much larger sample taken from the same sherd. This observation, that fine paste wares tend to be more uniform chemically, was also borne out in our recent study of some Greek pottery (Bieber et al. 1976a, ~~and~~ b) and by other studies of "Nile mud" wares (Perlman and Asaro 1969). Additional data on the variation of elementary concentration on replicate sampling will be found in Bieber, Jr. (1977).

However, if we wish to relate fine paste wares by their chemical compositions to existing clay sources, one further difficulty enters. The pottery-maker may, in preparing his clay, have levigated it to remove coarse extraneous material to yield a working clay with improved properties, for example, elasticity. We were concerned that the coarse and fine fractions of a single clay might differ in their chemical makeup, and therefore devised a routine procedure for separating clay into such fractions (actually, clay as received, and a fine fraction). On the basis of many such paired analyses we find, with a few exceptions, that clays as received, and fine fractions of them, tend to be very similar chemically. In cluster analysis (see below) the paired fractions often come out together. Attas et al. (1977), however, working with clays from Central Greece, found substantial changes in composition in the levigated fraction, as we have observed in a few cases. We feel that these analyses, giving us an idea of the magnitude of change in pattern due to levigation, are important in cases where we wish to relate archaeological ceramics to modern clays.

In the laboratory, we employed the following routine procedures, in connection with sampling:

i) A full description of the specimen, its provenience, source, excavation data, field numbers etc. were recorded, and a photograph taken for reference. A Brookhaven number was assigned.

ii) The outer layer of the edge of the sherd or an inconspicuous spot on the surface of a whole vessel were ground away, using a tungsten carbide motor-driven burr.

iii) The sherd or vessel was then drilled in the cleaned spot using a solid tungsten carbide drill bit. The powder was collected on a clean weighing paper. If possible, the sherd was drilled at several points to provide a more representative, combined sample. At all points an effort was made to sample the interior portion of the sherd body.

iv) Sherds too small or too thin to drill were prepared by grinding off all the outer surface with the burr, then crushing the whole remainder in an agate mortar. In general, 100-200 mg of powder were sought.

v) Clays, as mentioned above, were analyzed "as received", and "levigated". The dry clays were crushed and mixed in an agate mortar. The levigation consisted in mixing 5 gms of clay with 40 ml of distilled water in a mixing cylinder, with vigorous shaking for 4 hr. The suspension was then allowed to stand for 2 min., at the end of which time the supernatant, containing the fine fraction, was poured off and allowed to dry at room temperature.

vi) Both sherd and clay samples were finally dried for 18 hours at 110°C. There is no question that clay dried in this fashion will still contain a few percent more water than fired ceramics of the clay identically dried. This will necessarily introduce a small overall concentration difference which can, however, be easily compensated mathematically since the water acts as a pure diluent. In other research (Brooks et al., 1975) we have shown that firing under various conditions of time and temperature does not cause loss of the elements being determined. Attas et al. (1977) also found little or no effect of firing temperature. These results are also in agreement with a recent extensive study of pottery-making villages in Guatemala where questions concerning culturally influenced variability of trace elements in pottery were examined (Rice 1978). Our preferred method at the present date is to form briquettes out of clay to be analyzed, to fire these and then treat them exactly as pottery.

B →

Packaging for Bombardment

About 40 mg of each dried sample was weighed to the nearest 0.01 mg into a quartz ampoule: these ampoules were prepared from ultra-high purity Suprasil T-20 2 mm i.d. fused quartz tubing (U.S. Fused Quartz Company) by sealing at one end, boiling in aqua regia, rinsing with distilled water and drying. After weighing in the sample, the quartz ampoule was sealed off in vacuo and labeled with India ink. Empty labeled ampoules were also included with each run as a check on the purity of the silica and ink. Sealed ampoules are never touched except with tweezers or cotton gloves after cleaning and before bombardment.

Two reactor neutron irradiations, for a short and a long exposure period, were performed on all samples (see 3 below): for the short irradiation the ampoules were placed in a plastic "rabbit" which could be moved into the active zone of the reactor. For long irradiations, the group of ampoules were first sealed into an envelope of ordinary quartz, which then entered the reactor in an irradiation can.

5 Standardization

Although in principle one could calculate concentrations of elements observable in NAA from a knowledge of integrated flux, neutron capture cross-sections etc. it is almost universal practice instead to include standards with the unknown samples being bombarded. If one knows accurately the concentrations of elements in the standard, then the concentration of the same elements in the unknown may be established through simple ratios of the recorded signals of the radiations representing the different radioisotopes in the standard and unknown. As standards we employ all six U.S.G.S. analyzed rocks: they are designated AGV-1, BCR-1, DTS-1, PCC-1, G3P-1 and G-2. Samples of these rocks have been analyzed by many laboratories (Flanagan 1967, 1969, 1973, 1976) and at Brookhaven we have prepared a table of "best values" using Chauvenet's Criterion to reject extreme values (Table I, Abascal et al. 1974). The concentrations appearing in this Table are those adopted for standardization in the present research, except for La_2O_3, where we have taken AGV-1 = 42.5, BCR-1 = 29.6, GSP-1 = 244.4, and G-2 = 108.0 ppm. Although these "new" Lanthanum values change the calculated concentration of that element by about 8%, they have no more than 1/2% effect on the mean Euclidean distance (see below) which is a basis for cluster analysis.

Not every standard rock is used to calibrate every element. Our choice, and the rational therefore, are given in Bieber et al. 1976a. Our practice is to weigh out, dry, encapsulate, bombard and count the rock standards together with each group of ceramics and clay samples. In the event that other investigators wish to compare their analyses with ours, the best results would be achieved by their employing the same rock standard. Some archaeometric laboratories are, however, at present employing the Asaro-Perlman pottery standard (Perlman and Asaro 1969). We have compared the Asaro-Perlman standard to the mean values of the USGS Rock standards using our normal analytical procedures and also recently have compared the results of a large number of analyses of "Nile Mud" ware in this laboratory , to comparable results obtained by Permlan and Asaro (1969) on a different set of samples of the same ware. In general, agreement was good, but could be improved by adjusting their data to our standardization. This suggests that data obtained using the Perlman-Asaro standard may readily be converted to data quite compatible with our data bank, in other areas of the world as well, specifically, with other analyses of Mayan sherds. We plan to publish in the near future a note which will include the numbers appropriate for making this transformation.

B →

Bombardment with Neutrons

Because the many radioisotopes activated by neutrons in pottery decay with a variety of half-lives, it is necessary to perform at least two bombardments, one of short and one of long duration. Both were, in general, carried out at the Brookhaven High Flux Beam Reactor. Short and long bombardments followed two distinct procedures:

i) A long activation was made for 3.5 hours in the core position at fluxes up to 5 x 10^{14} neutrons/cm^2 sec to activate the long-lived elements. Then, after 8 or 9 days, during which the intense activity of the short-lived elements died down, the latter were re-activated by a short bombardment of 1 min at a flux of 1 x 10^4 n/cn^2 sec (position V-11). The samples were then cooled 2-5 hours, loaded into a sample-changer connnected to the germanium counter, and counted twice. The first count, of short duration (typically 400 seconds) measured manganese-56 and sodium-24 and the second, of 4000 seconds, the remainder of the radioelements, including better values for sodium-24.

ii) The second procedure inverted the order, the short bombardment being first and the long bombardment second (Abascal et al. 1974) with separate countings following each bombardment. Each procedure has advantages and disadvantages of a technical nature, which need not be discussed here.

B →

Counting

The counter and data-recording procedures have not changed (Abascal et al. 1974; Sabloff 1975; Hammond et al. 1976) recently and will be only briefly summarized here. The detector fed samples by a 48-position sample-changer (Atomic Development and Machine Co.), was a Princeton Gammatech 7% Ge-Li crystal of 1.82 keV resolution on cobalt-60. The pulses from this detector were amplified (Ortec 472) and fed to a Nuclear Data 2400 4096-channel pulse height analyzer modified to record not only the gamma spectrum but elapsed time, spectrum tagword and date as well on a magnetic tape. Dead time was corrected by means of a special, locally-designed, all-solid-state pulser. Reliable peak values are obtained for the elements Na, K, Rb, Cs, Ba, Sc, La, Ce, Eu, Lu, Hf, Th, Ta, Cr, Mn, Fe, Co, Sb, Sm, Yb, and Ca. However, calcium, and titanium as well, are better analyzed by X-ray fluorescence than by NAA (see below). Although in principle a few more elements could have been determined, a substantially greater expenditure of time and effort would have been required for this. It should be noted here, as has already been mentioned above, that Mesoamerican and other archaeological ceramics have been analyzed in this laboratory for nearly 25 years. This period has witnessed a steady development in sensitivity, precision and ease of operation with the result that some materials analyzed early on could be reanalyzed in the period 1972-73 to take advantage of improved methods. All the analytical data listed in Table 1 is thus on a common basis, internally intercomparable and externally also capable of comparison with our entire data bank. In Table 1 some entries are missing: these cases reflect occasional technical difficulties, or, stages in the development and improvement of methodology. We do not feel that this missing data can in any way compromise the validity of our conclusions.

C. Preliminary Data Processing

The raw gamma spectra are analyzed by the program BRUTAL (Gunnink et al. 1967) which yields intensities of the gamma rays corrected for background and sample weight. The output cards from BRUTAL form the input to our locally developed programs ELCALC and SMPCALC which apply decay and dead-time corrections, calculate calibration coefficients, average them, and ultimately calculate and punch out the analytical data for each sample. These sample data cards (two per sample, format and coding available on request) contain space for up to 36 elements, reported as element oxides (Abascal et al. 1974).

[illegible]. Analysis by X-ray Fluorescence

To determine the elements calcium and titanium we employed X-ray fluorescence. The instrument was a Siemens, and the X-rays emerged from a chromium target. The six U.S.G.S. rock standards described above were also employed here: quite satisfactory calibration was achieved when the "best values" of Flanagan (1969: Table 4, 109) were employed.

Petrographic Examination

One of the unusual features of this investigation, already partially reported (Rands et al. 1975:534) was the correlation of petrographic and chemical data obtained for the fine-paste Mayan ceramics (see Chapter 3). The petrographic examinations, carried out by Paul H. Benson and Pei-yuan Chen, employed both binocular and thin-section techniques. Paste color and selected petrographic variables such as mica, feldspar, volcanic dust and opal phytoliths were scored for all sherds and provided important information in the final grouping and provenience attribution of ceramics.

The Formation of Archaeological Ceramic Groups

Introduction

All available information, chemical and petrographic analyses, ceramic paste type, form, decoration, and archaeological context should eventually be considered in the assignment of pottery specimens to groups which in accordance with the Provenience Postulate appear to have originated from common sources. This becomes increasingly important when micro-regional variation is sought (cf. Bishop 1979). The present investigation is essentially confined to two wares, that is Mayan Fine Orange and Fine Gray and the clays out of which they might have been fabricated. To the extent that this restriction is conformed to, the task of classification is definitely simplified in that one would expect the number of sources to be limited to a relatively small subset of those from which all types of Mesoamerican pottery stemmed. However, even within this constellation of pottery the problem of statistical classification is sufficiently complex that a progressive stepwise procedure was followed, in which one first attempted to classify the specimens upon chemical parameters alone and then to refine or confirm the groupings that had been established through consideration of petrographic and archaeological information.

Data Transformations

In several publications (Sabloff 1975; Harbottle 1976; Sayre 1977) we have given the reasons for the possible choice of a logarithmic transformation of our analytical data, namely, to give equal weight to a given fractional change in elementary concentration, regardless of its absolute magnitude, in forming taxa, and to produce in-group distributions that closely approximate normality in accordance with the observation that elements quite often are distributed in nature not normally in concentration but lognormally (or as Student's t for small samples). One needs to meet this "normal distribution" requirement in order to calculate probability of group membership, through the calculation of the Mahalanobis distance (Mahalanobis 1936, Sneath and Sokal 1973, pp. 127 and 405, Cooley and Lohnes 1971, Hodson et al. 1971:62). Another procedure often employed standardizes the raw data without log transform by subtracting the mean value from every measurement of an element, and dividing by the standard deviation (Sokal and Rohlf 1969: 380 ff). We have, at various stages in our numerical taxonomy, used both log transform and raw-data standardization. As mentioned in other papers (Harbottle 1976; Bishop 1975; Al Kital et al. 1969; Krumbein and Graybill 1965: Table 5.4; Mason 1966:98) the question appears to be an open one. In current research at Brookhaven we are studying the nature of these distributions, and hope to be able to present data soon relating to this question. At this point we can only state that there does not appear to be a clear-cut decision for either type of distribution, normal or lognormal.

Cluster Analysis

We have found that the most convenient procedure in the cluster analysis of the Fine Paste data is not to include chemical, archaeological, and mineralogical variables in one great computer program, but to begin with chemical groups, then juxtapose the other, more or less independent data. This juxtaposition will be dealt with in Chapter 3, here we will deal solely with the chemical data.

Since we have already described our procedures at length (Harbottle 1977; Weigand et al. 1977; Bieber et al. 1976a, Sayre 1977; Bishop, Rands and Harbottle 1979) we will only summarize them here. Several years of experience in applying various procedures of cluster analysis have caused us to appreciate the fact that if there are discrete (or "natural") groups present in our data set, most of the available clustering algorithims will recover them. However, when there are several subtle distinctions or divisions to be drawn, the choice of a particular clustering approach over another can have significant influence on the resulting partitions, (cf. Sneath and Sokal 1973; Everitt 1977). It cannot be stressed too strongly that there is no "cookbook" approach to data reduction. One must proceed in a manner that is compatible with the research goals and employ all available data to evaluate the chemical groups that are formed. Rigorous parametric statistical evaluation is not often possible due to the sampling design or small numbers of samples comprising a compositional group. Therefore, in the end, having employed high computer technology, the final acceptance of a chemically based ceramic group often must rely on pragmatic or common sense evaluation. With this in mind we will now discuss the procedures that were used in the present treatment of the Fine Orange-Fine Gray data.

We begin with a hyperspace of n dimensions scaled off in the transformed coordinates described above. Each point in that hyperspace represents a particular set of p analytical concentrations, the total analysis we have made of one particular sample. A significant source-group is then represented by a cluster of points in hyperspace: it is to discover these clusters that we carry out the cluster analysis.

Clustering procedures may be glossed into two major categories (Lance and Williams 1967a, 1967b): hierarchical methods and iterative partitioning. A hierarchical agglomerative procedure begins with the calculation of a similarity or dissimilarity ("distance") matrix, giving a measure of chemical agreement between all possible sample pairs (Harbottle 1977:46-49). One hierarchical clustering procedure analyzes the distance matrix and joins the two entities which are nearest to each other. The matrix is then analyzed for the next two closest samples and the procedure is continued until all entities are joined into a single cluster (Sneath and Sokal 1973:201) A usual method of representing the sample to sample relationships is in the form of a dendrogram (Sneath and Sokal 1973:58) Sequential, agglomerative, hierarchical, non-overlapping cluster analysis was employed in the early stages of the Fine Orange-Fine Gray project. However, for the present summarization we preferred to use an alternative partitioning approach for the initial formation of compositional groups.

Unlike the technique previously discussed, iterative partitioning procedures give no hierarchical relationship between resulting clusters nor is the initial group make-up final. Using the program CLUS (Rubin and Friedman 1967) the data matrix is searched for internal geometric evidence of the existence of groups. A partition of n-samples into g-groups is considered to be optimal when a selected criterion function is maximized. The function T is calculted by the fundamental partition equation (Wilks 1962):

$$T = B + W$$

where B is the pooled within-group matrix of weighted squares and cross products of deviations of group centroids from the grand centroid; W is the matrix of squares and cross products of the deviation of the samples from their respective group centroids. These two components sum to T which is the matrix of weighted squares and cross products of the deviations of the group centroids from the grand centroid. The elements of each of the matrices are given in Cooley and Lohnes (1971). We are searching for the number of groups that will contain the smallest amount of variation within the groups and the greatest amount of separation between the groups (this is the basic tenet of the Fisher F-test). If only a single variable were involved T = W + B is a statement about scalers and since T is constant one need only to minimize W in order to maximize B. For more than one variable, the equation refers to matrices and the ratio of the matrix determinants may be used to assign group membership. The $|T| / |W|$ is a generalized variance ratio which has the attractive properties of including the effects of the covariance within each group as well as the variable covariance across the total number of samples. In addition, the ratio is invariant under non-singular linear transformations of the original data (such as standardization), and does not assume that the groups within the data are spherical in nature--it does, however, assume that all the groups have a similar hyperdimensional shape (cf. Scott and Symons 1971; Everitt 1977).

In brief, the Fine Orange-Fine Gray clustering was performed by CLUS starting with the raw chemical concentrations. These data were standardized and the eigenvectors were calculated, ten being retained as the new variables for clustering. An initial random partition into two groups was made and then iteratively evaluated by a series of sample reallocations until the "best" partition was obtained as evaluated by the maximization of $|T| / |W|$. The change in log (max ($|T| / |W|$)) as the number of groups increased was used as an informal indicator of the number of "natural" groups contained in the data set (see Chapter 3, Figure 3).

Assessment and refinement of the trial groups formed by CLUS drew upon a battery of related techniques utilizing variable correlations and the heuristic use of multivariate statistics.

8 → Single group evaluation: Mahalanobis D^2

It has been known for some time (Harbottle 1970) that in some groups of archaeological ceramics two or more elements are correlated: correlation coefficients higher than 0.90 are frequently encountered (Brooks et al. 1974). Correlation of elements A and B in effect removes some of the value of the analytical information: if we have analyzed a sample for element A, then we also know, at least roughly, the concentration of element B. On the other hand, for a group of samples, the fact that A and B (and perhaps other) elements are correlated is itself useful knowledge, enabling us to distinguish groups from one another. To return to the hyperspace of analytical data described in section C above, we may see that uncorrelated groups would be (hyper) spherical, while correlated groups would be represented by stretched out ellipsoid (cigar shapes). The degree of correlation was determined in the Mayan fine-paste groups by calculating a correlation matrix -- i.e., the correlation coefficient between all possible element pairs. When a group has been established, we may calculate the Mahalanobis (1936) distance D^2 between each sample and the centroid of the group (Sneath and Sokal 1973:405): such distances, for infinite multivariate-normal distributions, are distributed as chi-squared. For smaller (randomly-drawn) populations, the probability of group membership may be calculated for any point in the hyperspace, including any sample-point, from Hotellings T^2, the multivariant equivalent of Students' t.

Multiple groups: Discriminant Functions

With more than a single group under consideration the problem becomes one of discrimination and involves the technique of linear discriminant analysis (Fisher 1936; Rao 1948). The original variables are weighted into new combinations that will best separate the groups under consideration. This new set of axes is usually fewer in number than the original number of variables; thus visual separation of the data points may be enhanced. The Mahalanobis distance between group centroids and the distance of any sample to its group centroid are calculated and the probability of group separation or sample inclusion within a group is again evaluated by Hotelling's T^2.

Two differences between our use of a single group evaluation by ADCORR and multiple discriminant analysis require mention. ADCORR operates in a standardized log concentration hyperspace and requires about a 3 to 1 ratio of samples to variables before there can be real confidence in the probabilty statements. It is, therefore, most useful for group evaluation where large numbers of analyses are available.

Discriminant analysis as performed by SPSS (Nie et al. 1975) operated in a standardized concentration space (although a log transformation could have been performed as a prior step). Under SPSS Version 7, a pooled variance-covariance matrix was used. That is, the group separations were viewed relative to a matrix calculated over all groups. This allowed for the evaluation of systems in which some groups had only a few members. Both the programs ADCORR and SPSS are useful in testing and refining groups, and as such form links in an iterative chain leading to final groupings.

Q-mode Factor Analysis

Q-mode factor analysis is a multivariate technique which was employed to investigate the relationship among Fine Orange-Fine Gray and other, possibly related, pottery groups. While this technique has received fairly extensive application in geology (cf. Joreskog, Klovan, and Reyment 1976), it has been infrequently utilized in compositional characterization studies. Archaeometric applications include Bishop 1975; Rands et al. 1975; Bishop 1979; Veakis 1979).

Briefly, it requires that a suitable measure of similarity between the objects be chosen and then based on that measure, an N by N matrix is formed containing the degree of similarity pairwise among all N items. For the present investigation, the "index of proportional similarity" as proposed by Imbrie and Purdy (1962) was used. That is, the similarity between two row vectors is defined by the cosine of the angle between the vectors in the p-dimensional variable space. The N by N matrix is frequently quite large; thus, finding the rank of the matrix by eigen-analysis may provide a way of describing the sample relationships in fewer dimensions. This reduced rank matrix can be thought of as representing theoretical "end members" of which the samples are considered linear combinations. We also want to know the composition of the end members in terms of the original variates. According to Imbrie (1963) these end members may have the most divergent compositions.

As stated above the end members are approximated by the "significant" eigenvalues. To assist in seeking end members that are maximally distinct in composition, a varimax rotation of the axes may be used. The relationship of the objects is then described relative to these new reference vectors. (The details of the actual procedure that was used may be found in Klovan and Imbrie 1971; Bishop and Veakis nd. present an overview of the technique with archaeological applications).

This chapter has summarized the analytical and mathematical procedures that have played a major role in the preparation of the present report. The discussion of statistical techniques employed in various stages of the data reduction has not been exhaustive in that the fine paste data have also been considered from many other statistical perspectives.

We close by reiterating the need for purely chemical data to be supplemented by other types of information--petrographic, archaeological, etc. In the absence of such independent verification, it is doubtful if the splitters' view taken by Bishop and Rands (Chapter 3) could have been sustained on purely chemical grounds. The Maya Fine Orange-Fine Gray project well illustrates that an investigation into ceramic production zones must be truly multi-disciplinary in nature if the archaeological potential is to be realized.

NOTE

1. The authors acknowledge with pleasure the continuing assistance of the High Flux Beam Reactor operating crew and the fine technical assistance rendered by Mrs. Elaine Rowland.

This work was carried out under the auspices of the U. S. Department of Energy.

CHAPTER THREE

Mayan Fine Paste Ceramics:

A Compositional Perspective

by

Ronald L. Bishop and
Robert L. Rands

this time a reasonably extensive chemical data base for fine paste pottery had been realized at the Brookhaven National Laboratory. The speed of the computer combined with the power of multivariate statistical techniques provided means of probing the relationships among chemical and petrographic data. Although general agreement was obtained between petrography and Brookhaven's provisionally recognized chemical groups, petrographic heterogeneity was observed within the Fine Orange-Fine Gray section of the dendrogram (Rands et al. 1975; Fig. 2, A-P). In view of current hypotheses regarding a single source of Fine Orange-Fine Gray ceramics, such heterogeneity indicated the need of additional sampling and numerical refinement. It was believed that petrographic data would serve to interpret and evaluate chemical patterns, the combination of the two approaches being more satisfactory for archaeological reconstruction than either considered in isolation (cf. Harbottle 1977: 64).

Not included in the paper cited above (Rands et al. 1975) were fine paste ceramics from Altar de Sacrificios and Seibal, which had previously been analyzed at Brookhaven National Laboratory. Subsequently, Bishop (1975) considered these materials along with fine paste pottery from sites on the Usumacinta River. The predominance of Pabellon Modeled-carved in one of his resulting groups was striking. Then-available petrographic data supported the chemically-derived groups.

Utilizing more sophisticated clustering procedures, Bishop (1976a) continued the Fine Orange-Fine Gray investigation. Provisional chemical groupings were identified, having loci toward the Pasion and downstream on the Usumacinta. Petrographic patterning was indicated, although

INTRODUCTION

Ceramics included in the present investigation of Fine Orange and related wares reflect diversity in sampling. Typologically recognized units from the Maya Terminal Classic bear the thrust of the present investigation, although materials dating from earlier in the Classic and from the Postclassic are represented. In addition, fine past pottery from outside the Maya area, which has been considered to have a possible relationship to Maya Fine Orange and Fine Gray, is included. Also considered are certain pottery samples, from within the Maya area, which provide needed perspective. This is to say that sampling has been extended slightly beyond what many archaeologists would regard as "good" Fine Orange or Fine Gray. Certain Maya fine paste ceramics, which diverge widely from "standard" Fine Orange-Fine Gray, are excluded. In some cases, the divergence was initially observed by the archaeologist on stylistic grounds or because of ware characteristics such as paste color. In other cases, marked divergence within fine paste pottery has been demonstrated by chemical analysis of paste composition, thereby eliminating the pottery from present consideration.

Sampling methods varied in the selection of pottery submitted for neutron activation. In some instances sherds having clearly identified typological affiliations were submitted, although in other cases diagnostics consisted of little more than paste color and texture. Such a frequent lack of clear cultural diagnostics confounds interpretive efforts.

Although Rands (1969) had previously utilized petrography in the investigation of both fine paste and tempered pottery in the Palenque region, the first major attempt to relate petrographic and chemical data for fine paste ceramics was not published until 1975 (Rands et al.). By insufficient analyses prevented firm conclusions from being drawn. Steps were taken to rectify this weakness. Additional thin sections were prepared and analyzed, obtaining comparative information from specimens which had previously undergone neutron activation.

In 1969, sherds from the Peabody Museum excavations at Altar de Sacrificos and Seibal had been submitted to Rands for petrographic analysis, and certain of these eventually underwent neutron activation. Thus, an expanded, although incomplete, petrographic data base was established for the Altar Ceramic Group. This supplemented extensive petrographic data derived from Rands' survey in northern Chiapas and adjacent Tabasco. All petrographic analyses were carried out by Dr. Pei-yuan Chen, currently with the Indiana Geological Survey.[1]

The investigative stages summarized above encouraged us to seek the finest interpretable partitions provided by the compositional analyses. Increasingly, our objective has been to obtain stable chemical groupings that reflect petrographic patterning and are useful to the archaeologist. The hypothesis of a single locus of Maya Fine Orange manufacture was being tested (Sabloff and Willey 1967; Sabloff 1970, 1973). Problem areas included the nature of relationships of the Terminal Classic Altar and Balancan Groups of Fine Orange Ware, one to another and with the Tres Naciones and Chablekal Groups of Fine Gray Ware. Compositional relationships with Postclassic Fine Orange ceramics were also being explored as a guide to continuity of the Maya fine paste tradition. Chemical relationships of the Maya materials with fine paste pottery from outside the Maya area could have become an important focus of the investigations, but it was quickly apparent that such relationships do not exist in the sampled ceramics on the refined level of analysis which was being followed (cf. Harbottle and Sayre 1975).

ANALYTICAL STEPS

Following the preliminary investigations summarized above, a series of steps led to increasing refinement and evaluation of the Fine Orange-Fine Gray compositional data. For convenience, these will be numbered sequentially; operationally, statistical analysis proceeded along these general lines.

1. Drawing on Bishop's preliminary report (1976a), Fine Orange and Fine Gray ceramics from the Maya area were viewed relative to fine paste materials of non-Maya provenience. Non-Maya sampling was from Lambityeco, Oaxaca; El Tajin and San Lorenzo Tenochtitlan, Veracruz; and the Tuxtla area sites of Tres Zapotes, El Picayo, Matacapan and Matalapan. Fine paste oranges and grays were largely represented in this sampling.

Normalizing the chemical variables to the percent of their range, the data were subjected to a Q-Mode factor analysis. Three factors were extracted and rotated to varimax positions. These factors served as apices of a triangular diagram which displays 95 percent of the variation within the data (Fig. 2). The varimax factor matrix is presented in Table 2.

Separation of the Maya and non-Maya pottery is pronounced along the first factor, which primarily reflects chromium and cobalt concentrations. In addition, the non-Maya ceramics tend to separate according to site provenience. The factoral partition of Maya from non-Maya fine pastes appeared sufficiently strong to warrant consideration of pottery from the Maya area as a distinct compositional unit, subject to further subdivision.

2. A more exhaustive search was made of the extant data base to bring together all examples of Maya-provenience Fine Orange and Fine Gray wares and pottery of apparently close affiliation. Recognizing the problems inherent in a limited sample size, data reduction of this range of fine paste ceramics led to certain heuristic procedures and observations.

2.a. Although the iterative clustering procedure being utilized (CLUS) has performed well in other applications (Bishop 1976b), it has been found to be quite sensitive to highly divergent specimens. Clustering efficiency is lost, groupings tending to isolate individual divergent specimens rather than providing overall patterning within the data set.

To prevent this, removal of the highly divergent specimens appeared useful. This was accomplished by calculating a specimen's Mahalanobis distance (D^2) from the overall group centroid. Those specimens lying outside a 95 percent confidence interval were removed. After five iterations, considerable group stability resulted (Table ~~2~~ 3). The 76 samples which had not been removed were then ready for "pre-classification" analysis by CLUS (Rubin and Friedman 1967). This total is only slightly less than the 78 sherds which had been removed—pottery that, for one reason or another, had been considered close enough to "standard" Fine Orange-Fine Gray to have been submitted for analysis. Also among the 78 sherds were fine paste materials, from Tortugero and Comalcalco, which had been included for the perspective which they offered to paste compositional or stylistic considerations.

The 76 samples which had been retained by D^2 iteration were then input to CLUS. Operating in the space of the first ten principal components, accounting for 99 percent of the variance, CLUS was stepped from two groups to seven. At each step group membership was determined in accordance with the maximization of the Wilks-Lambda criterion, i.e. log $\frac{/T/}{/W/}$. Of interest is the manner in which the values of the log maximum $\frac{/T/}{/W/}$ reflect the group structure within the Fine Orange-Fine Gray ceramics. Following the initial formation of two groups, a declining gradient is present throughout the graph (Fig. 3). The major deflections in the graphed function occur after the formation of five and six groups. The small changes in gradient attest to the overall similarity of the ceramic paste composition. The stronger deflections beyond five groups reflects the formation of splinter groups composed of one or two sherds. Although weakly expressed, five clusters seemed best to represent the number of "natural", empirically-derived groups inherent in the data. Not fully appreciated at first was the significance of the declining gradient following the initial formation of two groups. A possible explanation for this phenomenon will be given when considering paste compositional units and typological correlations.

The now-clustered 76 samples were then subjected to discriminant function analysis using the SPSS package (Nie et al. 1975).[2] On the basis of their discriminating power, the chemical variables were selected stepwise by the program. The discriminating criterion was the overall multivariate F ratio used to test the differences between the group centroids. All of the chemical variables were found to contribute significant discrimination. The greatest discrimination was provided by barium and thorium and the lest by titanium, sodium and lutecium. The coefficients for the four standardized discriminant functions are listed in Table 4. Using the classification options of SPSS, 100 percent of the 76 cases were found to be correctly classified; however, four specimens had probabilities of group containment outside of the 95 percent confidence interval suggesting that they were not members of any of the groups being considered. These specimens were removed. Three sherds which had been removed during the initial data screening stage and four sherds for which CLUS data were missing were found to have high probabilities of projected group membership according to SPSS and were therefore added to their respective group. A final run through the discriminant analysis revealed 100 percent correct classification with all samples laying within a 95 percent confidence interval about their respective group centroid.

The five clusters derived by CLUS and evaluated by SPSS represent our operational Chemical Paste Compositional Reference Units (CPCRUs).[3] This set provides the chemical basis for our finest division of standard Fine Orange-Fine Gray--a "splitter's" rather than "lumper's" view of the archaeological problem. Compression of the five groups is possible, thereby forming a different set of reference units (see Data Step 2.b).

Correspondence found with the available, independently-derived petrographic data serves as a form of validation of the CPCRUs. The extent of congruence between chemical and petrographic data provides perspective on the relative utility of a splitting or lumping approach to specific archaeological problems. Although a degree of circularity is involved, an additional form of validation follows from the amenability of the CPCRUs to archaeological interpretation.

The five Maya Fine Orange-Fine Gray CPCRUs will now be considered as to their substantive content.

The distribution of the five CPCRUs can be seen in two dimensional discriminant space in Figures 4-6. The separation of CPCRU 3 from the other reference units is apparent along the major axis of discrimination, the X axis of Figures 4 and 5. Also well separated is CPCRU 1. On the other hand, the combination of the second and third discriminant functions isolates Units 2 and 4 (Figure 6). Throughout, CPCRU 5 maintains a centralized position. For convenience, broken lines have been added to the plot of Discriminant Functions 1 and 2. These serve to reference the CPCRU positions in subsequent figures, where the sample coordinates are held constant and supplemental information is projected.

Figure 7 permits correspondences to be seen between the chemically-derived groups and a single petrographic variable, volcanic dust. The dust, or volcanic glass, is minute in particle size and would occur naturally in the clay matrix rather than being added as a tempering material. Characteristic presence of volcanic dust in all other fine paste reference units contrasts sharply with its total absence (in petrographically analyzed ceramics) in CPCRU 3. Quantitatively, there is greater abundance of volcanic dust in CPCRUs 2 and 4 than in other units. Thus, from both chemical and petrographic data, CPCRU 3 stands sharply apart. As will be discussed subsequently, this unit is mostly represented by decorated types of the Altar Ceramic Group of Fine Orange Ware.

Figures 8 and 9 show provenience for the five CPCRUs. Essentially this is done according to site in Figure 8. The regional breakdown in Figure 9 corresponds generally to archaeological provenience along the Usumacinta drainage. "Upstream" and "Downstream" positions are indicated. The "Upstream" division comprises the Usumacinta River sites of Piedras Negras and Altar de Sacrificios plus the Pasion River site of Seibal.

Various sites on the Usumacinta River below Boca del Cerro are included in the "Downstream" category; sherds from Jonuta and Calatrava are best represented.

"Upstream" sites are primarily represented in CPCRUs 3 and 4. Conversely, "Downstream" sites occur largely in Units 2 and 5. Lying just outside the Usumacinta drainage, the site of Palenque is represented only in the 1 and 5 groupings. Among the comparatively small number of specimens unidentified as to location in Figure 9, sherds from Yucatan occur mainly in Unit 1 and those from Peten and Belize mostly in Unit 3. It is with reference to this distribution within the Usumacinta drainage that the terms "Upstream" and "Downstream" are given an extended connotation, being applied to chemically-defined reference units (CPCRUs 2-5) as well as to their relative geographic position.

2.b. Utilizing the petrographic and distributional patterns, a modification was made, compressing the five CPCRUs into three divisions. Unit 3, striking for its absence of volcanic dust and its strong Upstream locus, was retained. Units 2, 4 and 5 were merged. Ceramics of these reference units share appreciable amounts of volcanic dust and a distribution that is primarily in the Usumacinta drainage. Unit 1 is characterized by sites lying barely to substantially outside this drainage system. Archaeologically, Silho Group (X) Fine Orange is well represented in this reference unit. With the addition of non-chemical information, a new conceptual category emerged, the Paste Compositional Reference Unit (PCRU).[4]

Chemical variables of this compressed set of three paste compositional reference units were fed into SPSS, two new discriminant functions being defined (Table 5). The location of the data points relative to the discriminant axes is shown in Figure 10. Again, as evaluated by the classification procedures of SPSS, 100 percent "correct" classification occurred.

2.c. The three PCRUs of step 2.b. were combined with closely related fine paste materials from the Maya area and finely textured non-Maya pottery of essentially orange and gray paste colors. The petrographically distinct ceramics from Tortugeuro (Rands et al. 1975: 538) were included because of chemical and occasional stylistic similarities to some of the Maya Fine Orange-Fine Gray pottery, thus providing perspective. Ceramics from the non-Maya sites were included to give Maya Fine Orange a still larger perspective. Subjected to less rigorous clustering procedures, these non-Maya groups have been formed partly on the basis of ceramic provenience, as is suggested by their distribution in Figure 2. Thus, to the three PCRUs were added Tortuguero, which had been removed during initial screening (step 2.a, Table 7.6), and the three non-Maya groups.

The seven resulting groups were subjected to discriminant analysis. Standardized discriminant function coefficients are given in Table 6, and the plot of the samples relative to the first two discriminant axes is shown in Figure 11. Sherds from Labityeco, Oaxaca, were projected onto the axes defined for the above groups. The separation observed along the first dimension reinforces the distinction between Maya and non-Maya Fine Orange-Fine Gray as seen in Figure 2.

3. A large number of samples, many typologically defined, had been removed as group "outliers" prior to partitioning by CLUS (see Step 2.a). Therefore, it was important to consider their possible relationships to reference units that were ultimately obtained. Relationships were viewed relative to the five CPCRUs and the three PCRUs (Steps 2.a, 2.b; Figs. ~~3-5, 9~~ 4-6, 10), each outlying sample being projected onto the discriminant axes. Additionally, each sample's resemblance to the nearest group centroid was calculated. For the five CPCRUs, only eight samples fell within any group's 95 percent confidence interval, whereas 18 samples have this projection for the three PCRUS (Table ~~6.7~~ 7.7).

PASTE COMPOSITIONAL UNITS AND TYPOLOGICAL CORRELATIONS

Non-Maya. Set off chemically from Maya Fine Orange and Fine Gray Wares, three non-Maya fine paste groupings show strong regional patterning (Fig. ~~10~~ 11). These groups comprise pottery from the major sites of El Tajin and San Lorenzo Tenochtitlan and from a site cluster in the Tuxtlas. These clusterings should not be regarded as final; subdivisions are possible, especially in the group defined for the Tuxtlas. Not included in the above, sherds of Lambityeco provenience pose a special problem. The case by case projection of samples repeatedly indicates strong probabilities of membership in the Tuxtlas group. On the other hand, various dendrogrammatic representations have suggested that some separation between Lambityeco and the Tuxtlas is possible. Although trade in sampled fine paste ceramics can probably be ruled out between the Maya and non-Maya regions, the relationships of Lambityeco and the Tuxtlas remains open to speculation. (Fine paste samples from sites in Oaxaca and Veracruz are considered in detail in Sayre and Harbottle n.d.).

Maya: Upstream and Downstream Usumacinta Divisions. Broadly conceived, most of the Maya fine paste pottery sampled in the present investigation has projected affiliations with the Usumacinta. In part, this may be due to the proximity of sites, from which samples were taken, to this river. What is the role of this riverine system? This question has dual aspects. One concerns the Usumacinta as an artery of distribution for fine paste ceramic trade. The second, pertaining more directly to mineralogical and chemical differentiation of naturally occurring materials along the riverine drainage, is crucial to problems relating to resource procurement and manufacture.

Interpretations may now be drawn for the Upstream and Downstream CPCRU distributions of Figure 9. Recalling the graph of the clustering criterion function (Fig. 3), the steepest gradient resulted from the formation of two groups. Utilizing the coordinates derived for the five CPCRUs (Step 2.a), a line has been drawn to enclose one of the two initially formed groups (Fig. 12). With few exceptions, the encircled unit dominated by the "U" symbol contains ceramics with an Upstream provenience. Although cutting across petrographic lines for volcanic dust as observed earlier (Fig. 7), this suggests that important chemical differentiation is present in the Upstream and Downstream groupings. Apparently the first partition of the data set by CLUS reflects a broad level of riverine chemical differentiation, whereas a number of subsequent partitions form units which are more homogeneous, both chemically and petrographically.

<u>Maya: "Usumacinta", "Pasion" and "X" divisions</u> (CPCRUs 2, 4, 5; 3; and 1, respectively). Formation of the three PCRUs (Fig. 10) took into consideration chemical, petrographic, geographic and typological information. We now examine the latter aspect.

Fine Orange and Fine Gray wares are shown for the three PCRUs in Figure 13. Fine Gray Ware is relatively abundant in PCRU 2 and virtually absent in PCRU 3. It may be noted, however, that a number of the sherds in the latter group are not fully oxidized.

Ceramic groups are given in Figure 14. Partly reflecting differential sampling, the Altar (Y) Group of Fine Orange Ware is well represented in the PCRUs compared to Balacan (Z) and Silho (X), with only a single example of the Matillas (V) Ceramic Group being present. In Fine Gray Ware, the Tres Naciones and Chablekal Groups have modest representation. Miscellaneous fine paste orange and gray pottery, not assigned to ceramic group, are included in the diagram.

The predominance of the Altar Group in PCRU 3 is striking (76 percent). This ceramic group is also represented in PCRU 2 but is absent from Unit 1. The Balancan Ceramic Group (five specimens) can be observed in all units, its greatest frequency being in PCRU 2. Absent from Unit 3, specimens of the Silho Group are found in PCRUs 2 and 1. In the latter unit, members of the Silho Group comprise over 50 percent of the total. In the PCRUs, Fine Gray Ware is represented exclusively by the Chablekal Group in Unit 1 and by the Tres Naciones Group in Unit 3, both ceramic groups being present in Unit 2; occurrences are low, however, consisting of only one or two specimens in each unit.

Ceramic type totals for the three PCRUs are listed in Table 7, which includes categories for Fine Orange and Fine Gray Wares, unspecified as to type. The exclusive occurrence in PCRU 3 of Pabellon Modeled-carved (comprising 32 percent of the unit), Islas Gouged-incised and Cedro Gadrooned suggests a close association with decorated types of the Altar Group.

Maya: "X," "Middle Usumacinta," "Pasion," "Upper Usumacinta" and "Lower Usumacinta" Divisions (CPCRUs 1-5, respectively). Sufficient distributional patterning exists to relate the previously numbered CPCRUs of Data Step 2 (Figs. ~~3-5~~ 4-6) to geographical loci. Except for "X," these terms have primary reference to subdivisions of the Usumacinta drainage; they are used by extension to designate the CPCRUs which have corresponding geographic associations. The units are now viewed from the standpoint of ceramic typology.

Fine Orange and Fine Gray Wares are indicated for the five CPCRUs in Figure ~~14~~ 15. Only minor additional insight is gained over that to be derived from Figure ~~12~~ 13 (three PCRUs). Fine Gray Ware constitutes a slim majority of the samples from Unit 4 (Upper Usumacinta); this ware was a minority in each of the three PCRUs.

Ceramic groups for the five CPCRUs are indicated in Figure ~~15~~ 16. Only subdivision of the Usumacinta PCRU 2 gives supplementary information to that shown in Figure ~~13~~ 14. The Balancan and especially Altar Groups reflect the composite nature of the Usumacinta division, being broadly represented in the CPCRUs. The Tres Naciones Group, however, has its major occurrence (67 percent) in CPCRU 4.

Ceramic types for the five CPCRUs are given in Table 8. As before, the Pabellon Modeled-carved association with Pasion (Unit 3) is most pronounced. Both Trapiche Incised and Tumba Black-on-orange -- member of the Altar Ceramic Group -- have principal compositional association with the Lower Usumacinta (CPCRU 5).

Maya: Non-reference Unit Fine Paste. Numerous Fine Orange and Fine Gray sherds were removed during the initial stages of Data Step 2. Table 7.7 indicates the stage of removal. These specimens constitute outliers to those ceramics that were subsequently partitioned into the chemical paste compositional reference units. The outliers are now considered in terms of their resemblance to the centroids of the three PCRUs of Data Step 2.b (Fig. 10).

In Figures 17-20, outliers are projected relative to the two discriminant axes defined for the three PCRUs of Figure 10, lines being added to enclose the general regions occupied by each PCRU. Symbols are given to outlier sherds according to ceramic group (Figure 17) and site (Figure 18). Although the majority of the outlying specimens are widely dispersed, recall that some samples projected within a 95 percent confidence interval about a PCRU centroid. Although general, some inferences can be drawn from the ceramic distributions shown in Figure 17.

Little patterning exists as to ceramic group in the regions defined for the three PCRUs. In that for Unit 2 (Usumacinta), the Chablekal Group is represented by Palenque and the Downstream site of Tierra Blanca. Balancan Group ceramics (Provincia Plano-relief Type), sometimes thought to have a Downstream or coastal locus, are represented in the region defined for Unit 3 by the sites of Piedras Negras and Seibal. Two sherds of the Silho Group lie near the region of PCRU 1, perhaps further strengthening the association of these ceramic and compositional units.

The most evident patterning observed in Figure ~~16~~ 17 is for members of the Matillas (V) Ceramic Group. Widely dispersed, these sherds tend to occupy peripheral positions on the plot and fail to fall within a working confidence interval about any of the PCRUs. Much the same can be said for Fine Orange Ware that is unassigned as to ceramic group. Although a few fine Orange specimens project into the regions assigned for the three PCRUs, others are so aberrant chemically as to have coordinates lying outside the limits of the plot. Of interest is the marked heterogeneity of specimens projected into the region of Unit 3. It will be recalled that this unit is based on the chemically, petrographically and typologically stable CPCRU 3. As seen in Figure ~~19~~ 20, the outlier sherds that project into the region of this unit are generally similar to CPCRU 3 in their absence of volcanic dust. This absence is seen elsewhere in the diagram, however.

The designation of outliers by site (Fig. 18) again shows little overall pattern. The small cluster of sherds from Comalcalco is of interest as is an only somewhat less closely spaced grouping of Tortuguero ceramics, although not all specimens from these sites are included in the clusters. Sherds from Becan are widely dispersed yet tend to occupy peripheral positions, low on the X and Y axes.

Typological assignment of outliers that did not enter into the formation of the CPCRUs are given in Table 8. Of the total Provincia Plano-relief sherds that are analyzed, only half are readily assignable to the PCRUs. On this and other grounds it appears that the Provincia Type, often considered a Balancan Group diagnostic, is not cohesive compositionally. Four sherds, constituting one-third of the sampling of Pabellon Modeled-carved, are non-assigned outliers, although otherwise the type is markedly homogeneous with its strong representation in Unit 3. On the other hand, the Altar Orange Type, which is widely distributed among the CPCRUs, has relatively few outliers (20 percent). Insufficient chemical sampling limits discussion of relative compositional uniformity among most of the types.

Table 9 lists, by site, the outlier samples that have had petrographic as well as chemical analysis. In seeking possible explanation of the chemical diversity, it is suggested that chemically aberrant sherds may also be divergent mineralogically. A single standard for comparison is necessary; the Usumacinta PCRU 2 of Figure 9 seems best to provide this as it alone merges divisions which are separate in the CPCRUs.

First, it is necessary to characterize petrographically "standard" Maya Fine Orange and Fine Gray as found in the Usumacinta division (Reference Unit 2). Three mineralogical components are pronounced. The clay matrix is consistently micaceous. Volcanic dust, also consistently present, varies in abundance, tending toward Chen's "Common" through "Rare" range (CPCRUs 2, 4 and 5 in Fig. 7). Total feldspar varies considerably but represents about four percent of the grains. The overall characterization can be extended to "X" (PCRU 1) in attenuated form and holds generally true, except for the striking absence of volcanic dust, in the Pasion division (PCRU 3).

Returning to Table 9, the direction of mineralogical divergence — greater or less than in the Usumacinta -- is indicated. Although sherds occur which do not appear to differ in petrographic diagnostics from those of the Usumacinta division, in approximately 85 percent of the cases deviation on at least one attribute can be observed. The most frequent mineralogical expression of deviance in outlier sherds appears to be the absence of volcanic glass, although the absence of a micaceous matrix may be of at least equal weight in contributing to the degree of chemical variation as a single outlier is considered relative to the Usumacinta. Fine paste ceramics from Comalcalco and Tortuguero require special mention, volcanic dust being consistently absent in both cases; additionally, feldspar tends to be unusually abundant at Tortuguero.

A →

ARCHAEOLOGICAL INTERPRETATION

The role of the Usumacinta drainage is central to the present structuring of the Maya Fine Orange-Fine Gray problem. It is recognized that "homelands" of this tradition may lie, in part, outside the drainage. Sherds analyzed chemically at Brookhaven National Laboratory are the basis of the present investigation. With the exception of non-Maya fine paste pottery from Veracruz and Oaxaca, sampling has predominantly been centered on or close to the Usumacinta. It is inevitable, therefore, that conclusions to be drawn from the study have an Usumacinta bias.

Chemical variability has been demonstrated in ceramics having an Usumacinta drainage provenience. Four of the five recognized chemical paste compositional reference units (Figs. ~~3-5~~ 4-6) apparently relate on distributional grounds to subdivisions of the drainage. Largely, we are discussing Fine Orange of the Altar and Balancan Ceramic Groups, although Fine Gray Ware, generally assignable to the Tres Naciones and Chablekal Groups, is also considered. These ceramic groups fail to provide chemically homogeneous units in paste composition. Rather, the distribution of chemical clusters is geographically more specific than that of the typological units. A major question confronting us is whether the heterogeneity of typological distribution essentially implies trading activities or is mainly a reflection of variation of raw-material procurement zones within the riverine system.

Two of the four chemical paste compositional reference units share a geographical locus downstream on the Usumacinta. These units comprise CPCRUs 2 and 5 (Middle and Lower Usumacinta). Within the sampled ceramics, materials from Calatrava and Jonuta predominate in Unit 5. Calatrava is also represented in Unit 2, along with the sites of Trinidad and Arenitas. Upstream on the Usumacinta drainage are the chemically and petrographically distinct CPCRUs 3 and 4 (Figs. ~~3-5, 11~~ 4-6, 12); best sampled are Seibal, Altar de Sacrificios and Piedras Negras. Units 2-5 are sparsely represented outside the Usumacinta drainage. Most notable are the Peten site of Uaxactun and the Belize sites of El Cayo and Lubaantun, each of these sites being represented in CPCRU 3. Two of the four sampled sherds representing these non-Usumacinta drainage sites are of the Pabellon Modeled-carved Type.

As will be recalled, the non-volcanic CPCRU 3 is exceptionally well represented by decorated types of the Altar Ceramic Group, especially Pabellon Modeled-carved. Why should this Upstream compositional unit, which has strong chemical affiliations with the Usumacinta in general and Unit 4 in particular, be petrographically and typologically distinct? A possible explanation takes into consideration the geological regions drained by the headwaters of the Usumacinta. The Salinas (Chixoy, Rio Negro) drains the volcanic uplands of Guatemala, thereby contributing a range of volcanic materials such as pumice, ash, and dust.[5] In contrast, the Pasion River arises farther to the north and east in essentially non-volcanic terrain.[6] It may be, therefore, that the region of resource procurement for CPCRU 3, as well as the archaeological concentration of this unit, lies in the Pasion drainage. The lower Pasion, in particular, is characterized by wide alluvial floodplains. The lagoons, oxbows and probable natural levees (Willey et al. 1975:11) offer an analogous hydrological situation to the lower Usumacinta. Annual flooding in these settings would have allowed the accumulation of fine sediments, suitable for the production of fine paste pottery. As shown by analyses at Brookhaven National Laboratory, clay samples from the region of the confluence of the Pasion and Salinas Rivers have strong chemical resemblances to clays obtained downstream on the Usumacinta, from Boca del Cerro to Jonuta. A homogeneous riverine system, with minor chemical differentiation, is indicated. It is under such circumstances that a petrographic variable such as volcanic dust provides means for assessing chemical similarity and differences.

Partly as the result of less extensive sampling, we cannot relate specific petrographic and hydrologic information to chemically distinct fine paste pottery, the provenience of which is centered outside the Usumacinta drainage. Nevertheless, more general environmental considerations appear relevant to the problem of sourcing Fine Orange and Fine Gray Wares of non-Usumacinta orientation.

CPCRU 1 may be considered in this connection. Primary cultural affiliations apparently exist to the Silho Group of Fine Orange Ware with secondary associations extending to the Fine Gray Chablekal Group, and archaeological proveniences of at least the Silho Group are centered outside the Usumacinta drainage. Nevertheless, it will be recalled that CPCRU 1 was not isolated in the initial formation of two groups by CLUS (Fig. 12), suggesting, as in the case of the other compositional groupings, that Unit 1 has affiliations to sediments from the Usumacinta drainage. Apparently, therefore, the production zone for Unit 1 is not a totally discrete or distant one. Possibly this CPCRU has its source in the deltaic system of the Usumacinta, where mixed sediments account for the observed chemical differences. Such mixture would seem to be most pronounced where distributaries of the Usumacinta and Grijalva merge, but Silho Group pottery is poorly known from this general area. Lying outside the relatively well defined eastern boundary of the Usumacinta delta, sediments to the east and north of Laguna de Terminos may be too divergent to have served as raw materials for CPCRU 1; several morphogenic systems provide discontinuities which are probably reflected in the sediment chemistry. Such rivers as the Candelaria empty into the Laguna de Terminos, carrying sediments which may have a different chemical fingerprint than those of the Usumacinta. A hilly karst region extends to the coast between Champoton and Campeche, separating the eastern Tabasco-Campeche alluvial plain from the narrow coastal belt of lagunal swamps and marshes to the north, and in spite of its heavy Silho occupation it appears questionable if the latter zone would provide requisite clays for CPCRU 1 Fine Orange Ware (see West 1964; Figs. 4, 18; West, Psuty and Thom 1969; Figs 16, 17; Eaton 1978: 4, 17-18). The evidence, then, is inconclusive, but these are some of the factors to be reckoned with in attempting to source CPCRU 1 or to determine the production zone or zones of the Silho Ceramic Group.

Compositional affiliations with the Usumacinta-oriented CPCRUs seem weaker for the Matillas Group than for Silho ceramics. On the basis of the limited sampling, diverse places of manufacture might be inferred for the chemically heterogeneous Matillas materials. However, a geographically limited area which includes alluvium from distinct sources could perhaps provide the level of chemical diversity which has been noted. This requirement might be met if manufacturing communities were located along active or abandoned channels of the Grijalva and Chilapa before and after merging with western distributaries of the Usumacinta (West, Psuty and Thom 1969; Figs. 8, 15-17). This is, in any case, a zone of abundant Matillas Group ceramics.

How is the trade, as investigated archaeologically, to be assessed? Minor chemical variation, typology, and sherd provenience have shown varying degrees of association. If there is a strongly patterned association, as in the case of Pabellon Modeled-carved, a restricted resource zone with subsequent trade may be inferred. For example, trade from the place of manufacture to such widely separated sites as Piedras Negras and Lubaantun is indicated. If, on the other hand, associations among paste composition, typology and provenience are blurred, the resulting lack of pattern gives the archaeologist little basis on which to assess trade. The sometimes arbitrary nature of ceramic typology additionally confounds such assessments. Distinctive clusters of stylistic features or other cultural variables not incorporated in the formal taxonomy provide further evidence on which to evaluate the possibility of trade, yet in the absence of technological information about the ceramic pastes, the diffusion of stylistic concepts is normally a ready alternative to the exchange of goods.

Obviously, the demonstration of geographically-distinct groups based on differences in ceramic paste does not, in itself, rule out the possibility of trade. Such groups can indeed provide a strong indication of exchange and the directional movement of the traded pottery when several conditions are met. (1) The chemical-compositional units are strongly clustered in statistical space; differences may be minor but are clearly defined. (2) Members of a single compositional group are found in several areas of differing resource procurement, as determined chemically or mineralogically. (3) These ceramic specimens have compositional configurations that are also diagnostic of one of the resource procurement zones. (The degree of similarity which is requisite between raw clays and finished ceramic products is a complex matter even in untempered ceramics; chemical and mineralogical changes due to such factors as levigation and firing require further investigation.) Unfortunately, geochemical information about resource procurement zones is usually imprecise to lacking; we have been able to refer only in general terms to chemical similarities in clays obtained from the Altar de Sacrificios and Boca del Cerro to Jonuta regions or to the probable absence of volcanic dust in sediments from the Pasion as compared to those of the Salinas and Usumacinta. On the other hand, the existence of significant environmental differences may be inferred on the basis of strong patterning in the ceramic data as the chemical analytical units and archaeological provenience are juxtaposed. This approach will be developed further in the following chapter; we note here the consistent, nonrandom occurrence of CPCRU 3 and 4 sherds at Upstream sites on the Pasion and southern Usumacinta and of CPCRU 2 and 5 sherds to the north, at Downstream locations. The inference to be drawn from this distribution is that the pottery generally had a localized, rather than extended, spread from its places of manufacture; patterned similarities in composition indicate the use of a limited number of distinguishable clays, each presumably indigenous to a single procurement-and-production zone. (4) Trade over a greater distance is to be inferred, however, when exceptions occur to this well established pattern. Examples are ceramics from Jonuta in CPCRU 3 (Pasion) and Tecolpan in Unit 4 (Upper Usumacinta) or, in the reverse direction, from Altar de Sacrificios in CPCRU 2 (Middle Usumacinta) and Seibal in Unit 5 (Lower Usumacinta). When one turns to the more diverse resource procurement zones, the presence of CPCRU 1 pottery at Palenque and Yucatecan sites appears to indicate even more widespread trade but from an as yet unidentified source.

A →

PETROGRAPHIC OBSERVATIONS

Although groupings based on chemical variables have been formulated (the CPCRUs) and considered relative to selected petrographic data, supplementary information is useful in characterizing the compositon of "standard" Maya Fine Orange-Fine Gray pottery and its analytical divisions. To this end, frequencies for petrographic variables are given in Figures ~~20-27~~ 21-28. Data are mostly rank-order; class intervals are based on Chen's more detailed analyses.

A partial petrographic profile of Fine Orange-Fine Gray ceramics is based on 46 specimens having membership in the CPCRUs and on variables relating to finely textured particles of mica, volcanic glass, feldspar and opal phytoliths. Four of the CPCRUs are evenly represented (six to eight sherds each), although a larger number (18) in Unit 5 gives a Downstream bias to the sample. Figures ~~20~~ 21 and ~~21~~ 22, which give data for the combined CPCRUs, show coherence in internal structure as compared to the individual CPCRUs (Figs. ~~22-27~~ 23-28), for which the data do not always show marked patterning. Even so, petrographic diagnostics of the separate units are occasionally suggested, at times forcefully.

A high frequency of "Micaceous" and to lesser degree "Very Micaceous" matrix is observed in Figure ~~20~~ 21 for the CPCRUs as a whole. Frequencies are shown in Figure ~~21~~ 22 for other variables relating to mica (muscovite and biotite occurring as grains), and these approximate normal distribution curves centered on the "Rare" interval. As seen in Figures ~~23, 24,~~ 24 and 25, the Downstream Units 5 and 2 have slightly higher concentrations of mica grains than the Upstream CPCRUs; the latter, Units 3 and 4, show almost identical frequency distributions for muscovite. Differences among the CPCRUs are not pronounced in the distributional patterns for mica in Figures ~~22-24~~ 23-25 but seem consonant with the Upstream-Downstream partition.

Volcanic dust also peaks on the "Rare" interval for the combined CPCRUs but shows greater variation for individual compositional groups (Figs. ~~21, 25~~ 22, 26). As discussed earlier, the total absence of volcanic dust in CPCRU 3 is striking. Of further interest is the gradual decrease observed sequentially in CPCRUs 4 (Upper Usumacinta), 2 (Middle Usumacinta) and 5 (Lower Usumacinta). Althought sampling is limited, this is congruent with the decreasing concentrations that might be expected as one moves northward from the volcanic highlands of Guatemala. According to our hypothesis of waterborne transportation of these volcanic particles down the Pasion-Usumacinta and in the absence of overriding factors, the concentration in alluvial deposits would be lessened further from the source area as tributaries, draining non-volcanic terrain, added their sedimentary loads to that of the Usumacinta. Clearly, this is a problem requiring expanded technological sampling of the ceramics and problem-oriented field geology.

Feldspar shows generally higher concentrations in the Upstream than Downstream units (Fig. ~~26~~ 27). Differential abundance is pronounced, however, only in the case of CPCRU 4, and the lowest value is that for Unit 1, geographically peripheral to the Usumacinta drainage. Possibly feldspar has undergone progressively heavier weathering in the Upstream to Downstream sediments. The pattern of decrease along the major artery of the Usumacinta drainage, as expressed in CPCRUs 4, 2 and 5, is that observed for volcanic dust but not for mica grains.

A still different pattern of frequency distributions is found for opal phytoliths, minute opaline particles which are derived from silica-accumulator plants such as grasses (Rovner 1971). Concentrations in the combined CPCRUs are low relative to mica and volcanic dust, phytoliths being undetected (absent or virtually absent) in almost 50 percent of the cases (Fig. ~~21~~ 22). This high absence largely reflects frequencies for CPCRUs 3 and 1 (Fig. 28). For CPCRU 3, the total absence of phytoliths and volcanic dust serves to set off the unit petrographically from the other CPCRUs. In the case of CPCRU 1, the general absence of phytoliths combines with random or unstructured frequency distributions in volcanic dust and mica grains to present a distinct configuration within the "standard" Fine Orange-Fine Gray materials. Heterogenity of sediments within the CPCRU 1 procurement region seems to be indicated, and with additional sampling division of the unit may prove to be necessary. On the basis of the petrographic data considered here, Units 1 and 3 are the most divergent of the CPCRUs; these are the two having loci which are peripheral to the Usumacinta River, forming two of the three PCRUs.

Although patterning exists for petrographic data and the multivariately-derived chemical groups, it is difficult to discern direct correlation between the discreet mineralogical and chemical variables. Units 2 and 4 separate from the other CPCRUs on the second discriminant axis (Figure 4), which possibly reflects the elemental expression of greater volcanic dust abundance (Figures 7, 26). Previous experimentation by analyzing concentrated volcanic ash fractions of pottery from the Usumacinta sites of Trinidad and Tierra Blanca reveal higher concentrations of barium and rubidium as the ash content increases; this observation appears consonant with the findings of Rice (1978), working with pottery from the Guatemala Highlands. Inspection of the Fine Orange-Fine Gray data, however, fails to strongly support the previous associations (see Table 1). Unlike the pronounced changes in elemental concentrations engendered by the addition of temper (Rice 1978; Bishop 1979), direct chemical and mineralogical correlations in fine paste pottery must await further experimentation.

SUMMARY

With full recognition of areas of uncertainty due to smallness of sample size and unevenness of geographic coverage, the following conclusions are advanced.

1. Major compositional differences exist between Fine Orange-Fine Gray ceramics from the Maya area and from the Veracruz-Oaxaca regions.

2. Within the Maya area, the Usumacinta drainage appears to be a major locus of Fine Orange and Fine Gray production of the traditionally recognized Altar and Balancan Ceramic Groups.

3. Micro-compositional differences are discernible within ceramics from the Usumacinta drainage. This argues against trade from a single production center. Archaeological proveniences within the reference units suggest Upstream and Downstream divisions. If sampling is representative, the existence of a number of localized production zones or centers appears highly probable.

4. Pabellon Modeled-carved is the dominant type in a distinct group which may have a manufacturing locus on the Rio Pasion.

5. The Silho Ceramic Group forms a somewhat distinct compositional unit from those of the Usumacinta drainage. This ceramic group, traditionally associated with Chichen Itza and the Campeche Coast, is best represented in our sample by specimens from Palenque.

The investigation of Fine Orange-Fine Gray ceramics has highlighted certain considerations of methodology.

1. Problems of lumping or splitting of conceptual constructs have been met by the use of Chemical Paste Compositional Reference Units and Paste Compositional Reference Units. The chemically-based CPCRUs are statistically derived and represent the primary manipulative device. By incorporating petrographic information with the chemical data, the less specific PCRUs enable geographic-environmental correlates to be utilized.

2. Moreover, verification of chemically-based units by independent data such as that provided by petrology and archaeology is needed. This is especially true when probabilistic statistics are not applicable because of sampling design or insufficient group members.

3. As yet it is not clear if each of our analytical units, the CPCRUs, relates to various sites within a resource procurement zone or is relatively site specific as an indicator of manufacturing locale. It will be interesting to see if added sampling results in subdivision of these units.

4. When questions of trade are probed with highly sensitive analytical techniques, the relationship of ceramic taxonomies and units defined on paste composition must be rethought. What, for example, is the significance of the Altar Orange Type to the exclusion of Balancan Orange in Downstream CPCRUs? Not only must spatial and temporal dimensions be clarified but the adequacy of current taxonomies in dealing with exchange requires re-examination.

NOTES

1. We wish to acknowledge the importance of the petrographic analyses by Pei-yuan Chen, which early alerted us to compositional heterogeneity in Fine Orange pottery from the western Maya area. This material is based on work supported by the National Science Foundation under Grants GS-1455X, BNS76-03397. Research for this chapter also was supported by the U.S. Department of Energy.

2. The statistical analysis of the Fine Orange-Fine Gray pottery occurred during 1976-1977 and the original probabilities fo group containment were obtained by the SPSS, Version 6 discriminant analysis program. Subsequently we have learned that the IBM discriminant analysis routine was programmed in a single precision, which, at times created erroneous "inflated" probabilities. The probabilities and percentages reported here were recalculated using SPSS, Version 7, implemented on a CDC 7600 computer.

3. <u>The chemical paste compositional reference unit</u> (CPCRU) is an operational category derived statistically from chemical data that relate to ceramic pastes. It offers a means of comparing grouped chemical data with analogous units. Moreover, it provides a background against which to project non-chemical information. Patterns in the independently projected data serve to validate the CPCRU. A basic problem when using solely chemical information is that of determining an archaeologically useful level of probability of group membership. An acceptable level of probability, therefore, is relative to a particular research orientation and the amount of patterned similarities between chemical and non-chemical data.

4. <u>The paste compositional reference unit</u> (PCRU) is a polythetically derived group relating to ceramic pastes against which additional data have been projected. As used in the present paper, it is less strictly defined than the chemical paste compositional reference unit. We may merge chemical and mineralogical data to from a unit of paste composition that, although less rigorously defined, may be heuristically more useful. Additionally, spatical, temporal or typological information may be input to reformulate a compositional unit that becomes more operational archaeologically. Thus, interfacing of varied data sets characterized the PCRU.

5. The Salinas and its tributaries penetrate the Volcanic Province of Guatemala, as well as draining parts of the Central Guatemalan Cordillera which have thick beds of pumice and dust (Williams 1960; Figs. 1, 2; McBirney 1963; Fig. 1, pp. 206-210; Koch and McLean 1975; Figs. 1, 12).

6. Although the Maya Mountains are a source of volcanic ash (Hazelden 1973), their western slope is drained primarily by the northward flowing ~~Mopan and~~ Chiquibul, rather than by the Pasion (Santa Isabel) and its tributaries such as the Machaquila (Wadell 1938: 338-339; Army Map Service 1964).

CHAPTER FOUR

Maya Fine Paste Ceramics: An Archaeological Perspective

by

Robert L. Rands,
Ronald L. Bishop, and
Jeremy A. Sabloff

~~FINE ORANGE AND FINE GRAY WARES: ARCHAEOLOGICAL PERSPECTIVES~~

OVERVIEW

Most of the patterned chemical differences which have been discussed in the previous chapter are discernible only on a refined level of analysis. As would have been expected, the widely distributed Altar, Balancan and Silho Ceramic Groups of Fine Orange Ware show close compositional correspondences. But even this body of ceramics is subject to more effective subdivision than would be suspected according to the hypothesis of a common source, indicating that the shared level of similarity may be on the order of a common fluvial environment rather than that of a specific locality or tightly nucleated region. Moreover, some Fine Orange pottery from the Maya area, including the poorly sampled Matillas and Cunduacan Groups, lies well outside this compositional range. To go farther afield, based on the present chemical sampling, one can no longer entertain the possibility that fairly intensive, widespread ceramic commerce was responsible for the similarities which exist between Maya and Veracruz-Oaxaca orange or gray fine paste pottery (cf. Paddock 1970:21).

In the Altar, Balancan and Silho Groups, significant trade continues to be indicated as an exchange that cuts across the formal boundaries of the type-variety system. Certain of the types in the Altar Group such as Pabellon Modeled-carved are fairly stable chemically, appearing to have been widely traded. However, the Altar Orange Type is relatively variable in composition, indicating that a number of manufacturing centers existed, and this is also true of Provincia Plano-relief, traditionally considered a type marker for the Balancan Ceramic Group. The Silho Group, which is poorly sampled, may or may not prove to have greater chemical uniformity, but in any case the Silho-oriented compositional unit, CPCRU 1, extends beyond the ceramic group to include non-Silho types.

In the ceramic sampling, a bias exists toward the Usumacinta-Pasion drainages and, to lesser degree, the Lower Grijalva, relative to coastal Campeche, the Yucatan Peninsula, and other portions of the Maya area. In part this reflects problem-orientation (the hypothesis of a single coastal Tabasco homeland and center of production for Fine Orange-Fine Gray ceramics) and in part the fact that the archaeologists who contributed most samples for analysis were connected directly or indirectly with projects at Seibal and Altar de Sacrificios (Sabloff) and with Piedras Negras and a regional survey centered on Palenque (Rands). The bias may be implicit in the designation of "Upstream" and "Downstream" chemical groups with reference to the Usumacinta drainage. However, the emphasis is consonant with the probability that clays used in Fine Orange and Fine Gray Ware are naturally transported, apparently exploited from riverine floodplains (Brainerd 1958: 78), and also with the geographic patterning observed in the distribution of the CPCRUs.

An important aspect of the parsimonious subdivision of materials largely assignable to the Altar-Balancan Ceramic Groups is provided by petrographic analysis and the demonstration of chemical differences which correlate with the presence or absence of volcanic dust. Perhaps the presence of minute particles of volcanic glass in some of the fine paste pottery may be ascribed to the weathering of volcanic ash in the Guatemala highlands, with subsequent transportation of silt-sized particles down the Salinas and thence into the Usumacinta proper. Deposited in lagoons after seasonal flooding, volcanic glass would occur naturally in the clays, serving as an index to the chemical profiles of ceramics manufactured along the Lower Salinas or the Usumacinta; the dust would be absent, however, from pottery made from alluvial clays on tributaries in the drainage system such as the Pasion. According to this interpretation, production centers lying outside the Usumacinta drainage utilized clays which may not only have lacked volcanic dust but were further differentiated by chemical configurations characterizing different river systems.[1] These factors, in conjunction with the complexities of alluvial deposition along the Tabasco-southwestern Campeche coast (West, Psuty and Thom 1969), would appear to account satisfactorily for the compositional variation in those fine paste Maya ceramics reported on in the previous chapter.

It must be understood, however, that the data set is not based on all chemically-analyzed fine paste ceramics from the Maya area, or even on all that would be classed archaeologically as Fine Orange or Fine Gray Ware. Certain sherds which have been analyzed as part of the project have proved to have so little resemblance to the usual chemical profiles for these wares that they have not been considered in Chapter 3. To do so would have drastically increased variability within the data set, thereby obscuring variations within the usual Fine Orange-Fine Gray materials. In addition, the present analysis omits specimens which have been reported on in preliminary form from Kixpec and Zacualpa in the Guatemala Highlands

---

[1] The other great river of the Tabasco lowlands, the Grijalva (Mezcalapa), also deposits volcanic materials derived from the Guatemala highlands (West, Psuty and Thom 1969: 38).

and the Carlos Greene site in Tabasco (Sayre, Chan and Sabloff 1971: Figs. A.6, A.11; Wauchope 1975: 211, 262, 279). The subject of early investigation, these sherds were not available for reanalysis under current conditions of analytical standardization.

Omitted because of their highly divergent chemical composition are a number of fine paste specimens from the Tamay Complex of Piedras Negras, consisting mostly of oxidized materials which have been designated Fine Pale-orange Ware but including reduced examples which would usually be classified as Fine Gray[2] (Rands 1973b: 176-177; Rands et al. 1975). Ceramics having close stylistic and chemical affiliations with the Tamay materials are known from Palenque and Yoxiha, Chiapas, and San Jose del Rio, Tabasco; these specimens, too, are excluded from the present analysis. Nevertheless, correspondences extend to a restricted range of vessel forms and decorative techniques present in the Chablekal Ceramic Group of Fine Gray Ware. It is evident, therefore, that compositional variation within the Fine Gray materials from the Maya Lowlands is far greater than is indicated in the preceding chapter. Within the fine paste tradition, we have been dealing merely with the tip of the iceberg.

Stylistic features which are sometimes diagnostic in subdividing Fine Orange Ware extend to chemically divergent ceramics. In the early analysis at the Brookhaven National Laboratory, most of the fine paste pottery from Tortuguero was provisionally excluded from Matching Fine Orange, being designated as a separate group, "Tortuguero high-chromium" (Abascal M., Harbottle, Meijers and Sayre 1970). Petrographically as well

---

[2] Although noting close similarities in form and decoration, Brainerd (1958: 78) considers the Piedras Negras materials distinct from his Fine Grayware of Yucatan.

as chemically outside the normal range of Fine Orange materials, the orange-brown paste ceramics of Tortuguero have compositional affiliations on the one hand to Fine Orange and on the other to Fine Brown of Palenque (Rands et al. 1975). In the present report, the Tortuguero unit is treated heuristically, being included in certain statistical analyses but excluded in others; its outlying position is indicated in Figure ~~10~~ 11 of Chapter 3. It is of no little interest, therefore, that the Balancan Group is represented in these materials, for Tortuguero lies outside the Usumacinta drainage on the western Maya frontier. Traditionally, the Lower Usumacinta site of Jonuta has been considered a foremost center of Z Fine Orange (Berlin 1956), and this position is not questioned here. The presence of stylistic features attributable to the Balancan Group in the chemically-abberant Tortuguero pottery is subject to varied explanations. Because of the general petrographic and chemical stability in the long fine paste tradition at Tortuguero, it is possible that an early stage in the development of the Balancan Ceramic Group is represented (Rands 1973b). On the other hand, white-slipped pottery with a fine, creamish-white paste occurs closer to Jonuta, at Trinidad and other Usumacinta sites in the early-facet Naab Complex (Fig.) and could provide an ancestral form for the white slip characteristic of the Balancan Ceramic Group. Chemically and petrographically, this Fine Cream pottery is far removed from Fine Orange Ware and therefore is not considered in Chapter 3 (Rands 1973b; Rands et al. 1975).

Specimens selected for illustration do not include those examples which have already been published in a detailed preliminary report of the Brookhaven investigations (Sayre, Chan and Sabloff 1971). References to ceramic illustrations are given in Table 7 of Chapter 3.

ARCHAEOLOGICAL AND CHEMICAL ALIGNMENTS

A synthesis is attempted, building on the new compositional perspectives but giving greater weight to major patterns of archaeological distribution, through time and space, than has been accorded the limited number of chemically-analyzed sherds. Recognizing problems of sampling, we extrapolate from the juxtoposition of archaeological and chemical data. Discussions are keyed to a series of tables (10-15) and charts (Figs. 29-31).

The Tables. Table 10 presents a geographically-ordered alignment of sites from which project sherds were analyzed and matches this against the CPCRUs, the latter arranged so as to obtain the best patterning. Frequency distributions cluster along a gradient connecting the greater Peten and Upper Usumacinta (upper right) and Middle and Lower Usumacinta, Chiapas-Tabasco Foothills, Lower Grijalva, and northern Yucatan (lower left). This general arrangement of sites and analytical units -- southeast to northwest and north, Upstream to Downstream and miscellaneous -- is maintained for ceramic groups and types in Tables 11-14.

Although linearly patterned, it should be noted that this gradient does not conform strictly to a "nearest neighbor" distribution. From the site of Jonuta (Lower Usumacinta), the alignment shifts south and west to sites along the Chiapas-Tabasco Foothills before turning in a northeastern direction to the Yucatan Peninsula. Sites are clustered rather than distributed uniformly along the alignment. Determined in part by the arterial system of the Pasion and Usumacinta it is, nevertheless, geographically based rather than random. The sequential correlation of analytical units (the CPCRUs) with sites and regional divisions along the alignment therefore has significance.

Relationships of the various regional units to archaeological zones of the Maya Lowlands require little comment here (see Culbert 1973). The Upper, Middle and Lower Usumacinta are used as defined in Rands (1973b: 167-69); as will be seen, this somewhat unorthodox division conforms well to the distribution of the CPCRUs. The Lower Grijalva is defined broadly to include the general area extending east from Comalcalco to the coalesced systems of the Grijalva, Chilapa and Usumacinta Rivers.

Tables 10 and 11 differ somewhat, the latter giving CPCRU totals as modified by the addition of eight outlier specimens that fall within a group's 95 percent confidence interval (Step 3 and Table 7.7 of Chapter 3). Totals in the Unplaced column are correspondingly reduced. Using this somewhat less rigorous treatment, patterned alignment of the CPCRUs down the Usumacinta drainage remains virtually unchanged. Five of the added specimens have the expected Upstream or Downstream position and, consistently with Table 10, two specimens from the Chiapas foothills are placed in CPCRU 1. The Middle Usumacinta geographical locus of CPCRU 2 is strengthened. Maintenance of pattern on slightly different levels of refinement is indicative of the archaeological utility of the analytical units.

The basis for totals differs from one table to another. Most, although not all, of the analyzed sherds belong to one of the established ceramic groups, and type designations within a group have not always been assigned. Sabloff and Rands examined most of the sherds in May, 1976, and the use of an asterisk indicates a degree of doubt, beyond those general reservations expressed in the text, as to the correct typological identification; in no instance does a total which is so qualified effect more than a single sherd (compare Table 7 in Chapter 3). Varieties are not specified.

The Charts. Conforming to the arrangement of the regional units as given in Tables 10 and 11, ceramic complexes are shown in a chronological chart (Fig. 29). The chart serves as a base on which to indicate spatial and temporal occurrences of ceramic groups belonging to Fine Gray Ware (Fig. 30) and Fine Orange Ware (Fig. 31). In some cases, the ceramic group which predominates in a given complex cannot be definitely assigned on the basis of published data but educated guesses are attempted; however, the Altar and Balancan Groups are combined, inasmuch as distinguishing criteria often vary in published reports or are incompletely presented. The Early Postclassic Silho Group is accorded special treatment. Its pottery is poorly represented at several of the sites, relationships to Late Classic ceramic complexes being obscure. Rather arbitrarily, therefore, we assign the Silho Group occurrences in the Southern Lowlands to a period between A.D. 900 and 1000, a beginning date somewhat earlier than that generally given but one for which we sense a growing preference among workers in the Maya Lowlands (Ball 1978: 102-103). Widely ~~Boldly~~ hachured conventions are employed to indicate a relatively abundant representation of a given ceramic group, closer spacing ~~lighter shading~~ suggesting a weaker occurrence. Arbitrary decisions are unavoidable but it is hoped that the schematic presentation results in minimal distortion of the facts as these are currently understood.

Precision in dating the ceramic complexes from which specimens have been drawn for chemical analysis varies considerably, as does completeness in describing the fine paste assemblages. In general, dating is more finely calibrated for the Southern Lowlands, where indirect ties can be made with Long Count dates, than in those regions for which such information is lacking. This may be a principal reason why periodization in the Southern Lowlands gives the appearance of more accelerated ceramic change than is observable in Yucatan, although other factors, including relative cultural stability in ceramic production, are perhaps involved. Within one of the fine paste wares, a single ceramic group is generally shown as predominant throughout a given complex; exceptions are made to this practice when it appears that change in the Fine Orange or Fine Gray pottery proceded at a faster rate than is discernible for the ceramic complex as a whole. Such instability suggests a specialized, dynamic aspect to fine paste ceramic production and dissemination, and we wonder if this was peculiar to parts of the Southern Lowlands or if chronological refinement would show a comparable rapidity of change in the Yucatan Peninsula.

In looking at the chronological charts, one is impressed by the longevity and intensity of the Fine Orange-Fine Gray tradition on the Campeche Coast compared even to that other region traditionally considered a possible homeland for Maya fine paste ceramics, Tabasco. The sustained nature of the tradition is also notable in Yucatan. In part, this may reflect such factors as differences in archaeological sampling and periodization or differing demographic stability, perhaps related to the Classic collapse and abandonment. Another factor may be the inclusion of Brainerd's (1958) Dzibilchaltun Fine Orange and Ball's possibly related "Isla" Fine Orange-buff (Ball 1978: 95-96) whereas, as previously noted, Rands' Fine Cream of the Middle Usumacinta and Palenque is considered to lie outside the specific Fine Orange-Fine Gray problem and therefore is not included in the charts. Chemically distinctive, untempered orange-paste ceramics are known from still earlier contexts at Palenque (Fig. 32), and on the basis of present evidence we hesitate to ascribe ultimate origins of the Maya Fine Orange-Fine Gray tradition to the Campeche Coast rather than to Tabasco. This is a reasonable inference, however, if the patterning indicated in Figures 30 and 31 is to be taken at face value. The poor representation of the Campeche Coast in the chemical sampling (one probable specimen) is unfortunate.

With additions and slight modifications, the chronological charts are based on information summarized by Smith (1971), Rands (1973a) and Ball (1977, 1978). Distributional summaries, which extend beyond the regions covered in the present project, are given by Smith (1958; 1971: 18-22), Smith and Gifford (1965: Figs. 4, 5) and Ball (1978). A number of reports, some preliminary in nature, relate to Fine Orange and Fine Gray Ware in the regions under consideration. Listed under the geographic units employed in Table 10, with special attention to sites from which sherds have been chemically analyzed, these include: <u>Rio Bec</u>

(Ball 1977: 45-47, 135); Peten-Belize (Smith 1955: 28-30, 34-35; Thompson 1939: 150-151, 260; Hammond 1975: 326-328); Passion-Upper Usumacinta (Sabloff 1970, 1973: 119-129, 1975; Adams 1971, 1973a, 1973b; Willey 1972; Butler 1935: 10, 11, 20, 24; Rands 1973b: 176-178); Middle Usumacinta (Rands 1969: 10-12, 33-34; 1973b: 178-180); Lower Usumacinta (Berlin 1956; Shook 1957; Rands 1973b: 180-183); Chiapas-Tabasco Foothills (Rands 1967, 1969: 56, 1973b: 190-201, 1974: 73-74; Vaillant 1927, Fig. 385; Dieseldorff 1933, Fig. 109; Lehmann 1935, Figs. 6,8,9; Blom and LaFarge 1926-1927: 226-230); Lower Grijalva (Berlin 1956; Peniche Rivero 1973: 38-46, 55-61, 70-73); Campeche (Smith 1957; Ruz Lhuillier 1969; Matheny 1970; Pina Chan 1968; Ball 1978); Yucatan Plains (Brainerd 1941, 1953, 1958; Smith 1971; Corson 1976; Ball 1978). Especially for Campeche and Yucatan, references include sites or regions additional to those which are represented in the chemical analyses. Thus, Smith's 1971 report on the pottery of Mayapan, which is basic to a comparative study of the Fine Orange ceramic groups, incorporates data from the Puuc as well as from Chichen Itza.

B →

Beginnings of the Maya Fine Paste Tradition. The ultimate origin of Maya fine paste pottery may lie in a Gulf coastal tradition extending back to the Preclassic period (Adams 1971: 136). Fine paste pottery of probable Early Classic date, which lies outside the chemical range to be expected for Fine Orange Ware, is known from the Tabasco site of Tortuguero (Fig. 33a), As has been seen, a fine textured, orange-paste figurine from an Early Classic deposit at Palenque diverges even more widely in chemical composition (Fig. 32). Early Classic fine paste "Ivory Ware" vessels from Kaminaljuyu and Tikal have been considered imports from the Tabasco-Gulf Coast region (Coggins 1975: 152, 276-277), but chemical analysis is not available for this pottery. Little more can be said aside from noting the plausibility of such diversity during the slow adoption of a technological tradition, during which local experimentation in peripheral regions was abetted by sporadic longer distance trade.

6 → <u>Emergence of Maya Fine Orange and Fine Gray Wares</u>. We are dealing mainly with earlier segments of the Maya Fine Orange and Fine Gray traditions, a series of distinctive but related developments which took place relatively early in the Late Classic period prior to the rise of the Balancan, Altar and Tres Naciones Ceramic Groups. The earliest of the ceramic groups to emerge may be the Chablekal Group of Fine Gray Ware. Whereas the Altar and Tres Naciones Groups are linked by a number of modes that cut across wares, the Chablekal Group is largely set apart, stylistically and in vessel shape, from possibly contemporaneous Fine Orange.

This conclusion must be qualified. Archaeologists currently working with the concept of a Chablekal Ceramic Group undoubtedly regard it in somewhat different ways. Smith (1971: 18) has identified a number of types for this group but these have not been formally described, and boundaries with the other ceramic group recognized for Fine Gray Ware, Tres Naciones, are inevitably blurred. Chablekal Group ceramics have been characterized as having a matte gray finish which does not differ from the paste (Smith and Gifford 1965: 52) but if other identifying modes indicate group membership, pottery with zoned or overall black surface is included with the possibility of separation on a varietal level or, as has not been attempted here, by establishing new types. The Chablekal and Tres Naciones Groups have sometimes been differentiated along temporal lines as belonging to the Late and Terminal Classic periods, respectively (Ball 1978: 82). Thus, on the Campeche Coast, the appearance of the Chablekal Group is placed in the Vacio Ceramic Complex, somewhere in the A.D. 550-700 interval, with Tres Naciones materials characterizing the following Recogida Complex, c. 700-900/1000 A.D. (Fig. 30). However, Smith assigns the Chablekal Group to the Motul and Cehpech Complexes, roughly spanning both of the Campeche phases, and this dating seems also to be indicated in current estimates for Dzibilchaltun (Copo 1 and 2). Farther to the south, in the Chiapas-Tabasco foothills, along the Lower and Middle Usumacinta, and extending upriver as far as Altar de Sacrificios, Rands sees temporal priority of at least some of the Chablekal Group types over those of Tres Naciones. However, the appearance of Chablekal group ceramics on an early Balunte-late Naab-Tamay-early Boca horizon, probably well within the century between A. D. 750-850, is significantly later than dates given for the Yucatan Peninsula. If the various chronological estimates are substantially correct, a northern origin for the Chablekal Group, outside the Tabasco-Usumacinta region, is indicated.

With the exception of the short-lived site-unit intrusion represented by the Tamay Complex at Piedras Negras, the Upper Usumacinta-Pasion region appears to have been little influenced by the Chablekal Group. At Altar de Sacrificios, however, an early-facet Boca cache contained unnamed black-slipped vessels which approximate ~~types~~ shapes of the Chablekal Group, ~~in~~ ~~shapes and surface treatment~~ (Adams 1971: 105, Figs. 58d, f, 65f, ~~cf.~~ 72b). ~~Berlin 1956, Fig. 4p, s~~). Of comparative interest is a tempered vessel (type undesignated) from a Tepejilote midden at Seibal; in certain aspects

THIS PAGE

WAS INTENTIONALLY

LEFT BLANK

of surface treatment, shape and monkey design, this incised dichrome resembles the Chicxulub Incised Type of the Chablekal Ceramic Group (Sabloff 1975: 151, Fig. 285). Aberrant at Altar de Sacrificios and Seibal, these Chablekal-affiliated vessels underscore the temporal priority of the Chablekal Group over Tres Naciones within the Fine Gray tradition and indicates affiliations to the north.

Apparently untempered orange paste pottery may occur as early as the Chablekal materials but is even less firmly placed according to ceramic group. The Ulum Incised Type, dated at A. D. 670-710 at Tikal, is considered to be a forerunner of Z (Balancan) Fine Orange by Coggins (1975: 276-278, 292), having its source in the Lower Usumacinta-Gulf Coast region. Berlin (1956) and Rands (1973b) note the sporadic occurrence of fine paste orange sherds in relatively early deposits along the Lower and Middle Usumacinta, as early as the Taxinchan Complex (Tepeu 1 equivalent). As seen above, the Dzibilchaltun Group remains an illusive, vaguely defined construct but again indicates the presence of Fine Orange Ware on a horizon antedating the Altar and Balancan Ceramic Groups.

On the basis of its archaeological distribution and the limited number of chemical analyses, Chablekal Group pottery (Figs. 34-36) appears to have been widely traded but from diverse centers. A number of sherds, especially from Tierra Blanca and Palenque, are chemically divergent, failing to find membership in any of the CPCRUs established for Fine Orange-Fine Gray ceramics (Table 12.1). Other sherds in the project sampling attain membership in the Downstream Units 5 and 2, as well as in the Silho-oriented CPCRU 1, but the Upstream Units 3 and 4 are not represented.

Little of the early Fine Orange Ware has been analyzed. Failing to achieve CPCRU membership are unnamed sherds from the Taxinchan Complex at Trinidad and Murcielagos/early-facet Balunte at Palenque (Fig. 33b, c). The latter, a unique black-and-white painted gouged-incised bowl, bears a glyph band in Classic style. On the other hand, a finely-textured, orange-paste polychrome plate of Late Classic style from Calatrava, dating from late-facet Naab, has membership in the Downstream CPCRU 2 (Fig. 37). There is a vague suggestion that at Calatrava CPCRU 2 may tend to be earlier than the other Downstream unit, CPCRU 5.

<u>Terminal Late Classic Fine Orange and Fine Gray Wares: the Altar, Balancan and Tres Naciones Ceramic Groups</u>. Developmental stages are complex, apparently being partly rooted in earlier Maya fine paste developments such as those noted above, in part derived from Classic and non-Classic Maya traditions, and also reflecting influences from outside the Maya area. Smith (1971: 237) observes that design characteristics of the Balancan Group conform to those of the Classic Maya ceramic tradition. The rise of the Altar and Balancan Groups was rapid, a widespread distribution in the Southern Maya Lowlands being probable by A. D. 830. In particular, firm associations with Long Count dates are present at Seibal in 10.1.0.0.0 (A. D. 849).

The temporal and spatial distribution of the combined Altar and Balancan Groups is indicated in Figure 30 for the regional units included in the present investigation. Were these ceramic groups to be differentiated on the basis of their relative abundance, a traditional separation would tend to place the ceramic complexes dominated by the Altar Group on the left hand portion of the chart with those characterized by the Balancan Group occupying the observer's right. Thus, Z (Balancan) Fine Orange has been considered to characterize the Campeche Coast (Ruz Lhuillier 1969; Matheny 1970) and Tabasco (Berlin 1956; Smith 1958), but as a more tightly defined and restructured typology has emerged under the type-variety system, a strong representation of the Altar Group is indicated (e.g. Adams 1973b for Los Guarixes); much of the pottery which once would have been considered Z Fine Orange is now placed in the Altar Group. It is generally believed that the Altar and Balancan Groups are approximately coeval. Ball (1977: 46) has recently argued that group level separation of types comprising the Balancan and Altar Groups represents an artificial subdivision and should be abandoned.

In estimating relative frequencies of the two ceramic groups in a given complex, we perceive the traditional split to be a valid one in those cases where Altar-Balancan materials are especially abundantly represented (Fig. 30) Thus, the Altar Group predominates in the Jimba and Bayal Complexes of Altar de Sacrificios and Seibal with the Balancan Group (or at least its decorated types) characterizing the Jonuta Horizon of the Lower Usumacinta.

The Tres Naciones Group of Fine Gray Ware apparently centers at Altar de Sacrificios and Seibal in the Jimba and Bayal Complexes. This picture may or may not change when the Chablekal Group is adequately described; evaluation of Fine Gray Ware as a whole will certainly be in order.

The Altar, Tres Naciones and Balancan Groups comprise the primary membership of CPCRUs 2-5 and are only occasionally represented in the other chemical reference units. However, of the total of 75 analyzed sherds which belong to the three ceramic groups, 28 percent fails to achieve membership in any of the CPCRUs. This is one indication of a substantial degree of compositional heterogeneity within the ceramic groups, as established under the demands of rigorous statistical scrutiny. But what of the patterned variation within the CPCRUs, on the one hand, and in the ceramic groups on the other? Taken in conjunction, the tables are highly revealing.

A pattern, observable in Table 1 which includes all project sherds from the Maya area, is especially pronounced for the Altar Ceramic Group (Table 12.2). As one moves northwest from Peten and Belize sites, following the Pasion and Usumacinta Rivers and the Chiapas-Tabasco Foothills, archaeological provenience reflects an orderly progression of the chemical compositional units. The Upstream CPCRU 3 dominates the Peten, Belize, Pasion and Upper Usumacinta regions, the other Upstream unit, CPCRU 4, also being represented at Altar de Sacrificios and Piedras Negras. Farther down the Usumacinta, the Upstream units virtually disappear, being replaced by CPCRU 2 along the Middle Usumacinta and Finally by CPCRU 5 on the Lower Usumacinta. This regional configuration of the analytical units is an indication that ceramics of the Altar Group were manufactured at several locations along the Usumacinta drainage with exportation to adjacent regions (the Pasion-oriented CPCRU 3 to the Peten, Belize and Piedras Negras, the Downstream CPCRU 5 to the Chiapas-Tabasco Foothills).

Attention shifts from ceramic groups to types in Table 13.2. As to be expected in view of its strong representation, the Altar Orange Type (Figs. 38-40) shares the distributional pattern seen for the Altar Ceramic Group as a whole. Similar inferences may be drawn, that a number of production centers were coupled with significant although only sporadic widespread trade. However, in the decorated pottery of the Altar Group (Figs. 41, 42), associations are tighter between given types and chemical units (Cedro Gadrooned, Islas Gouged-incised and Pabellon Modeled-carved with Upstream CPCRU 3;

Trapiche Incised and Tumba Black-on-orange with Downstream Unit 5). Additional sampling would be desirable for each of the decorated types, which might be supposed to be more highly prized and therefore to have entered into relatively extensive trade. Membership in only two rather than four of the established CPCRUs may indicate the existence of a smaller number of manufacturing centers for the decorated types, each of which, perhaps, channeled a significant part of its production into a fairly widereaching distributional system. However, in our sampling (26 decorated sherds of the Altar Group and 25 examples of Altar Orange), a greater number of the decorated ceramics are divergent in their failure to achieve CPCRU membership.

The Tres Naciones Group has primary affiliations with Upstream CPCRU 4. In the project sampling as in general archaeological investigations, the Tres Naciones Group is best known from Pasion-Upper Usumacinta sites. At Palenque, CPCRU membership changes to Downstream Unit 5 for the single analyzed Tres Naciones sherd (Tables 12.4, 13.4, Fig. 43). A regionalized focus of ceramic trade, rather than widespread commerce, is once again indicated.

The Balancan Ceramic Group reflects greater chemical variation (Tables 12.3, 13.3). Examples from Pasion-Upper Usumacinta sites are for the most part unplaced in the CPCRUs. The Provincia Plano-relief Type (Figs. 44-47) is markedly heterogeneous, occurring even in the Silho-oriented CPCRU 1 and the aberrant Tortuguero compositional group. Yet in spite of the compositional diversity, a focus toward the Lower Usumacinta and the west is evidenced in the alignment of site distribution and CPCRU membership. From our sampling we cannot infer the existence of significant widespread trade along the Usumacinta in Balancan Group ceramics.

The Altar and Balancan Ceramic Groups are combined in Table 14. Major changes from the Altar Group, as shown in Table 13, consist of: (1) increased diversity in the Chiapas-Tabasco Foothills due to the inclusion of two new compositional units, Tortuguero and CPCRU 1, and (2) a relative weakening of Pasion-Upper Usumacinta homogeneity, as seen in the increased numbers of sherds which are not placed in any of the CPCRUs. This is in contrast to the notable tendency of ceramics from sites on the Lower and Middle Usumacinta to be firmly placed in one or another of the currently established compositional units. A possible inference is that during the terminal Late Classic a somewhat smaller number of centers producing Fine Orange Ware were present on the Lower and Middle Usumacinta than in the Seibal-Altar de Sacrificios-Piedras Negras area. No unplaced specimens in either the Peten-Belize region or in the Chiapas-Tabasco Foothills result from combining the Altar and Balancan Groups, and the same line of reasoning would suggest that these areas, relatively distant from requisite clays on the floodplains of the Pasion and Usumacinta, were supplied by a limited number of centers which specialized in the standardized production and trade of Fine Orange Ware.

Early Postclassic Fine Orange Ware: the Silho Ceramic Group. Traditionally associated with the "Toltec" horizon, this is the most distinctive group of Fine Orange Ware in number of types, elaboration of vessel forms, use of polychrome, and development of abstract symmetry. Stylistic antecedents have been seen to lie in Veracruz, relationships to Tohil Plumbate also being noted (Brainerd 1941, 1953). In advocating this position Brainerd adds, however, that "The Mexicans seem...to have arrived as a non-pottery making group and to have superimposed their fashions, but not their techniques, on the local craftsmen," deriving these techniques from the earlier Maya Fine Orange tradition (Brainerd 1958: 276-277). Smith, on the other hand, tends to emphasize stylistic differences between the Silho Ceramic Group and Veracruz Fine Orange Ware and notes stylistic connections of the Silho Group with the Classic Maya ceramic tradition (Smith 1957: 143; 1971: 21, 237). Ball (1977: 46) sees significant continuity between Balancan-Altar Group pottery and that of the Silho Group, suggesting that the first appearance of the latter might be at least a century earlier than the traditionally ascribed date of A.D. 1000 (Ball 1978: 102-103).

In the chronological chart (Fig. 30), we indicate the beginning of the Silho Group as A.D. 900 in certain cases but retain the more conventional dating in others. By utilizing the beginning tenth century date at Uaxactun and Palenque, awkward gaps are avoided between the estimated end of Terminal Classic ceramic complexes and the appearance of the rare Silho Group ceramics. Perhaps the horizon marking the appearance of the Silho Group should be lowered for all regions; alternatively, following effective abandonment of sites in the Southern Lowlands, scattered re-occupations by people with Silho Group pottery may have taken place.

The Silho Group is especially well represented on the Campeche and northwest Yucatan coasts, major inland occurrences being at Chichen Itza, Mayapan and Dzibilchaltun. The approximate southern limit of its continuous distribution on the Campeche Coast is given as Champoton (Ball 1978: 103). Closer to the Usumacinta, in the Magle Complex of Aguacatal, Matheny

(1970: 89) identifies the Aguacatal Group as a distinct but coeval ceramic unit, having a greater frequency than Silho. Attention is again directed to the small chemical sampling of Silho Group materials with special reference to Chichen Itza (poorly represented) and the Campeche Coast (completely absent, although the Silho-oriented CPCRU 1 is apparently known from this region, as seen in Table 10 and Figure 48). On the other hand, the Chiapas-Tabasco Foothills are disproportionately represented.

As a whole, chemically-analyzed ceramics of the Silho Group (Figs. 49-51) have two compositional loci (Table 12.5). The strongest, CPCRU 1, is represented at Palenque and nearby Bajio as well as at Chichen Itza, indicating widespread dissemination from an unidentified production center. The Downstream Units 2 and 5 form the second locus, present not only on the Middle Usumacinta but at Uaxactun. In addition, several sherds, including one from Chichen Itza, are unplaced in the CPCRUs. Of the sampled types, Pocboc Gouged-incised stands out because of its relative compositional variability and lack of membership in CPCRU 1 (Table 13.5).

<u>Late Postclassic and Protohistoric Fine Orange Ware: the Matillas and Cunduacan Ceramic Groups.</u> The better-known Matillas Group of the Late Postclassic is generally believed to have been replaced in the Protohistoric period by the Cunduacan Group. Recognizing the possible primacy of Matillas Group ceramics over those of the Cunduacan Group, Ball (1978: 91-92) believes that Matillas pottery survived into Protohistoric and even Colonial times and that the two ceramic groups are primarily set apart in geographic distribution, Cunduacan in Tabasco and Matillas in Campeche and the Yucatan Peninsula, rather than by temporal factors.

However, Ball also emphasizes continuities between ceramics of the Silho and Matillas Groups. (Figs. ~~24, 25~~ 52, 53)

Analyzed pottery of the Matillas Group is from Tabasco and adjacent Chiapas. Chemical heterogeneity is pronounced (Tables ~~3.6, 3.7, 4.6, 4.7~~ 12.6, 12.7, 13.6, 13.7). Only a single specimen, from Calatrava, has membership in a CPCRU (Unit 5, which is well represented in earlier fine paste ceramics from the site). Lack of standardization in chemical profile suggests that the production of Fine Orange Ware was less centralized than in the Terminal Classic and Early Postclassic periods. However, definitive conclusions must await wider sampling, especially from sites such as Mayapan to which the pottery was presumably imported. The single specimen representing the Cunduacan Ceramic Group is also chemically distinctive.

B → <u>Fine Orange Ware: Figurines</u>. Moldmade figurines of Fine Orange paste are best known from Jaina, the adjacent Campeche Coast, Jonuta, and Altar de Sacrificios. Of these, the general Classic Maya figurine style is present only in examples from Jonuta. In view of stylistic differences both from Jonuta and most Campeche materials, Willey (1972: 62) derives the Jimba figurines of Altar de Sacrificios from an unknown locality in the Tabasco-Campeche region, and he explains the lack of Fine Orange figurines at Seibal as due to the site's relatively early abandonment or, perhaps, to the closer proximity of Altar de Sacrificios to the source of the figurines (Willey 1978: 8-9). Corson (1976: 165-166) proposes a localized development of Early Postclassic Fine Orange figurines on the Campeche Coast but sees this as stemming from direct contacts between the Jonuta region and Jaina.

Chemical sampling is limited, consisting of only two figurines. The specimen from Calatrava, of generalized Classic Maya style (Fig. ~~26~~ 54), has membership in Downstream CPCRU 5. The second, a fragmentary head from Jonuta in non-Classic style (Sayre, Chan and Sabloff 1971; Fig. A.10 no. 53), belongs to the Upstream Unit 3.

A ->

SOURCES OF MANUFACTURE

Places of manufacture which have previously been suggested for the various Fine Orange-Fine Gray ceramic groups are reviewed in the light of new perspectives provided by the Brookhaven analyses. As an initial generalization, it is no longer tenable to look to a limited set of production centers in Tabasco or adjacent Campeche for Fine Orange and Fine Gray Ware, an hypothesis which appeared to be in accordance with preliminary chemical findings and was developed with special reference to the Altar, Balancan and Tres Naciones Ceramic Groups. To hold this would fly in the face of the nonrandomly patterned geographic distribution of the analytical units[3] at sites along the Usumacinta River (x^2 probabilities less than .001, Table 6). Conclusions about manufacturing centers are much more provisional for the other ceramic groups, which have distributions that do not center on the Usumacinta drainage.

Smith (1958: 153) considers the Altar Group to be centered in the Peten but manufactured elsewhere, as suitable clays would not be available in that limestone region; more specifically southwestern Campeche or eastern Tabasco is designated a likely place of origin (Smith 1971: 162). Seeing compositional identity between the Altar and Balancan Groups, a number of recent workers believe Altar Orange and other types in its group to have been manufactured in the general Jonuta area of Tabasco. The chemical analyses and data reduction, in conjunction with sherd provenience and mineralogical considerations, indicate the probability of manufacturing loci on the floodplains of the Pasion and the Upper, Middle and Lower Usumacinta (CPCRUs 3, 4, 2 and 5). Slightly upstream, the alluvial valley of the northern Salinas should perhaps be linked with or substitute for the Upper Usumacinta (CPCRU 4). We cannot be sure whether each of the CPCRUs represents a single manufacturing center or a larger number of pottery-producing communities which cluster statistically on the basis of regional but not site-specific differentiation in the clays. That some specialized production for trade existed may be inferred from the concentration of decorated types in Units 3 (Pasion) and 5 (Lower Usumacinta) to the exclusion, on the basis of present sampling, of CPCRUs 2 and 4.

The place of origin of the Balancan Group is given as the Campeche Coast by Brainerd (1958: 54) and Ruz Lhuillier (1969: 204) and as southwestern Campeche or eastern Tabasco by Smith (1971: 19, 162). Ball (1978: 88) follows Smith in locating the presumed zone of production as somewhere in the eastern Tabasco-western Campeche region, including Isla del Carmen. A center of manufacture in the Tabasco-Lower Usumacinta region has often been favored in recent years. Based largely on the Provincia Plano-relief Type, the Brookhaven findings suggest diverse places of production along the Usumacinta drainage (CPCRUs 5, 2 and 3) and locations to the west and perhaps north (Tortuguero and CPCRU 1).

In comparison to the probably contemporaneous Fine Orange of the Altar and Balancan Groups, the Tres Naciones Group of Fine Gray Ware appears to have a more sharply defined focus of manufacture (CPCRU 4, with minor representation in Units 3,2 and 5). In view of the distribution and prevalence of volcanic dust in Tres Naciones ceramics, the alluvial valley of the northern Salinas-southern Usumacinta, in the general locality of

Altar de Sacrificios, is a plausible center of production.

The Silho Group is considered by Brainerd (1958: 57) to have been manufactured in coastal Veracruz or in Tabasco, whereas Smith believes that it was made somewhere along the Campeche Coast, pointing out that the very rare occurrence of Silho materials tends to eliminate Tabasco as a possible source (Smith 1958: 154; 1971: 184). Ball (1978: 103) notes an apparent present consensus that the production zone for the Silho Group is located "somewhere along the northwest coast of the Yucatan Peninsula, possibly in the state of Campeche," a zone that is well separated geographically from Tabasco. Nevertheless, the Downstream CPCRUs 5 and 2, which are centered in the Usumacinta floodplain of Tabasco and adjacent Chiapas, are represented in the Silho Group.

The major focus of Silho Group production (CPCRU 1) appears peripheral to the Usumacinta drainage but not markedly so. Characterized by the heaviest occurrence of Silho ceramics, the northwest Campeche-Yucatan coast may be too distant, geographically and in the chemical composition of its clays, to provide the requisite raw materials (Chapter 3). This is a problem for future research, and it is possible that Silho Group pottery from the region does not relate primarily to CPCRU 1, as we might now infer. Sampling is needed.

The Matillas Group is described as having originated in coastal Tabasco, where it enjoyed its greatest popularity and was manufactured in quantity for exportation to other regions (Smith and Gifford 1965: 531; see Smith 1971: 204). Ball (1978: 92) suggests the possibility of two distinct traditions of Fine Orange production, one of which would link the Silho and Matillas Groups on the Campeche Coast, the second the Altar/Balancan and Cunduacan Groups farther to the west. Small in number, the

Matillas and Cunduacan specimens are mostly unplaced in the CPCRUs and with a single exception (CPCRU 5) would appear, therefore, to have been manufactured outside the production areas for both the Usumacinta CPCRUs and Silho-oriented Unit 1. The analytical data indicate diverse places of production for these chemically-heterogeneous materials. These manufacturing centers may have been widely dispersed or, perhaps, concentrated in a zone of mixed alluvial deposits such as that of the Chilapa, Chilapilla and Grijalva Rivers on the western edge of the Usumacinta Delta (Chapter 3). Potentially this is an attractive area because of the heavy occurrence of Matillas Group ceramics.

Little published attention has been directed to possible production areas of the Chablekal Ceramic Group of Fine Gray Ware. Compositional similarities exist with the Silho Group, as indicated by membership in the same CPCRUs (1, 5 and 2), but there is a relatively stronger representation of the Downstream Usumacinta units. An unusually large number of the Chablekal Group ceramics are unplaced in the CPCRUs, in some cases being so chemically divergent as not to have been included in the present statistical analysis. Contrast with the Fine Gray Tres Naciones Group is notable in the degree of compositional heterogeneity as well as in the absence of Upstream units. A large number of production centers, partly along the Usumacinta but extending well beyond it, is indicated. Once again, the ambiguous nature of the Chablekal Group as currently understood must be borne in mind, along with recognition of the widespread distribution of at least two of its members, the highly distinctive Telchac Composite and Chicxulub Incised Types.

CHRONOLOGICAL OBSERVATIONS

The chemical paste compositional reference units operate primarily on a spatial rather than temporal dimension; they help the archaeologist to source artifacts rather than to date them. Nevertheless, changes in CPCRU membership can be observed as the Fine Orange and Fine Gray Ceramic Groups are viewed sequentially. A dynamic factor, to be explained in historical and processual terms, is introduced when such changes are pronounced.

CPCRU 1 is present on both Late Classic and Early Postclassic levels (the Fine Gray Chablekal and Fine Orange Silho Groups). Its presence on a Terminal Classic horizon is less well documented although, as noted, the Silho Ceramic Group may have been present by this time. Much of our data for this compositional unit comes from Palenque, and in this respect as in others the fine-paste orientation of the site seems different from that of the Southern Lowlands as a whole. The unusually large number of ceramics which are unplaced in the CPCRUs underscores this difference; compared to the unplaced specimens of Seibal and Altar de Sacrificios, those of Palenque tend to be eliminated on an early D^2 removal (Table 10; Table 7 in Chapter 3).

Most of the compositional units relate to sources on major rivers in the Usumacinta drainage. Among these, the Downstream CPCRUs 2 and 5 have greater time depth than the Upstream Units 3 and 4. Although best represented in the Terminal Classic Balancan and Altar Groups, CPCRUs 2 and 5 are known in the somewhat earlier and later ceramics of the Chablekal and Silho Groups, respectively: as sampled, Unit 5 continues in Matillas pottery into the Late Postclassic. In contrast, the Upstream CPCRUs

3 and 4 are restricted to the Terminal Classic horizon. This differential longevity is consonant with the widely held opinion that the homeland of the Balancan-Altar tradition was downstream, toward the Gulf Coast; a short-lived transplant of this to the alluvial plains of the western Pasion and Upper Usumacinta-northern Salinas is indicated. It can only be guessed if fine paste pottery utilizing the CPCRU 3 and 4 clays would have continued to be produced in the new location had the Southern Lowlands not suffered drastic depopulation.

Farther downstream, large portions of the Usumacinta also appear to have undergone marked population loss, as may be reflected by a general shift of Fine Orange pottery away from an Usumacinta chemical profile. In composition, the few analyzed examples of Late Postclassic and Protohistoric Fine Orange Ware are so diverse as to argue against pre-industrial mass production at a few major centers, although these techniques of production and distribution might have been so widely shared in Late Postclassic society as to explain the observed chemical diversity (compare Rathje, Gregory and Wiseman 1978: 168-173).

~~THE INVASION HYPOTHESIS~~

B →

The Invasion Hypothesis

The full scale Fine Paste project was initiated in 1967 with the express purpose of testing some simple hypotheses about the probable importation of Fine Paste ceramics into the upper portion of the Pasion-Usumacinta drainage near the close of the Classic Period. Furthermore, these hypotheses were linked with suggestions of possible incursions into the Pasion-Usumacinta drainage by non-Classic Maya peoples and, ultimately, with questions about the relation of postulated incursions with the collapse of Classic Maya civilizations.

While there had been a long standing interest in the origins of Fine Paste ceramics (see Smith 1958; Berlin 1956), the excavations at Altar de Sacrificios (see Adams 1971, 1973a) and Seibal (see Sabloff 1973, 1975), which found these ceramics in association with other data which were thought to indicate that the sites had been invaded, stimulated new interest in Fine Paste pottery and its origins. This interest was further heightened by the discussions at the School of American Research Advanced Seminar on the collapse of Classic Maya civilization (see Culbert, editor, 1973) held in Santa Fe in October 1970, in which a more complete picture was revealed of the nature and extent of the spread of Fine Paste ceramics through time and space than hitherto had been available. Additionally, the rich Fine Paste tradition in the Palenque region, including many non-Fine Orange and Fine Gray types, was discussed in detail for the first time by Rands. One result of these discussions was the realization that the development of Fine Paste pottery, or its movement into the Maya lowlands, was much more complex than originally hypothesized at the beginning of the Brookhaven Project (see Chapter One). Varying hypotheses of at least two major incursions of Fine Paste bearing peoples were brought forward (see Adams 1973a; Sabloff 1973; also see Graham 1973), although the role which such incursions might have played in the collapse, as a cause or as a result, was hotly debated (see Willey and Sabloff 1973 for a summary review).

The preliminary results of the Brookhaven Project appeared to support the early, simpler hypothesis of a single source for much of the Altar Group Fine Orange and Tres Naciones Group Fine Gray and the possibility of one major incursion into the Upper Usumacinta-Pasion region (Sayre, Chan, and Sabloff 1971). However, significant refinement in measurements, a broadening of the Fine Paste sample, and the additional information provided by the petrographic analyses have shown that these initial results offered an oversimplified picture. The results reported in Chapter Three and discussed above in this chapter support a growing feeling among Maya archaeologists that the manufacture and distribution of various Fine Paste ceramics was quite complex. Moreover, the complicated ceramic situation probably reflects the complex economic changes (see Sabloff and Rathje 1975) and population movements which occurred towards the end of the Classic Period in Southern Mesoamerica.

The new trends in archaeological thinking about the nature of the Terminal Classic and Early Postclassic Periods are perhaps best exemplified in the recent writing of Joseph W. Ball (1977, 1978). On the basis of his ceramic studies in Campeche and Yucatan, Ball (1978-137) points out that: "the Middle through Terminal Classic span represents a time of complex and continuously changing lines and directions of interaction among the various settlements of the Campeche-Yucatan littoral and those of the peninsular inland and east coast regions." He argues that the Putun groups of the Tabasco-Campeche region, which archaeologists, following Thompson (1970), have linked with the manufacture and distribution of Fine Paste ceramics, speculatively may be identified in coastal Campeche as early as the fifth century A. D. and that the Putun were drawn there by the lure of coastal salt resources. The following centuries saw various Putun groups and other inland peoples vying for the control of the salt beds, and other resources, and the distribution of the salt (see also Sabloff 1974; Sabloff and Rathje 1975; Eaton 1977; and Andrews 1978, among others). Ball speculates that the complicated patterns of Fine Paste ceramic manufacture and spread reflect the ebb and flow of the fluid economic and political fortunes of differing Putun groups.

The compositional data presented in Chapter Three indicate that the speculative model presented by Ball is worth persuing more rigorously. Unfortunately, the results of the Brookhaven Fine Paste Project cannot be used to test any of Ball's or other scholars' hypotheses except in the most general fashion. The results have shown that the initial guiding hypotheses of the project were incorrect in their simpleness. Moreover, the available data are not complete enough to test more complex phyotheses. However, on the positive side, these data do provide a strong indication of the productive potential of a combined neutron activation-petrographic approach to studying ceramic production and distribution, particularly with the ideal case of temperless Fine Paste pottery. Furthermore, the CPCRU data provide a framework for future investigations and a clear indication of the possible production zones which future follow-up studies should sample.

One basic need is an imaginatively conceived hypothesis which attempts to explain the general economic changes which marked the transitional period from A. D. 800 - 1000 in Southern Mesoamerica. Second, specific predictions about the movement of "Putun" groups and the manufacture and distribution of Fine Paste ceramics could be advanced. Third, the newly developed Bishop-Rands-Sayre-Harbottle analytical procedures combining neutron activation and petrogrphic studies could be expanded into a productive methodology which would allow archaeologists to link the predictions of population movements and ceramic production/distribution with the archaeological record, so as to provide adequate tests of these predictions. Finally, new Fine Paste pottery and clay samples should be collected from appropriate sources, in order to test the predictions.

One of the major contributions of the Brookhaven Fine Paste

Project, we believe, has been the creation of a general foundation for the kind of future study just outlined. In addition, the project has created the basis for a productive methodology which may allow archaeologists to link ideas of economic development to ceramic production/distribution to population movements or trading activities. What is needed now is ethnographic and/or historic research which will allow archaeologists to first link certain economic behaviors with material consequences and, second, to link the material expressions of these behaviors with the nature of the archaeological record. The procedures discussed in this monograph should be indispensible in helping to provide the second link, while research patterned after current successful ethnoarchaeological studies could provide the first.

In sum, both the analytical procedures and substantive results reported here hopefully will stimulate new studies which will build on the start made by the Brookhaven project. While the project was initiated in order to test the relationship of Fine Paste ceramics to an hypothesized invation of the Southern Maya Lowlands by non-Classic Maya peoples during the ninth century A. D. --and ultimately to the collapse of Classic Maya civilization— archaeologists have come to realize in recent years that the distribution of Fine Paste ceramics is related to broader economic and political changes throughout the Maya lowlands. Moreover, it has become clear that attempts to understand these changes have much more productive potential for explaining the collapse and lack of recovery in the Southern Maya Lowlands and the concomitant florescence in the north than those which focus more narrowly on invasions along the western and southern borders of the Maya Lowlands. Study of the production and distribution of Fine Paste ceramics offers one useful starting point in modeling these changes, and compositional analysis is an important way to begin researching such production/distribution.

THE END

REFERENCES CITED

Abascal M., Rafael, Garman Harbottle, and E. V. Sayre

1974 Correlations Between Terra Cotta Figurines and Pottery From the Valley of Mexico and Source Clays by Neutron Activation Analysis. In Archaeological Chemistry, edited by C. W. Beck, pp. 81-99. American Chemical Society, Washington

Abascal M., Rafael, Garman Harbottle, Pieter Meijers and E. V. Sayre

1970 Second Interim Report on the Analysis of Fine Orange (and Other Fine Paste) Ceramics. Brookhaven National Laboratory, Upton, New York.

Adams, R. E. W.

1971 The Ceramics of Altar de Sacrificios, Guatemala. Papers of the Peabody Museum, Vol. 63, No. 1. Harvard University, Cambridge Massachusetts.

1973a Maya Collapse: Transformation and Termination in the Ceramic Sequence at Altar de Sacrificios. In The Classic Maya Collapse, edited by T. P. Culbert, pp. 133-164. A School of American Research book. University of New Mexico Press, Albuquerque.

1973b Fine Orange Pottery as a Source of Ethnological Information.

In Studies in Ancient Mesoamerica, edited by John A. Graham, pp. 1-10. Contributions of the University of California Archaeological Research Facility, No. 18, Berkeley.

Al Kital, R. A., L. Chan and E. V. Sayre

1969 Neutron Activation Analysis of Pottery from Hajar Bin Humeid and Related Areas. In Hajar Bin Humeid: Investigations at a Pre-Islamic Site in South Arabia. Appendix II, 387-398. John Hopkins Press, Baltimore.

Army Map Service

1964 British Honduras. D.O.S. 649 (Series E552). Washington, D. C.

Andrews, Anthony P.

1978 Puertos Costeros del Postclassico Temprano en el Norte de Yucatan. Estudios de Cultura Maya XI: 75-93.

Arnold, D. E., P. M. Rice, W. A. Jester, W. N. Deutsch, B. K. Lee and R. I. Kirsch

1978 Neutron Activation Analysis of Contemporary Pottery and Pottery Materials from the Valley of Guatemala. In The Ceramics of Kaminaljuyu, edited by R. K. Wetherington, 543-586. The Pennsylvania State University Press, State College, Pennsylvania.

Attas, M., L. Jaffe and J. M. Fossey

1977 Neutron Activation Analysis of Early Bronze Age Pottery from Lake Vouliagmeni, Perakhora, Central Greece. Archaeometry 19:33-43.

Ball, J. W.

1977a The Archaeological Ceramics of Becan, Campeche, Guatemala.

Middle American Research Institute, Tulane University, Publication 43, New Orleans, Louisiana.

1977b An Hypothetical Outline of Coastal Maya Prehistory: 300 B. C. - A. D. 1200. In Social Process in Maya Prehistory, edited by Norman Hammond, pp. 167-196. Academic Press, London.

1978 Archaeological Pottery of the Yucatan - Campeche Coast. In Studies in the Archaeology of Coastal Yucatan and Campeche, Mexico, pp. 69-146. Middle American Research Institute, Tulane University, Publication 46, New Orleans, Louisiana.

Berlin, Heinrich

1956 Late Pottery Horizons of Tabasco, Mexico. Carnegie Institution of Washington Publication No. 606. Contributions to American Anthropology and History, No. 59, pp. 95-153.

Bieber, Jr., A. M.

1977 Neutron Activation Analyzing Archaeological Ceramics from Cyprus. Ph.D. Dissertation, University of Connecticut.

Bieber, Jr., A. M., D. W. Brooks, Gorman Harbottle and E. V. Sayre

1976a Application of Multivariate Techniques to Analytical Data on Aegean Ceramics. Archaeometry 1:59-74.

1976b Compositional Groupings of Some Ancient Aegean and Eastern Mediterranean Pottery. Atti dei Convegni Lincei II. Applicazione de method nucleari nel campo della opere d'arte, pp. 111-144. Accademia nazionale die Lincei; Roma.

Bishop, R. L.

1975 Western Lowland Maya Ceramic Trade: An Archaeological Application of Nuclear Chemistry and Geological Data Analysis. Ph.D. dissertation, Southern Illinois University, Carbondale, Illinois.

1976a Mayan Fine Orange Pottery: A Preliminary Report to the Peabody Museum and Brookhaven National Laboratory. University Museum, Southern Illinois University, Carbondale, Illinois (xeroxed).

1976b Textural and Chemical Variation in a Numerical Study of Western Lowland Maya Ceramic Trade. In Archaeological Frontier: Papers on New World High Cultures in Honor of J. Charles Kelley. R. B. Pickering, editor, pp. 1-44. University Museum Studies Research Records, No. 4, University Museum, Southern Illinois University, Carbondale, Illinois.

1979 Aspects of Ceramic Compositional Modeling. Brookhaven National Laboratory Reports, BNL - 26877, Upton, New York.

Bishop, R. L. and E. Veakis

n.d. Interpreation of Compositional Variability in Archaeological Objects Using Q-mode Factor Analysis. Unpublished manuscript.

Blom, F. F., and Oliver LaFage

1926-27 Tribes and Temples: A Record of the Expedition to Middle America Conducted by the Tulane University of Louisiana in 1925. Middle American Research Institute, Publication 1, New Orleans, Louisiana.

Brainerd, G. W.

1941 Fine Orange Pottery in Yucatan. Revista Mexicana de Estudios Anthropologicos 5:163-184. Mexico, D. F.

1953 On the Design of the Fine Orange Pottery Found at Chichen Itza, Yucatan," Revista Mexicana de Estudios Anthropologicos 13 (2 and 3):463-473. Mexico, D. F.

1958 The Archaeological Ceramics of Yucatan Anthropological Records, Vol. 19, University of California, Berkeley and Los Angeles.

Brill, R. H., (editor)

1971 Science and Archaeology, MIT Press, Cambridge, Massachusetts.

Brooks, D., A. M. Bieber Jr., Garman Harbottle and E. V. Sayre

1974 Biblical Studies Through Activation Analysis of Ancient Pottery. In Archaeological Chemistry, edited by C. W. Beck, pp. 81-99. American Chemical Society, New York.

Butler, Mary

1935 Piedras Negras Pottery, Piedras Negras Preliminary Papers, No. 4, University Museum, University of Pennsylvania, Philadelphia.

Caley, E. R.

1962 Analysis of Ancient Glasses 1790-1957. The Corning Museum of Glass, New York.

Coggins, C. C.

1975 Painting and Drawing Styles at Tikal; an Historical and Iconographic Reconstruction. Ph.D. dissertation, Harvard University, Cambridge, Massachusetts.

Cooley, W. W. and P. R. Lohnes

1971 Multivariate Data Anaysis. John Wiley and Sons, New York.

Corson, Christopher

1976 Maya Anthropomorphic Figurines from Jaina Island, Campeche. Ballena Press Studies in Mesoamerican Art, Archaeology and Ethnohistory, No. 1. Ramona, California.

Culbert, T. Patrick

1973 Introduction: A Prologue to Classic Maya Culture and the Problem of its Collapse. In The Classic Maya Collapse, edited by T. P. Culbert, pp. 3-20. A School of American Research book. University of New Mexico Press, Albuquerque.

Culbert, T. Patrick (editor)

1973 The Classic Maya Collapse. A School of American Research book. Univeristy of New Mexico Press, Albuquerque.

Dieseldorff, E. P.

1933 Kunst und Religion der Mayavolker, Vol. 3. J. Springer, Berlin.

Eaton, J. D.

1978 Archaeological Survey of the Yucatan-Campeceh Coast. In Studies in the Archaeology of Coastal Yucatan and Campeche, Mexico, pp. 1-67. Middle American Research Institute, Tulane University, Publication 46, New Orleans, Louisiana.

Everitt, B.

1977 Cluster Analysis. Heinemann Educational Books, London.

Fillieres, D.

1978 Contribution a L'etude de la production et de l'exportation des amphores dites Marseillaises et des ceramiques Grecques d'occodent de midi de la France an Moyen d'analyses par activation neutronique avec traitement taxinomique de resultats. Ph.D. dissertation, University of Paris, Paris.

Fisher, R. A.

1936 The Use of Multiple Measurements in Taxonomic Problems. Ann. Eugen. London 7:179-188.

Flanagan, F. J.

1967 U. S. Geological Survey silicate rock standards. Geochimica et Cosmochimica Acta 31:289-308.

1969 U. S. Geological Survey Standards--II. First compilation of data for the new U.S.G.S. rocks. Geochemica et Cosmochemica Acta 33:81.

1973 1972 Values for International Geochemical Reference Samples. Geochemica et Cosmochemica Acta 37:1189

Flanagan, F. J. (editor)

1976 Descriptions and Analyses of Eight New U.S.G.S. Rock Standards. Geological Survey Professional Paper 840. United States Government Printing Office, Washington, D. C.

Graham, John A.

1973 Aspects of Non-Classic Presence in the Inscriptions and Sculptural Art of Deibal. In The Classic Maya Collapse, edited by T. Patrick Culbert, pp. 207-220. A School of American Research book. University of New Mexico Press, Albuquerque.

Gunnick, R., H. B. Levy and J. B. Niday

1967 Identification and Determination of Gamma and Emitters by Computer Analysis of Eg(Li) Spectra. Paper presented at the American Chemical Society Symposium on Nuclear Methods of Chemical Analysis, April 10-14.

Hammond, Norman

1975 Lebaantun, A Classic Maya Realm. Monographs of the Peabody Museum, No. 2, Harvard University, Cambridge, Massachusetts.

Hammond, Norman, Garman Harbottle, and T. Gazard

1976 Neutron Activation and Statistical Analysis of Maya Ceramics and Clays from Lubaantun, Belize. Archaeometry:18:147-168.

Harbottle, Garman

1970 Neutron Activation Analysis of Potsherds from Knossos and Mycenae. Archaeometry:12:23-34.

1976 Activation Analysis in Archaeology. In Radiochemistry, edited by G. W. A. Newton, Chapter 2. The Chemical Society, London.

1977 Activation Analysis in Archaeology. Radiochemistry, Chemical Society Specialist Periodical Report 3:33-72. London.

Harbottle, Garman, E. V. Sayre and Rafael Abascal M.

1976 Neutron Activation Analysis of Thin Orange Pottery. Brookhaven Laboratory Report, C-1992, Upton, New York.

Harbottle, Garman and Edward V. Sayre

1975 Current Status of Examination of Sherds of Fine Paste Ceramics from Altar de Sacrificios and Seibal and Their Comparison with Other Maya Fine Paste Ceramics. In

Excavations at Seibal, Department of Peten, Guatemala, pp. 241-253. Memoirs of the Peabody Museum, Vol. 13, No. 2, Cambridge, Massachusetts.

Hodson, F. R., D. G. Kendall and D. Tautu, (editors)

1971 Mathematics in the Archaeological and Historical Sciences, Aldine, Chicago.

Hazeldon, John

n.d. The Soils and Geology of the Orange Walk and Corozal Districts. In British Museum-Cambridge University Corozal Project, 1973 Interim Report, edited by Norman Hammond, pp. 74-85, Cambridge, England.

Imbrie, J.

1963 Factor and Vector Analysis Programs for Analyzing Geologic Data. Office Naval Research, Geographical Branch, Technical Report 6.

Imbrie J. and E. Purdy

1962 Classification of Modern Bahamian Carbonate Sediments. In Classification of Carbonate Rocks. American Association of Petroleum Geologists Memoir 7:253-272.

Joreskög, K. G., J. E. Klovan and R. A. Reyment

1976 Geological Factor Analysis. Elsevier Scientific Publishing Company, New York.

Klovan, J. E. and J. Imbrie

1971 An Algorithm and FORTRAN-IV Program for Large Scale Q-mode Factor Analyses and Calculation of Factor Scores. Mathematical Geology 3:61-67.

Koch, A. J. and Hugh McLean

1975 Pleistocene Tephra and Ash-Flow Deposits in the Volcanic Highlands of Guatemala. Geological Society of America Bulletin 529-541.

Krumbein, W. C. and F. A. Graybill

1965 An Introduction to Statistical Models in Society. McGraw-Hill Book Co. New York.

Lance, G. N. and W. T. Williams

1967a A General Theory of Classificatory Sorting Strategies, I: Hierarchial Systems. Computer Journal 9:373-380.

1967b A General Theory of Sorting Strategies, II: Clustering Systems. Computer Journal 10:271-277.

Lehmann, Heinz

1935 LeFonds du Musee d'Ethnographie du Trocadero de Paris. Maya Research 345-366.

Mason, B.

1966 Principles of Geochemistry. John Wiley and Sons, New York.

Mahalanobis, P. C.

1936 On the Generalized Distance in Statistics. Proceedings of the National Institute of Science, India 12:49-55.

Matheny, R. T.

1970 The Ceramics of Aguacatal, Campeche, Mexico. Papers of The New World Archaeological Foundation, No. 27, Provo, Utah.

McBirney, A. R.

1963 Geology of a Part of the Central Guatemalan Cordillera. University of California Publication in Geological Sciences 38(4):177-231, Berkeley and Los Angeles.

Mie, Morma G., C. Hadlia Hull, Jean G. Jenkins, Karin Steinbrenner and Dale H. Bent.

1975 Statistical Package for the Social Sciences. McGraw-Hill New York.

Paddock, John

1970 "Oaxaca in Ancient Mesoamerica," in Ancient Oaxaca: Discoveries in Mexico Archaeology and History, John Paddock, editor, pp. 83-242. Stanford University Press, Stanford.

Peniche Pivero, Piedad

1973 Comalcalco, Tabasco: su Ceramica, Artifeactos y Enterramientos. Thesis, Universidad de Yucatan, Merida

Perlman, I. and F. Asaro

1969 Pottery Analysis by Neutron Activation. Archaeometry 11: 21-52.

Piña Chan, Roman

1968 Jaina, La Casa en el Agua. Instituto Nacional de Anthropologia e Historia, Mexico.

Rainey, Froelich and Elizabeth K. Ralph

1966 Archaeology and Its New Technology. Science 153:1481-1491.

Rands Robert L.

1967 Ceramica de la Region de Palenque, Mexico. Estudios de Cultura Maya VI:111-147.

1969 Mayan Ecology and Trade: 1967-1968. Mesoamerican Studies, University Museum, Southern Illinois University, Carbondale, Illinois.

1973a The Classic Collapse in the Southern Maya Lowlands: Chronology. In The Classic Maya Collapse, edited by T. P. Culbert, pp. 43-62. A School of American Research book. University of New Mexico Press, Albuquerque.

1973b The Classic Maya Collapse: Usumacinta Zone and the Northwestern

Periphery. In The Classic Maya Collapse, edited by T. P. Culbert, pp. 165-206. A School of American Research book. University of New Mexico Press, Albuquerque.

1974 The Ceramic Sequence at Palenque, Chiapas. In Mesoamerican Archaeology: New Approaches, edited by Norman Hammond, pp. 51-76. University of Texas Press, Austin.

Rands, Robert L., P. H. Benson, R. L. Bishop, P. y. Chen, Garman Harbottle, B. C. Rands and E. V. Sayre

1975 Western Maya Fine Paste Pottery: Chemical and Petrographic Correlations. Actas del XLI Congreso Internacional de Americanistas, Vol. 1, pp. 534-541, Mexico, D. F.

Rao, C. R.

1948 Tests of Significance in Multivariate Analysis. Biometrika 35:58-79.

Rathje, William L., D. A. Gregory and F. M. Wiseman

1978 Trade Modesl and Archaeological Problems: Classic Maya Examples. In Mesoamerican Communication Routes and Cultural Contacts, edited by T. A. Lee and Carlos Navarrete, pp. 147-176. Papers of the New World Archaeological Foundation, No. 40, Provo, Utah.

Rice, P. M.

1978 Clear Answers to Vague Questions: Some Assumptions of Provenience Studies on Pottery. In The Ceramics of Kaminaljuyu, edited by R. K. Wetherington, pp. 511-542. The Pennsylvania State University Press, State College, Pennsylvania.

Richards, T. W.

1895 The Composition of Athenian Pottery. Journal of the American Chemical Society 17:152-153.

Rovner, Irwin

1971 Potential of Opal Phytoliths for Use in Paleoecological Reconstruction. Quaternary Research 1: 343-359.

Rubin, J. and H. P. Friedman

1967 A Cluster Analysis and Taxonomy System for Grouping and Classifying Data. I.B.M. Corporation, Scientific Center, New York.

Ruz Lhuillier, Alberto

1969 La Costa de Campeche en los Tiempos Prehispanicos. Instituto Nacional de Antropologia e Historia, Investigaciones, No. 18, Mexico, D. F.

Sabloff, J. A.

1970 Type Descriptions of the Fine Paste Ceramics of the Bayal Boca Complex, Seibal, Peten, Guatemala. In Monographs and Papers in Maya Archaeology, edited by W. R. Bullard, pp. 357-404. Papers of the Peabody Museum, Vol. 61, Harvard University, Cambridge, Massachusetts.

1973 Continuity and Disruption During Terminal Late Classic Times at Seibal: Ceramic and Other Evidence. In The Classic Maya Collapse, edited by T. P. Culbert, pp. 107-132. A School of American Research book. Univeristy of New Mexico Press, Albuquerque.

1974 Old Myths, New Myths: The Role of Sea Traders in the Development of Ancient Maya Civilization. In The Sea in the Pre-Columbian World, edited by Elizabeth P. Benson, pp. 67-96. Dumbarton Oaks Research Library and Collections, Washington, D. C.

1975 Excavation at Seibal: Ceramics. Mrmoirs of the Peabody Museum, Vol. 13, No. 2, Harvard University, Cambridge, Massachusetts.

Sabloff, Jeremy A. and William L. Rathje

1975 The Rise of a Maya Merchant Class. Scientific American 233(4):72-82.

Sabloff, J. A. and G. R. Willey

1967 The Collapse of Maya Civilization in the Southern Lowlands: A Consideration of History and Process. Southwestern Journal of Anthropology 23:311-336.

Sayre, E. V.

1977 Brookhaven Procedures for Statistical Analysis of Multivariate Archaeometric Data. Brookhaven National Laboratory Report, BNL-21693, Upton, New York.

Sayre, E. V., A. Murrenhoff and C. F. Weick

1958 The Non-destructive Analysis of Ancient Potsherds Through Neutron Activation. Brookhaven National Laboratory Report, BNL-508 (-122), Upton, New York.

Sayre, E. V., L. H. Chan, and Jeremy A. Sabloff

1971 High-Resolution Gamma Ray Spectoscopic Analyses of Mayan Fine Orange Pottery. In Science and Archaeology, edited by R. H. Brill, pp. 165-179. The MIT Press, Cambridge Massachusetts.

Sayre, Edward V. and Garman Harbottle

n.d. The Analysis by Neutron Activation of Archaeological Ceramics Related to Teotihuacan: Local Wares and Trade Sherds. To be published in Urbanization at Teotihuacan, Vol. 4, R. Millon, editor. University of Texas Press, Austin.

Scott, A. J. and M. J. Symons

1971 Clustering Methods Based on Likelihood Ratio Criteria. Biometrics 27:387-398.

Shook, E. M.

1957 Dentate and Dentate Rocker Stamping from Tabasco. American Antiquity 22:285-287.

Seigel, S.

1956 Nonparametric Statistics for the Behavioral Sciences. McGraw-Hill, New York.

Smith, Robert E.

1955 Ceramic Sequence at Uaxactun, Guatemala. Middle American Research Institute, Tulane University, Publication 20, New Orleans, Louisiana

1957 The Marquez Collection of X Fine Orange and Fine Orange Polychrome Vessels. Carnegie Institution of Washington, Notes on Middle American Archaeology and Ethnology, No. 131, Washington, D. C.

1958 The Place of Fine Orange Pottery in Mesoamerican Archaeology. American Antiquity 24:151-160.

1971 *The Pottery of Mayapan: Including Studies of Ceramic Material from Uxmal, Kabah and Chichen Itza.* Papers of the Peabody Museum, Vol. 66, Harvard Univeristy, Cambridge, Massachusetts.

Smith, Robert E. and James C. Gifford

1965 Pottery of the Maya Lowlands. In Handbook of Middle American Indians, Vol. 2, edited by Robert Wauchope (general editor) and G. R. Willey (volume editor), pp. 498-534. University of Texas Press, Austin.

Sneath, P. and R. R. Sokal

1973 *Principles of Numerical Taxonomy.* W. H. Freeman and Co., San Francisco.

Sokal, R. R. and F. J. Rohlf

1969 *Biometry.* W. H. Freeman and Company, San Francisco.

Thompson, J. E. S.

1939 *Excavations at San Jose, British Honduras.* Carnegie Institution of Washington, Publication 506, Washington, D. C.

1970 *Maya History and Religion.* University of Oklahoma Press, Norman.

Vaillant, G. C.

1927 *The Chronological Significance of Maya Ceramics.* Ph.D. Dissertation, Harvard University, Cambridge, Massachusetts.

Veakis, E.

1979 *Archaeometric Study of Native Copper in Prehistoric North America.* Ph.D. Dissertation, State University of New York, Stony Brook, New York.

Wadell, Hakon

1938 Physical-Geological Features of Peten, Guatemala. In The Inscriptions of Peten by S. G. Morley, Vol. 4, pp. 336-348, Carnegie Institution of Washington, Washington, D. C.

Wauchope, Robert

1975 Zacualpa, El Quiche, Guatemala: An Ancient Provincial Center of the Highland Maya. Middle American Research Institute, Tulane University, Publication 39, New Orleans, Louisiana.

Weigand, P. C., Garman Harbottle and E. V. Sayre

1977 Turquoise Sources and Source Areas: Mesoamerica and the Southwestern U. S. A. In Exchange Systems in Prehistory, edited by T. K. Earle and J. E. Erickson, pp. 5-32, Academic Press, New York.

West, R. C.

1964 Surface Configuration and Associated Geology of Middle America. In Handbook of Middle American Indians, Vol. 1, edited by Robert Wauchope (general editor) and R. C. West (volume editor), pp. 38-83. University of Texas Press, Austin.

West, R. C., N. P. Psuty and B. G. Thom

1969 The Tabasco Lowlands of Southeastern Mexico. Louisiana State University Press, Coastal Studies Series No. 27, Baton Rouge, Louisiana.

Wilks, S. S.

1962 Mathematical Statistics. John Wiley and Sons, New York.

Willey, Gordon R.

1972 The Artifacts of Altar de Scarificios. Papers of the Peadoby Museum, Vol. 64, No. 1, Harvard University, Cambridge, Massachusetts.

1978 Excavation at Seibal: Artifacts. Memoirs of the Peabody Museum, Vol. 14, No. 1, Harvard University, Cambridge, Massachusetts.

Willey, Gordon R. and Demitri B. Shimkin

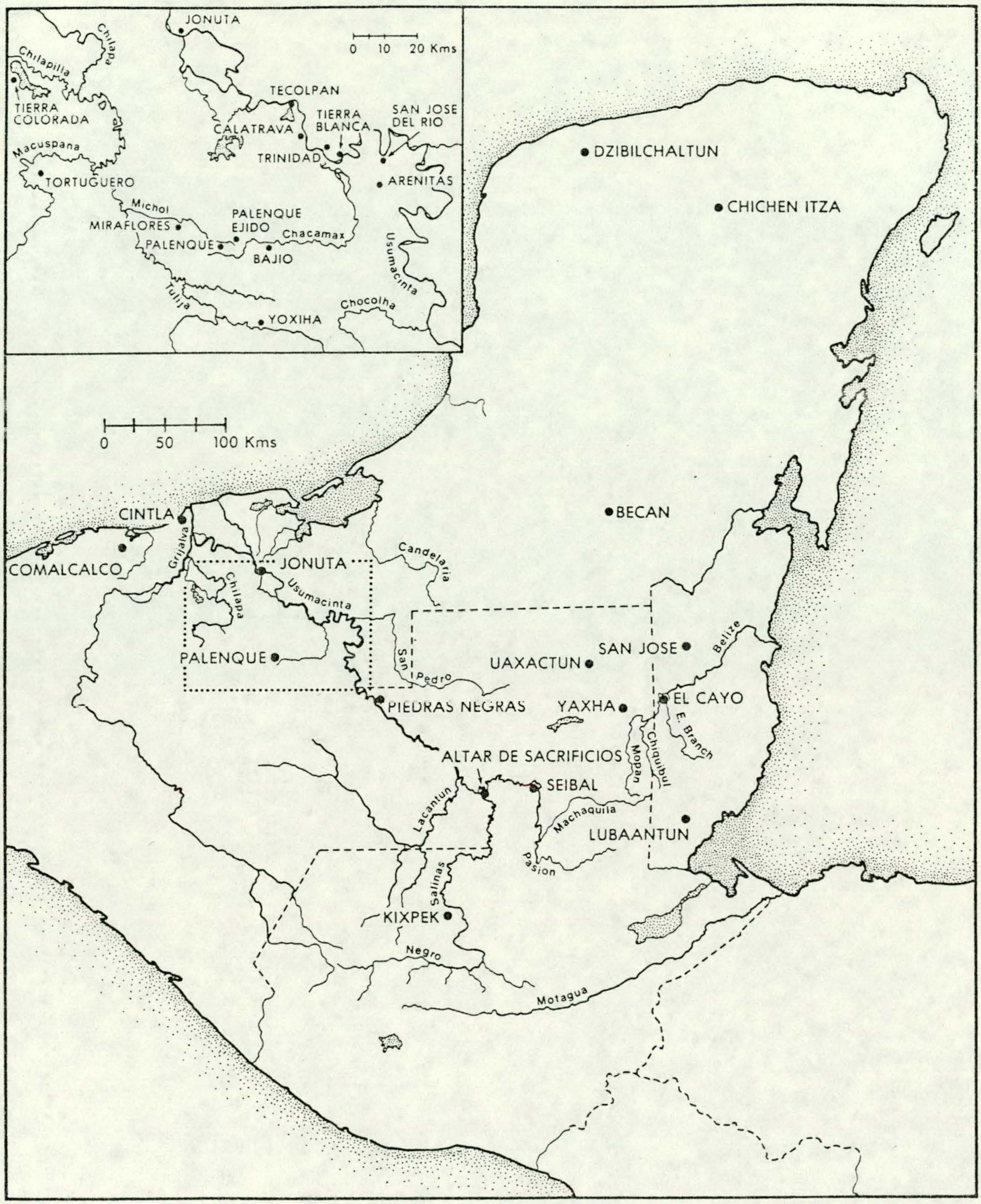
1973 The Maya Collapse: A Summary View. In The Classic Maya Collapse, edited by T. P. Culbert, pp. 457-502. A School of American Research book. University of New Mexico Press, Albuquerque.

Willey, Gordon R., A. L. Smith, Gair Tourtellot III, and Ian Graham

1975 Excavations at Seibal: Introduction: The Site and Its Setting. Memoirs of the Peabody Museum, Vol. 13, No. 1. Cambridge, Massachussets.

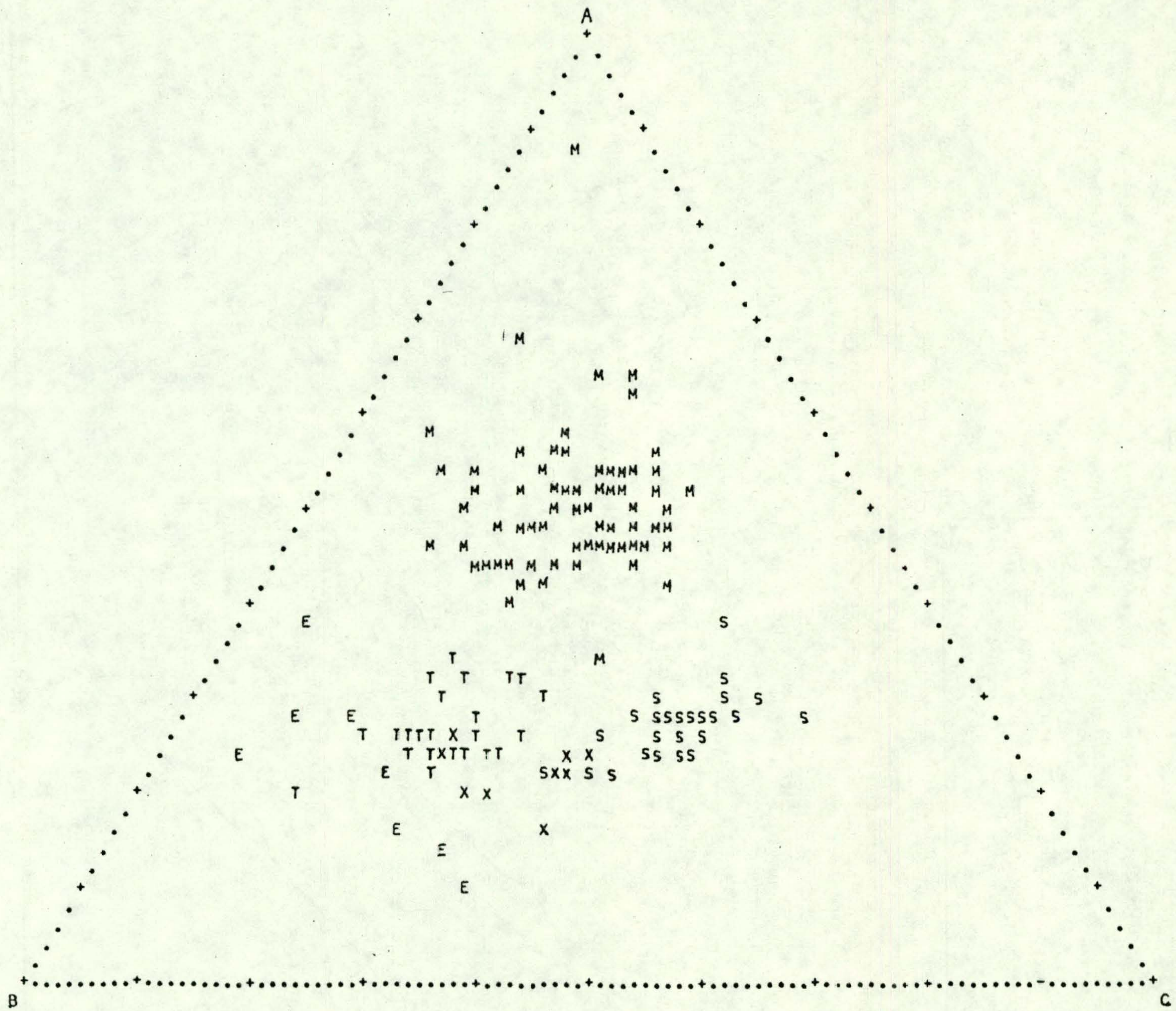
Williams, Howel

1960 Volcanic History of the Guatemalan Highlands. University of California Publications in Geological Sciences, Vol. 38, No. 1, pp. 1-86, Berkeley and Los Angeles.

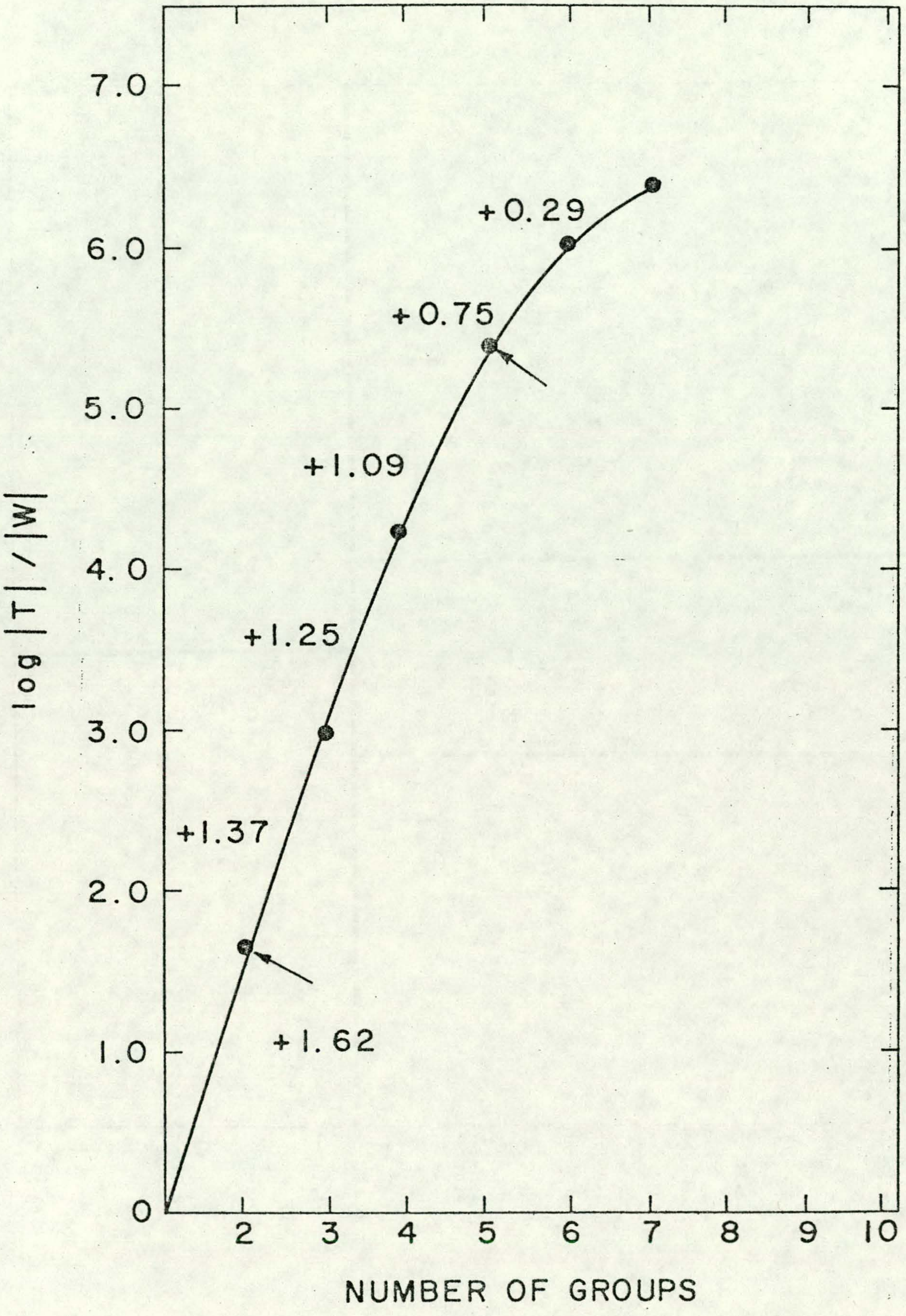


JONUTA
0 10 20 Kms
Chilapa
Chilapilla
TIERRA COLORADA
TECOLPAN
CALATRAVA
TIERRA BLANCA
SAN JOSE DEL RIO
TRINIDAD
Macuspana
TORTUGUERO
ARENITAS
Michol
MIRAFLORES
PALENQUE EJIDO
Chacamax
PALENQUE
BAJIO
Usumacinta
Tulija
Chocolha
YOXIHA
DZIBILCHALTUN
CHICHEN ITZA
0 50 100 Kms
CINTLA
BECAN
COMALCALCO
Grijalva
JONUTA
Candelaria
Chilapa
Usumacinta
SAN JOSE
Belize
UAXACTUN
PALENQUE
San Pedro
EL CAYO
PIEDRAS NEGRAS
YAXHA
E. Branch
Mopan
Chiquibul
ALTAR DE SACRIFICIOS
SEIBAL
Lacantun
Machaquila
LUBAANTUN
Pasion
Salinas
KIXPEK
Negro
Motagua

Figure 1



Chap 3, Fig 2, BNL 4-805-80



Chap 3, Fig 3, BNL 4-888-80

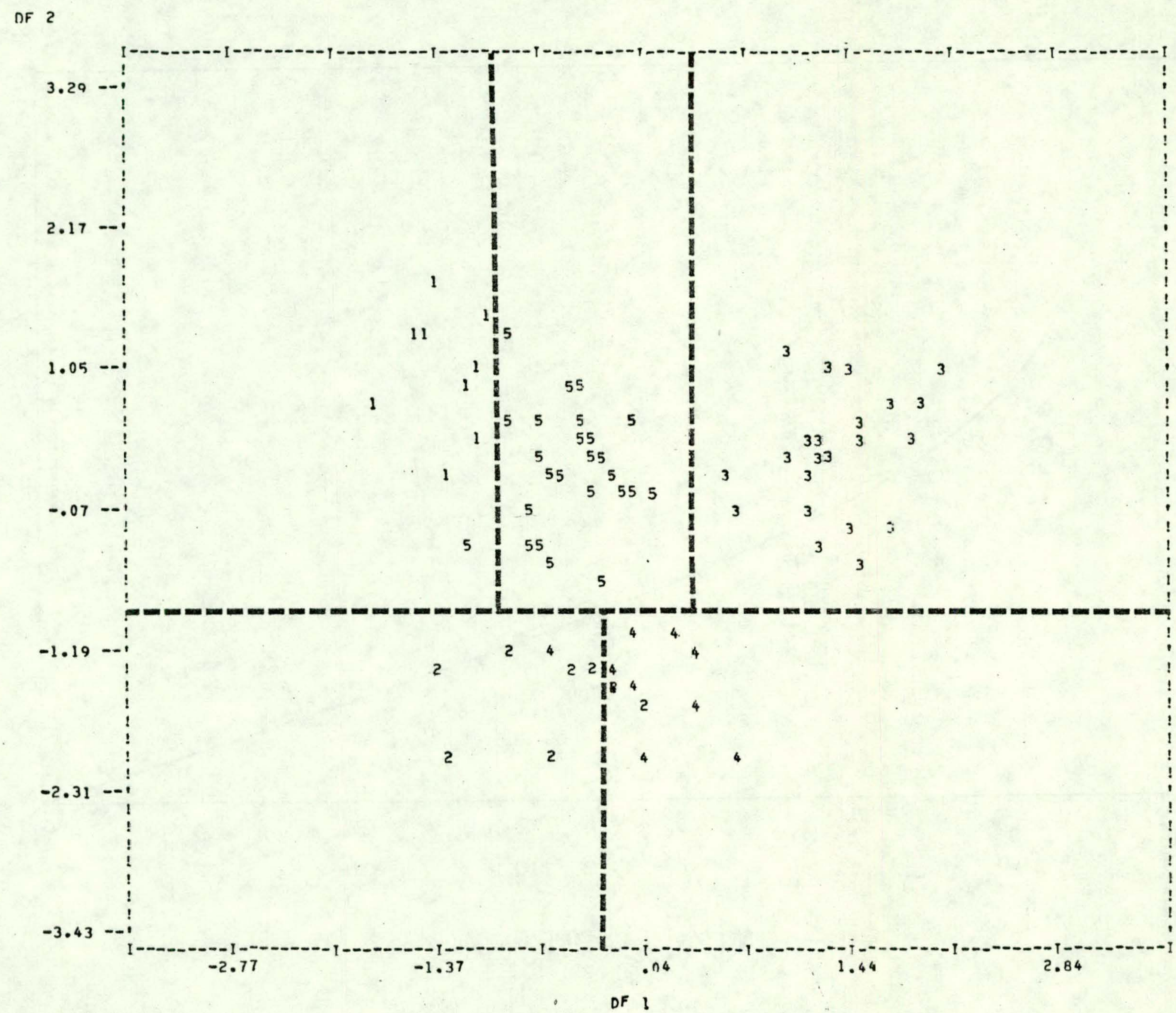


Fig 4 BNL - 4-225-80

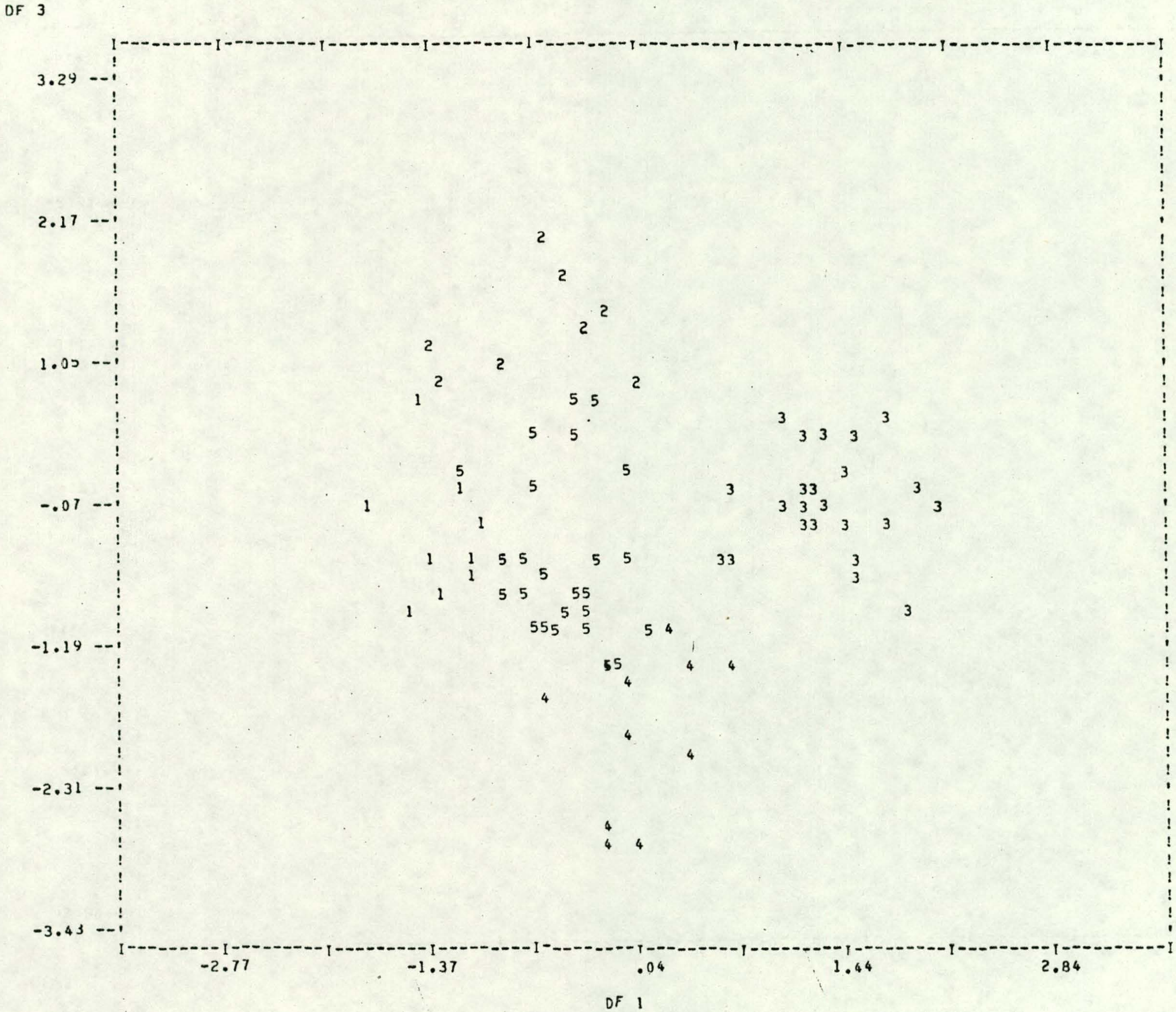


Fig. 5, BNL 4221-80

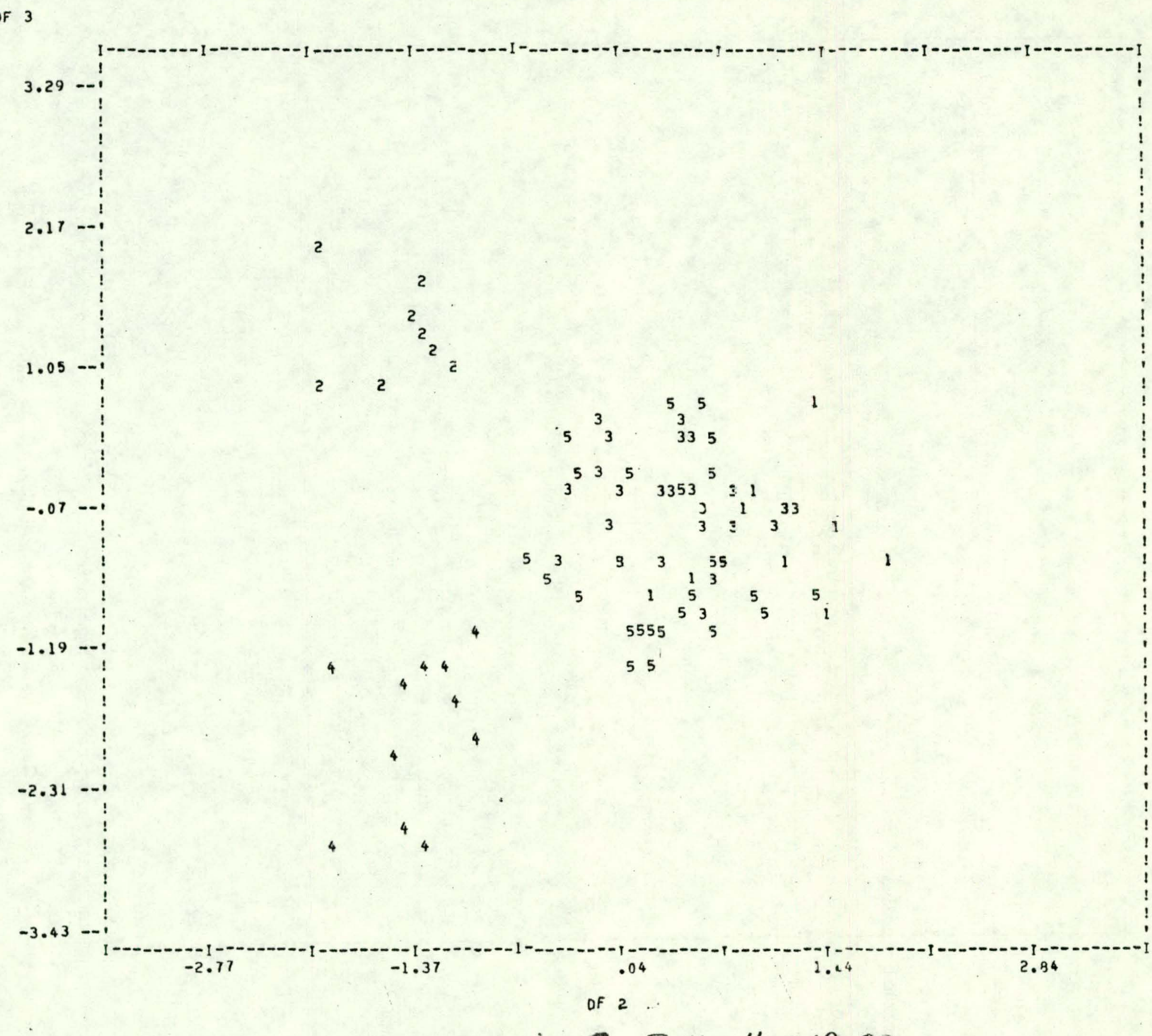


Fig 6, BNL 4-219-80

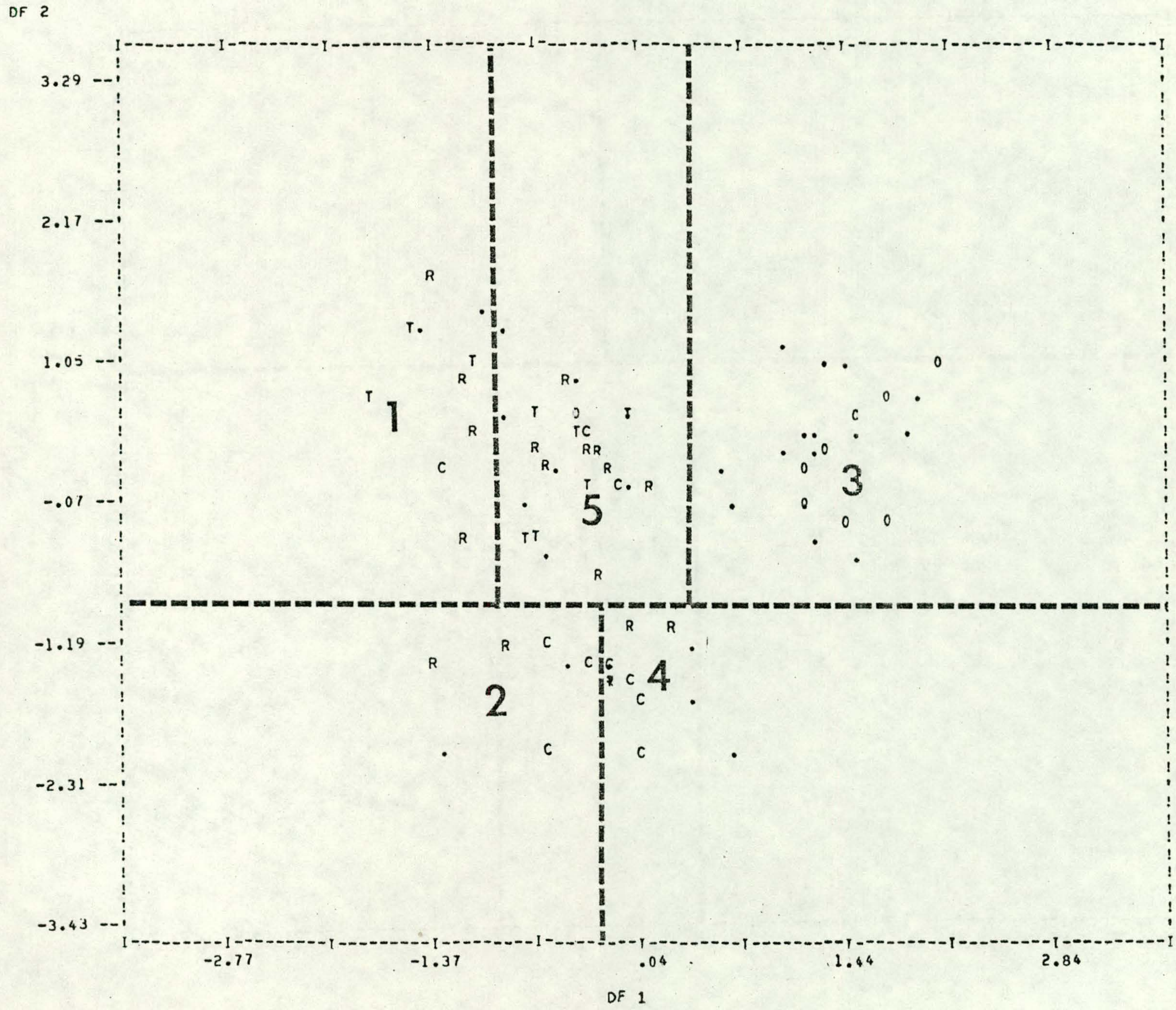


Fig 7, BNL 4-226-80

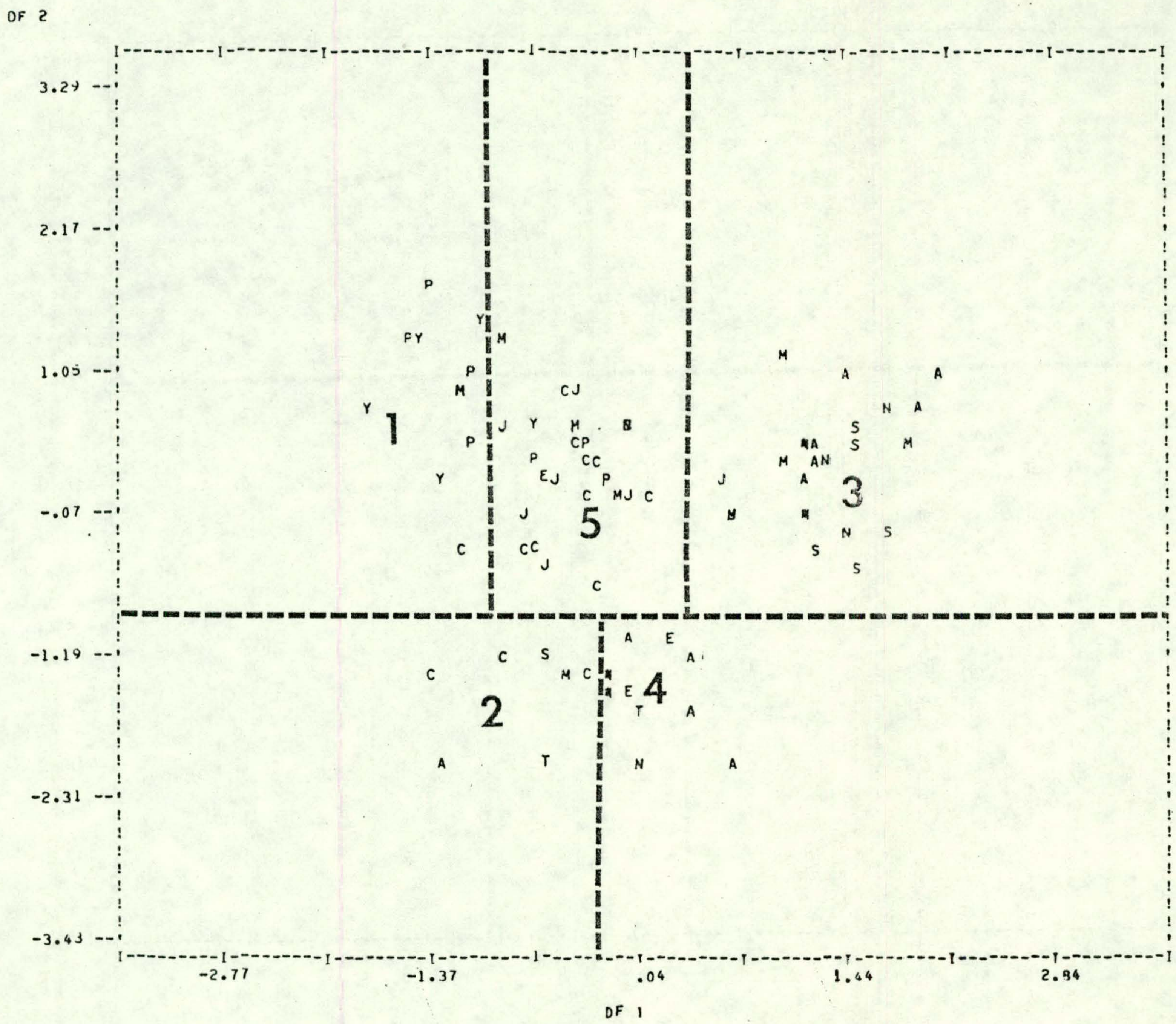


Fig 8, BNL 4-220-80

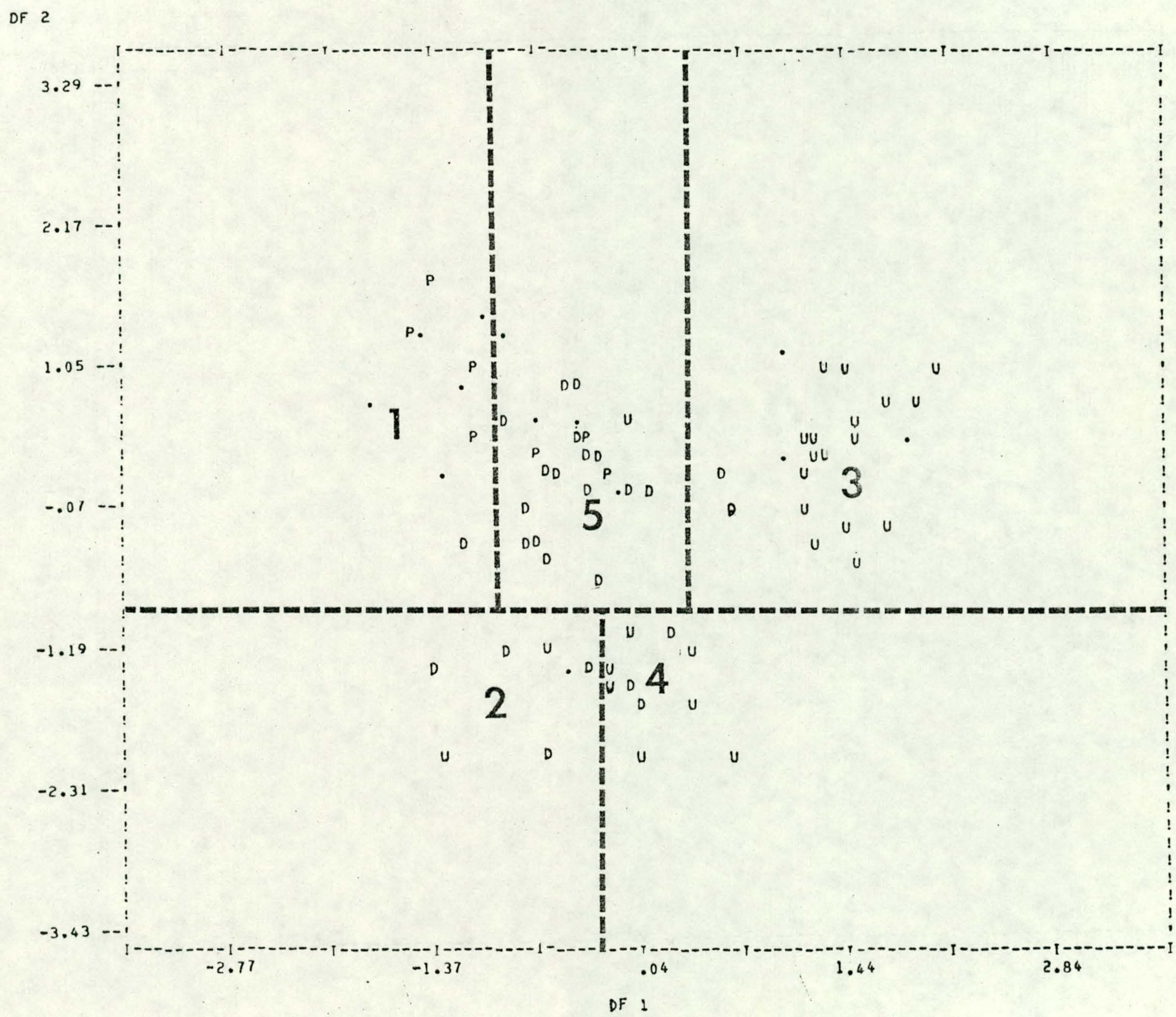


Fig 8, BKL 4-216-80

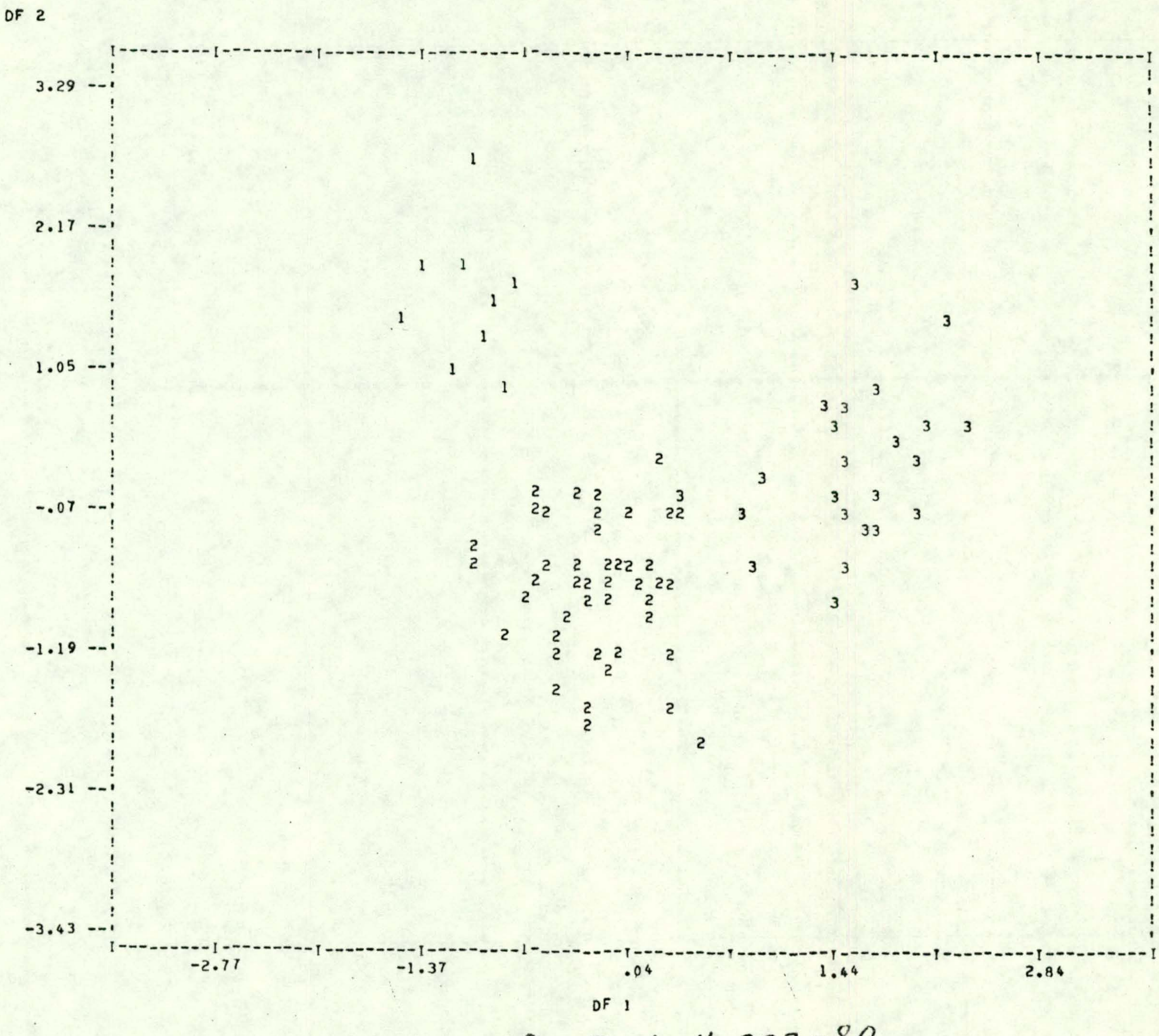


Fig 10, BNL 4-222-80

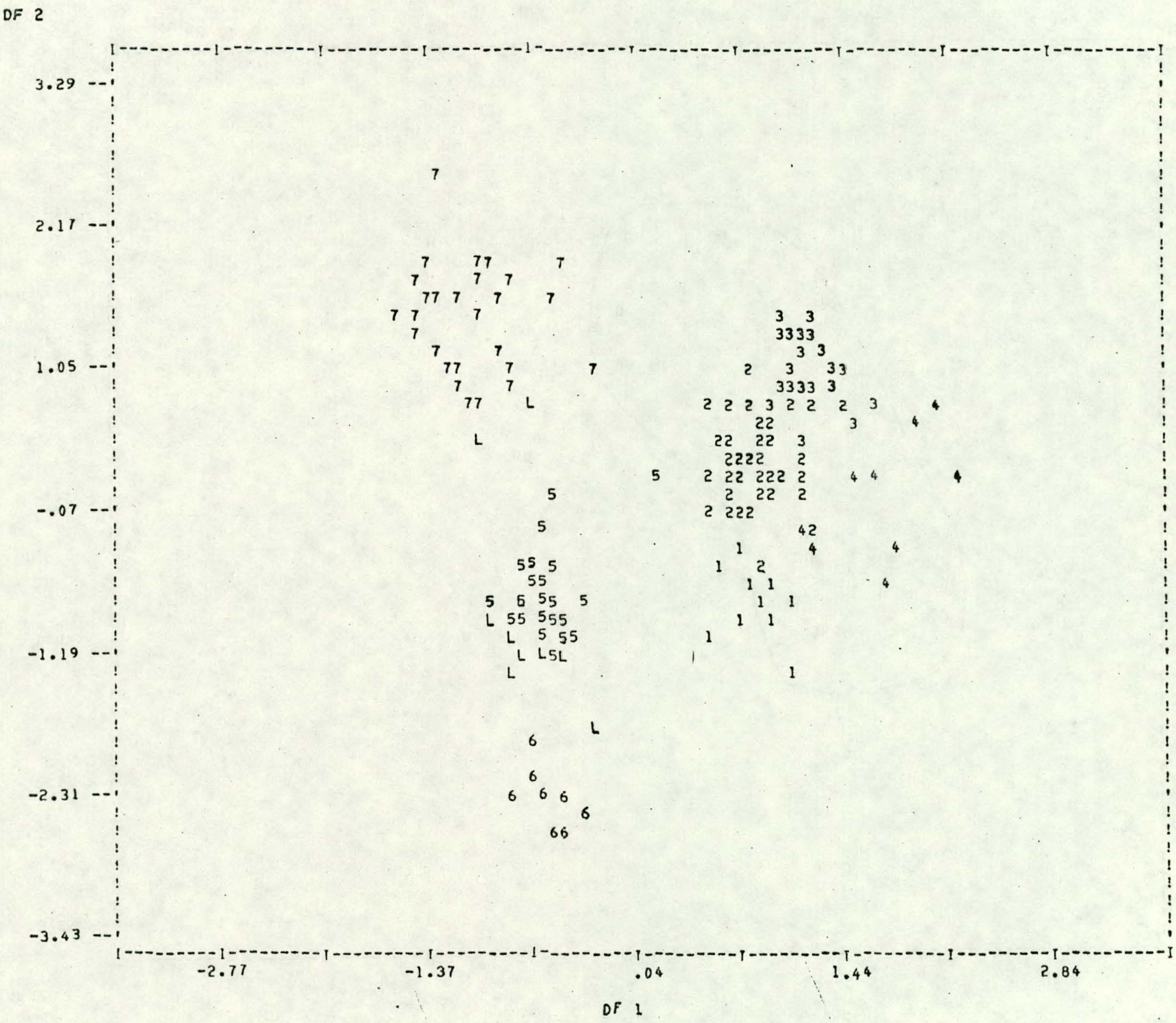


Fig 11. BNL 4-214-80

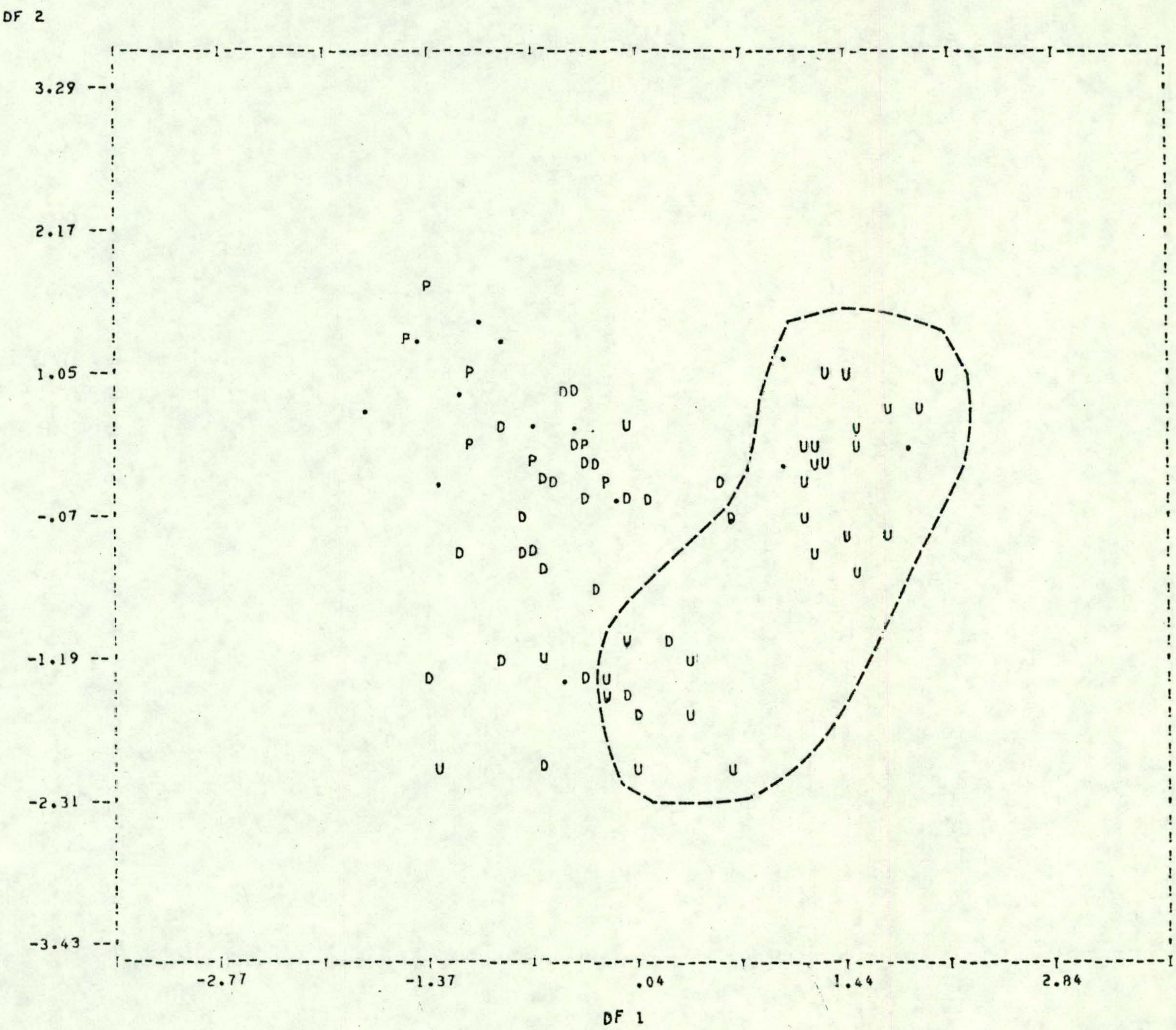


Fig 12, BNL 4-215-80

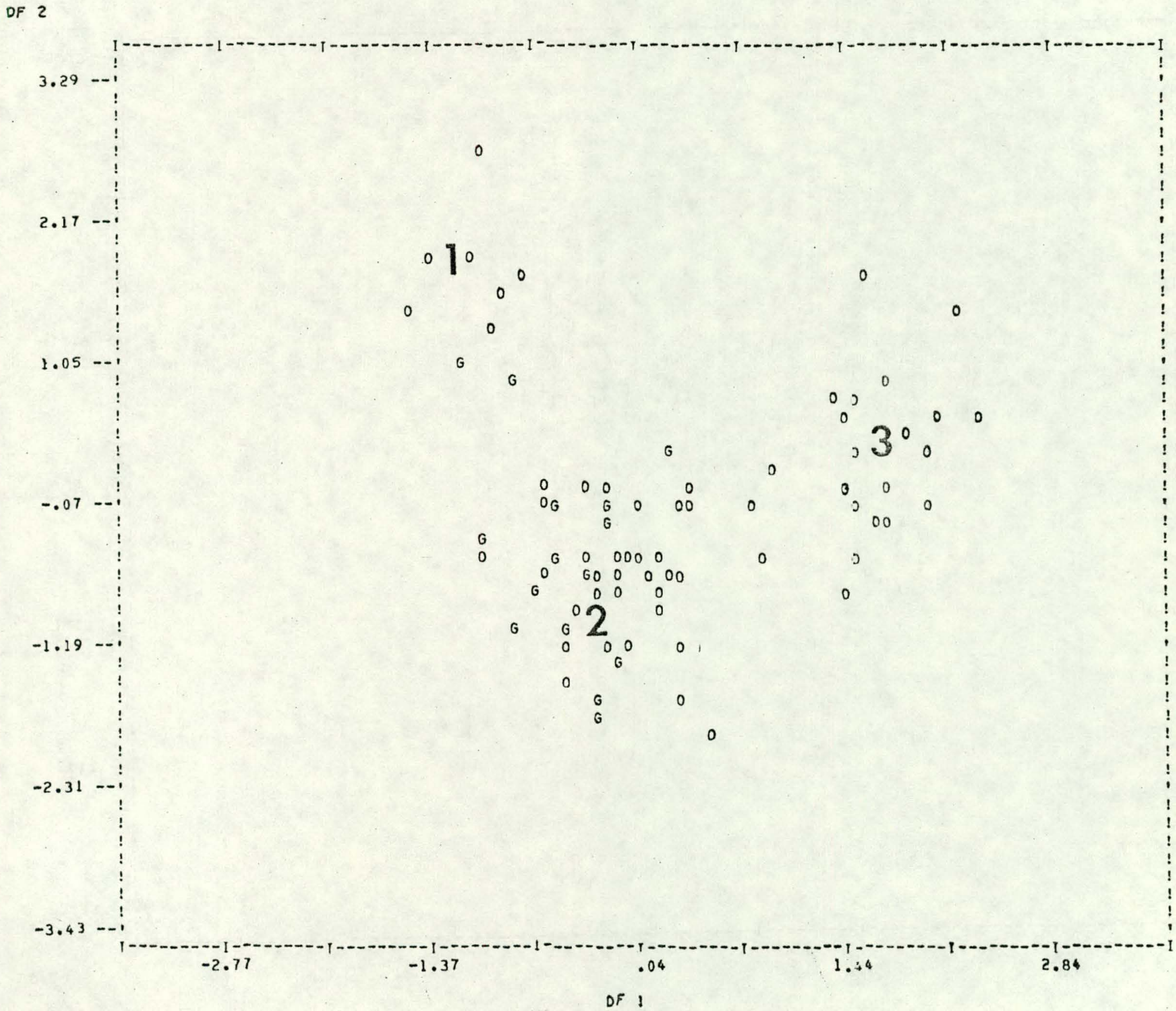


Fig 13, BNL 4-223-80

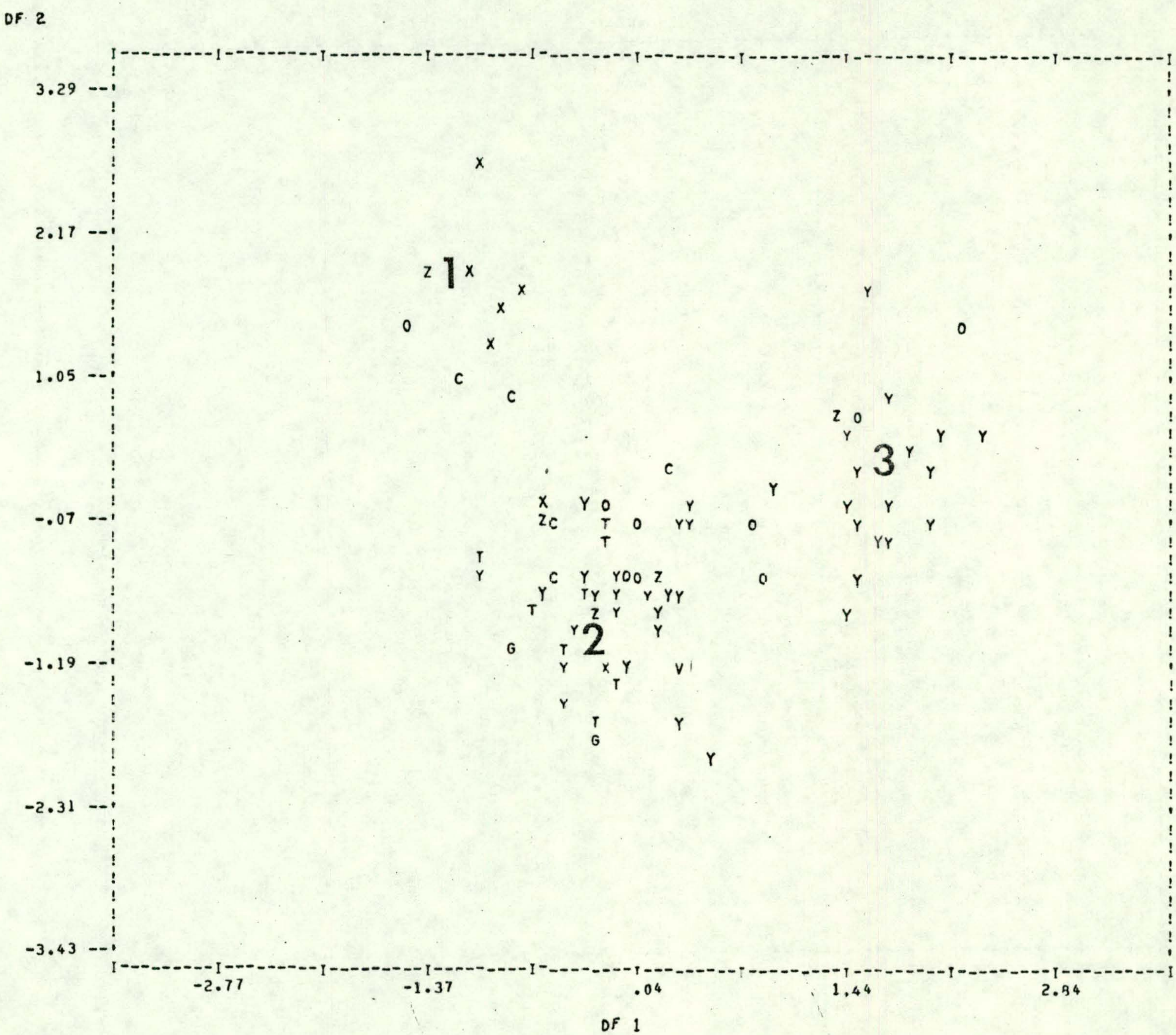


Fig 14, PNL 4-218-80

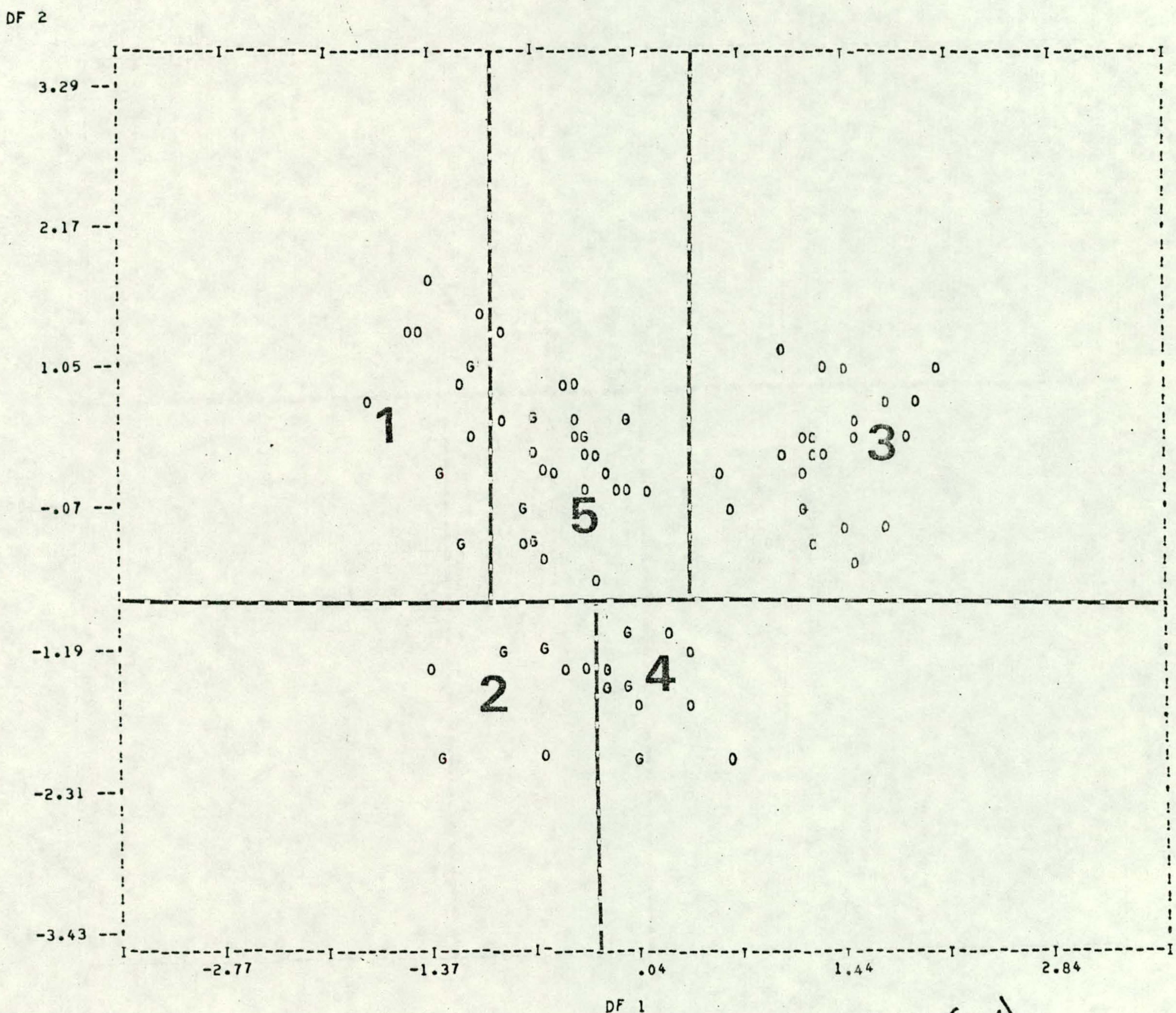


Fig 15, BNL 4-217-80 (modified)

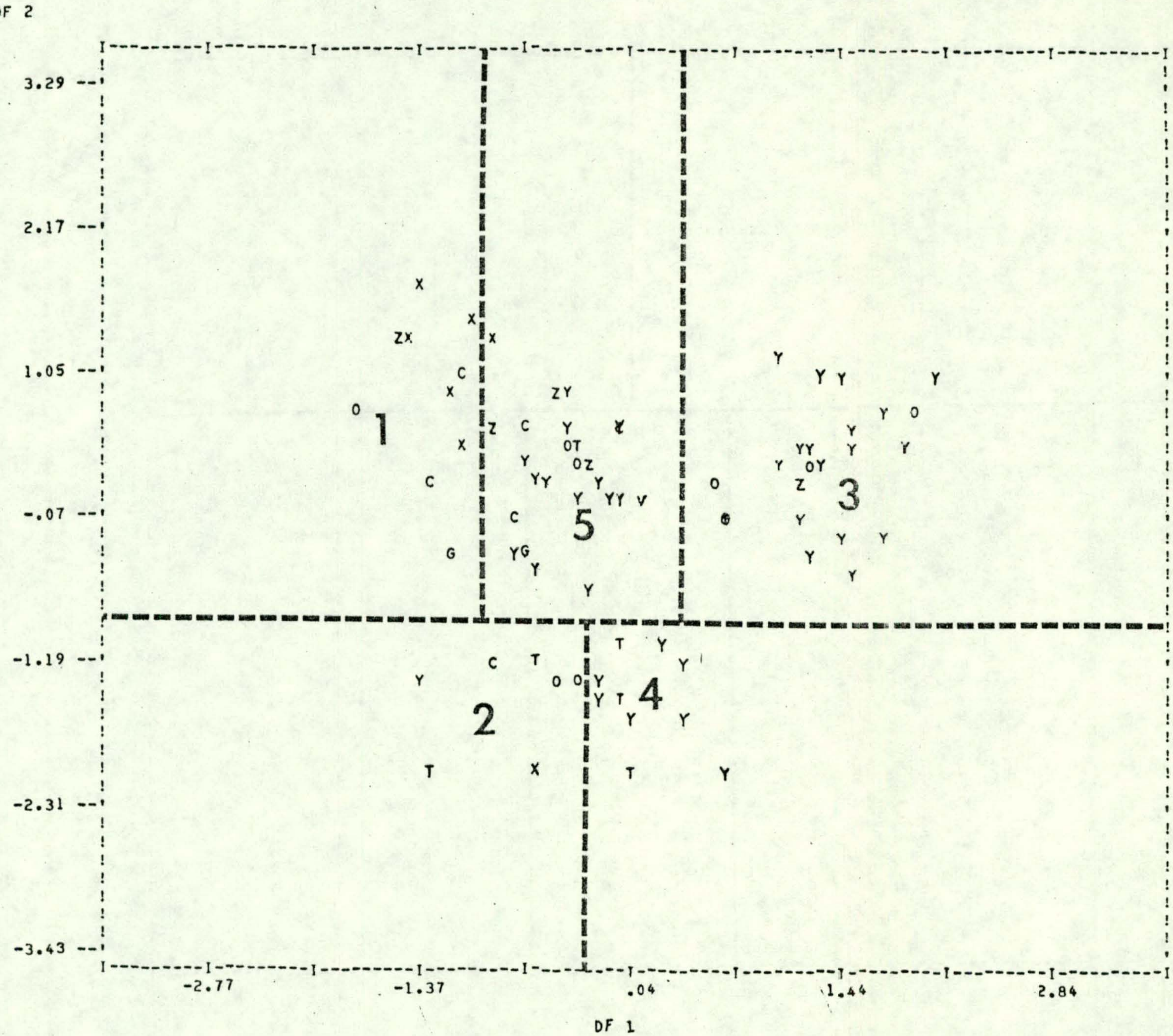


Fig 16, BNL 4-229-80

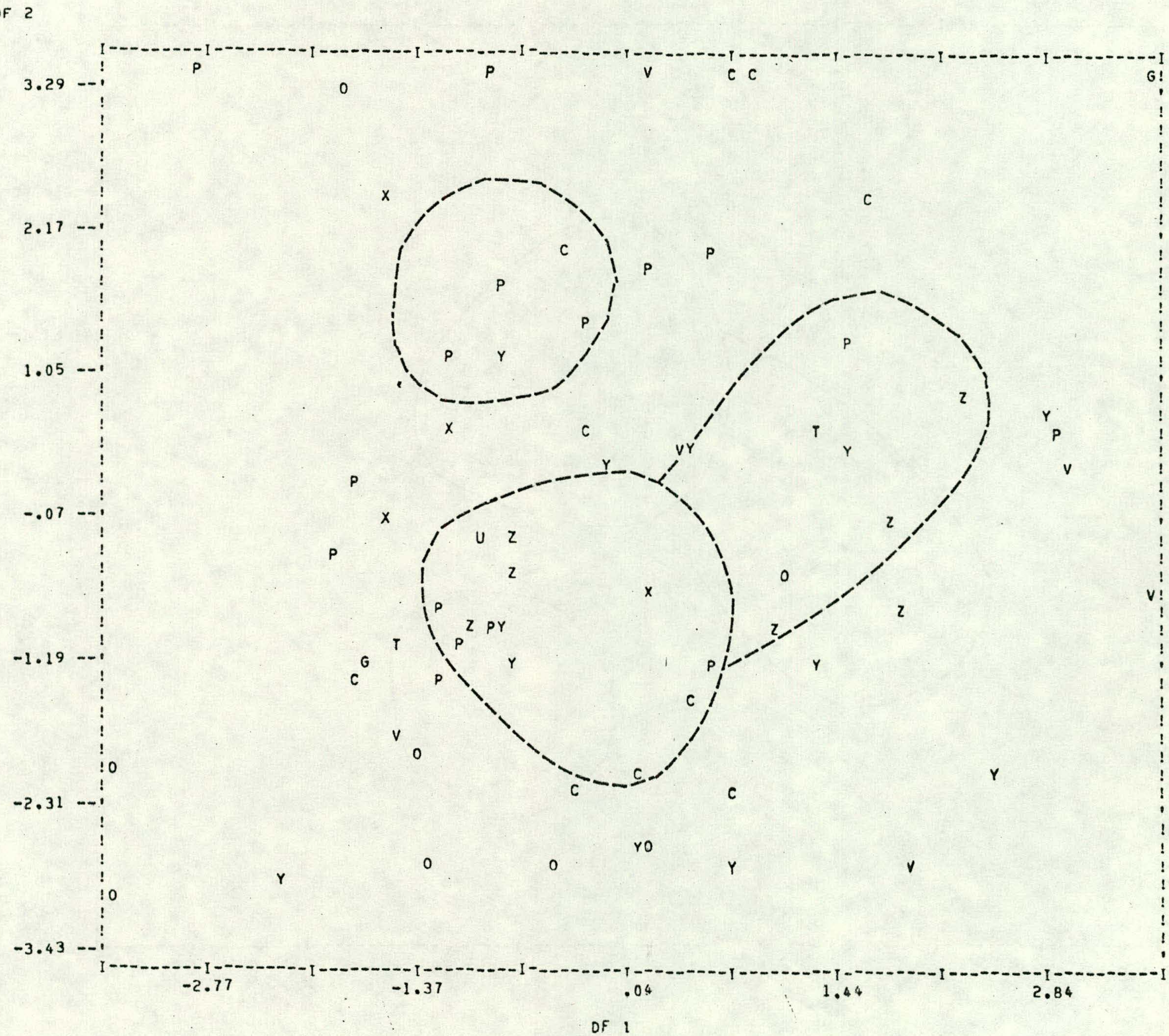


Fig 17, BNL 4-227-80

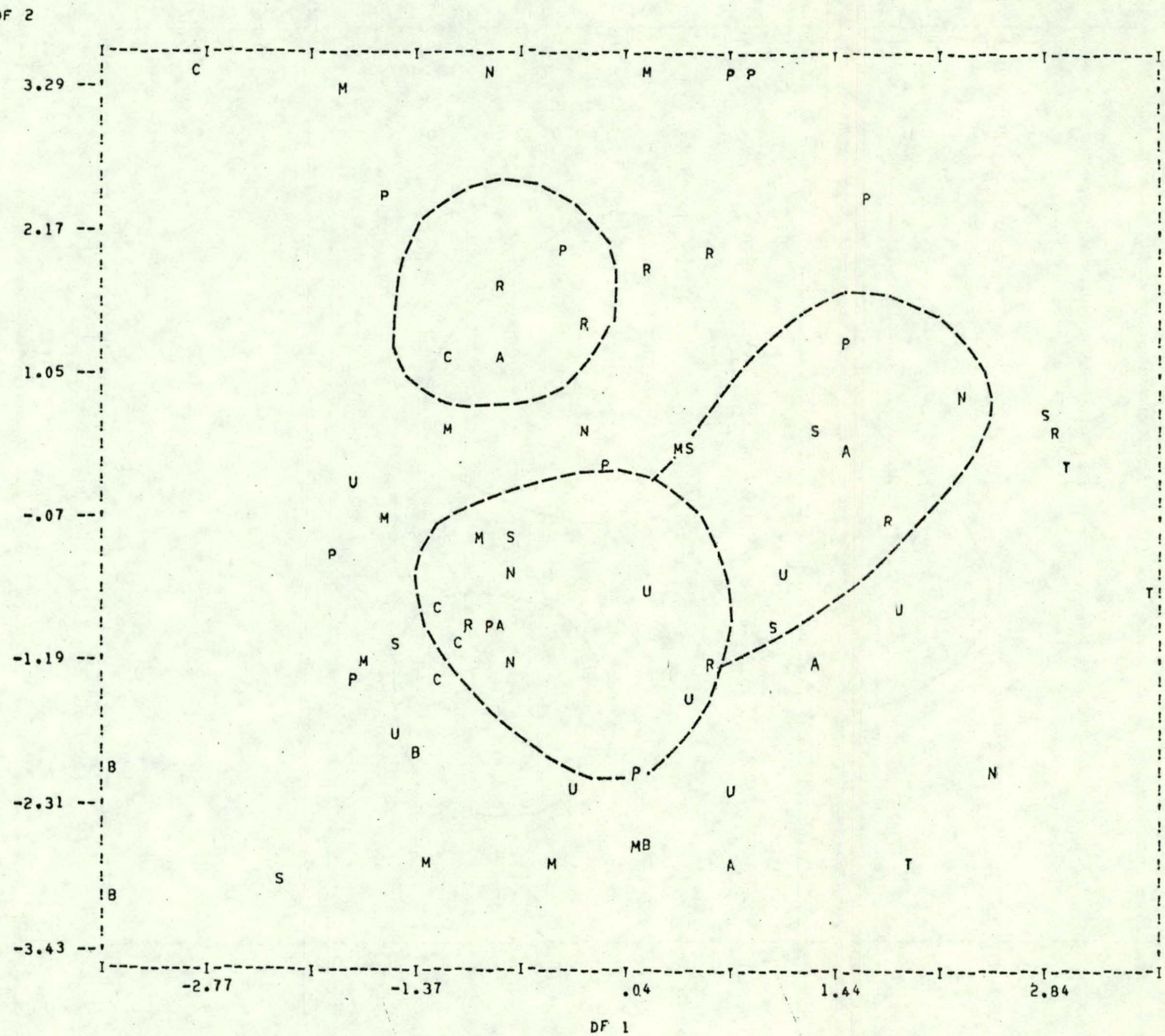


Fig. 18, BNL 4-228-80

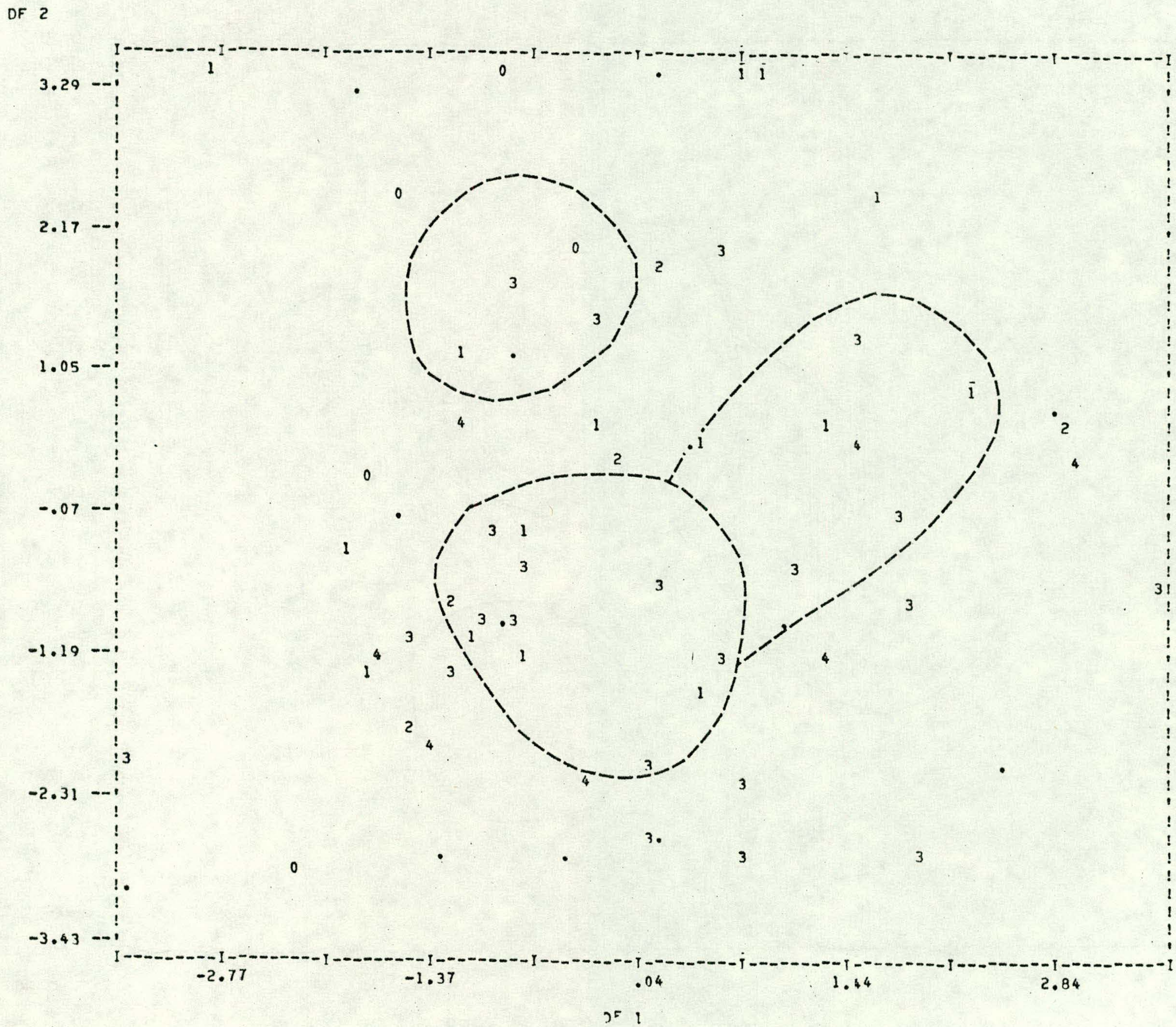


Fig 19, BNL 4-238-80

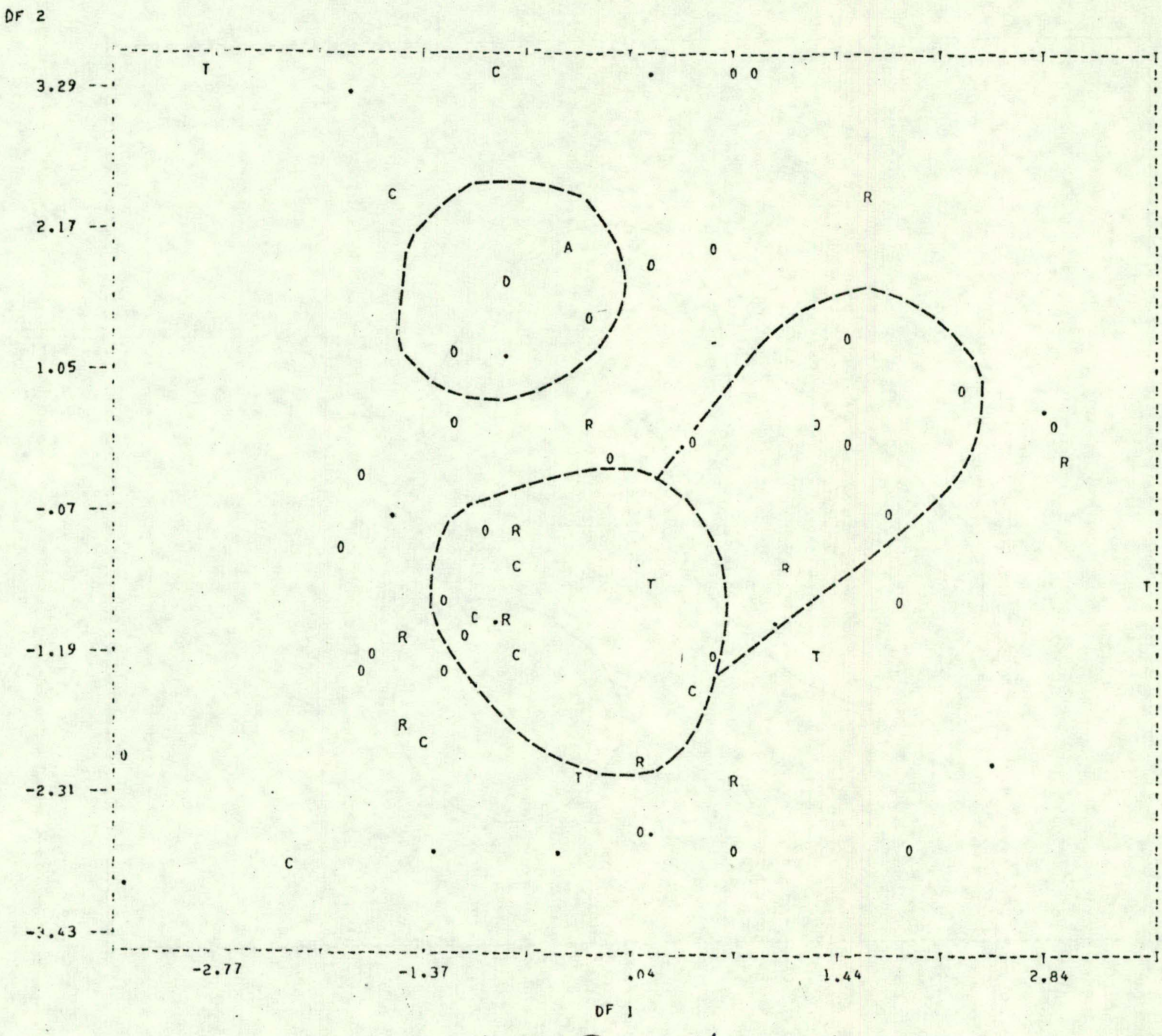


Fig 20, BNL 4-224-80

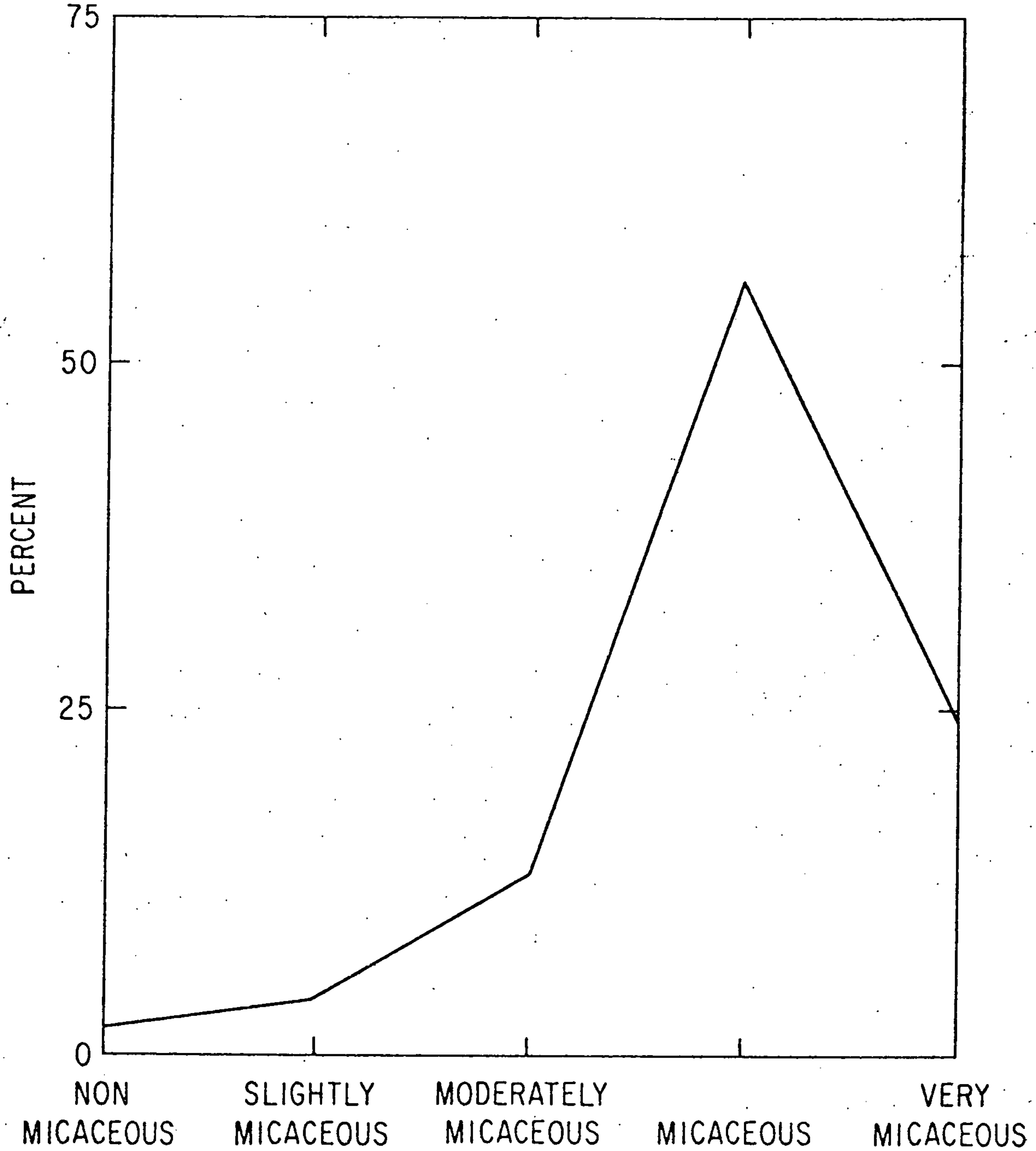


Fig 21, BNL 4-231-80

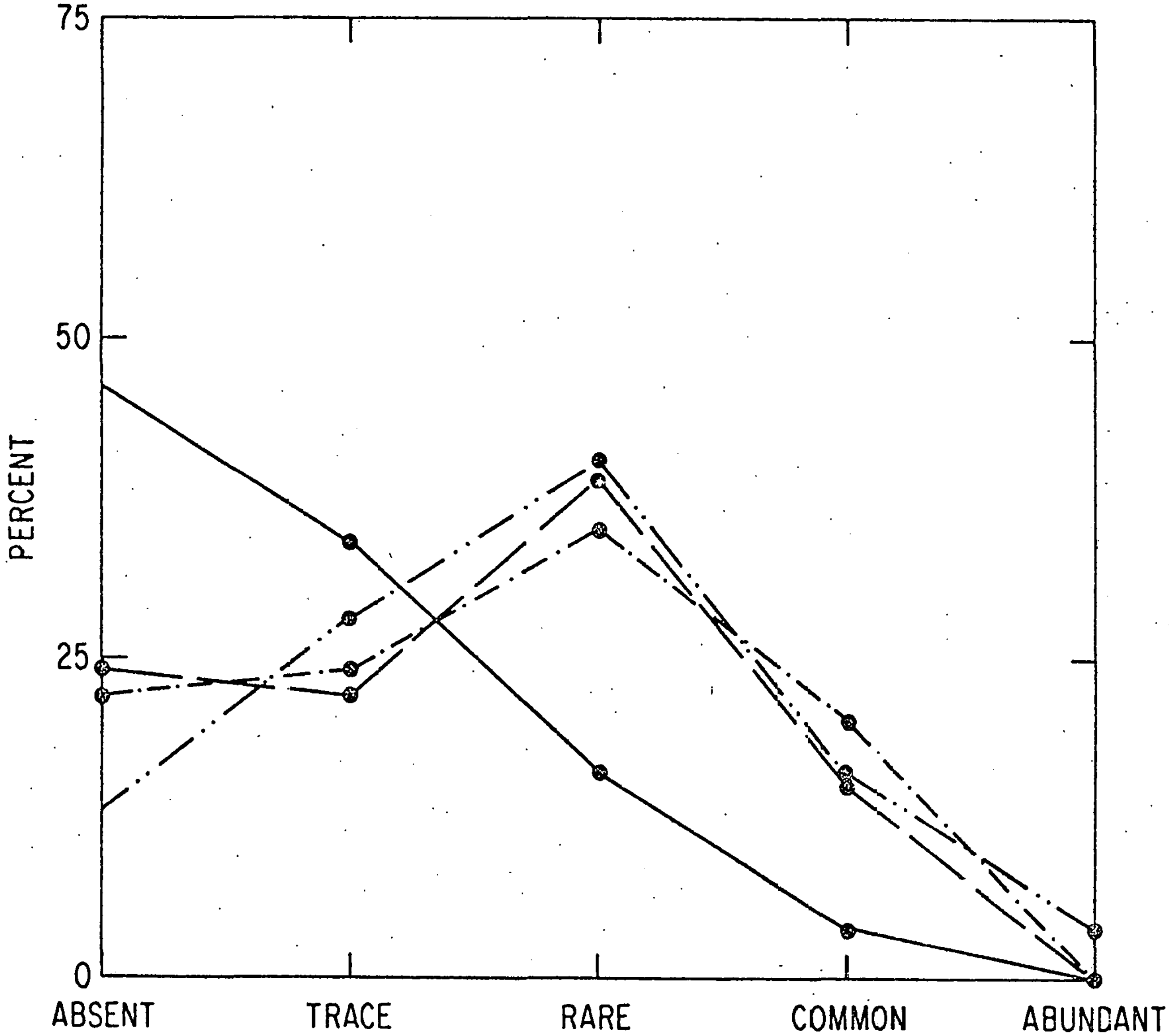


Fig 22, BNL 4-234-80

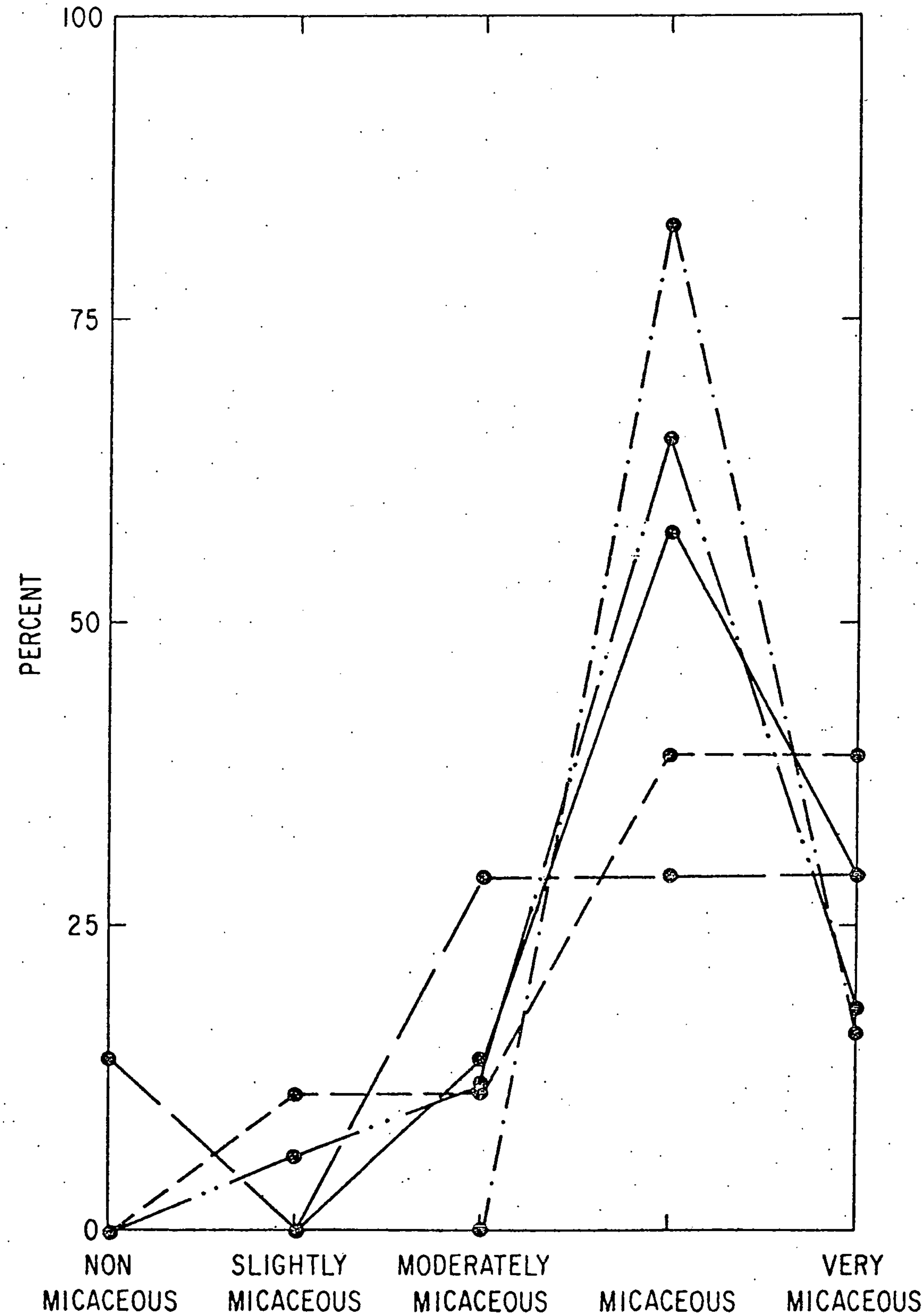


Fig 23, BNL 4-232-80

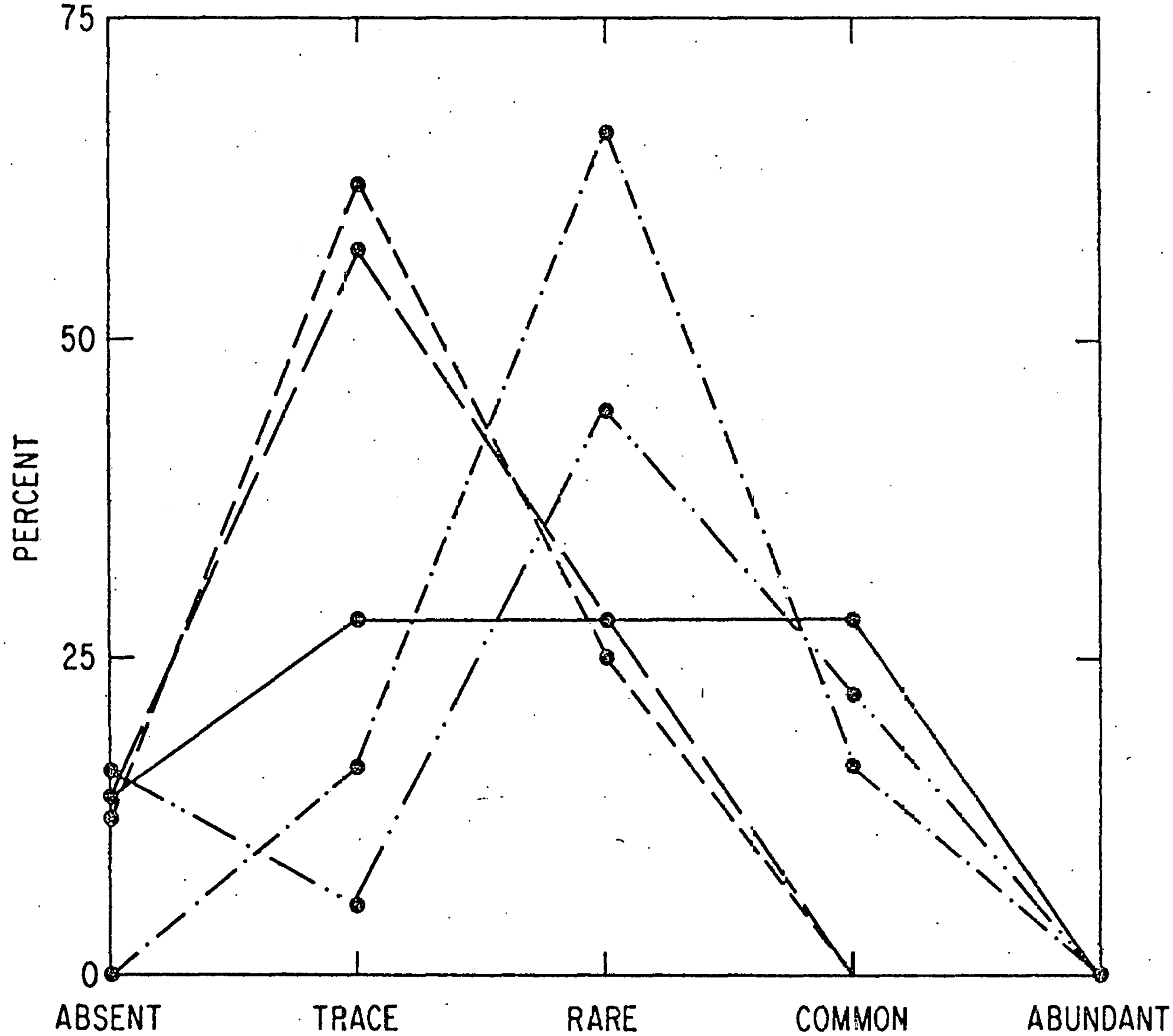


Fig 24. BNL 4-235-80

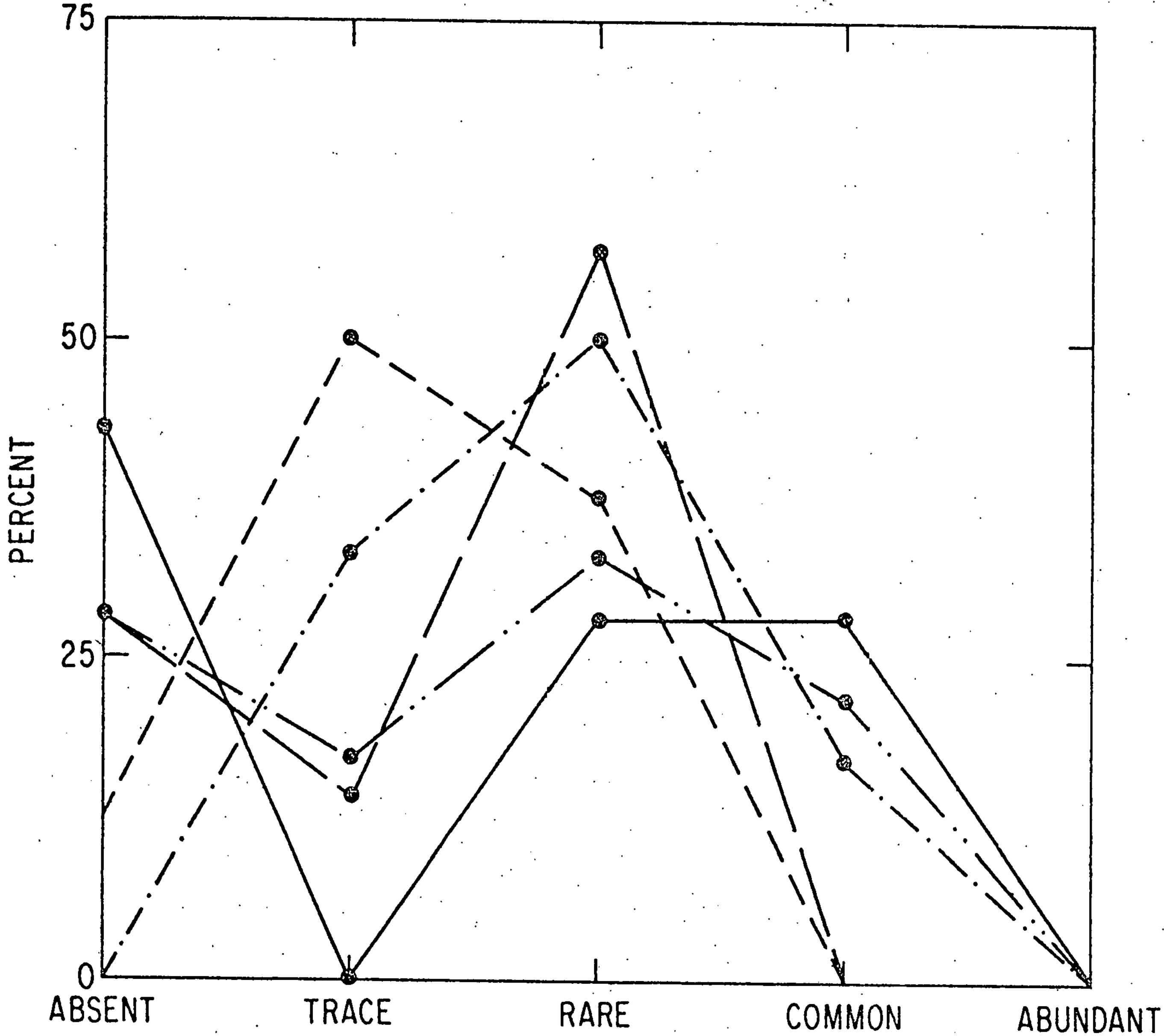


Fig 25, BNL 4-236-80

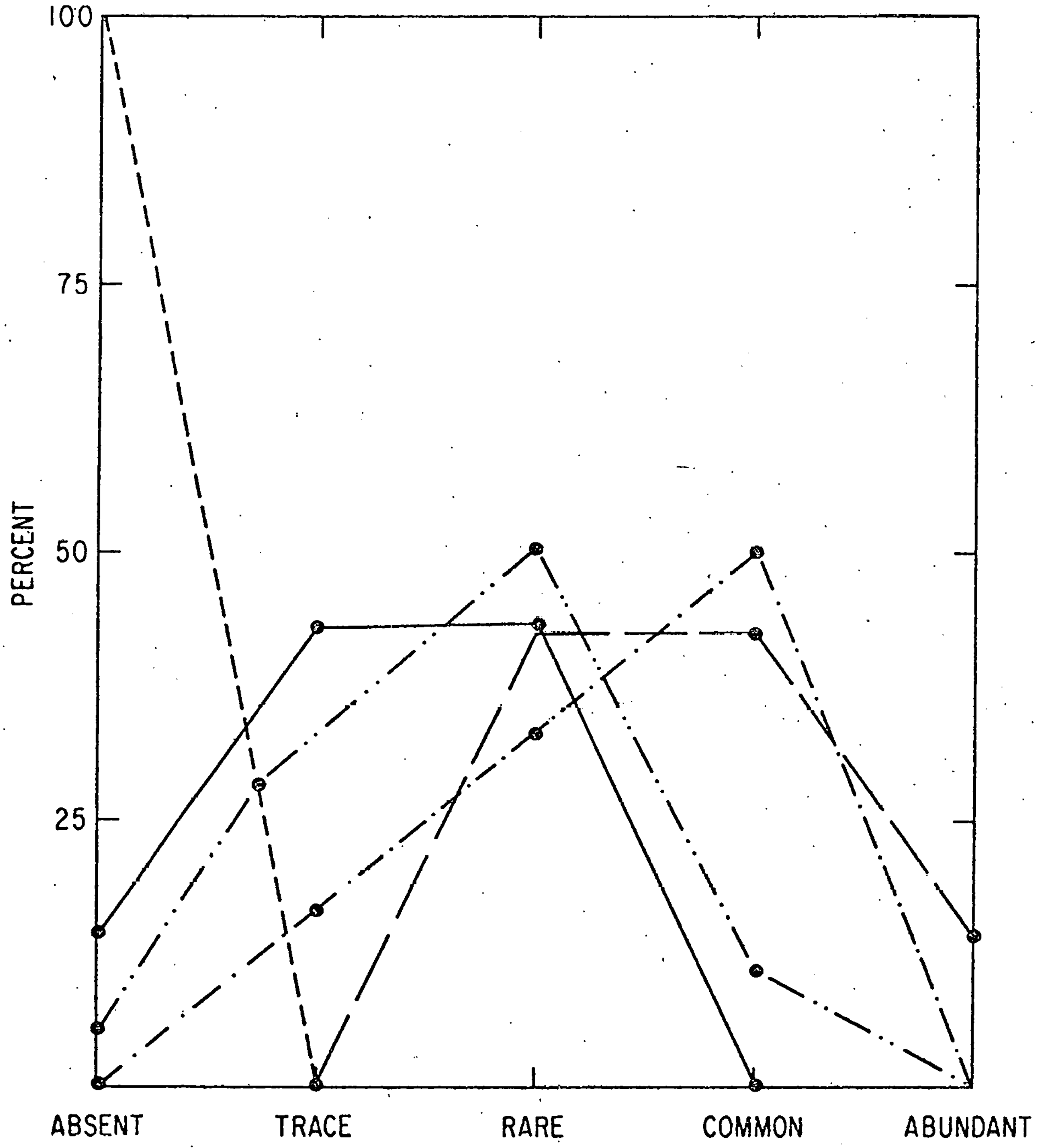


Fig. 26, BNL 4-233-80

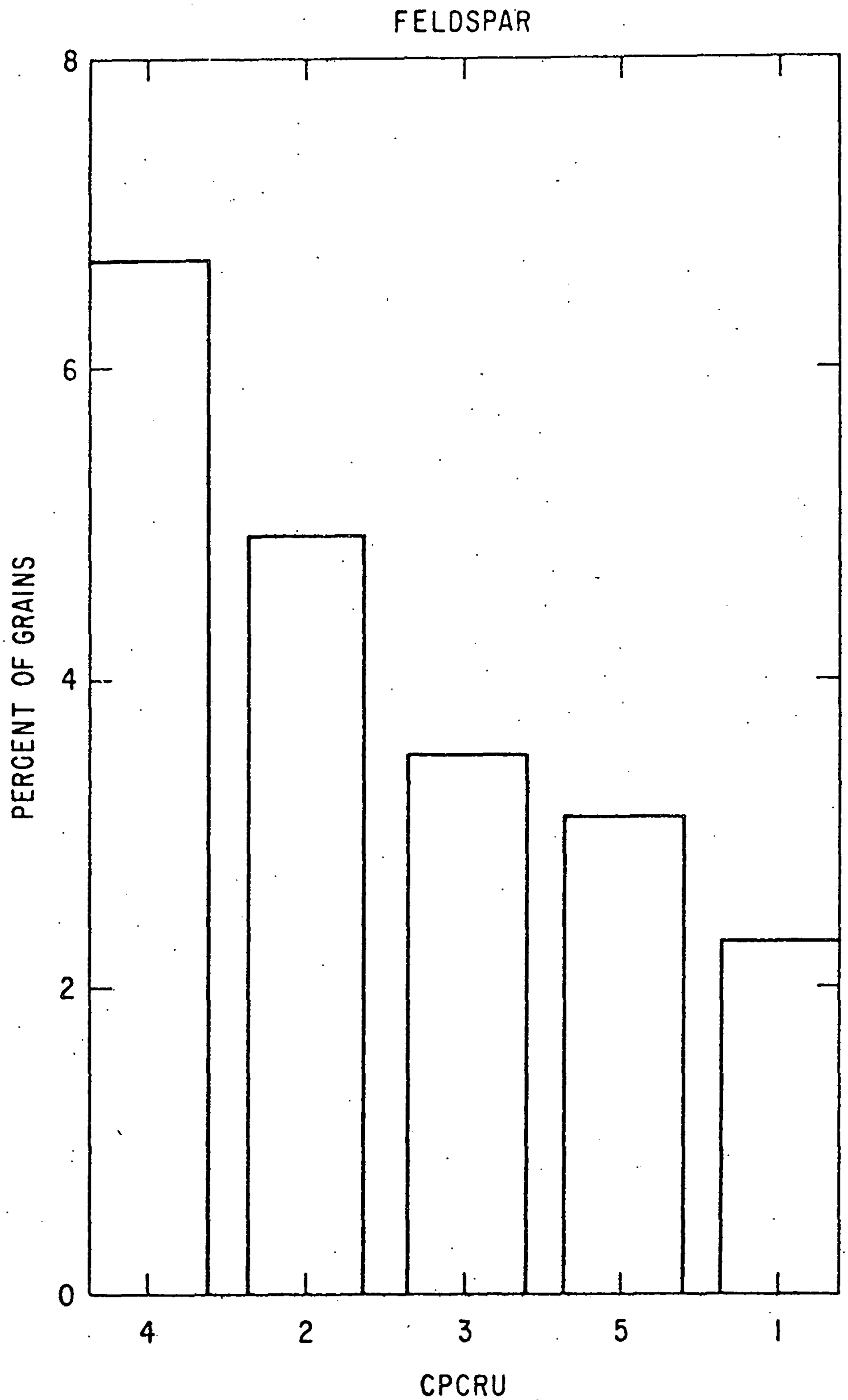


Fig 27, BNL 4-237-80

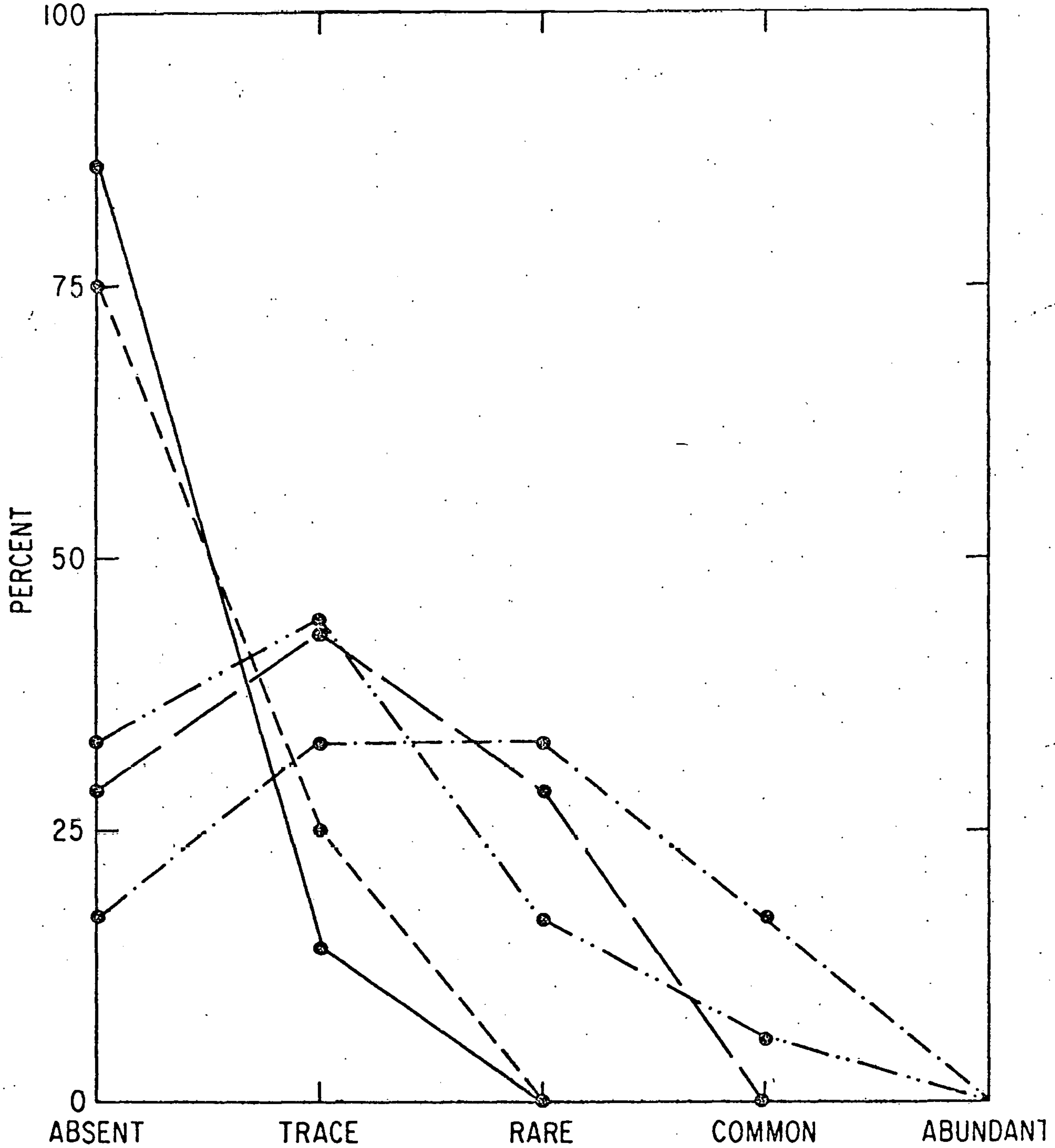


Fig 28, BNL 4-2 30-80

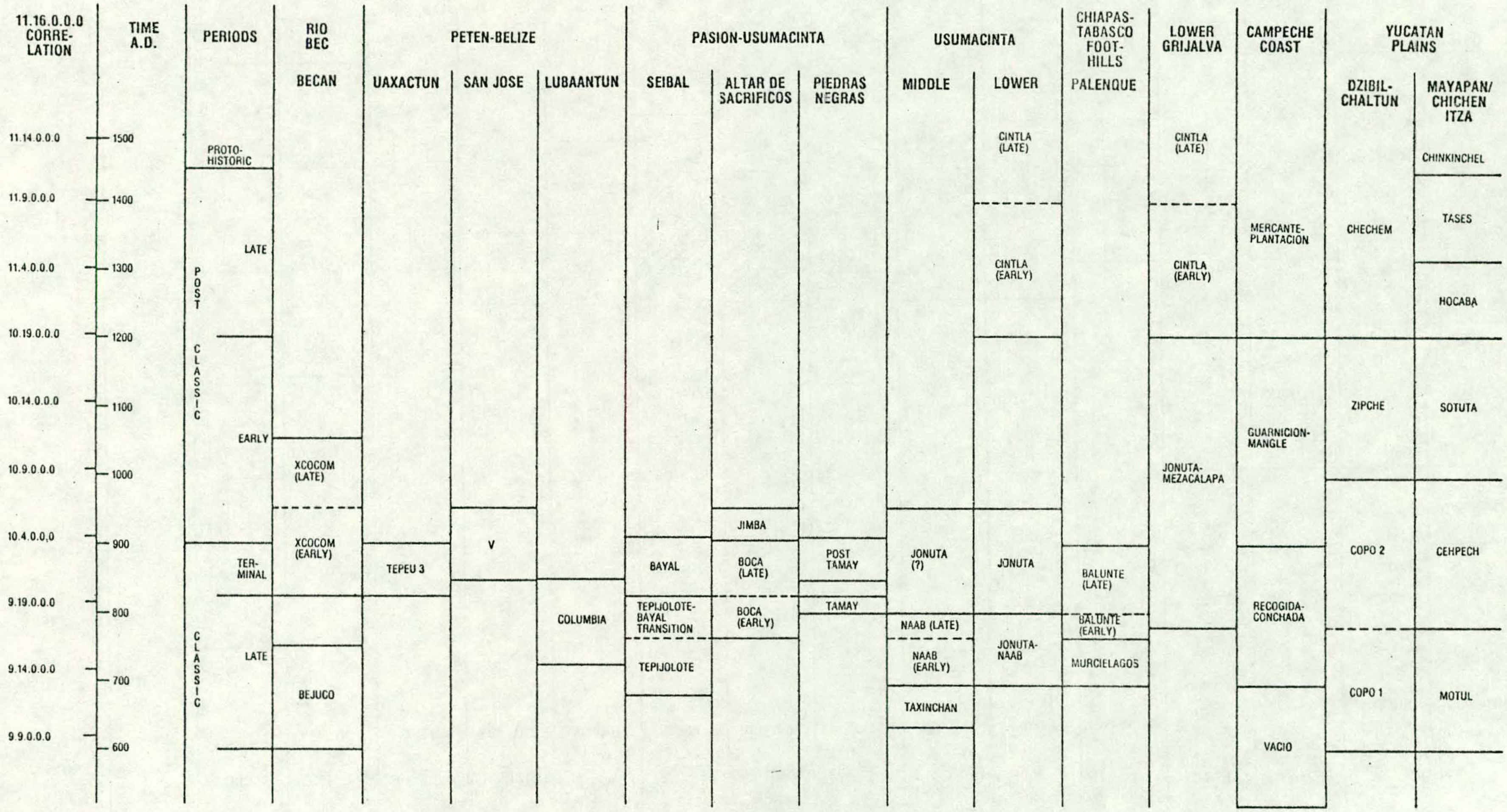


Fig. 29 BNL 4-806-80

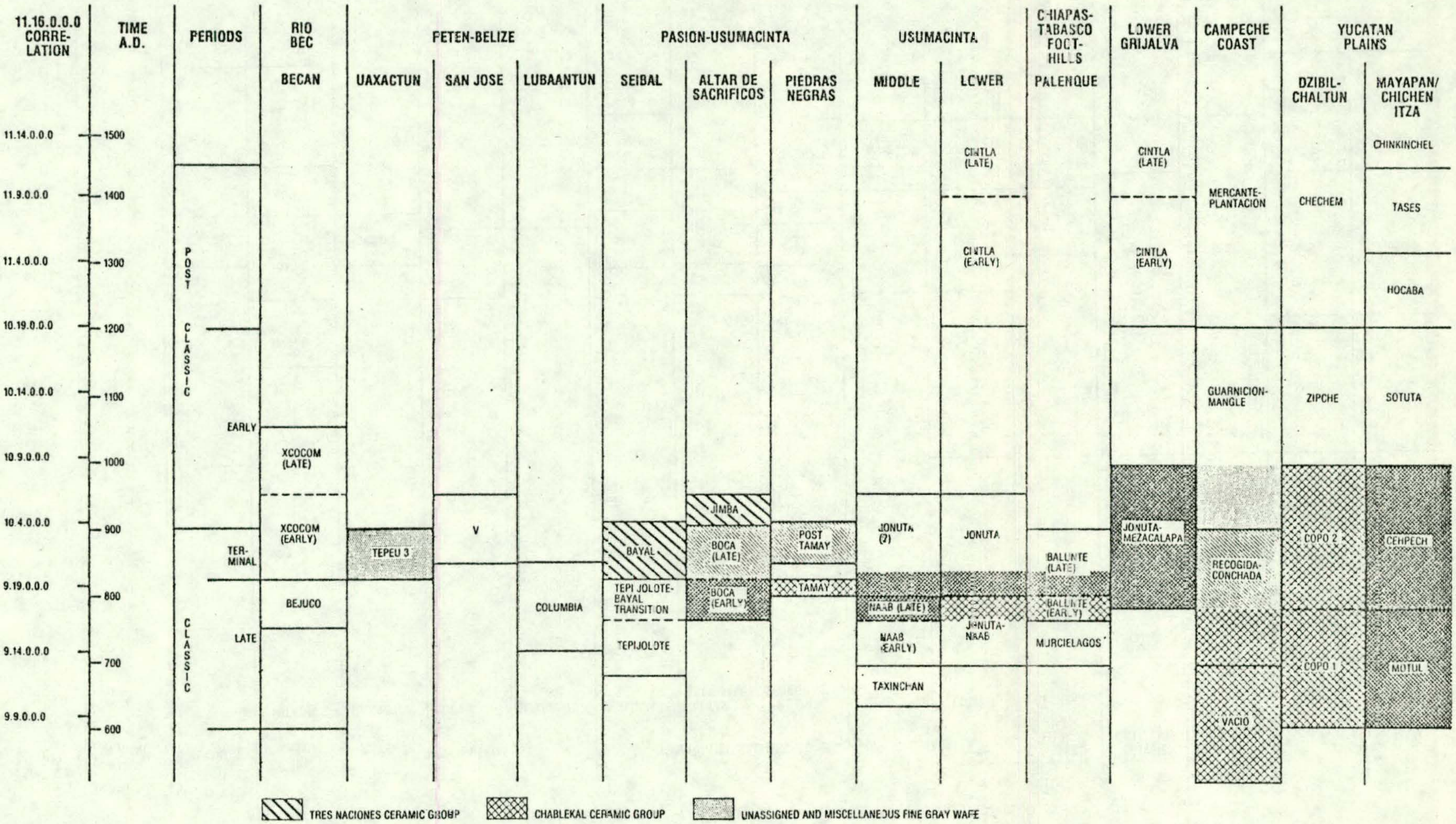


Fig.30, BNL 4-808-80

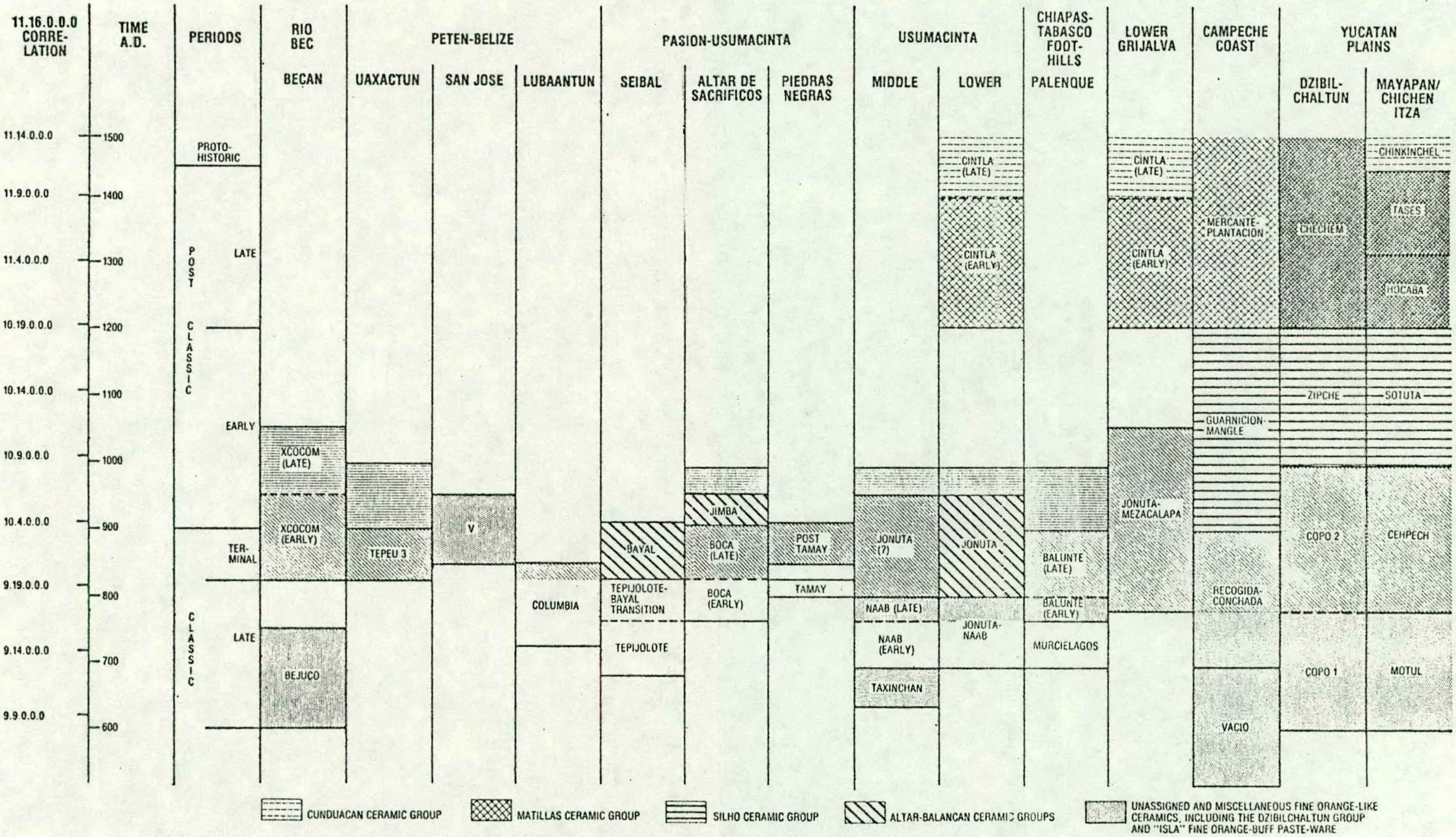


Fig. 31, BNL 4-807-80

F 1174
76-27
Fig. #1377

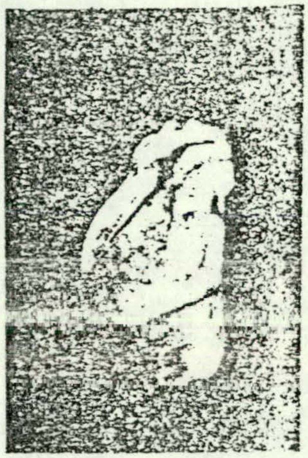


Figure 31. Fine orange paste figurine. Palenque, Specimen # 1174, Early Classic and Preclassic deposit, unplaced in CPCRUs.

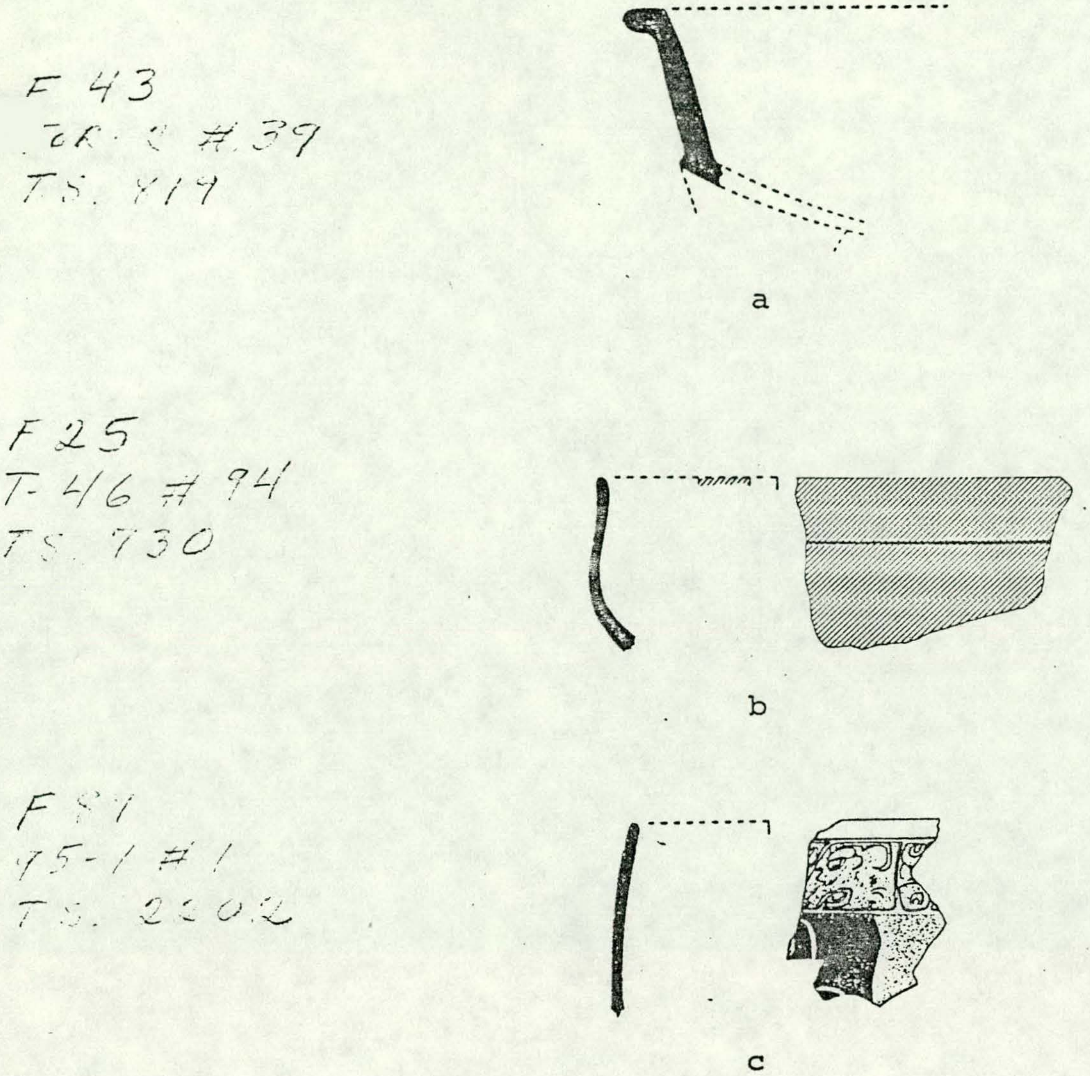


Figure 33. Early fine paste including Fine Orange Ware (b, c). a. Tortuguero, Specimen # 43, black (compare Tzakol sharp Z-angle bowls), Tortuguero compositional group; b. Trinidad, Specimen # 25, unnamed incised orange, Taxinchan Ceramic Complex, unplaced in CPCRUs; c. Palenque, Specimen [redacted] # 89, unnamed gouged-incised black-and-white-on-orange with Classic style glyph band, Murcielagos/early-facet Balunte Ceramic Complex, unplaced in CPCRUs. One-third scale.

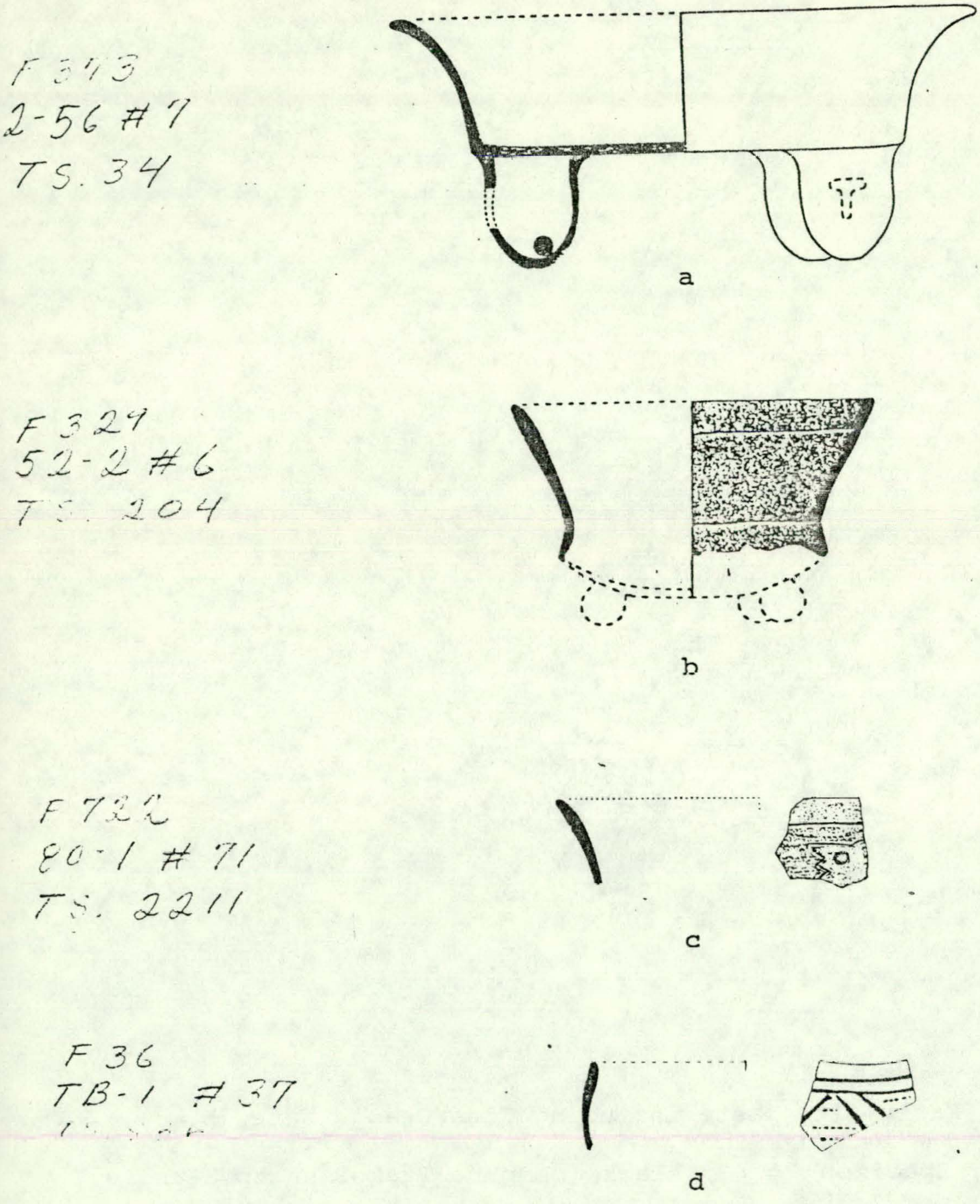
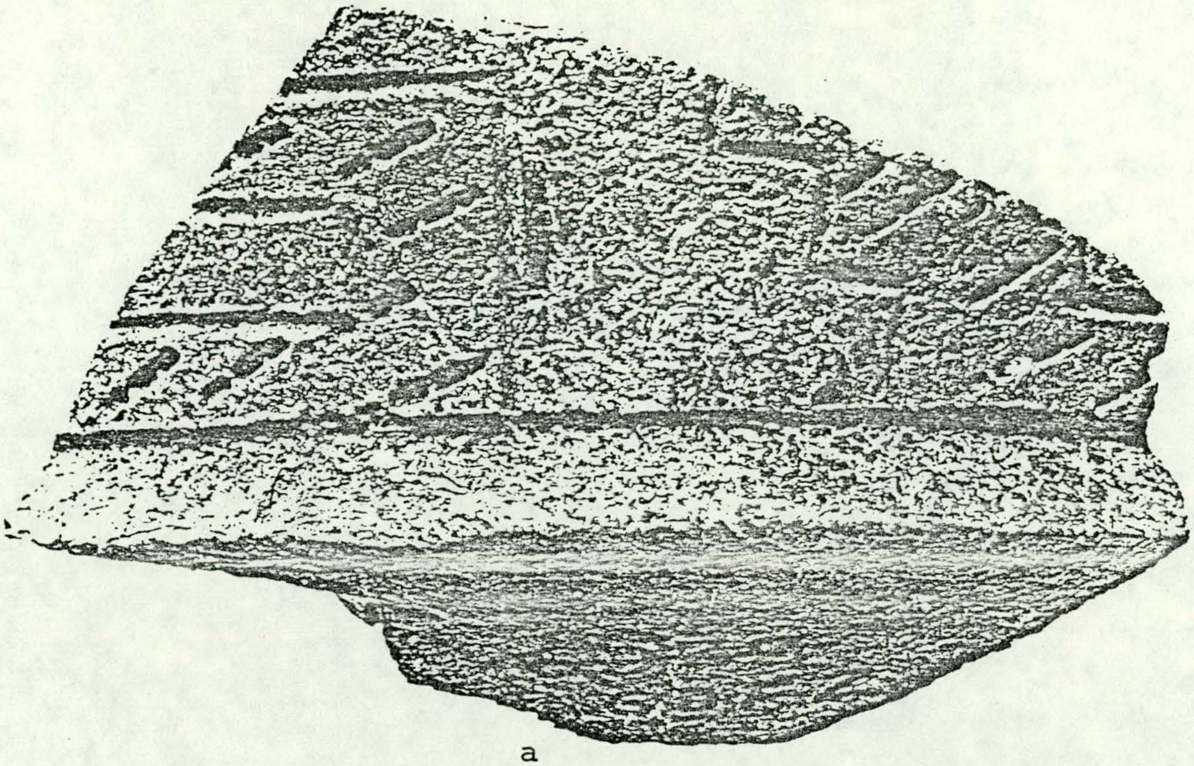
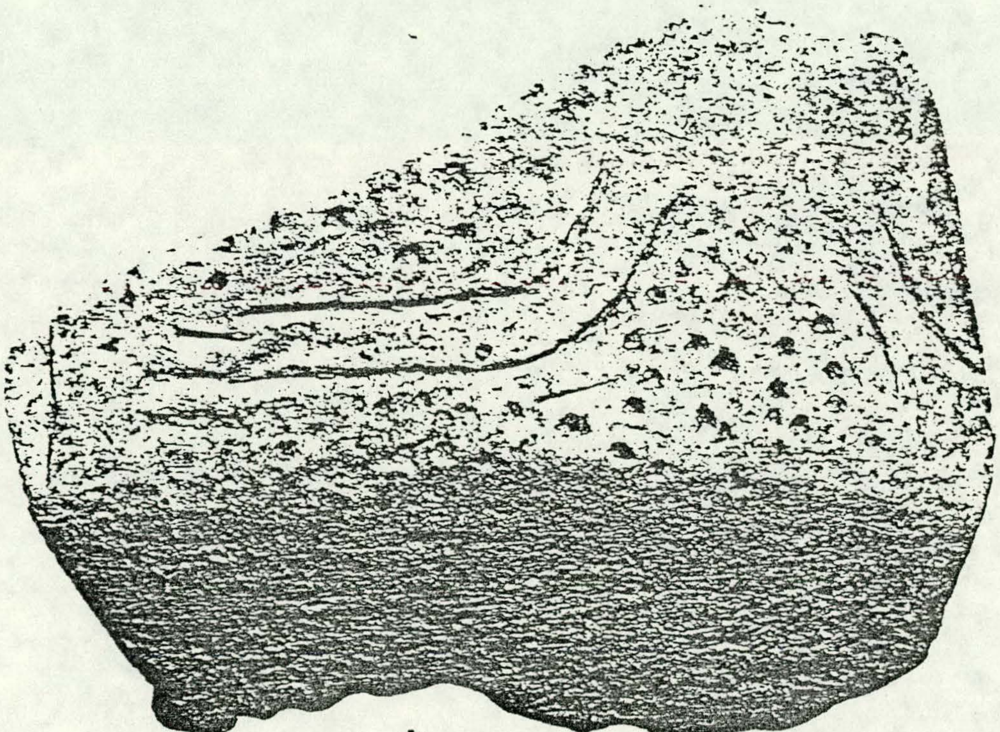


Figure 34. Fine Gray Ware, Chablekal Ceramic Group. a-c. Palenque, Balunte Ceramic Complex; d. Tierra Blanca, Naab Ceramic Complex. a. Specimen # 373, Chablekal Gray Type; b. Specimen # 329, Chicxulub Incised Type; c. Specimen # 722, Telchac Composite Type; d. Specimen # 36, Telchac Composite Type. a. CPCRU 1; b-d. Unplaced in CPCRUs. One-third scale.



a



b

Figure 35. Fine Gray Ware, Chablekal Ceramic Group. a. Piedras Negras, Specimen # 322, Telchac Composite Type, Tamay Ceramic Complex, CPCRU 5; b. Dzibilchaltun, Specimen # 1234, Telchac Composite Type, Copo 1 or 2 Ceramic Complex, CPCRU 1.

F 84
52-2 #9
TS 2032

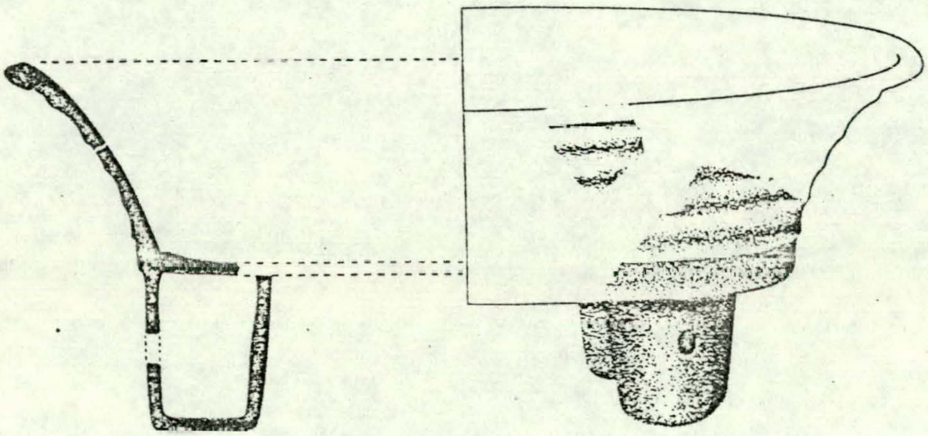


Figure 36. Fine Gray Ware, Chablekal Ceramic Group. Palenque, Specimen # 84, Cholul Fluted Type, Balunte Ceramic Complex, unplaced in CPCRUs. One-third scale.

F229
C-1-8
#15
TS 2064

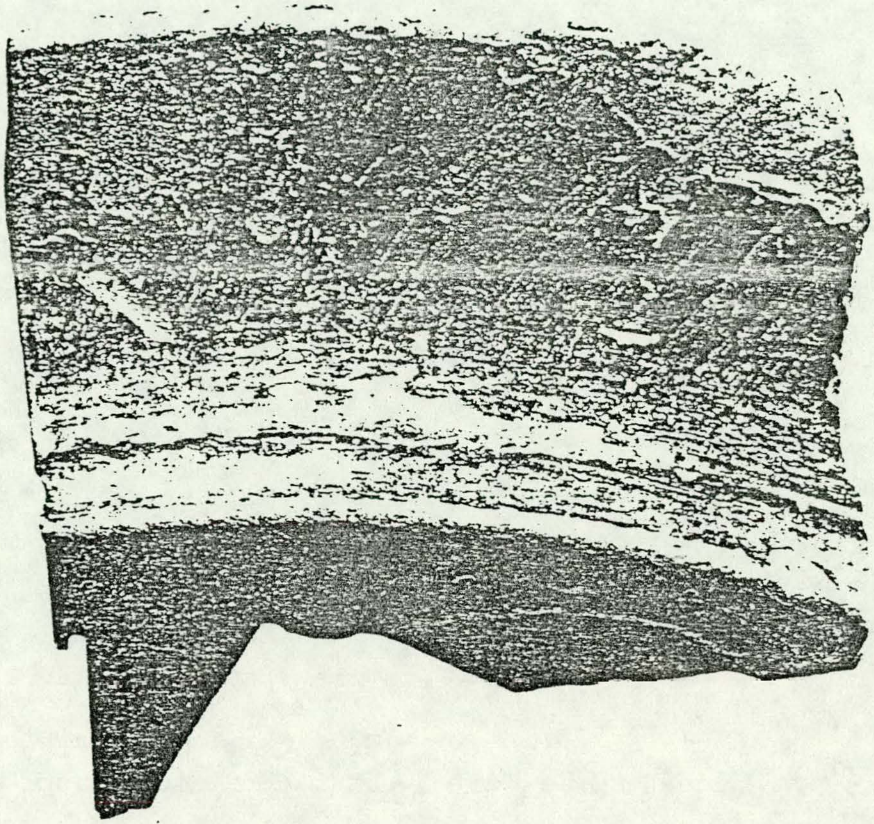


Figure 37. Early Fine Orange Ware. Calatrava, Specimen # 229, unnamed Classic style polychrome, Naab Ceramic Complex, CPCRU 2.

Graph fig. 9 a, b

F 231
A-2 #1
T.S. 1000

F 273
T-11 # 349
T.S. 1419

Figure 38. Fine Orange Ware, Altar Ceramic Group. a. Arenitas, Specimen # 231; b. Trinidad, Specimen # 273. a, b. Altar Orange Type, Jonuta horizon, CPCRU 2. One-third scale.

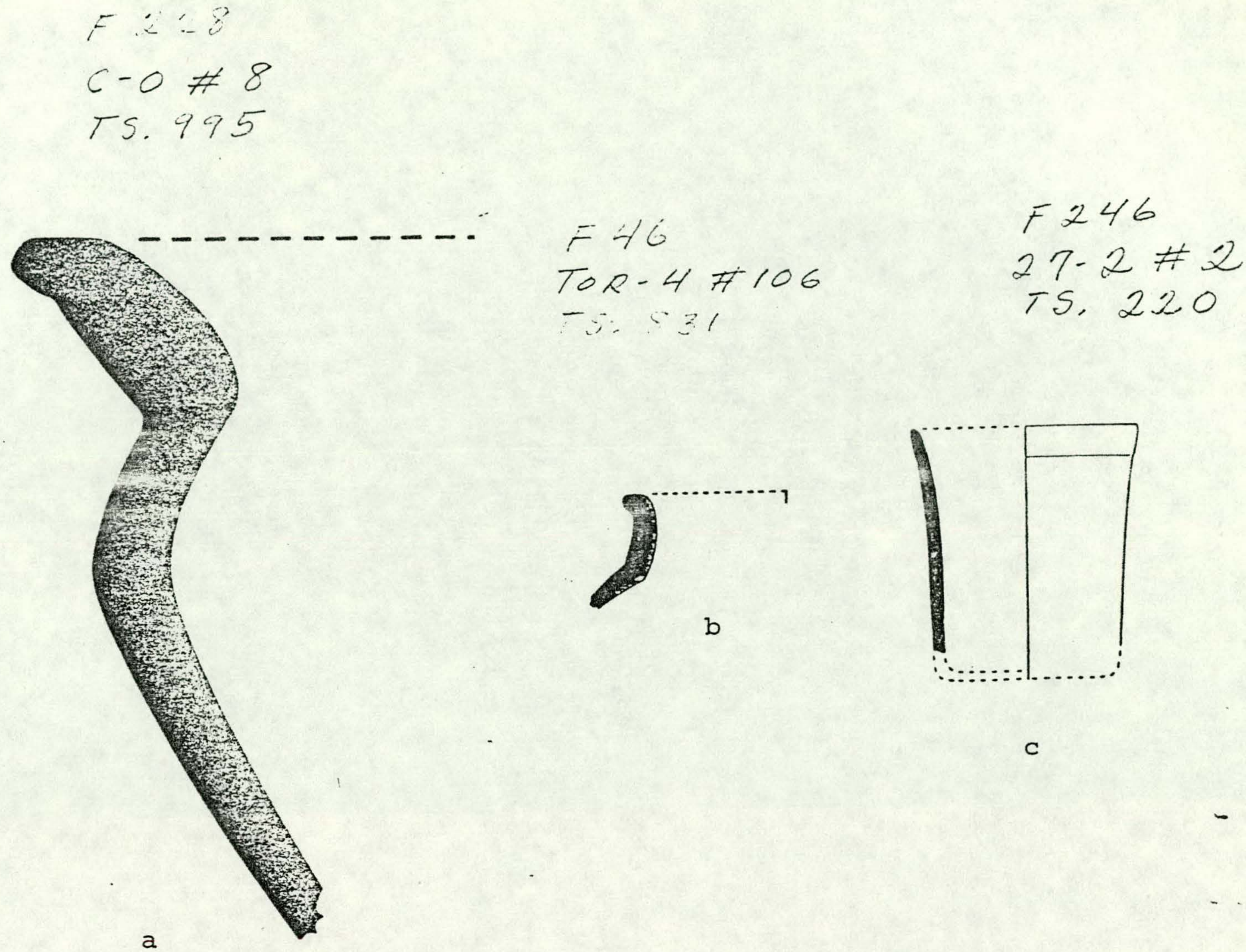


Figure 39. Fine Orange Ware, Altar Ceramic Group. a. Calatrava, Specimen # 228, Jonuta horizon; b. Tortuguero, Specimen # 46; c. Palenque, Specimen # 246, Balunte Ceramic Complex. a-c. Altar Orange Type, CPCRU 5. One-third scale.

F 317

TS. 1699

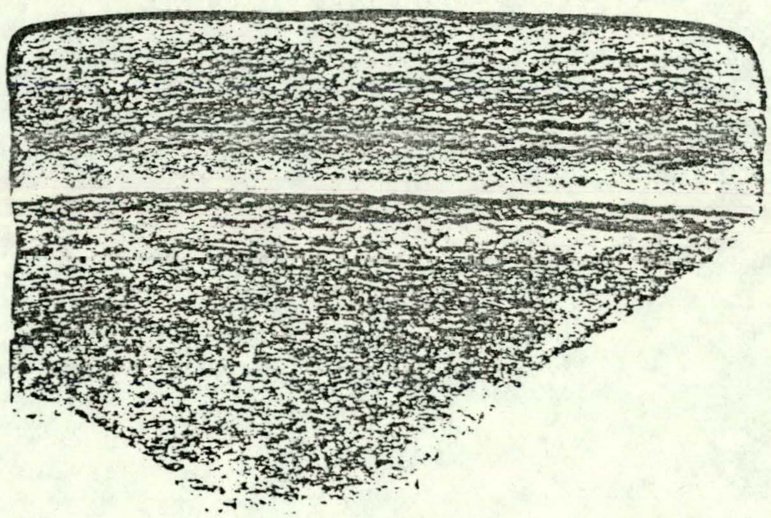


Figure 40. Fine Orange Ware, Altar Ceramic Group.

Piedras Negras, Specimen # 317, Altar Orange Type,

Post-Tamay horizon, CPCRU 1.

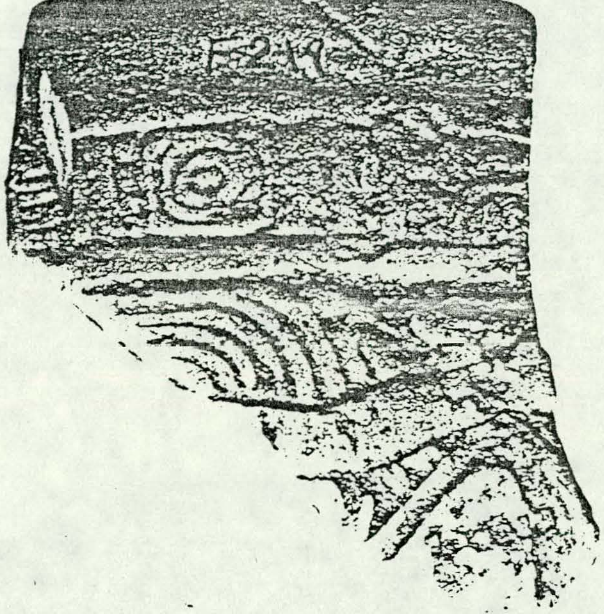
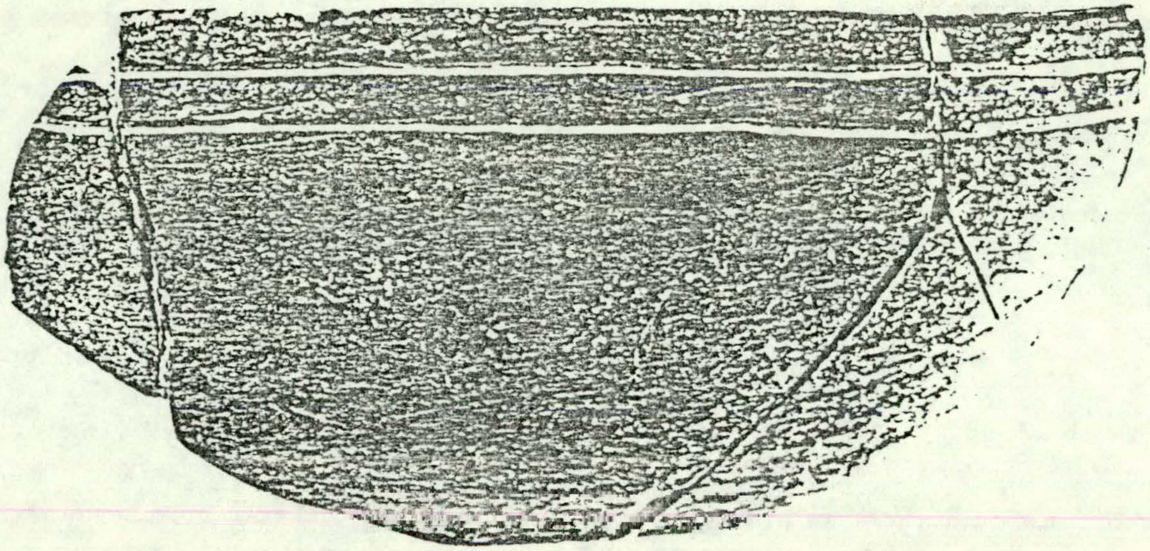
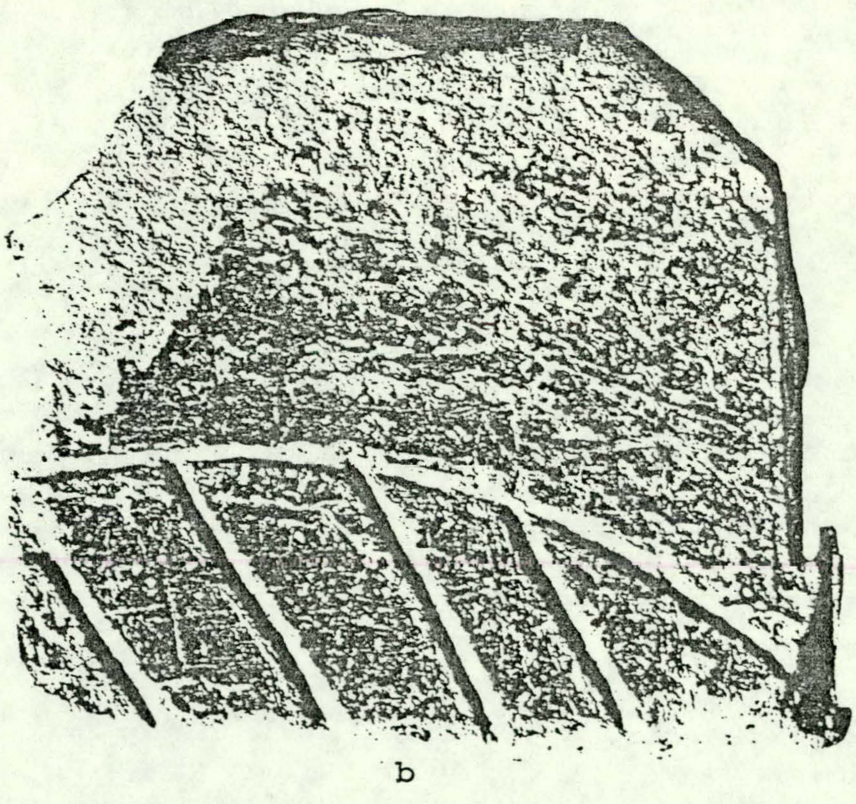


Figure 41. Fine Orange Ware, Altar Ceramic Group. Piedras Negras, Specimen # 219, Pabellon Modeled-carved Type, Post-Tamay horizon, CPCRU 3.



a



b

Figure 42. Fine Orange Ware, Altar Ceramic Group. a. Calatrava, Specimen # 226, Tumba Black-on-orange Type, Jonuta horizon; b. Palenque, Specimen # 66, Trapiche Incised Type, Balunte Ceramic Complex. a, b. CPCRU 5.

F 247
43-1 #14
T.S. 2042

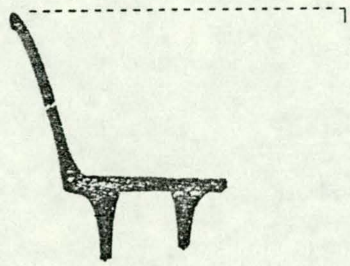
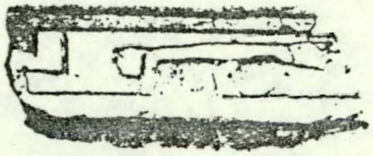


Figure 43. Fine Gray Ware, Tres Naciones Ceramic Group.

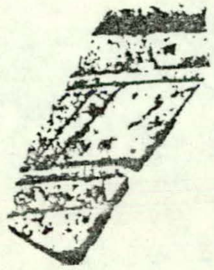
Palenque, Specimen # 247, Tres Naciones Gray Type,

Balunte Ceramic Complex, CPCRU 5. One-third scale.

F 218
L-16-998
TS. 989



a

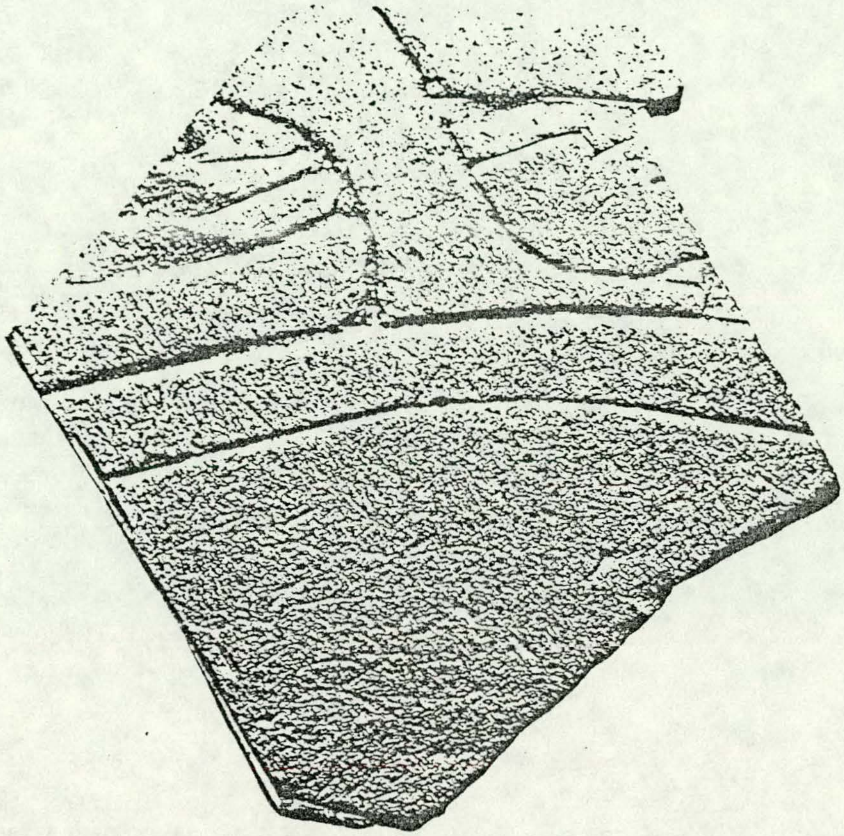


b

F 21
TS. 22

Figure 44. Fine Orange Ware, Balancan Ceramic Group.

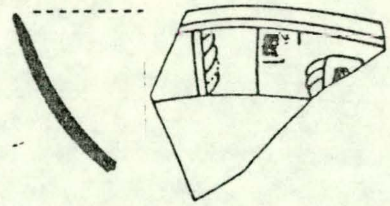
a, b. Piedras Negras, Provincia Plano-relief Type, Post-Tamay horizon, unplaced in CPCRUs. a. Specimen # 218; b. Specimen # 217.



F 10
C-0
TS. 504

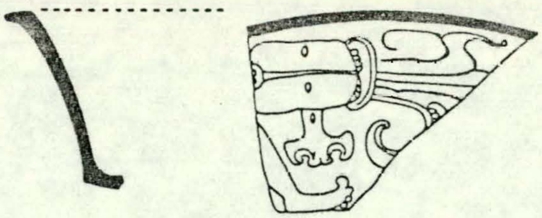
Figure 45. Fine Orange Ware, Balancan Ceramic Group. Calatrava, Specimen # 10, Provincia Plano-relief Type, Jonuta horizon, CPCRU 5.

F.C.C.5
C-1-6 # 14
TS. [illegible]



a

F 47
TOR-2 # 15
TS. #33



b

Figure 46. Fine Orange Ware (a), Balancan Ceramic Group. a. Calatrava, Specimen # 225, Provincia Plano-relief Type, Jonuta horizon, CPCRU 5; b. Tortuguero, Specimen # 47, Provincia Plano-relief Type, Tortuguero compositional group. One-third scale.

F 57
2-54...
#40
T.S. 776

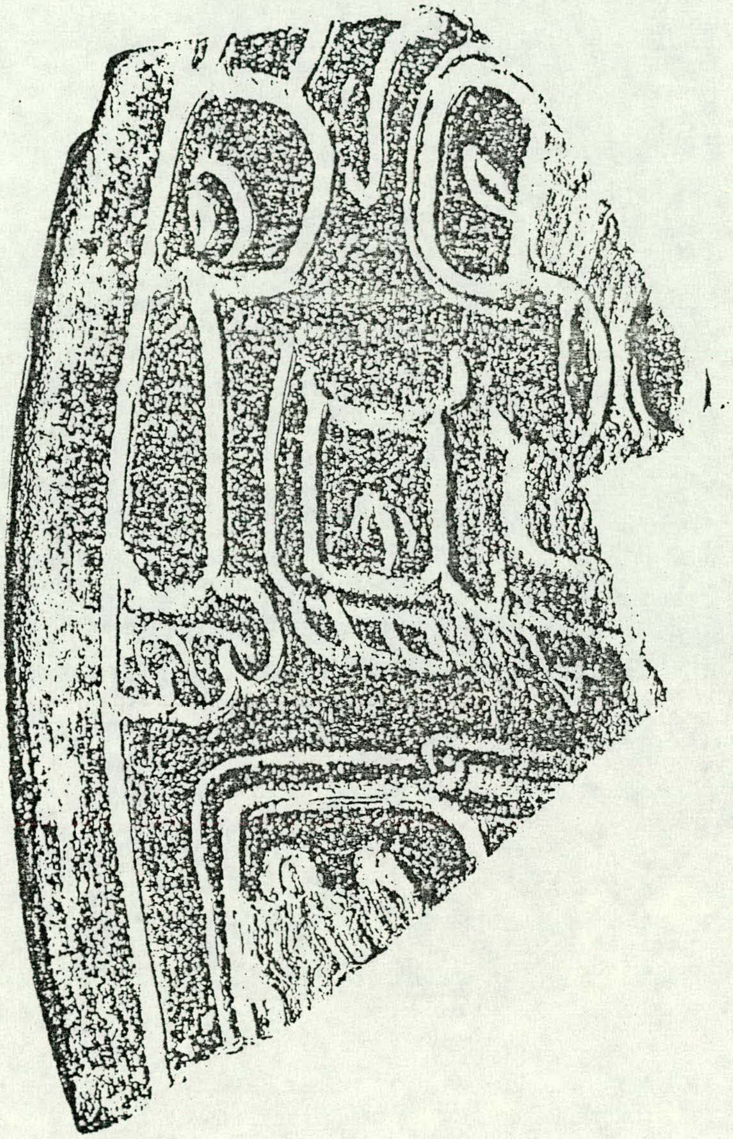


Figure 47. Fine Orange Ware, Balancan Ceramic Group. Palenque, Specimen # 57, Provincia Plano-relief Type, Balunte Ceramic Complex, CPCRU 1.

F 1237
TS 655

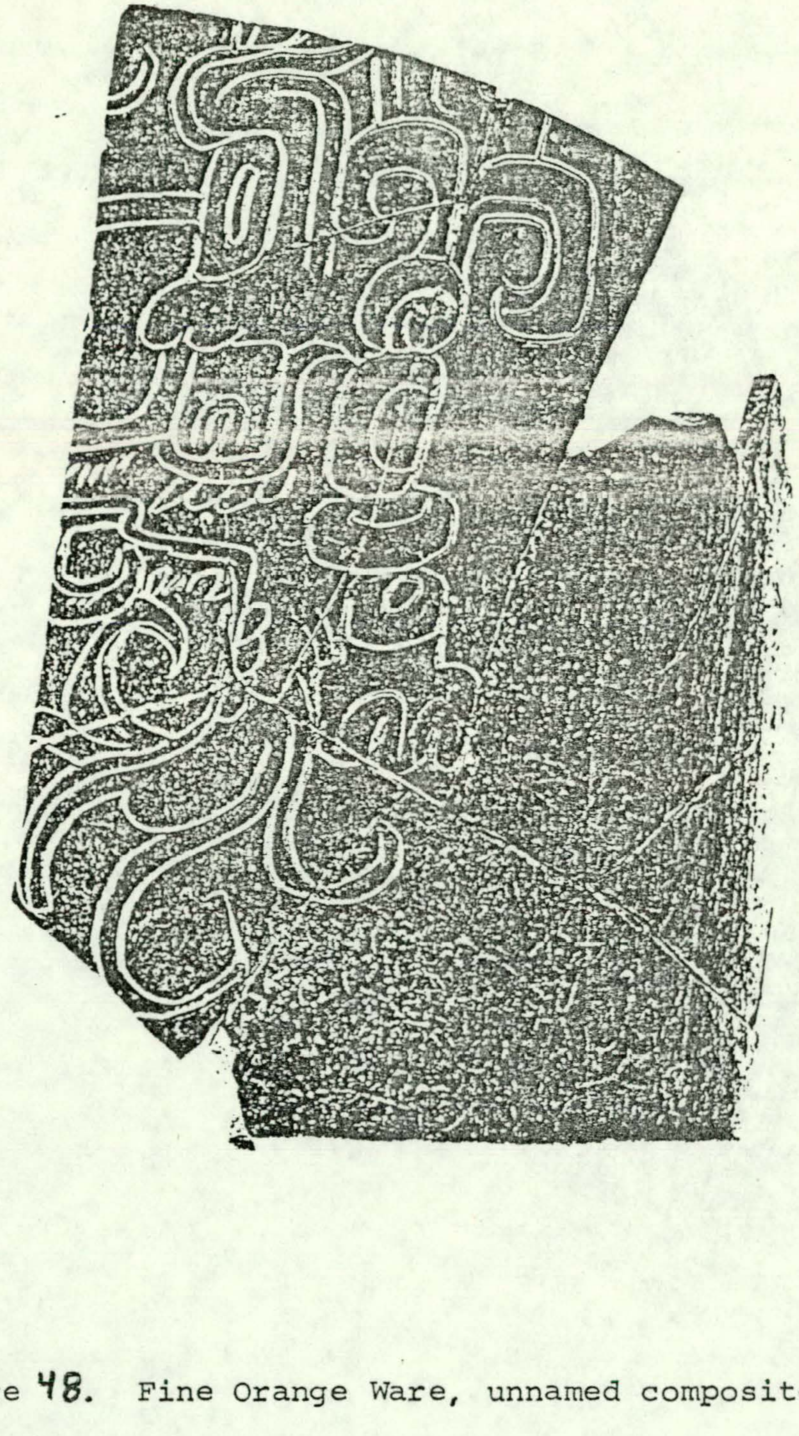
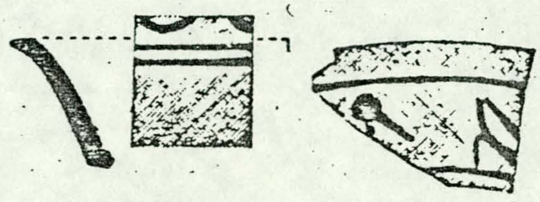


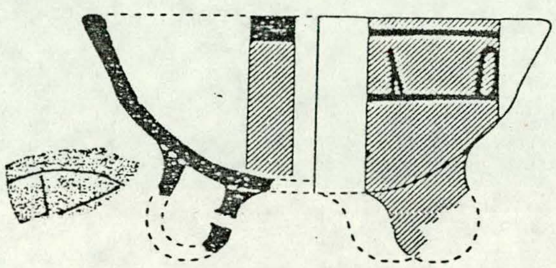
Figure 48. Fine Orange Ware, unnamed composite type. Campeche (?), Specimen # 1239. Black-on-orange (compare Tumba Type); incised design compares closely to Figure 19 (Provincia Plano-relief Type, Palenque), which also is in CPCRU 1.

F 54
2-37 # 39
TS. 661



a

F 81
50-15 # 5
TS. 872



b

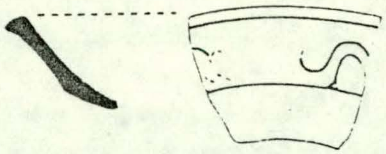
Figure 49. Fine Orange Ware, Silho Ceramic Group.

a, b. Palenque, Yalton Black-on-orange Type,

Terminal Classic to Early Postclassic, CPCRU 1.

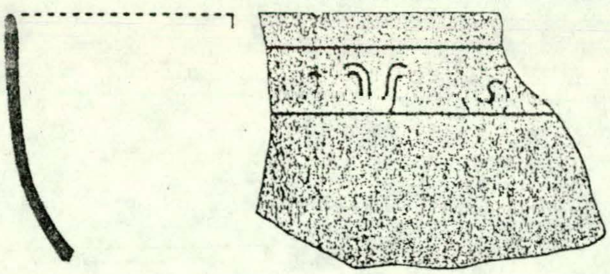
a. Specimen # 54; b. Specimen # 81. One-third scale.

F 271
T-10 # 348
TS. 666



a

F 272
T-11 # 346
TS. 272



b

Figure 50. Fine Orange Ware, Silho Ceramic Group. a, b. Trinidad, Pocboc Gouged-incised Type, Terminal Classic to Early Postclassic. a. Specimen 271, unplaced in CPCRUs; b. Specimen 272, CPCRU 2. One-third scale.

F 1231
BO-(104)P
TS·2527

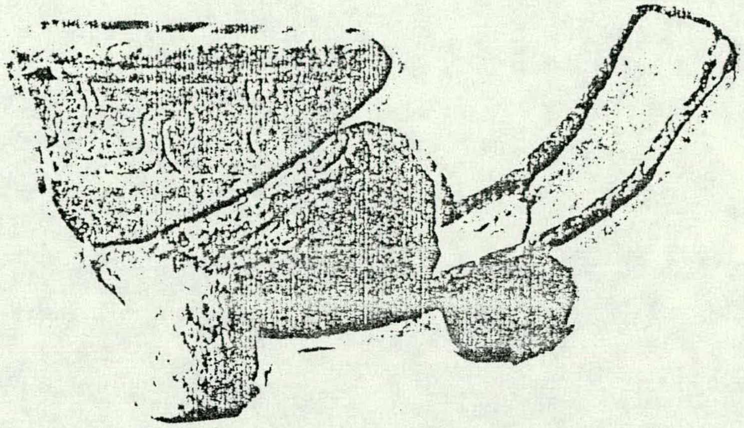


Figure 51. Fine Orange Ware, Silho Ceramic Group. Bajio, Specimen # 1231, Pocboc Gouged-incised Type, Terminal Classic to Early Postclassic, unplaced in CPCRUs.

F168
C-O
T.J. 841

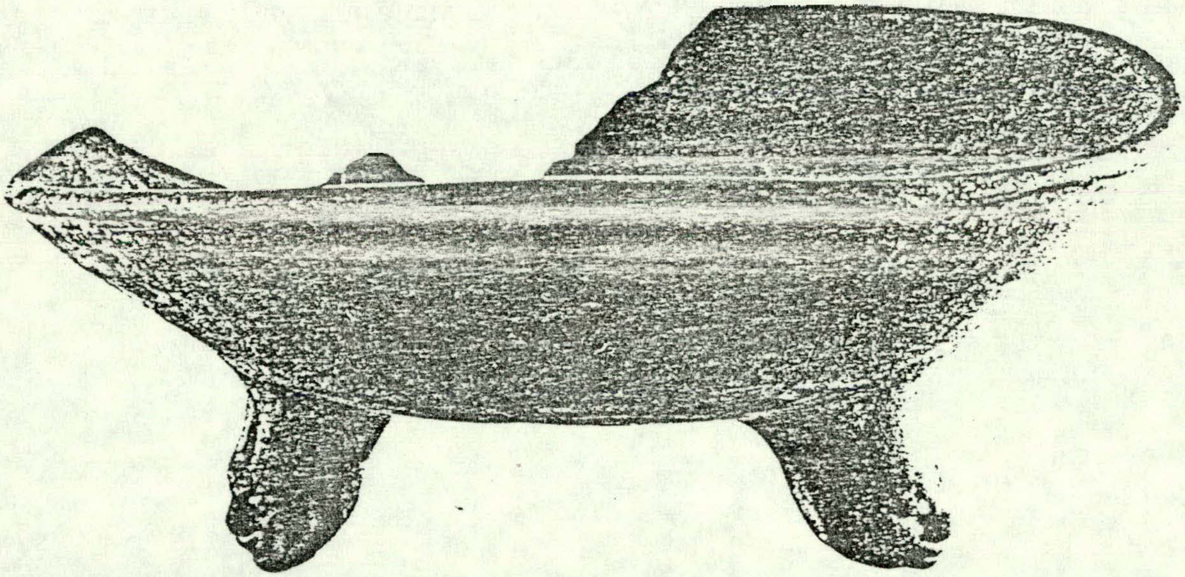


Figure 52. Fine Orange Ware, Matillas Ceramic Group. Calatrava, Specimen # 168, Matillas Orange Type, Late Postclassic, CPCRU 5.

F 880
SJR-2 #1
TS 2208

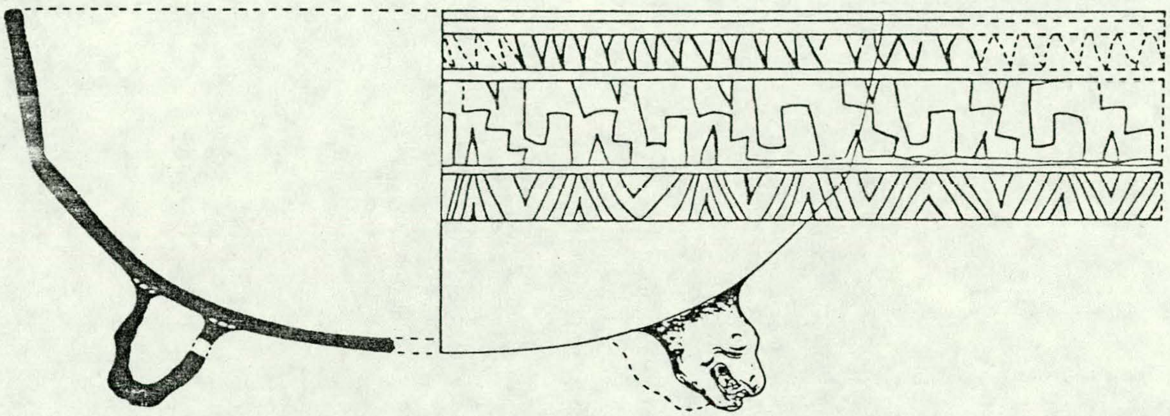


Figure 53. Fine Orange Ware, Matillas Ceramic Group. San Jose del Rio, Specimen # 880, Villahermosa Incised Type, Late Postclassic, unplaced in CPCRUs. One-third scale.

F 270
C-0
TS. 1054

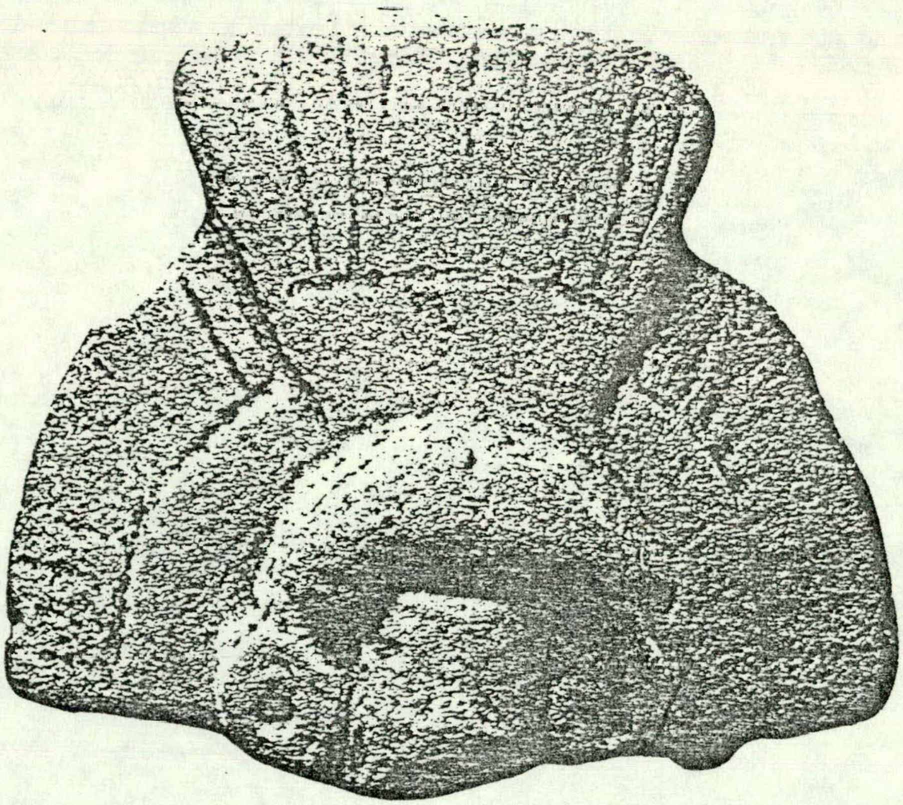


Figure 54. Fine Orange Ware figurine. Calatrava, Specimen # 270, Jonuta horizon, CPCRU 5.

CHEMICAL PASTE COMPOSITIONAL REFERENCE UNIT 1

SAMPLE	NA2O PCT	K2O PCT	RB2O PPM	CS2O PPM	BAO PPM	SC2O3 PPM	LA2O3 PPM	CEO2 PPM	EU2O3 PPM	LU2O3 PPM	HFO2 PPM	THO2 PPM	TA2O5 PPM	CR2O3 PPM	MNO PPM	FE2O3 PCT	COO PPM	SB2O3 PPM	CAO PCT	TIO2 PCT
1230	.935	1.930	82.100	3.210	553.000	25.400	35.600	90.600	1.700	.636	7.360	11.800	2.240	767.000	659.000	6.520	37.200		4.980	.902
54	.800	1.590	78.000	4.300	474.000	25.500		82.000	1.470	.490	6.750	11.700	1.380	800.000	607.000	6.420	37.100		5.230	.790
57	.887	1.630	110.000	4.900	448.000	24.000		78.000	1.450	.690	7.090	10.300	1.320	589.000	836.000	6.010	29.800		7.470	.910
81	1.100	2.000	100.000	4.500	540.000	24.800	44.000	110.000	1.920		8.210	11.100	1.460	790.000	752.000	6.410	33.500	.510	3.970	.870
373	.972	1.980	94.600	3.970	521.000	29.100	40.800	104.000	1.790	.599	5.710	12.400	1.140	586.000	1070.000	7.130	34.900	.354	6.780	.850
1239	1.430	2.290	93.700	3.590	542.000	25.000	30.400	74.700	1.580	.541	5.750	10.300	2.170	497.000	891.000	6.280	31.000	.902	7.020	.753
1234	1.030	2.350	96.800	4.280	574.000	25.000	35.000	89.700	1.590	.628	6.620	12.000	2.110	555.000	1000.000	6.350	33.100		6.090	.966
F050	1.040	1.770	121.000	4.480	518.000	25.700	42.200	87.500	1.520	.763	6.860	11.300	1.230	550.000	716.000	6.480	36.100	1.520	8.410	.900
F052	.909	1.960	101.000	3.470	574.000	23.700	37.900	82.300	1.590	.478	6.130	10.900	1.320	639.000	515.000	5.910	33.700	.580	5.580	.910
MEAN	.987	1.954	96.690	4.043	525.502	25.217	39.117	89.105	1.628	.596	6.679	11.279	1.546	644.431	763.734	6.382	33.946	.682	6.139	.928
STD DEV	.184	.251	13.900	.608	45.970	1.259	5.539	11.969	.133	.105	.834	.769	.468	117.845	205.050	.350	2.697	.504	1.601	.049
(PCT)	18.668	12.837	14.376	15.040	8.749	4.991	14.531	13.585	8.157	17.697	12.492	6.821	30.300	18.287	26.848	5.486	7.944	73.931	26.084	5.936

CHEMICAL PASTE COMPOSITIONAL REFERENCE UNIT 2

SAMPLE	NA2O PCT	K2O PCT	RB2O PPM	CS2O PPM	BAO PPM	SC2O3 PPM	LA2O3 PPM	CEO2 PPM	EU2O3 PPM	LU2O3 PPM	HFO2 PPM	THO2 PPM	TA2O5 PPM	CR2O3 PPM	MNO PPM	FE2O3 PCT	COO PPM	SB2O3 PPM	CAO PCT	TIO2 PCT
1010	1.010	2.360	119.000	4.600	983.000	29.900	49.000	109.000	1.900	.716	6.910	12.300	1.370	729.000	860.000	7.350	39.300			
F049	1.090	2.240	108.000	4.530	982.000	27.400	45.100	97.900	1.850	.593	6.740	13.000	1.500	450.000	947.000	7.000	32.900	1.130	.978	1.460
231	.843	2.110	91.300	2.710	827.000	32.500	54.700	108.000	2.110	.651	6.800	15.500	1.270	559.000	1600.000	7.620	39.000		1.130	2.000
272	.822	2.160	94.300	3.360	1020.000	30.700	49.900	104.000	1.930	.655	7.050	13.500	2.300	693.000	1240.000	7.750	39.100	.599	1.000	3.780
273	.822	2.550	126.000	4.080	881.000	31.700	51.300	110.000	2.130	.762	5.870	13.500	2.990	671.000	1790.000	8.040	45.100	.627	.930	3.250
12	.898	1.880	102.000	4.040	827.000	24.700	34.500	94.000	1.550	.648	6.060	11.900	1.090	590.000	1640.000	6.620	38.400	.566	.590	6.750
229	1.040	2.550	121.000	3.890	856.000	29.400	52.900	105.000	2.020	.582	6.310	13.500	1.010	535.000	1360.000	7.010	35.600	1.220	.990	6.080
230	.879	2.410	97.700	3.550	826.000	29.200	50.100	94.500	1.750	.574	6.170	12.900	1.130	537.000	1400.000	7.000	38.000	.303	.950	6.960
MEAN	.920	2.272	106.709	3.797	897.095	29.629	49.983	103.139	1.899	.645	6.477	13.238	1.474	590.462	1316.647	7.285	38.299	.668	.900	3.741
STD DEV	.109	.249	13.893	.719	83.628	2.062	5.409	6.121	.205	.067	.458	1.094	.690	99.728	391.649	.488	3.604	.446	.208	3.178
(PCT)	11.877	10.957	13.020	18.949	9.322	6.960	11.084	5.934	10.749	10.414	7.076	8.264	46.774	16.890	29.858	6.705	9.412	66.758	23.126	84.950

CHEMICAL PASTE COMPOSITIONAL REFERENCE UNIT 3

SAMPLE	NA2O PCT	K2O PCT	RB2O PPM	CS2O PPM	BAO PPM	SC2O3 PPM	LA2O3 PPM	CEO2 PPM	EU2O3 PPM	LU2O3 PPM	HFO2 PPM	THO2 PPM	TA2O5 PPM	CR2O3 PPM	MNO PPM	FE2O3 PCT	COO PPM	SB2O3 PPM	CAO PCT	TIO2 PCT
F042	.905	2.980	144.000	3.960	726.000	30.900	45.700	105.000	1.950	.649	6.590	14.100	1.720	677.000	1040.000	7.500	39.200	.790	1.000	2.720
F043	1.050	2.490	142.000	4.330	706.000	29.300	44.300	115.000	1.980	.859	7.550	14.000	1.730	767.000	1100.000	7.430	44.800	.666	.990	.920
F046	.858	2.550	173.000	5.700	686.000	34.000	59.700	120.000	2.130	.949	7.750	16.300	1.830	619.000	1060.000	8.320	39.400	.839	1.090	1.230
LU49	.652	1.800	79.500	2.010	501.000	35.400	54.900	123.000	2.450	1.010	8.990	16.900	2.260	939.000	972.000	8.800	44.000	.730	1.260	.890
F016	.845	2.800	140.000	4.120	621.000	34.200	52.500	121.000	2.330	.717	6.880	15.100	1.850	681.000	1220.000	8.580	41.400	.745	1.140	1.730
F017	.761	2.710	139.000	4.360	660.000	34.400	50.700	119.000	2.030	.685	6.060	15.500	1.910	643.000		8.450	41.300	.902	1.090	.100
F018	.985	3.030	139.000	4.000	809.000	32.000	57.100	111.000	2.190	.837	8.490	15.700	2.710	776.000	719.000	7.790	37.000	.907	1.000	.870
F019	.845	2.620	149.000	4.630	831.000	32.600	50.900	115.000	2.170	.719	7.180	15.400	2.060	718.000	1050.000	8.500	42.600	.887	1.140	1.430
F020	.846	2.830	145.000	4.490	706.000	32.800	53.500	129.000	2.360	.730	7.910	16.500	1.960	703.000	1210.000	8.010	44.500	.753	1.010	1.080
F025	.976	2.680	127.000	3.720	705.000	31.300	49.000	109.000	2.040	.721	7.530	15.000	1.490	905.000	1090.000	7.860	42.300	.831	1.090	1.170
F028	.785	3.120	172.000	5.230	665.000	33.600	49.800	109.000	2.220	.800	6.480	14.900	1.920	741.000	1020.000	8.050	39.600	.742	.930	.890
F029	.854	2.620	142.000	4.670	710.000	33.300	48.500	108.000	2.200	.727	6.760	14.800	2.010	739.000	1080.000	8.230	39.500	.899	.990	2.810
F032	.979	2.730	122.000	4.330	650.000	31.400	50.000	111.000	2.070	.945	9.360	14.400	1.420	917.000	878.000	7.730	40.000		.930	1.540
F034	.860	2.670	132.000	4.450	691.000	30.900	50.100	107.000	2.150	.655	7.250	15.000	2.010	765.000	1010.000	7.580	36.800	.899	1.070	1.530
F035	.994	2.670	125.000	4.200	631.000	31.200	49.800	109.000	2.050	.719	7.950	14.900	2.450	877.000	816.000	7.790	36.200	.845	1.050	1.020
F037	1.070	3.060	150.000	4.740	690.000	29.600	48.800	117.000	1.890	.800	7.460	14.500	1.810	904.000	1010.000	7.130	37.600	.463	1.010	.960
F038	1.080	2.780	137.000	4.250	693.000	29.600	45.900	105.000	1.850	.630	7.950	14.300	1.840	900.000	1000.000	7.030	45.900	.791	1.040	1.040
F039	.922	2.530	109.000	2.730	703.000	30.100	50.000	115.000	1.920	.765	8.560	15.300	1.650	857.000	1260.000	7.660	42.700		1.100	1.290
219	.699	2.400	127.000	4.470	681.000	36.300	65.300	124.000	2.450	.722	7.380	16.800	1.240	714.000	1220.000	8.420	45.700	1.900	1.140	1.080
220	.726	2.650	138.000	4.350	639.000	34.900	58.300	124.000	2.420	.741	7.030	18.000	.935	549.000	917.000	8.370	39.200	1.230	1.190	1.220
222	.887	2.490	128.000	3.800	744.000	34.900	54.900	131.000	2.430	.797	7.730	17.400	1.460	616.000	1020.000	8.480	35.900		1.150	1.150
223	.800	2.430	118.000	3.450	648.000	32.600	51.900	117.000	2.430	.742	7.100	17.700	1.520	571.000	909.000	7.500	31.300		1.130	1.130
491	.701	2.320	130.000	3.690	694.000	30.900	44.300	117.000	2.010	.901	6.610	15.100	1.970	792.000	1350.000	8.380	41.300	.842	1.120	1.790
1	.870	2.220	136.000	4.600	660.000	29.800		93.000	1.930	.460	6.800	14.200	1.570	677.000	1500.000	7.790	37.900	.810	.990	4.600
F053	1.000	2.870	145.000	4.760	693.000	31.600	51.000	101.000	1.990	.848	7.030	13.600	1.390	610.000	1270.000	7.820	39.700	.719	.990	3.360
MEAN	.870	2.622	134.152	4.126	682.146	32.227	52.337	113.904	2.134	.752	7.386	15.425	1.748	737.612	1059.395	7.955	40.080	.836	1.056	1.252
STD DEV	.129	.318	21.615	.947	66.592	2.345	6.601	9.335	.208	.127	.745	1.220	.436	124.924	189.242	.488	3.707	.247	.094	1.236
(PCT)	14.833	12.132	16.112	22.954	9.762	7.276	12.612	8.193	9.732	16.935	10.088	7.909	24.932	16.936	17.880	6.136	9.254	29.517	8.870	98.726

Table 1, a
BNL 4-811-80

CHEMICAL PASTE COMPOSITIONAL REFERENCE UNIT 4

SAMPLE	NA2O PCT	K2O PCT	RB2O PPM	CS2O PPM	BAO PPM	SC2O3 PPM	LA2O3 PPM	CEO2 PPM	EU2O3 PPM	LU2O3 PPM	HFO2 PPM	THO2 PPM	TA2O5 PPM	CR2O3 PPM	NIO PPM	FE2O3 PCT	COO PPM	SB2O3 PPM	TIO2 PCT	CAO PCT
F026	1.090	2.470	116.000	4.900	651.000	29.500	58.300	104.000	2.230	.679	8.100	14.100	1.640	508.000	1150.000	7.560	37.600	1.050	1.020	1.400
F030	1.220	2.600	151.000	5.580	748.000	29.800	49.200	112.000	2.000	1.060	9.510	15.100	1.470	588.000	2020.000	7.550	42.100	.894	1.040	1.340
F040	1.260	2.560	129.000	5.400	746.000	29.800	50.200	104.000	2.050	.641	8.520	14.400	1.940	541.000	1010.000	7.390	38.200	1.190	.900	1.270
F041	1.170	2.250	140.000	6.640	719.000	2[illegible].400	5[illegible].700	105.000	1.930	.939	9.920	15.100	1.410	624.000	949.000	7.010	48.100	.602	.920	1.370
F047	1.270	2.870	148.000	6.570	798.000	29.300	58.800	106.000	1.970	.739	7.820	15.500	1.320	463.000	1170.000	7.470	37.900	.947	.990	1.310
F048	1.520	2.650	144.000	5.260	751.000	29.400	45.100	97.900	1.850	.646	9.260	14.400	1.500	597.000	1100.000	7.020	36.000	1.110	.940	1.220
1178	1.160	2.340	143.000	5.680	654.000	28.200	42.900	121.000	2.050	.822	8.520	15.100		476.000	1190.000	7.130	38.600		1.000	1.290
314	1.320	2.970	104.000	4.630	551.000	29.500	5[illegible].900	129.000	2.190	.877	10.100	15.400	1.620	583.000	1350.000	7.790	36.900	1.150	1.020	1.400
317	1.260	2.660	101.000	5.140	637.000	28.200	45.100	120.000	1.970	.859	9.770	15.100	1.520	625.000	1120.000	7.480	38.600	.923	.990	1.450
1226	.980	2.980	133.000	5.680	750.000	30.300	42.000	104.000	2.090	.725	6.740	14.300	1.720	566.000	1280.000	7.520	37.800		.907	4.210
1227	1.040	2.860	106.000	3.850	587.000	29.000	4[illegible].500	106.000	2.140	.748	8.050	14.200	2.050	653.000	1970.000	7.350	42.700		.997	3.340
MEAN	1.200	2.645	127.340	5.345	696.421	29.689	47.087	109.544	2.029	.786	8.609	14.791	1.605	562.584	1262.618	7.384	39.369	.965	.952	1.613
STD DEV	.154	.260	20.770	.902	69.624	1.190	4.241	9.567	.132	.137	1.100	.537	.238	67.565	352.468	.250	3.444	.235	.075	.850
(PCT)	12.831	9.816	16.311	16.872	9.997	4.009	9.007	8.733	6.491	17.474	12.779	3.628	14.798	12.010	27.916	3.380	8.747	24.341	7.833	52.685

CHEMICAL PASTE COMPOSITIONAL REFERENCE UNIT 5

SAMPLE	NA2O PCT	K2O PCT	RB2O PPM	CS2O PPM	BAO PPM	SC2O3 PPM	LA2O3 PPM	CEO2 PPM	EU2O3 PPM	LU2O3 PPM	HFO2 PPM	THO2 PPM	TA2O5 PPM	CR2O3 PPM	NIO PPM	FE2O3 PCT	COO PPM	SB2O3 PPM	TIO2 PCT	CAO PCT
F044	.955	2.360	119.000	4.820	518.000	29.900	37.800	83.200	1.660	.561	6.140	10.900	1.610	603.000	1030.000	7.350	38.400	.779	.970	6.500
F023	.724	2.430	111.000	3.630	688.000	3[illegible].500	44.600	102.000	1.920	.796	5.860	13.600	1.490	657.000	1070.000	8.050	41.100	.474	1.070	2.520
322	.735	1.910	76.200	2.560	530.000	29.400	47.000	120.000	2.000	.906	7.990	14.600	1.530	854.000	1130.000	7.900	40.400	1.160	1.010	3.440
9	.870	2.230	92.000	4.300	697.000	32.800		94.000	1.850	.480	5.400	12.800	1.410	766.000	1260.000	7.690	40.000	.340	.950	2.800
10	.880	2.220	111.000	5.300	529.000	32.100		84.000	1.960	.720	6.400	12.000	1.420	735.000	1340.000	7.700	40.100	.730	.790	7.980
13	.820	2.090	95.000	4.900	726.000	34.900		89.000	1.700	.660	4.900	12.400	1.380	625.000	1610.000	7.360	41.500	.360	.450	5.890
168	.991	2.250	104.000	4.130	620.000	32.300	53.000	94.400	2.120	.601	7.180	14.800	1.260	826.000	1230.000	8.350	51.800	1.240	.970	3.210
225	.799	2.190	126.000	3.980	689.000	32.300	43.300	104.000	1.820	.568	5.060	12.600	1.500	595.000	1390.000	7.610	41.200	1.120	.950	4.970
226	.915	2.390	128.000	5.390	575.000	31.200	53.800	101.000	2.090	.666	6.570	13.000	1.070	643.000	1400.000	7.500	42.800	.390	.870	6.390
227	1.180	2.230	110.000	4.650	622.000	29.300	55.700	112.000	1.950	.665	7.750	13.100	1.160	765.000	1710.000	7.030	42.300		.940	3.480
228	.867	2.450	109.000	5.060	535.000	32.000	54.400	106.000	2.000	.614	5.030	13.900	1.110	446.000	1290.000	7.400	38.300		.450	6.980
270	1.070	2.410	125.000	4.300	587.000	29.700	45.900	99.500	1.880	.609	7.500	12.600	2.260	632.000	1030.000	7.510	39.500		.940	3.780
335	.698	2.060	97.600	4.120	794.000	34.100	43.000	88.900	1.980	.666	6.060	13.400	1.160	633.000	1290.000	8.450	43.200	.803	1.020	.280
1228	.847	2.520	113.000	4.930	612.000	31.200	37.700	96.100	1.900	.707	6.040	12.900	2.250	615.000	1230.000	7.830	43.600	1.490	.946	6.500
2	.740		116.000	4.900	622.000	31.500		84.000	1.740	.430	5.900	12.800	1.270	665.000	1180.000	8.110	41.700	.550	.910	4.600
3	.800	2.100	134.000	5.000	788.000	32.000		93.000	1.820	.760	5.700	13.800	1.440	545.000	1240.000	8.170	37.400	.790	.890	5.410
4	.860	2.230	106.000	4.800	641.000	29.900		93.000	1.770	.750	6.800	13.400	1.550	641.000	1140.000	7.710	39.500	.530		5.440
5	.800	2.010	103.000	4.300	634.000	29.900		85.000	1.520	.410	5.900	13.000	1.320	628.000	1030.000	7.730	41.600	.320	.840	7.370
6	.710	2.090	111.000	5.100	772.000	29.800		86.000	1.490	.450	6.200	13.000	1.430	654.000	1450.000	8.100	40.100	.450	.860	5.260
7	1.010	2.280	114.000	4.900	653.000	29.300		89.000	1.940	.760	6.600	12.600	1.400	605.000	1070.000	7.210	38.300	.210	1.030	6.050
242	.932	2.450	102.000	3.940	557.000	32.200	52.800	109.000	2.150	.659	7.580	14.300	1.530	698.000	1290.000	8.170	45.700	.447	1.150	1.490
66	.732	1.540	101.000	2.800	526.000	30.500		91.000	2.250	.680	7.780	13.300	1.940	736.000	1230.000	7.800	43.000		.910	5.210
246	.995	2.120	96.900	3.830	555.000	29.700	47.500	101.000	1.870	.727	8.290	14.300	1.330	725.000	1220.000	7.740	43.200	.705	1.070	2.480
247	.981	2.210	88.500	3.030	578.000	29.500	50.700	107.000	1.790	.753	6.930	14.500	1.780	590.000	1250.000	7.850	38.600	.669	1.020	7.730
46	.728	2.100	102.000	3.600	685.000	33.100		91.000	1.950	.580	5.500	13.600	1.470	657.000	1190.000	8.310	42.000	.190	1.020	2.060
1236	.913	2.420	103.000	4.200	552.000	29.300	35.100	92.300	1.930	.650	6.340	12.900	2.200	645.000	1110.000	7.440	43.600	.581	.894	6.460
MEAN	.859	2.201	106.698	4.254	625.303	30.907	47.309	95.987	1.883	.636	6.460	13.207	1.480	655.628	1236.385	7.764	41.445	.589	.936	4.115
STD DEV	.129	.238	14.032	.909	84.343	1.461	7.308	9.437	.146	.136	.917	.913	.332	93.093	169.768	.376	2.900	.401	.093	4.229
(PCT)	14.981	10.830	13.151	21.374	13.492	4.726	15.447	9.831	7.747	21.413	14.197	6.912	22.456	14.199	13.731	4.850	6.998	68.190	9.963	102.782

TORTUGUERO REFERENCE UNIT

SAMPLE	NA2O PCT	K2O PCT	RB2O PPM	CS2O PPM	BAO PPM	SC2O3 PPM	LA2O3 PPM	CEO2 PPM	EU2O3 PPM	LU2O3 PPM	HFO2 PPM	THO2 PPM	TA2O5 PPM	CR2O3 PPM	NIO PPM	FE2O3 PCT	COO PPM	SB2O3 PPM	TIO2 PCT	CAO PCT
248	1.230	1.780	87.400	3.620	432.000	27.000	43.100	92.900	1.700	.581	9.910	10.500	1.240	1730.000	520.000	7.430	51.800	.719	.990	1.630
39	1.710	2.270	112.000	4.400	566.000	22.000		91.000	1.690	.650	7.500	9.700	1.450	955.000	457.000	6.340	42.400	.300	.900	1.590
40	1.610	2.320	122.000	6.400	611.000	25.500		90.000	1.910	.750	7.500	11.200	1.720	1010.000	547.000	6.600	29.500	.590	1.000	1.320
41	.747	1.780	111.000	5.500	427.000	35.200		89.000	1.990	.510	4.100	10.400	1.300	1390.000	978.000	9.420	66.100	.660	.890	6.770
42	1.450	2.200	97.000	4.900	508.000	24.200		81.000	1.580	.480	8.200	9.400	1.560	1130.000	355.000	7.090	36.400	.400	.870	1.180
43	1.090	1.340	69.000	3.800	412.000	29.700		77.000	1.580	.450	7.200	9.500	1.330	2550.000	1060.000	8.110	76.400	.470	.910	1.770
44	.820	1.510	113.000	4.200	632.000	25.800		82.000	1.590	.680	6.200	9.500	1.350	1310.000	624.000	7.100	43.600	.510	.970	1.300
45	1.140	1.610	119.000	5.500	321.000	35.100		75.000	1.750	.820	6.300	10.700	1.180	1460.000	1140.000	8.890	50.000	.550	.910	1.810
47	1.200	1.700	97.000	3.800	548.000	33.300		104.000	2.330	.710	4.900	12.000	1.500	803.000	771.000	8.930	56.800	.610	.990	1.570
MEAN	1.181	1.805	101.471	4.597	484.982	28.274	43.100	85.720	1.776	.614	6.661	10.289	1.395	1301.550	667.306	7.698	48.463	.518	.935	1.779
STD DEV	.382	.380	20.682	1.013	119.975	5.253		10.249	.248	.143	2.045	.909	.177	536.782	333.746	1.178	16.564	.161	.051	1.219
(PCT)	32.325	21.066	20.382	22.047	24.739	18.578		11.819	13.958	23.382	30.694	8.831	12.674	41.242	50.014	15.300	34.179	31.151	5.502	68.508

Table 1 b
BNL 4-810-80

NON-GROUPED SPECIMENS

SAMPLE	NA2O PCT	K2O PCT	RB2O PPM	CS2O PPM	BAO PPM	SC2O3 PPM	LA2O3 PPM	CEO2 PPM	EU2O3 PPM	LU2O3 PPM	HFO2 PPM	THO2 PPM	TA2O5 PPM	CR2O3 PPM	MNO PPM	FE2O3 PCT	COO PPM	SB2O3 PPM	TIO2 PCT	CAO PCT
1009	1.110	2.280	111.000	5.840	1140.000	34.200	47.400	113.000	1.740	.587	4.890	11.800	1.890	609.000	720.000	9.670	46.300	.549		
1011	.632	2.640	90.600	7.020	1960.000	26.100		72.800	1.590	.590	5.910	8.960	1.250	95.700		5.580	16.400	4.510		5.230
1012	.817	2.300	114.000	4.290	1370.000	33.600	44.300	107.000	1.760	.583	5.720	12.000	1.490	770.000	1190.000	8.160	43.900	.535		3.530
1237	.975	2.830	93.500	3.880	1610.000	27.000	32.200	81.500	1.530	.589	5.400	10.300	2.650	526.000	1000.000	6.600	34.000		.427	4.480
1238	.824	2.300	84.500	6.030	2020.000	25.500	35.500	86.100	1.920	.538	5.770	11.100	1.630	132.000	428.000	6.000	16.400	.863	.754	11.700
969	2.180	1.900	84.200	4.000	1050.000	14.500	24.600	60.300	.719	.415	6.640	15.300	1.340	65.200	665.000	4.020	19.600	1.560		1.710
970	.338	2.540	287.000	26.000	1060.000	33.900	37.300	92.400	1.340	.641	6.740	18.700	1.870	155.000	137.000	7.680	10.100	1.980		
F045	1.370	2.290	115.000	4.710	551.000	44.200	33.600	70.100	2.040	.893	6.230	8.670	.910	180.000	1010.000	8.520	28.800	1.690	1.390	1.150
F015	.865	2.630	178.000	4.910	814.000	33.200	54.400	127.000	2.350	.745	7.130	18.000	2.010	652.000	1160.000	8.310	37.000	.695	1.110	.990
F022	.736	3.060	90.900	2.470	544.000	32.800	55.500	131.000	2.420	.791	7.160	17.800	1.900	621.000	1340.000	9.170	44.100	.885	1.230	1.780
1176	.751	2.160	75.000	2.820	379.000	32.200	65.900	148.000	2.510	1.120	7.950	18.100		990.000	1060.000	8.470	48.600		1.190	1.370
1177	1.030	2.510	120.000	7.370	569.000	24.600	44.400	112.000	2.190	.793	7.140	14.300		429.000	1270.000	7.360	37.100		.950	1.180
1180	1.710	2.400	97.800	8.410	1010.000	24.900	44.000	132.000	2.400	.879	10.200	15.000		568.000	1170.000	7.010	35.700		.900	1.650
1181	.961	1.530	138.000	4.760	607.000	29.800	63.400	145.000	2.050	.993	6.990	16.400		696.000	1150.000	7.350	54.200	.819	1.430	1.220
1183	1.560	2.090	97.200	4.250	951.000	25.000	42.400	129.000	1.810	.781	9.240	15.600		532.000	1080.000	6.510	35.400		.890	1.890
F031	1.190	2.610	101.000	3.080	793.000	27.100	44.700	94.100	1.740	.813	10.700	12.700	1.550	1190.000	933.000	6.860	38.000	.642	.990	.940
F033	1.490	2.390	113.000	4.600	855.000	24.600	37.400	79.500	1.560	.640	6.610	11.300	1.600	448.000	554.000	6.530	23.600		.920	1.120
F036	.848	3.150	145.000	4.790	901.000	30.800	39.900	101.000	1.740	.651	5.260	15.300	1.550	545.000	1570.000	8.180	38.600		1.100	1.270
1179	1.320	2.250	113.000	6.160	538.000	27.900	39.400	127.000	1.700	.771	9.640	14.800		522.000	1180.000	7.160	37.500		.900	1.250
1182	.953	2.770	134.000	6.260	940.000	34.600	50.400	148.000	2.460	.897	7.580	16.700		720.000	1600.000	8.360	49.400	1.580	1.050	2.720
162	1.160	2.070	104.000	5.660	660.000	28.000	65.500	89.500	1.920	.595	7.090	14.100	1.650	751.000	860.000	7.190	35.200	1.040	.960	3.210
217	.736	2.220	137.000	4.100	667.000	29.200	55.600	143.000	2.240	.733	7.600	19.200	1.870	802.000	1070.000	8.930	40.700	1.310	1.270	1.470
218	1.760	1.920	111.000	4.590	651.000	25.900	49.200	115.000	1.770	.740	10.900	13.400	1.390	693.000	1000.000	7.010	38.300	.886	.970	1.550
221	1.660	1.960	84.500	3.220	659.000	27.700	57.500	114.000	2.050	.620	10.400	14.900	1.320	648.000	1320.000	7.540	39.700		1.080	1.870
318	.879	1.300	110.000	6.250	988.000	18.100	45.800	107.000	1.580	.693	5.680	18.000	1.640	355.000	1190.000	3.920	23.000	.977	.820	1.260
1352	.632	2.580	95.000	3.480	531.000	39.700	62.000	144.000	2.400	.891	7.740	19.700	2.470	898.000	1470.000	10.200	52.000	1.230	1.350	1.050
880	1.180	1.050	92.200	6.330	921.000	31.000	44.400	89.600	1.900	.709	6.460	12.600	.778	776.000	1170.000	7.880	41.100		.951	3.110
29	.712	2.440	118.000	5.400	1140.000	31.200		82.000	1.560	.710	4.900	12.500	1.230	600.000	1410.000	8.050	39.900		.980	2.500
35	.922	2.500	137.000	5.300	1190.000	31.500		93.000	1.930	.790	6.600	13.600	1.580	648.000	1110.000	7.800	38.700	.410	.950	3.560
36	.851	2.290	140.000	5.400	1210.000	31.700		94.000	1.930	.820	7.800	12.500	1.360	887.000	1340.000	7.960	40.500	.410	.940	3.370
25	.970	2.420	135.000	5.400	728.000	39.100		94.000	1.990	.840	6.200	13.200	1.620	605.000	1270.000	7.130	38.000	.690	.850	4.200
27	.410	2.050	123.000	4.500	1270.000	29.600		93.000	2.330	.820	7.100	11.100	1.670	135.000	740.000	6.020	14.300	.690	1.300	.940
271	.849	1.810	52.300	1.720	788.000	28.300	52.500	117.000	2.440	.766	9.370	12.000	2.380	1440.000	1270.000	7.620	49.900	.867	.960	4.270
11	.710	2.440	102.000	3.600	1140.000	35.700		102.000	2.000	.630	5.200	14.300	1.540	585.000	1300.000	8.610	48.100	.670	1.070	1.460
224	.783	2.980	144.000	4.200	821.000	36.200	67.000	135.000	2.250	.705	6.640	18.100	1.290	385.000	1440.000	8.430	37.900	.839	1.170	2.820
1231	1.510	1.670	62.700	4.510	478.000	21.600	32.900	121.000	1.960	.651	13.300	11.600	2.360	1270.000	508.000	6.230	38.100	1.590	.947	2.560
56	.162	.570	43.000	4.100	491.000	23.100		81.000	1.520	.600	11.800	14.100	2.410	1620.000	196.000	3.700	20.100		1.340	1.540
59	.792	1.210	25.000	1.200	559.000	34.300		76.000	1.750	.610	5.510	10.200	.920	821.000	755.000	8.960	47.200		1.090	1.110
74	1.020	1.630	65.000	1.670	628.000	32.300	58.000		2.150		14.700	16.500	1.950	739.000	1310.000	7.930	36.200	1.150	1.150	1.570
84	.830	1.730	180.000	4.550	540.000	28.000	49.000	107.000	1.910		6.400	15.200	1.340	600.000	1140.000	7.230	37.100	.550	.890	6.680
88	1.300	2.000	131.000	7.210	772.000	36.200	57.000		2.240		6.050	14.300	1.930	503.000	1380.000	10.400	49.300	.840	1.150	1.640
89	.760	1.740	111.000	4.560	612.000	32.100	50.000		1.880		14.200	13.200	1.580	580.000	1320.000	8.780	42.500	.450	.950	6.560
244	.982	1.760	64.600	2.560	454.000	24.500	47.000	107.000	1.710	.655	7.850	10.500	1.590	1370.000	1610.000	6.860	50.100	.757	.350	5.060
245	.654	1.420	63.200	2.880	382.000	23.000	37.800	80.400	1.510	.479	5.250	9.330	1.720	914.000	889.000	6.120	39.100	.801	.720	11.700
249	1.400	1.980	96.200	3.830	818.000	29.100	49.400	101.000	1.940	.620	5.460	11.400	1.690	381.000	961.000	7.150	36.700	.635	1.150	2.580
329	1.190	2.740	101.000	6.720	705.000	26.700	38.100	90.500	1.620	.665	4.610	14.500	1.350	620.000	403.000	6.190	35.400	1.320	.740	1.320
331	.074	.709	17.200	.200	211.000	18.000	43.500	89.500	1.970	.676	15.000	14.800	2.140	1810.000	216.000	6.810	41.200	.500	1.330	.420
722	.143	1.020	57.900	2.870	316.000	22.000	44.900	95.000	1.930	.682	12.300	13.100	2.080	1610.000	286.000	6.070	39.700	.262	1.280	.550
1174	1.140	1.880	57.900	2.880	398.000	35.300	47.400	134.000	2.200	1.010	6.040	14.700		501.000	555.000	10.200	34.400		1.490	1.920
235	.964	2.510	78.400	2.950	743.000	33.100	51.500	106.000	1.950	.648	6.450	13.900	1.270	175.000	685.000	8.100	21.800	.923	1.130	7.630
8336	.025	.155	20.100	.200	126.000	19.300	32.600	133.000	1.370	.566	13.800	16.600	1.260	2260.000	730.000	6.110	28.900	.454	1.400	.300
38	1.350	1.980	104.000	6.100	520.000	29.500		71.000	1.790	.500	6.900	10.600	1.520	1510.000	506.000	7.390	33.000	.740	.940	1.530
37	.710	2.090	111.000	5.100	1200.000	29.800		94.000	1.830	.640	5.900	8.800	1.200	2160.000	820.000	9.890	74.900	.520	.980	3.080
165	.732	1.750	156.000	4.260	999.000	33.500	49.900	97.100	2.130	1.030	7.590	13.000	1.200	1730.000	1090.000	9.450	57.800		.990	3.950
166	1.150	1.430	103.000	3.540	885.000	30.800	45.400	90.800	2.190	.642	9.040	12.600	1.370	1970.000	728.000	8.680	55.500		1.020	1.530
167	.616	2.020	81.500	4.980	935.000	39.400	40.000	76.900	1.930	.564	6.240	10.400	1.350	664.000	670.000	9.070	47.800		1.070	1.930
F054	1.920	2.400	111.000	4.710	662.000	25.300	42.000	84.100	1.750	.596	5.630	10.300	1.300	839.000	377.000	5.710	21.400	.641	1.030	1.070
F055	1.190	2.430	132.000	5.030	530.000	31.800	44.800	95.700	1.930	.651	5.770	12.100	1.110	749.000	750.000	7.930	41.700	.457	.940	3.190
14	.860	1.960	88.000	4.800	1120.000	34.000		90.000	2.080	.850	4.300	12.000	1.160	544.000	582.000	8.250	31.900	.650	1.150	1.840
15	1.180	2.110	78.000	4.200	1510.000	37.000		118.000	2.700	.630	4.900	11.900	1.480	421.000	1010.000	9.000	47.500	.820	1.240	1.430
16	1.310	2.110	109.000	4.700	946.000	30.700		91.000	2.050	.710	5.600	11.500	1.430	496.000	866.000	7.750	33.600	.740	1.080	2.040
17	1.290	2.080	101.000	6.100	1390.000	34.700		85.000	2.010	.710	7.500	11.000	1.850	158.000	216.000	3.580	9.500	.750	1.520	.510
343	1.080	1.670	82.500	3.390	1140.000	32.700	45.200	87.500	1.950	.752	6.030	11.600	1.000	462.000	775.000	8.390	23.900	.968	1.170	1.870
344	.339	.772	46.100	4.230	739.000	22.300	43.400	110.000	1.760	.549	8.600	13.400	1.970	362.000	320.000	3.650	15.300	.863	1.720	1.380
1235	1.200	2.790	120.000	6.520	750.000	33.600	45.900	114.000	2.430	.707	5.260	13.400	2.270	330.000	481.000	7.570	48.200	1.750	1.200	1.310
F051	1.080	2.500	104.000	6.950	552.000	25.400	40.400	85.500	1.760	.529	6.750	11.400	1.440	692.000	794.000	6.680	39.600	.859	.790	8.030

, Table 1c
BNL 4-809-80

TABLE 2

Q-MODE SCALED VARIMAX FACTOR SCORES

Variable	Q-Factor 1	Q-Factor 2	Q-Factor 3
Na	0.38	1.16	-0.67
K	0.48	2.07	-0.37
Rb	0.63	0.82	0.33
Cs	-0.19	1.32	-0.13
Ba	-0.08	1.04	0.68
Sc	0.37	0.98	0.84
Eu	0.23	0.56	1.33
Lu	2.38	-1.36	0.52
Hf	0.72	0.03	2.25
Th	0.53	0.61	0.75
Cr	1.01	-0.43	-0.06
Mn	1.61	0.47	-2.08
Fe	0.83	0.97	0.28
Co	1.50	-0.21	-0.30
Variance	44.90	43.46	5.87
Cumulative Variance	44.90	88.35	94.23

TABLE 3

R-MODE FACTOR COMMUNALITY ESTIMATES

Pass		1	2	3	4	5
Number of Factors[1]		5	4	4	4	4
Variance Accounted		81%	74%	77%	79%	80%
	Na	.892	.597	.726	.769	.817
	K	.750	.654	.640	.672	.699
	Rb	.878	.771	.751	.793	.764
	Cs	.851	.702	.749	.753	.867
	Ba	.619	.428	.484	.450	.587
	Sc	.826	.892	.926	.928	.927
	Eu	.801	.804	.805	.845	.825
	Hf	.687	.814	.837	.867	.856
	Th	.827	.860	.895	.915	.885
	Cr	.833	.759	.793	.810	.712
	Fe	.862	.830	.839	.857	.875
	Co	.858	.817	.812	.771	.734
Number of Specimens Removed[2]		22	20	13	14	9

Notes: 1 Factors extracted with eigenvalues greater than 1.00.

2 Specimens removed when laying outside a 95% confidence region from centroid.

TABLE 14

STANDARDIZED DISCRIMINANT FUNCTION COEFFICIENTS FOR CHEMICAL PASTE COMPOSITIONAL REFERENCE UNITS

Variable	DF 1	DF 2	DF 3	DF 4
Na	0.24	0.01	0.32	0.28
K	-0.63	-0.22	0.17	0.10
Rb	-1.73	0.90	-0.27	0.40
Cs	0.42	-0.64	1.03	0.24
Ba	-0.18	-1.10	-1.35	-0.22
Sc	-0.57	0.86	-0.95	-1.00
Eu	0.27	-0.81	-0.09	-0.63
Lu	0.18	-0.04	-0.04	-0.22
Hf	-0.58	-1.07	0.10	0.24
Th	-1.30	0.23	0.37	-0.54
Cr	-0.81	0.81	-0.11	-0.25
Mn	-0.16	-0.68	-0.15	0.26
Fe	0.03	-0.13	0.94	1.00
Co	0.39	-0.21	-0.01	0.50
Ti	0.25	0.22	0.29	-0.04
Eigenvalue	7.36	4.30	2.23	1.42
Percent of Trace	48.1	28.1	14.6	9.3

TABLE 5

STANDARDIZED DISCRIMINANT FUNCTION
COEFFICIENTS FOR PASTE COMPOSITIONAL REFERENCE UNITS

Variable	DF 1	DF 2
Na	-0.27	-0.17
K	0.49	-0.21
Rb	1.47	0.64
Cs	-0.77	-0.32
Ba	0.06	-0.55
Sc	1.01	-0.63
Eu	-0.52	0.16
Lu	-0.18	0.17
Hf	0.21	-0.74
Th	1.21	0.52
Cr	1.03	0.52
Mn	-0.02	-0.58
Fe	-0.19	-0.77
Co	-0.41	-0.50
Ti	-0.22	0.20
Eigenvalue	6.83	1.98
Percent of Trace	77.5	22.5

TABLE 6

STANDARDIZED DISCRIMINANT FUNCTION COEFFICIENTS FOR MAYAN FINE ORANGE-FINE GRAY AND OTHER FINE PASTE POTTERY

Variable	DF 1	DF 2	DF 3	DF 4	DF 5
Na	0.27	0.17	0.81	0.53	0.40
K	-0.21	0.34	-0.75	-0.36	-0.33
Rb	0.82	0.62	-0.15	-0.76	0.32
Cs	-0.78	-0.42	0.49	0.95	-0.07
Ba	-0.38	0.02	0.14	0.36	-0.31
Sc	-0.43	0.72	0.67	0.32	-0.09
Eu	0.02	0.22	0.54	0.28	0.65
Hf	-0.28	-0.28	-0.40	0.35	0.76
Th	0.48	0.66	-0.67	-0.22	-0.18
Cr	1.59	1.60	1.65	-0.44	-0.26
Mn	0.19	-0.31	-0.99	0.87	-0.13
Fe	-0.37	0.37	0.21	0.42	0.19
Co	1.00	-1.31	-0.38	0.62	0.30
Eigenvalue	11.4	3.1	2.9	0.5	0.3
Percent of Trace	62.3	17.2	16.1	2.8	1.4

TABLE 7.1
SPECIMENS FROM THE MAYA AREA CONSIDERED IN THIS STUDY

SITE	SPECIMEN	ILLUSTRATION	D^2 REMOVAL	CLUS GROUP	SPSS	WARE	CERAMIC GROUP	CERAMIC TYPE
<u>Chemical Paste Composition Reference Unit 1</u>								
Bajio	1230			A		FO	Silho	Champan Red-on-orange
Palenque	54	Fig. 21a		A		FO	Silho	Yalton Black-on-orange
	57	Fig. 19		miss.	+	FO	Balancan	Provincia Plano-relief
	81	Fig. 21b		A		FO	Silho	Yalton Black-on-orange
	373	Fig. 6a		A		FG	Chablekal	Chablekal Gray
"Campeche"	1239	Fig. 20		A		FO	-	-
Dzibilchaltun	1234	Fig. 7b		A		FG	Chablekal	Telchac Composite
Chichen Itza	FO50	SCS 12.6 # 50		A		FO	Silho	Silho Orange
	FO52	SCS 12.6 # 52		A		FO	Silho	Kilican Composite

TABLE 7.2

SITE	SPECIMEN	ILLUSTRATION	D² REMOVAL	CLUS GROUP	SPSS	WARE	CERAMIC GROUP	CERAMIC TYPE
<u>Chemical Paste Composition Reference Unit 2</u>								
Becan	1010			B		FO	-	-
Altar de Sacrificios	F049	SCS A.4 # 49		B		FG	Tres Naciones	-
Arenitas	231	Fig. 10a		B		FO	Altar	Altar Orange
Trinidad	272	Fig. 22b		B		FO	Silho	Pocboc Gouged-incised
	273	Fig. 10b		B		FO	Altar*	Altar Orange*
Calatrava	12			B		FO	Altar	Altar Orange
	229	Fig. 9		B		FO	-	-
	230			B		FG	Chablekal	Chablekal Gray

TABLE 7.3

SITE	SPECIMEN	ILLUSTRATION	D^2 REMOVAL	CLUS GROUP	SPSS	WARE	CERAMIC GROUP	CERAMIC TYPE
Chemical Paste Composition Reference Unit 3								
Uaxactun	F042	SCS A-8 # 42		C		FO	Altar	Islas Gouged-incised*
	F043	SCS A-8 # 43		C		FO	Altar	Altar Orange
El Cayo	F046	SCS A-9 # 46		C		FO	Altar	Pabellon Modeled-carved
Lubaantun	NH48		4		+	FO	Altar	Pabellon Modeled-carved
SEIBAL	F016	SCS A.1 # 16		C		FO	Altar	Pabellon Modeled-carved*
	F017	SCS A.1 # 17		C		FO	Altar	Islas Gouged-incised
	F018	SCS A.1 # 18		C		FO	Altar	Altar Orange
	F019	SCS A.1 # 19		C		FO	Altar	Cedro Gadrooned
	F020	SCS A.1 # 20		C		FO	Altar	Altar Orange
	F025	SCS A.2 # 25		C		FO	Altar	Islas Gouged-incised
Altar de Sacrificios	F028	SCS 12.1 # 28		C		FO	Altar	Pabellon Modeled-carved
	F029	SCS 12.1 # 29		C		FO	Altar	Pabellon Modeled-carved
	F032	SCS 12.1 # 32		C		FO	Altar	Altar Orange
	F034	SCS A.3 # 34		C		FO	Balancan	Provincia Plano-relief
	F035	SCS A.3 # 35		C		FO	Altar	Tumba Black-on-orange
	F037	SCS A.5 # 37		C		FO	-	-
	F038	SCS A.5 # 38		C		FO	-	-
	F039			C		FG	Tres Naciones	-
Piedras Negras	219	Fig. 13		C		FO	Altar	Pabellon Modeled-carved
	220			C		FO	Altar	Pabellon Modeled-carved
	222			C		FO	Altar	Cedro Gadrooned
	223			C		FO	Altar*	-
	491			miss.	+	FO	Altar	Pabellon Modeled-carved
Jonuta	1			C		FO	-	-
	F053	SCS A.10 # 53		C		FO	-	-

TABLE 7.4

SITE	SPECIMEN	ILLUSTRATION	D^2 REMOVAL	CLUS GROUP	SPSS	WARE	CERAMIC GROUP	CERAMIC TYPE
<u>Chemical Paste Composition Reference Unit 4</u>								
SEIBAL	F026	SCS A.2 # 26		D		FG	Tres Naciones	Tres Naciones Gray
Altar de Sacrificios	F030	SCS A.3 # 30		D		FO	Altar	Altar Orange
	F040	SCS A.5 # 40		D		FG	Tres Naciones	Tres Naciones Gray
	F041	SCS A.5 # 41	3		+	FG	Tres Naciones	-
	F047	SCS A.4 # 47		D		FO	Altar	Altar Orange
	F048	SCS A.4 # 48		D		FO	Altar	Altar Orange
	1178			D		FG	Tres Naciones	Chorrito Plano-relief
Piedras Negras	314			D		FG	Tres Naciones	Tres Naciones Gray
	317	Fig. 12		D		FO	Altar	Altar Orange
Tecolpan	1226			D		FO	Altar	Altar Orange
	1227			D		FG	Tres Naciones*	Tres Naciones Gray*

TABLE 7.5

SITE	SPECIMEN	ILLUSTRATION	D^2 REMOVAL	CLUS GROUP	SPSS	WARE	CERAMIC GROUP	CERAMIC TYPE
<u>Chemical Paste Composition Reference Unit 5</u>								
Uaxactun	FO44	SCS A.8 # 44		E		FO	Silho*	–
SEIBAL	FO23	SCS A.2 # 23		E		FO	Altar	Tumba Black-on-orange
Piedras Negras	322	Fig. 7a		E		FG	Chablekal	Telchac Composite
Calatrava	9			miss.	+	FO	–	–
	10	Fig. 17		E		FO	Balancan	Provincia Plano-relief
	13			E		FG	–	–
	168	Fig. 24		E		FO	Matillas	Matillas Orange
	225	Fig. 18a		E		FO	Balancan	Provincia Plano-relief
	226	Fig. 14a		E		FO	Altar	Tumba Black-on-orange
	227			E		FO	Altar	Altar Orange
	228	Fig. 11a		E		FO	Altar	Altar Orange
	270	Fig. 26		E		FO	–	–
	335			E		FG	–	–
Tecolpan	1228			E		FO	Altar	Altar Orange
Jonuta	2			E		FO	Altar	Trapiche Incised
	3			E		FO	Altar	Tumba Black-on-orange
	4			E		FO	Altar	Altar Orange
	5			E		FO	Balancan	Provincia Plano-relief
	6			E		FO	Altar	Altar Orange
	7			E		FG	Chablekal	Chablekal Gray
Palenque Ejido	242			E		FO	Altar	Altar Orange
Palenque	66	Fig. 14b	3		+	FO	Altar	Trapiche Incised
	246	Fig. 11c		E		FO	Altar	Altar Orange
	247	Fig. 15		E		FG	Tres Naciones*	Tres Naciones Gray*
Tortuguero	46	Fig. 11b		miss.	+	FO	Altar	Altar Orange
Dzibilchaltun	1236			E		FG	Chablekal	Chicxulub Incised

TABLE 7.6

SITE	SPECIMEN	ILLUSTRATION	D^2 REMOVAL	CLUS GROUP	SPSS	WARE	CERAMIC GROUP	CERAMIC TYPE
Tortuquero Reference Unit								
Palenque	248		3			FP	-	-
Tortuguero	39		3			FP	-	-
	40		3			FP	-	-
	41		2			FP	-	-
	42		4			FP	-	-
	43	Fig. 5a	1			FP	-	-
	44		4			FP	-	-
	45		2			FP	Balancan	Balancan Orange
	47	Fig. 18b	2			FP	Balancan	Provincia Plano-relief

TABLE 7

SITE	SPECIMEN	ILLUSTRATION	D^2 REMOVAL	CLUS GROUP	SPSS	PROJECTED MEMBERSHIP CPCRU	PROJECTED MEMBERSHIP PCRU	WARE	CERAMIC GROUP	CERAMIC TYPE
<u>Unplaced Samples</u>										
Becan	1009		3					FO	–	–
	1011		1					FO	–	–
	1012		4					FO	–	–
	1237		2					FO	–	–
	1238		1					FO	–	–
Yaxha	969		1					FO	–	–
	970		1				3	FO	–	–
San Jose	F045	SCS A.9 # 45	1					FO	–	–
SEIBAL	F015	SCS A.1 # 15	4					FO	Altar	Pabellon Modeled-carved
	F022	SCS A.2 # 22	4					FO	Balancan	Provincia Plano-relief
	1176		3					FG	Tres Naciones	Tres Naciones Gray
	1177		4					FG	Tres Naciones	Poite Incised
	1180		1					FO	Altar	Trapiche Incised
	1181		2			5		FO	Altar	Pabellon Modeled-carved
	1183		3				3	FO	Balancan	Provincia Plano-relief
Altar de Sacrificios	F031	SCS 12.1 # 31	3				2	FO	Altar	Altar Orange
	F033	SCS 12.1 # 33	5				1	FO	Altar	Altar Orange
	F036	SCS A.3 # 36	4					FO	Altar	Islas Gouged-incised
	1179		5				(3)	FO	Altar	Altar Orange
	1182		4				(2)	FO	Altar	Pabellon Modeled-carved
Piedras Negras	162		5					FG	Chablekal	Chicxulub Incised
	217	Fig. 16b	2				2	FO	Balancan	Provincia Plano-relief
	218	Fig. 16a	4			4	3	FO	Balancan	Provincia Plano-relief
	221		4			4	(3)	FO	Altar	Trapiche Incised
	318		2					FP	–	–
	1352		miss.		#			FO	Altar	Pabellon Modeled-carved

TABLE 7.7 (Continued)

SITE	SPECIMEN	ILLUSTRATION	D^2 REMOVAL	CLUS GROUP	SPSS	PROJECTED MEMBERSHIP CPCRU	PROJECTED MEMBERSHIP PCRU	WARE	CERAMIC GROUP	CERAMIC TYPE
San Jose del Rio	880	Fig. 25	3					FO	Matillas	Villahermosa Incised
Tierra Blanca	29		5			2	(3)	FG	Chablekal	Chablekal Gray
	35		3					FG	Chablekal	Chablekal Gray
	36	Fig. 6d	4					FG	Chablekal	Telchac Composite
Trinidad	25	Fig. 5b	2					FO	–	–
	27		1				1	FP	–	–
	271	Fig. 22a	2			2	3	FO	Silho	Pocboc Gouged-incised
Calatrava	224			B	–			FO	Balancan	Provincia Plano-relief
	11			B			(1)	FO	Altar	Altar Orange
Bajio	1231	Fig. 23	2				1	FO	Silho	Pocboc Gouged-incised
Palenque	56		1					FP	–	–
	58		2					FG	Chablekal	Chablekal Gray
	74		1					FG	Chablekal	Chablekal Gray
	84	Fig. 8	1					FG	Chablekal	Cholul Fluted
	88		2					FO	–	–
	89	Fig. 5c	1					FO	–	–
	244		4			5	(3)	FO	Altar	Altar Orange
	245			A				FO	Silho	Yalton Black-on-orange
	249		4					FP	–	–
	329	Fig. 6b				1		FG	Chablekal	Chicxulub Incised
	331		1					FG	Chablekal	Telchac Composite
	722	Fig. 6c	2					FG	Chablekal	Telchac Composite
	1174	Fig. 4	1					FP	–	–
Miraflores	235		3			5	(3)	FO	Cunduacan	Buey Modeled
Yoxiha	336		1					FG	–	–

TABLE 7.7 (Continued)

SITE	SPECIMEN	ILLUSTRATION	D^2 REMOVAL	CLUS GROUP	SPSS	PROJECTED MEMBERSHIP CPCRU	PCRU	WARE	CERAMIC GROUP	CERAMIC TYPE
Tortuguero	38		2					FP	-	-
Tierra Colorada	37		1					FO	Matillas	Matillas Orange
	165		1					FO	Matillas	Matillas Orange
	166		2					FO	Matillas	Matillas Orange
	167		2					FO	Matillas	Matillas Orange
Cintla	FO54	A.10 # 54	1				(3)	FO	Matillas*	Matillas Orange*
	FO55	A.10 # 55		E	-			FO	Matillas	Matillas Orange
Comalcalco	14		4					FP	-	-
	15		1					FP	-	-
	16		5					FP	-	-
	17		1				(1)	FP	-	-
	343		2					FP	-	-
	344		1					FP	-	-
Dzibilchaltun	1235		2					FG	-	-
Chichen Itza	FO51	12.6 # 51	5					FO	Silho	Yalton Black-on-orange

TABLE 8

TYPOLOGY AND COMPOSITIONAL GROUPINGS

CERAMIC GROUP/ CERAMIC TYPE	PCRU			CPCRU "Usumacinta"					UNPLACED	TORTU-GUERO
	1	2	3	2	4	5	3	1		
<u>Altar Ceramic Group</u>										
Altar Orange		16	4	3	5	8	4		5	
Cedro Gadrooned			2				2			
Islas Gouged-incised			3*				3*		1	
Pabellon Modeled-carved			8*				8*		4	
Trapiche Incised		2				2			2	
Tumba Black-on-orange		3	1			3	1			
Unspecified			1				1			
<u>Balancan Ceramic Group</u>										
Balancan Orange										1
Provincia Plano-relief	1	3	1			3	1	1	5	1

TABLE 8 (continued)

CERAMIC GROUP/ CERAMIC TYPE	PCRU 1	PCRU 2	PCRU 3	CPCRU "Usumacinta" 2	CPCRU "Usumacinta" 4	CPCRU "Usumacinta" 5	CPCRU 3	CPCRU 1	UNPLACED	TORTU-GUERO
<u>Cunduacan Ceramic Group</u>										
Buey Modeled									1	
<u>Matillas Ceramic Group</u>										
Matillas Orange		1				1			6*	
Villahermosa Incised									1	
<u>Silho Ceramic Group</u>										
Champan Red-on-orange	1							1		
Kilikan Composite	1							1		
Pocboc Gouged-incised		1		1					2	
Silho Orange	1							1		
Yalton Black-on-orange	3							3	1	
Unspecified		1*				1*				
<u>Unspecified Fine Orange</u>				2		2	4	1	11	

TABLE 8 (continued)

CERAMIC GROUP/ CERAMIC TYPE	PCRU			CPCRU "Usumacinta"					UNPLACED	TORTU- GUERO
	1	2	3	2	4	5	3	1		
<u>Chablekal Ceramic Group</u>										
Chablekal Gray	1	2		1		1		1	4	
Chicxulub Incised		1				1			2	
Cholul Fluted									1	
Telchac Composite	1	1				1		1	3	
<u>Tres Naciones Ceramic Group</u>										
Chorrito Plano-relief		1			1					
Poite Incised									1	
Tres Naciones Gray		5*			4*	1*			1	
Unspecified		2	1	1	1		1			
<u>Unspecified Fine Gray</u>		2				2			2	
<u>Unspecified Fine Paste</u>									12	7

TABLE 9

PETROGRAPHIC VARIABLES

SITE	SPECIMEN	MICACEOUS MATRIX	VOLCANIC DUST	FELDSPAR	WARE	CERAMIC GROUP	CERAMIC TYPE
Becan	1237	+			FO	-	-
	1238		-		FO	-	-
SEIBAL	1176		-	-	FG	Tres Naciones	Tres Naciones Gray
	1177				FG	Tres Naciones	Poite Incised
	1180	-			FO	Altar	Trapiche Incised
	1181	-	-		FO	Altar	Pabellon Modeled-carved
	1183	-			FO	Balancan	Provincia Plano-relief
Altar de Sacrificios	F031		-	+	FO	Altar	Altar Orange
	F036		-		FO	Altar	Islas Gouged-incised
	1179			+	FO	Altar	Altar Orange
	1182			+	FO	Altar	Pabellon Modeled-carved
Piedras Negras	162				FG	Chablekal	Chicxulub Incised
	217		-		FO	Balancan	Provincia Plano-relief
	218			+	FO	Balancan	Provincia Plano-relief
	221			+	FO	Altar	Trapiche Incised
	318				FP	-	-
San Jose del Rio	880				FO	Matillas	Villahermosa Incised
Tierra Blanca	29	+	-		FG	Chablekal	Chablekal Gray
	35				FG	Chablekal	Chablekal Gray
	36			-	FG	Chablekal	Telchac Composite

TABLE 9 (Continued)

SITE	SPECIMEN	MICACEOUS MATRIX	VOLCANIC DUST	FELDSPAR	WARE	CERAMIC GROUP	CERAMIC TYPE
Trinidad	25			-	FO	-	-
	27	-	-	-	FP	-	-
	271		-		FO	Silho	Pocboc Gouged-incised
Calatrava	224				FO	Balancan	Provincia Plano-relief
Bajio	1231				FO	Silho	Pocboc Gouged-incised
Palenque	56	-	-		FP	-	-
	58	-	-	-	FG	Chablekal	Chablekal Gray
	74				FG	Chablekal	Chablekal Gray
	84				FG	Chablekal	Cholul Fluted
	88		-	+	FO	-	-
	89		+		FO	-	-
	244		-		FO	Altar	Altar Orange
	248				FP	-	-
	249	-	-	+	FP	-	-
	329	-	+	-	FG	Chablekal	Chicxulub Incised
	331		-	-	FG	Chablekal	Telchac Composite
	722	-	-		FG	Chablekal	Telchac Composite
Miraflores	235				FO	Cunduacan	Buey Modeled
Yoxiha	336				FG	-	-
Tortuguero	38				FP	-	-
	39		-	+	FP	-	-
	40		-	+	FP	-	-
	41		-	-	FP	-	-
	42		-	+	FP	-	-
	43		-		FP	-	-
	44		-		FP	-	-
	45		-	+	FP	Balancan	Balancan Orange
	47		-	+	FP	Balancan	Provincia Plano-relief

TABLE 9 (Continued)

SITE	SPECIMEN	MICACEOUS MATRIX	VOLCANIC DUST	FELDSPAR	WARE	CERAMIC GROUP	CERAMIC TYPE
Tierra Colorada	37		-	-	FO	Matillas	Matillas Orange
	165		-	+	FO	Matillas	Matillas Orange
	166	+			FO	Matillas	Matillas Orange
	167	+	-		FO	Matillas	Matillas Orange
Comalcalco	14		-	-	FP	-	-
	15		-	+	FP	-	-
	16		-		FP	-	-
	17	-	-		FP	-	-
	343		-	-	FP	-	-
	344	-	-		FP	-	-
"Campeche"	1239				FO	-	-
Dzibilchaltun	1235				FG	-	-

TABLE 10
PROJECT SHERDS

REGION	SITE	CPCRU: Tortuguero	1	5	2	4	3	Unplaced
RIO BEC	Becan	-	-	-	1	-	-	5
PETEN-BELIZE	Uaxactun	-	-	1	-	-	2	-
	Yaxha	-	-	-	-	-	-	2
	San Jose	-	-	-	-	-	-	1
	El Cayo	-	-	-	-	-	1	-
	Lubaantun	-	-	-	-	-	1	-
PASION-USUMACINTA	SEIBAL	-	-	1	-	1	6	7
	Altar de Sacrificios	-	-	-	1	6	8	5
	Piedras Negras	-	-	1	-	2	3	6
USUMACINTA: MIDDLE	Arenitas	-	-	-	1	-	-	-
	San Jose del Rio	-	-	-	-	-	-	1
	Tierra Blanca	-	-	-	-	-	-	3
	Trinidad	-	-	-	2	-	-	3
USUMACINTA: LOWER	Calatrava	-	-	10	3	-	-	2
	Tecolpan	-	-	1	-	2	-	-
	Jonuta	-	-	6	-	-	2	-
CHIAPAS-TABASCO FOOTHILLS	Bajio	-	1	-	-	-	-	1
	Palenque Ejido	-	-	1	-	-	-	-
	Palenque	1	4	3	-	-	-	13
	Miraflores	-	-	-	-	-	-	1
	Yoxiha	-	-	-	-	-	-	1
	Tortuguero	8	-	1	-	-	-	1
LOWER GRIJALVA	Tierra Colorada	-	-	-	-	-	-	4
	Cintla	-	-	-	-	-	-	2
	Comalcalco	-	-	-	-	-	-	6
	"Campeche"	-	1	-	-	-	-	-
YUCATAN PLAINS	Dzibilchaltun	-	1	1	-	-	-	1
	Chichen Itza	-	2	-	-	-	-	1

TABLE 11

REGION	SITE	CPCRU: Tortuguero	1	5	2	4	3	Unplaced
RIO BEC	Becan	–	–	–	1	–	–	5
PETEN-BELIZE	Uaxactun	–	–	1	–	–	2	–
	Yaxha	–	–	–	–	–	–	2
	San Jose	–	–	–	–	–	–	1
	El Cayo	–	–	–	–	–	1	–
	Lubaantun	–	–	–	–	–	1	–
PASION-USUMACINTA	SEIBAL	–	–	2	–	1	6	6
	Altar de Sacrificios	–	–	–	1	6	8	5
	Piedras Negras	–	–	1	–	4	5	4
USUMACINTA: MIDDLE	Arenitas	–	–	–	1	–	–	–
	San Jose del Rio	–	–	–	–	–	–	1
	Tierra Blanca	–	–	–	1	–	–	2
	Trinidad	–	–	–	3	–	–	2
USUMACINTA: LOWER	Calatrava	–	–	10	3	–	–	2
	Tecolpan	–	–	1	–	2	–	–
	Jonuta	–	–	6	–	–	2	–
CHIAPAS-TABASCO FOOTHILLS	Bajio	–	1	–	–	–	–	1
	Palenque Ejido	–	–	1	–	–	–	–
	Palenque	1	5	4	–	–	–	11
	Miraflores	–	–	1	–	–	–	–
	Yoxiha	–	–	–	–	–	–	1
	Tortuguero	8	–	1	–	–	–	1
LOWER GRIJALVA	Tierra Colorada	–	–	–	–	–	–	4
	Cintla	–	–	–	–	–	–	2
	Comalcalco	–	–	–	–	–	–	6
	"Campeche"	–	1	–	–	–	–	–
YUCATAN PLAINS	Dzibilchaltun	–	1	1	–	–	–	1
	Chichen Itza	–	2	–	–	–	–	1

Table 12.1

CHABLEKAL CERAMIC GROUP

(Gray + Black Surfaces)

SITE	CPCRU:						
	Tortu-quero	1	5	2	4	3	Un-placed
Piedras Negras	–	–	1	–	–	–	1
Tierra Blanca	–	–	–	–	–	–	3
Calatrava	–	–	–	1	–	–	–
Jonuta	–	–	1	–	–	–	–
Palenque	–	1	–	–	–	–	6
Dzibilchaltun	–	1	1	–	–	–	–

Table 12.2

ALTAR CERAMIC GROUP

SITE	CPCRU: Tortu-quero	1	5	2	4	3	Un-placed
Uaxactun	–	–	–	–	–	2	–
El Cayo	–	–	–	–	–	1	–
Lubaantun	–	–	–	–	–	1	–
SEIBAL	–	–	1	–	–	6	3
Altar de Sacrificios	–	–	–	–	3	4	5
Piedras Negras	–	–	–	–	1	5 *	2
Arenitas	–	–	–	1	–	–	–
Trinidad	–	–	–	1 *	–	–	–
Calatrava	–	–	3	1	–	–	1
Tecolpan	–	–	1	–	1	–	–
Jonuta	–	–	4	–	–	–	–
Palenque Ejido	–	–	1	–	–	–	–
Palenque	–	–	2	–	–	–	1
Tortuguero	–	–	1	–	–	–	–

Table 12.3

BALANCAN CERAMIC GROUP

SITE	CPCRU: Tortuguero	1	5	2	4	3	Unplaced
SEIBAL	–	–	–	–	–	–	2
Altar de Sacrificios	–	–	–	–	–	1	–
Piedras Negras	–	–	–	–	–	–	2
Calatrava	–	–	2	–	–	–	1
Jonuta	–	–	1	–	–	–	–
Palenque	–	1	–	–	–	–	–
Tortuguero	2	–	–	–	–	–	–

Table 12.4

TRES NACIONES CERAMIC GROUP

SITE	CPCRU: Tortuquero	1	5	2	4	3	Unplaced
SEIBAL	–	–	–	–	1	–	2
Altar de Sacrificios	–	–	–	1	3	1	–
Piedras Negras	–	–	–	–	1	–	–
Tecolpan	–	–	–	–	1*	–	–
Palenque	–	–	1*	–	–	–	–

Table 12.5

SILHO CERAMIC GROUP

SITE	CPCRU: Tortu-quero	1	5	2	4	3	Un-placed
Uaxactun	–	–	1*	–	–	–	–
Trinidad	–	–	–	1	–	–	1
Bajio	–	1	–	–	–	–	1
Palenque	–	2	–	–	–	–	1
Chichen Itza	–	2	–	–	–	–	1

Table 3.6

MATILLAS CERAMIC GROUP

SITE	CPCRU: Tortuquero	1	5	2	4	3	Unplaced
San Jose del Rio	–	–	–	–	–	–	1
Calatrava	–	–	1	–	–	–	–
Tierra Colorada	–	–	–	–	–	–	4
Cintla	–	–	–	–	–	–	2*

Table 3.7

CUNDUACAN CERAMIC GROUP

SITE	CPCRU: Tortuquero	1	5	2	4	3	Unplaced
Miraflores	–	–	–	–	–	–	1

Table 13.1

CERAMIC TYPES

TYPES (BY CERAMIC GROUP)	SITE	CPCRU: Tortu-quero	1	5	2	4	3	Un-placed
Chablekal Ceramic Group								
Chablekal Gray	Tierra Blanca	–	–	–	–	–	–	2
	Calatrava	–	–	–	1	–	–	–
	Jonuta	–	–	1	–	–	–	–
	Palenque	–	1	–	–	–	–	2
Chicxulub Incised	Piedras Negras	–	–	–	–	–	–	1
	Dzibilchaltun	–	–	1	–	–	–	–
	Palenque	–	–	–	–	–	–	1
Cholul Fluted	Palenque	–	–	–	–	–	–	1
Telchac Composite	Piedras Negras	–	–	1	–	–	–	–
	Tierra Blanca	–	–	–	–	–	–	1
	Palenque	–	–	–	–	–	–	2
	Dzibilchaltun	–	1	–	–	–	–	–

Table 13. CERAMIC TYPES

TYPES (BY CERAMIC GROUP)	SITE	Tortuquero	1	5	2	4	3	Unplaced
<u>Altar Ceramic Group</u>								
Altar Orange	Uaxactun	–	–	–	–	–	1	–
	SEIBAL	–	–	–	–	–	2	–
	Altar de Sacrificios	–	–	–	–	3	1	3
	Piedras Negras	–	–	–	–	1	–	–
	Arenitas	–	–	–	1	–	–	–
	Trinidad	–	–	–	1 *	–	–	–
	Calatrava	–	–	2	1	–	–	1
	Tecolpan	–	–	1	–	1	–	–
	Jonuta	–	–	2	–	–	–	–
	Palenque Ejido	–	–	1	–	–	–	–
	Palenque	–	–	1	–	–	–	1
	Tortuguero	–	–	1	–	–	–	–
Cedro Gadrooned	SEIBAL	–	–	–	–	–	1	–
	Piedras Negras	–	–	–	–	–	1	–
Islas Gouged-incised	Uaxactun	–	–	–	–	–	1*	–
	SEIBAL	–	–	–	–	–	2	–
	Altar de Sacrificios	–	–	–	–	–	–	1
Pabellon Modeled-carved	El Cayo	–	–	–	–	–	1	–
	Lubaantun	–	–	–	–	–	1	–
	SEIBAL	–	–	–	–	–	1*	2
	Altar de Sacrificios	–	–	–	–	–	2	1
	Piedras Negras	–	–	–	–	–	3	1
Trapiche Incised	SEIBAL	–	–	–	–	–	–	1
	Piedras Negras	–	–	–	–	–	–	1
	Jonuta	–	–	1	–	–	–	–
	Palenque	–	–	1	–	–	–	–
Tumba Black-on-orange	SEIBAL	–	–	1	–	–	–	–
	Altar de Sacrificios	–	–	–	–	–	1	–
	Calatrava	–	–	1	–	–	–	–
	Jonuta	–	–	1	–	–	–	–

Table B.3

CERAMIC TYPES

TYPES (BY CERAMIC GROUP)	SITE	CPCRU: Tortuguero	1	5	2	4	3	Unplaced
<u>Balancan Ceramic Group</u>								
Balancan Orange	Tortuguero	1	–	–	–	–	–	–
Provincia Plano-relief	SEIBAL	–	–	–	–	–	–	2
	Altar de Sacrificios	–	–	–	–	–	1	–
	Piedras Negras	–	–	–	–	–	–	2
	Calatrava	–	–	2	–	–	–	1
	Jonuta	–	–	1	–	–	–	–
	Palenque	–	1	–	–	–	–	–
	Tortuguero	1	–	–	–	–	–	–

Table 13.4

CERAMIC TYPES

TYPES (BY CERAMIC GROUP)	SITE	CPCRU: Tortuquero	1	5	2	4	3	Unplaced
Tres Naciones Ceramic Group								
Chorrito Plano-relief	Altar de Sacrificios	-	-	-	-	1	-	-
Poite Incised	SEIBAL	-	-	-	-	-	-	1
Tres Naciones Gray	SEIBAL	-	-	-	-	1	-	1
	Altar de Sacrificios	-	-	-	-	1	-	-
	Piedras Negras	-	-	-	-	1	-	-
	Tecolpan	-	-	-	-	1*	-	-
	Palenque	-	-	1*	-	-	-	-

Table 13.5

CERAMIC TYPES

TYPES (BY CERAMIC GROUP)	SITE	Tortu-quero	1	5	2	4	3	Un-placed
Silho Ceramic Group								
Champan Red-on-orange	Bajio	–	1	–	–	–	–	–
Kilikan Composite	Chichen Itza	–	1	–	–	–	–	–
Pocboc Gouged-incised	Trinidad	–	–	–	1	–	–	1
	Bajio	–	–	–	–	–	–	1
Silho Orange	Chichen Itza	–	1	–	–	–	–	–
Yalton Black-on-orange	Palenque	–	2	–	–	–	–	1
	Chichen Itza	–	–	–	–	–	–	1

Table [illegible].6

CERAMIC TYPES

TYPES (BY CERAMIC GROUP)	SITE	CPCRU: Tortu-quero	1	5	2	4	3	Un-placed
Matillas Ceramic Group								
Matillas Orange	Calatrava	-	-	1	-	-	-	-
	Tierra Colorada	-	-	-	-	-	-	4
	Cintla	-	-	-	-	-	-	2 *
Villahermosa Incised	San Jose del Rio	-	-	-	-	-	-	1

Table 4.7

CERAMIC TYPES

TYPES (BY CERAMIC GROUP)	SITE	CPCRU: Tortu-quero	1	5	2	4	3	Un-placed
Cunduacan Ceramic Group								
Buey Modeled	Miraflores	-	-	-	-	-	-	1

TABLE 14

COMBINED ALTAR AND BALANCAN GROUPS OF FINE ORANGE WARE

SITE	Tortuquero	1	5	2	4	3	Unplaced
Uaxactun	–	–	–	–	–	2	–
El Cayo	–	–	–	–	–	1	–
Lubaantun	–	–	–	–	–	1	–
SEIBAL	–	–	1	–	–	6	5
Altar de Sacrificios	–	–	–	–	3	5	5
Piedras Negras	–	–	–	–	1	5*	4
Arenitas	–	–	–	1	–	–	–
Trinidad	–	–	–	1*	–	–	–
Calatrava	–	–	5	1	–	–	2
Tecolpan	–	–	1	–	1	–	–
Jonuta	–	–	5	–	–	–	–
Palenquc Ejido	–	–	1	–	–	–	–
Palenque	–	1	2	–	–	–	1
Tortuguero	2	–	1	–	–	–	–

Table 15

Southern provenience:		Upstream CPCRUs CPCRUs (3, 4)	Downstream CPCRUs (2, 5)
Uaxactun	(n= 2)	2	
El Cayo	1	1	
Lubaantun	1	1	
Seibal	8	7	1
Altar	13	12	1
P.N.	7	7	
Total	32	30	2

Northern provenience:			
Arenitas	1		1
Trinidad	1		1
Calatrava	6		6
Tecolpan	3	2	1
Jonuta	5		5
Pal. Ejido	1		1
Palenque	3		3
Tortuguero	1		1
Total	21	2	19

Test A $x^2 = 338$, $p < .001$ (Siegal 1956, Eq. 6.4)

Upstream provenience:			
Seibal	8	7	1
Altar	13	12	1
P.N.	7	7	
Total	28	26	2

Downstream provenience:			
Arenitas	1		1
Trinidad	1		1
Calatrava	6		6
Tecolpan	3	2	1
Jonuta	5		5
	16	2	14

Test B $x^2 = 25$, $p < .001$ (Siegal 1956, Eq. 6.4)