Comp

Composition Analysis of the O'Neil Site Ceramics: A Study of Raw Material Use in Northwestern Lower Michigan

By

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ABSTRACT

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In this study the chemical compositions of prehistoric ceramic vessels from the O'Neil Site of northwestern lower Michigan were determined by Instrumental Neutron Activation Analysis (INAA) in order to test whether the residential patterns noted during and after excavation were apparent in the pottery paste. A secondary purpose was to determine whether an intensive sampling and analysis of pottery from a single intermittently occupied site could provide meaningful information about the behavior of the prehistoric inhabitants of the Upper Great Lakes.

The results of the analyses of pottery and clay samples from the O'Neil Site, as well as clay and temper samples from the nearby Skegemog Point Site, suggest that simple relationships between raw clays and prehistoric pottery in the Great Lakes do not exist. Several possible explanations for this are considered, and the need for additional information regarding the composition of geologic clays and archaeologically-derived clays is discussed.

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Of critical importance to the completion of this study was the technical support provided by Edward A. Birdsall, Engineering Technician, Nuclear Reactor, Michigan Memorial Phoenix Project. His assistance was facilitated by Philip A. Simpson, Assistant Manager for Research Support Activities, Nuclear Reactor, Michigan Memorial Phoenix Project, who coordinated the analysis at the reactor.

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INTRODUCTION

For archaeologists the study of behavior involves extracting information from the remains of material culture. This can be accomplished by examining patterns of artifacts and land use at archaeological sites, or by intensively extracting information from individual artifacts or groups of artifacts. In this study the latter approach is taken in an attempt to discern patterns of behavior relating to the manufacture, use, and discard of pottery vessels, and the relationship of this behavior to raw material (clay) acquisition in the early and late Late Woodland periods in northwestern lower Michigan.

Clay and pottery samples from the O'Neil Site, a stratified Late Woodland through protohistoric occupation site, as well as additional samples from a nearby site, were analyzed compositionally in an attempt to discern whether habitation patterns at the site could be seen in the concentrations of elements in the pottery samples. Intensive within-site elemental analyses of pottery from single sites in the Upper Great Lakes have not been previously performed. Hence this investigation was undertaken in part to determine whether such an intra-site analysis could provide information about the use of clay resources within a small region.

The results of this study indicate that compositional analyses of pottery are far more complex than originally believed. Not only do the individual components of pottery paste (clay and temper) each contribute to the analytical results, but the natural variability of the clay and tempering material also appear to affect the results. These factors may have little impact on the outcomes of larger regional studies where the variability of raw materials between regions may be far greater than that within the region. But for the analysis of pottery and clay collected from closely-spaced sites, the natural range of variation of the raw materials used to manufacture the pottery becomes crucial in the interpretation of the results. Likewise, the effects of mixing varying amounts of clay and temper to produce the final paste must be considered. These factors are detailed in the following sections with the hope that future analyses of pottery paste will address these concerns.

BACKGROUND

Description of Problem

The interaction of human populations and the environments in which they find themselves has recently been the subject of much anthropological study (e.g. Orlove 1980; Vayda and McCay 1975; Moran 1979). In the Great Lakes this interest in the ecological approach has often been reflected in archaeological studies dealing with food resources and the carrying capacity of certain environments (Cleland 1966; Yarnell 1964). The emphasis on food availability, procurement, preparation and storage is in large part a reflection of the importance of food procurement in prehistory. However, it also reflects the relative abundance of food-related artifacts in archaeological sites in the Upper Great Lakes region, where projectile points, animal bone, floral remains, and in later sites, ceramic materials dominate the prehistoric artifact assemblages of this region (Fitting 1975; Griffin 1983).

Non-food resources utilized by prehistoric hunter-gatherer groups have also been the focus of research in the Great Lakes area. Predominant among these are studies of the availability, acquisition and use of chert (e.g. Ellis 1969; Luedtke 1976; Wahla 1981) which was fashioned into projectile points, knives, scrapers and other tools (Fitting 1975). Others have addressed the role of exotic materials in the material culture of the Great Lakes Indians, and the importance of trade in the social and economic networks in prehistory (e.g. Griffin 1983; Brose, *et al.* 1985).

Only recently have the "everyday" utilitarian items such as clay cooking and storage vessels been examined in terms of resource utilization. Although the prehistoric pottery of the Great Lakes has long been examined on stylistic grounds in an attempt to establish regional chronologies, to define cultural groups, and to identify spheres of social interaction, only in recent years has the chemical composition of the pottery vessels been the subject of serious inquiry (Trigger, *et al.* 1980; Clark 1991). In part, this stems from the inability, until recently, to analyze clays for minute traces of elements which might

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distinguish one clay source from another. It also results from the unstated assumption that where clay is ubiquitous --- as it is in Michigan and other areas with an abundance of glacial deposits (Dorr and Eschman 1977: 134) --- pottery-making took place *in situ* at individual occupation locales. It has been assumed that potters manufactured their wares whenever vessels were needed, and in areas where habitation sites and clay sources were coincident. However, recent interest in regional studies, as well as successful elemental analyses of pottery and other artifacts throughout the world, have have spurred an interest in the analysis of these cultural materials.

The study of pottery from the standpoint of resource utilization is of particular interest. Pottery first made its appearance in the Upper Great Lakes region in the Early Woodland period, or around 600 B.C. (Fitting 1973; Griffin 1983), and is found in nearly all Woodland sites in Michigan (Fitting 1975). Therefore, the presence of prehistoric pottery in Michigan spans a period of at least 2,000 years. Together these factors permit pottery sherds to be studied extensively over time and space, or intensively at a single location or for a single period in prehistory. In addition pottery vessels can have fairly short use-lives. It is assumed that since the prehistoric pottery of the Upper Great Lakes was heavy and prone to breakage, it was probably used for short periods of time before being discarded. In fact, the pottery sherds found in archaeological sites are likely to reflect relatively short periods in the lifetimes of the potters who manufactured them. As such, the study of pottery paste composition can provide a snapshot of time, preserving in the ceramic matrix evidence of behaviors relating to raw material acquisition and its modification into domestic implements.

Although pottery vessels were used extensively in the Great Lakes region throughout prehistory, in the seventeenth and eighteenth centuries European metal kettles began to replace pottery vessels in most Native American communities of this region (Kinietz 1965), largely because the metal kettles were more durable and better able to withstand the direct heat of cooking fires (Holman and Egan 1985: 63). Because metal

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kettles so quickly replaced pottery vessels, little is known about the types of raw material sought for pottery-making, the people who took part in the procurement, preparation, or manufacturing of the vessels, the method of pottery manufacture, the specific use(s) to which each vessel was put, or the significance of pottery in the culture of the Great Lakes Indians.

However, some information can be gleaned from the artifacts themselves, as well as from analogy with the pottery-making processes of the native potters of the southwestern United States. We know, for example, that pottery in the Upper Great Lakes is made from clay and a tempering material such as grit. It was fired at low temperatures, without the benefit of kilns, resulting in a somewhat hard but brittle ware. Like the pottery of the Southwest (Bunzel 1972), Great Lakes pottery is believed to have been made by women. A unique 17th Century description of pottery making among the Huron by the French explorer Sagard supports this assertion:

> But as for our Huron and other peoples and sedentary nations, they had (and they still have) the usage and the skill of making earthen pots, that they bake on their hearth; these are very good and never break in the fire, even though there is no water in them; but yet they cannot withstand humidity or cold water for long without softening and breaking at the least blow that is given them, otherwise they last a very long time. The Indian women make them, taking suitable earth, which they clean and knead very well, mixing in it a little sandstone [as a tempering material], then the mass being reduced to a ball, they make a hole in it with the fist, which they enlarge continuously while beating it inside with a little wooden paddle, as much and as long as is necessary to complete them; these pots are made without feet and without handles and are entirely round like a ball, except the mouth which projects out a little (Kinietz 1965: 47).

However, the prehistoric pottery of the Upper Great Lakes differs from that of the Southwest in its construction and decoration. Prehistoric pottery of the Southwest was made by the coiling technique, and was frequently decorated with painted designs (Bunzel 1965). The late prehistoric pottery of the Great Lakes, on the other hand, was prepared with a paddle-and-anvil technique (Kinietz 1965), and was decorated only with incisions

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Although the role of pottery in the prehistoric exchange networks of the Great Lakes region is not well understood, certain elements have been shown to have been "exchanged" both within and between groups (see for example, Trigger, *et al.* 1980; Brashler 1981). In this way pottery styles have served as markers of interaction between adjacent and more distant groups of people in prehistory.

The analysis of pottery paste adds another dimension to the large body of data dealing with pottery structure and decoration. The determination of the chemical composition of pottery matrices makes possible the comparison of vessels on non-stylistic grounds. On a regional scale, this permits the assessment of clay and pottery from various areas, which in turn can provide information about the movement of clay, pottery, or potters throughout the area of study. This process has been successfully used in the Near East (Bieber *et al.* 1976; Gunneweg and Mommsen 1990; Hancock, *et al.* 1989) and in parts of Mesoamerica (Arnold, *et al.* 1991; Minc, *et al.* 1989; Olin and Blackman 1989), but its use in the Great Lakes area is rare. Trigger and colleagues (1980) used X-ray Fluorescence to compare the pottery of sixteen Iroquois village sites in Ontario. The data thus obtained suggest that the transporting of pots from one village to another may account for the presence of stylistically foreign vessels at certain sites. Further analysis indicated that intra-site patterning at the household level may reveal itself in the composition of ceramic vessels.

More recently Clark (1991) examined the analytical results of Instrumental Neutron Activation Analysis (INAA) of pottery and clay samples from over 30 late Late Woodland sites in the Lake Superior region. His results imply two patterns of cultural interaction within the Lake Superior basin. One of these involves the transfer of finished pots throughout the region by exchange or importation. The other involves the local manufacture of pottery of a particular style in various regions of the study area, implying

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Work on ceramic composition analysis on a more local level is nearly absent in the Great Lakes region. Although the analysis by Trigger, *et al.* (1980) consisted in part of within-site comparisons, no other work of this nature is known for this area. For this reason, the intensive sampling and analysis of pottery from a single semi-stratified site in northern Michigan was undertaken. The broad goals of the project were to determine whether populations residing at the site on a seasonal basis manufactured their pottery vessels locally from nearby clays, and whether these vessels could be differentiated from the vessels made by short-term occupants of the site. The results of this analysis could therefore provide information regarding the nature of resource (clay) utilization in northern Michigan, as well as data related to the movement and settlement patterns of prehistoric populations.

A secondary purpose of the project was to test whether this method of analysis could be used at the site level in the Upper Great Lakes area. Studies of paste composition have successfully been performed on materials derived from state level societies (for example in Mesoamerica and the Near East), whose populations are relatively sedentary and whose resource bases are well-defined. Paste composition has also provided information of a regional nature on artifacts from band-level societies. However, assays of pottery from a single site occupied by hunter-gatherers involved in seasonal migrations have not been performed in this region. The results of an intensive intra-site sampling and analysis program would therefore provide data regarding the variability in the paste composition of vessels found at a single site. It would also prove useful in determining whether, based on such variability, single vessels from one site could be considered representative of the pottery from that site in larger regional studies of paste composition.

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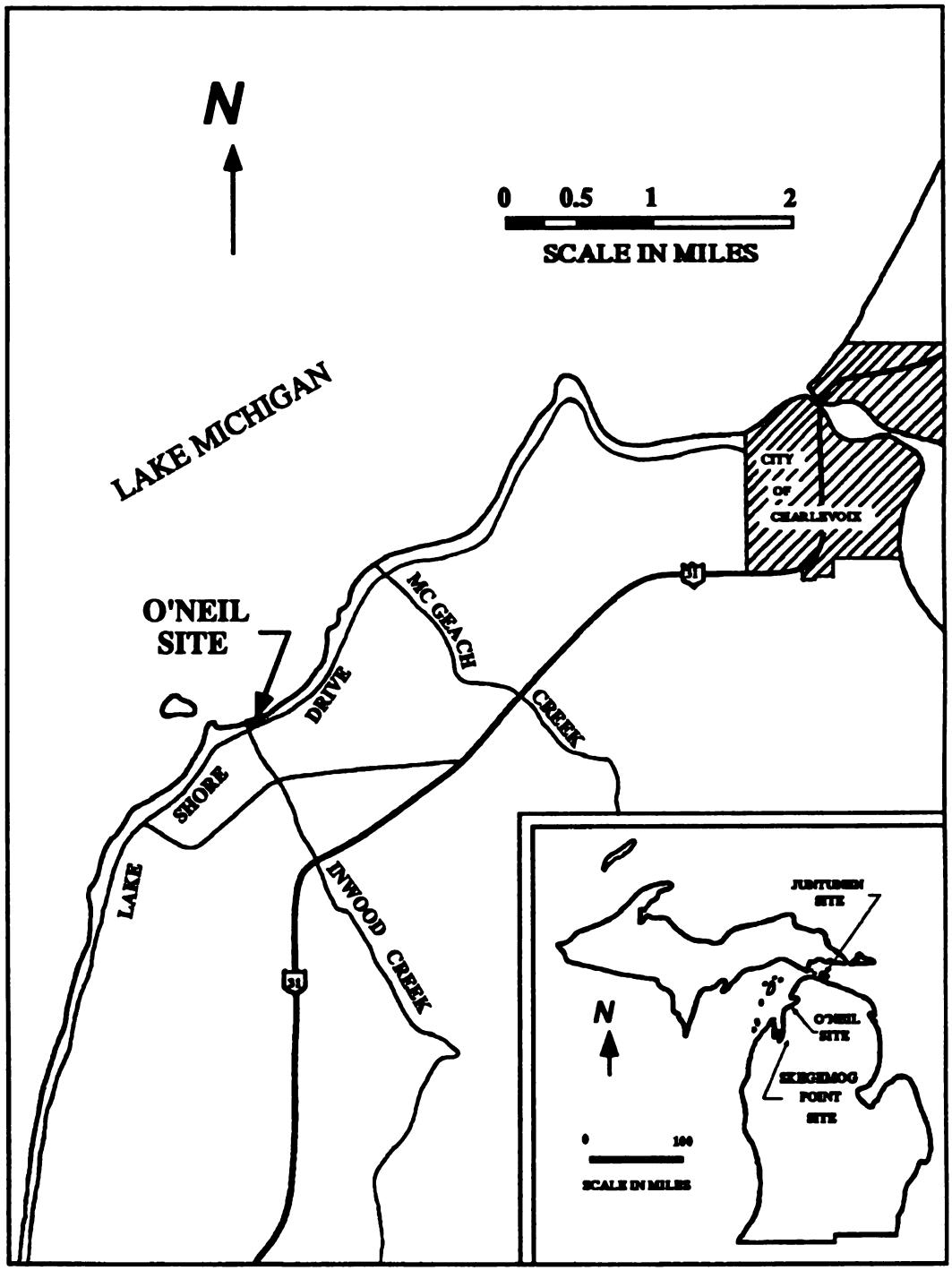
Description of Site

The site chosen for this analysis was the O'Neil Site (20CX18), a partially stratified site excavated by crews from the Michigan State University Museum, Division of Anthropology in 1969 and 1971. The site lies along the shore of Lake Michigan in the so-called "Traverse Corridor" (Lovis 1973), midway between the loci of the Northern and Southern pottery traditions of northwestern Lower Michigan. Because the site contained pottery from both traditions, each of which spans the Late Woodland cultural sequence, it serves as an ideal site for posing questions of behavior centered around clay procurement and its manufacture into pottery during the Late Woodland period.

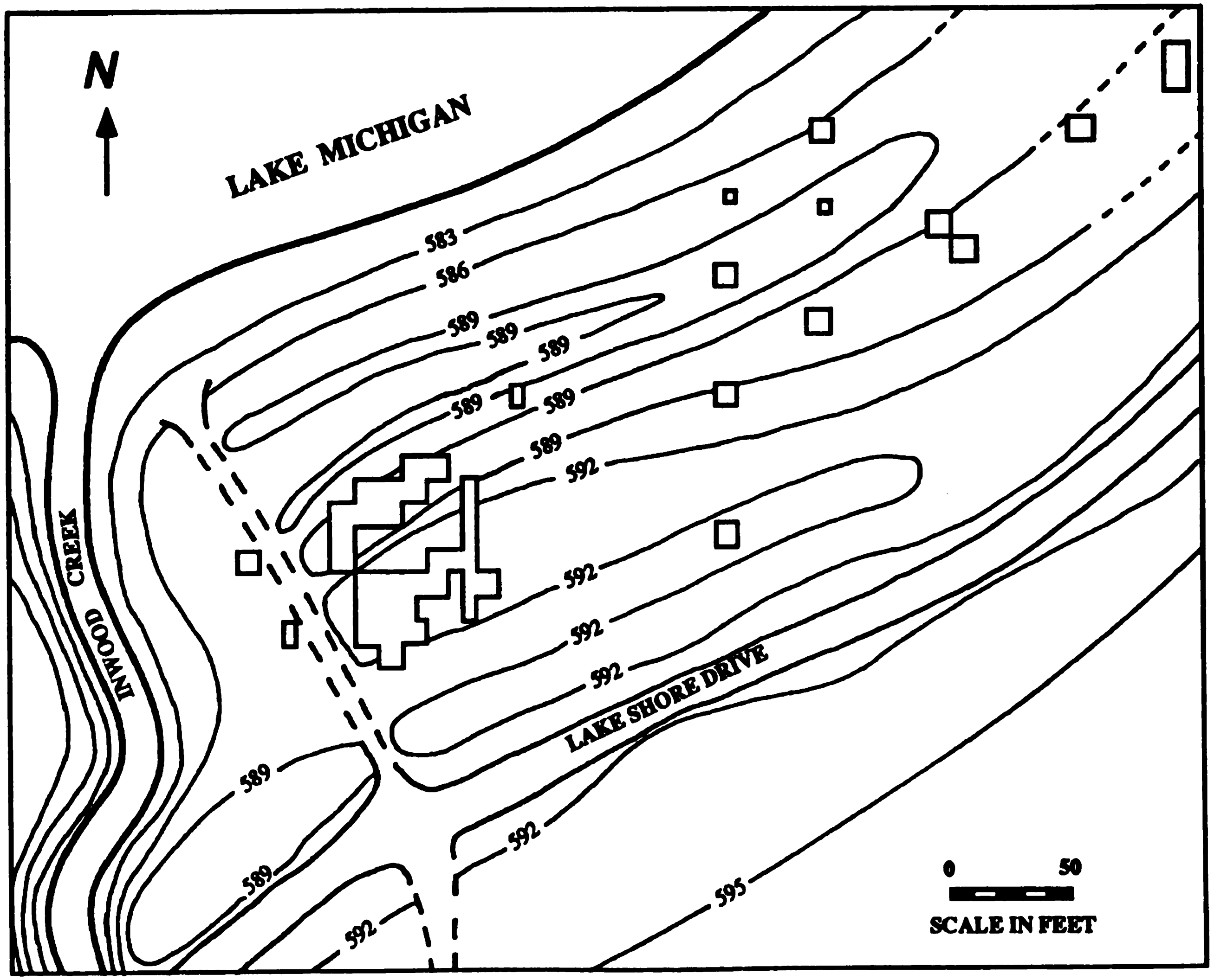
The O'Neil Site is located in the NE quarter of the SE quarter of Section 7, T 33 N, R 9 W in Charlevoix County, Michigan (Lovis 1973) (see Figure 1). At the time of the archaeological investigation, the site was located on an active beach dune near the mouth of Inwood Creek. Excavations at the site uncovered a partially-stratified Late Woodland village site which contained ceramics, lithic material, bone and charred wood from the early and late phases of the Late Woodland period, as well as some ceramics and European trade items dating to the early historic period (Lovis 1973, 1991). Preceding the initial excavation of the site, the area to be investigated was sectioned off into ten-foot by ten -foot excavation units designated by unique unit numbers (see Figures 2 and 3) which are retained in the catalogue numbers of the artifacts.

Initial work at the site revealed that most of the human activity occurred in one region of the site, which was further subdivided into Areas A and B on the basis of the degree of stratification noted during the excavations (see Figures 2 and 3). Area A was the more deeply-stratified area of the site and was overlain by a layer of loose, wind-blown sand up to 0.5 feet thick. Beneath this was a humic zone of deep grey loamy sands 0.3-1.0 feet thick, which was designated Occupation Zone I. Aboriginal materials and European



(After Lovis 1973: Figure 5)

Figure 1 - Map Showing Location of O'Neil Site



(After Lovis 1973: Figure 6)

Figure 2 - Map of O'Neil Site

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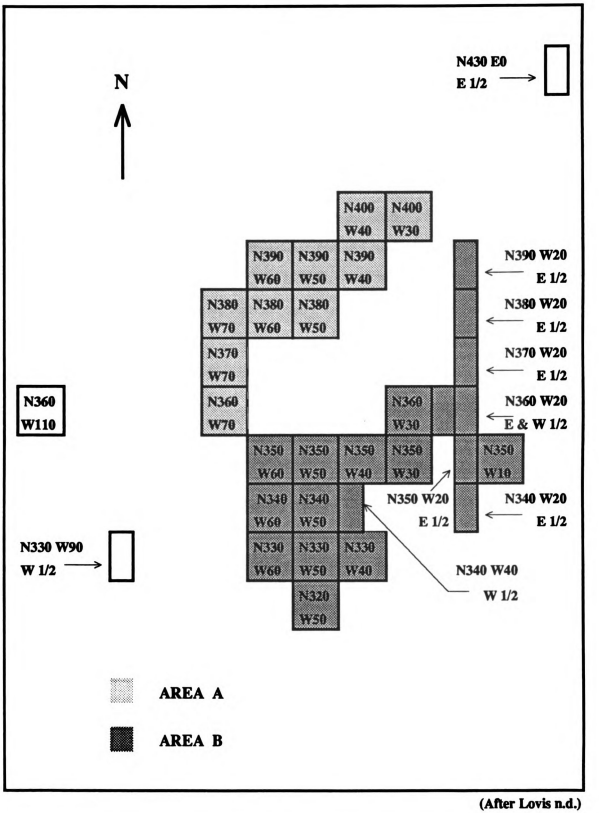

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Figure 3 - O'Neil Site Showing Areas A and B

trade goods dating to the late Seventeenth and early Eighteenth Centuries were recovered form this zone. In the eastern parts of Area A an additional level could be discerned. It was designated Occupation Zone Ib, and consisted of a light grey sand zone extending to 1.0 feet below the humus zone, with a sand lens separating the two zones. Immediately below the first occupation zone was a layer of sand devoid of cultural material, followed by a lens of black organic material. This black lens contained cultural material and was designated Occupation Zone II. Beneath this zone was a thick layer of water-lain sands containing black laminae. Carbon-14 analysis of carbonized organic materials incorporated into these sands provided a date of 905 ± 115 B.P., corrected to A.D. 1073-1155 (N-1268). This date is not compatible with the dates obtained for the underlying occupation zone, and is thought to be caused by foreign materials introduced into the site during the deposition of the lacustrine sands (Lovis 1973: 24-34, 1991: 196-7).

The basal occupation level in Area A, which ranges in thickness from 0.05 to 0.3 feet, represents an intensive use of the site by Late Woodland period peoples. This level, designated as Occupation Zone III, consists of a series of thin, grey-black sand layers whose individual lenses were not possible to isolate. Two ^{14}C dates, both of which were compatible with associated cultural materials, were obtained from charred wood remains collected from a hearth. These organic materials yielded dates of 740 ± 100 B.P., corrected to A.D. 1277 (M-2406) and 670 ± 100 B.P., corrected to A.D. 1283 (M-2405) (Lovis 1973: 34, 1991: 196).

The stratigraphy of Area B is less complex, and is roughly the same as the upper portions of Area A. This area was overlain by tan, wind-blown sands, under which lay a dark grey loamy zone. Beneath the loam was an occupation zone consisting of black sands. This zone yielded a ^{14}C date of 430 ± 100 B.P., corrected to A.D. 1441 (M-2398), for carbon associated with a hearth designated as Feature 8. Based on the refitting of sherds from this level and Occupation Zone II of Area A, it is thought that the occupation

zone of Area B may correspond to the intermediate occupation zone of Area A (Lovis 1971: 35-39, 1991: 197).

Underlying the occupation zone of Area B were basal yelow-tan sands. Material for a ^{14}C analysis was obtained from Feature 3, a hearth which was intrusive into this level. The date obtained for this material was 1000 ± 140 B.P.(M2401), corrected to A.D. 1004-1019, which was compatible with the materials found nearby in the occupation zone of Area B (Lovis 1973: 35-39, 1991: 197). In addition to the excavations of Areas A and B, a series of test pits were also dug to the northeast and southwest of the major occupation area (Lovis 1973) (see Figure 2).

The depositional and occupational history of the site is one of dune formation through wind-blown and water-lain sand, interspersed by depositions of cultural materials. It is thought (Lovis 1973, 1991) that by A.D. 1000, parts of Area B were stable, and that after this time occupations took place in Area B and parts of Area A. Some time prior to A.D. 1200 further stabilization of Area A occurred, leading to the occupation of this area as well as of Area B. This was followed by the inundation of Area A and the deposition of water-borne sands; during this phase no occupations took place in Area A. Subsequently there was a limited occupation of Area A, after which the area was covered by wind-blown sands. By the fifteenth century, Areas A and B had become somewhat stabilized, and were re-occupied. Further wind activity precluded the complete stabilization and formation of discrete layers of occupation. The later occupations of the site in the ensuing years, along with the deposition of sand and organic material, covered the site with a modern sand loam. The final stabilization of Area A occurred in the late seventeenth and early eighteenth centuries, when groups of historic Native Americans visited the site (Lovis 1973: 39-40, 1991: 197-9). Throughout its occupational history, the site was inhabited on a seasonal basis (probably during the warm season) for varying lengths of time. No evidence of permanent, year-round habitations were recovered at the site (Lovis 1973, 1991).

The ceramic assemblage from the site consists of pottery from the early and late Late Woodland period. The early Late Woodland is characterized by Mackinac Ware vessels and by Skegemog Ware vessels; the late Late Woodland is represented by Juntunen Ware pottery as well as by Traverse Ware vessels (Lovis 1971). The Mackinac and Juntunen Wares represent wares whose styles reflect the Northern pottery tradition of upper Michigan. The type site for these wares is the Juntunen Site, located on Bois Blanc Island in the Straits of Mackinac (McPherron 1967). The Southern pottery tradition is illustrated at the O'Neil site by the Skegemog and Traverse Wares, both of which were named for pottery found at the Skegemog Point Site in Grand Traverse County, Michigan (Hambacher 1992).

A recent re-analysis of the O'Neil Site artifacts from a spatial point of view (Lovis 1991) indicates that the site was occupied in two different ways. The occupations of the site by groups manufacturing Mackinac, Juntunen and Traverse Ware pottery consisted of residential, or long-term habitations containing areas related to domestic and/or core-reduction activities. The occupations of the site by groups using Skegemog Ware vessels, on the other hand, are characterized by "logistic," or extractive camps. Although all of groups are thought to have visited the site in part to collect chert from the nearby Pi-wan-go-ning Quarry, the groups responsible for the Skegemog Ware sherds at the O'Neil Site were thought to have stayed at this site only long enough to extract the chert and to perform some basic core-reduction activities. The other occupations of the site are believed to have been longer in duration and are thought to have encompassed more activities than the Skegemog occupations. Furthermore, it is presumed that during the Mackinac, Juntunen and Traverse occupations, the site would have been utilized by more diverse groups of individuals, probably representing family groups rather than age- and gender-specific groups which most likely utilized the site during the logistic forays (Lovis 1991).

Because the two different forms of occupation correspond to different pottery types, this site is ideal for examining the relationship between residency and pottery

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manufacturing behavior. In addition, the presence of four ceramic types representing two pottery traditions as well as two time periods permits the paste composition results to be examined from several points of reference. Also, the presence of raw clays at the site provides the necessary baseline against which to compare the pottery samples. Finally, the relatively small number of identifiable vessels found at the site permits the intensive sampling of the pottery vessels from this site. In short, the O'Neil Site provides an ideal set of samples for examining, within one site, the relationship between clay procurement and utilization.

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EXPERIMENTAL APPROACH AND HYPOTHESES

Experimental Approach

The analytical method chosen for exploring the relationship between population residence and the use of resources was Instrumental Neutron Activation Analysis (INAA). This method is capable of detecting and quantifying as many as 50 different elements in the sample matrix. It also combines ease of analysis with analytical accuracy and the ability to detect a large number of elements nearly simultaneously. Using this method, a majority of the identified vessels from the O'Neil Site were analyzed, and the data were subjected to cluster analysis in order to determine the statistical groupings based on the elemental compositions of the samples.

Hypotheses and Assumptions

Previous work at the O'Neil Site (Lovis 1991) suggested that the site was utilized in two different ways: as a seasonally-occupied residential site (represented by the Mackinac, Traverse and Juntunen pottery), and as a "logistic" occupation of considerable shorter duration (represented by the Skegemog pottery). This suggests that the people who utilized the site for seasonal habitation used most or all of the resources available to them at or near the site, including local clays. During shorter "logistic" occupations, however, it is expected that a more selective use of resources would have occurred, and that any clay vessels used at the site would have been manufactured elsewhere and brought to the site as needed. Further, this pattern is expected to have remained the same for potters of different pottery traditions throughout the Late Woodland period. These suppositions can be re-stated as follows:

> Groups occupying the site for long periods of time (residential occupants) would have manufactured their pottery locally from locally-obtained clays

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> and temper, while short-term occupants (logistic occupants) would not have made their pottery locally, but would have brought them to the O'Neil Site from other locations.
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> Residential occupants of the site at any point in the Late Woodland period would have made their pottery locally, while logistic occupants during any sub-phase of the Late Woodland would have made their pottery elsewhere.
>
> This differential pattern of pottery-making based on the use of the site is discernible in the chemical composition of ceramic pastes.

In addition, several assumptions about the nature of the materials to be analyzed, as well as presumptions about the behavior of the prehistoric potters are necessary. The first is that local and non-local clays are compositionally different from each other, permitting differentiation between local and non-local pottery. Although this assumption seems obvious, in fact it has not been tested for small areas (less than 100 mile radius) in the Upper Great Lakes area. For this reason, clays collected during archaeological excavations of the O'Neil Site and the nearby Skegemog Point Site, a Late Woodland occupation situated along Lake Skegemog about 40 miles to the southwest of the O'Neil Site (Hambacher 1992), were analyzed by INAA in order to determine the relative differences in the composition of clay from a nearby site.

The second assumption is that the clays collected during the archaeological excavations are representative of the clays used to manufacture prehistoric pottery vessels. This assumes that: 1) the clay sources remained the same throughout the Late Woodland period, and were not exhausted during this time, and 2) the clay deposits within the procurement area of a particular site were used in the same manner and to the same extent throughout the Late Woodland period. It further assumes that the clays collected at the O'Neil Site and the Skegemog Point Site are native to these respective areas, and were not simply brought to the site and discarded there. In spite of these assumptions, it is believed that the use of archaeological clays from the sites more truly represents the actual composition of the clays used in the manufacture of Late Woodland pottery, since these

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clays would have been obtained and prepared by the individuals involved in the pottery manufacture.

Ancillary assumptions regarding the nature of the pottery paste include assumptions about the manufacturing processes and the final composition of the ceramics. Although water is commonly added to the plastic material, this is assumed not to significantly alter the composition of the clay. Similarly, the addition of temper was assumed not to add elements to the paste in significant amounts, and was thought to only minimally "dilute" the clay. These assumptions stemmed from the belief that the grit temper in the paste (Lovis 1973) was sufficiently large so as to permit sampling which avoided the temper. As will be shown later, this assumption was not correct; temper was very well dispersed throughout the paste, and in most cases was so finely divided as to make avoiding it in the sampling procedure impossible. Finally, it was also assumed that the logistic and residential occupations identified by Lovis (1991) were correct, and that the pottery sherds used to identify the archaeological culture of the occupations could be re-identified by another analyst with similar outcomes.

Given the foregoing, the following hypotheses were established for this study:

1: There are no significant differences between the chemical compositions of the pottery from each of the residential occupations (i.e. the Mackinac, Traverse and Juntunen pottery).

2: There are no significant differences between the chemical compositions of the local (O'Neil Site) clay and the pottery from the residential occupations (i.e. the Mackinac, Traverse and Juntunen pottery).

3: There is a significant difference between the chemical compositions of the non-local (Skegemog Point Site) clay and the pottery from the residential occupations (i.e. the Mackinac, Traverse and Juntunen pottery).

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4: There is a significant difference between the chemical compositions of the pottery from the logistic occupations (i.e. the Skegemog Ware pottery) and the pottery from the residential occupations (i.e. the Mackinac, Traverse and Juntunen pottery)

The validity of these hypotheses were examined using a total of 52 samples of pottery and clay from the O'Neil Site, and 7 samples of clay and temper from the nearby Skegemog Site.

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Collection

The ceramic assemblage form the O'Neil Site has been previously described in detail (Lovis 1973). During the excavation of the site by Michigan State University researchers 9194 Late Woodland and proto-historic pottery sherds were recovered, of which 777 had decoration or surface treatment enabling categorization (Lovis 1973: 41, 50). Each of these 777 sherds were identified with an MSU Museum catalogue number [1], and were subsequently sorted into groups representing a minimum of approximately 80 vessels (Lovis 1973: 50). The distribution of identifiable vessels reported by Lovis (1973) is given in Table 1. Although a minimum of 79 vessels have been reported for the O'Neil site (Lovis 1973), it is believed that subsequent work on this collection expanded this number to at least 92 vessels, since the Minimum Vessel Sheets [2] for the O'Neil Site includes vessels with numbers ranging from 1 to 92 (Lovis n.d.). This same document, however, lacks information for vessel numbers 22, 27, 3, 45, 46, and 89.

The ceramic vessels represented at the O'Neil site consist primarily of pottery from the Late Woodland period, with some additional pottery from a proto-historic occupation (see Table 1). Within the Late Woodland period, vessels were attributed to the early and the late phases of the Late Woodland period, as well as to both the Northern and Southern pottery making traditions in Michigan (Lovis 1973). The Mackinac Ware vessels, representing the Northern pottery tradition of the early Late Woodland period at the O'Neil Site, are believed to date to around A.D. 800 - 1,000 (Lovis 1973: 59). The Skegemog Ware vessels from this site are thought to be roughly contemporaneous with the Mackinac Ware, and represent the Southern tradition of pottery in the early Late Woodland (Lovis 1973: 63).

The Juntunen Ware pottery at the O'Neil Site is a Northern pottery type. Its incidence at the site is dated to A.D. 1,200 - 1,300 as well as to the fifteenth century A.D.

Table 1 - Vessels From the O'Neil Site (20 CX18)

Ware Type	*Min. # Vessels*	*Pottery Tradition*	*Period*	*O'Neil Site Dates*	*References*
MACKINAC		Northern	early Late Woodland	A.D. 800-1200	(Lovis 1973: 59)

Table 1 - Vessels From the O'Neil Site (20 CX18)

Ware Type	Min. # Vessels	Pottery Tradition	Period	O'Neil Site Dates	References
MACKINAC		Northern	early Late Woodland	A.D. 800-1200	(Lovis 1973: 59)
Mackinac Undecorated	3				
Mackinac Undecorated	4				
SKEGEMOG		Southern	early Late Woodland	Probably same as Mackinac Ware	(Lovis 1973: 63)
Skegemog Straight Rim	3				
Skegemog Colared	2				
JUNTUNEN		Northern	late Late Woodland	A.D. 1200-1300 & 15th C. A.D.	(Lovis 1991: 207)
Juntunen Linear Punctate	7				
Juntunen Drag & Jab	4				
TRAVERSE		Southern	late Late Woodland	A.D. 1200-1500	(Lovis 1973: 85)
Traverse Punctate	9				
Traverse Undecorated	6				
Traverse Scalloped	1				
Traverse Pinched	1				
Traverse Aberrant	1				
O'NEIL				late 17th C. / early 18th C.	(Lovis 1973: 86-7)
O'Neil Curvilinear	2				
UNCLASSIFIED					
Type 1 (Incised, Chevron motif)					
Type 2 ("miniature")	1				
Type 3	2				
Type 4	1				
Type 5	2				
OTHER (sherds too small)	29				

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(Lovis 1991: 207). The Traverse Ware pottery, in turn, represents a Southern pottery type and spans the Period from A.D. 1,200 - 1,500 (Lovis 1973: 85).

The above four pottery types representing two cultural traditions as well as two archaeological time periods were used for the paste composition analysis in an attempt to compare the behavior involved in pottery making, use, and discard of these four groups. In order to simplify the data analysis, only the pottery type (Skegemog, Mackinac, Traverse or Juntunen) was recorded for each vessel number, the variety being considered a sub-group of the general pottery type. As will be shown in subsequent chapters, even this general pottery classification proved to be too fine a distinction for the classification based on composition alone.

After completing an initial inventory of all of the O'Neil pottery available at the time of the project, a list of the vessel number and cultural designation was compiled. The original cultural designations for 33 of the 92 vessels was determined using the original Minimum Vessel Sheets (Lovis n.d.) along with photographs of sherds with type/variety designations (Lovis 1973). Because complete cultural designations for each of the original vessels was not available, the vessels were re-typed by Michael Hambacher, whose designations of the known vessels (Michael Hambacher, personal communication 1991) closely matched those proposed by Lovis (1973) in the original analysis. However, four early Late Woodland vessel (Vessel 17, corresponding to Sample 13; Vessel 28, corresponding to Sample 5; Vessel 32, corresponding to Sample 6; and Vessel 53, corresponding to Sample 14) were identified differently by Hambacher and Lovis. These dual designations are maintained throughout this study. A listing of the pottery type designations given by both Lovis and Hambacher can be found in Table 2.

Pottery types were established by Hambacher for 54 of the 92 O'Neil vessels. Another 6 vessels could only be given tentative type designations, 6 could only be identified (or tentatively identified) within the early or late Late Woodland period, and 15 could not be identified at all (Michael Hambacher, personal communication 1991).

Table 2 - Vessels and Sherd Information

Vessel Number	*Sample Number*	*Ware Type (Lovis n.d., 1973)*	*Ware Type (Hambacher, pers. comm. 1991)*	*Notes*
1	*none*		Traverse	Vessel not sampled

Table 2 - Vessels and Sherd Information

Vessel Number	Sample Number	Ware Type (Lovis n.d., 1973)	Ware Type (Hambacher, pers. comm. 1991)	Notes
1	none		Traverse	Vessel not sampled
2	31		Traverse	
3	26		Traverse	
4	1	Skegemog	Skegemog	
5	57		Juntunen	
6	2	Skegemog	Skegemog	
7	none		possibly Skegemog	Vessel not sampled
8	3	Skegemog	Skegemog	
9	none		Traverse	Vessel not sampled
10	48	Juntunen	Juntunen	
11	29	Traverse	Traverse	
12	none		early Late Woodland	Vessel not sampled
13	none			Vessel not available
14	none		possibly Juntunen	Vessel not sampled
15	4		Skegemog	
16	11		Mackinac	
17	13	Mackinac	Skegemog	
18	none		Traverse	Vessel not sampled
19	none	Mackinac	Mackinac	Vessel not sampled (sherd too small)
20	none		late Late Woodland	Vessel not sampled
21	12	Mackinac	Mackinac	
22	none			No information available
23	none		possibly late Late Woodland	Vessel not sampled
24	none	O'Neil Curvilinear	O'Neil Curvilinear	Vessel not sampled

Table 2 (cont'd)

Vessel	*Sample*	*Ware Type*	*Ware Type* (H. Hatcher, pers. comm. 1991)	Notes

Table 2 (cont'd)

Vessel Number	Sample Number	Ware Type (Lovis n.d., 1973)	Ware Type (Hambacher, pers. comm. 1991)	Notes
25	51	Juntunen	Juntunen	
26	16	Mackinac	Mackinac	
27	none			No information available
28	5	Mackinac	Skegemog	
29	none	O'Neil Curvilinear	O'Neil Curvilinear	Vessel not sampled
30	49	Juntunen	Juntunen	Sample not used (too little material)
31	55	Juntunen	Juntunen	
32	6	Skegemog	Problematic	
33	none			No information available
34	none		unknown	Vessel not sampled
35	52	Juntunen	Juntunen	
36	18	Traverse	Traverse	
37	56	Juntunen	Juntunen	
38	none		possibly late Late Woodland	Vessel not sampled
39	none		Traverse	Vessel not sampled
40	none		unknown	Vessel not sampled
41	none	Traverse	Traverse	Vessel not sampled
42	none	Traverse	Traverse	Vessel not sampled
43	none		unknown	Vessel not sampled
44	17		Traverse	
45	none			No information available
46	none			No information available
47	none		unknown	Vessel not sampled
48	none		unknown	Vessel not sampled

Table 2 (cont'd)

Vessel Number	Sample Number	Ware Type (Lovis n.d., 1973)	Ware Type (Hambacher, pers. comm. 1991)	Notes
				Vessel not available

Table 2 (cont'd)

Vessel Number	Sample Number	Ware Type (Lovis n.d., 1973)	Ware Type (Hambacher, pers. comm. 1991)	Notes
49	none			Vessel not available
50	19 - 20		Traverse	Samples not used (contaminated)
51	7		Skegemog	
52	32		Traverse	
53	14	Mackinac	Skegemog	
54	21		Traverse	
55	none		unknown	Vessel not sampled
56	none		possibly Skegemog	Vessel not sampled
57	8 - 10	Skegemog	Skegemog	
58	none			Vessel not available
59	none	Traverse	Traverse	Vessel not sampled
60	none	Incised, Chevron	Incised, Chevron	Vessel not sampled
61	none		Traverse	Vessel not sampled
62	27		Traverse	
63	none		unknown	Vessel not sampled
64	none	Traverse	Traverse	Vessel not sampled
65	none		unknown	Vessel not sampled
66	none		unknown	Vessel not sampled
67	none		possibly Traverse	Vessel not sampled
68	none		possibly Skegemog	Vessel not sampled
69	15	Mackinac	Mackinac	
70	none		unknown	Vessel not sampled
71	none		Traverse	Vessel not sampled
72	none	Traverse	Traverse	Vessel not sampled

Table 2 (cont'd)

Vessel Number	Sample Number	Ware Type (Lovis n.d., 1973)	Ware Type (Hambacher, pers. comm. 1991)	Notes
73	none		possibly Skegemog	Vessel not sampled
74	none		unknown	

Table 2 (cont'd)

Vessel Number	Sample Number	Ware Type (Lovis n.d., 1973)	Ware Type (Hambacher, pers. comm. 1991)	Notes
73	none		possibly Skegemog	Vessel not sampled
74	none		unknown	Vessel not sampled
75	none		unknown	Vessel not sampled
76	none			Vessel not available
77	22	Traverse	Traverse	
78	none			Vessel not available
79	28		Traverse	
80	none		possibly late Late Woodland	Vessel not sampled
81	58		Juntunen	
82	none		possibly late Late Woodland	Vessel not sampled
83	none		unknown	Vessel not sampled
84	59	Juntunen	Juntunen	
85	23 - 25		Traverse	
86	none		unknown	Vessel not sampled
87	50		Juntunen	
88	none		Juntunen	Vessel not sampled
89	none			No information available
90	53 - 54	Juntunen	Juntunen	
91	none	"unclassified" (type 2)	unclassified	Vessel not sampled
92	none	Juntunen	Juntunen	Vessel not sampled

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Undoubtedly many of these 27 difficult-to-identify vessels correspond to Lovis's (1973) "other" category which contained 29 vessels represented by sherds too small to classify, and to the "unclassified" category, which contained 7 vessels of 5 "types" (see Table 1). Finally, 5 vessels were not available for sampling due to either being on display, or having been otherwise removed from the collection. For an additional 6 vessels both the pottery sherds and the Minimum Vessel Sheets corresponding to these vessels could not be located, suggesting that these may have been "vessels" which were assigned vessel numbers, but which were later found to be subsumed by other pots in the "minimum vessel" count.

Because the collection represented a small number of vessels, an attempt was made to sample as many of the identified containers as possible. Of the 54 vessels with known pottery types, 37 were sampled at least once (see Tables 2 and 3). The criteria used to determine whether a vessel would be sampled was four-fold. First, vessels from Area A were preferred over those from Area B, since the former was the stratified area of the site, and the latter was not. Likewise vessels from area A or B were preferred over those from the test pit area, since little habitation information was available from these test pits. Second, where practical, a preference was given to vessel whose sherds had complete unit and level information recorded on the Minimum Vessel Sheets or on the Museum catalogue cards (Michigan State University Museum n.d.). Third, a representative number of samples from each of the four pottery types was required. For this reason, samples were taken from all of the Skegemog and all but one of the Mackinac vessels. (The Mackinac vessel designated as vessel 19 was not sampled simply because the single sherd representing this vessel was too small, and sampling would have destroyed the specimen.) Finally, as far as practicable, the number of vessels sampled from each of the four pottery types was kept relatively equal. Thus not all of the Traverse vessels were sampled, since the available vessels of other types was much lower than that available for the Traverse vessels.

The total number of vessels sampled is as follows:

Skegemog	6
Skegemog / "Problematic"	1
Mackinac / Skegemog	3
Mackinac	4
Traverse	12
Juntunen	11

For most of these vessels, samples were removed from only one sherd. However, in the case of Vessel 57 (Samples 8-10), Vessel 50 (Samples 19-20), Vessel 85 (Samples 23-25), Vessel 90 (Samples 53-54) and Vessel 11(Samples 29-30), samples were taken from multiple sherds both to test for the reproducibility of the INAA results across a given vessel (e.g. Vessels 57, 50, 85, and 90) and to check for the effect of diagenesis in the case of vessels whose sherds were found in multiple locations (e.g. Vessels 50, 85, and 90). In addition, because the temper pieces were so large in one vessel (Vessel 11) it was possible to isolate some of the temper fragments and collect them as a separate sample (Sample 30) which could then be compared to the corresponding paste sample from the same vessel (Sample 29). Likewise, when vessel 52 was sampled, it was noted that most of the resulting sample consisted of untempered clay. This "pure" clay was collected as Sample 32.

In addition, three clay nodules collected from the O'Neil Site during the 1969-71 excavations were also sampled in duplicate or triplicate (Samples 33-35, 37-40). These dried nodules proved to be very sandy and broke apart easily when slight pressure was applied. "Sand" collected from just beneath one of the nodules during the original O'Neil Site excavations was also sampled for this analysis (Sample 36). Four prepared clay nodules collected from the Skegemog Point Site during the this site's original excavations in the 1960's (Michigan State University Museum n.d.) were also sampled in singletons or

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duplicates (Samples 41-43, 45-47, 60). Finally, one piece of presumed temper from the Skegemog Point Site was also sampled (Sample 44).

A total of 60 pottery, temper, clay and sand samples were collected. Two of these samples (Sample 8 and Sample 53) were run in duplicate (hereafter designated as S8N1/2 and S53N1/2, respectively) to test the homogeneity of ground samples and the reproducibility of the INAA results. Three other samples were not analyzed by INAA. Samples 19 and 20 (Traverse Ware) were not run due to suspected contamination of the sample by the adhesive and India ink used in the curation of the sampled sherds. Sample 49 (Juntunen ware) was not run due to insufficient material having been collected. (A total of 100 - 200 milligrams (mg) of sample was required for the INAA analysis. Sample 49 provided only 46 mg of material.)

In addition to the pottery, clay and temper, each lot of dental bits used to remove the pottery and clay samples from the artifacts were also analyzed by INAA in order to check for possible contamination of the samples with filings from the bits. Two bits from each lot were sampled by breaking off the tips of the bits and running these in a separate INAA batch (see Chapter 5, Method). A complete listing of sample number, vessel number, pottery type, sherd provenience, INAA batch, and bit lot number can be found in Table 3.

Sampling Procedure

The artifacts used in this analysis were sampled by grinding off material from the inner surfaces of the sherds with Tungsten-Vanadium hardened steel dental bits (Pfingst & Company, Inc., South Plainfield, NJ). The dental bits, which were cleaned with distilled water and powder-free tissues, were used in conjunction with a Dremel Tool for the sample collection. The sherds were prepared for sampling by first removing 1-2 millimeters (mm) of surface material in a 1-2 square centimeter area and discarding this material. The

Table 3 - Sherd Provenience and Sampling Information

Specific Provenience †	Bit	Area	Notes †††

Table 3 - Sherd Provenience and Sampling Information

Spl #	V #	MSU Cat. #	Ware Type	Artifact Provenience †			Bit Lot #	Area Sampled	Notes †††
				Area	Unit	Level ††			
1	4	3468.8.3	Skegemog	A	N360 W70	level 3	442988 *	body (glued to rim)	
2	6	3468.43.3	Skegemog	Test pits	N530 E240	level 3	442988	rim	ware relatively hard
3	8	3468.20.6	Skegemog	B	N350 W30 Pott Conc A	level 3 below sod	442988 *	rim	
4	15	3468.39.2	Skegemog	Test pits	N490 E190	level 2	442988	rim	
5	28	3468.22.2	Mackinac/ Skeg **	B	N360 W30	level 2	442988 *	rim	
6	32	3468.20.9	Skegemog/ Prob ***	B	N350 W30	level 4	442988	rim	
7	51	3468.21.4	Skegemog	A	N370 W70	Occup. Zone II	442988 *	rim	very coarse grit in sample
8N1/2	57	3468.22.3	Skegemog	A	N360 W30	level 3	442988	rim	
9	57	3468.22.3	Skegemog	A	N360 W30	level 3	442988	rim	
10	57	3468.20.12	Skegemog	B	N350 W30	(unknown)	442988	rim	
11	16	3468.39.2	Mackinac	Test pits	N490 E190	level 2	442988 *	rim	ware very hard with much mica-like grit
12	21	3468.55	Mackinac	B	N320 W50	level 3 fea 35 (hearth)	442988	rim	ware very hard

Table 3 (cont'd)

Spl #	V #	MSU Cat. #	Ware Type	Artifact Provenience †			Bit Lot #	Area Sampled	Notes †††
				Area	Unit	Level ††			
13	17	3468.58.3	Mesa[illegible]	D	N360/W40	level 3	555828 *	rim	ware very hard with

Table 3 (cont'd)

Spl #	V #	MSU Cat. #	Ware Type	Artifact Provenience †			Bit Lot #	Area Sampled	Notes †††
				Area	Unit	Level ††			
13	17	3468.58.3	Mackinac/ Skeg **	B	N350 W40	level 3 to 0.9"	555828 *	rim	ware very hard with small-grained grit
14	53	3468.15.6	Mackinac/ Skeg **	A	N390 W60	top Occ. Zone II	555828	rim	ware somewhat hard
15	69	3468.27.5	Mackinac	B	N350 W20 E 1/2	level 3	555828 *	rim	ware very hard with small-grained grit
16	26	3468.5	Mackinac	Test pits	N480 E190	level 2, fea 30 pottery cache (1 pot)	555828	body	ware somewhat hard
17	44	3468.21.5	Traverse	A	N370 W70	lower Occ. Zone II	555828 *	rim	ware extremely gritty (sample up to 50% grit)
18	36	3468.21.6	Traverse	A	N370 W70	lower Occ. Zone II pottery conc.	625828 *	body	ware extremely gritty (sample up to 50% grit)
19	50	3468.10.4	Traverse	A	N380 W60	Occup. Zone II	625828 *	rim	not used (sample contaminated w/ India ink from catalogue number)
20	50	3468.18.6	Traverse	A	N380 W70	Occ. Zone II hearth SE corner	625828 *	body	not used (sample contaminated w/ India ink from catalogue number)
21	54	3468.21.4	Traverse	A	N370 W70	Occup. Zone II	625828 *	rim	ware somewhat gritty
22	77	3468.21.5	Traverse	A	N370 W70	lower Occ. Zone II	625828 *	rim	soft paste with large pieces of temper

Table 3 (cont'd)

Spl #	V #	MSU Cat. #	Ware Type	Artifact Provenience †			Bit Lot #	Area Sampled	Notes †††
				Area	Unit	Level ††			
23	83						625828 *	rim	soft paste with large pieces

Table 3 (cont'd)

Spl #	V #	MSU Cat. #	Ware Type	Artifact Provenience †			Bit Lot #	Area Sampled	Notes †††
				Area	Unit	Level ††			
23	85	3468.15.6	Traverse	A	N390 W60	top Occ. Zone II	625828 *	rim	soft paste with large pieces of temper
24	85	3468.15.6	Traverse	A	N390 W60	top Occ. Zone II	625828 *	rim	soft paste with large pieces of temper
25	85	3468.14.2	Traverse	B	N330 W60	Occ zone under old sod	625828 *	body	soft paste with large pieces of temper
26	3	3468.16.1	Traverse	B	N340 W50	old sod zone	625828 *	rim	relatively soft paste with medium- to large-sized temper
27	62	3468.16.1	Traverse	B	N340 W50	old sod zone	625828 *	rim	relatively soft paste with medium- to large-sized temper
28	79	3468.59.2	Traverse	B	N320 W50	level 2	625828 *	rim	reddish, brittle ware with medium-sized temper
29	11	3468.48	Traverse	B	N360 W20 E 1/2	strata 2 feature 27	625828 *	rim	large-grained grit in the ware
30	11 (temper)	3468.48	Traverse	B	N360 W20 E 1/2	strata 2 feature 27	625828 *	rim	temper (large-grained grit) taken from matrix of Sample 29
31	2	3468.30.2	Traverse	B	N360 W20 E 1/2	strata 2	625828 *	rim	relatively soft paste with large-grained temper
32	52 (clay)	3468.20.9	Traverse	B	N350 W30	level 4	625828 *	rim	relatively soft paste with almost no temper where sample taken; sample consists primarily of clay
33	Clay	3468.41.6	O'Neil Site	Test pits	N510 E90	2 ft. b.s.	625828 *	lump 1	"Prepared clay sample" from O'Neil Site; sandy consistency

Table 3 (cont'd)

Spl #	V #	MSU Cat. #	Ware Type	Artifact Provenience †			Bit Lot #	Area Sampled	Notes †††
				Area	Unit	Level ††			
34	Clay	3468.41.6	O'Neil	Test	N510 E90				

Table 3 (cont'd)

Spl #	V #	MSU Cat. #	Ware Type	Artifact Provenience †			Bit Lot #	Area Sampled	Notes †††
				Area	Unit	Level ††			
34	Clay	3468.41.6	O'Neil Site	Test pits	N510 E90	2 ft. b.s.	625828 *	lump 2	"Prepared clay sample" from O'Neil Site; sandy consistency
35	Clay	3468.41.6	O'Neil Site	Test pits	N510 E90	2 ft. b.s.	625828 *	lump 3	"Prepared clay sample" from O'Neil Site; sandy consistency
36	Sand	3468.41.6	O'Neil Site	Test pits	N510 E90	2 ft. b.s.	625828 *	"sand"	"Fired sand found beneath clay" from O'Neil Site
37	Clay	3468.61.6	O'Neil Site	Test pits	N400 W40	Occ. Zone III	625828 *	lump 1	"Clay sample" from O'Neil Site; sandy consistency
38	Clay	3468.61.6	O'Neil Site	Test pits	N400 W40	Occ. Zone III	625828 *	lump 2	"Clay sample" from O'Neil Site; sandy consistency
39	Clay	3469.49	O'Neil Site	Test pits	N500 E180	level 2 fea 28	625828 *	lump 1	"Sample of clay oxidized by iron" from O'Neil Site; very sandy consistency
40	Clay	3469.49	O'Neil Site	Test pits	N500 E180	level 2 fea 28	625828 *	lump 2	"Sample of clay oxidized by iron" from O'Neil Site; very sandy consistency
41	Clay	2855.191.01	Skegemog Pt. Site	N/A	(Skegemog Pt. Site) S230 E90	level 3 0.6-0.9 ft feature 15	625828 *	lump 1	"Pottery Clay" from Skegemog Pt. Site ; very sandy consistency with some temper
42	Clay	2855.191.01	Skegemog Pt. Site	N/A	(Skegemog Pt. Site) S230 E90	level 3 0.6-0.9 ft feature 15	625828 *	lump 2	"Pottery Clay" from Skegemog Pt. Site ; very sandy consistency with some temper

Table 3 (cont'd)

Spl #	V #	MSU Cat. #	Ware Type	Artifact Provenience †			Bit	Area	Notes †††
				Area	Unit	Level ††			
43	Clay	2855.53.03	Skegemog						

Table 3 (cont'd)

Spl #	V #	MSU Cat. #	Ware Type	Artifact Provenience †			Bit Lot #	Area Sampled	Notes †††
				Area	Unit	Level ††			
43	Clay	2855.53.03	Skegemog Pt. Site	N/A	(Skegemog Pt. Site) 66W 10x10 #4	level 3 0.6-0.9" [ft ?]	625828 *	lump 1	"pieces [of] clay" from Skegemog Pt. Site
44	Tmpr	2855.53.03	Skegemog Pt. Site	N/A	(Skegemog Pt. Site) 66W 10x10 #4	level 3 0.6-0.9" [ft ?]	625828 *	"temper"	"pieces [of] tempering material" from Skegemog Pt. Site; appears unlike temper in vessels
45	Clay	2855.2.10	Skegemog Pt. Site	N/A	(Skegemog Pt. Site) SW 1/4	(unknown)	625828 *	lump 1	"Potter's Clay ??? " from Skegemog Pt. Site; no apparent temper
46	Clay	2855.38.05	Skegemog Pt. Site	N/A	(Skegemog Pt. Site) NW 1/4	level 1	625828 *	lump 1	"Potter's Clay ? " from Skegemog Pt. Site; no apparent temper
47	Clay	2855.38.05	Skegemog Pt. Site	N/A	(Skegemog Pt. Site) NW 1/4	level 1	625828 *	lump 2	"Potter's Clay ? " from Skegemog Pt. Site; no apparent temper
48	10	3468.21.6	Juntunen	A	N370 W70	lower Occ. Zone II pottery conc	625828 *	rim	ware very hard with much ground grit temper
49	30	3468.21.5	Juntunen	A	N370 W70	lower Occ. Zone II	625828 *	body	ware very hard not used (too little material)
50	87	3468.9.4	Juntunen	A	N380 W50	Occ. Zone II	625828 *	body (neck)	ware very hard (sampled from areas without much temper)

Table 3 (cont'd)

Spl #	V #	MSU Cat. #	Ware Type	Artifact Provenience †
51	25	3468.5[illegible]		

Table 3 (cont'd)

Spl #	V #	MSU Cat. #	Ware Type	Artifact Provenience †			Bit Lot #	Area Sampled	Notes †††
				Area	Unit	Level ††			
51	25	3468.53	Juntunen	A	N390 W40	Occ. Zone III Feature 33 pottery conc.	625828 *	body (neck)	ware very hard (sampled from reas without much temper)
52	35	3468.21.6	Juntunen	A	N370 W70	lower Occ. Zone II pottery conc.	625828 *	body (neck)	ware relatively hard (sampled from softer areas)
53N1/2	90	3468.20.4	Juntunen	B	N350 W30	unknown	625828 *	body	surface relatively soft with little temper
54	90	3468.10.4	Juntunen	A	N380 W60	Occ. Zone II	625828 *	body (neck)	surface relatively soft w/ little temper in first 1-2mm of surface
55	31	3468.19.6	Juntunen	B	N350 W40	hearth in 3rd level	625828 *	body (neck)	ware fairly soft with visible pieces of grit
56	37	3468.30.1	Juntunen	B	N360 W20 E 1/2	strata #1 humus	625828 *	rim	ware fairly soft with visible pieces of grit
57	5	3468.17.2	Juntunen	B	N340 W40 W 1/2	base of old sod	625828 *	body	ware fairly soft with little visible grit
58	81	3468.16.1	Juntunen	B	N340 W50	old sod zone	625828 *	body (neck)	ware soft with much grit
59	84	3468.12.1	Juntunen	B	N340 W 60	old sod level	625828 *	rim	ware very hard with softer material in first 0.5 mm of surface; much grit in rest of ware
60	Clay	2855.19.02	Skegemog Pt. Site	N/A	(Skegemog Pt. Site) So E10	level 2	625828 *	lump 1	"Potter's Clay " from Skegemog Pt. Site

Table 3 (cont'd)

Spl #	V #	MSU Cat. #	Ware Type	Artifact Provenience †			Bit Lot #	Area Sampled	Notes †††
				Area	Unit	Level ††			
B1-1	bit	lot 442988	(for spls	Not Applicable			N/A	1 of 2	tip of used bur[illegible]

Table 3 (cont'd)

Spl #	V #	MSU Cat. #	Ware Type	Artifact Provenience †			Bit Lot #	Area Sampled	Notes †††
				Area	Unit	Level ††			
B1-1	bit	lot 442988	(for spls 1-12)	Not Applicable			N/A	1 of 2	tip of used bud-shaped bit lot 442988
B1-2	bit	lot 442988	(for spls 1-12)	Not Applicable			N/A	2 of 2	tip of used bud-shaped bit lot 442988
B2-1	bit	lot 555828	(for spls 13-17)	Not Applicable			N/A	1 of 2	tip of unused cone-shaped bit lot 555828
B2-2	bit	lot 555828	(for spls 13-17)	Not Applicable			N/A	2 of 2	tip of unused cone-shaped bit lot 555828
B3-1	bit	lot 625828	(for spls 18-20)	Not Applicable			N/A	1 of 2	tip of used bud-shaped bit lot 625828
B3-2	bit	lot 625828	(for spls 18-20)	Not Applicable			N/A	2 of 2	tip of used bud-shaped bit lot 625828

† O'Neil Site (unless otherwise indicated).

†† Data from Michigan State University Museum (n.d.) and Lovis (n.d.).

††† Data in quotes (" ") from Michigan State University Museum (n.d.).

* New bit used (otherwise cleaned bit from previous sample used).

** Mackinac per Lovis (1973); Skegemog per Hambacker (personal communication 1991).

*** Skegemog pottery type per Lovis (1973); "problematic" per Hambacher (personal communication 1991).

samples for INAA were then removed from the newly-exposed area. This was done in order to avoid collecting samples from areas which might have been contaminated by exposure to the soil in the archaeological context, or by handling during the curation of the artifact.

In order to further avoid contaminating the samples during collection, powder-free polyvinyl chloride gloves were worn during the sampling procedure. The gloves were discarded after each sample was collected. Samples were collected on weighing paper and transferred to Nalgene high density polyethylene (HDPE) bottles (4 mL size with screw-top caps) which had been previously washed with dilute nitric acid, rinsed three times with distilled water, and allowed to air-dry at room temperature.

The sampling technique utilized in this study permitted the collection of samples which were relatively free of soil and other potential contaminants. It also allowed the collection of relatively thin sections of the sherd, and affected an area of only 1-2 square centimeters. However, although it permitted large pieces of temper to be avoided, complete avoidance of temper was not possible, since in most cases the temper was thoroughly mixed with the clay. An exception to this was found in Vessel 52, which, as described above, contained apparently untempered clay on the surface of the vessel. The extent of the untempered clay was not determined, but it extended to at least three mm below the inner surface of the vessel.

The presence of temper throughout the vessel matrix was apparent in two ways. First, the sherds were significantly harder and resistant to grinding than were the clay samples. Second, the ground pottery samples (except for Sample 32) contained both a powdery material (clay) and granular material of varying sizes (temper). The larger pieces of this temper were removed from the pottery samples, but grains less than 1-2 mm in diameter could not easily be removed. Therefore, except for Sample 32 the pottery samples are all considered to be mixtures of clay and small-grained temper. The effect of this admixture is discussed under Results (Chapter 6).

Two styles of dental bits were used for the sample collection. One was a "cone" shaped bit (size 023, lot number 555828), and the other a "bud" shaped bit (size 023, lot numbers 442988 and 625828). The best results were obtained from the "bud" shaped bits, and consequently this style was used for the majority of the samples. Initially each bit was used for the collection of two samples, with the bit being cleaned with distilled water and powder-free tissues between samples. However, this practice was soon abandoned, since the wear on the bits made the collection of the second samples difficult. Although the bits were made of a hardened steel, they became heavily abraded during use. Presumably the grit temper (consisting primarily of crushed granite [Lovis 1973]) had the effect of grinding off the sharp edges of the bits during the collection of the sample. Because of this contamination of the samples with the metal from the dental bits, the bits themselves were sampled for analysis. Two representative bits from each lot were cleaned, after which the tips of the bits were broken off with clean pliers. The tips were then weighed and analyzed in the same manner as the pottery and raw material samples.

During the sampling, differences in the composition and hardness of the sampled sherds were noted. These are summarized in Table 3, which also provides a listing of the dental bit lot numbers used for each sample.

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METHOD

Sample Preparation

All of the pottery and raw material samples were dried overnight in a 90° Celcius (C) oven. After drying the samples were weighed on a Mettler AE 200 balance into glass vials prepared from high purity quartz tubing (Supersil T/21, lot 22942, Herasil Amersil, Inc., Buford, GA). As much as possible, sample weights and standard weights were kept comparable (approximately 130-175 mg). In some cases, however, insufficient amounts of sample material forced the sample weights to be as low as 70-100 mg. In one case, the amount of sample material was so little (Sample 49, which consisted of a total of 46 mg) as to preclude it from being run by INAA. A listing of the weight of each of the samples and standards in each of the batches can be found in Table 4.

Prior to weighing the samples, the one-meter long tubing sections were cut into sections, and one end of each section was sealed with a flame torch. The resulting vials were then cleaned by soaking them in a solution of Pierce RBS-pf cleaning agent (Pierce Chemical Co., Rockford, IL) and rinsing them five times with distilled water. All manual operations following the soaking of the vials was performed using clean surgical gloves. The tubes were subsequently dried overnight in a 90° C oven and marked with a sample number using a glass-scribing tool. After filling the vials with the samples, the open ends of the vials were sealed using a flame torch and set aside for irradiation. All subsequent operations involving the samples were performed by Michigan Memorial Phoenix Project / Ford Nuclear Reactor personnel due to safety considerations in the handling of radioactive materials.

The pottery and raw materials samples were prepared and analyzed in three batches, each of which was run with a blank (empty) vial, and three vials containing standards whose elemental concentrations were subsequently averaged and used as the batch standard. Additionally, a vial containing a "check standard" was run. This "check

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Table 4 - INAA Batch Information

INAA Unit Number	INAA Sample Type	Sample Number	Vessel Number	Ware Type	INAA Spl Wt (mg)
Samples in INAA Batch Number 1					
1	Blank	N/A	N/A	N/A	0.0
2	NBS Standard 1633a	N/A	N/A	N/A	166.0
3	Sample	1	4	Skegemog	164.0
4	Sample	2	6	Skegemog	164.5
5	Sample	3	8	Mac / Skeg **	111.4
6	Sample	4	15	Skegemog	70.0
7	Sample	5	28	Skegemog	142.4
8	Sample	6	32	Skeg / Prob ***	150.1
9	Sample	7	51	Skegemog	113.3
10	Sample	8 N1	57	Skegemog	151.2
11	Sample	8 N2	57	Skegemog	132.9
12	Sample	9	57	Skegemog	133.5
13	Sample	10	57	Skegemog	153.0
14	Sample	11	16	Mackinac	164.6
15	NBS Standard 1633a	N/A	N/A	N/A	156.6
16	Ck Std (NBS 1633a)	N/A	N/A	N/A	157.3
17	Sample	12	21	Mackinac	158.9
18	Sample	13	17	Mac / Skeg **	96.9
19	Sample	14	53	Mac / Skeg **	151.6
20	Sample	15	69	Mackinac	93.5
21	Sample	16	26	Mackinac	163.8
22	Sample	17	44	Traverse	158.6
23	Sample	18	36	Traverse	161.8
N/A	N/A	19	50	Traverse	not run
N/A	N/A	20	50	Traverse	not run
24	Sample	21	54	Traverse	155.4
25	Sample	22	77	Traverse	157.6
26	Sample	23	85	Traverse	150.8
27	Sample	24	85	Traverse	101.1
28	Sample	25	85	Traverse	154.2
29	Sample	26	3	Traverse	160.4
30	NBS Standard 1633a	N/A	N/A	N/A	151.8

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Table 4 (cont'd)

INAA Unit Number	INAA Sample Type	Sample Number	Vessel Number	Ware Type	INAA Spl Wt (mg)
Samples in INAA Batch Number 2					
1	Blank	N/A	N/A	N/A	0.0
2	NBS Standard 1633a	N/A	N/A	N/A	156.0
3	Sample	27	62	Traverse	172.0
4	Sample	28	79	Traverse	145.0
5	Sample	29	11	Traverse	149.7
6	Sample	30	11 (temper)	Traverse	130.2
7	Sample	31	2	Traverse	153.8
8	Sample	32	52 (clay)	Traverse	151.7
9	Sample	33	Clay	O'Neil Site	163.0
10	Sample	34	Clay	O'Neil Site	167.0
11	Sample	35	Clay	O'Neil Site	154.6
12	Sample	36	Sand	O'Neil Site	173.3
13	Sample	37	Clay	O'Neil Site	162.6
14	Sample	38	Clay	O'Neil Site	163.7
15	NBS Standard 1633a	N/A	N/A	N/A	153.0
16	Ck Std (NBS 1633a)	N/A	N/A	N/A	164.0
17	Sample	39	Clay	O'Neil Site	155.5
18	Sample	40	Clay	O'Neil Site	158.1
19	Sample	41	Clay	Skegemog Site	168.0
20	Sample	42	Clay	Skegemog Site	154.4
21	Sample	43	Clay	Skegemog Site	167.1
22	Sample	44	Temper	Skegemog Site	154.5
23	Sample	45	Clay	Skegemog Site	152.3
24	Sample	46	Clay	Skegemog Site	156.1
25	Sample	47	Clay	Skegemog Site	166.1
26	Sample	48	10	Juntunen	164.5
N/A	N/A	49	30	Juntunen	not run
27	Sample	50	87	Juntunen	113.2
28	NBS Standard 1633a	N/A	N/A	N/A	166.2

INAA Unit Number	
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Table 4 (cont'd)

INAA Unit Number	INAA Sample Type	Sample Number	Vessel Number	Ware Type	INAA Spl Wt (mg)
Samples in INAA Batch Number 3					
1	Blank	N/A	N/A	N/A	0.0
2	NBS Standard 1633a	N/A	N/A	N/A	155.7
3	Sample	51	25	Juntunen	155.7
4	Sample	52	35	Juntunen	153.0
5	Sample	53 N1	90	Juntunen	152.8
6	Sample	53 N2	90	Juntunen	164.3
7	Sample	54	90	Juntunen	151.9
8	Sample	55	31	Juntunen	167.8
9	NBS Standard 1633a	N/A	N/A	N/A	162.1
10	Ck Std (NBS 1633a)	N/A	N/A	N/A	156.8
11	Sample	56	37	Juntunen	156.2
12	Sample	57	5	Juntunen	152.0
13	Sample	58	81	Juntunen	160.2
14	Sample	59	84	Juntunen	158.6
15	Sample	60	Clay	Skegemog Site	158.3
16	NBS Standard 1633a	N/A	N/A	N/A	159.8
Samples in INAA Batch Number 4					
1	Blank	N/A	N/A	N/A	0.0
2	NBS Standard 1633a	N/A	N/A	N/A	224.4
3	Sample	B1-1	bit	(for spls 1-12)	50.6
4	Sample	B1-2	bit	(for spls 1-12)	48.6
5	Sample	B2-1	bit	(for spls 13-17)	20.2
6	NBS Standard 1633a	N/A	N/A	N/A	258.2
7	Ck Std (NBS 1633a)	N/A	N/A	N/A	261.9
8	Sample	B2-2	bit	(for spls 13-17)	23.2
9	Sample	B3-1	bit	(for spls 18-60)	48.4
10	Sample	B3-2	bit	(for spls 18-60)	50.8
11	NBS Standard 1633a	N/A	N/A	N/A	252.6

* New bit used (otherwise cleaned bit from previous sample used)

** Mackinac per Lovis (1973); Skegemog per Hambacker (pers. comm. 1991)

*** Skegemog pottery type per Lovis (1973); problematic per Hambacher (personal communication 1991)

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standard" consisted of a standard run as an unknown sample to check for within- and between-batch reproducibility. The standard used for all the batch standards and check standards was the National Bureau of Standards's (NBS) Standard Reference Material 1633a, Trace Elements in Coal Fly Ash, lot 682306, which previously had been dried in an oven for one week by Phoenix Project personnel. A listing of the samples and standards contained in each batch can be found in Table 4, while Table 5 lists the known concentration of each element in the standard.

The batch of dental bit tips (Batch 4) was prepared in a manner similar to the preparation of the first three batches, with the exception that plastic sample vials were used in place of glass vials since the lower irradiation time for this batch (see below) allowed for the use of plastic vials. As with the first three batches, this batch was run with one blank vial, three standards vials, and one check standard vial. The vials for this batch were prepared by personnel from the Michigan Memorial Phoenix Project / Ford Nuclear Reactor, who also weighed the samples and standards.

During the weighing of the samples differences in the consistencies and densities [3] of the samples were noted. The clay samples from the O'Neil Site as well as two clay samples from the Skegemog Point Site (Samples 41 and 42) were very sandy. The density of this clay was similar to that of most of the pottery samples. However, the remaining clay samples from the Skegemog Point Site (Samples 43, 45, 46 and 47) were very powdery and were approximately half the density of the previous clay samples.

For the most part the Skegemog Ware samples (including Samples 1-10) were very light and finely divided, and seemed slightly less dense than the following pottery samples. The Mackinac Ware samples (except for Samples 12 and 13, but including samples 11, 14, and 15) were more granular (possibly due to more grit temper in the samples) and less powdery than the Skegemog Ware samples. Samples 12 and 13 (Mackinac Ware) appeared more like the Skegemog Ware samples (Samples 1-10) than like the other Mackinac Ware samples.

Table 5 - Concentration of Elements in NBS Standard 1633a

Table 5 - Concentration of Elements in NBS Standard 1633a

Elements Counted After 1 Week of Decay	
Element	**Concentration (ppm)**
* Barium	1420 ± 100
* Bromine	2.3 ± 0.5
Cadmium	1.00 ± 0.15
* Lanthanum	84 ± 8
* Lutetium	1.12 ± 0.18
* Molybdenum	30 ± 3
* Neodynium	74 ± 10
* Samarium	17 ± 1.5
Uranium	10.2 ± 0.1
* Ytterbium	7.4 ± 0.7

Certified Values are from Table 1 of NBS 1633A Certificate of Analysis dated 1/5/85.

Non-Certified Values (marked by an *) are consensus values as reported in NBS Publication 260-111, 11/1/87.

Elements Counted After 5 Weeks of Decay	
Element	**Concentration (ppm)**
Antimony	6.8 ± 0.4
* Cerium	175 ± 7
* Cesium	10.5 ± 0.7
Chromium	196 ± 6
* Cobalt	43 ± 3
* Europium	3.7 ± 0.2
* Gadolinium	19 ± 4
* Hafnium	7.4 ± 0.3
* Indium	0.16 ± 0.01
Iron	94,000 ± 1,000
Mercury	0.16 ± 0.01
Nickel	127 ± 4
Rubidium	131 ± 2
* Scandium	39 ± 3
Selenium	10.3 ± 0.6
Strontium	830 ± 30
* Tantalum	2.0 ± 0.2
* Terbium	2.5 ± 0.3
Thorium	24.7 ± 0.3
* Thulium	2.4 ±
* Tin	10 ± 6
Zinc	220 ± 10
* Zirconium	330 ± 80

In contrast, the Traverse Ware samples tended to be very granular and contained a great deal of grit temper. An exception to this was Sample 32 which was believed to have consisted almost entirely of clay. This sample was very powdery and was half as dense as the pottery samples; essentially it behaved like the second group of Skegemog Point Site clay samples described above. The Juntunen Ware samples were grainy and very finely divided, but exhibited some variation in the consistency of the samples. Sample 50 had the consistency of the clay samples, but had the density of the other pottery samples. Likewise Samples 56-57 had a consistency resembling that of the lighter clay samples and, like these clay samples, had densities one half to two thirds that of the other pottery samples. Finally, Sample 58 was somewhat gritty and less finely divided, resembling the Traverse Ware samples more than the other Juntunen samples.

Analytical Procedure

The concentrations of the elements in the pottery matrix and the raw materials were determined using Instrumental Neutron Activation Analysis (INAA) which permits the fast and simultaneous detection of a variety of elements ranging in amounts from the percent (%) to the part-per-million (ppm) levels.

With INAA the sample to be analyzed is placed in a radioactive flux where it is bombarded with neutrons. While situated in this flux the elements in the sample absorb one or more neutrons, transforming these elements into radioactive isotopes of the original elements . These isotopes then undergo radioactive decay, emitting energy in the form of gamma rays and other forms of radiation (Nuclear Reactor Laboratory 1988). Each radioactive isotope has a characteristic half-life and emission spectrum (Erdtman 1976, 1979; Brown, 1986) which is used to identify the element originally present in the sample. Quantitative information is obtained by a direct comparison of the intensity of the emission spectrum of the standards with those of the sample, since the quantity of a given element is

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directly proportional to the intensity of a given spectral line (Nuclear Reactor Laboratory 1988).

The pottery, clay and temper samples (Batches 1-3) were irradiated for six hours in the two mega-Watt Ford Nuclear Reactor of the Michigan Memorial Phoenix Project, University of Michigan, Ann Arbor, Michigan. The samples were irradiated in-core in a nominal flux of 1×10^{13} neutrons/cm^2/second (Nuclear Reactor Laboratory 1988) within a sample holder which spins on its axis in order to ensure equal irradiation of the samples within each batch (Edward Birdsall, personal communication 1991). Following irradiation the samples were allowed to decay for approximately one week, and the gamma radiation emitted from the samples was counted on a Lithium-drifted Germanium (GeLi) gamma ray detector equipped with an automatic sample changer. Each sample and standard was counted for 4000 seconds (live time), and the results were electronically transferred to a Nuclear Data 6700 computer system, which automatically background-corrects the data by subtracting the values obtained for the "blank" from the sample values. The samples and standards were allowed to decay for another four weeks (for a total of five weeks) and were counted in the same manner as the week-one counts. The week-one counts provide information on elements with half-lives of between one and twelve days, while the week-five counts provide information on elements with half-lives of between fifteen days and five years (Nuclear Reactor Laboratory n.d.)

Due to the high metal content of the dental bits, these samples were irradiated separately for only one hour in batch number four. This change was necessary since samples with high metal concentrations activate very easily, and when they are irradiated for long periods of time produce isotopes with activity levels beyond the safe limits of this reactor (Edward Birdsall, personal communication 1991). The subsequent decay and counting of batch 4 was identical to the parameters utilized in batch numbers 1-3.

Following irradiation and counting, data from the "peaks" (spectral emission lines as seen by the gamma counter) were collected through the computer interface. The energy

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of these peaks, which is measured in thousands of electron volts, or KeV, provides qualitative information about the identity of the element producing the emission. The intensity, or activity level of the peaks (measured in counts per second, or cpm) provides quantitative information about the amount of each element in the sample. The initial listing of peaks for the week one and week five counts was checked against tables of neutron activation (Erdtman 1976; Brown 1986) in order to select the peaks with the highest intensity and the least interference from other peaks for each element in the standard. The lines selected are listed in Table 6 by element. As a quick glance of the calculated results indicates (see Appendix A), some of the lines selected proved not to be useful in the final analysis of the data, since they were not found in all of the standards for each batch.

Subsequent to the selection of the lines to be used in the analysis, the following information was entered into the computer for each batch: mass (mg) of each sample and standard, concentration (ppm) of each element in the standard (as reported on the Certificate of Analysis for the NBS standard), the half-life of each element in the standard, and the energy emission line(s) attributed to each element in the standard. This information, together with the peak intensity data (corrected for background) were run through the Nuclear Data "Gamma Spectroscopy" and "NAA" software packages. Using the afore-mentioned data, this software calculated the concentration of each of the specified elements in every sample [4]. Subsequently, a report of the results obtained during the week-one and week-five counts was generated for each batch.

These reports contained calculated concentration values for 31 elements in each of the samples analyzed, as well as "standard deviation" values (error estimates) associated with each concentration value. A digital version (on floppy-disk) of these reports is on file at the Michigan Memorial Phoenix Project / Ford Nuclear Reactor under file number R481, and a hard copy version is on file at the Michigan State University Museum, Anthropology Division. The concentration and standard deviation data from these reports are summarized in Appendix A.

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Table 6 - Energy Lines and Half -Lives used in Calculations

Elements Counted After 1 Week of Decay				
Element	**Half-Life**	**Energy**	**Energy**	**Energy**
		Line 1 (KeV)	**Line 2 (KeV)**	**Line 3 (KeV)**
Barium	11.7 days	123.7	373.2	496.3
Bromine	35.4 hour	554.3	776.5	
Lanthanum	40.23 hour	815.8		
Lutetium	6.71 days	208.3		
Molybdenum	66.02 hour	140.5	739.7	
Neodynium	10.98 days	91.1	531	
Samarium	46.5 hour	103.2		
Uranium	2.35 days	99.5	106	277.6
Ytterbium	4.19 days	282.6		
Elements Counted After 5 Weeks of Decay				
Element	**Half-Life**	**Energy**	**Energy**	**Energy**
		Line 1 (KeV)	**Line 2 (KeV)**	**Line 3 (KeV)**
Antimony	60.2 days	1691.04		
Cerium	32.38 days	145.45		
Cesium	2.062 years	604.7	795.76	
Chromium	27.70 days	320.01		
Cobalt	5.27 years	1332.51		
Europium	12.7 years	1085.8	1112	1408.08
Gadolinium	241.6 days	103.2		
Hafnium	42.5 days	482.16		
Iron	45.1 days	1099.22	1291.6	
Mercury	46.59 days	279.17		
Nickel	70.78 days	810.75		
Rubidium	18.6 days	1076.63		
Scandium	83.85 days	889.26		
Selenium	120.4 days	136.00		
Strontium	64.73 days	513.99		
Tantalum	115.0 days	1189.00	1221.28	
Terbium	72.1 days	879.37	1178.00	
Thorium	27.4 days	311.9		
Thulium	128.6 days	84.26		
Tin	115.1 days	391.71		
Zinc	243.8 days	115.52		
Zirconium	64.4 days	756.72		

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RESULTS

Data Evaluation

As seen in Appendix A, the percent standard deviation associated with the measurement of each element varies widely by element and even varies somewhat between samples for the same element. As will be shown below, these standard deviation values helped to determine which elements would be used in the final analysis of the INAA data.

For some of the elements present in the NBS standard it was possible to use more than one energy line to calculate the concentrations of the elements in the samples and standards (see for example Ytterbium, Europium and Terbium in Appendix A). For other elements, however, multiple lines gave different concentration values (see for example Barium, Neodymium and Cesium in Appendix A). In such cases, the check standard for each batch was examined to determine which line(s) provided the calculated value of concentration corresponding most closely to the known concentration of that element in the check standard. Using this method the following multiple-line elements were eliminated from further analysis:

Barium (373.2 KeV line)

Uranium (99.5 KeV line)

Gadolinium (103.3 KeV line)

An additional review of the concentration of elements in the check standards revealed that the values for certain elements did not closely approximate the known concentrations of these elements in the standards. In addition, some of the elements could not be found in the batch standards by INAA, and therefore no accurate concentration values could be calculated for the check standards. Finally, in a few cases the concentrations of elements in the check standards could only be reported as "less than" some value since the baseline level in this area of the spectrum was too high to yield a more

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accurate measurement. For these reasons, the following 10 elements were eliminated from further data analysis:

Bromine (554.4 and 776.6 KeV lines)

Molybdenum (793.7 KeV line)

Mercury (297.2 KeV line)

Nickel (810.8 KeV line)

Selenium (136.5 KeV line)

Strontium, 514.0 KeV line)

Terbium (879.4 and 1178.0 KeV lines)

Thulium (84.3 KeV line)

Tin (391.7 KeV line)

Zirconium (756.7 KeV line).

Similarly, elements whose concentration values had percent standard deviation values in excess of 15% were not used in the analysis. This latter procedure eliminated the following additional elements from consideration :

Molybdenum (140.5 KeV line)

Neodymium (91.2 and 531.2 KeV lines)

Uranium (106.1 and 277.7 KeV lines)

Ytterbium (282.5 KeV line)

Antimony (1690.5 KeV line)

Europium (1085.6 and 1112.2 KeV lines)

Tantalum (1189.1 and 1221.5 KeV line)

In addition, the 604.4 and 795.5 KeV lines for Cesium had relatively low standard deviation values for most of the samples except for the O'Neil clay samples, which had standard deviation values on the order of 10-30%. However the Cesium concentration results for these clay samples were between one and two orders of magnitude smaller than the Cesium concentration values for the remaining samples. Therefore, even with a high

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percent standard deviation, the Cesium concentration values in the O'Neil clay samples was significantly different from that in the other samples. For this reason, this element was included in the final analysis of the INAA data. The 795.9 KeV line was chosen over the 604.7 KeV line because the concentration of Cesium in the check standards calculated with the former energy line was closer to the known value than was the concentration calculated with the latter energy line.

Finally, several elements were not used because they were thought to be possible contaminants from the drill bits used in collecting the samples. The elements which were represented in significantly greater proportions in the dental bits than in the samples were presumed to have been added to the in the pottery samples through contamination by the bits and were eliminated from further consideration. The following elements represent such potential contaminants:

Chromium (320.2 KeV line)

Cobalt (1332.5 KeV line)

Iron (1099.3 and 1291.6 KeV lines)

Since it was known that the drill bits were comprised in large part of Iron, the concentration of this element in the bits and in the samples provided a useful measure of the degree of contamination of the samples by the drill bits. As shown in Appendix A, Iron comprises 82.5% to 89.3 % (825,000 ppm and 893,000 ppm, respectively) of the matrix of the drill bits. In the pottery samples --- samples which were most contaminated by the drill bits due to the hardness of the sherds --- Iron is found in levels ranging from 2.58% to 7.10% (25,800 ppm to 71,000 ppm, respectively). Hence, taking into account the purity of the iron in the bits (as low as 82.5% pure iron) the greatest amount of contamination of the samples by the bits is 8.6% [5]. Even with this low level of potential contamination, however, two other elements were eliminated from further data analysis:

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Zinc (115.6 KeV line).

Although the exact concentrations of these elements could not be determined in the drill bits, their maximum concentration levels were as much as two to three times the concentrations of these elements in the pottery samples, thereby raising the question of potential contamination of the samples by the drill bits.

In one instance, the concentrations of elements in the drill bits relative to those in the samples were used to select one calculated concentration value over another. In this manner, the calculated concentration of Barium using the 123.7 KeV line was selected over the concentration calculated using the 496.3 KeV line, since in the latter the maximum concentration of Barium in the drill bits exceeded the concentration of barium in the pottery samples, whereas with the 123.7 KeV line the concentrations of this element in the pottery samples and in the drill bits were approximately equal.

The elimination of the foregoing elements from subsequent analysis yielded a list of eleven elements which could be used to further examine the pottery and clay samples. For each of these eleven elements --- Barium, Lanthanum, Lutetium, Samarium, Ytterbium, Cerium, Cesium, Europium, Hafnium, Scandium, and Thorium --- the concentrations in each sample, along with the associated percent standard deviation of each concentration value, are listed in Appendix 2. These eleven elements represent the elements whose calculated concentrations in the check standards closely matched the known concentrations of these standards as reported on the Certificate of Analysis for the NBS Standard. They also represent only those elements whose concentrations were reported with relatively low percent standard deviation values. Finally, the potential contamination of these elements from the bits is considered to be negligible, since the concentration of these elements in the bits was, for the most part, lower than the concentrations in the pottery samples. For these reasons, the reported concentrations of these eleven elements in the samples are believed to accurately represent the concentration of these elements in the pottery and clay samples.

One exception to this are the reported concentrations for Sample 46, a Skegemog Point Site Clay sample which was collected from the same artifact box as Sample 47. As is shown in Appendix A, many of the percent standard deviation values for the elements in this sample exceeded 15% and several exceed 25%. When only the above-listed eleven elements are considered, the percent standard deviations for this sample are higher than for any other single sample. It is presumed, therefore, that this sample represents a measuring outlier, and that the results reported are not accurate representations of the concentrations of these elements in the sample. No other such outliers were noted in the samples analyzed.

Data Analysis

Following the selection of elements, the concentration of elements in each sample was analyzed. Due to the multivariate nature of the data, the logarithms of the concentrations were calculated and used in the analysis, since the log of concentration standardizes the data and "corrects" for differences in magnitudes between elements whose concentrations range from the percent level to the part-per-million level (Sayre 1977; Bishop and Neff 1989).

A cluster diagram using centroid linkage of Euclidian distances was generated for all of the pottery, clay, and temper samples using the Systat 5.0 Statistical Package (Wilkinson 1989). As shown in Figure 4, this cluster diagram separated the O'Neil Site clays and the Skegemog Point Site clays from each other and from the majority of the pottery samples, but did not produce the expected clusters of "local" clay and pottery versus "non-local" clay and pottery.

In order to determine whether only one or a few of the eleven elements used in the analysis were responsible for producing the cluster outcome, the samples were sorted by increasing order of concentration for each of the eleven elements. The resulting compilation of ranked concentration values, listed by element in Appendix C, indicates that

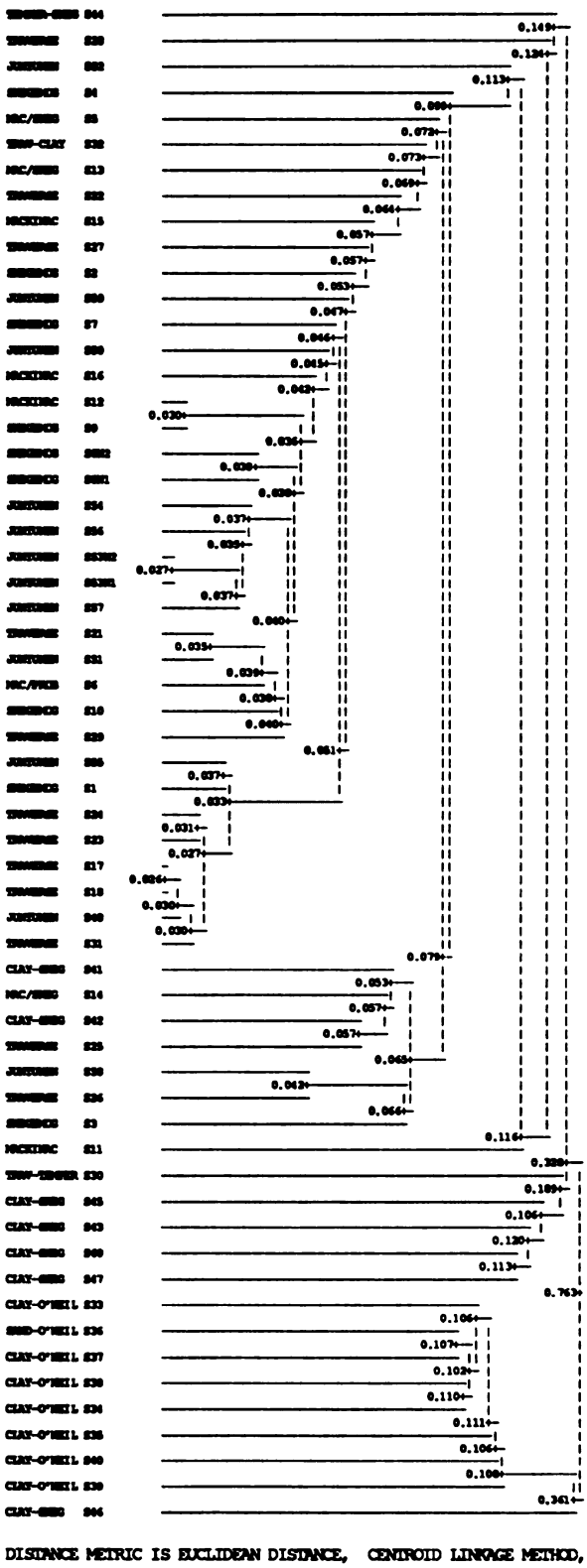

Figure 4 - Centroid Linkage Dendrogram Using 11 Elements

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each of the eleven elements alone more or less reproduces the cluster result obtained with all eleven elements. Similarly, a series of clusters diagrams produced using only ten of the eleven elements --- sequentially deleting each of the eleven elements in turn --- also produced results similar to the cluster diagram formed with all eleven elements (see Appendix D). Hence, since there was no reason to believe that any one element produced a better clay or pottery "fingerprint" than any other element, or that any one element was adding unnecessary "noise" to the cluster diagram, the original eleven-element cluster diagram was used for subsequent interpretations.

To determine the optimal number of groups into which the multivariate samples could be subdivided, a partitioning of the sample via K-means was performed (Wilkinson 1989). This method determines the best way in which to divide the collection of samples in order to maximally separate the groups (Wilkinson 1989: 25). Without specifying the number of groups into which the samples were to be divided, the K-means clustering option yielded only two groups, one containing all of the O'Neil Site clay samples and some of the Skegemog Point Site clay samples, and another group containing the remainder of the samples . By specifying the number of desired groups (i.e., by "forcing" the results into a given number of groups) the samples were subsequently divided into from three to eleven groups, respectively (see Appendix E).

A further examination the eleven-element cluster diagram revealed that based on the joining distances --- a measure of the relative distances from the center of one cluster to the center of the next nearest cluster --- the cluster diagram could be subdivided into six major groups whose components are listed below. A schematic drawing of the six groups illustrating their relative joining distances is shown in Figure 5.

Group 1: All pottery samples (Samples 1-29, 31-32, 48-59)
+ Skegemog Point Site clay samples (Samples 41 and 42)

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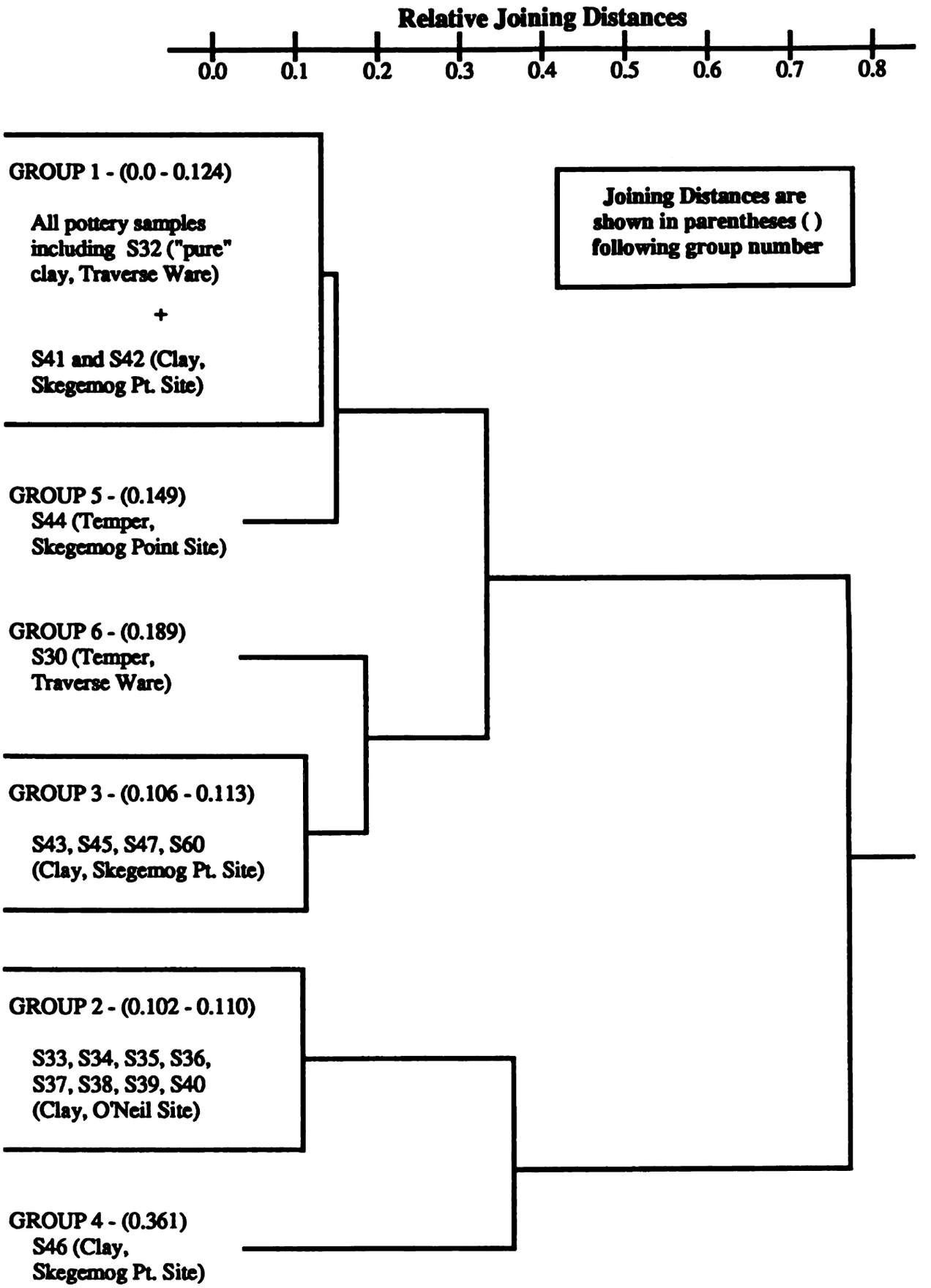

Figure 5 - Schematic Dendrogram of Groups 1-6

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Group 2: O'Neil Site Clay & Sand Samples (Samples 33-40)

Group 3: Skegemog Point Site Clay Samples (Samples 43, 45, 47, 60)

Group 4: Skegemog Point Site Clay Sample (Sample 46) - Probable Outlier

Group 5: Skegemog Point Site Temper Sample (Sample 44)

Group 6: Temper Sample from Traverse vessel (S30)

The components of these six groups also correspond exactly to the group membership in the six-group K-means cluster, suggesting that the division of the samples into six major groups provides the best possible separation, while simultaneously dividing the samples into meaningful groups.

Because Group 1 contains the majority of the samples analyzed, a schematic diagram of this group, showing joining distances within it, was produced (see Figure 6). Subsequent examination of the Group 1 cluster revealed that the pottery samples did not cluster by pottery tradition (Northern or Southern tradition), by time period (early or late Late Woodland time periods), by site provenience (Area A or B, or levels 1 through 4), or by sherd type (rim or body sherd). In fact, with the exception of one small cluster of five Juntunen samples representing three Juntunen Vessels (Samples 53N1, 53N2, and 54, all representing Vessel 90; Sample 56 representing Vessel 37; and Sample 57 representing Vessel 5), few unrelated samples of the same pottery type joined directly to another sample of the same type. This lack of pairing, however, is not due to an inability of the Neutron Activation Analysis to detect similar concentrations of elements in similar sherds. Nor is it due to an inability of the clustering program to match similar samples. Instead, the lack of

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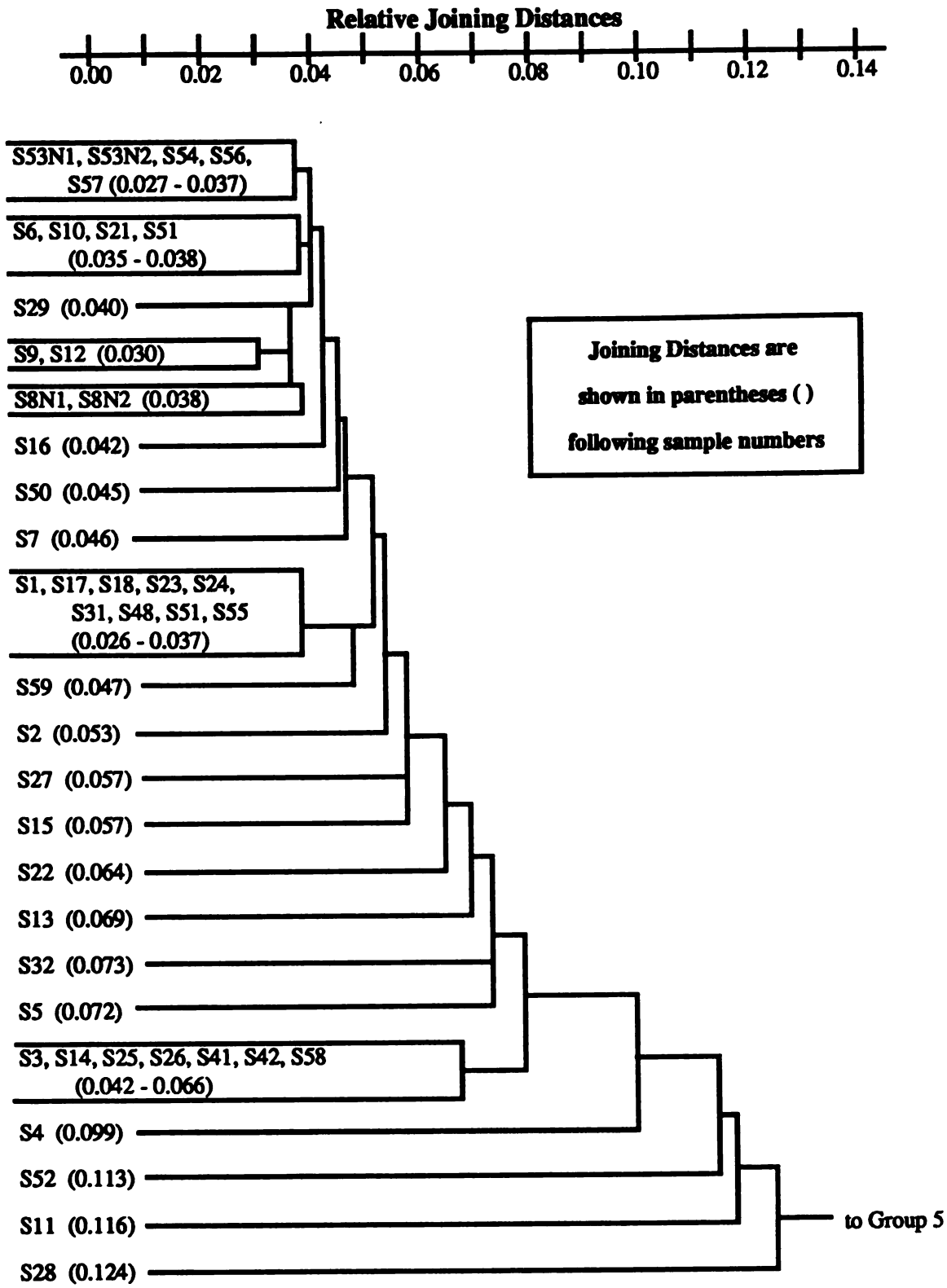

Figure 6 - Schematic Dendrogram of Group 1

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pairing of sherds of the same pottery types seems to be due to the large within-type variability in the sherd matrix, a variability which is greater than that between pottery types.

The ability of the INAA and clustering methods to pair samples of similar composition is borne out by the results of the analysis of duplicate samples. Samples 8 and 53, representing a Skegemog and a Juntunen vessel, respectively, were analyzed in duplicate by INAA, and the results of these analyses are summarized in Appendixes A and B as Samples 8N1, 8N2, 53N1, and 53N2. When these results were clustered with the other samples in the eleven-element cluster, both pairs of samples joined with its corresponding duplicate sample (see Figure 4). Furthermore, the duplicate samples in each pair join at very low joining distances, indicating that these duplicate samples are seen as being very similar in composition to one another, and that these pairs are closer in composition to each other than to any other samples.

Although the method is capable of pairing duplicate samples of pottery, it is less successful in pairing samples taken from lumps of clay collected from the same location and curated together in the same storage bags or boxes. For example, Samples 33, 34, and 35 (collected from three lumps O'Neil Site clay from the same archaeological provenience) do not join together directly, but instead are part of a larger cluster (Group 2) including Samples 36, 37, and 38. In fact, none of the clay samples from the O'Neil Site which were collected from the same archaeological context joined together directly in the eleven-element cluster.

On the other hand, Sample 36, described as "fired sand found beneath clay" (Michigan State University Museum n.d.) appears to be compositionally very similar to the O'Neil Site clay samples. This, together with the sandy texture of the O'Neil Site clay samples suggests either that these clays were naturally rich in sand, or that sand was added to the clays during the preparation of the clays by prehistoric potters. Given the available data, preference cannot be given to either of these possibilities.

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Within the Skegemog Point Site clay samples only two pairs of samples were collected from lumps of clay with the same archaeological provenience. One of these pairs contained Samples 46 and 47, but since Sample 46 appears to be an outlier, no comparison of this pair can be accomplished. However, the other pair of Skegemog clay samples --- Samples 41 and 42 --- while they do not pair together, do appear in a small cluster with low joining distances. However, this small cluster appears within Group 1, and, in addition to the clay samples, also contains samples from every pottery type sampled (see Figures 4 and 6). The remaining Skegemog Point site clay samples are clustered in Group 2.

As noted in the previous chapter, Samples 41 and 42 had a sandier consistency than the other Skegemog Point Site clay samples. Also, unlike any of the other clay samples, the densities of these samples were similar to the densities of the pottery samples. Since some "temper" was noted in the clay lumps during sampling, it suggests that temper had been added to this clay by the prehistoric potter who prepared the clay. However, it is also possible that these lumps of clay contained natural inclusions which mimic temper in composition and cause these samples to fall in the pottery group.

The joining pattern of the raw material samples indicates that the clay samples from the two sites are clearly distinguishable from each other. It also indicates that, with the exception of Samples 41 and 42 (Skegemog Point Site clay), the O'Neil Site clay samples and the Skegemog Site clay samples are more similar to themselves than to any of the pottery samples. What is not clear, however, is what is responsible for the differences between the clay samples and the pottery samples. If these differences are due only to the elements in the clays, one could then conclude that the the clays sampled are not the same clays used to manufacture the pottery from the O'Neil Site. However, because most of the pottery samples analyzed contain temper, the contribution of this material to the elemental composition of the samples must also be considered.

In order to address this question of added temper, a mathematical test of mixing was conducted according to the method described by Vogel, *et al.* (1989). Using this

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method, the mixing of two components can be evaluated by plotting the ratios of any four elements a, b, c, and d found in the samples. According to Vogel, *et al.* (1989: 17,948) a rigorous test is performed by plotting two pairs of ratios: the ratio of a/b versus the ratio c/d, which should form a hyperbola, and the ratio a/b or c/d versus the ratio of the original denominators (i.e. b/d or d/b) which should form a straight line. If the plots of these ratios do not yield the expected hyperbola and straight line, then more than one process must be responsible for the mixtures in the samples (Thomas Vogel, personal communication). In order to perform this test, related samples containing both clay and temper were needed. Since the relationship between the individual vessels was not known with certainty, only samples from the same vessel were plotted together. Three vessels --- Vessel 57, a Skegemog Ware pot represented by Samples 8N1, 8N2, 9 and 10; Vessel 90, a Juntunen Ware vessel represented by Samples 53N1, 53N2 and 54; and Vessel 85, a Traverse Ware vessel represented by Samples 23 - 25 --- provided a sufficient number of samples necessary to determine whether the plots of the ratios produced the expected curves. For these samples, in order to achieve the greatest possible separation of plotted points, four elements with high within-vessel variability were selected for analysis. A list of the elements used as well as the numerical value of the ratios a/b, c/d and d/b appears in Table 7.

The plots of the ratios a/b versus c/d (i.e. La/Sm vs. Ce/Eu) and a/b versus d/b (i.e. La/Sm vs. Eu/Sm) for vessels 57, 90 and 85 are shown in Figures 7-9. As shown in these figures, the plots of these ratios do not provide the necessary hyperbolas and straight lines necessary to confirm the simple mixing of two components. Therefore it must be presumed that even within individual vessels more than one mixing process was responsible for producing the resultant mixture of clay and temper. One possibility is that the temper added to the clay in the pottery-making process was not a homogeneous substance, and therefore added elements in varying amounts to the clay substrate. The crushed granite temper used in these samples (Lovis 1973), if not thoroughly pulverized

Table 7 - Concentration and Ratios of Selected Elements From Duplicate Samples

Sample #	Vessel #	Ware Type	Element Concentration (ppm)				Ratios		
			La (815 KeV)	Sm (103 KeV)	Ce (145 KeV)	Eu (1408 KeV)	La / Sm	Ce / Eu	Eu / Sm
S8N1	57	Skegemog	37.0	6.07	92.6	1.33	6.10	69.6	0.219
S8N2	57	Skegemog	35.6	5.82	82.9	1.23	6.12	67.4	0.211
S9	57	Skegemog	36.8	6.44	71.4	1.38	5.71	51.7	0.214
S10	57	Skegemog	30.9	5.23	60.1	1.03	5.91	58.3	0.197
S53N1	90	Juntunen	32.2	4.79	62.7	0.992	6.72	63.2	0.207
S53N2	90	Juntunen	32.2	4.65	64.1	0.970	6.92	66.1	0.209
S54	90	Juntunen	36.7	5.70	78.2	1.26	6.44	62.1	0.221
S23	85	Traverse	36.9	5.42	61.7	1.15	6.80	53.7	0.212
S24	85	Traverse	34.5	5.46	64.1	1.07	6.32	59.9	0.196
S25	85	Traverse	25.2	4.25	44.5	0.944	5.93	47.1	0.234
S33	Clay	O'Neil Site	8.78	0.582	10.6	0.108	15.1	98.1	0.186
S34	Clay	O'Neil Site	5.01	0.609	8.05	0.131	8.23	61.5	0.215
S35	Clay	O'Neil Site	7.33	0.545	7.93	0.115	13.4	69.0	0.211
S36	"Sand"	O'Neil Site	5.02	0.611	7.89	0.125	8.22	63.1	0.200

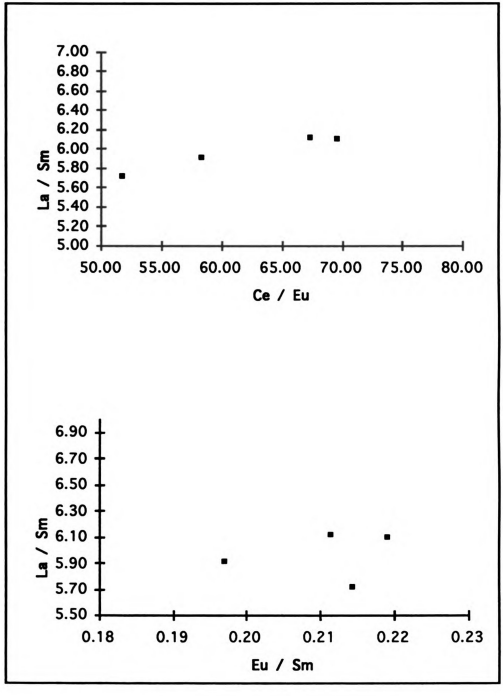

Figure 7 - Plots of Ratios for Samples 8-10

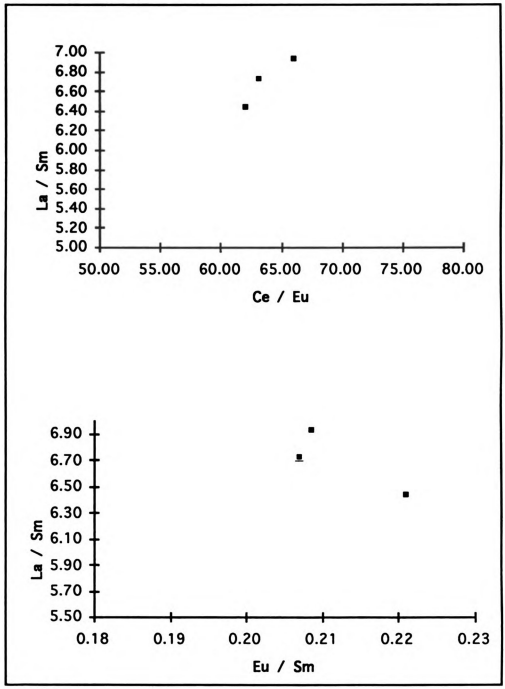

Figure 8 - Plots of Ratios for Samples 53-54)

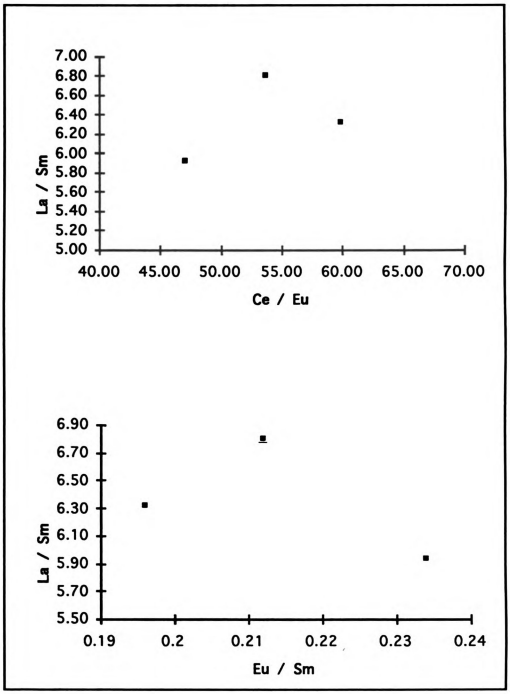

Figure 9 - Plots of Ratios for Samples 23-25

and mixed by the potter prior to addition, could be considered such a non-homogeneous substance, since granite itself is made up of several minerals including quartz, feldspar, mica and/or hornblende (Dorr and Eschman 1977: 36). In addition, the clay itself may not be completely homogeneous. For example, when the test for mixing was performed on three lumps of clay collected together from the O'Neil Site (Samples 33-36), the plots did not yield the expected straight line and hyperbola for a simple mixing process (see Figure 10). In spite of the fact that these clay samples contain a great deal of sand, the mixing process (either natural or as a result of human activity) was apparently not a simple mixing process of sand and clay. Therefore, it appears that the components used to make pottery are themselves heterogeneous mixtures of several materials.

Another possibility is that diagenesis within the site is not uniform, thereby causing sherds found in different areas to have some elements differentially added to or extracted from the individual sherds, and producing a reconstructed vessel whose component sherds contain widely different concentrations of one or more elements. However, this appears not to be the case for two of the three groups of samples taken from a single vessel. For both the Skegemog Ware Vessel 57 (Samples 8-10) and the Juntunen Ware Vessel 90 (Samples 53-54), the multiple samples taken from each pot cluster closely together with small joining distances, in spite of the fact that the sherds sampled from each vessels were found in different archaeological contexts (see Table 8). Such is not the case, however, for Traverse Ware Vessel 85 (Samples 23-25). Although the two sherds found in the same unit (Samples 23 and 24) pair together with very small joining distances (see Figures 4 and 6), the third sample from this vessel (Sample 25), which was taken from a sherd collected from Area B, has more similarity with other pottery and clay samples than with the two other samples from the same vessel (see Figures 4 and 6).

These results preclude the complete dismissal of the role of diagenesis in the analytical results obtained. However, two other factors could also account for this lack of grouping of the three samples taken from Vessel 85. The first is the previously-mentioned

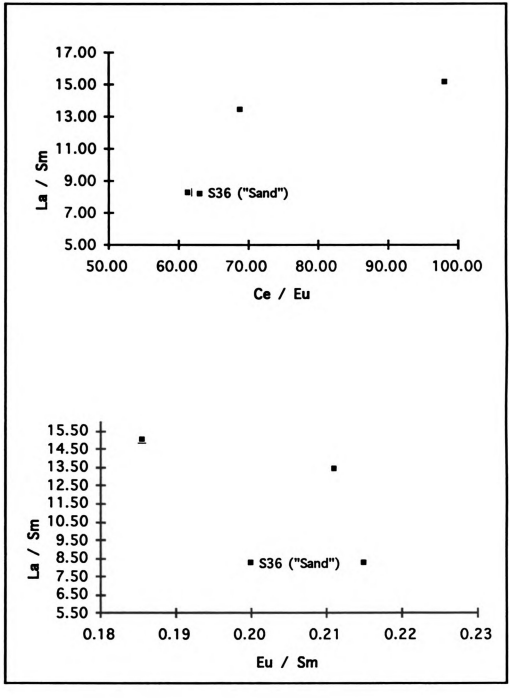

Figure 10 - Plots of Ratios for Samples 33-36

Table 8 - Multiple Samples Taken From Single Vessels

Ware	Sample Number	Vessel Number	Location on Vessel	Area	Unit	Level
Skegemog	8	57	rim	A	N360 W30	3
Skegemog	9	57	rim	A	N360 W30	3
Skegemog	10	57	rim	B	N350 W30	?
Traverse	23	85	rim	A	N390 W60	top Occ. Zone II
Traverse	24	85	rim	A	N390 W60	top Occ. Zone II
Traverse	25	85	body	B	N330 W60	Occ. Zone under old sod
Traverse (not run)	19	50	rim	A	N380 W60	Occ. Zone II
Traverse (not run)	20	50	body	A	N380 W70	Occ. Zone II (hearth
						in SE corner)
Juntunen	53	90	body	B	N350 W30	?
Juntunen	54	90	body (neck)	A	N380 W60	Occ. Zone II

heterogeneity within vessels, caused by the inclusion of varying proportions of clay and temper in the analytical samples, or by the heterogeneity of the raw materials themselves (i.e. clay and temper). The second possibility is that the classification of the vessels is not completely accurate, and that more than one vessel is represented by Samples 23-25.

In addition to the groups of pottery and clay noted above, three other groups, each with a single member, were found by the cluster analysis. Group 4 consists of Sample 46, a Skegemog Site clay sample considered to be an outlier. Groups 5 and 6 are temper samples collected during the excavation of the Skegemog Point Site (Sample 44) and during the sampling of a Traverse Ware vessel (Sample 30, collected from Vessel 11). Group 5 (Sample 44) join most closely to Group 1 (pottery samples), while Group 6 (Sample 30) joins most closely to Group 3 (Skegemog Point Site clays), indicating that the composition of the temper collected at the Skegemog Point Site is most similar in composition to the pottery samples from the O'Neil site, and the temper collected from Vessel 11 has elemental concentrations most similar to the clay from the Skegemog Point Site. The latter result is surprising, since the temper was taken from a mixture of clay and temper (Sample 29, containing both clay and temper from Vessel 11) which, when analyzed, fell within Group 1 and showed little similarity to Sample 30. This suggests that both the clay and temper are contributing to the elements contained in the pottery samples, and that each component by itself will not necessarily determine the group to which a particular sample is assigned. However, given the results of the mixing test described above, it appears that not only is the temper itself adding to the elemental composition of the pottery samples, but individual fractions of the temper and/or clay are probably contributing elements differentially to the overall mixture.

Although the elemental concentrations of the majority of clay samples support the contention that both clay and temper are necessary for determining group membership, three samples of clay contradict this premise. First, the two previously-mentioned clay samples from the Skegemog Point Site (S41 and 42) are found within the pottery cluster

(Group 1), and more specifically within a smaller cluster containing a Juntunen Ware sample (Sample 58, from Vessel 81), two Traverse Ware samples (Sample 25, from Vessel 85; and Sample 26, from Vessel 3), a Skegemog Ware sample (Sample 3, from Vessel 53) and a vessel attributed to both Mackinac and Skegemog Wares by different investigators (Sample 14, from Vessel 53). These clay samples, then, are compositionally similar to each of these wares. This is not surprising, since these clay specimens were observed during sampling to have contained pieces of temper (see Table 3).

Likewise, the "pure clay" sample collected from Vessel 52 (Sample 32), when evaluated by multivariate analysis, was also placed in Group 1. This sample's placement near the small cluster containing Samples 41 and 42 (Skegemog Point Site clay samples) suggests that each of these three clay samples are relatively similar to each other. Further, the placement of these clay samples inside Group 1 indicates that these clay samples have more similarities with the pottery (clay + temper) samples than with the other clay samples. This suggests that in certain cases the composition of the clay alone may be sufficient in determining the groups to which pottery samples belong. It also underscores the variability in the composition of archaeologically-obtained "raw" clays, particularly if they have been altered through the addition of temper.

Clearly, several factors are at work within the samples analyzed for this study. The importance of temper, as well as the non-homogeneity of the temper and/or clay used is suggested by the differences in elemental concentrations between samples from the same vessel. Differences in the composition of the clay samples from the same site are seen in the large joining distances within the O'Neil Site and Skegemog Point Site clay groups, and in the placement of a pair of Skegemog Point Site clay samples with the pottery samples. In addition, the potential use of a variety of temper and clay raw materials by the prehistoric potters may further complicate the analytical outcomes, resulting in a cluster diagram which does not replicate the known pottery groups in the samples. Such is indeed the case for the pottery samples found in Group 1 (see Figure 6).

Within Group 1, only six small sub-groups can be found, the remainder of the group being comprised of single stringers attaching sequentially to these sub-groups. Of the six sub-groups, only one is comprised exclusively of one ware type. This sub-group contains five Juntunen Ware samples, including three samples (Samples 53N1, 53N2 and 54) from one vessel, and two samples (Samples 56 and 57) from two additional vessels. Given the many sources of variability described above, this sub-group stands out in its relative homogeneity, which is underscored by the small relative joining distance of 0.037 within this sub-group. The significance of the joining distances of this sub-group is apparent when compared to the relatively small joining distance of 0.038 for the duplicate samples S8N1 and S8N2 (Mackinac Ware), which comprise a second sub-group within Group 1.

Three other sub-groups of Group 1 also have relatively small joining distances, but none are comprised solely of samples attributed to the same ware, pottery tradition, time period, or provenience within the O'Neil Site. One sub-group consists of Sample 6 (Skegemog/"Problematic" Ware), Sample 10 (Skegemog Ware), Sample 21 (Traverse Ware), and Sample 51 (Juntunen Ware),. Another consists of Samples 9 and 10 (Mackinac Ware). A third sub-group is comprised of Sample 1 (Skegemog Ware), Samples 17, 18, 23, 24 and 31 (Traverse Ware), and Samples 48, 51 and 55 (Juntunen Ware). Finally, the last sub-group within Group 1 has larger joining distances than the previously-described sub-groups (from 0.042 to 0.066), and additionally contains both pottery and clay samples. This set consists of Sample 3 (Skegemog Ware), Sample 14 (Mackinac/Skegemog Ware), Sample 25 and 26 (Traverse Ware), Sample 58 (Juntunen Ware), and Samples 41 and 42 (Skegemog Point Site clay).

The dearth of clusters within Group 1 representing single ware types suggests three possible explanations. The first is that the INAA and multivariate analytical methods are incapable of separating the samples into their proper groupings. This possibility is negated both by the ability of the methods to group duplicate samples, and by their ability to form a

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closely-related cluster of Juntunen Ware samples within Group 1. The second possibility is that the variety of raw materials used by the potters, as well as the inherent variability within each raw material, makes this type of composition analysis difficult for within-site comparisons of vessels. However, the between-sample variability of the pottery sherds is roughly the same as the variability within the clay samples from each site (see Figure 5), and is less than the difference between the pottery samples and the clay or temper samples. If the raw materials sampled are analogous to those actually used to manufacture Late Woodland pottery vessels, this implies that the mixing of the ingredients obliterated the unique chemical compositions inherent in the clay and temper samples and produced pottery which closely resembles all of the other pottery from the site. Alternatively, the raw materials used to make the pottery may have been unlike those sampled for this study. However, the fact that two of the Skegemog Point Site clay samples (Samples 41 and 42) cluster with the pottery samples suggests that the sampling procedure was capable of capturing at least some of the materials used to manufacture the pottery from the O'Neil Site.

The third possible explanation of the lack of clustering by pottery type is that the pottery types are not generally congruent to behaviors which would cause the vessels to group together by type. That is, vessels of different types could be assembled by different groups of potters from local materials of similar composition. Conversely, vessels produced by the same group or individual could be manufactured from different materials procured at the site or elsewhere. In either case the style of the vessel, which determines the ware category to which it is assigned, would not necessarily be parallel to the chemical composition of the vessel's paste.

Summary of Data

Since the Late Woodland ware categories are based largely on stylistic considerations (primarily vessel form and design) it should not be entirely surprising that the composition of these vessels does not conform to the same categories as the stylistic classification. In the upper Great Lakes region, archaeological sites frequently contain pottery samples representing a variety of styles and time periods. Occasionally, as in the case of the O'Neil Site, pottery vessels from separate pottery-making traditions within the same time periods are found. The presence of these different pottery types at the same site has frequently been interpreted as evidence for the occupation of the site by culturally distinct groups, each with unique pottery-making traditions. What the results of this study suggest, however, is that the technological and stylistic realms may function independently of one another, producing stylistic categories which do not match clusters based on composition analysis.

However, it must also be recalled that the analysis indicated a high degree of variability in the composition of the raw materials. This variability undoubtedly accounts for a large proportion of the within-ware variability. One conspicuous exception is the cluster comprised of three Juntunen Ware vessels (Vessels 5, 37 and 90) which cluster very closely together, in spite of consisting of sherds found throughout the site at various levels. The similarity in the composition of these three vessel suggests that they were manufactured from identical or nearly-identical raw materials, possibly by the same person or group of people. The fact that sherds from these vessels were found across the site is somewhat surprising, but may simply be an indication of the amount of post-depositional churning which occurred at the site. Alternatively, it may represent different areas utilized by one individual or a single group at the site. If the latter is true, then further studies of paste composition may reveal that areas in a site used by a single potter or family may be discernible from the elemental composition of sherds found at the site.

Based on the results of the clustering algorithm, several conclusions regarding the nature of the pottery and raw material samples can be drawn. The first is that the O'Neil clay samples are unlike any of the pottery samples and unlike the clay samples from the Skegemog Point Site. Similarly, with the exception of Samples 41 and 42, the Skegemog Point Site clay samples are unlike any of the pottery samples. In order to test for the homogeneity of clay samples collected from the same deposit at the site, multiple nodules of clay from the same storage box or bag were sampled and analyzed. The results indicate that although these pairs frequently join together, their joining distances are large, indicating a relatively large degree of difference between these samples. These differences could be due to inherent differences in the distribution pattern of elements within geologic clays, especially sedimentary clays. It may also reflect a different pattern of diagenesis between adjacent nodules of clay. Further, due to the unfired nature of "raw" clays, the absorption of elements from the soil, or conversely the leaching of elements from the individual clay nodules, may result in larger differences between nodules than between sherds of fired pottery. Finally, some of the differences between the clay samples --- especially within the O'Neil Site clay samples --- may simply be due to the effects of statistical counting errors, which are larger for smaller concentrations of elements such as were found in these samples, or to errors associated with the measurement of concentrations far smaller that those found in the standards.

The two temper samples analyzed --- Sample 44 which consists of material collected at the Skegemog Site and identified as "temper," and Sample 30, which is comprised of relatively large pieces of temper from Vessel 11 --- are not grouped with either the pottery or the clay samples. However, the temper sample from the Skegemog Point Site (Sample 44) is more closely related to the pottery samples than it is to either the temper from Vessel 11 (Sample 30), or to the clay samples. This suggests that material similar to that collected as temper from the Skegemog Site was used as temper in at least

some of the pottery analyzed, since the composition of this material is not unlike that of some of the vessels found at the O'Neil Site.

However, the fact that the temper taken from Vessel 11 clusters more closely to the Skegemog Point Site clay group (Group 3) than to either the pottery samples (Group 1) or the Skegemog Point Site temper (Group 5) is intriguing. It is possible that the collection method precluded the possibility of obtaining a representative sample of temper from this vessel. Since only the larger pieces of temper were collected, this may have skewed the results in favor of elements included only in the larger-grained temper fragments. Alternatively, the larger pieces of temper in this vessel may represent only one of several tempering materials used in the vessel, one which adds a lower concentration of elements to the total pottery sample than do the other potential tempers in the pottery.

Since the elemental concentrations of both temper samples lie between the higher pottery concentration values and the lower clay values, it appears that the temper has the effect of enriching the clay with most of the elements examined. However, this assumes that the clay samples analyzed were the same clays which were used to make the pottery vessels from the O'Neil Site. Such an assumption at this time may be unwarranted, possibly leading to incorrect conclusions regarding the use of clay at the O'Neil Site.

An alternative view is that the temper collected from Vessel 11 (Sample 30) accurately represents the temper from this vessel. If this is the case, it would appear that the temper has the effect of "diluting" the pottery sample, since the elemental concentrations for the temper are lower than those of the pottery (clay + temper). If this is the case, then the concentrations of elements in the clay raw material should be greater than those found in the temper. This clearly is not the case for the clay samples collected from the O'Neil Site and the Skegemog Point Site. Two options are therefore possible. First, the assumption that the temper is diluting the clay may not be correct. The second possibility is that the assumption is correct, but that the clays analyzed (i.e. the O'Neil Site and Skegemog Point

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Site clays) are not the clays which were actually used to manufacture the pottery found at the O'Neil Site.

The incorporation of Samples 41 and 42 (Skegemog Site clay samples) as well as Sample 32 ("pure" clay from Vessel 52, a Traverse Ware pot) in the group containing all of the pottery samples (Group 1) is also of interest. Given that the temper in the pottery may be either enriching or diluting the clay used to make the pottery, the inclusion of these raw clays with samples of pottery suggests that these clay samples may have contained small grains of temper. Alternatively the clays themselves may be sufficiently similar to the mixture of clay and temper as to make them more similar to the pottery samples than to the clay samples from either site. Unfortunately, neither tempering material nor a pottery sample with temper and clay was collected from Vessel 52, making impossible a determination of the effect of known temper inclusion on the chemical composition of the paste. In any case, the difference in the chemical composition between Samples 41 and 42 (Skegemog Point Site clay samples) and the other Skegemog Point clay samples is important to note, since it suggests that the clays from this site are quite dissimilar from each other. (It also suggests that Sample 44, another Skegemog Point Site clay sample, may not be an outlier, but may represent the other extreme in the range of variation within the Skegemog Point Site clays.) Whether this dissimilarity is due to added temper in some samples, or to differences in the elemental content of various nodules of geologic clays, or even to the presence at one archaeological site of clays transported from other archaeological sites, the large difference in the chemical composition of these clays suggests that single clay samples from single sites do not adequately represent the variety of clay composition at any one site.

Other conclusions can be drawn from the pattern of clustering within Group 1, the group consisting of all of the pottery samples analyzed. Unlike the small cluster of five Juntunen Ware samples noted above, no other cluster of this size is comprised of a single pottery type. Nor are any composed of samples from a single pottery tradition, time

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period, or provenience on the site. Furthermore, except for Samples 8N1 and 8N2, no Skegemog Ware samples pair with each other. That is, at least compositionally, the Skegemog Ware samples appear more like other wares than like the Skegemog Ware (see Figures 4 and 6). For example, Skegemog Ware samples pair with Mackinac Ware samples (e.g. Sample 9 and Sample 12) and with Juntunen Ware samples (e.g. Sample 1 and Sample 55). Other Skegemog Ware samples are grouped with Juntunen-Traverse pairs (e.g. Sample 3 with Samples 58 and 26, and Samples 10 and 6 with Samples 21 and 51). In even larger clusters within Group 1 Skegemog Ware falls into clusters with all three of the other ware types.

The pattern of grouping for the Mackinac Ware is not dissimilar to that of the Skegemog Ware. No Mackinac Ware samples pair with each other. This includes all of the samples designated "Mackinac" and "Mackinac/Skegemog." In one instance a Mackinac Ware vessel is paired with a Skegemog Ware vessel (Sample 12 with Sample 9). Also one Mackinac Ware sample is clustered with a Traverse Ware pot and a sample of clay from the Skegemog Point Site (Sample 14 with Samples 25 and 42). All other Mackinac Ware samples are grouped with larger clusters containing the three other pottery types.

Traverse Ware samples, however, do pair with each other, as shown by Samples 17 and 18, and Samples 23 and 24. They also pair with Juntunen Ware samples, as exhibited by the pairing of Sample 26 with Sample 58, and the pairing of Sample 21 with Sample 51. Traverse Ware pottery also forms a small cluster of five Traverse Ware and one Juntunen Ware samples (i.e., Samples 17, 18, 23, 24, 31, and 48). This small cluster has joining distances of 0.026 - 0.031 --- the smallest joining distances for any cluster. In another instance Traverse Ware is found in a cluster of two Traverse Ware, two Skegemog Ware and one Juntunen Ware samples (Samples 6, 10, 21, 29, and 51). As noted above, the sample of "pure clay" from a Traverse Ware pot (Sample 32) lies within Group 1. It falls in a cluster containing samples from all four pottery types. The remaining Traverse Ware samples (Samples 22 and 27) group with large clusters containing all pottery types.

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Except for Samples 53N1 and 53N2, the Juntunen Ware pottery does not pair with itself. However, as noted above, it does form one distinct cluster of five samples (S53N1, S53N2, S57, S56, and S54) representing three separate vessels. The joining distances within this cluster (0.027 - 0.037) is very small; only the above-mentioned Traverse / Juntunen cluster has smaller joining distances than this five-sample Juntunen cluster. Juntunen Ware samples also group with Traverse Ware samples, as previously described. In larger clusters, the Juntunen Ware samples are found in clusters containing all other pottery types.

Interestingly, the more recent Late Woodland pottery in this study tends to form pairs and small clusters with the same pottery types. This may indicate that more vessels manufactured with the same raw materials (perhaps at roughly the same time by the same or related potters) are more likely to be found at the O'Neil site in the later time period. However, it may also simply be a consequence of the larger number of samples available for analysis from the late Late Woodland period, resulting in a higher probability in pairing within the ware type.

In general, the clustering pattern of the clay and pottery samples indicates that there is a great deal of variability in the clay and pottery samples. The fact that the within-pottery variability is similar to the within-clay variability is puzzling, since the inclusion of temper in the pottery samples is presumed to contribute additional variability to these samples. Several possible explanations for this phenomenon are possible.

1. The pottery was made from a more uniform clay (either a different O'Neil Site clay or clay from another location).

2. The clay from the O'Neil and Skegemog Sites is "prepared clay" with more or less material (temper) added to it. Because of the presence of this added material, the variability within the clays is as great as that within the pottery group.

3. The clay samples analyzed are "rejects" which were considered by the prehistoric potters to have been unsuitable for pottery-making. The

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fact that these pieces of clay were apparently discarded may support this explanation.

4. The mixing of clay and temper results in a fortuitous mixture which is relatively similar for all pottery.

The last possibility seems highly unlikely, since it would imply that each potter throughout time and space had similar mental "recipes" for pottery which resulted in similar paste composition regardless of the composition of the raw materials. This possibility also seems to be negated by the results reported by Trigger, *et al.* (1980) and Clark (1991) which indicate that variations in pottery composition occur over large regional areas. Therefore, it appears that the clay collected from the O'Neil Site and analyzed by INAA was not the clay used to manufacture the pottery at the O'Neil site, or, if it was, the clay analyzed was so modified as to render a definitive conclusion impossible. In the case of the Skegemog Point Site clay it is tempting to suggest that the clay nodules which clustered with the pottery samples (Samples 41 and 42) represent the clay used to manufacture these vessels. However, the variability within the Skegemog Site clay samples is greater than that of the O'Neil Site clay samples, and therefore any conclusions regarding the nature of individual clay samples from the Skegemog Point Site are at best tenuous.

With very few exceptions, the pottery samples grouped more frequently with other pottery types (including types of a dissimilar pottery tradition or time period) than they did with the same pottery types. The duplicate samples (Samples 8N1 and 8N2, and Samples 53N1 and 53N2), however, join at the first level of joining. Therefore for a given portion of a given sherd, the results obtained by INAA are reproducible. For multiple samples taken from a Skegemog Ware vessel (Samples 8-10, representing Vessel 57) the analytical results were very similar to one another. Likewise, the samples taken from the same Juntunen Ware vessel (Samples 53-54, representing Vessel 90) gave very similar composition profiles. However, for the multiple samples collected from a Traverse Ware vessel (Samples 23-24, representing Vessel 85), only two of the three samples show close

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similarity in composition. The relative dissimilarity of the third sample (Sample 25) raises the possibility that one or more factors may be operating differentially within a single vessel. The results obtained may be due to the incomplete mixing of clay and temper by the prehistoric potter, leading to differential sampling of clay and temper from the three sherds. Alternatively, the variability within these three samples may be due to differential diagenesis across the site, or even to the incorrect assignment of these three sherds to the same vessel. The analytical results from this single vessel, therefore, illustrates the range of problems associated with each of the vessels analyzed.

Validity of Hypotheses

Given the results obtained in this study, only tentative conclusions can be drawn with regard to the behavior of the potters manufacturing the Late Woodland pottery of the O'Neil Site. In fact, most of the hypotheses put forth are not supported by the results obtained. The first hypothesis states that:

> 1: There are no significant differences between the chemical compositions of the pottery from each of the residential occupations (i.e. the Mackinac, Traverse and Juntunen pottery).

Although it appears that each pottery vessel from the residential occupations is similar to every other vessel from residential occupations, the significance of this result is questionable, since all of the pottery samples --- both those from residential and those from logistic occupations --- are chemically similar to each other. No clear differentiation between the presumably locally-made pottery from the residential occupations and the purported non-locally-made pottery associated with the logistic occupations was possible. This negates the validity of the fourth hypothesis which states that:

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4: There is a significant difference between the chemical compositions of the pottery from the logistic occupations (i.e. the Skegemog Ware pottery) and the pottery from the residential occupations (i.e. the Mackinac, Traverse and Juntunen pottery)

As previously shown, all of the pottery samples analyzed are compositionally similar to one another, and the samples from residential occupations are intermixed with samples from logistic occupations in the cluster of Group 1.

Likewise, the second hypothesis, which states that:

2: There are no significant differences between the chemical compositions of the local (O'Neil Site) clay and the pottery from the residential occupations (i.e. the Mackinac, Traverse and Juntunen pottery)

is not supported, since the pottery from the residential occupations is grouped separately (in Group 1) from the O'Neil Site clay samples (Group 2).

The final hypothesis to be considered (hypothesis 3) states that:

3: There is a significant difference between the chemical compositions of the non-local (Skegemog Point Site) clay and the pottery from the residential occupations (i.e. the Mackinac, Traverse and Juntunen pottery).

For most of the Skegemog Point clay samples the hypothesis is supported. However, for two Skegemog Site clay samples (Samples 41 and 42) which are found in Group 1, the results do not support the hypothesis, since these non-local clay samples are chemically similar to the pottery from residential (as well as logistic) occupations.

The inability to support the majority of the hypotheses indicates that the underlying assumptions about the nature of the clay and pottery samples may be invalid. That is, the homogeneity of the clay samples, as well as the relationship of the clay samples to the pottery samples may not be as clear-cut as expected. The results also suggests that the assumptions about the regularity of past behaviors may not be correct. The pattern of clay

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procurement and manufacture into pottery containers may be highly variable, even within the context of a residential community occupying a site with clay resources. These assumptions will be dealt with in the following summary chapter.

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SUMMARY

Errors in Original Assumptions

In undertaking this project, several assumptions about the nature of the materials being analyzed, as well as about the behaviors which produced the archaeological materials were necessary. Some of these assumptions were stated from the outset, and were based on the results obtained by previous investigators. Other underlying assumptions, however, were not obvious until after the analytical data were reviewed and the results were found not to be in accord with the expected results. Some of these assumptions are practical in nature and involve simply the choice of sampling tools or the extent of sampling within a site. Others are more theoretical in nature and require a modification of the research design in order to control for them in future investigations. What follows is a list of the underlying assumptions regarding the nature of the raw materials and finished pottery, as well as assumptions relating to the behavior of the prehistoric potters and analytical procedure.

The local clays are compositionally different from the non-local clays. This assumption held true for the O'Neil Site clays versus the Skegemog Site clays. However, the O'Neil Site clays were extremely sandy and crumbly, while the Skegemog Site clays were more compact and firm. This raises the question of whether the O'Neil Site clays contain added sand (possibly as a tempering material) which would have the effect of diluting the clay substrate. The fact that the "fired sand found beneath [the] clay" at the O'Neil Site (Sample 36) falls in the middle of the O'Neil Site clay cluster supports the premise that the O'Neil Site clay samples may be showing more similarity to its sand components than to its clay components. Of course, it is also possible that the O'Neil Site clays are by nature very sandy, and the elemental composition obtained by INAA is representative of the composition of the geologic clays found in this area. In order to definitively resolve this issue, a systematic sampling and analytical program is required in

order to determine the elemental composition of geologic and archaeological clay samples within a small region such as the so-called Traverse Corridor.

The clays from one site are similar to themselves (i.e. these clays are fairly homogeneous). Surprisingly, what this study revealed is a great deal of variability in the composition of the clays collected from these archaeological sites. Whether this heterogeneity in the clays from a particular site is due to the variability of the parent clay formation, to the addition of temper to the "raw" clays, or to the importation of clays from other sites cannot as yet be determined. Again, a systematic analysis of geologic and archaeological clays from a variety of sites would be helpful in ascertaining the cause of this variability.

Unworked clays were not transported long distances, but instead were mined near the area where the vessels were made. One of the major premises of this study was that locally-made pottery could be distinguished from non-locally-made pottery on the basis of the composition of the ceramic paste. In addition to assuming that local clays were similar to themselves and different from non-local clays, it was also assumed that the vessels made from non-local clays were not manufactured at the O'Neil Site, but instead were made at another site near the source of the clay raw material. While this may indeed be the case for the majority of vessels, it may not be true in all cases. In particular the large variability of the composition of the Skegemog Point Site clays suggests that some of these clay raw materials could have been brought to the Skegemog Point Site from another location. Whether this clay was then used to manufacture pottery is still an open question, but it suggests that clay (and temper) procurement behavior was probably more variable than once believed.

The clays collected from the archaeological context are representative of clays used to manufacture prehistoric pottery vessels. This assumption is related to the above two premises that clays found locally are in fact local clays and are homogeneous in composition. However, it also includes the assumption that potters were exploiting the

same sources of geologic clays throughout the prehistoric period, and that a sample of unused clay found in an archaeological context is representative of all of the clays used to manufacture pottery vessels at that site. At this point it is not clear whether the potters who occupied the O'Neil Site used the clay sources within their procurement area in the same manner and to the same extent throughout the Late Woodland period. Nor is it known whether the clay sources available to Late Woodland potters remained the same throughout this period, or whether some clay deposits became exhausted during this time. Analyses of presently-available geologic clays as well as archaeologically-derived clays could shed some light on this question, provided that the archaeological clays have not been extensively modified by the addition of temper.

The clays from the O'Neil Site (and/or the Skegemog Point Site) are compositionally similar to some of the pottery samples. None of the pottery analyzed proved to be similar in composition to the clay from the O'Neil Site. Likewise, most of the clay samples from the Skegemog Point Site were unlike any of the pottery samples. One simple explanation for this may be that the pottery was not manufactured from the O'Neil Site clays or from most of the clay found at the Skegemog Point Site. However, the complexities of the clusters discussed previously suggests that a such a facile explanation is not adequate. What is apparent, though, is that behaviors involved in the production of prehistoric pottery are far more complex than originally assumed, and that hypotheses dealing with the chemical composition of pottery sherds must be more carefully constructed.

Temper added to the raw clays does not significantly alter the chemical composition of the resultant pottery. This assumption appears to be incorrect, although a definitive answer is not possible. The fact that the temper samples from the Skegemog Point Site lies closer to the pottery samples than do all of the clays from the O'Neil Site and most of the clays from the Skegemog Point Site suggests that the elements contained in the temper may be adding constituent elements to the pottery samples. However, the inclusion of the

"pure" clay sample from Vessel 52 (Samples 32) as well as the inclusion of the Skegemog Point Site clay samples (Samples 41 and 42) with the pottery samples in Group 1, suggests that in some cases temper may not be necessary for determining the group membership of the sample.

Temper is evenly dispersed throughout the vessel, its composition is homogeneous, and it is constant between vessels. All of these assumptions are negated by the observations of the pottery paste made during the sample collection step. Both the size of the temper granules and the amount of temper contained in the sherds was found to vary between vessels, although there was a greater degree of similarity in the physical composition of the sherds within the same pottery types. Also noted visually were the individual light- and dark-colored grains which comprised the crushed-granite temper. The lack of temper homogeneity suggested by the light- and dark-colored fragments is also supported by the results of the mathematical test of mixing performed on samples of pottery. These results indicate that the pottery matrix (composed of clay and temper) is the result of more than one mixing process, that is, either more than two components were mixed together to produce the pottery, or the clay and temper themselves were made up of several components. Finally, as discussed previously, the inclusion of varying amounts of temper in the samples analyzed by INAA is suspected to have contributed, at least in part, to the large variability in the composition all four pottery wares. One extreme end of the spectrum of temper inclusion was seen in Sample 32 which contained no visible temper. Other samples (for example Sample 29) contained such large amounts of temper that the larger pieces in the original sample were removed prior to placing the material in the sample bottles. In both cases the remaining pottery sherds from these vessel were not examined to determine if the amount of temper in the samples were representative of the amount in the vessels, but it is suspected that the amount of temper does vary within each pottery vessel. That the relative amount of temper varies *between* vessels is undeniable. Therefore, if the inclusion of temper has either an additive or diluting effect on the final composition of the

sherd, then varying amounts of temper in the sample will yield varying results. Although Mommsen and others (Mommsen 1981; Mommsen, *et al.* 1988) have established means of mathematically sorting out temper from clay in INAA results, this method requires analyses of known temper and clay raw materials. Certainly, additional studies of both temper and clay composition would assist in eliminating this problem for future research.

Temper can be avoided in the sampling process. Even with the use of a fine-tipped dental bit it was found that temper could not be completely avoided. By using these bits only the larger pieces of temper could be avoided and/or removed from the sample before placing the remainder in the collection bottle. But because even the small grains of temper are larger than the individual clay particles, it may be possible, in future investigations, to separate the clay from the temper with soil sieves, with a mechanical shaker, or by means of flotation using ultra-pure water. Although such procedures would add significantly to the sample collection time, the resulting clay and temper samples obtained could more easily be used to interpret past behaviors relating to the procurement of raw materials and their manufacture into pottery.

The addition of water by potters during the preparation of the clay does not alter the chemical composition of the finished pottery vessel. This assumption was not tested in this study but reportedly (Thomas Vogel, personal communication 1991) the addition of fresh water would not add significant amounts of trace elements to the pottery matrix. This may be a factor, however, for pottery made at locations where sea water might have been used in the manufacturing process.

The sampling procedure will not contaminate the samples. In an attempt to avoid temper as much as possible in the collection of the samples, hardened steel (Tungsten-Vanadium) dental bits were used to collect the samples. However, the bit material proved to be softer than the temper in the pottery sherds, and the bits became heavily abraded by the sherds. Therefore, although care was taken to avoid contaminating the samples with other materials, the samples became contaminated with metal filings from the dental bits.

Fortunately the extent of the contamination could be determined by analyzing representative bits, but the contamination of the samples precluded the use in this analysis of certain elements (notably Iron) which might have been useful in separating the samples into more meaningful clusters. One solution to this problem might be to use a harder drill bit, such as a carbide bit, but the brittleness of such materials may also lead to contamination of the samples. Another alternative is to use an agate mortar and pestle to break apart the pottery sherds. However, this method would not permit the removal of the surface material from the sherd prior to sampling --- material which could include soil and other potential contaminants not desired in the final sample. Also, care would need to be exercised in order to avoid breaking up the grains of temper to such an extent as to make their separation from the clay particles impossible. All in all, where temper inclusion can affect the final analytical results, it appears that the best alternative is to use a drill bit made from the hardest material available, to incorporate a method or removing small-grained temper from the clay, and to analyze the drill bit(s) used in order to determine the extent of possible contamination of the samples with the drill bit(s).

The elements analyzed for and used in the clustering program are important in differentiating between different types of pottery and between clays from different sites. This assumption was found to be at least partially correct, since the analytical procedure was able to differentiate between the clays from the O'Neil Site and those from the Skegemog Point Site. However, the same analysis clustered all of the pottery into a single group, with only small sub-groups within it. Whether this was due to characteristics inherent in the pottery matrix, or to the choice of elements used for the clustering program cannot be determined. Other investigators have used a variety of elements to specify groups within the sample population (see Appendix F for a listing of the elements used by these investigators). At present there is no consensus as to which elements provide the best differentiation between pottery types or clay sources, although for the Michigan clays the concentrations of Iron, Magnesium, Potassium, and Sodium are thought to be effective

markers for differentiating clays from different sources (Randy Schaetzl, personal communication 1991). In this study Magnesium and Potassium were not determined, since their half-lifes were too short for the method used. Sodium is not detectable using the standards at the Michigan Memorial Phoenix Project. Finally, Iron was not used in the data analysis due to the contamination of the samples with metal filings from the drill bits.

Although the concentration of Iron may be useful in differentiating one clay source from another, the addition of crushed granite temper (Lovis 1973) would significantly alter the concentration of Iron in the pottery since granite and other rocks of igneous origin are rich in Iron (Randy Schaetzl, personal communication 1991). The inability of Iron to differentiate the pottery from the O'Neil Site is borne out in Table 9, which lists the mean Iron concentration of each sample in increasing order. As this table illustrates, the concentration of Iron in the pottery samples cannot distinguish between pottery types, and is not helpful in determining whether or not the O'Neil Site clay or the Skegemog Point Site clay was used to manufacture the pottery from the O'Neil Site. The usefulness of Magnesium, Potassium, or Sodium in differentiating clays from nearby sites or in distinguishing one group of pottery from another has yet to be determined.

The pottery sherds analyzed belong to discrete ware types discernable on stylistic grounds. The validity of this last assumption is perhaps the most difficult to determine, since the analytical results of the pottery samples were inconclusive. Although it has been argued that much of the variability seen in the paste composition of the four pottery types is due in large part to methodological problems and variable behavior on the part of the potters, it could also be argued that some of the variability is due to the classification of the pottery itself. In many region in Michigan, the prehistoric pottery frequently exhibits structural and decorative attributes similar to those of adjacent areas (see for example Brashler 1981). Similarly, the evolution of pottery design from one style to another over time rarely proceeds with sharp breaks between pottery types. Instead, pottery styles, like other aspects of material culture, are often fluid and ever-changing. Because of this, there

Table 9 - Mean Iron Concentrations, in Increasing Order

Spl #	Sample Type	Site or Ware Type	Mean Fe Conc. (ppm)	Grp
33	clay	O'Neil	1,250	2
35	clay	O'Neil	1,270	2
34	clay	O'Neil	1,490	2
37	clay	O'Neil	1,580	2
36	sand	O'Neil	1,600	2
38	clay	O'Neil	2,870	2
46	clay	Skeg. Pt	7,240	4
40	clay	O'Neil	13,400	2
47	clay	Skeg. Pt.	14,000	3
30	temper	Trav (V11)	18,300	6
43	clay	Skeg. Pt.	19,200	3
60	clay	Skeg. Pt.	19,300	3
45	clay	Skeg. Pt.	21,900	3
41	clay	Skeg. Pt.	23,800	1
42	clay	Skeg. Pt.	24,600	1
39	clay	Skeg. Pt.	25,900	2
14	pottery	Mac / Skeg	29,000	1
58	pottery	Juntunen	29,700	1
25	pottery	Traverse	32,100	1
31	pottery	Traverse	32,400	1
48	pottery	Juntunen	32,500	1
18	pottery	Traverse	33,100	1
26	pottery	Traverse	33,200	1
17	pottery	Traverse	33,500	1
1	pottery	Skegemog	34,300	1
3	pottery	Skegemog	36,100	1
29	pottery	Traverse	36,100	1
13	pottery	Mac / Skeg	36,900	1
24	pottery	Trsaverse	37,000	1
23	pottery	Trsaverse	37,200	1
16	pottery	Mackinac	37,300	1
21	pottery	Traverse	38,900	1
5	pottery	Mac / Skeg	39,400	1
12	pottery	Mackinac	40,100	1
52	pottery	Juntunen	40,100	1
10	pottery	Skegemog	40,200	1
50	pottery	Juntunen	40,300	1
22	pottery	Juntunen	40,300	1
6	pottery	Skeg / Prob	41,700	1
27	pottery	Traverse	42,000	1
51	pottery	Juntunen	42,300	1
15	pottery	Mackinac	42,700	1
4	pottery	Skegemog	42,900	1
8N2	pottery	Skegemog	43,300	1
11	pottery	Mackinac	44,300	1
7	pottery	Skegemog	48,000	1
8N1	pottery	Skegemog	48,200	1
22	pottery	Traverse	48,900	1
56	pottery	Juntunen	49,600	1
9	pottery	Skegemog	50,000	1
32	"clay"	Trav (V52)	50,900	1
2	pottery	Skegemog	51,800	1
53N1	pottery	Juntunen	55,300	1
53N2	pottery	Juntunen	55,400	1
57	pottery	Juntunen	56,400	1
44	temper	Skeg. Pt.	58,900	5
59	pottery	Juntunen	62,700	1
54	pottery	Juntunen	68,200	1
28	pottery	Traverse	71,000	1
	Ck Std	batch 4	92,700	N/A
	Ck Std	batch 1	93,300	N/A
	Ck Std	batch 3	95,900	N/A
	Ck Std	batch 2	96,500	N/A
	Drill Bit	(lot 555828)	831,000	N/A
	Drill Bit	(lot 442988)	841,000	N/A
	Drill Bit	(lot 625828)	850,000	N/A
	Drill Bit	(lot 625828)	859,000	N/A
	Drill Bit	(lot 555828)	878,000	N/A
	Drill Bit	(lot 442988)	892,000	N/A

is the risk of lumping "transitional" pottery types into earlier or later pottery styles, simply because the classificatory scheme is not sufficiently detailed to accommodate it. Likewise pottery vessels with design elements borrowed from adjacent areas have the potential of being misidentified and assigned to the wrong cultural group. Finally, and perhaps because of these problems, there is the potential of having classificatory schemes which are interpreted differently by different investigators. Some evidence of this was seen with this collection, as exemplified by the conflicting pottery types assigned to Vessel 17 (Sample 13), Vessel 28 (Sample 5), Vessel 32 (Sample 6), and Vessel 53 (Sample 14). The extent of these potential classificatory problems and their effect on matrix studies of this type is as yet undetermined. However, future studies may reveal that ceramic categorization by paste composition is not precise enough to separate the pottery discarded at a single site. Conversely, once the sources of variation in paste composition analysis are sufficiently well understood, this analytical method may prove useful in the classification of pottery types.

Significance of Results

This study attempted to discern from the chemical composition of the O'Neil Site ceramic assemblage the residency of the prehistoric potters in the hopes of shedding light on the question of resource utilization among the Late Woodland hunter-gatherers of northern Michigan. Instead, what was found was a ceramic collection which could not be easily differentiated into sub-groups on the basis of chemical composition. In addition, a high degree of variability was found in the samples of archaeologically-derived clays from the O'Neil and Skegemog Point Sites. Further, little correspondence between these clays and the pottery samples from the O'Neil Site was apparent. Although the expected results of this study were not forthcoming, some tentative conclusions about the behavior of the prehistoric potters can be suggested.

Although the O'Neil Site was re-occupied several times, it was never intensively occupied, and the re-occupations took place over a period of several centuries (Lovis 1973, 1991). The site is known to have been occupied throughout the Late Woodland period by groups with different pottery traditions. In addition to having their own pottery making traditions, these groups may also have had different strategies for obtaining raw materials for pottery manufacturing. In this light, the lack of large distinct clusters corresponding to one pottery type or even to one pottery tradition or time period is not entirely unexpected, given the mobility of the groups in question and the access to a potentially large number of clay and temper resources.

The lack of such clusters implies that the people making the O'Neil Site pottery were obtaining their raw materials from a variety of locations, most likely including the Skegemog Point Site, and possibly including the O'Neil Site itself. In addition, the occupants of the O'Neil Site may have brought finished vessels to the site, but the evidence for this is still inconclusive. What is evident, however, is that the potters manufacturing the vessels found at the O'Neil Site were not limited to discreet sources of clay and temper which would manifest themselves in clear clusters of vessels and a tighter grouping of unfired clays. Instead, one sees pottery types whose ranges of variation are as great as the range of variation of all the pottery samples combined. This implies not only the use of a variety of raw materials, but potentially a mixing of pottery styles and populations, resulting in pottery whose stylistic attributes are not congruent to the elemental composition of its paste.

The unexpectedly high variability in the clay samples, particularly those from the Skegemog Point Site, may simply be a reflection of the variability of the geologic clays available in the immediate vicinity. Alternatively, it may indicate that raw clays were transported to the site from other locations within the seasonally-traversed territory of the groups inhabiting the site. Two reasons for transporting raw clays from one occupation to another can be envisioned. The first is that although clay is ubiquitous in Michigan, those

clays desired for pottery-making may not have been abundant in all areas. The second reason is that the difficulty in transporting clay may have been offset by the greater difficulty in transporting finished pottery from one location to another. Fired pottery, particularly the pottery of the Upper Great Lakes which is fired at low temperatures, is relatively fragile. Raw clay, on the other hand, is also relatively fragile in its dried state, but with the addition of water it can easily be re-molded into a lump of clay, or, with the further addition of temper and subsequent firing, it can be fashioned into a pottery vessel. Although it is not suggested that all pottery vessels were made from lumps of clay which were carried from one site to another, it is probable that some vessels were made from such imported raw material. A final possibility is simply that the clay samples obtained from the O'Neil Site and the Skegemog Point Site were representative of various stages of clay preparation. Thus samples 41 and 42, which were noted as having some temper in them, may represent the stage of clay preparation just prior to its being shaped into a vessel, whereas other clay samples might have been discarded or lost by the potter prior to the addition of temper. Further investigations into the range of variation of the naturally-occurring geologic clays are necessary before these premises can be considered more fully.

Given the large variability in the analytical results of both the clay samples and the pottery samples, the small tightly-clustered group of three Juntunen Ware vessels, (represented by Samples 53N1, 53N2, 54, 56 and 57) is quite unexpected. This small group of vessels represents the only cluster of pottery whose members are comprised of the same pottery type. Yet the similarity between the members of this group is greater than that between some lumps of clay collected together at the same site. This suggests that these vessels were manufactured from identical or nearly-identical raw materials, and possibly by the same potter or group of potters during a single work episode. The question of where these vessels were manufactured still cannot be not resolved, but a close temporal and spatial relationship between these vessels is suggested. A novel application of this method of analysis thus emerges from these results. Although the analysis of ceramics for gross

similarities between pottery types has proven to be difficult due to the potential variability of the clay and temper, this technique may be useful in determining whether any vessels at a given site were made with the same raw materials, and presumably by the same potter(s) at roughly the same time period. Finally, the near absence of clusters of the same pottery type may be a further indication of the wide availability of raw materials for pottery making, as well as a potential marker of the relatively mobility of the groups manufacturing the pottery.

Future Directions

Previous investigations of paste composition have shown that INAA is useful in helping to identify sources of clays used for pottery making among settled populations. It has also been used with some success on a regional level for more mobile hunter-gatherer populations. However, more work is needed to determine whether this method is useful in the intra-site analysis of hunter-gatherer behavior.

Of primary importance for future work on paste composition in the Great Lakes area is a determination of the natural range of variation in the chemical composition of geologic clays collected from particular regions. This would require an intensive and systematic sampling program of geologic clays throughout Michigan and other areas. Additionally, it would be useful to include samples of archaeologically-derived clays in order to determine whether these clays are representative of natural clays from the region. The analysis of archaeological clays alongside natural clays could also help establish whether the archaeological clays had been modified in prehistory by the addition of other materials. It may also help determine whether the clays found in archaeological contexts are native to the region of study.

In addition to analyzing the clays from various regions, it would also be useful to analyze Late Woodland pottery collections from nearby sites in order to establish the

relationship between the pottery from the O'Neil Site and similar pottery from neighboring sites. This would help determine whether or not the pottery collected from within small geographic areas in Michigan can be differentiated on the basis of paste composition. It would also help establish the general relationship between raw clay samples and pottery samples recovered from various archaeological sites.

Finally, any further work on the analysis of pottery composition within small regions should take into account the effect of temper on the final concentration of elements in the pottery samples. If temper cannot be avoided in the sampling process, care should be taken to analyze enough temper samples to enable the effects of this material to be "subtracted" from the concentration values of the whole pottery samples. Alternatively, methods for separating ground temper from powdered clay could be explored. If such separations are possible, this would enable the individual components of pottery to be analyzed separately, and would permit the comparison of pottery clays to geologic clays.

The use of Instrumental Neutron Activation Analysis for the determination of pottery paste composition is relatively rare in the Upper Great Lakes. Research has indicated that this method can be useful in large-scale regional studies relating the composition of pottery paste with past human behavior. This study has shown that archaeologically-derived clays from closely-spaced sites can be differentiated by INAA. However, the determination of the relationship between these clays and archaeologically-related pottery sherds is difficult to establish, presumably due to the effect of temper which is incorporated into the pottery samples, and possibly also because of the natural variation between clay samples collected from the same site. It is hoped that future work in the area of paste composition analysis can resolve some of the methodological problems identified in this study.

NOTES

1 The MSU Museum, Anthropology Division catalogue number consists of a unique accession number which identifies the site, as well as a series of decimal suffixes which identify the provenience of the artifact within the site.

2 The Minimum Vessel Sheets (Lovis n.d.) are internal working documents originally used to assist in the analysis of the O'Neil Site pottery. The vessel numbers assigned to each vessel are recorded only on these Minimum Vessel Sheets and in the storage boxes where each individual vessel is stored. The original Minimum Vessel Sheets do not indicate the type/variety designation of each vessel. In fact, no listing correlating vessel numbers to pottery types could be obtained.

3 Densities were not measured, but were noted visually as gross differences in volume (height of sample in the sample tube) relative to the weight of the samples in the tubes.

4 This process is performed in two steps. First the K, or constant (in cps/mg/ppm) for each element in each standard is calculated according to the equation:

$$K_{std} = \frac{\left[(\text{Peak area}_{std} - \text{Background area}_{std}) / \text{live counting time}_{std}\right] e^{(0.693)(t/T)}}{(\text{Mass}_{std})(\text{Concentration}_{std})}$$

where t = decay time in seconds for each element (relative to the time of irradiation, t_o)

and T = half-life in seconds for each element

In addition, the counting error associated with each peak in the standard is calculated according to the formula:

$$\text{Error of Peak}_{std} = \left[2(\text{background area}_{std}) + \text{area of peak}_{std} \right]^{1/2}$$

This error value for the peak is then plugged into the formula for the constant K_{std} in order to yield an error associated with K_{std}, or Error of K_{std}. An additional error associated with the concentration of the standard (i.e. the "error" of the concentration value) is not used in this analysis because the current software package is incapable of handling this variable.

Other potential sources of error which affect the calculated values of K include variations in the neutron flux received by each sample due to the sample's position in the reactor, errors in weighing the samples and standards, errors related to the determination of the concentration of elements in the standards (leading to later calculation errors), and errors due to non-homogeneous standards (Meyers and Denies 1972: 21). Due to the many sources of error, Birdsall (personnal communication 1991) estimates that the final concentration values obtained from INAA at this facility are within ± 10% of the true values for these concentrations.

Once the K_{std} values and associated error values for each element in the standard are calculated, the mean K_{std} (or K_{std} "bar") is calculated using the equation:

$$\bar{K}_{std} = \left(\sum_{i=1}^{n} K_{std_i} \right) / n$$

where n = number of standards in each batch

and the error of K_{std} (error K_{std} "bar") is calculated according to the equation:

$$\text{Error of } \bar{K}_{std} = \left\{ \left(\sum_{i=1}^{n} [\text{Error of } K_{std_i}]^2 \right)^{1/2} \right\} / n$$

(Edward Birdsall, personal communication 1991).

The second part of the computer calculation involves the calculation of the concentrations of elements in each sample. This is done according to the following equation:

$$\text{Conc}_{spl} = \frac{\left[(\text{Peak area}_{spl} - \text{Background area}_{spl}) / \text{live counting time}_{spl} \right] e^{(0.693)(t/T)}}{(\text{Mass}_{spl})} \Bigg/ \bar{K}_{std}$$

where $\bar{K}_{std}$, t and T are as defined above.

(Edward Birdsall, personal communication 1991).

Likewise, the calculation of the counting error associated with each peak in the sample is analogous to the calculation performed for the standards. Thus

$$\text{Error of Peak}_{spl} = \left[2(\text{background area}_{spl}) + \text{area of peak}_{spl} \right]^{1/2}$$

The concentration represented by this error estimate is obtained by plugging this value into the formula for determining the concentration of each element in the sample, or Conc_{spl}. Once the concentration errors related to each peak in the standards and samples are established, a "standard deviation" (or error estimate for each concentration measurement) can be determined for each concentration determination according to the equation:

$$\text{Std. Deviation} = \left\{ \left(\sum_{1}^{n} [\text{Error of } \bar{K}_{std}]^2 + [\text{Error of sample}]^2 \right)^{1/2} \right\} / \, n$$

The concentration values for each of the elements, as well as the associated standard deviation values for each sample are reported in Appendix A.

5 If the greatest amount of Iron in the samples is 7.1%, and the least amount of Iron in the bits is 82.5%, then the greatest level of contamination of the samples by the bits is

$$\left[(7.1\% \text{ Fe in samples}) / (82.5\% \text{ Fe in bits}) \right] \times 100\% = 8.6\%$$

APPENDICES

APPENDIX A

APPENDIX A

Concentration and Standard Deviation Results (All Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM) COUNTED AFTER 1 WEEK OF DECAY					
SPL #	Barium (123.7 KEV) Conc (ppm)	Barium (123.7 KEV) % Std Dev	Barium (373.2 KEV) Conc (ppm)	Barium (373.2 KEV) % Std Dev	Barium (496.3 KEV) Conc (ppm)	Barium (496.3 KEV) % Std Dev
Ck Std (batch 1)	1380	2.75	1520	11.5	1510	3.55
Ck Std (batch 2)	1350	2.61	1280	11.2	1430	3.67
Ck Std (batch 3)	1460	2.42	1330	10.7	1410	3.68
Ck Std (batch 4)	1420	3.96	1320	17.2	1570	5.95
1	665	3.57	892	11.6	747	4.19
2	625	3.76	558	16.2	586	5.10
3	528	4.51	499	21.1	701	5.39
4	619	5.44	796	20.1	633	7.37
5	620	4.01	558	17.7	588	5.48
6	748	3.31	931	11.6	812	4.36
7	861	3.38	951	13.7	1080	4.24
8 N1	913	2.87	1240	10.3	976	3.86
8 N2	881	3.10	1070	11.1	950	4.09
9	727	3.66	860	13.4	730	4.80
10	833	2.98	1180	10.2	876	3.86
11	633	3.51	822	11.6	717	4.22
12	715	3.28	782	12.6	718	4.54
13	415	6.45	582	19.4	452	7.87
14	464	4.50	486	17.2	517	5.49
15	548	4.95	517	23.5	610	6.65
16	571	4.04	928	9.31	653	4.62
17	575	3.85	737	12.8	578	4.89
18	570	3.64	554	14.6	608	4.47
19	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
20	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
21	580	3.98	649	14.5	617	5.07
22	758	3.03	1060	9.95	796	4.26
23	678	3.37	899	10.8	773	4.32
24	741	3.80	849	14.5	778	5.10
25	542	3.88	556	14.9	529	5.22
26	654	3.30	751	12.1	704	4.35
27	660	3.11	582	13.4	704	4.25
28	228	8.10	104	66.7	326	8.56
29	750	2.95	795	10.8	845	3.82
30	679	2.84	927	9.09	803	3.39
31	588	3.55	810	10.5	660	4.35
32	770	3.34	732	13.4	941	3.99

APPENDIX A (cont'd)

Concentration and Standard Deviation Results (All Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM) COUNTED AFTER 1 WEEK OF DECAY					
SPL #	Barium (123.7 KEV) Conc (ppm)	Barium (123.7 KEV) % Std Dev	Barium (373.2 KEV) Conc (ppm)	Barium (373.2 KEV) % Std Dev	Barium (496.3 KEV) Conc (ppm)	Barium (496.3 KEV) % Std Dev
33	326	4.93	364	11.8	339	4.00
34	402	3.87	477	9.37	374	3.67
35	248	6.77	329	13.0	349	4.00
36	198	6.46	357	10.4	263	4.45
37	219	4.84	282	11.7	257	4.57
38	225	4.87	290	12.3	230	4.95
39	156	6.67	206	18.2	187	6.60
40	120	7.43	153	20.6	146	7.50
41	470	3.70	479	13.8	478	4.90
42	451	3.93	398	16.5	470	5.29
43	249	5.37	270	20.3	305	6.31
44	736	3.26	643	15.7	818	4.58
45	149	8.66	111	37.2	184	9.40
46	35.8	26.60	58.5	49.8	88.3	11.20
47	229	5.29	204	21.1	260	6.21
48	528	3.63	505	15.3	593	4.81
49	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
50	603	3.92	475	19.4	681	5.24
51	648	3.20	713	11.4	736	4.04
52	836	2.89	746	11.7	973	3.54
53 N1	639	3.47	638	13.4	720	4.57
53 N2	625	3.21	666	11.8	681	4.28
54	730	3.21	710	13.4	772	4.34
55	751	2.62	1100	8.48	842	3.58
56	654	3.17	746	12.0	756	4.12
57	705	3.33	812	11.3	906	3.92
58	595	3.23	614	11.5	605	4.3
59	726	3.03	933	10.6	841	3.75
60	267	5.19	270	17.8	299	5.85
Bit 1-1 (lot 442988)	<497	not detectable	<2440	not detectable	<844	not detectable
Bit 1-2 (lot 442988)	<476	not detectable	<2280	not detectable	<799	not detectable
Bit 2-1 (lot 555828)	<819	not detectable	<3810	not detectable	<1310	not detectable
Bit 2-2 (lot 555828)	<728	not detectable	<3420	not detectable	<1190	not detectable
Bit 3-1 (lot 625828)	<505	not detectable	<2450	not detectable	<855	not detectable
Bit 3-1 (lot 625828)	<467	not detectable	<2270	not detectable	<791	not detectable

APPENDIX A (cont'd)

Concentration and Standard Deviation Results (All Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM) COUNTED AFTER 1 WEEK OF DECAY					
SPL #	Bromine (554.4 KEV) Conc (ppm)	Bromine (554.4 KEV) % Std Dev	Bromine (776.6 KEV) Conc (ppm)	Bromine (776.6 KEV) % Std Dev	Lanthanum (815 KEV) Conc (ppm)	Lanthanum (815 KEV) % Std Dev
Ck Std (batch 1)	1.97	13.9	<1.15	not detectable	83.3	0.839
Ck Std (batch 2)	1.78	47.7	not in stds	not detectable	85.8	1.40
Ck Std (batch 3)	<1.56	not detectable	not in stds	not detectable	84.4	1.33
Ck Std (batch 4)	1.25	37.6	1.80	30.5	83.8	0.994
1	2.35	8.77	4.4	14.0	33.6	1.03
2	1.56	10.6	2.25	17.3	30.2	1.25
3	1.41	13.4	1.20	23.5	19.1	1.91
4	4.65	8.37	7.90	13.8	44.9	1.29
5	2.53	9.37	4.57	14.4	36.8	1.14
6	1.91	10.9	3.69	15.7	34.7	1.09
7	0.683	24.8	1.12	29.8	36.4	1.35
8 N1	1.12	15.3	2.55	17.5	37.0	1.11
8 N2	1.54	13.7	2.43	19.9	35.6	1.27
9	1.53	14.4	1.89	23.4	36.8	1.32
10	0.973	18.0	1.03	28.6	30.9	1.36
11	2.33	9.92	4.90	14.3	26.8	1.45
12	2.44	10.0	4.02	15.1	35.8	1.25
13	2.08	12.4	3.90	18.0	32.0	1.68
14	2.65	9.07	4.70	14.3	23.3	1.70
15	2.99	10.9	5.50	16.2	44.3	1.43
16	2.61	10.0	4.68	14.1	37.6	1.18
17	2.24	10.7	3.14	15.8	31.9	1.36
18	1.88	11.6	3.81	15.0	33.7	1.35
19	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
20	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
21	2.10	11.8	3.45	18.0	37.6	1.31
22	1.13	18.3	1.00	39.6	31.9	1.54
23	2.67	10.5	4.65	15.2	36.9	1.39
24	1.82	15.8	4.15	18.2	34.5	1.77
25	2.12	11.6	2.73	19.5	25.2	1.69
26	1.42	16.3	0.998	34.9	23.6	1.91
27	1.52	30.5	not in stds	not detectable	38.7	1.53
28	1.98	30.9	not in stds	not detectable	32.7	1.83
29	1.94	29.4	not in stds	not detectable	32.7	1.87
30	1.93	27.7	not in stds	not detectable	17.2	2.56
31	2.53	27.4	not in stds	not detectable	33.9	1.71
32	1.72	35.0	not in stds	not detectable	36.0	1.93

APPENDIX A (cont'd)

Concentration and Standard Deviation Results (All Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM) COUNTED AFTER 1 WEEK OF DECAY					
SPL #	Bromine (554.4 KEV) Conc (ppm)	Bromine (554.4 KEV) % Std Dev	Bromine (776.6 KEV) Conc (ppm)	Bromine (776.6 KEV) % Std Dev	Lanthanum (815 KEV) Conc (ppm)	Lanthanum (815 KEV) % Std Dev
33	3.10	22.8	not in stds	not detectable	8.78	2.65
34	2.19	23.0	not in stds	not detectable	5.01	3.96
35	3.39	22.7	not in stds	not detectable	7.33	3.12
36	2.46	23.2	not in stds	not detectable	5.02	3.99
37	1.93	24.1	not in stds	not detectable	5.35	3.85
38	3.39	22.7	not in stds	not detectable	5.88	3.76
39	<.472	not detectable	not in stds	not detectable	5.84	5.12
40	0.584	42.2	not in stds	not detectable	4.73	5.37
41	1.45	34.8	not in stds	not detectable	22.5	2.49
42	3.19	26.8	not in stds	not detectable	26.0	2.29
43	8.12	22.5	not in stds	not detectable	12.7	3.81
44	1.56	49.4	not in stds	not detectable	45.9	2.02
45	9.70	22.4	not in stds	not detectable	12.8	3.68
46	7.90	22.3	not in stds	not detectable	2.78	8.66
47	5.31	23.2	not in stds	not detectable	7.64	5.17
48	2.58	30.2	not in stds	not detectable	36.3	2.06
49	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
50	4.09	28.6	not in stds	not detectable	35.5	2.65
51	2.45	21.5	not in stds	not detectable	32.7	1.72
52	4.25	19.2	not in stds	not detectable	61.0	1.25
53 N1	2.78	21.5	not in stds	not detectable	32.2	1.96
53 N2	3.01	22.0	not in stds	not detectable	32.2	1.90
54	1.53	31.4	not in stds	not detectable	36.7	1.87
55	2.37	22.5	not in stds	not detectable	33.6	1.74
56	1.37	34.0	not in stds	not detectable	36.5	1.83
57	1.66	31.7	not in stds	not detectable	35.2	2.05
58	2.65	22.8	not in stds	not detectable	25.3	2.24
59	4.52	19.4	not in stds	not detectable	33.3	2.01
60	6.53	17.3	not in stds	not detectable	9.42	4.18
Bit 1-1 (lot 442988)	<4.31	not detectable	<3.99	not detectable	<2.93	not detectable
Bit 1-2 (lot 442988)	<4.53	not detectable	<4.44	not detectable	<3.24	not detectable
Bit 2-1 (lot 555828)	<6.83	not detectable	<6.65	not detectable	<4.58	not detectable
Bit 2-2 (lot 555828)	<6.83	not detectable	<6.99	not detectable	<5.12	not detectable
Bit 3-1 (lot 625828)	<4.81	not detectable	<4.60	not detectable	<3.14	not detectable
Bit 3-1 (lot 625828)	<4.62	not detectable	<4.73	not detectable	<3.42	not detectable

APPENDIX A (cont'd)

Concentration and Standard Deviation Results (All Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM) COUNTED AFTER 1 WEEK OF DECAY					
	Lutetium	Lutetium	Molybde'm	Molybde'm	Molybde'm	Molybde'm
SPL #	(208.5 KEV)	(208.5 KEV)	(140.5 KEV)	(140.5 KEV)	(739.7 KEV)	(739.7 KEV)
	Conc (ppm)	% Std Dev	Conc (ppm)	% Std Dev	Conc (ppm)	% Std Dev
Ck Std (batch 1)	1.10	1.66	29.8	4.06	25.5	40.8
Ck Std (batch 2)	1.13	1.75	29.5	4.94	not in stds	not detectable
Ck Std (batch 3)	1.09	1.77	28.1	5.08	<60.5	not detectable
Ck Std (batch 4)	1.16	2.39	27.4	5.31	not in stds	not detectable
1	0.331	2.94	<1.3	not detectable	<11.3	not detectable
2	0.291	3.29	4.20	13.1	<11.1	not detectable
3	0.261	3.37	5.14	13.0	<12.4	not detectable
4	0.395	3.94	5.84	13.7	<17.6	not detectable
5	0.457	2.52	<1.61	not detectable	<12.8	not detectable
6	0.342	2.91	5.58	10.4	<12.4	not detectable
7	0.399	2.96	6.62	12.2	<14.9	not detectable
8 N1	0.364	2.78	4.05	15.8	<13.1	not detectable
8 N2	0.352	3.16	4.35	14.5	<13.9	not detectable
9	0.397	2.91	6.53	11.0	<14.3	not detectable
10	0.347	3.07	5.88	11.1	<12.8	not detectable
11	0.257	3.54	<1.39	not detectable	<11.9	not detectable
12	0.396	2.57	3.59	16.4	<12.9	not detectable
13	0.269	4.47	<1.89	not detectable	<15.8	not detectable
14	0.237	3.52	<1.34	not detectable	<11.8	not detectable
15	0.319	3.72	<2.04	not detectable	<17.3	not detectable
16	0.397	2.51	5.06	13.9	<13.0	not detectable
17	0.290	3.17	2.82	21.8	<12.3	not detectable
18	0.314	3.04	<1.42	not detectable	<12.4	not detectable
19	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
20	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
21	0.333	3.06	6.30	11.4	<13.3	not detectable
22	0.361	3.00	6.64	10.9	<14.2	not detectable
23	0.312	3.29	<1.57	not detectable	<13.6	not detectable
24	0.278	4.34	<1.99	not detectable	<16.9	not detectable
25	0.267	3.41	3.52	14.3	<12.0	not detectable
26	0.254	3.58	5.29	12.4	<12.9	not detectable
27	0.358	2.66	4.46	15.9	not in stds	not detectable
28	0.363	3.11	6.39	12.1	not in stds	not detectable
29	0.301	3.21	3.07	22.5	not in stds	not detectable
30	0.132	5.50	<1.37	not detectable	not in stds	not detectable
31	0.297	3.13	3.14	20.2	not in stds	not detectable
32	0.445	2.74	4.72	18.9	not in stds	not detectable

APPENDIX A (cont'd)

Concentration and Standard Deviation Results (All Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM) COUNTED AFTER 1 WEEK OF DECAY					
SPL #	Lutetium (208.5 KEV) Conc (ppm)	Lutetium (208.5 KEV) % Std Dev	Molybde'm (140.5 KEV) Conc (ppm)	Molybde'm (140.5 KEV) % Std Dev	Molybde'm (739.7 KEV) Conc (ppm)	Molybde'm (739.7 KEV) % Std Dev
33	0.0696	6.46	<1.02	not detectable	not in stds	not detectable
34	0.040	9.82	<.952	not detectable	not in stds	not detectable
35	0.036	12.0	<1.09	not detectable	not in stds	not detectable
36	0.105	3.99	<.897	not detectable	not in stds	not detectable
37	0.083	4.81	<.845	not detectable	not in stds	not detectable
38	0.0462	8.31	<.884	not detectable	not in stds	not detectable
39	0.0334	11.50	<.933	not detectable	not in stds	not detectable
40	0.0481	7.58	0.998	25.7	not in stds	not detectable
41	0.245	3.17	2.56	25.7	not in stds	not detectable
42	0.295	2.92	3.77	16.4	not in stds	not detectable
43	0.148	4.77	<1.33	not detectable	not in stds	not detectable
44	0.301	4.06	4.05	22.2	not in stds	not detectable
45	0.154	4.65	<1.36	not detectable	not in stds	not detectable
46	0.0324	12.60	2.04	20.8	not in stds	not detectable
47	0.0918	6.27	2.62	20.8	not in stds	not detectable
48	0.308	2.58	<1.89	not detectable	not in stds	not detectable
49	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
50	0.318	3.8	4.49	22.9	not in stds	not detectable
51	0.330	2.52	5.40	13.5	<31.6	not detectable
52	0.356	2.82	4.18	19.9	<33.6	not detectable
53 N1	0.339	2.67	4.83	14.2	<36.2	not detectable
53 N2	0.336	2.72	5.79	12.5	<34.9	not detectable
54	0.355	3.04	5.94	14.4	<38.2	not detectable
55	0.299	3.09	<1.54	not detectable	<30.9	not detectable
56	0.350	2.80	6.61	11.9	<36.8	not detectable
57	0.324	3.24	6.07	15.6	<40.1	not detectable
58	0.231	3.49	5.38	14.4	<30.2	not detectable
59	0.315	3.15	5.26	15.9	<36.0	not detectable
60	0.0780	6.21	<1.24	not detectable	<21.9	not detectable
Bit 1-1 (lot 442988)	<.180	not detectable	71.4	8.71	not in stds	not detectable
Bit 1-2 (lot 442988)	<.172	not detectable	71.3	10.1	not in stds	not detectable
Bit 2-1 (lot 555828)	<.295	not detectable	75.6	15.8	not in stds	not detectable
Bit 2-2 (lot 555828)	<.261	not detectable	280	4.89		not detectable
Bit 3-1 (lot 625828)	<.183	not detectable	146	10.1	not in stds	not detectable
Bit 3-1 (lot 625828)	<.171	not detectable	138	5.50	not in stds	not detectable

APPENDIX A (cont'd)

Concentration and Standard Deviation Results (All Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM) COUNTED AFTER 1 WEEK OF DECAY					
SPL #	Neodymium (91.2 KEV)	Neodymium (91.2 KEV)	Neodymium (531.2 KEV)	Neodymium (531.2 KEV)	Samarium (103.2 KEV)	Samarium (103.2 KEV)
	Conc (ppm)	% Std Dev	Conc (ppm)	% Std Dev	Conc (ppm)	% Std Dev
Ck Std (batch 1)	65.8	5.02	80.4	10.6	16.8	0.189
Ck Std (batch 2)	79.3	4.44	68.6	12.3	17.6	0.266
Ck Std (batch 3)	75.0	4.08	68.7	11.9	17.3	0.250
Ck Std (batch 4)	89.3	7.52	80.9	16.3	16.8	0.241
1	24.9	8.26	30.2	16.0	5.67	0.271
2	20.5	9.33	14.6	29.2	4.37	0.316
3	11.7	17.4	10.9	41.6	3.14	0.459
4	29.4	11.3	35.2	19.6	6.97	0.377
5	29.3	8.41	41.0	13.3	7.69	0.263
6	26.6	8.01	26.9	17.5	5.39	0.311
7	24.9	10.0	31.2	18.7	6.40	0.324
8 N1	29.4	7.40	22.7	20.7	6.07	0.294
8 N2	26.5	8.59	30.5	15.6	5.82	0.323
9	28.2	8.29	22.7	21.0	6.44	0.308
10	26.0	7.54	24.4	18.3	5.23	0.321
11	16.0	11.6	17.9	21.3	3.65	0.399
12	31.6	6.65	23.2	17.7	6.52	0.292
13	27.8	8.97	37.0	15.8	5.26	0.421
14	16.3	10.6	27.9	15.0	3.95	0.389
15	30.8	9.23	36.6	17.0	5.38	0.435
16	31.3	6.47	29.0	15.3	6.42	0.296
17	24.4	7.67	21.4	18.7	5.10	0.345
18	27.2	6.84	20.8	17.9	5.26	0.339
19	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
20	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
21	28.0	7.02	19.8	21.5	5.22	0.355
22	24.1	7.99	35.1	13.8	4.78	0.382
23	26.2	8.05	25.4	18.2	5.42	0.357
24	28.3	8.62	28.2	20.8	5.46	0.439
25	20.5	1.73	30.4	14.1	4.25	0.406
26	18.7	9.60	21.7	18.2	3.93	0.437
27	31.9	5.85	36.0	13.4	6.33	0.359
28	27.2	7.43	29.0	17.0	5.30	0.448
29	25.9	7.29	25.8	17.4	5.28	0.436
30	10.3	14.5	17.0	21.6	2.16	0.752
31	29.2	6.51	29.2	14.7	5.36	0.432
32	27.0	7.91	32.3	16.4	5.88	0.458

APPENDIX A (cont'd)

Concentration and Standard Deviation Results (All Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM) COUNTED AFTER 1 WEEK OF DECAY					
SPL #	Neodymium (91.2 KEV) Conc (ppm)	Neodymium (91.2 KEV) % Std Dev	Neodymium (531.2 KEV) Conc (ppm)	Neodymium (531.2 KEV) % Std Dev	Samarium (103.2 KEV) Conc (ppm)	Samarium (103.2 KEV) % Std Dev
33	1.17	102.4	2.79	50.1	0.582	2.11
34	2.72	40.7	<3.03	not detectable	0.609	1.92
35	4.88	24.1	6.73	24.8	0.545	2.41
36	3.15	30.2	3.16	41.1	0.611	1.77
37	2.44	35.9	4.97	27.4	0.733	1.40
38	6.45	16.9	2.95	49.3	0.751	1.40
39	2.95	31.2	6.63	31.9	0.517	1.94
40	3.37	25.7	4.16	37.1	0.635	1.64
41	18.8	7.72	27.5	13.8	3.81	0.530
42	21.7	7.35	31.2	13.5	4.65	0.496
43	9.35	13.2	8.16	33.5	1.82	0.863
44	35.5	6.32	30.4	17.4	6.12	0.514
45	11.6	12.3	8.13	31.6	1.93	0.867
46	1.32	65.6	<3.46	not detectable	0.355	2.84
47	4.57	22.7	1.39	160	1.10	1.21
48	27.6	6.64	29.0	14.8	5.03	0.550
49	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
50	28.7	7.81	29.8	17.4	5.42	0.642
51	27.5	6.34	29.9	15.6	5.49	0.396
52	45.6	4.70	44.0	12.0	7.99	0.334
53 N1	25.8	7.12	22.4	20.1	4.79	0.458
53 N2	23.5	7.39	20.1	21.3	4.65	0.454
54	28.6	6.74	27.3	17.4	5.70	0.423
55	26.9	6.18	35.6	12.0	5.38	0.404
56	29.3	6.28	19.2	21.1	5.48	0.441
57	26.0	7.77	20.0	23.0	4.82	0.516
58	18.4	8.42	18.2	19.4	3.65	0.555
59	26.7	6.67	21.9	17.9	5.15	0.496
60	5.90	19.1	6.39	36.4	1.46	1.01
Bit 1-1 (lot 442988)	<50.1	not detectable	<103	not detectable	<0.143	not detectable
Bit 1-2 (lot 442988)	<47.5	not detectable	<98.8	not detectable	<0.147	not detectable
Bit 2-1 (lot 555828)	<83.4	not detectable	<160	not detectable	<0.242	not detectable
Bit 2-2 (lot 555828)	<73.2	not detectable	<149	not detectable	<0.231	not detectable
Bit 3-1 (lot 625828)	<50.5	not detectable	<105	not detectable	<0.149	not detectable
Bit 3-1 (lot 625828)	<46.9	not detectable	<98.6	not detectable	<0.148	not detectable

APPENDIX A (cont'd)

Concentration and Standard Deviation Results (All Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM) COUNTED AFTER 1 WEEK OF DECAY					
SPL #	Uranium (99.5 KEV) Conc (ppm)	Uranium (99.5 KEV) % Std Dev	Uranium (106.1 KEV) Conc (ppm)	Uranium (106.1 KEV) % Std Dev	Uranium (277.7 KEV) Conc (ppm)	Uranium (277.7 KEV) % Std Dev
Ck Std (batch 1)	8.92	1.75	10.2	1.66	10.1	3.63
Ck Std (batch 2)	12.3	1.36	14.6	2.83	9.97	5.37
Ck Std (batch 3)	9.74	1.32	13.3	2.58	9.81	5.21
Ck Std (batch 4)	10.2	3.08	10.3	2.17	9.68	4.92
1	<.115	not detectable	1.31	5.94	2.32	7.48
2	0.617	8.03	1.54	4.93	1.92	8.47
3	4.75	2.22	3.76	2.65	3.56	5.25
4	<.203	not detectable	1.29	10.2	2.12	12.6
5	1.73	4.27	2.15	4.66	3.23	6.50
6	<.131	not detectable	1.77	5.02	2.34	7.9
7	<.159	not detectable	1.83	5.72	2.71	8.47
8 N1	<.135	not detectable	1.57	5.74	2.10	8.93
8 N2	<.144	not detectable	1.52	6.35	2.03	9.83
9	<.149	not detectable	1.58	6.31	2.09	9.31
10	0.923	6.58	1.50	5.67	2.23	8.05
11	<.127	not detectable	1.42	5.98	1.97	8.73
12	<.142	not detectable	1.86	5.00	2.89	6.90
13	<.180	not detectable	1.79	6.51	2.41	9.22
14	<.123	not detectable	2.05	4.06	2.20	8.26
15	<.183	not detectable	1.26	9.81	2.23	11.5
16	<.149	not detectable	3.49	2.80	3.76	5.60
17	<.131	not detectable	1.19	7.33	1.66	10.80
18	1.01	7.48	1.03	8.53	1.28	13.20
19	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
20	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
21	0.750	8.37	1.64	5.8	2.45	8.10
22	0.975	6.64	2.27	4.07	3.07	7.04
23	<.146	not detectable	1.39	6.92	1.79	11.3
24	<.183	not detectable	1.38	8.88	1.74	14.4
25	0.759	8.35	1.21	6.77	1.93	9.47
26	<.14	not detectable	1.50	6.35	2.47	8.64
27	<.108	not detectable	2.05	7.52	1.63	13.9
28	0.845	6.88	2.69	6.29	3.63	7.81
29	<.116	not detectable	2.33	7.27	2.40	10.6
30	<.0921	not detectable	0.911	15.2	0.815	23.7
31	<.111	not detectable	1.47	11.2	2.20	11.2
32	<.133	not detectable	<.396	not detectable	3.22	9.44

APPENDIX A (cont'd)

Concentration and Standard Deviation Results (All Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM) COUNTED AFTER 1 WEEK OF DECAY					
SPL #	Uranium (99.5 KEV) Conc (ppm)	Uranium (99.5 KEV) % Std Dev	Uranium (106.1 KEV) Conc (ppm)	Uranium (106.1 KEV) % Std Dev	Uranium (277.7 KEV) Conc (ppm)	Uranium (277.7 KEV) % Std Dev
33	<.0658	not detectable	<.216	not detectable	<.227	not detectable
34	0.188	18.0	<.203	not detectable	<.214	not detectable
35	<.0697	not detectable	<.23	not detectable	<.235	not detectable
36	<.0585	not detectable	<.192	not detectable	<.203	not detectable
37	<.0548	not detectable	0.357	23	<.201	not detectable
38	<.0573	not detectable	<.184	not detectable	0.350	30.6
39	0.222	14.6	0.272	34.2	0.181	59.0
40	<.0527	not detectable	<.169	not detectable	0.237	44.4
41	2.34	2.63	1.73	8.76	1.39	15.4
42	<.110	not detectable	1.77	8.60	2.40	10.6
43	2.05	2.77	3.53	4.61	2.30	8.83
44	5.40	1.91	1.93	12.1	2.39	13.9
45	1.54	3.62	3.24	5.07	2.18	8.69
46	0.483	6.16	1.61	7.92	1.11	12.3
47	1.53	3.20	2.18	6.36	1.29	14.1
48	<.131	not detectable	1.36	13.2	1.36	19.1
49	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
50	<.171	not detectable	1.82	13.7	1.94	17.4
51	0.581	8.60	2.08	7.22	2.40	9.97
52	<.139	not detectable	1.68	10.1	2.40	11.0
53 N1	4.84	1.64	2.3	7.27	2.38	11.1
53 N2	4.57	1.67	2.29	7.09	2.13	12.0
54	4.83	1.72	1.75	9.95	2.05	13.5
55	<.115	not detectable	1.59	9.32	1.89	11.5
56	5.42	1.58	2.40	7.37	3.18	8.73
57	0.457	13.1	2.6	7.76	3.23	9.30
58	<.115	not detectable	1.69	9.17	1.92	12.2
59	4.73	1.77	1.35	12.8	1.66	15.4
60	1.60	3.36	2.86	4.92	2.81	7.43
Bit 1-1 (lot 442988)	<1.86	not detectable	3.42	28.1	<3.90	not detectable
Bit 1-2 (lot 442988)	<1.86	not detectable	3.95	22.7	<3.89	not detectable
Bit 2-1 (lot 555828)	<3.13	not detectable	4.14	36.7	<6.26	not detectable
Bit 2-2 (lot 555828)	<2.95	not detectable	2.36	64.2	<5.93	not detectable
Bit 3-1 (lot 625828)	<1.91	not detectable	1.88	52.8	<4.00	not detectable
Bit 3-1 (lot 625828)	<1.88	not detectable	2.11	46.2	<3.92	not detectable

APPENDIX A (cont'd)

Concentration and Standard Deviation Results (All Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM) COUNTED AFTER 1 WEEK OF DECAY			
SPL #	Ytterbium (282.5 KEV) Conc (ppm)	Ytterbium (282.5 KEV) % Std Dev	Ytterbium (396.5 KEV) Conc (ppm)	Ytterbium (396.5 KEV) % Std Dev
Ck Std (batch 1)	7.38	2.73	7.47	1.66
Ck Std (batch 2)	7.16	3.08	7.70	1.98
Ck Std (batch 3)	7.31	2.66	6.70	1.74
Ck Std (batch 4)	6.82	4.15	7.32	2.31
1	2.48	4.43	2.38	2.73
2	2.12	5.07	2.25	3.02
3	2.07	5.82	2.21	3.05
4	3.05	5.77	3.00	3.52
5	3.39	3.86	3.50	2.29
6	2.42	4.6	2.36	2.94
7	3.07	4.36	3.21	2.79
8 N1	2.55	4.7	2.41	2.89
8 N2	2.67	4.73	2.51	3.11
9	2.70	4.87	2.74	2.87
10	2.48	4.55	2.37	2.68
11	1.55	6.63	1.70	3.35
12	2.94	3.98	2.82	2.49
13	1.96	6.74	2.04	4.29
14	1.74	5.85	1.87	3.46
15	2.50	5.77	2.54	3.59
16	2.72	4.26	2.90	2.56
17	2.28	4.72	2.22	3.06
18	2.31	4.66	2.30	2.98
19	NOT RUN	NOT RUN	NOT RUN	NOT RUN
20	NOT RUN	NOT RUN	NOT RUN	NOT RUN
21	2.06	5.51	2.41	3.03
22	2.24	5.12	2.41	3.11
23	2.00	5.79	2.16	3.22
24	1.97	7.19	2.12	3.96
25	1.78	5.51	1.94	3.37
26	1.88	5.7	1.95	3.26
27	2.49	4.32	2.83	2.53
28	2.38	4.97	2.60	3.04
29	2.03	5.30	2.46	2.79
30	0.990	8.63	0.984	5.63
31	2.18	4.85	2.31	2.92
32	2.38	5.32	2.71	3.11

APPENDIX A (cont'd)

Concentration and Standard Deviation Results (All Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM) COUNTED AFTER 1 WEEK OF DECAY			
SPL #	Ytterbium (282.5 KEV) Conc (ppm)	Ytterbium (282.5 KEV) % Std Dev	Ytterbium (396.5 KEV) Conc (ppm)	Ytterbium (396.5 KEV) % Std Dev
33	0.497	10.50	0.499	5.35
34	0.218	19.50	0.310	8.61
35	0.189	23.50	0.271	9.69
36	0.792	6.34	0.766	3.44
37	0.460	9.48	0.420	5.72
38	0.300	15.0	0.340	7.47
39	0.210	23.0	0.247	12.1
40	0.245	16.7	0.282	8.31
41	1.41	6.33	1.61	3.48
42	2.21	4.58	2.03	3.13
43	0.732	9.83	0.757	5.99
44	1.82	7.73	2.02	4.6
45	0.802	8.95	0.822	5.61
46	0.124	32.5	0.163	15.3
47	0.595	10.3	0.480	7.67
48	2.02	5.54	2.39	3.21
49	NOT RUN	NOT RUN	NOT RUN	NOT RUN
50	2.36	6.04	2.46	3.77
51	2.10	4.78	2.44	2.75
52	2.72	4.37	2.93	2.57
53 N1	2.08	5.24	2.70	2.87
53 N2	1.94	5.71	2.41	3.00
54	2.51	4.87	2.61	3.10
55	1.95	5.18	2.40	2.65
56	2.42	4.59	2.42	3.11
57	2.22	5.59	2.54	3.18
58	1.50	6.37	1.67	3.82
59	2.31	4.99	2.37	3.20
60	0.761	9.00	0.738	6.12
Bit 1-1 (lot 442988)	<2.25	not detectable	<1.25	not detectable
Bit 1-2 (lot 442988)	<2.18	not detectable	<1.21	not detectable
Bit 2-1 (lot 555828)	<3.60	not detectable	<1.97	not detectable
Bit 2-2 (lot 555828)	<3.29	not detectable	<1.84	not detectable
Bit 3-1 (lot 625828)	<2.27	not detectable	<1.27	not detectable
Bit 3-1 (lot 625828)	<2.16	not detectable	<1.22	not detectable

APPENDIX A (cont'd)

Concentration and Standard Deviation Results (All Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM) COUNTED AFTER 5 WEEKS OF DECAY					
SPL #	Antimony (1690.7 KEV)	Antimony (1690.7 KEV)	Cerium (145.5 KEV)	Cerium (145.5 KEV)	Cesium (795.9 KEV)	Cesium (795.9 KEV)
	Conc (ppm)	% Std Dev	Conc (ppm)	% Std Dev	Conc (ppm)	% Std Dev
Ck Std (batch 1)	6.67	4.19	169	0.750	9.73	2.60
Ck Std (batch 2)	6.75	4.86	180	0.761	10.8	2.93
Ck Std (batch 3)	6.75	4.68	182	0.759	10.9	2.94
Ck Std (batch 4)	6.12	11.2	170	1.66	10.8	7.02
1	0.323	21.2	73.8	0.799	3.47	3.41
2	0.783	11.0	67.2	0.903	3.95	3.35
3	0.774	11.2	41.7	1.54	4.98	3.01
4	0.525	20.2	102	1.02	2.37	7.34
5	0.455	20.1	87.9	0.847	4.47	3.22
6	<.191	not detectable	73.6	0.925	5.98	2.59
7	0.633	15.5	85.9	0.970	4.32	3.84
8 N1	0.622	17.9	92.6	0.846	5.73	2.77
8 N2	0.549	15.2	82.9	0.952	4.97	3.17
9	0.483	20.7	71.4	1.16	4.96	3.38
10	<.187	not detectable	60.1	1.21	5.06	2.91
11	<.166	not detectable	55.1	1.26	1.83	6.66
12	0.413	18.8	66.9	1.11	4.26	3.25
13	<.216	not detectable	58.5	1.51	4.81	3.65
14	0.413	15.8	46.9	1.36	3.75	3.35
15	1.27	10.4	106	0.986	3.71	4.64
16	<.179	not detectable	81.6	0.925	5.10	2.77
17	0.674	11.0	58.1	1.15	3.77	3.34
18	0.417	17.0	55.1	1.18	3.45	3.50
19	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
20	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
21	<.188	not detectable	70.2	1.04	4.89	2.99
22	0.745	13.8	58.6	1.23	7.70	2.25
23	0.727	13.1	61.7	1.15	3.74	3.57
24	0.707	15.3	64.1	1.36	3.26	4.93
25	0.412	15.0	44.5	1.38	2.45	4.62
26	0.426	17.8	47.3	1.36	5.50	2.56
27	0.419	26.7	79.3	0.972	3.02	4.81
28	1.92	7.88	78.1	1.10	6.16	3.32
29	0.520	16.5	66.8	1.15	6.84	2.85
30	0.222	24.1	31.8	1.86	3.44	3.97
31	0.466	18.4	68.1	1.10	2.91	5.18
32	0.562	22.0	97.7	0.966	7.02	3.10

APPENDIX A (cont'd)

Concentration and Standard Deviation Results (All Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM) COUNTED AFTER 5 WEEKS OF DECAY					
	Antimony	Antimony	Cerium	Cerium	Cesium	Cesium
SPL #	(1690.7 KEV)	(1690.7 KEV)	(145.5 KEV)	(145.5 KEV)	(795.9 KEV)	(795.9 KEV)
	Conc (ppm)	% Std Dev	Conc (ppm)	% Std Dev	Conc (ppm)	% Std Dev
33	0.230	19.3	10.6	3.26	0.183	17.60
34	0.108	43.1	8.05	4.31	0.193	19.20
35	0.277	19.3	7.93	5.14	0.127	29.90
36	0.152	27.6	7.89	4.08	0.191	19.70
37	0.269	17.7	8.49	4.26	0.242	15.80
38	0.193	24.8	9.78	3.34	0.256	18.60
39	0.144	35.0	6.92	5.11	0.348	19.40
40	0.141	39.5	7.02	4.48	0.125	33.10
41	0.584	13.3	51.0	1.22	2.65	4.73
42	1.03	8.71	51.5	1.29	2.74	4.86
43	0.329	21.5	35.8	1.48	2.28	4.86
44	<.245	not detectable	106	0.947	13.4	2.30
45	0.357	18.0	28.3	1.80	2.08	5.08
46	<.120	not detectable	7.36	4.53	1.08	5.97
47	0.234	26.8	40.9	1.27	2.24	4.36
48	0.493	17.7	64.5	1.13	3.13	4.62
49	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
50	<.264	not detectable	84.8	1.14	4.16	4.79
51	0.684	14.0	66.5	1.14	5.43	3.38
52	0.489	19.3	123	0.790	4.65	3.64
53 N1	0.442	27.8	62.7	1.28	6.03	3.47
53 N2	0.551	18.7	61.1	1.21	5.76	3.44
54	0.812	14.2	78.2	1.11	5.42	3.73
55	0.515	17.1	67.4	1.07	4.15	3.78
56	0.540	20.4	76.7	10.8	6.89	2.94
57	0.994	10.7	75.0	1.15	5.80	3.46
58	0.478	15.5	54.1	1.25	5.18	3.13
59	0.973	11.2	73.4	1.07	3.61	4.39
60	0.356	18.7	25.3	1.92	1.80	5.59
Bit 1-1 (lot 442988)	11.2	15.9	<14.8	not detectable	<3.68	not detectable
Bit 1-2 (lot 442988)	8.52	19.7	<14.7	not detectable	<3.68	not detectable
Bit 2-1 (lot 555828)	23.1	17.7	<31.8	not detectable	<6.17	not detectable
Bit 2-2 (lot 555828)	15.6	19.7	<27.6	not detectable	<5.88	not detectable
Bit 3-1 (lot 625828)	11.0	16.2	<16.0	not detectable	<3.91	not detectable
Bit 3-1 (lot 625828)	8.96	17.3	<15.2	not detectable	<3.95	not detectable

APPENDIX A (cont'd)

Concentration and Standard Deviation Results (All Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM) COUNTED AFTER 5 WEEKS OF DECAY					
SPL #	Cesium (604.7 KEV)	Cesium (604.7 KEV)	Chromium (320.2 KEV)	Chromium (320.2 KEV)	Cobalt (1332.5 KEV)	Cobalt (1332.5 KEV)
	Conc (ppm)	% Std Dev	Conc (ppm)	% Std Dev	Conc (ppm)	% Std Dev
Ck Std (batch 1)	9.67	1.63	192	1.20	42.9	0.604
Ck Std (batch 2)	13.0	1.77	204	1.46	44.4	0.724
Ck Std (batch 3)	8.54	2.14	198	1.51	43.9	0.739
Ck Std (batch 4)	8.31	5.74	194	3.06	42.6	1.76
1	2.30	2.87	74.3	1.49	11.3	0.994
2	2.81	2.65	113	1.17	14.7	0.877
3	3.55	2.42	79.0	1.72	8.82	1.33
4	1.48	6.44	83.3	2.11	13.8	1.32
5	3.09	2.44	88.6	1.49	12.4	1.00
6	4.00	2.06	96.6	1.39	13.5	0.958
7	3.03	3.04	88.4	1.70	16.1	0.984
8 N1	4.08	2.14	114	1.30	17.5	0.844
8 N2	3.69	2.38	103	1.42	15.6	0.929
9	3.53	2.57	122	1.31	17.4	0.892
10	3.46	2.28	82.1	1.57	12.9	0.956
11	1.06	5.72	85.9	1.39	13.0	0.914
12	2.93	2.63	79.8	1.58	11.0	1.03
13	3.25	2.91	83.3	1.89	9.24	1.41
14	2.55	2.74	66.5	1.65	9.61	1.11
15	2.62	3.58	93.9	1.85	14.4	1.13
16	3.50	2.23	98.3	1.38	11.0	1.02
17	2.70	2.67	59.1	1.89	10.3	1.04
18	2.40	2.77	57.5	1.91	10.9	1.01
19	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
20	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
21	3.55	2.18	104	1.30	14.1	0.905
22	5.46	1.71	102	1.42	10.9	1.05
23	2.56	2.84	76.8	1.59	13.1	0.959
24	2.31	3.79	74.5	1.99	13.8	1.11
25	1.57	3.89	80.0	1.46	8.48	1.15
26	3.99	1.93	79.5	1.50	10.5	1.04
27	2.19	4.20	101	1.59	15.1	1.07
28	5.21	2.34	69.6	2.37	21.8	0.976
29	5.05	2.23	79.6	2.01	10.7	1.36
30	2.63	3.12	34.7	3.14	7.08	1.72
31	2.35	3.76	71.3	2.1	11.4	1.28
32	5.29	2.43	116	1.69	15.9	1.12

APPENDIX A (cont'd)

Concentration and Standard Deviation Results (All Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM) COUNTED AFTER 5 WEEKS OF DECAY					
SPL #	Cesium (604.7 KEV)	Cesium (604.7 KEV)	Chromium (320.2 KEV)	Chromium (320.2 KEV)	Cobalt (1332.5 KEV)	Cobalt (1332.5 KEV)
	Conc (ppm)	% Std Dev	Conc (ppm)	% Std Dev	Conc (ppm)	% Std Dev
33	0.258	9.21	2.03	21.6	0.475	7.04
34	0.136	15.1	2.62	17.0	0.452	6.46
35	0.0872	20.7	2.10	19.9	0.416	7.13
36	0.162	13.6	2.76	16.9	0.475	6.40
37	0.106	18.9	2.22	18.8	0.438	7.00
38	0.231	11.6	3.45	13.5	0.945	4.48
39	0.115	23.0	1.77	32.1	0.140	17.6
40	0.246	12.4	1.88	24.1	0.243	10.7
41	2.08	3.41	37.9	3.12	6.62	1.60
42	2.08	3.81	41.1	3.10	6.88	1.66
43	1.65	3.71	48.1	2.23	19.7	0.943
44	10.1	1.65	184	1.35	20.4	0.996
45	1.56	3.98	33.7	2.97	2.83	2.56
46	0.701	5.35	16.9	3.93	1.69	3.29
47	1.52	3.73	33.0	2.71	3.14	2.32
48	2.35	4.05	62.6	2.35	10.5	1.30
49	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
50	3.00	3.90	82.3	2.28	15.7	1.27
51	3.83	2.87	101	1.70	15.4	1.12
52	3.69	3.16	86.3	1.75	14.6	1.15
53 N1	4.18	2.73	133	1.51	17.5	1.06
53 N2	4.43	2.78	136	1.43	17.8	1.02
54	4.02	3.10	153	1.42	22.8	0.944
55	3.20	2.98	87.0	1.74	14.2	1.12
56	5.26	2.24	119	1.60	16.4	1.08
57	4.47	2.71	143	1.47	16.1	1.11
58	3.46	2.79	74.6	1.85	10.8	1.28
59	2.66	3.77	173	1.25	17.5	1.04
60	1.42	3.88	36.3	3.00	5.04	1.87
Bit 1-1 (lot 442988)	<2.08	not detectable	2,230	1.89	50.5	3.24
Bit 1-2 (lot 442988)	<2.10	not detectable	2,150	1.94	49.1	3.38
Bit 2-1 (lot 555828)	<3.57	not detectable	2,730	2.24	64.5	4.75
Bit 2-2 (lot 555828)	<3.44	not detectable	3,260	2.04	286	2.11
Bit 3-1 (lot 625828)	<2.21	not detectable	2,430	1.90	286	1.59
Bit 3-1 (lot 625828)	<2.14	not detectable	2,450	1.87	288	1.57

APPENDIX A (cont'd)

Concentration and Standard Deviation Results (All Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM) COUNTED AFTER 5 WEEKS OF DECAY					
SPL #	Europium (1085.6 KEV)	Europium (1085.6 KEV)	Europium (1112.2 KEV)	Europium (1112.2 KEV)	Europium (1408.1 KEV)	Europium (1408.1 KEV)
	Conc (ppm)	% Std Dev	Conc (ppm)	% Std Dev	Conc (ppm)	% Std Dev
Ck Std (batch 1)	3.39	5.26	3.84	3.47	3.63	1.74
Ck Std (batch 2)	3.51	5.33	3.79	3.68	3.77	1.96
Ck Std (batch 3)	3.51	5.91	3.71	3.97	3.90	1.86
Ck Std (batch 4)	3.78	10.8	3.77	9.07	3.87	4.26
1	1.20	7.03	1.35	4.36	1.15	2.36
2	0.927	9.44	0.969	6.31	0.898	2.93
3	0.554	15.1	0.655	10.1	0.605	4.12
4	1.33	10.4	1.46	6.61	1.20	3.41
5	1.47	6.89	1.57	4.47	1.33	2.45
6	1.10	8.59	1.07	6.13	1.07	2.62
7	1.20	9.33	1.32	6.00	1.19	2.81
8 N1	1.37	7.49	1.30	5.50	1.33	2.43
8 N2	1.47	6.83	1.51	4.95	1.23	2.62
9	1.47	8.11	1.40	5.55	1.38	2.53
10	1.08	8.69	1.05	6.37	1.03	2.70
11	0.687	12.1	0.71	8.28	0.767	3.03
12	1.36	7.04	1.53	4.72	1.33	2.35
13	1.26	8.53	1.22	6.43	0.826	3.68
14	0.898	9.11	1.07	4.94	0.863	2.77
15	1.10	10.8	1.31	6.72	1.10	3.07
16	1.43	6.71	1.34	5.04	1.26	2.32
17	1.04	8.13	1.09	5.46	1.03	2.49
18	1.17	7.28	1.26	4.93	1.09	2.42
19	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
20	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
21	0.939	8.99	1.58	5.01	1.06	2.65
22	0.934	9.47	0.955	7.01	0.902	2.98
23	0.970	8.97	0.908	6.80	1.15	2.46
24	1.15	9.27	1.05	6.62	1.07	3.07
25	812	9.70	0.790	6.56	0.944	2.66
26	1.05	8.13	0.680	7.83	0.799	2.87
27	1.28	7.69	1.11	6.07	1.22	2.79
28	0.875	12.3	1.05	8.03	0.933	3.61
29	1.07	9.39	0.899	6.79	1.01	3.16
30	0.348	16.8	0.422	11.5	0.491	4.71
31	1.25	7.31	1.06	5.71	1.11	3.04
32	1.20	8.94	1.08	6.95	1.20	3.17

APPENDIX A (cont'd)

Concentration and Standard Deviation Results (All Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM) COUNTED AFTER 5 WEEKS OF DECAY					
SPL #	Europium (1085.6 KEV) Conc (ppm)	Europium (1085.6 KEV) % Std Dev	Europium (1112.2 KEV) Conc (ppm)	Europium (1112.2 KEV) % Std Dev	Europium (1408.1 KEV) Conc (ppm)	Europium (1408.1 KEV) % Std Dev
33	0.111	22.8	0.186	10.6	0.108	9.55
34	0.161	16.2	<.0784	not detectable	0.131	9.00
35	0.173	15.2	<.0848	not detectable	0.115	9.35
36	0.118	19.9	0.176	11.2	0.125	9.29
37	0.176	16.1	<.0862	not detectable	0.156	9.03
38	0.221	16.3	0.166	14.1	0.147	8.09
39	0.124	38.3	0.126	24.5	0.121	8.61
40	0.186	17.6	0.0826	30.8	0.134	8.55
41	0.796	9.11	0.841	6.31	0.775	3.53
42	0.941	8.26	0.956	6.10	1.00	3.17
43	0.327	19.8	0.404	13.0	0.286	6.22
44	0.912	11.8	0.836	9.61	0.925	3.78
45	0.317	18.3	0.281	13.8	0.333	5.63
46	0.0922	35.9	<.0660	not detectable	0.0501	18.2
47	0.325	15.6	0.203	16.0	0.182	7.39
48	1.13	8.21	1.15	5.66	1.02	3.06
49	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
50	1.54	8.44	1.03	7.45	1.10	3.41
51	1.14	10.0	1.11	6.99	1.17	2.92
52	1.40	8.12	1.49	5.74	1.14	2.69
53 N1	1.06	10.7	1.17	7.25	0.992	3.28
53 N2	0.964	11.3	1.20	7.08	0.97	3.26
54	1.21	10.3	1.56	6.26	1.26	2.98
55	1.23	8.32	1.25	5.62	1.11	2.87
56	1.16	9.93	0.954	7.91	1.06	3.18
57	0.920	11.1	0.872	8.19	0.971	8.06
58	0.820	9.94	0.873	7.03	0.757	3.65
59	1.20	9.59	1.11	7.25	1.02	3.17
60	0.19	32.8	0.359	12.1	0.219	6.81
Bit 1-1 (lot 442988)	<3.25	not detectable	<2.08	not detectable	1.72	13.8
Bit 1-2 (lot 442988)	<3.13	not detectable	<2.09	not detectable	<0.489	not detectable
Bit 2-1 (lot 555828)	<5.11	not detectable	<3.60	not detectable	1.81	27.0
Bit 2-2 (lot 555828)	<5.36	not detectable	<3.70	not detectable	1.56	25.4
Bit 3-1 (lot 625828)	<3.68	not detectable	<2.54	not detectable	<0.534	not detectable
Bit 3-1 (lot 625828)	<3.58	not detectable	<2.45	not detectable	0.638	30.2

APPENDIX A (cont'd)

Concentration and Standard Deviation Results (All Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM) COUNTED AFTER 5 WEEKS OF DECAY					
SPL #	Gadolinium (103.3 KEV) Conc (ppm)	Gadolinium (103.3 KEV) % Std Dev	Hafnium (482.3 KEV) Conc (ppm)	Hafnium (482.3 KEV) % Std Dev	Iron (1099.3 KEV) Conc (ppm)	Iron (1099.3 KEV) % Std Dev
Ck Std (batch 1)	<4.71	not detectable	7.59	2.60	93,800	0.327
Ck Std (batch 2)	16.7	15.4	8.20	3.04	96,500	0.413
Ck Std (batch 3)	16.7	16.8	7.78	3.17	96,300	0.420
Ck Std (batch 4)	27.7	18.0	7.95	6.68	92,300	0.948
1	10.9	14.9	5.93	2.07	34,200	0.458
2	7.72	20.1	7.58	1.91	51,500	0.385
3	10.8	17.9	5.79	2.32	25,800	0.527
4	15.6	16.8	5.63	3.00	42,400	0.609
5	8.53	21.6	6.48	2.15	39,200	0.462
6	11.0	17.0	4.77	2.62	41,600	0.445
7	17.3	13.8	6.27	2.45	47,800	0.472
8 N1	8.77	20.1	6.27	2.22	48,300	0.414
8 N2	5.76	30.4	5.70	2.51	43,200	0.462
9	5.59	34.6	6.53	2.37	50,300	0.428
10	<2.83	not detectable	5.79	2.35	40,000	0.446
11	10.9	15.9	6.65	2.04	44,200	0.416
12	7.90	22.3	6.77	2.13	40,200	0.440
13	5.73	35.3	5.00	2.94	37,100	0.567
14	5.74	25.2	4.25	2.57	29,000	0.516
15	<3.84	not detectable	5.90	2.80	42,700	0.545
16	<2.89	not detectable	6.64	2.12	37,400	0.451
17	<2.63	not detectable	4.89	2.45	33,400	0.478
18	<2.57	not detectable	4.51	2.46	33,200	0.481
19	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
20	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
21	5.42	27.4	5.21	2.42	38,700	0.454
22	10.1	17.9	5.43	2.50	48,800	0.402
23	3.54	40.9	4.68	2.60	37,200	0.469
24	<3.45	not detectable	4.73	3.01	36,800	0.554
25	1.84	48.7	5.99	2.10	32,000	0.490
26	3.19	42.6	4.91	2.35	33,100	0.483
27	12.4	13.7	7.52	2.33	41,900	0.552
28	9.94	17.3	7.98	2.43	71,000	0.468
29	8.02	18.8	4.70	3.08	36,200	0.624
30	2.61	41.6	2.90	3.83	18,100	0.910
31	9.34	17.3	5.42	2.84	32,300	0.654
32	7.07	24.4	6.13	3.01	50,700	0.538

APPENDIX A (cont'd)

Concentration and Standard Deviation Results (All Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM) COUNTED AFTER 5 WEEKS OF DECAY					
SPL #	Gadolinium (103.3 KEV) Conc (ppm)	Gadolinium (103.3 KEV) % Std Dev	Hafnium (482.3 KEV) Conc (ppm)	Hafnium (482.3 KEV) % Std Dev	Iron (1099.3 KEV) Conc (ppm)	Iron (1099.3 KEV) % Std Dev
33	<1.51	not detectable	0.695	5.58	1,070	3.84
34	<1.44	not detectable	1.18	4.09	1,330	3.04
35	<1.59	not detectable	0.919	4.65	1,210	3.39
36	<1.33	not detectable	0.943	4.55	1,440	2.85
37	<1.31	not detectable	1.26	3.90	1,330	3.17
38	<1.40	not detectable	0.994	4.86	2,630	2.15
39	<1.44	not detectable	1.02	5.67	25,800	0.685
40	<1.31	not detectable	1.26	4.34	13,400	0.922
41	3.81	32.0	3.53	3.31	23,900	0.711
42	4.39	28.4	4.65	3.00	24,700	0.736
43	4.30	24.1	2.00	4.40	19,100	0.812
44	9.56	20.6	4.58	3.95	59,100	0.504
45	3.34	32.2	1.52	5.42	22,000	0.758
46	<1.41	not detectable	0.535	8.88	7,230	1.28
47	3.05	29.3	1.36	5.34	13,900	0.922
48	5.84	25.0	4.95	2.83	32,400	0.628
49	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
50	10.2	19.3	4.62	3.73	40,200	0.681
51	8.43	20.9	5.57	2.86	42,400	0.569
52	15.3	14.0	5.29	2.98	40,000	0.583
53 N1	7.58	23.5	6.08	2.90	55,300	0.502
53 N2	8.41	20.7	7.00	2.61	55,800	0.492
54	5.91	30.7	6.35	2.89	68,200	0.468
55	7.46	20.6	5.93	2.63	40,200	0.560
56	11.6	7.73	6.40	2.75	49,600	0.531
57	8.87	21.5	5.58	3.10	56,500	0.506
58	5.89	26.3	5.31	2.72	29,500	0.668
59	7.32	22.3	6.81	2.51	62,700	0.470
60	2.17	45.4	1.48	5.27	19,400	0.793
Bit 1-1 (lot 442988)	<24.3	not detectable	<2.35	not detectable	893,000	0.737
Bit 1-2 (lot 442988)	<24.2	not detectable	<2.36	not detectable	836,000	0.762
Bit 2-1 (lot 555828)	<51.2	not detectable	<4.12	not detectable	870,000	1.02
Bit 2-2 (lot 555828)	<46.1	not detectable	<3.83	not detectable	838,000	0.992
Bit 3-1 (lot 625828)	<25.5	not detectable	<2.53	not detectable	852,000	0.766
Bit 3-1 (lot 625828)	<24.2	not detectable	<2.46	not detectable	856,000	0.756

APPENDIX A (cont'd)

Concentration and Standard Deviation Results (All Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM) COUNTED AFTER 5 WEEKS OF DECAY					
	Iron	Iron	Mercury	Mercury	Nickel	Nickel
SPL #	(1291.6 KEV)	(1291.6 KEV)	(297.2 KEV)	(297.2 KEV)	(810.8 KEV)	(810.8 KEV)
	Conc (ppm)	% Std Dev	Conc (ppm)	% Std Dev	Conc (ppm)	% Std Dev
Ck Std (batch 1)	92,800	0.375	0.424	758.8	135	20.2
Ck Std (batch 2)	96,500	0.472	not in stds	not detectable	155	26.6
Ck Std (batch 3)	95,400	0.478	not in stds	not detectable	141	22.1
Ck Std (batch 4)	93,200	1.08	not in stds	not detectable	<66.7	not detectable
1	34,300	0.532	<.283	not detectable	42.5	26.7
2	52,100	0.443	<.304	not detectable	71.9	21.1
3	36,400	0.612	<.313	not detectable	<31.9	not detectable
4	43,400	0.698	<.452	not detectable	47.4	38.8
5	39,600	0.532	<.328	not detectable	57.9	25.6
6	41,800	0.507	<.323	not detectable	43.8	31.3
7	48,200	0.537	<.379	not detectable	<36.6	not detectable
8 N1	48,100	0.479	<.339	not detectable	48.4	30.2
8 N2	43,400	0.527	<.343	not detectable	45.9	32.0
9	49,700	0.501	<.362	not detectable	<35.1	not detectable
10	40,400	0.513	<.309	not detectable	38.3	33.9
11	44,300	0.475	<.284	not detectable	112	15.7
12	40,000	0.508	<.314	not detectable	43.0	32.6
13	36,800	0.653	<.378	not detectable	35.5	40.0
14	29,100	0.595	<.265	not detectable	<25.2	not detectable
15	42,700	0.625	<.711	not detectable	<38.9	not detectable
16	37,200	0.518	<.309	not detectable	93.1	18.1
17	33,500	0.545	<.276	not detectable	<26.3	not detectable
18	33,000	0.55	<.272	not detectable	<25.8	not detectable
19	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
20	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
21	39,100	0.517	<.301	not detectable	86.9	18.9
22	49,100	0.465	<.327	not detectable	59.5	25.8
23	37,200	0.535	<.297	not detectable	<28.6	not detectable
24	37,200	0.645	<.364	not detectable	<34.7	not detectable
25	32,200	0.568	<.258	not detectable	<24.4	not detectable
26	33,300	0.550	<.277	not detectable	38.5	31.7
27	42,000	0.631	not in stds	not detectable	105	24.8
28	71,100	0.541	not in stds	not detectable	82.8	28.9
29	36,000	0.719	not in stds	not detectable	72.6	29.2
30	18,400	1.05	not in stds	not detectable	89.8	24.0
31	32,500	0.741	not in stds	not detectable	49.2	35.8
32	51,100	0.615	not in stds	not detectable	72.5	32.8

APPENDIX A (cont'd)

Concentration and Standard Deviation Results (All Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM) COUNTED AFTER 5 WEEKS OF DECAY					
SPL #	Iron (1291.6 KEV) Conc (ppm)	Iron (1291.6 KEV) % Std Dev	Mercury (297.2 KEV) Conc (ppm)	Mercury (297.2 KEV) % Std Dev	Nickel (810.8 KEV) Conc (ppm)	Nickel (810.8 KEV) % Std Dev
33	1,440	3.81	not in stds	not detectable	<9.88	not detectable
34	1,650	3.11	not in stds	not detectable	<9.72	not detectable
35	1,320	3.71	not in stds	not detectable	<9.63	not detectable
36	1,760	2.90	not in stds	not detectable	<9.54	not detectable
37	1,820	3.11	not in stds	not detectable	<10.00	not detectable
38	3,120	2.30	not in stds	not detectable	<11.7	not detectable
39	26,000	0.813	not in stds	not detectable	<18.2	not detectable
40	13,500	1.10	not in stds	not detectable	<14.5	not detectable
41	23,700	0.828	not in stds	not detectable	33.6	39.9
42	24,500	0.851	not in stds	not detectable	48.3	33.6
43	19,200	0.920	not in stds	not detectable	80.3	22.6
44	58,700	0.580	not in stds	not detectable	73.9	34.8
45	21,900	0.892	not in stds	not detectable	<24.7	not detectable
46	7,240	1.52	not in stds	not detectable	<14.5	not detectable
47	14,100	1.06	not in stds	not detectable	<21.9	not detectable
48	32,700	0.723	not in stds	not detectable	44.9	40.0
49	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
50	40,400	0.778	not in stds	not detectable	<48.3	not detectable
51	42,300	0.654	not in stds	not detectable	31.9	44.2
52	40,100	0.674	not in stds	not detectable	16.7	84.0
53 N1	55,300	0.585	not in stds	not detectable	83.0	24.2
53 N2	55,000	0.574	not in stds	not detectable	80.5	23.3
54	68,300	0.539	not in stds	not detectable	<38.8	not detectable
55	40,500	0.643	not in stds	not detectable	40.1	35.4
56	49,600	0.611	not in stds	not detectable	57.3	29.9
57	56,200	0.586	not in stds	not detectable	51.2	32.9
58	29,900	0.755	not in stds	not detectable	53.4	26.0
59	62,600	0.549	not in stds	not detectable	54.3	28.1
60	19,100	0.927	not in stds	not detectable	<20.1	not detectable
Bit 1-1 (lot 442988)	892,000	0.867	not in stds	not detectable	<227	not detectable
Bit 1-2 (lot 442988)	845,000	0.892	not in stds	not detectable	272	38.9
Bit 2-1 (lot 555828)	887,000	1.20	not in stds	not detectable	548	40.3
Bit 2-2 (lot 555828)	825,000	1.17	not in stds	not detectable	408	45.7
Bit 3-1 (lot 625828)	848,000	0.893	not in stds	not detectable	486	30.3
Bit 3-1 (lot 625828)	861,000	0.877	not in stds	not detectable	412	31.9

APPENDIX A (cont'd)

Concentration and Standard Deviation Results (All Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM) COUNTED AFTER 5 WEEKS OF DECAY					
SPL #	Rubidium (1076.8 KEV) Conc (ppm)	Rubidium (1076.8 KEV) % Std Dev	Scandium (889.3 KEV) Conc (ppm)	Scandium (889.3 KEV) % Std Dev	Selenium (136.5 KEV) Conc (ppm)	Selenium (136.5 KEV) % Std Dev
Ck Std (batch 1)	122	7.29	38.5	0.135	6.52	11.7
Ck Std (batch 2)	131	8.23	40.3	0.162	8.56	6.37
Ck Std (batch 3)	144	7.74	39.9	0.164	11.3	5.57
Ck Std (batch 4)	117	17.2	38.6	0.405	8.22	15.1
1	98.4	5.64	9.76	0.225	4.03	10.2
2	119	5.33	11.2	0.214	5.12	8.72
3	126	5.74	9.45	0.288	3.21	15.6
4	81.5	9.00	9.68	0.356	3.76	17.1
5	98.8	5.95	10.4	0.237	3.40	14.9
6	171	4.65	12.1	0.215	2.66	17.6
7	120	6.11	12.0	0.259	3.65	15.4
8 N1	141	5.14	13.2	0.208	2.75	17.7
8 N2	128	5.33	11.9	0.242	3.38	15.2
9	130	5.67	13.5	0.228	3.49	15.1
10	134	5.11	11.3	0.230	<.966	not detectable
11	80.8	6.72	9.53	0.235	3.97	11.8
12	101	5.95	12.3	0.217	1.99	21.3
13	121	6.20	10.2	0.288	<1.2	not detectable
14	107	5.65	7.78	0.276	<.838	not detectable
15	100	7.12	11.7	0.282	<1.3	not detectable
16	133	5.17	11.8	0.219	<.974	not detectable
17	101	5.78	8.83	0.253	2.25	18.0
18	95.7	6.01	8.67	0.255	1.56	23.3
19	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
20	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
21	100	6.14	10.5	0.240	<.937	not detectable
22	164	4.83	13.0	0.212	<.997	not detectable
23	118	5.30	9.95	0.245	1.98	21.2
24	123	6.01	9.65	0.306	2.14	24.4
25	86.2	6.01	6.74	0.300	3.96	11.8
26	108	5.45	8.59	0.262	<.881	not detectable
27	93.8	7.33	11.1	0.282	3.56	8.97
28	48.2	14.30	10.6	0.321	4.20	8.96
29	132	6.26	9.52	0.328	2.39	13.3
30	97.0	6.61	4.59	0.494	1.33	19.8
31	71.5	8.52	8.56	0.341	2.82	11.7
32	152	6.39	16.4	0.25	3.30	11.6

APPENDIX A (cont'd)

Concentration and Standard Deviation Results (All Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM) COUNTED AFTER 5 WEEKS OF DECAY					
SPL #	Rubidium (1076.8 KEV) Conc (ppm)	Rubidium (1076.8 KEV) % Std Dev	Scandium (889.3 KEV) Conc (ppm)	Scandium (889.3 KEV) % Std Dev	Selenium (136.5 KEV) Conc (ppm)	Selenium (136.5 KEV) % Std Dev
33	12.0	15.9	0.261	1.93	<.352	not detectable
34	12.2	14.8	0.406	1.51	0.578	18.9
35	14.1	14.1	0.258	2.04	0.324	45.3
36	16.8	11.5	0.406	1.49	0.456	32.9
37	18.7	10.8	0.360	1.64	0.919	16.5
38	16.6	13.1	0.477	1.43	0.457	31.9
39	25.6	15.0	0.307	2.36	0.563	29.7
40	21.4	13.2	0.381	1.83	0.698	22.2
41	71.5	7.50	6.83	0.366	1.34	17.5
42	85.1	7.31	7.49	0.357	2.88	10.4
43	49.3	10.1	4.34	0.456	1.10	20.5
44	205	5.80	20.1	0.220	1.73	21.0
45	40.6	10.9	3.22	0.549	0.961	22.8
46	20.1	13.8	0.914	1.02	<.349	not detectable
47	50.0	8.69	3.04	0.539	0.748	26.3
48	78.2	7.90	8.94	0.323	2.34	12.7
49	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
50	99.4	8.57	10.9	0.347	2.35	16.6
51	108	7.11	10.7	0.288	2.79	11.9
52	124	6.47	10.9	0.300	3.43	10.4
53 N1	122	7.61	13.4	0.271	2.84	12.8
53 N2	125	6.71	13.6	0.263	4.07	8.91
54	153	6.84	14.0	0.269	3.83	10.1
55	103	7.45	9.12	0.313	2.91	10.7
56	141	6.27	12.7	0.275	3.83	9.51
57	119	7.42	13.8	0.271	3.21	11.9
58	111	6.91	7.96	0.337	2.87	10.5
59	104	7.29	8.75	0.333	3.57	8.94
60	42.0	10.5	3.60	0.504	0.911	24.5
Bit 1-1 (lot 442988)	<178	not detectable	<0.294	not detectable	<8.28	not detectable
Bit 1-2 (lot 442988)	<174	not detectable	<0.286	not detectable	<8.37	not detectable
Bit 2-1 (lot 555828)	<293	not detectable	<0.468	not detectable	<17.4	not detectable
Bit 2-2 (lot 555828)	<285	not detectable	<0.463	not detectable	<15.5	not detectable
Bit 3-1 (lot 625828)	<195	not detectable	<0.322	not detectable	<8.68	not detectable
Bit 3-1 (lot 625828)	<191	not detectable	<0.308	not detectable	<8.37	not detectable

APPENDIX A (cont'd)

Concentration and Standard Deviation Results (All Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM) COUNTED AFTER 5 WEEKS OF DECAY					
SPL #	Strontium (514.0 KEV) Conc (ppm)	Strontium (514.0 KEV) % Std Dev	Tantalum (1189.1 KEV) Conc (ppm)	Tantalum (1189.1 KEV) % Std Dev	Tantalum (1221.5 KEV) Conc (ppm)	Tantalum (1221.5 KEV) % Std Dev
Ck Std (batch 1)	1130	10.6	2.10	8.52	2.19	4.92
Ck Std (batch 2)	801	13.0	2.40	8.73	2.01	5.76
Ck Std (batch 3)	719	15.2	1.99	9.16	2.05	5.79
Ck Std (batch 4)	729	28.6	1.83	22.7	1.98	15.1
1	260	16.9	0.838	9.60	0.807	5.73
2	<104	not detectable	1.05	8.91	0.890	5.63
3	<115	not detectable	1.12	8.69	0.881	6.48
4	<151	not detectable	0.808	14.60	0.858	8.28
5	<110	not detectable	2.41	6.21	2.37	3.63
6	37.8	92.7	1.00	9.76	0.869	6.6
7	<129	not detectable	1.04	10.50	0.945	6.51
8 N1	184	27.4	1.12	9.96	1.08	5.58
8 N2	130	36.0	0.981	10.4	0.948	6.16
9	<125	not detectable	0.935	10.7	1.04	6.18
10	105	45.1	1.10	9.62	1.06	5.31
11	<96.5	not detectable	1.42	7.46	1.25	4.69
12	<107	not detectable	1.11	8.93	0.979	5.57
13	<127	not detectable	0.796	12.1	0.848	7.60
14	<91.8	not detectable	0.703	10.5	0.595	7.69
15	<140	not detectable	0.853	13.0	0.797	8.22
16	<105	not detectable	1.16	8.72	1.20	5.13
17	<95.1	not detectable	0.749	10.8	0.724	6.28
18	151	28.1	0.741	11.2	0.682	6.74
19	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
20	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
21	<104	not detectable	0.685	11.5	0.830	6.17
22	<112	not detectable	1.30	8.57	1.01	5.72
23	107	40.2	0.630	12.3	0.685	7.21
24	115	45.6	0.986	11.0	0.776	7.50
25	<87.4	not detectable	0.759	10.3	0.902	5.53
26	166	26.1	0.752	10.5	0.707	6.86
27	176	28.2	0.989	11.9	0.950	6.90
28	<126	not detectable	1.83	8.5	1.79	5.54
29	84.3	54.5	1.13	9.45	1.21	6.24
30	290	15.6	0.449	18.6	0.469	11.1
31	126	34.6	0.851	13.5	0.794	7.46
32	<136	not detectable	1.06	12.1	1.18	6.34

APPENDIX A (cont'd)

Concentration and Standard Deviation Results (All Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM) COUNTED AFTER 5 WEEKS OF DECAY					
SPL #	Strontium (514.0 KEV) Conc (ppm)	Strontium (514.0 KEV) % Std Dev	Tantalum (1189.1 KEV) Conc (ppm)	Tantalum (1189.1 KEV) % Std Dev	Tantalum (1221.5 KEV) Conc (ppm)	Tantalum (1221.5 KEV) % Std Dev
33	140	12.4	0.106	25.4	0.0913	21.4
34	152	11.9	<.0754	not detectable	<0.0459	not detectable
35	174	10.6	<.0756	not detectable	<0.0498	not detectable
36	132	13.8	<.0672	not detectable	<0.0455	not detectable
37	99.6	18.4	<.0766	not detectable	0.110	18.0
38	142	14.8	<.0815	not detectable	0.110	20.1
39	<46.1	not detectable	<.112	not detectable	<0.0619	not detectable
40	<39.3	not detectable	0.106	37.4	0.0456	59.0
41	<87.5	not detectable	0.588	13.7	0.352	12.6
42	<94.8	not detectable	0.809	12.4	0.399	13.4
43	<75.2	not detectable	0.248	30.3	0.396	11.0
44	<150	not detectable	0.912	14.3	0.605	11.9
45	<70.2	not detectable	0.495	16.9	0.289	12.9
46	<43.1	not detectable	0.221	19.0	0.162	18.3
47	<62.2	not detectable	0.314	17.7	0.227	13.8
48	113	37.6	0.786	12.7	0.604	9.49
49	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
50	<137	not detectable	1.21	10.4	0.868	9.00
51	<120	not detectable	0.688	13.1	0.857	7.48
52	<122	not detectable	0.895	11.0	1.02	6.56
53 N1	<134	not detectable	1.01	9.44	1.00	7.61
53 N2	<131	not detectable	0.912	9.99	0.947	7.33
54	<142	not detectable	0.899	12.1	0.945	7.43
55	102	45.6	0.845	11.1	0.918	6.49
56	96.1	60.9	0.922	10.4	1.05	6.89
57	<137	not detectable	1.13	9.60	1.18	6.21
58	89.3	45.2	0.621	12.7	0.677	7.95
59	163	30.9	0.721	14.4	0.913	7.29
60	<74.1	not detectable	0.442	13.4	0.414	10.4
Bit 1-1 (lot 442988)	<1,190	not detectable	<2.79	not detectable	<1.60	not detectable
Bit 1-2 (lot 442988)	<1,190	not detectable	<2.92	not detectable	<1.64	not detectable
Bit 2-1 (lot 555828)	<2,080	not detectable	<5.17	not detectable	<3.44	not detectable
Bit 2-2 (lot 555828)	<1,970	not detectable	<5.37	not detectable	<3.34	not detectable
Bit 3-1 (lot 625828)	<1,280	not detectable	<3.41	not detectable	<2.09	not detectable
Bit 3-1 (lot 625828)	<1,220	not detectable	<3.34	not detectable	<1.94	not detectable

APPENDIX A (cont'd)

Concentration and Standard Deviation Results (All Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM) COUNTED AFTER 5 WEEKS OF DECAY					
SPL #	Terbium (879.4 KEV) Conc (ppm)	Terbium (879.4 KEV) % Std Dev	Terbium (1178.0 KEV) Conc (ppm)	Terbium (1178.0 KEV) % Std Dev	Thorium (312.0 KEV) Conc (ppm)	Thorium (312.0 KEV) % Std Dev
Ck Std (batch 1)	<.260	not detectable	3.07	5.79	24.7	0.796
Ck Std (batch 2)	2.76	7.55	2.55	6.36	25.6	0.965
Ck Std (batch 3)	2.52	8.33	2.64	6.02	24.8	0.987
Ck Std (batch 4)	1.63	20.9	2.89	13.9	23.9	2.27
1	0.736	8.8	0.939	7.57	9.99	0.909
2	0.429	15.2	0.754	10.3	13.3	0.810
3	0.324	22.6	0.600	11.8	8.63	1.220
4	0.818	12.8	0.91	11.4	15.7	1.020
5	0.994	7.99	1.26	6.98	16.7	0.757
6	0.327	20.8	0.937	7.85	10.9	0.987
7	0.594	14.4	1.14	8.50	13.6	0.984
8 N1	1.12	8.11	1.05	8.63	12.4	0.949
8 N2	0.693	11.3	0.903	9.44	10.7	1.27
9	0.980	9.15	1.21	8.06	11.7	1.09
10	0.482	14.4	0.285	20.8	10.1	1.090
11	0.846	9.46	0.216	24.9	13.3	0.846
12	0.486	13.7	0.954	8.48	13.0	1.030
13	0.887	9.28	0.670	12.9	13.5	1.110
14	0.370	17.3	0.344	15.4	7.16	1.310
15	0.784	12.3	0.446	19.9	10.0	1.390
16	0.421	14.6	0.714	9.91	14.5	0.861
17	0.458	14.1	0.399	15.4	8.20	1.20
18	0.437	14.5	0.850	8.37	8.20	1.170
19	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
20	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
21	0.532	13.4	0.246	23.7	10.1	1.09
22	0.292	23.3	0.206	24.4	13.1	0.944
23	0.577	11.7	0.804	9.52	8.70	1.19
24	0.470	17.9	0.627	12.5	9.09	1.41
25	0.354	7.87	0.674	9.59	7.98	1.19
26	0.396	15.1	0.207	27.3	7.63	1.25
27	0.875	11.2	1.02	8.01	12.9	1.05
28	0.592	18.6	0.719	11.5	15.8	1.01
29	0.602	15.5	0.379	18.8	11.0	1.20
30	0.292	23.4	0.255	19.4	5.32	1.82
31	0.757	11.4	0.641	11.3	8.02	1.54
32	0.511	21.3	0.751	11.6	14.2	1.21

APPENDIX A (cont'd)

Concentration and Standard Deviation Results (All Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM) COUNTED AFTER 5 WEEKS OF DECAY					
	Terbium	Terbium	Terbium	Terbium	Thorium	Thorium
SPL #	(879.4 KEV)	(879.4 KEV)	(1178.0 KEV)	(1178.0 KEV)	(312.0 KEV)	(312.0 KEV)
	Conc (ppm)	% Std Dev	Conc (ppm)	% Std Dev	Conc (ppm)	% Std Dev
33	0.132	16.8	<.0606	not detectable	1.08	4.05
34	0.108	21.9	<.0594	not detectable	0.78	5.33
35	0.0713	32.6	<.0640	not detectable	0.623	6.80
36	0.128	20.4	0.101	29.0	0.732	4.99
37	0.0841	32.7	<.0625	not detectable	0.691	5.88
38	0.103	26.4	0.035	73.6	1.04	4.34
39	0.0533	69.2	<.0863	not detectable	0.680	7.34
40	0.135	24.6	<.0766	not detectable	0.762	5.50
41	0.484	16.1	0.546	10.2	6.35	1.53
42	0.763	11.9	0.758	9.01	6.70	1.64
43	0.0935	55.3	<.130	not detectable	4.94	1.80
44	0.646	17.3	0.793	11.9	14.4	1.15
45	0.166	30.7	0.230	17.3	2.83	2.91
46	0.101	33.1	0.0891	28.5	1.06	4.98
47	0.135	37.0	0.111	31.3	3.38	2.07
48	0.502	17.1	0.550	11.7	7.75	1.45
49	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
50	0.687	17.5	0.638	14.5	12.0	1.33
51	0.830	12.3	0.765	10.1	9.75	1.28
52	0.889	12.2	0.896	8.92	18.9	8.72
53 N1	0.535	20.5	0.460	15.5	15.5	1.00
53 N2	0.382	24.7	0.709	11.6	15.5	0.980
54	0.758	14.9	0.956	9.92	15.8	1.02
55	0.838	11.3	0.693	10.6	10.2	1.18
56	0.818	13.3	0.743	10.4	16.7	0.95
57	0.742	15.4	0.506	15.2	13.2	1.23
58	0.460	17.2	0.447	13.6	8.13	1.45
59	0.699	12.9	0.540	14.8	13.9	1.02
60	<.126	not detectable	0.159	24.7	3.95	1.94
Bit 1-1 (lot 442988)	<2.24	not detectable	<2.51	not detectable	<2.05	not detectable
Bit 1-2 (lot 442988)	<2.18	not detectable	<2.47	not detectable	<2.04	not detectable
Bit 2-1 (lot 555828)	<3.73	not detectable	<4.81	not detectable	<3.87	not detectable
Bit 2-2 (lot 555828)	<3.60	not detectable	<4.76	not detectable	<3.62	not detectable
Bit 3-1 (lot 625828)	<2.38	not detectable	<3.11	not detectable	<2.20	not detectable
Bit 3-1 (lot 625828)	<2.32	not detectable	<2.88	not detectable	<2.11	not detectable

APPENDIX A (cont'd)

Concentration and Standard Deviation Results (All Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM) COUNTED AFTER 5 WEEKS OF DECAY					
	Thulium	Thulium	Tin	Tin	Zinc	Zinc
SPL #	(84.3 KEV)	(84.3 KEV)	(391.7 KEV)	(391.7 KEV)	(115.6 KEV)	(115.6 KEV)
	Conc (ppm)	% Std Dev	Conc (ppm)	% Std Dev	Conc (ppm)	% Std Dev
Ck Std (batch 1)	not in stds	not detectable	not in stds	not detectable	212	1.30
Ck Std (batch 2)	<.524	not detectable	8.35	38.7	244	1.99
Ck Std (batch 3)	2.25	15.5	<2.79	not detectable	219	2.06
Ck Std (batch 4)	not in stds	not detectable	<10.6	not detectable	199	6.29
1	not in stds	not detectable	not in stds	not detectable	33.0	3.06
2	not in stds	not detectable	not in stds	not detectable	33.1	3.64
3	not in stds	not detectable	not in stds	not detectable	26.2	4.55
4	not in stds	not detectable	not in stds	not detectable	44.0	3.79
5	not in stds	not detectable	not in stds	not detectable	84.9	1.72
6	not in stds	not detectable	not in stds	not detectable	54.9	2.40
7	not in stds	not detectable	not in stds	not detectable	36.3	3.97
8 N1	not in stds	not detectable	not in stds	not detectable	125	1.42
8 N2	not in stds	not detectable	not in stds	not detectable	111	1.53
9	not in stds	not detectable	not in stds	not detectable	45.9	3.28
10	not in stds	not detectable	not in stds	not detectable	36.0	3.52
11	not in stds	not detectable	not in stds	not detectable	43.3	2.89
12	not in stds	not detectable	not in stds	not detectable	40.6	3.13
13	not in stds	not detectable	not in stds	not detectable	26.9	5.01
14	not in stds	not detectable	not in stds	not detectable	30.5	3.34
15	not in stds	not detectable	not in stds	not detectable	<3.50	not detectable
16	not in stds	not detectable	not in stds	not detectable	54.6	2.43
17	not in stds	not detectable	not in stds	not detectable	29.5	3.64
18	not in stds	not detectable	not in stds	not detectable	25.0	4.06
19	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
20	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
21	not in stds	not detectable	not in stds	not detectable	<2.59	not detectable
22	not in stds	not detectable	not in stds	not detectable	35.9	3.70
23	not in stds	not detectable	not in stds	not detectable	33.3	3.88
24	not in stds	not detectable	not in stds	not detectable	36.5	4.15
25	not in stds	not detectable	not in stds	not detectable	25.9	4.10
26	not in stds	not detectable	not in stds	not detectable	50.4	2.40
27	<0.304	not detectable	<3.24	not detectable	49.0	4.39
28	<0.359	not detectable	<0.380	not detectable	79.3	3.32
29	<0.320	not detectable	<3.31	not detectable	45.8	4.67
30	<0.264	not detectable	<2.58	not detectable	21.6	7.02
31	0.460	40.4	<3.10	not detectable	38.4	5.17
32	<0.382	not detectable	<4.06	not detectable	78.6	3.45

APPENDIX A (cont'd)

Concentration and Standard Deviation Results (All Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM) COUNTED AFTER 5 WEEKS OF DECAY					
	Thulium	Thulium	Tin	Tin	Zinc	Zinc
SPL #	(84.3 KEV)	(84.3 KEV)	(391.7 KEV)	(391.7 KEV)	(115.6 KEV)	(115.6 KEV)
	Conc (ppm)	% Std Dev	Conc (ppm)	% Std Dev	Conc (ppm)	% Std Dev
33	<0.173	not detectable	<1.02	not detectable	74.3	2.09
34	<0.168	not detectable	<1.09	not detectable	63.5	2.38
35	<0.185	not detectable	<1.09	not detectable	72.1	2.26
36	<0.158	not detectable	<1.02	not detectable	49.6	2.45
37	<0.151	not detectable	<1.05	not detectable	76.5	2.25
38	<0.157	not detectable	<1.11	not detectable	96.4	1.93
39	<0.165	not detectable	<1.45	not detectable	<1.82	not detectable
40	<0.154	not detectable	<1.25	not detectable	<1.60	not detectable
41	<0.252	not detectable	<2.61	not detectable	42.8	3.81
42	<0.278	not detectable	<2.81	not detectable	48.2	3.71
43	<0.228	not detectable	<2.28	not detectable	48.9	3.60
44	0.894	25.6	6.59	37.3	81.9	3.62
45	<0.220	not detectable	<2.11	not detectable	23.5	5.75
46	<0.163	not detectable	<1.37	not detectable	24.3	4.14
47	<0.195	not detectable	1.83	50.7	41.4	3.31
48	<0.295	not detectable	<3.00	not detectable	41.2	4.34
49	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
50	<0.391	not detectable	<4.07	not detectable	42.2	5.87
51	0.990	19.9	<1.56	not detectable	37.2	5.33
52	0.660	26.0	<1.58	not detectable	44.7	4.36
53 N1	0.831		23.7		not detectable	
53 N2	<0.387	not detectable	<1.69	not detectable	56.8	3.70
54	<0.415	not detectable	<1.81	not detectable	61.4	3.80
55	0.921	20.1	<1.43	not detectable	40.3	4.56
56	<0.391	not detectable	<1.69	not detectable	48.6	4.44
57	<0.425	not detectable	2.46	31.9	119	2.24
58	<0.327	not detectable	<1.35	not detectable	88.1	2.34
59	<0.362	not detectable	<1.52	not detectable	47.6	4.24
60	<0.251	not detectable	<0.978	not detectable	49.9	2.88
Bit 1-1 (lot 442988)	not in stds	not detectable	<31.2	not detectable	<72.1	not detectable
Bit 1-2 (lot 442988)	not in stds	not detectable	<30.2	not detectable	<75.4	not detectable
Bit 2-1 (lot 555828)	not in stds	not detectable	<55.0	not detectable	<129	not detectable
Bit 2-2 (lot 555828)	not in stds	not detectable	<51.8	not detectable	107	not detectable
Bit 3-1 (lot 625828)	not in stds	not detectable	<32.6	not detectable	<90.1	not detectable
Bit 3-1 (lot 625828)	not in stds	not detectable	<31.7	not detectable	<87.0	not detectable

APPENDIX A (cont'd)

Concentration and Standard Deviation Results (All Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM) COUNTED AFTER 5 WEEKS OF DECAY			
SPL #		Zirconium (756.7 KEV) Conc (ppm)	Zirconium (756.7 KEV) % Std Dev	
Ck Std (batch 1)		273	21.1	
Ck Std (batch 2)		298	28.7	
Ck Std (batch 3)		395	21.1	
Ck Std (batch 4)		<326	not detectable	
1		159	19.1	
2		242	15.7	
3		166	22.0	
4		106	38.3	
5		120	25.5	
6		298	14.2	
7		84.3	40.9	
8 N1		206	18.1	
8 N2		130	26.8	
9		147	25.3	
10		98.9	29.4	
11		174	18.1	
12		<66.9	not detectable	
13		<78.8	not detectable	
14		79.3	30.8	
15		<87.0	not detectable	
16		234	17.0	
17		<59.2	not detectable	
18		87.9	30.5	
19		NOT RUN	NOT RUN	
20		NOT RUN	NOT RUN	
21		223	15.7	
22		<70.2	not detectable	
23		<62.9	not detectable	
24		111	32.4	
25		300	13.4	
26		92.4	29.2	
27		236	22.0	
28		289	22.6	
29		156	30.9	
30		128	29.4	
31		99.4	38.1	
32		309	22.2	

APPENDIX A (cont'd)

Concentration and Standard Deviation Results (All Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM) COUNTED AFTER 5 WEEKS OF DECAY		
SPL #	Zirconium (756.7 KEV) Conc (ppm)	Zirconium (756.7 KEV) % Std Dev	
33	<24.5	not detectable	
34	57	26.7	
35	24.1	50.8	
36	34.0	34.5	
37	50.6	30.1	
38	38.7	35.7	
39	29.3	53.5	
40	56.0	32.3	
41	154	26.2	
42	106	36.1	
43	165	23.2	
44	<131	not detectable	
45	76.4	39.0	
46	<35.5	not detectable	
47	78.3	35.4	
48	243	22.2	
49	NOT RUN	NOT RUN	
50	<121	not detectable	
51	113	35.5	
52	118	35.9	
53 N1	3.61	44.6	
53 N2	160	28.3	
54	214	25.4	
55	115	34.1	
56	175	26.3	
57	113	39.8	
58	130	27.6	
59	161	27.8	
60	60.1	37.3	
Bit 1-1 (lot 442988)	<1,000	not detectable	
Bit 1-2 (lot 442988)	<996	not detectable	
Bit 2-1 (lot 555828)	<1,610	not detectable	
Bit 2-2 (lot 555828)	<1,550	not detectable	
Bit 3-1 (lot 625828)	<1,060	not detectable	
Bit 3-1 (lot 625828)	<1,030	not detectable	

APPENDIX B

APPENDIX B

Concentration and Standard Deviation Results (11 Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM)					
SPL #	Barium (123.7 KEV) Conc (ppm)	Barium (123.7 KEV) % Std Dev	Cerium (145.5 KEV) Conc (ppm)	Cerium (145.5 KEV) % Std Dev	Cesium (795.9 KEV) Conc (ppm)	Cesium (795.9 KEV) % Std Dev
Ck Std (batch 1)	1380	2.75	169	0.750	9.73	2.60
Ck Std (batch 2)	1350	2.61	180	0.761	10.8	2.93
Ck Std (batch 3)	1460	2.42	182	0.759	10.9	2.94
Ck Std (batch 4)	1420	3.96	170	1.66	10.8	7.02
1	665	3.57	73.8	0.799	3.47	3.41
2	625	3.76	67.2	0.903	3.95	3.35
3	528	4.51	41.7	1.54	4.98	3.01
4	619	5.44	102	1.02	2.37	7.34
5	620	4.01	87.9	0.847	4.47	3.22
6	748	3.31	73.6	0.925	5.98	2.59
7	861	3.38	85.9	0.970	4.32	3.84
8 N1	913	2.87	92.6	0.846	5.73	2.77
8 N2	881	3.10	82.9	0.952	4.97	3.17
9	727	3.66	71.4	1.16	4.96	3.38
10	833	2.98	60.1	1.21	5.06	2.91
11	633	3.51	55.1	1.26	1.83	6.66
12	715	3.28	66.9	1.11	4.26	3.25
13	415	6.45	58.5	1.51	4.81	3.65
14	464	4.50	46.9	1.36	3.75	3.35
15	548	4.95	106	0.986	3.71	4.64
16	571	4.04	81.6	0.925	5.10	2.77
17	575	3.85	58.1	1.15	3.77	3.34
18	570	3.64	55.1	1.18	3.45	3.50
19	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
20	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
21	580	3.98	70.2	1.04	4.89	2.99
22	758	3.03	58.6	1.23	7.70	2.25
23	678	3.37	61.7	1.15	3.74	3.57
24	741	3.80	64.1	1.36	3.26	4.93
25	542	3.88	44.5	1.38	2.45	4.62
26	654	3.30	47.3	1.36	5.50	2.56
27	660	3.11	79.3	0.972	3.02	4.81
28	228	8.10	78.1	1.10	6.16	3.32
29	750	2.95	66.8	1.15	6.84	2.85
30	679	2.84	31.8	1.86	3.44	3.97
31	588	3.55	68.1	1.10	2.91	5.18
32	770	3.34	97.7	0.966	7.02	3.10

APPENDIX B (cont'd)

Concentration and Standard Deviation Results (11 Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM)					
SPL #	Barium (123.7 KEV) Conc (ppm)	Barium (123.7 KEV) % Std Dev	Cerium (145.5 KEV) Conc (ppm)	Cerium (145.5 KEV) % Std Dev	Cesium (795.9 KEV) Conc (ppm)	Cesium (795.9 KEV) % Std Dev
33	326	4.93	10.6	3.26	0.183	17.60
34	402	3.87	8.05	4.31	0.193	19.20
35	248	6.77	7.93	5.14	0.127	29.90
36	198	6.46	7.89	4.08	0.191	19.70
37	219	4.84	8.49	4.26	0.242	15.80
38	225	4.87	9.78	3.34	0.256	18.60
39	156	6.67	6.92	5.11	0.348	19.40
40	120	7.43	7.02	4.48	0.125	33.10
41	470	3.70	51.0	1.22	2.65	4.73
42	451	3.93	51.5	1.29	2.74	4.86
43	249	5.37	35.8	1.48	2.28	4.86
44	736	3.26	106	0.947	13.4	2.30
45	149	8.66	28.3	1.80	2.08	5.08
46	35.8	26.60	7.36	4.53	1.08	5.97
47	229	5.29	40.9	1.27	2.24	4.36
48	528	3.63	64.5	1.13	3.13	4.62
49	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
50	603	3.92	84.8	1.14	4.16	4.79
51	648	3.20	66.5	1.14	5.43	3.38
52	836	2.89	123	0.790	4.65	3.64
53 N1	639	3.47	62.7	1.28	6.03	3.47
53 N2	625	3.21	61.1	1.21	5.76	3.44
54	730	3.21	78.2	1.11	5.42	3.73
55	751	2.62	67.4	1.07	4.15	3.78
56	654	3.17	76.7	10.8	6.89	2.94
57	705	3.33	75.0	1.15	5.80	3.46
58	595	3.23	54.1	1.25	5.18	3.13
59	726	3.03	73.4	1.07	3.61	4.39
60	267	5.19	25.3	1.92	1.80	5.59
Bit 1-1 (lot 442988)	<497	not detectable	<14.8	not detectable	<3.68	not detectable
Bit 1-2 (lot 442988)	<476	not detectable	<14.7	not detectable	<3.68	not detectable
Bit 2-1 (lot 555828)	<819	not detectable	<31.8	not detectable	<6.17	not detectable
Bit 2-2 (lot 555828)	<728	not detectable	<27.6	not detectable	<5.88	not detectable
Bit 3-1 (lot 625828)	<505	not detectable	<16.0	not detectable	<3.91	not detectable
Bit 3-1 (lot 625828)	<467	not detectable	<15.2	not detectable	<3.95	not detectable

APPENDIX B (cont'd)

Concentration and Standard Deviation Results (11 Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM)					
SPL #	Europium (1408.1 KEV) Conc (ppm)	Europium (1408.1 KEV) % Std Dev	Hafnium (482.3 KEV) Conc (ppm)	Hafnium (482.3 KEV) % Std Dev	Lanthanum (815 KEV) Conc (ppm)	Lanthanum (815 KEV) % Std Dev
Ck Std (batch 1)	3.63	1.74	7.59	2.60	83.3	0.839
Ck Std (batch 2)	3.77	1.96	8.20	3.04	85.8	1.40
Ck Std (batch 3)	3.90	1.86	7.78	3.17	84.4	1.33
Ck Std (batch 4)	3.87	4.26	7.95	6.68	83.8	0.994
1	1.15	2.36	5.93	2.07	33.6	1.03
2	0.898	2.93	7.58	1.91	30.2	1.25
3	0.605	4.12	5.79	2.32	19.1	1.91
4	1.20	3.41	5.63	3.00	44.9	1.29
5	1.33	2.45	6.48	2.15	36.8	1.14
6	1.07	2.62	4.77	2.62	34.7	1.09
7	1.19	2.81	6.27	2.45	36.4	1.35
8 N1	1.33	2.43	6.27	2.22	37.0	1.11
8 N2	1.23	2.62	5.70	2.51	35.6	1.27
9	1.38	2.53	6.53	2.37	36.8	1.32
10	1.03	2.70	5.79	2.35	30.9	1.36
11	0.767	3.03	6.65	2.04	26.8	1.45
12	1.33	2.35	6.77	2.13	35.8	1.25
13	0.826	3.68	5.00	2.94	32.0	1.68
14	0.863	2.77	4.25	2.57	23.3	1.70
15	1.10	3.07	5.90	2.80	44.3	1.43
16	1.26	2.32	6.64	2.12	37.6	1.18
17	1.03	2.49	4.89	2.45	31.9	1.36
18	1.09	2.42	4.51	2.46	33.7	1.35
19	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
20	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
21	1.06	2.65	5.21	2.42	37.6	1.31
22	0.902	2.98	5.43	2.50	31.9	1.54
23	1.15	2.46	4.68	2.60	36.9	1.39
24	1.07	3.07	4.73	3.01	34.5	1.77
25	0.944	2.66	5.99	2.10	25.2	1.69
26	0.799	2.87	4.91	2.35	23.6	1.91
27	1.22	2.79	7.52	2.33	38.7	1.53
28	0.933	3.61	7.98	2.43	32.7	1.83
29	1.01	3.16	4.70	3.08	32.7	1.87
30	0.491	4.71	2.90	3.83	17.2	2.56
31	1.11	3.04	5.42	2.84	33.9	1.71
32	1.20	3.17	6.13	3.01	36.0	1.93

APPENDIX B (cont'd)

Concentration and Standard Deviation Results (11 Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM)					
SPL #	Europium (1408.1 KEV)	Europium (1408.1 KEV)	Hafnium (482.3 KEV)	Hafnium (482.3 KEV)	Lanthanum (815 KEV)	Lanthanum (815 KEV)
	Conc (ppm)	% Std Dev	Conc (ppm)	% Std Dev	Conc (ppm)	% Std Dev
33	0.108	9.55	0.695	5.58	8.78	2.65
34	0.131	9.00	1.18	4.09	5.01	3.96
35	0.115	9.35	0.919	4.65	7.33	3.12
36	0.125	9.29	0.943	4.55	5.02	3.99
37	0.156	9.03	1.26	3.90	5.35	3.85
38	0.147	8.09	0.994	4.86	5.88	3.76
39	0.121	8.61	1.02	5.67	5.84	5.12
40	0.134	8.55	1.26	4.34	4.73	5.37
41	0.775	3.53	3.53	3.31	22.5	2.49
42	1.00	3.17	4.65	3.00	26.0	2.29
43	0.286	6.22	2.00	4.40	12.7	3.81
44	0.925	3.78	4.58	3.95	45.9	2.02
45	0.333	5.63	1.52	5.42	12.8	3.68
46	0.0501	18.2	0.535	8.88	2.78	8.66
47	0.182	7.39	1.36	5.34	7.64	5.17
48	1.02	3.06	4.95	2.83	36.3	2.06
49	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
50	1.10	3.41	4.62	3.73	35.5	2.65
51	1.17	2.92	5.57	2.86	32.7	1.72
52	1.14	2.69	5.29	2.98	61.0	1.25
53 N1	0.992	3.28	6.08	2.90	32.2	1.96
53 N2	0.97	3.26	7.00	2.61	32.2	1.90
54	1.26	2.98	6.35	2.89	36.7	1.87
55	1.11	2.87	5.93	2.63	33.6	1.74
56	1.06	3.18	6.40	2.75	36.5	1.83
57	0.971	8.06	5.58	3.10	35.2	2.05
58	0.757	3.65	5.31	2.72	25.3	2.24
59	1.02	3.17	6.81	2.51	33.3	2.01
60	0.219	6.81	1.48	5.27	9.42	4.18
Bit 1-1 (lot 442988)	1.72	13.8	<2.35	not detectable	<2.93	not detectable
Bit 1-2 (lot 442988)	<0.489	not detectable	<2.36	not detectable	<3.24	not detectable
Bit 2-1 (lot 555828)	1.81	27.0	<4.12	not detectable	<4.58	not detectable
Bit 2-2 (lot 555828)	1.56	25.4	<3.83	not detectable	<5.12	not detectable
Bit 3-1 (lot 625828)	<0.534	not detectable	<2.53	not detectable	<3.14	not detectable
Bit 3-1 (lot 625828)	0.638	30.2	<2.46	not detectable	<3.42	not detectable

APPENDIX B (cont'd)

Concentration and Standard Deviation Results (11 Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM)					
SPL #	Lutetium (208.5 KEV)	Lutetium (208.5 KEV)	Samarium (103.2 KEV)	Samarium (103.2 KEV)	Scandium (889.3 KEV)	Scandium (889.3 KEV)
	Conc (ppm)	% Std Dev	Conc (ppm)	% Std Dev	Conc (ppm)	% Std Dev
Ck Std (batch 1)	1.10	1.66	16.8	0.189	38.5	0.135
Ck Std (batch 2)	1.13	1.75	17.6	0.266	40.3	0.162
Ck Std (batch 3)	1.09	1.77	17.3	0.250	39.9	0.164
Ck Std (batch 4)	1.16	2.39	16.8	0.241	38.6	0.405
1	0.331	2.94	5.67	0.271	9.76	0.225
2	0.291	3.29	4.37	0.316	11.2	0.214
3	0.261	3.37	3.14	0.459	9.45	0.288
4	0.395	3.94	6.97	0.377	9.68	0.356
5	0.457	2.52	7.69	0.263	10.4	0.237
6	0.342	2.91	5.39	0.311	12.1	0.215
7	0.399	2.96	6.40	0.324	12.0	0.259
8 N1	0.364	2.78	6.07	0.294	13.2	0.208
8 N2	0.352	3.16	5.82	0.323	11.9	0.242
9	0.397	2.91	6.44	0.308	13.5	0.228
10	0.347	3.07	5.23	0.321	11.3	0.230
11	0.257	3.54	3.65	0.399	9.53	0.235
12	0.396	2.57	6.52	0.292	12.3	0.217
13	0.269	4.47	5.26	0.421	10.2	0.288
14	0.237	3.52	3.95	0.389	7.78	0.276
15	0.319	3.72	5.38	0.435	11.7	0.282
16	0.397	2.51	6.42	0.296	11.8	0.219
17	0.290	3.17	5.10	0.345	8.83	0.253
18	0.314	3.04	5.26	0.339	8.67	0.255
19	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
20	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
21	0.333	3.06	5.22	0.355	10.5	0.240
22	0.361	3.00	4.78	0.382	13.0	0.212
23	0.312	3.29	5.42	0.357	9.95	0.245
24	0.278	4.34	5.46	0.439	9.65	0.306
25	0.267	3.41	4.25	0.406	6.74	0.300
26	0.254	3.58	3.93	0.437	8.59	0.262
27	0.358	2.66	6.33	0.359	11.1	0.282
28	0.363	3.11	5.30	0.448	10.6	0.321
29	0.301	3.21	5.28	0.436	9.52	0.328
30	0.132	5.50	2.16	0.752	4.59	0.494
31	0.297	3.13	5.36	0.432	8.56	0.341
32	0.445	2.74	5.88	0.458	16.4	0.25

APPENDIX B (cont'd)

Concentration and Standard Deviation Results (11 Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM)					
SPL #	Lutetium (208.5 KEV) Conc (ppm)	Lutetium (208.5 KEV) % Std Dev	Samarium (103.2 KEV) Conc (ppm)	Samarium (103.2 KEV) % Std Dev	Scandium (889.3 KEV) Conc (ppm)	Scandium (889.3 KEV) % Std Dev
33	0.0696	6.46	0.582	2.11	0.261	1.93
34	0.040	9.82	0.609	1.92	0.406	1.51
35	0.036	12.0	0.545	2.41	0.258	2.04
36	0.105	3.99	0.611	1.77	0.406	1.49
37	0.083	4.81	0.733	1.40	0.360	1.64
38	0.0462	8.31	0.751	1.40	0.477	1.43
39	0.0334	11.50	0.517	1.94	0.307	2.36
40	0.0481	7.58	0.635	1.64	0.381	1.83
41	0.245	3.17	3.81	0.530	6.83	0.366
42	0.295	2.92	4.65	0.496	7.49	0.357
43	0.148	4.77	1.82	0.863	4.34	0.456
44	0.301	4.06	6.12	0.514	20.1	0.220
45	0.154	4.65	1.93	0.867	3.22	0.549
46	0.0324	12.60	0.355	2.84	0.914	1.02
47	0.0918	6.27	1.10	1.21	3.04	0.539
48	0.308	2.58	5.03	0.550	8.94	0.323
49	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN	NOT RUN
50	0.318	3.8	5.42	0.642	10.9	0.347
51	0.330	2.52	5.49	0.396	10.7	0.288
52	0.356	2.82	7.99	0.334	10.9	0.300
53 N1	0.339	2.67	4.79	0.458	13.4	0.271
53 N2	0.336	2.72	4.65	0.454	13.6	0.263
54	0.355	3.04	5.70	0.423	14.0	0.269
55	0.299	3.09	5.38	0.404	9.12	0.313
56	0.350	2.80	5.48	0.441	12.7	0.275
57	0.324	3.24	4.82	0.516	13.8	0.271
58	0.231	3.49	3.65	0.555	7.96	0.337
59	0.315	3.15	5.15	0.496	8.75	0.333
60	0.0780	6.21	1.46	1.01	3.60	0.504
Bit 1-1 (lot 442988)	<.180	not detectable	<0.143	not detectable	<0.294	not detectable
Bit 1-2 (lot 442988)	<.172	not detectable	<0.147	not detectable	<0.286	not detectable
Bit 2-1 (lot 555828)	<.295	not detectable	<0.242	not detectable	<0.468	not detectable
Bit 2-2 (lot 555828)	<.261	not detectable	<0.231	not detectable	<0.463	not detectable
Bit 3-1 (lot 625828)	<.183	not detectable	<0.149	not detectable	<0.322	not detectable
Bit 3-1 (lot 625828)	<.171	not detectable	<0.148	not detectable	<0.308	not detectable

APPENDIX B (cont'd)

Concentration and Standard Deviation Results (11 Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM)			
SPL #	Thorium (312.0 KEV) Conc (ppm)	Thorium (312.0 KEV) % Std Dev	Ytterbium (396.5 KEV) Conc (ppm)	Ytterbium (396.5 KEV) % Std Dev
Ck Std (batch 1)	24.7	0.796	7.47	1.66
Ck Std (batch 2)	25.6	0.965	7.70	1.98
Ck Std (batch 3)	24.8	0.987	6.70	1.74
Ck Std (batch 4)	23.9	2.27	7.32	2.31
1	9.99	0.909	2.38	2.73
2	13.3	0.810	2.25	3.02
3	8.63	1.220	2.21	3.05
4	15.7	1.020	3.00	3.52
5	16.7	0.757	3.50	2.29
6	10.9	0.987	2.36	2.94
7	13.6	0.984	3.21	2.79
8 N1	12.4	0.949	2.41	2.89
8 N2	10.7	1.27	2.51	3.11
9	11.7	1.09	2.74	2.87
10	10.1	1.090	2.37	2.68
11	13.3	0.846	1.70	3.35
12	13.0	1.030	2.82	2.49
13	13.5	1.110	2.04	4.29
14	7.16	1.310	1.87	3.46
15	10.0	1.390	2.54	3.59
16	14.5	0.861	2.90	2.56
17	8.20	1.20	2.22	3.06
18	8.20	1.170	2.30	2.98
19	NOT RUN	NOT RUN	NOT RUN	NOT RUN
20	NOT RUN	NOT RUN	NOT RUN	NOT RUN
21	10.1	1.09	2.41	3.03
22	13.1	0.944	2.41	3.11
23	8.70	1.19	2.16	3.22
24	9.09	1.41	2.12	3.96
25	7.98	1.19	1.94	3.37
26	7.63	1.25	1.95	3.26
27	12.9	1.05	2.83	2.53
28	15.8	1.01	2.60	3.04
29	11.0	1.20	2.46	2.79
30	5.32	1.82	0.984	5.63
31	8.02	1.54	2.31	2.92
32	14.2	1.21	2.71	3.11

APPENDIX B (cont'd)

Concentration and Standard Deviation Results (11 Elements)

SAMPLE	ELEMENT CONCENTRATION (PPM)			
SPL #	Thorium (312.0 KEV) Conc (ppm)	Thorium (312.0 KEV) % Std Dev	Ytterbium (396.5 KEV) Conc (ppm)	Ytterbium (396.5 KEV) % Std Dev
33	1.08	4.05	0.499	5.35
34	0.78	5.33	0.310	8.61
35	0.623	6.80	0.271	9.69
36	0.732	4.99	0.766	3.44
37	0.691	5.88	0.420	5.72
38	1.04	4.34	0.340	7.47
39	0.680	7.34	0.247	12.1
40	0.762	5.50	0.282	8.31
41	6.35	1.53	1.61	3.48
42	6.70	1.64	2.03	3.13
43	4.94	1.80	0.757	5.99
44	14.4	1.15	2.02	4.6
45	2.83	2.91	0.822	5.61
46	1.06	4.98	0.163	15.3
47	3.38	2.07	0.480	7.67
48	7.75	1.45	2.39	3.21
49	NOT RUN	NOT RUN	NOT RUN	NOT RUN
50	12.0	1.33	2.46	3.77
51	9.75	1.28	2.44	2.75
52	18.9	8.72	2.93	2.57
53 N1	15.5	1.00	2.70	2.87
53 N2	15.5	0.980	2.41	3.00
54	15.8	1.02	2.61	3.10
55	10.2	1.18	2.40	2.65
56	16.7	0.95	2.42	3.11
57	13.2	1.23	2.54	3.18
58	8.13	1.45	1.67	3.82
59	13.9	1.02	2.37	3.20
60	3.95	1.94	0.738	6.12
Bit 1-1 (lot 442988)	<2.05	not detectable	<1.25	not detectable
Bit 1-2 (lot 442988)	<2.04	not detectable	<1.21	not detectable
Bit 2-1 (lot 555828)	<3.87	not detectable	<1.97	not detectable
Bit 2-2 (lot 555828)	<3.62	not detectable	<1.84	not detectable
Bit 3-1 (lot 625828)	<2.20	not detectable	<1.27	not detectable
Bit 3-1 (lot 625828)	<2.11	not detectable	<1.22	not detectable

APPENDIX C

APPENDIX C

Concentration Values for 11 Elements, in Increasing Order

Barium (123 KV)			
Sample Number	Conc. (ppm)	Sample Number	Conc. (ppm)
46	35.8	5	620
40	120	2	625
45	149	53N2	625
39	156	11	633
36	198	53N1	639
37	219	51	648
38	225	26	654
28	228	56	654
47	229	27	660
35	248	1	665
43	249	23	678
60	267	30	679
33	326	57	705
34	402	12	715
13	415	59	726
42	451	9	727
14	464	54	730
41	470	44	736
3	528	24	741
48	528	6	748
25	542	29	750
15	548	55	751
18	570	22	758
16	571	32	770
17	575	10	833
21	580	52	836
31	588	7	861
58	595	8N2	881
50	603	8N1	913
4	619		

Cerium (145 KeV)			
Sample Number	Conc. (ppm)	Sample Number	Conc. (ppm)
39	6.92	53N2	64.1
40	7.02	48	64.5
46	7.36	51	66.5
36	7.89	29	66.8
35	7.93	12	66.9
34	8.05	2	67.2
37	8.49	55	67.4
38	9.78	31	68.1
33	10.6	21	70.2
60	25.3	9	71.4
45	28.3	59	73.4
30	31.8	6	73.6
43	35.8	1	73.8
47	40.9	57	75
3	41.7	56	76.7
25	44.5	28	78.1
14	46.9	54	78.2
26	47.3	27	79.3
41	51	16	81.6
42	51.5	8N2	82.9
58	54.1	50	84.8
11	55.1	7	85.9
18	55.1	5	87.9
17	58.1	8N1	92.6
13	58.5	32	97.7
22	58.6	4	102
10	60.1	15	106
23	61.7	44	106
53N1	62.7	52	123
24	64.1		

APPENDIX C (cont'd)

Concentration Values for 11 Elements, in Increasing Order

Cesium (795 KeV)			
Sample Number	Conc. (ppm)	Sample Number	Conc. (ppm)
40	0.125	2	3.95
35	0.127	55	4.15
33	0.183	50	4.16
36	0.191	12	4.26
34	0.193	7	4.32
37	0.242	5	4.47
38	0.256	52	4.65
39	0.348	13	4.81
46	1.08	21	4.89
60	1.8	9	4.96
11	1.83	8N2	4.97
45	2.08	3	4.98
47	2.24	10	5.06
43	2.28	16	5.1
4	2.37	58	5.18
25	2.45	54	5.42
41	2.65	51	5.43
42	2.74	26	5.5
31	2.91	8N1	5.73
27	3.02	53N2	5.76
48	3.13	57	5.8
24	3.26	6	5.98
30	3.44	53N1	6.03
18	3.45	28	6.16
1	3.47	29	6.84
59	3.61	56	6.89
15	3.71	32	7.02
23	3.74	22	7.7
14	3.75	44	13.4
17	3.77		

Europium (1408 KeV)			
Sample Number	Conc. (ppm)	Sample Number	Conc. (ppm)
46	0.0501	29	1.01
33	0.108	48	1.02
35	0.115	59	1.02
39	0.121	10	1.03
36	0.125	17	1.03
34	0.131	21	1.06
40	0.134	56	1.06
38	0.147	6	1.07
37	0.156	24	1.07
47	0.182	18	1.09
60	0.219	15	1.1
43	0.286	50	1.1
45	0.333	31	1.11
30	0.491	55	1.11
3	0.605	52	1.14
58	0.757	1	1.15
11	0.767	23	1.15
41	0.775	51	1.17
26	0.799	7	1.19
13	0.826	4	1.2
14	0.863	32	1.2
2	0.898	27	1.22
22	0.902	8N2	1.23
44	0.925	16	1.26
28	0.933	54	1.26
25	0.944	5	1.33
53N2	0.97	8N1	1.33
57	0.971	12	1.33
53N1	0.992	9	1.38
42	1		

APPENDIX C (cont'd)

Concentration Values for 11 Elements, in Increasing Order

Hafnium (482 KeV)			
Sample Number	Conc. (ppm)	Sample Number	Conc. (ppm)
46	0.535	58	5.31
33	0.695	31	5.42
35	0.919	22	5.43
36	0.943	51	5.57
38	0.994	57	5.58
39	1.02	4	5.63
34	1.18	8N2	5.7
37	1.26	3	5.79
40	1.26	10	5.79
47	1.36	15	5.9
60	1.48	1	5.93
45	1.52	55	5.93
43	2	25	5.99
30	2.9	53N1	6.08
41	3.53	32	6.13
14	4.25	7	6.27
18	4.51	8N1	6.27
44	4.58	54	6.35
50	4.62	56	6.4
42	4.65	5	6.46
23	4.68	9	6.53
29	4.7	16	6.64
24	4.73	11	6.65
6	4.77	12	6.77
17	4.89	59	6.81
26	4.91	53N2	7
48	4.95	27	7.52
13	5	2	7.58
21	5.21	28	7.98
52	5.29		

Lanthanum (815 KeV0			
Sample Number	Conc. (ppm)	Sample Number	Conc. (ppm)
46	2.78	29	32.7
40	4.73	51	32.7
34	5.01	59	33.3
36	5.02	1	33.6
37	5.35	55	33.6
39	5.84	18	33.7
38	5.88	31	33.9
35	7.33	24	34.5
47	7.64	6	34.7
33	8.78	57	35.2
60	9.42	50	35.5
43	12.7	8N2	35.6
45	12.8	12	35.8
30	17.2	32	36
3	19.1	48	36.3
41	22.5	7	36.4
14	23.3	56	36.5
26	23.6	54	36.7
25	25.2	5	36.8
58	25.3	9	36.8
42	26	23	36.9
11	26.8	8N1	37
2	30.2	16	37.6
10	30.9	21	37.6
17	31.9	27	38.7
22	31.9	15	44.3
13	32	4	44.9
53N1	32.2	44	45.9
53N2	32.2	52	61
28	32.7		

APPENDIX C (cont'd)

Concentration Values for 11 Elements, in Increasing Order

Lutetium (208 KeV)			
Sample Number	Conc. (ppm)	Sample Number	Conc. (ppm)
46	0.0324	48	0.308
39	0.0334	23	0.312
35	0.036	18	0.314
34	0.04	59	0.315
38	0.0462	50	0.318
40	0.0481	15	0.319
33	0.0696	57	0.324
60	0.078	51	0.33
37	0.083	1	0.331
47	0.0918	21	0.333
36	0.105	53N2	0.336
30	0.132	53N1	0.339
43	0.148	6	0.342
45	0.154	10	0.347
58	0.231	56	0.35
14	0.237	8N2	0.352
41	0.245	54	0.355
26	0.254	52	0.356
11	0.257	27	0.358
3	0.261	22	0.361
25	0.267	28	0.363
13	0.269	8N1	0.364
24	0.278	4	0.395
17	0.29	12	0.396
2	0.291	9	0.397
42	0.295	16	0.397
31	0.297	7	0.399
55	0.299	32	0.445
29	0.301	5	0.457
44	0.301		

Samarium (103 KeV)			
Sample Number	Conc. (ppm)	Sample Number	Conc. (ppm)
46	0.355	21	5.22
39	0.517	10	5.23
35	0.545	13	5.26
33	0.582	18	5.26
34	0.609	29	5.28
36	0.611	28	5.3
40	0.635	31	5.36
37	0.733	15	5.38
38	0.751	55	5.38
47	1.1	6	5.39
60	1.46	23	5.42
43	1.82	50	5.42
45	1.93	24	5.46
30	2.16	56	5.48
3	3.14	51	5.49
11	3.65	1	5.67
58	3.65	54	5.7
41	3.81	8N2	5.82
26	3.93	32	5.88
14	3.95	8N1	6.07
25	4.25	44	6.12
2	4.37	27	6.33
42	4.65	7	6.4
53N2	4.65	16	6.42
22	4.78	9	6.44
53N1	4.79	12	6.52
57	4.82	4	6.97
48	5.03	5	7.69
17	5.1	52	7.99
59	5.15		

APPENDIX C (cont'd)

Concentration Values for 11 Elements, in Increasing Order

Scandium (889 KeV)			
Sample Number	Conc. (ppm)	Sample Number	Conc. (ppm)
35	0.258	4	9.68
33	0.261	1	9.76
39	0.307	23	9.95
37	0.36	13	10.2
40	0.381	5	10.4
34	0.406	21	10.5
36	0.406	28	10.6
38	0.477	51	10.7
46	0.914	50	10.9
47	3.04	52	10.9
45	3.22	27	11.1
60	3.6	2	11.2
43	4.34	10	11.3
30	4.59	15	11.7
25	6.74	16	11.8
41	6.83	8N2	11.9
42	7.49	7	12
14	7.78	6	12.1
58	7.96	12	12.3
31	8.56	56	12.7
26	8.59	22	13
18	8.67	8N1	13.2
59	8.75	53N1	13.4
17	8.83	9	13.5
48	8.94	53N2	13.6
55	9.12	57	13.8
3	9.45	54	14
29	9.52	32	16.4
11	9.53	44	20.1
24	9.65		

Thorium (312 KeV)			
Sample Number	Conc. (ppm)	Sample Number	Conc. (ppm)
35	0.623	10	10.1
39	0.68	21	10.1
37	0.691	55	10.2
36	0.732	8N2	10.7
40	0.762	6	10.9
34	0.78	29	11
38	1.04	9	11.7
46	1.06	50	12
33	1.08	8N1	12.4
45	2.83	27	12.9
47	3.38	12	13
60	3.95	22	13.1
43	4.94	57	13.2
30	5.32	2	13.3
41	6.35	11	13.3
42	6.7	13	13.5
14	7.16	7	13.6
26	7.63	59	13.9
48	7.75	32	14.2
25	7.98	44	14.4
31	8.02	16	14.5
58	8.13	53N1	15.5
17	8.2	53N2	15.5
18	8.2	4	15.7
3	8.63	28	15.8
23	8.7	54	15.8
24	9.09	5	16.7
51	9.75	56	16.7
1	9.99	52	18.9
15	10		

APPENDIX C (cont'd)

Concentration Values for 11 Elements, in Increasing Order

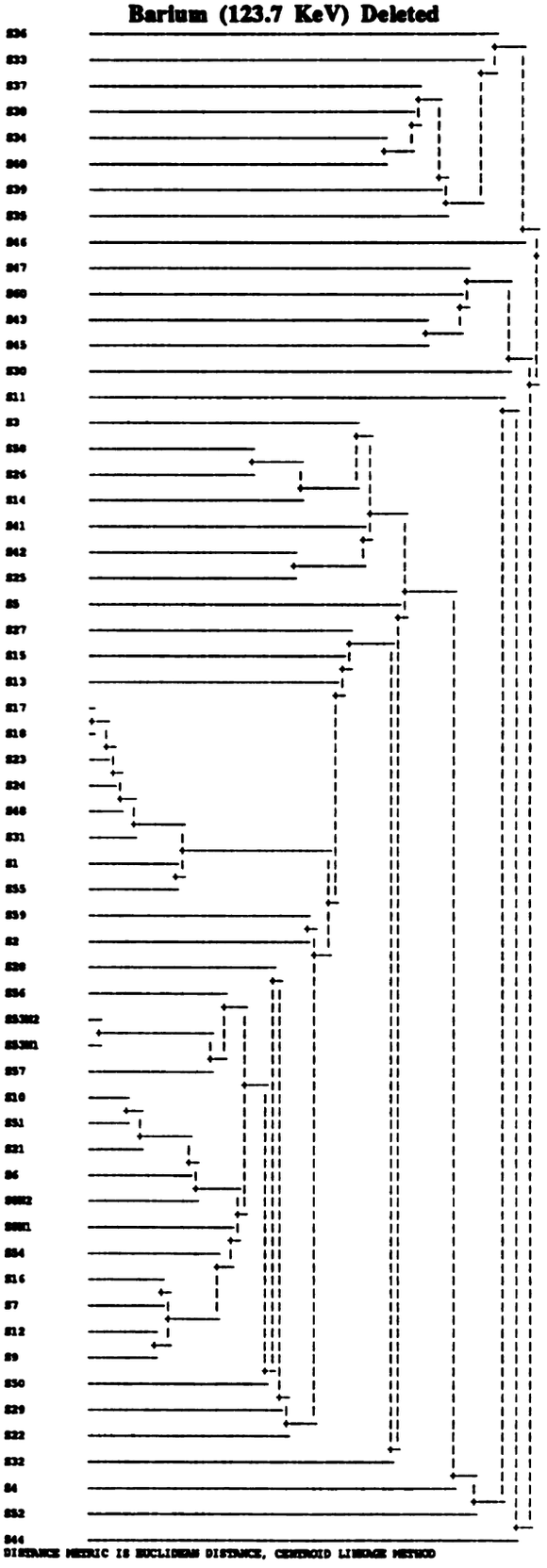
Ytterbium (369 KeV)			
Sample Number	Conc. (ppm)	Sample Number	Conc. (ppm)
46	0.163	6	2.36
39	0.247	10	2.37
35	0.271	59	2.37
40	0.282	1	2.38
34	0.31	48	2.39
38	0.34	55	2.4
37	0.42	8N1	2.41
47	0.48	21	2.41
33	0.499	22	2.41
60	0.738	53N2	2.41
43	0.757	56	2.42
36	0.766	51	2.44
45	0.822	29	2.46
30	0.984	50	2.46
41	1.61	8N2	2.51
58	1.67	15	2.54
11	1.7	57	2.54
14	1.87	28	2.6
25	1.94	54	2.61
26	1.95	53N1	2.7
44	2.02	32	2.71
42	2.03	9	2.74
13	2.04	12	2.82
24	2.12	27	2.83
23	2.16	16	2.9
3	2.21	52	2.93
17	2.22	4	3
2	2.25	7	3.21
18	2.3	5	3.5
31	2.31		

APPENDIX D

APPENDIX D

Centroid Linkage Dendrograms Using 10 of 11 Elements

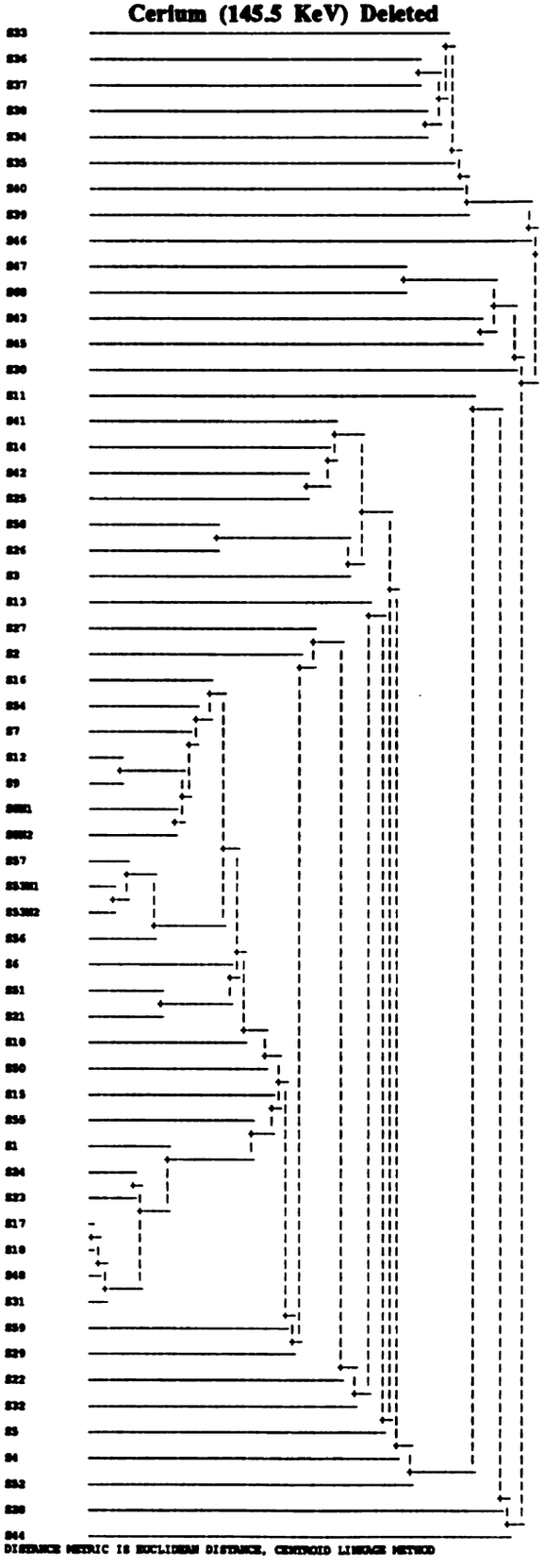
Barium (123.7 KeV) Deleted



APPENDIX D (cont'd)

Centroid Linkage Dendrograms Using 10 of 11 Elements

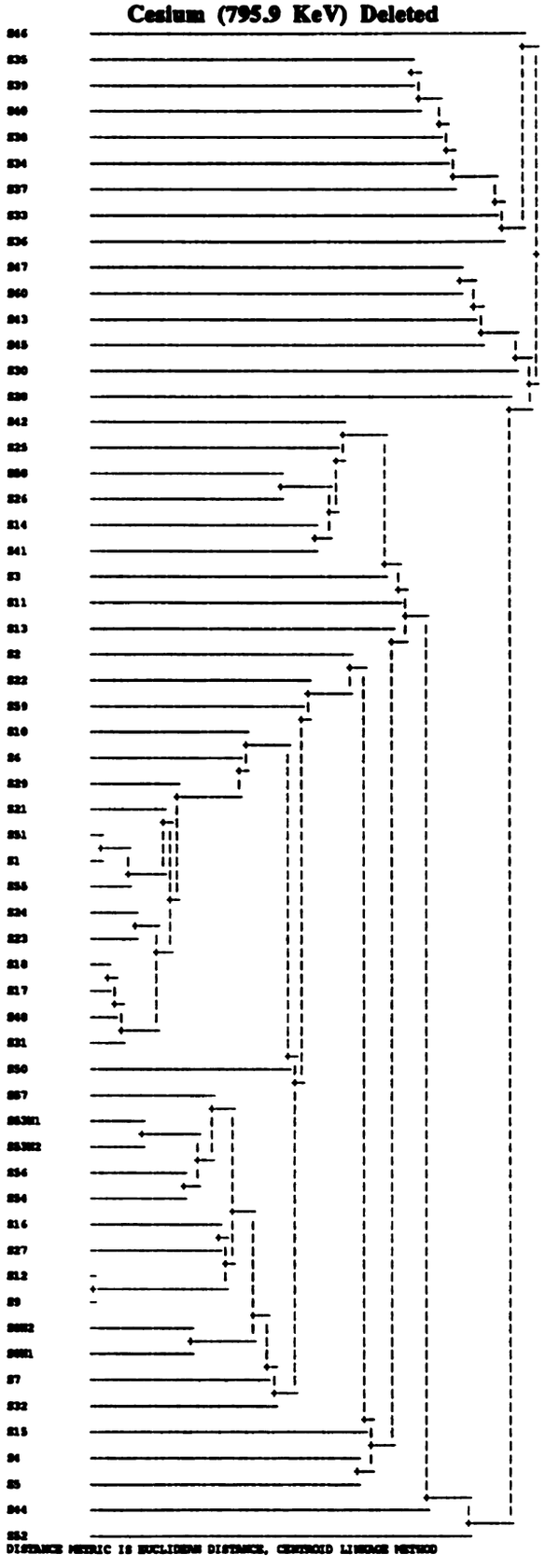
Cerium (145.5 KeV) Deleted



APPENDIX D (cont'd)

Centroid Linkage Dendrograms Using 10 of 11 Elements

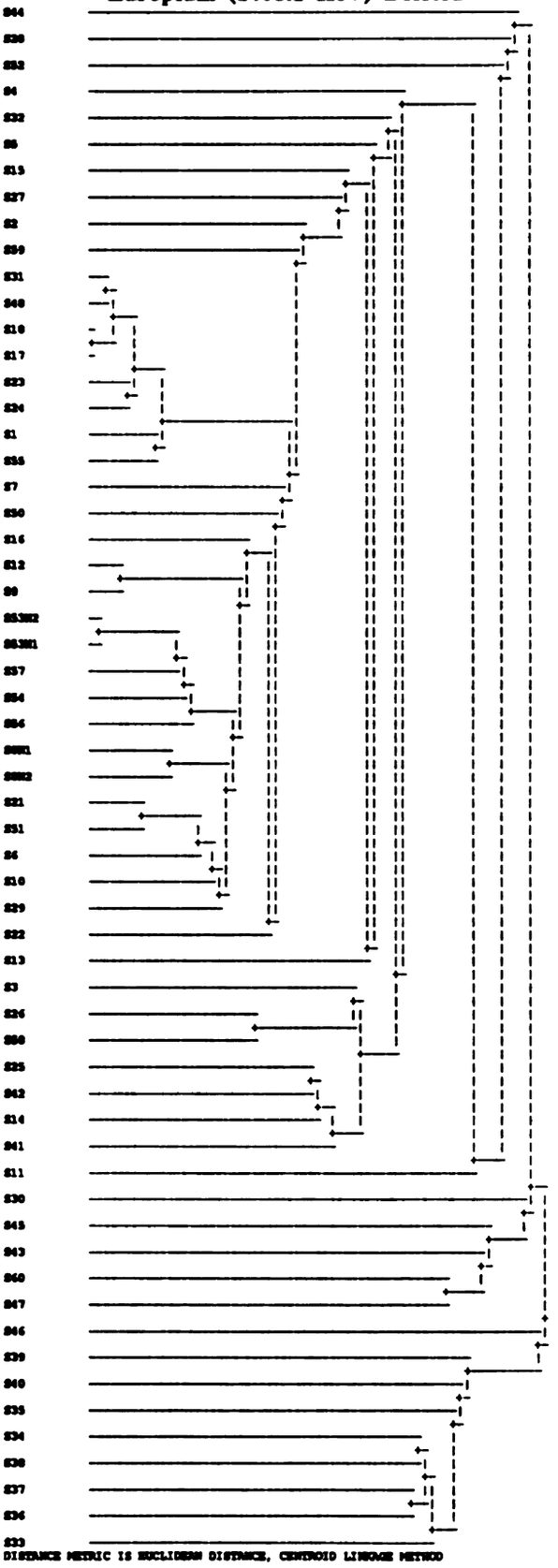
Cesium (795.9 KeV) Deleted



APPENDIX D (cont'd)

Centroid Linkage Dendrograms Using 10 of 11 Elements

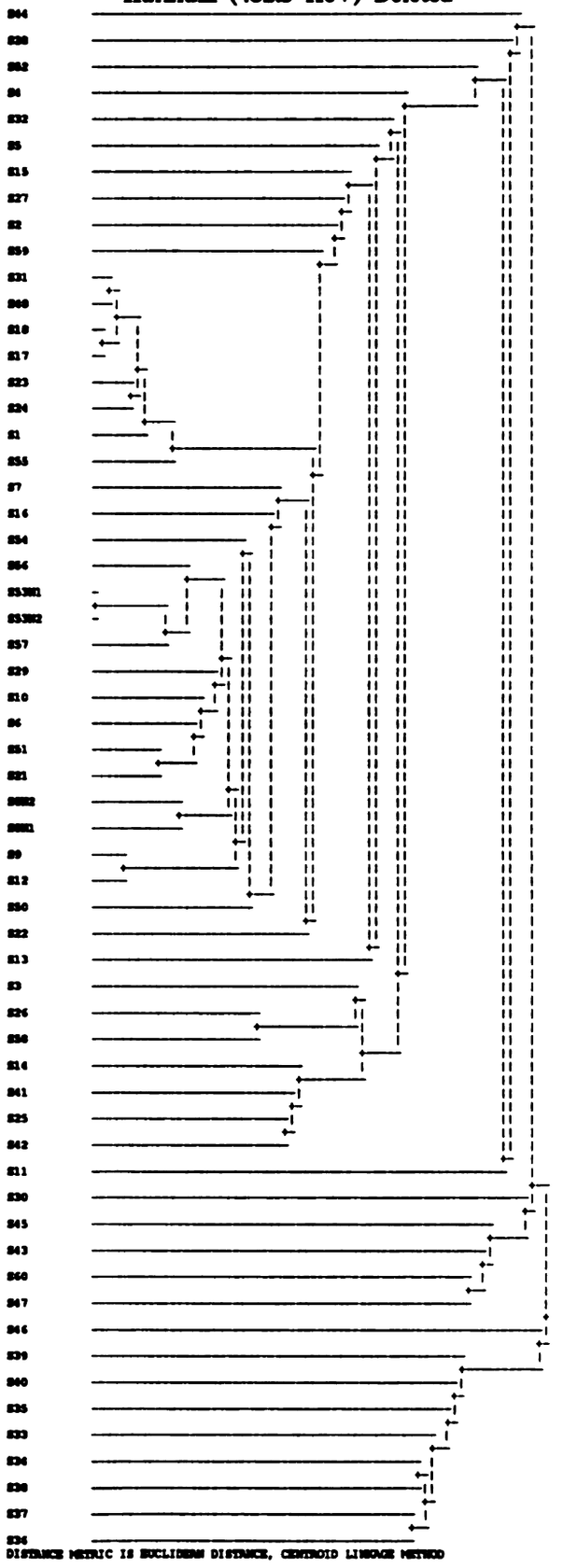
Europium (1408.1 KeV) Deleted



APPENDIX D (cont'd)

Centroid Linkage Dendrograms Using 10 of 11 Elements

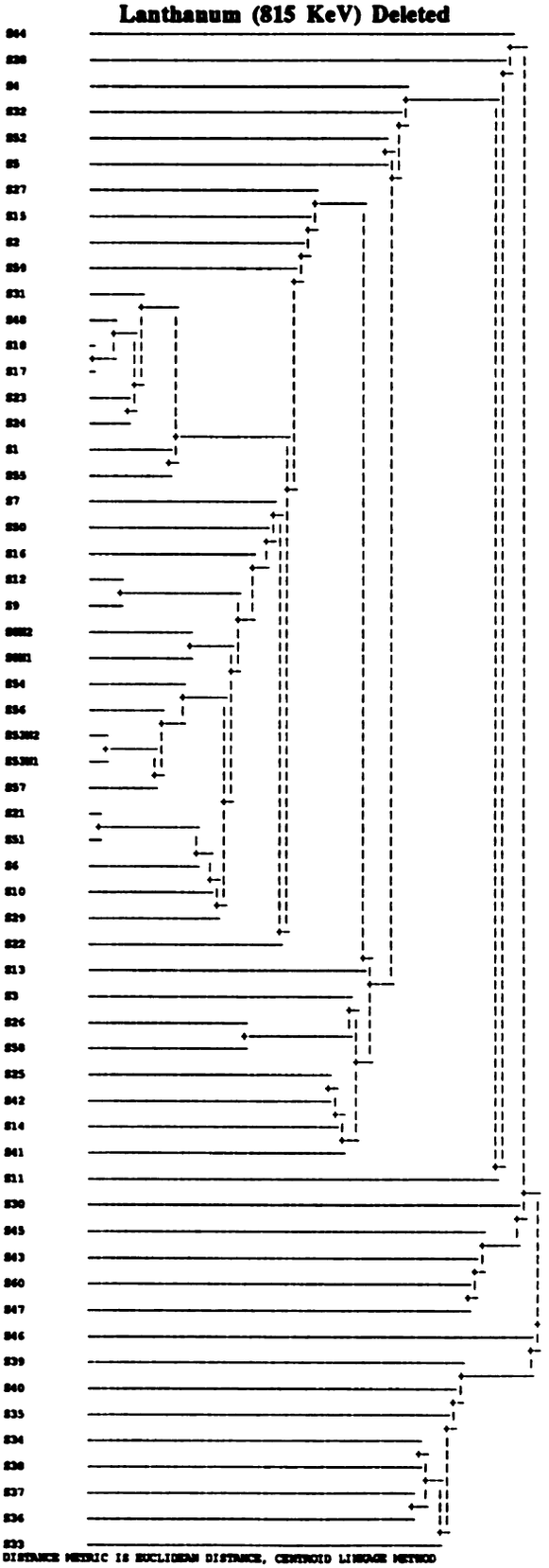
Hafnium (482.3 KeV) Deleted



APPENDIX D (cont'd)

Centroid Linkage Dendrograms Using 10 of 11 Elements

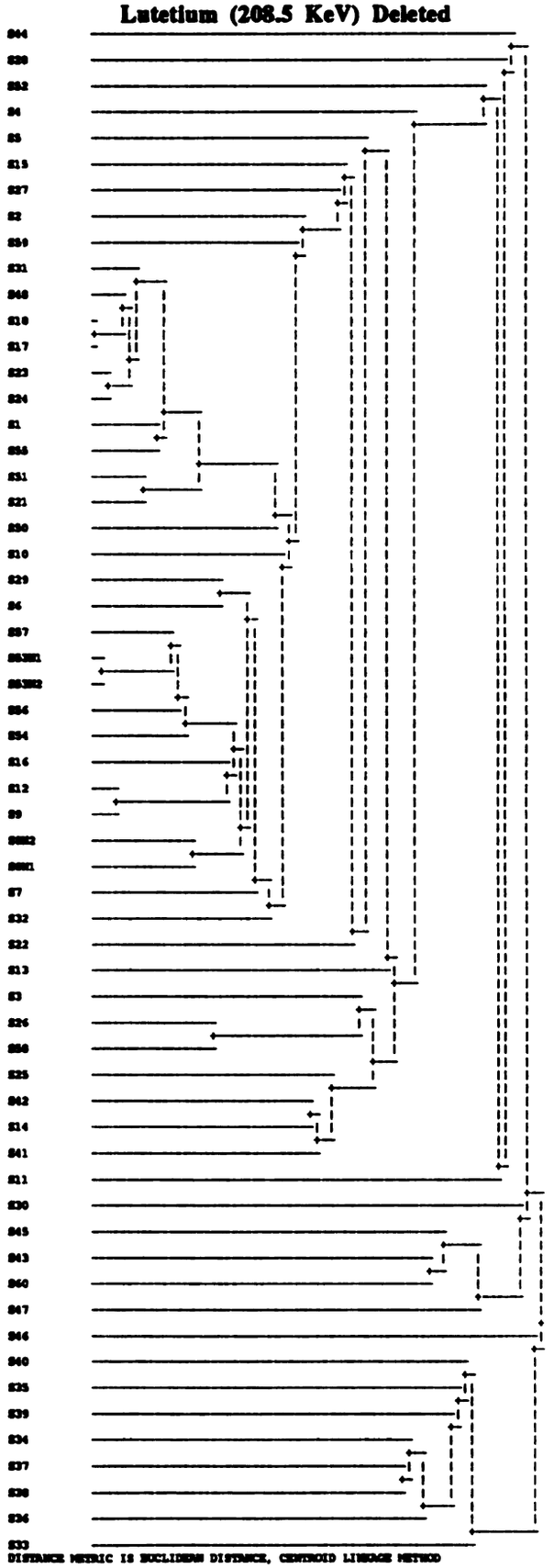
Lanthanum (815 KeV) Deleted



APPENDIX D (cont'd)

Centroid Linkage Dendrograms Using 10 of 11 Elements

Lutetium (208.5 KeV) Deleted

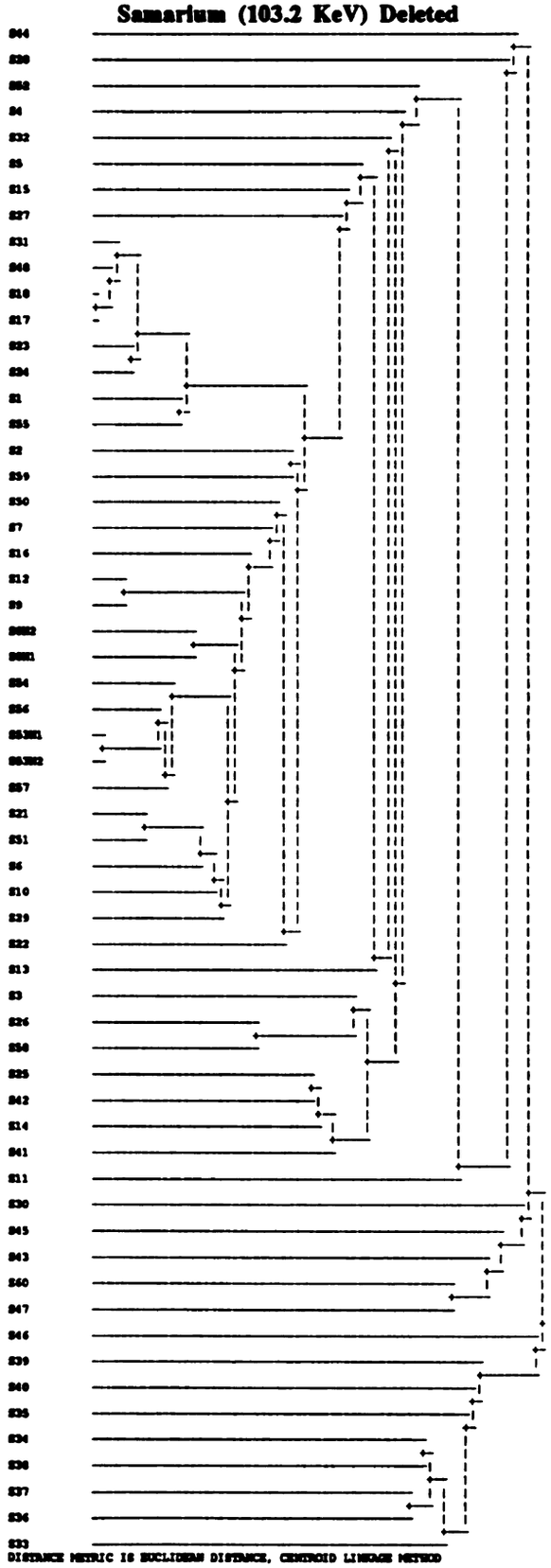


DISTANCE METRIC IS EUCLIDEAN DISTANCE, CENTROID LINKAGE METHOD

APPENDIX D (cont'd)

Centroid Linkage Dendrograms Using 10 of 11 Elements

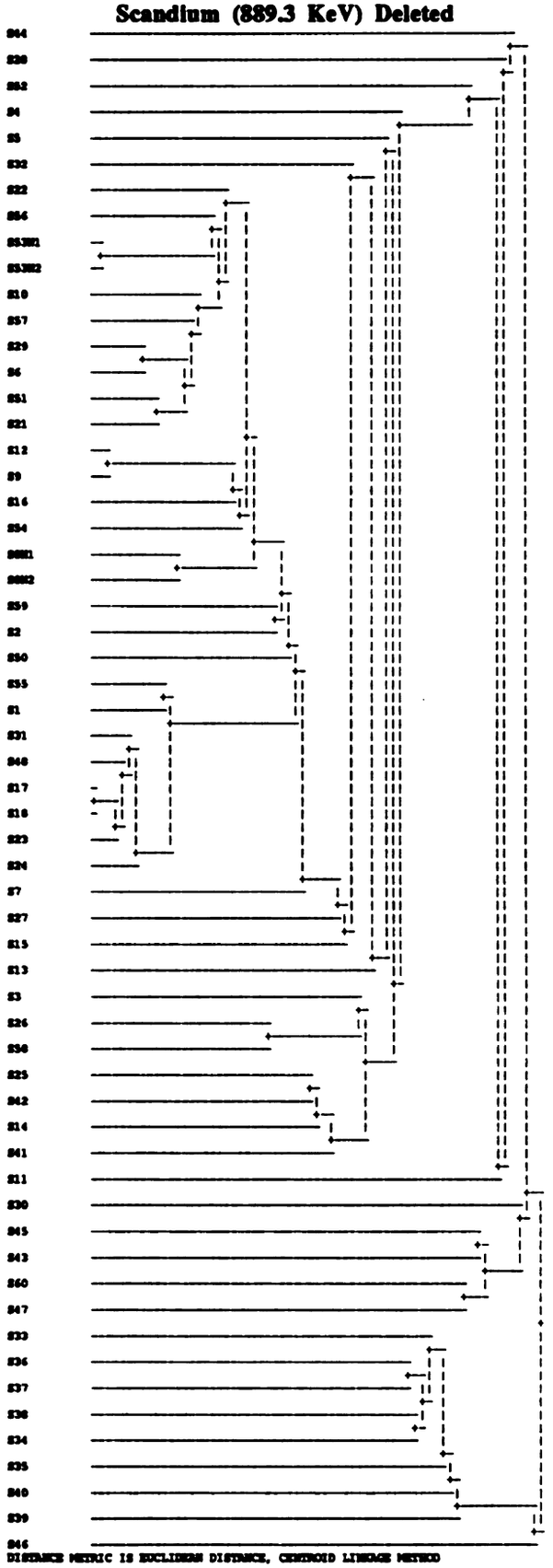
Samarium (103.2 KeV) Deleted



APPENDIX D (cont'd)

Centroid Linkage Dendrograms Using 10 of 11 Elements

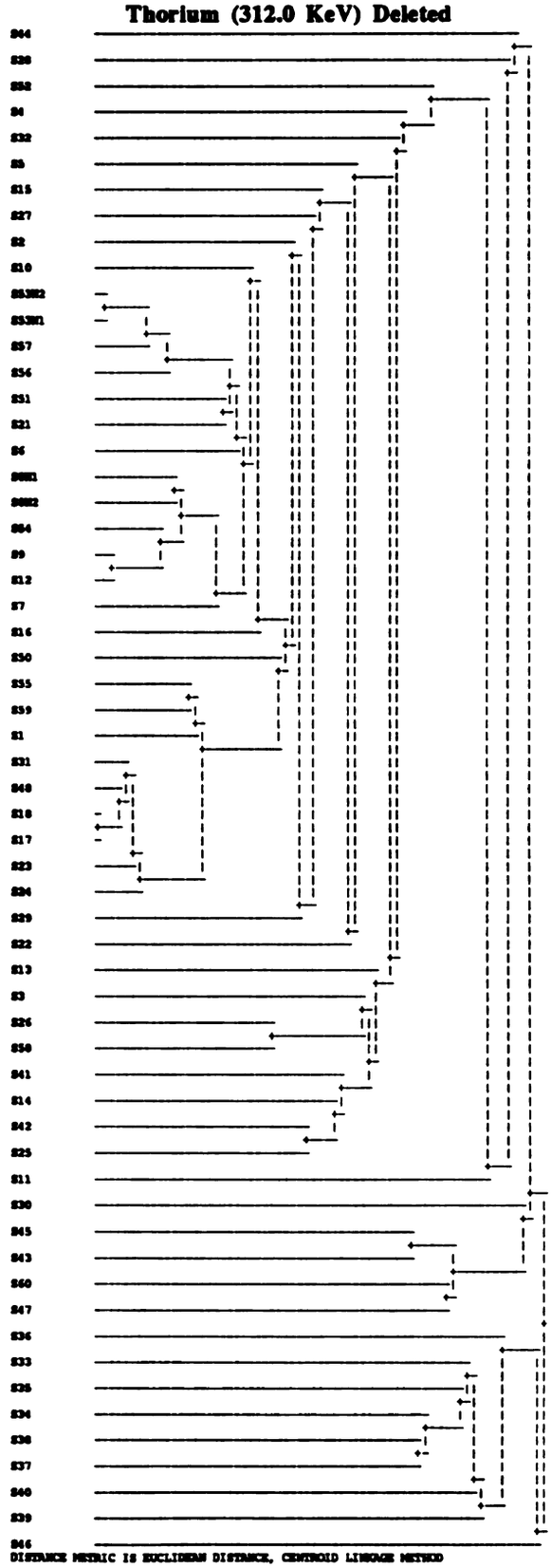
Scandium (889.3 KeV) Deleted



APPENDIX D (cont'd)

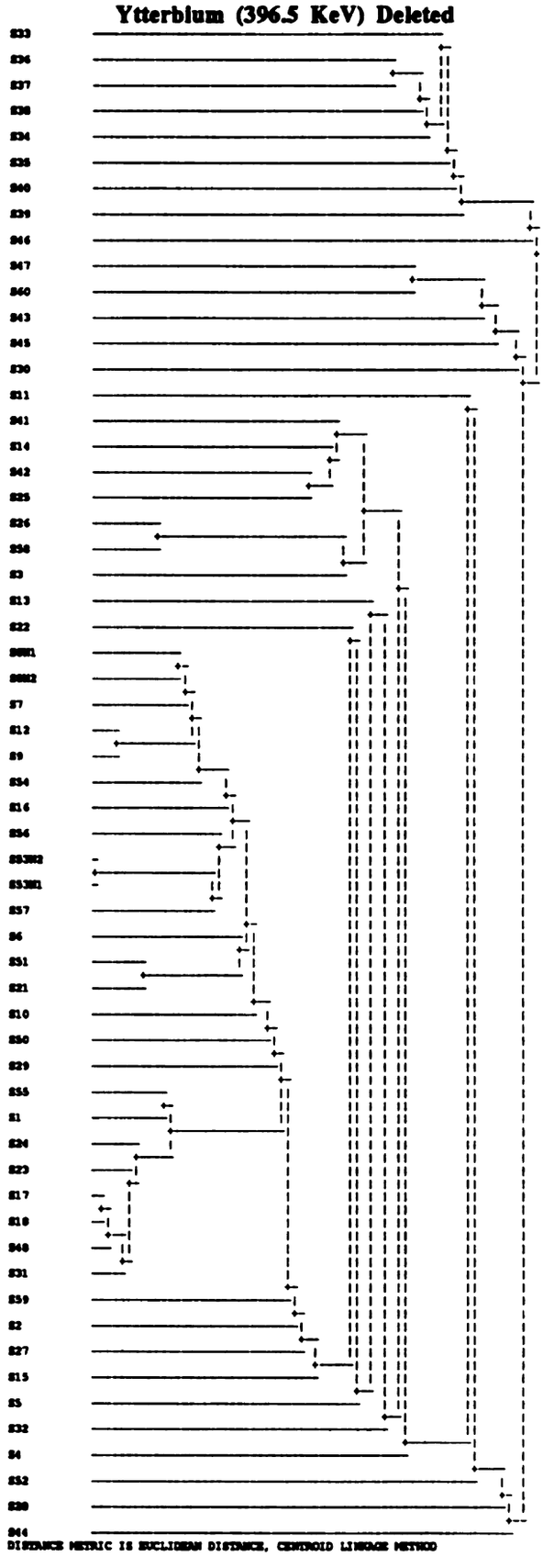
Centroid Linkage Dendrograms Using 10 of 11 Elements

Thorium (312.0 KeV) Deleted



APPENDIX D (cont'd)

Centroid Linkage Dendrograms Using 10 of 11 Elements



APPENDIX E

APPENDIX E

K-means Clusters Using 11 Elements

No Number of Clusters Specified

SUMMARY STATISTICS FOR 2 CLUSTERS

VARIABLE	BETWEEN SS	DF	WITHIN SS	DF	F-RATIO	PROB
LOGBA	2.223	1	1.792	57	70.720	0.000
LOGLA	4.802	1	0.970	57	282.144	0.000
LOGLU	4.959	1	0.914	57	309.188	0.000
LOGSM	6.728	1	1.087	57	352.859	0.000
LOGY	5.426	1	1.211	57	255.458	0.000
LOGCE	5.697	1	1.448	57	224.303	0.000
LOGCS	10.583	1	3.338	57	180.724	0.000
LOGEU	6.937	1	1.139	57	347.261	0.000
LOGHF	4.578	1	0.986	57	264.670	0.000
LOGSC	13.742	1	2.555	57	306.619	0.000
LOGTH	8.875	1	1.996	57	253.389	0.000

CLUSTER NUMBER: 1

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S1	0.05	LOGBA	2.17	2.78	2.96	0.14
S2	0.06	LOGLA	1.10	1.50	1.79	0.12
S3	0.13	LOGLU	-0.88	-0.51	-0.34	0.11
S4	0.14	LOGSM	0.26	0.69	0.90	0.13
S5	0.13	LOGY	-0.12	0.35	0.54	0.13
S6	0.07	LOGCE	1.45	1.82	2.09	0.13
S7	0.11	LOGCS	0.26	0.63	1.13	0.16
S8N1	0.11	LOGEU	-0.54	-0.01	0.14	0.14
S8N2	0.08	LOGHF	0.18	0.72	0.90	0.13
S9	0.10	LOGSC	0.51	1.00	1.30	0.14
S10	0.06	LOGTH	0.45	1.02	1.28	0.16
S11	0.14					
S12	0.09					
S13	0.07					
S14	0.11					
S15	0.09					
S16	0.10					
S17	0.05					
S18	0.06					
S21	0.04					
S22	0.10					
S23	0.05					
S24	0.06					
S25	0.12					
S26	0.10					
S27	0.10					
S28	0.16					
S29	0.07					
S30	0.29					
S31	0.07					
S32	0.14					
S41	0.15					
S42	0.11					
S43	0.39					
S44	0.20					
S45	0.46					
S48	0.07					
S50	0.05					
S51	0.05					

No Number of Clusters Specified (cont'd)

S52	0.17
S53N1	0.09
S53N2	0.09
S54	0.10
S55	0.04
S56	0.10
S57	0.07
S58	0.10
S59	0.06

CLUSTER NUMBER: 2

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S33	0.18	LOGBA	1.55	2.28	2.60	0.27
S34	0.15	LOGLA	0.44	0.77	0.97	0.14
S35	0.21	LOGLU	-1.49	-1.26	-0.98	0.18
S36	0.17	LOGSM	-0.45	-0.17	0.16	0.16
S37	0.12	LOGY	-0.79	-0.43	-0.12	0.20
S38	0.06	LOGCE	0.84	1.02	1.61	0.24
S39	0.15	LOGCS	-0.90	-0.45	0.35	0.43
S40	0.18	LOGEU	-1.30	-0.89	-0.66	0.15
S46	0.36	LOGHF	-0.27	0.01	0.17	0.12
S47	0.42	LOGSC	-0.59	-0.24	0.56	0.39
S60	0.43	LOGTH	-0.21	0.03	0.60	0.27

APPENDIX E (cont'd)

K-means Clusters Using 11 Elements

3 Clusters Specified

SUMMARY STATISTICS FOR 3 CLUSTERS

VARIABLE	BETWEEN SS	DF	WITHIN SS	DF	F-RATIO	PROB
LOGBA	2.563	2	1.452	56	49.420	0.000
LOGLA	5.194	2	0.579	56	251.365	0.000
LOGLU	5.316	2	0.558	56	266.776	0.000
LOGSM	7.377	2	0.438	56	472.118	0.000
LOGY	6.068	2	0.569	56	298.727	0.000
LOGCE	6.595	2	0.550	56	335.916	0.000
LOGCS	12.145	2	1.776	56	191.444	0.000
LOGEU	7.543	2	0.532	56	396.742	0.000
LOGHF	5.131	2	0.432	56	332.287	0.000
LOGSC	15.647	2	0.650	56	674.426	0.000
LOGTH	10.089	2	0.782	56	361.135	0.000

CLUSTER NUMBER: 1

CASE	MEMBERS DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S1	0.04	LOGBA	2.36	2.80	2.96	0.10
S2	0.06	LOGLA	1.28	1.52	1.79	0.09
S3	0.15	LOGLU	-0.64	-0.49	-0.34	0.07
S4	0.13	LOGSM	0.50	0.72	0.90	0.08
S5	0.11	LOGY	0.21	0.37	0.54	0.07
S6	0.05	LOGCE	1.62	1.84	2.09	0.10
S7	0.09	LOGCS	0.26	0.65	1.13	0.16
S8N1	0.09	LOGEU	-0.22	0.02	0.14	0.07
S8N2	0.06	LOGHF	0.55	0.75	0.90	0.07
S9	0.07	LOGSC	0.83	1.03	1.30	0.10
S10	0.05	LOGTH	0.80	1.05	1.28	0.12
S11	0.15					
S12	0.07					
S13	0.08					
S14	0.13					
S15	0.08					
S16	0.08					
S17	0.06					
S18	0.07					
S21	0.03					
S22	0.09					
S23	0.06					
S24	0.07					
S25	0.14					
S26	0.12					
S27	0.08					
S28	0.16					
S29	0.07					
S31	0.08					
S32	0.12					
S41	0.17					
S42	0.13					
S44	0.19					
S48	0.08					
S50	0.04					
S51	0.04					
S52	0.15					
S53N1	0.07					
S53N2	0.07					

3 Clusters Specified (cont'd)

S54	0.08					
S55	0.04					
S56	0.09					
S57	0.06					
S58	0.12					
S59	0.06					

CLUSTER NUMBER: 2

CASE	MEMBERS DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S33	0.15	LOGBA	1.55	2.26	2.60	0.29
S34	0.12	LOGLA	0.44	0.73	0.94	0.13
S35	0.13	LOGLU	-1.49	-1.30	-0.98	0.17
S36	0.15	LOGSM	-0.45	-0.24	-0.12	0.09
S37	0.10	LOGY	-0.79	-0.48	-0.12	0.18
S38	0.08	LOGCE	0.84	0.91	1.03	0.06
S39	0.10	LOGCS	-0.90	-0.62	0.03	0.27
S40	0.11	LOGEU	-1.30	-0.94	-0.81	0.14
S46	0.37	LOGHF	-0.27	-0.02	0.10	0.12
		LOGSC	-0.59	-0.41	-0.04	0.16
		LOGTH	-0.21	-0.09	0.03	0.09

CLUSTER NUMBER: 3

CASE	MEMBERS DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S30	0.18	LOGBA	2.17	2.44	2.83	0.22
S43	0.06	LOGLA	0.88	1.06	1.24	0.12
S45	0.11	LOGLU	-1.11	-0.93	-0.81	0.12
S47	0.13	LOGSM	0.04	0.22	0.33	0.10
S60	0.09	LOGY	-0.32	-0.13	-0.01	0.10
		LOGCE	1.40	1.50	1.61	0.07
		LOGCS	0.26	0.37	0.54	0.09
		LOGEU	-0.74	-0.55	-0.31	0.15
		LOGHF	0.13	0.25	0.46	0.12
		LOGSC	0.48	0.57	0.66	0.07
		LOGTH	0.45	0.60	0.73	0.10

APPENDIX E (cont'd)

K-means Clusters Using 11 Elements

4 Clusters Specified

SUMMARY STATISTICS FOR 4 CLUSTERS

VARIABLE	BETWEEN SS	DF	WITHIN SS	DF	F-RATIO	PROB
LOGBA	3.124	3	0.890	55	64.352	0.000
LOGLA	5.290	3	0.482	55	201.008	0.000
LOGLU	5.357	3	0.517	55	190.019	0.000
LOGSM	7.429	3	0.386	55	353.039	0.000
LOGY	6.178	3	0.459	55	246.694	0.000
LOGCE	6.597	3	0.548	55	220.865	0.000
LOGCS	12.625	3	1.296	55	178.587	0.000
LOGEU	7.693	3	0.383	55	368.284	0.000
LOGHF	5.199	3	0.365	55	261.463	0.000
LOGSC	15.800	3	0.497	55	583.396	0.000
LOGTH	10.106	3	0.765	55	242.052	0.000

CLUSTER NUMBER: 1

CASE MEMBERS	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S1	0.04	LOGBA	2.36	2.80	2.96	0.10
S2	0.06	LOGLA	1.28	1.52	1.79	0.09
S3	0.15	LOGLU	-0.64	-0.49	-0.34	0.07
S4	0.13	LOGSM	0.50	0.72	0.90	0.08
S5	0.11	LOGY	0.21	0.37	0.54	0.07
S6	0.05	LOGCE	1.62	1.84	2.09	0.10
S7	0.09	LOGCS	0.26	0.65	1.13	0.16
S8N1	0.09	LOGEU	-0.22	0.02	0.14	0.07
S8N2	0.06	LOGHF	0.55	0.75	0.90	0.07
S9	0.07	LOGSC	0.83	1.03	1.30	0.10
S10	0.05	LOGTH	0.80	1.05	1.28	0.12
S11	0.15					
S12	0.07					
S13	0.08					
S14	0.13					
S15	0.08					
S16	0.08					
S17	0.06					
S18	0.07					
S21	0.03					
S22	0.09					
S23	0.06					
S24	0.07					
S25	0.14					
S26	0.12					
S27	0.08					
S28	0.16					
S29	0.07					
S31	0.08					
S32	0.12					
S41	0.17					
S42	0.13					
S44	0.19					
S48	0.08					
S50	0.04					
S51	0.04					
S52	0.15					
S53N1	0.07					
S53N2	0.07					

4 Clusters Specified (cont'd)

S54	0.08					
S55	0.04					
S56	0.09					
S57	0.06					
S58	0.12					
S59	0.06					

CLUSTER NUMBER: 2

CASE MEMBERS	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S33	0.13	LOGBA	2.08	2.34	2.60	0.15
S34	0.09	LOGLA	0.67	0.77	0.94	0.09
S35	0.11	LOGLU	-1.48	-1.28	-0.98	0.17
S36	0.14	LOGSM	-0.29	-0.21	-0.12	0.06
S37	0.08	LOGY	-0.61	-0.44	-0.12	0.15
S38	0.08	LOGCE	0.84	0.92	1.03	0.06
S39	0.13	LOGCS	-0.90	-0.70	-0.46	0.14
S40	0.12	LOGEU	-0.97	-0.89	-0.81	0.05
		LOGHF	-0.16	0.01	0.10	0.08
		LOGSC	-0.59	-0.45	-0.32	0.09
		LOGTH	-0.21	-0.11	0.03	0.08

CLUSTER NUMBER: 3

CASE MEMBERS	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S30	0.18	LOGBA	2.17	2.44	2.83	0.22
S43	0.06	LOGLA	0.88	1.06	1.24	0.12
S45	0.11	LOGLU	-1.11	-0.93	-0.81	0.12
S47	0.13	LOGSM	0.04	0.22	0.33	0.10
S60	0.09	LOGY	-0.32	-0.13	-0.01	0.10
		LOGCE	1.40	1.50	1.61	0.07
		LOGCS	0.26	0.37	0.54	0.09
		LOGEU	-0.74	-0.55	-0.31	0.15
		LOGHF	0.13	0.25	0.46	0.12
		LOGSC	0.48	0.57	0.66	0.07
		LOGTH	0.45	0.60	0.73	0.10

CLUSTER NUMBER: 4

CASE MEMBERS	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S46	0.00	LOGBA	1.55	1.55	1.55	0.00
		LOGLA	0.44	0.44	0.44	0.00
		LOGLU	-1.49	-1.49	-1.49	0.00
		LOGSM	-0.45	-0.45	-0.45	0.00
		LOGY	-0.79	-0.79	-0.79	0.00
		LOGCE	0.87	0.87	0.87	0.00
		LOGCS	0.03	0.03	0.03	0.00
		LOGEU	-1.30	-1.30	-1.30	0.00
		LOGHF	-0.27	-0.27	-0.27	0.00
		LOGSC	-0.04	-0.04	-0.04	0.00
		LOGTH	0.03	0.03	0.03	0.00

APPENDIX E (cont'd)

K-means Clusters Using 11 Elements

5 Clusters Specified

SUMMARY STATISTICS FOR 5 CLUSTERS

VARIABLE	BETWEEN SS	DF	WITHIN SS	DF	F-RATIO	PROB
LOGBA	3.129	4	0.885	54	47.720	0.000
LOGLA	5.309	4	0.463	54	154.696	0.000
LOGLU	5.358	4	0.516	54	140.162	0.000
LOGSM	7.434	4	0.301	54	263.658	0.000
LOGY	6.182	4	0.455	54	183.504	0.000
LOGCE	6.634	4	0.511	54	175.372	0.000
LOGCS	12.862	4	1.058	54	164.056	0.000
LOGEU	7.695	4	0.301	54	272.840	0.000
LOGHF	5.208	4	0.356	54	197.298	0.000
LOGSC	15.877	4	0.419	54	510.959	0.000
LOGTH	10.118	4	0.753	54	181.402	0.000

CLUSTER NUMBER: 1

CASE MEMBERS	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S1	0.04	LOGBA	2.36	2.80	2.96	0.10
S2	0.06	LOGLA	1.28	1.52	1.79	0.09
S3	0.15	LOGLU	-0.64	-0.49	-0.34	0.07
S4	0.13	LOGSM	0.50	0.72	0.90	0.08
S5	0.11	LOGY	0.21	0.38	0.54	0.07
S6	0.06	LOGCE	1.62	1.84	2.09	0.10
S7	0.09	LOGCS	0.26	0.64	0.89	0.14
S8N1	0.09	LOGEU	-0.22	0.02	0.14	0.08
S8N2	0.06	LOGHF	0.55	0.75	0.90	0.07
S9	0.08	LOGSC	0.83	1.02	1.21	0.09
S10	0.05	LOGTH	0.80	1.05	1.28	0.12
S11	0.15					
S12	0.07					
S13	0.08					
S14	0.13					
S15	0.08					
S16	0.08					
S17	0.06					
S18	0.07					
S21	0.03					
S22	0.09					
S23	0.05					
S24	0.06					
S25	0.13					
S26	0.12					
S27	0.08					
S28	0.16					
S29	0.07					
S31	0.08					
S32	0.12					
S41	0.17					
S42	0.13					
S48	0.07					
S50	0.04					
S51	0.04					
S52	0.15					
S53N1	0.07					
S53N2	0.07					
S54	0.08					

5 Clusters Specified (cont'd)

S55	0.04					
S56	0.09					
S57	0.06					
S58	0.12					
S59	0.05					

CLUSTER NUMBER: 2

CASE MEMBERS	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S33	0.13	LOGBA	2.08	2.34	2.60	0.15
S34	0.09	LOGLA	0.67	0.77	0.94	0.09
S35	0.11	LOGLU	-1.48	-1.28	-0.98	0.17
S36	0.14	LOGSM	-0.29	-0.21	-0.12	0.06
S37	0.08	LOGY	-0.61	-0.44	-0.12	0.15
S38	0.08	LOGCE	0.84	0.92	1.03	0.06
S39	0.13	LOGCS	-0.90	-0.70	-0.46	0.14
S40	0.12	LOGEU	-0.97	-0.89	-0.81	0.05
		LOGHF	-0.16	0.01	0.10	0.08
		LOGSC	-0.59	-0.45	-0.32	0.09
		LOGTH	-0.21	-0.11	0.03	0.08

CLUSTER NUMBER: 3

CASE MEMBERS	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S30	0.18	LOGBA	2.17	2.44	2.83	0.22
S43	0.06	LOGLA	0.88	1.06	1.24	0.12
S45	0.11	LOGLU	-1.11	-0.93	-0.81	0.12
S47	0.13	LOGSM	0.04	0.22	0.33	0.10
S60	0.09	LOGY	-0.32	-0.13	-0.01	0.10
		LOGCE	1.40	1.50	1.61	0.07
		LOGCS	0.26	0.37	0.54	0.09
		LOGEU	-0.74	-0.55	-0.31	0.15
		LOGHF	0.13	0.25	0.46	0.12
		LOGSC	0.48	0.57	0.66	0.07
		LOGTH	0.45	0.60	0.73	0.10

CLUSTER NUMBER: 4

CASE MEMBERS	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S46	0.00	LOGBA	1.55	1.55	1.55	0.00
		LOGLA	0.44	0.44	0.44	0.00
		LOGLU	-1.49	-1.49	-1.49	0.00
		LOGSM	-0.45	-0.45	-0.45	0.00
		LOGY	-0.79	-0.79	-0.79	0.00
		LOGCE	0.87	0.87	0.87	0.00
		LOGCS	0.03	0.03	0.03	0.00
		LOGEU	-1.30	-1.30	-1.30	0.00
		LOGHF	-0.27	-0.27	-0.27	0.00
		LOGSC	-0.04	-0.04	-0.04	0.00
		LOGTH	0.03	0.03	0.03	0.00

CLUSTER NUMBER: 5

CASE MEMBERS	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S44	0.00	LOGBA	2.87	2.87	2.87	0.00
		LOGLA	1.66	1.66	1.66	0.00

APPENDIX E (cont'd)

K-means Clusters Using 11 Elements

5 Clusters Specified (cont'd)

|	LOGLU	-0.52	-0.52	-0.52	0.00
|	LOGBM	0.79	0.79	0.79	0.00
|	LOGY	0.31	0.31	0.31	0.00
|	LOGCE	2.03	2.03	2.03	0.00
|	LOGCS	1.13	1.13	1.13	0.00
|	LOGEU	-0.03	-0.03	-0.03	0.00
|	LOGHF	0.66	0.66	0.66	0.00
|	LOGSC	1.30	1.30	1.30	0.00
|	LOGTH	1.16	1.16	1.16	0.00

APPENDIX E (cont'd)

K-means Clusters Using 11 Elements

6 Clusters Specified

SUMMARY STATISTICS FOR 6 CLUSTERS

VARIABLE	BETWEEN SS	DF	WITHIN SS	DF	F-RATIO	PROB
LOGBA	3.321	5	0.693	53	50.789	0.000
LOGLA	5.349	5	0.423	53	134.116	0.000
LOGLU	5.361	5	0.512	53	110.911	0.000
LOGSM	7.450	5	0.364	53	216.722	0.000
LOGY	6.202	5	0.436	53	150.910	0.000
LOGCE	6.634	5	0.511	53	137.701	0.000
LOGCS	12.900	5	1.021	53	133.984	0.000
LOGEU	7.765	5	0.311	53	264.540	0.000
LOGHF	5.264	5	0.300	53	185.897	0.000
LOGSC	15.887	5	0.409	53	411.383	0.000
LOGTH	10.140	5	0.732	53	146.851	0.000

CLUSTER NUMBER: 1

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S1	0.04	LOGBA	2.36	2.80	2.96	0.10
S2	0.06	LOGLA	1.28	1.52	1.79	0.09
S3	0.15	LOGLU	-0.64	-0.49	-0.34	0.07
S4	0.13	LOGSM	0.50	0.72	0.90	0.08
S5	0.11	LOGY	0.21	0.38	0.54	0.07
S6	0.06	LOGCE	1.62	1.84	2.09	0.10
S7	0.09	LOGCS	0.26	0.64	0.89	0.14
S8N1	0.09	LOGEU	-0.22	0.02	0.14	0.08
S8N2	0.06	LOGHF	0.55	0.75	0.90	0.07
S9	0.08	LOGSC	0.83	1.02	1.21	0.09
S10	0.05	LOGTH	0.80	1.05	1.28	0.12
S11	0.15					
S12	0.07					
S13	0.08					
S14	0.13					
S15	0.08					
S16	0.08					
S17	0.06					
S18	0.07					
S21	0.03					
S22	0.09					
S23	0.05					
S24	0.06					
S25	0.13					
S26	0.12					
S27	0.08					
S28	0.16					
S29	0.07					
S31	0.08					
S32	0.12					
S41	0.17					
S42	0.13					
S48	0.07					
S50	0.04					
S51	0.04					
S52	0.15					
S53N1	0.07					
S53N2	0.07					
S54	0.08					

6 Clusters Specified (cont'd)

S55	0.04					
S56	0.09					
S57	0.06					
S58	0.12					
S59	0.05					

CLUSTER NUMBER: 2

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S33	0.13	LOGBA	2.08	2.34	2.60	0.15
S34	0.09	LOGLA	0.67	0.77	0.94	0.09
S35	0.11	LOGLU	-1.48	-1.28	-0.98	0.17
S36	0.14	LOGSM	-0.29	-0.21	-0.12	0.06
S37	0.08	LOGY	-0.61	-0.44	-0.12	0.15
S38	0.08	LOGCE	0.84	0.92	1.03	0.06
S39	0.13	LOGCS	-0.90	-0.70	-0.46	0.14
S40	0.12	LOGEU	-0.97	-0.89	-0.81	0.05
		LOGHF	-0.16	0.01	0.10	0.08
		LOGSC	-0.59	-0.45	-0.32	0.09
		LOGTH	-0.21	-0.11	0.03	0.08

CLUSTER NUMBER: 3

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S43	0.08	LOGBA	2.17	2.34	2.43	0.10
S45	0.10	LOGLA	0.88	1.02	1.11	0.10
S47	0.10	LOGLU	-1.11	-0.95	-0.81	0.13
S60	0.07	LOGSM	0.04	0.19	0.29	0.10
		LOGY	-0.32	-0.16	-0.09	0.09
		LOGCE	1.40	1.50	1.61	0.08
		LOGCS	0.26	0.32	0.36	0.04
		LOGEU	-0.74	-0.61	-0.48	0.10
		LOGHF	0.13	0.20	0.30	0.06
		LOGSC	0.48	0.55	0.64	0.06
		LOGTH	0.45	0.57	0.69	0.09

CLUSTER NUMBER: 4

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S46	0.00	LOGBA	1.55	1.55	1.55	0.00
		LOGLA	0.44	0.44	0.44	0.00
		LOGLU	-1.49	-1.49	-1.49	0.00
		LOGSM	-0.45	-0.45	-0.45	0.00
		LOGY	-0.79	-0.79	-0.79	0.00
		LOGCE	0.87	0.87	0.87	0.00
		LOGCS	0.03	0.03	0.03	0.00
		LOGEU	-1.30	-1.30	-1.30	0.00
		LOGHF	-0.27	-0.27	-0.27	0.00
		LOGSC	-0.04	-0.04	-0.04	0.00
		LOGTH	0.03	0.03	0.03	0.00

CLUSTER NUMBER: 5

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S44	0.00	LOGBA	2.87	2.87	2.87	0.00
		LOGLA	1.66	1.66	1.66	0.00

APPENDIX E (cont'd)

K-means Clusters Using 11 Elements

6 Clusters Specified (cont'd)

	LOGLU	-0.52	-0.52	-0.52	0.00
	LOGSM	0.79	0.79	0.79	0.00
	LOGY	0.31	0.31	0.31	0.00
	LOGCE	2.03	2.03	2.03	0.00
	LOGCS	1.13	1.13	1.13	0.00
	LOGEU	-0.03	-0.03	-0.03	0.00
	LOGHF	0.66	0.66	0.66	0.00
	LOGSC	1.30	1.30	1.30	0.00
	LOGTH	1.16	1.16	1.16	0.00

CLUSTER NUMBER: 6

MEMBERS			STATISTICS			
CASE	DISTANCE	VARIABLE	MINIMUM	MEAN	MAXIMUM	ST.DEV.
S30	0.00	LOGBA	2.83	2.83	2.83	0.00
		LOGLA	1.24	1.24	1.24	0.00
		LOGLU	-0.88	-0.88	-0.88	0.00
		LOGSM	0.33	0.33	0.33	0.00
		LOGY	-0.01	-0.01	-0.01	0.00
		LOGCE	1.50	1.50	1.50	0.00
		LOGCS	0.54	0.54	0.54	0.00
		LOGEU	-0.31	-0.31	-0.31	0.00
		LOGHF	0.46	0.46	0.46	0.00
		LOGSC	0.66	0.66	0.66	0.00
		LOGTH	0.73	0.73	0.73	0.00

APPENDIX E (cont'd)

K-means Clusters Using 11 Elements

7 Clusters Specified

SUMMARY STATISTICS FOR 7 CLUSTERS

VARIABLE	BETWEEN SS	DF	WITHIN SS	DF	F-RATIO	PROB
LOGBA	3.366	6	0.648	52	44.990	0.000
LOGLA	5.463	6	0.309	52	152.976	0.000
LOGLU	5.471	6	0.403	52	117.586	0.000
LOGSM	7.560	6	0.254	52	257.631	0.000
LOGY	6.306	6	0.331	52	165.100	0.000
LOGCE	6.857	6	0.287	52	206.717	0.000
LOGCS	13.145	6	0.776	52	146.849	0.000
LOGEU	7.833	6	0.243	52	279.077	0.000
LOGHF	5.330	6	0.234	52	197.531	0.000
LOGSC	16.067	6	0.229	52	606.874	0.000
LOGTH	10.527	6	0.345	52	264.457	0.000

CLUSTER NUMBER: 1

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S1	0.06	LOGBA	2.36	2.82	2.96	0.11
S2	0.07	LOGLA	1.48	1.55	1.79	0.06
S4	0.12	LOGLU	-0.57	-0.46	-0.34	0.05
S5	0.08	LOGSM	0.64	0.75	0.90	0.06
S6	0.05	LOGY	0.31	0.41	0.54	0.05
S7	0.06	LOGCE	1.77	1.88	2.09	0.08
S8N1	0.06	LOGCS	0.37	0.69	0.89	0.11
S8N2	0.05	LOGEU	-0.08	0.04	0.14	0.06
S9	0.05	LOGHF	0.66	0.78	0.90	0.06
S10	0.06	LOGSC	0.94	1.06	1.21	0.06
S12	0.05	LOGTH	0.99	1.11	1.28	0.08
S13	0.10					
S15	0.08					
S16	0.04					
S21	0.05					
S22	0.08					
S27	0.07					
S28	0.15					
S29	0.08					
S32	0.08					
S50	0.05					
S51	0.05					
S52	0.12					
S53N1	0.06					
S53N2	0.06					
S54	0.05					
S55	0.06					
S56	0.06					
S57	0.04					
S59	0.06					

CLUSTER NUMBER: 2

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S33	0.13	LOGBA	2.08	2.34	2.60	0.15
S34	0.09	LOGLA	0.67	0.77	0.94	0.09
S35	0.11	LOGLU	-1.48	-1.28	-0.98	0.17
S36	0.14	LOGSM	-0.29	-0.21	-0.12	0.06
S37	0.08	LOGY	-0.61	-0.44	-0.12	0.15
S38	0.08	LOGCE	0.84	0.92	1.03	0.06
S39	0.13	LOGCS	-0.90	-0.70	-0.46	0.14
S40	0.12	LOGEU	-0.97	-0.89	-0.81	0.05
		LOGHF	-0.16	0.01	0.10	0.08
		LOGSC	-0.59	-0.45	-0.32	0.09
		LOGTH	-0.21	-0.11	0.03	0.08

7 Clusters Specified (cont'd)

CLUSTER NUMBER: 3

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S43	0.08	LOGBA	2.17	2.34	2.43	0.10
S45	0.10	LOGLA	0.88	1.02	1.11	0.10
S47	0.10	LOGLU	-1.11	-0.95	-0.81	0.13
S60	0.07	LOGSM	0.04	0.19	0.29	0.10
		LOGY	-0.32	-0.16	-0.09	0.09
		LOGCE	1.40	1.50	1.61	0.08
		LOGCS	0.26	0.32	0.36	0.04
		LOGEU	-0.74	-0.61	-0.48	0.10
		LOGHF	0.13	0.20	0.30	0.06
		LOGSC	0.48	0.55	0.64	0.06
		LOGTH	0.45	0.57	0.69	0.09

CLUSTER NUMBER: 4

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S46	0.00	LOGBA	1.55	1.55	1.55	0.00
		LOGLA	0.44	0.44	0.44	0.00
		LOGLU	-1.49	-1.49	-1.49	0.00
		LOGSM	-0.45	-0.45	-0.45	0.00
		LOGY	-0.79	-0.79	-0.79	0.00
		LOGCE	0.87	0.87	0.87	0.00
		LOGCS	0.03	0.03	0.03	0.00
		LOGEU	-1.30	-1.30	-1.30	0.00
		LOGHF	-0.27	-0.27	-0.27	0.00
		LOGSC	-0.04	-0.04	-0.04	0.00
		LOGTH	0.03	0.03	0.03	0.00

CLUSTER NUMBER: 5

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S44	0.00	LOGBA	2.87	2.87	2.87	0.00
		LOGLA	1.66	1.66	1.66	0.00
		LOGLU	-0.52	-0.52	-0.52	0.00
		LOGSM	0.79	0.79	0.79	0.00
		LOGY	0.31	0.31	0.31	0.00
		LOGCE	2.03	2.03	2.03	0.00
		LOGCS	1.13	1.13	1.13	0.00
		LOGEU	-0.03	-0.03	-0.03	0.00
		LOGHF	0.66	0.66	0.66	0.00
		LOGSC	1.30	1.30	1.30	0.00
		LOGTH	1.16	1.16	1.16	0.00

CLUSTER NUMBER: 6

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S30	0.00	LOGBA	2.83	2.83	2.83	0.00
		LOGLA	1.24	1.24	1.24	0.00

APPENDIX E (cont'd)

K-means Clusters Using 11 Elements

7 Clusters Specified (cont'd)

LOGLU	-0.88	-0.88	-0.88	0.00
LOGSM	0.33	0.33	0.33	0.00
LOGY	-0.01	-0.01	-0.01	0.00
LOGCE	1.50	1.50	1.50	0.00
LOGCS	0.54	0.54	0.54	0.00
LOGEU	-0.31	-0.31	-0.31	0.00
LOGHF	0.46	0.46	0.46	0.00
LOGSC	0.66	0.66	0.66	0.00
LOGTH	0.73	0.73	0.73	0.00

CLUSTER NUMBER: 7

MEMBERS			STATISTICS			
CASE	DISTANCE	VARIABLE	MINIMUM	MEAN	MAXIMUM	ST.DEV.
S3	0.11	LOGBA	2.65	2.75	2.87	0.06
S11	0.12	LOGLA	1.28	1.45	1.57	0.09
S14	0.06	LOGLU	-0.64	-0.56	-0.50	0.04
S17	0.04	LOGSM	0.50	0.64	0.74	0.08
S18	0.05	LOGY	0.21	0.31	0.38	0.05
S23	0.07	LOGCE	1.62	1.73	1.83	0.06
S24	0.07	LOGCS	0.26	0.53	0.74	0.13
S25	0.06	LOGEU	-0.22	-0.04	0.06	0.08
S26	0.08	LOGHF	0.55	0.70	0.82	0.06
S31	0.06	LOGSC	0.83	0.93	1.00	0.05
S41	0.09	LOGTH	0.80	0.91	1.12	0.07
S42	0.06					
S48	0.06					
S58	0.08					

APPENDIX E (cont'd)

K-means Clusters Using 11 Elements

8 Clusters Specified

SUMMARY STATISTICS FOR 8 CLUSTERS

VARIABLE	BETWEEN SS	DF	WITHIN SS	DF	F-RATIO	PROB
LOGBA	3.619	7	0.396	51	66.601	0.000
LOGLA	5.463	7	0.309	51	128.785	0.000
LOGLU	5.484	7	0.390	51	102.467	0.000
LOGSM	7.557	7	0.258	51	213.797	0.000
LOGY	6.316	7	0.321	51	143.466	0.000
LOGCE	6.869	7	0.275	51	181.760	0.000
LOGCS	13.134	7	0.787	51	121.652	0.000
LOGEU	7.853	7	0.222	51	257.348	0.000
LOGHF	5.351	7	0.213	51	183.142	0.000
LOGSC	16.064	7	0.232	51	504.667	0.000
LOGTH	10.490	7	0.302	51	200.321	0.000

CLUSTER NUMBER: 1

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S1	0.06	LOGBA	2.74	2.84	2.96	0.06
S2	0.08	LOGLA	1.48	1.56	1.79	0.06
S4	0.12	LOGLU	-0.54	-0.45	-0.34	0.05
S5	0.08	LOGSM	0.64	0.75	0.90	0.06
S6	0.05	LOGY	0.35	0.41	0.54	0.05
S7	0.05	LOGCE	1.77	1.89	2.09	0.08
S8N1	0.06	LOGCS	0.37	0.68	0.89	0.12
S8N2	0.04	LOGEU	-0.05	0.05	0.14	0.05
S9	0.05	LOGHF	0.66	0.78	0.88	0.06
S10	0.06	LOGSC	0.94	1.07	1.21	0.06
S12	0.04	LOGTH	0.99	1.11	1.28	0.08
S15	0.08					
S16	0.05					
S21	0.05					
S22	0.09					
S27	0.07					
S29	0.08					
S32	0.08					
S50	0.05					
S51	0.05					
S52	0.12					
S53N1	0.06					
S53N2	0.06					
S54	0.04					
S55	0.06					
S56	0.06					
S57	0.05					
S59	0.06					

CLUSTER NUMBER: 2

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S33	0.13	LOGBA	2.08	2.34	2.60	0.15
S34	0.09	LOGLA	0.67	0.77	0.94	0.09
S35	0.11	LOGLU	-1.48	-1.28	-0.98	0.17
S36	0.14	LOGSM	-0.29	-0.21	-0.12	0.06
S37	0.08	LOGY	-0.61	-0.44	-0.12	0.15
S38	0.08	LOGCE	0.84	0.92	1.03	0.06
S39	0.13	LOGCS	-0.90	-0.70	-0.46	0.14

8 Clusters Specified (cont'd)

S40	0.12	LOGEU	-0.97	-0.89	-0.81	0.05
		LOGHF	-0.16	0.01	0.10	0.08
		LOGSC	-0.59	-0.45	-0.32	0.09
		LOGTH	-0.21	-0.11	0.03	0.08

CLUSTER NUMBER: 3

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S43	0.08	LOGBA	2.17	2.34	2.43	0.10
S45	0.10	LOGLA	0.88	1.02	1.11	0.10
S47	0.10	LOGLU	-1.11	-0.95	-0.81	0.13
S60	0.07	LOGSM	0.04	0.19	0.29	0.10
		LOGY	-0.32	-0.16	-0.09	0.09
		LOGCE	1.40	1.50	1.61	0.08
		LOGCS	0.26	0.32	0.36	0.04
		LOGEU	-0.74	-0.61	-0.48	0.10
		LOGHF	0.13	0.20	0.30	0.06
		LOGSC	0.48	0.55	0.64	0.06
		LOGTH	0.45	0.57	0.69	0.09

CLUSTER NUMBER: 4

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S46	0.00	LOGBA	1.55	1.55	1.55	0.00
		LOGLA	0.44	0.44	0.44	0.00
		LOGLU	-1.49	-1.49	-1.49	0.00
		LOGSM	-0.45	-0.45	-0.45	0.00
		LOGY	-0.79	-0.79	-0.79	0.00
		LOGCE	0.87	0.87	0.87	0.00
		LOGCS	0.03	0.03	0.03	0.00
		LOGEU	-1.30	-1.30	-1.30	0.00
		LOGHF	-0.27	-0.27	-0.27	0.00
		LOGSC	-0.04	-0.04	-0.04	0.00
		LOGTH	0.03	0.03	0.03	0.00

CLUSTER NUMBER: 5

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S44	0.00	LOGBA	2.87	2.87	2.87	0.00
		LOGLA	1.66	1.66	1.66	0.00
		LOGLU	-0.52	-0.52	-0.52	0.00
		LOGSM	0.79	0.79	0.79	0.00
		LOGY	0.31	0.31	0.31	0.00
		LOGCE	2.03	2.03	2.03	0.00
		LOGCS	1.13	1.13	1.13	0.00
		LOGEU	-0.03	-0.03	-0.03	0.00
		LOGHF	0.66	0.66	0.66	0.00
		LOGSC	1.30	1.30	1.30	0.00
		LOGTH	1.16	1.16	1.16	0.00

CLUSTER NUMBER: 6

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S30	0.00	LOGBA	2.83	2.83	2.83	0.00
		LOGLA	1.24	1.24	1.24	0.00
		LOGLU	-0.88	-0.88	-0.88	0.00

APPENDIX E (cont'd)

K-means Clusters Using 11 Elements

8 Clusters Specified (cont'd)

	LOGBM	0.33	0.33	0.33	0.00
	LOGY	-0.01	-0.01	-0.01	0.00
	LOGCE	1.50	1.50	1.50	0.00
	LOGCS	0.54	0.54	0.54	0.00
	LOGEU	-0.31	-0.31	-0.31	0.00
	LOGHF	0.46	0.46	0.46	0.00
	LOGSC	0.66	0.66	0.66	0.00
	LOGTH	0.73	0.73	0.73	0.00

CLUSTER NUMBER: 7

MEMBERS			STATISTICS			
CASE	DISTANCE	VARIABLE	MINIMUM	MEAN	MAXIMUM	ST.DEV.
S3	0.11	LOGBA	2.62	2.74	2.87	0.07
S11	0.12	LOGLA	1.28	1.45	1.57	0.09
S13	0.09	LOGLU	-0.64	-0.56	-0.50	0.04
S14	0.06	LOGBM	0.50	0.65	0.74	0.08
S17	0.04	LOGY	0.21	0.31	0.38	0.05
S18	0.05	LOGCE	1.62	1.73	1.83	0.06
S23	0.07	LOGCS	0.26	0.54	0.74	0.13
S24	0.07	LOGEU	-0.22	-0.04	0.06	0.08
S25	0.07	LOGHF	0.55	0.70	0.82	0.06
S26	0.08	LOGSC	0.83	0.93	1.01	0.06
S31	0.06	LOGTH	0.80	0.92	1.13	0.09
S41	0.09					
S42	0.06					
S48	0.06					
S58	0.08					

CLUSTER NUMBER: 8

MEMBERS			STATISTICS			
CASE	DISTANCE	VARIABLE	MINIMUM	MEAN	MAXIMUM	ST.DEV.
S28	0.00	LOGBA	2.36	2.36	2.36	0.00
		LOGLA	1.51	1.51	1.51	0.00
		LOGLU	-0.44	-0.44	-0.44	0.00
		LOGBM	0.72	0.72	0.72	0.00
		LOGY	0.41	0.41	0.41	0.00
		LOGCE	1.89	1.89	1.89	0.00
		LOGCS	0.79	0.79	0.79	0.00
		LOGEU	-0.03	-0.03	-0.03	0.00
		LOGHF	0.90	0.90	0.90	0.00
		LOGSC	1.03	1.03	1.03	0.00
		LOGTH	1.20	1.20	1.20	0.00

APPENDIX E (cont'd)

K-means Clusters Using 11 Elements

9 Clusters Specified

SUMMARY STATISTICS FOR 9 CLUSTERS

VARIABLE	BETWEEN SS	DF	WITHIN SS	DF	F-RATIO	PROB
LOGBA	3.621	8	0.394	50	57.506	0.000
LOGLA	5.468	8	0.304	50	112.554	0.000
LOGLU	5.583	8	0.290	50	120.139	0.000
LOGSM	7.557	8	0.258	50	183.405	0.000
LOGY	6.433	8	0.205	50	196.445	0.000
LOGCE	6.869	8	0.275	50	156.159	0.000
LOGCS	13.135	8	0.786	50	104.394	0.000
LOGEU	7.854	8	0.222	50	220.881	0.000
LOGHF	5.352	8	0.211	50	158.268	0.000
LOGSC	16.069	8	0.227	50	442.263	0.000
LOGTH	10.491	8	0.380	50	172.409	0.000

CLUSTER NUMBER: 1

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S1	0.06	LOGBA	2.74	2.84	2.96	0.06
S2	0.08	LOGLA	1.48	1.56	1.79	0.06
S4	0.12	LOGLU	-0.54	-0.45	-0.34	0.05
S5	0.08	LOGSM	0.64	0.75	0.90	0.06
S6	0.05	LOGY	0.35	0.41	0.54	0.05
S7	0.05	LOGCE	1.77	1.89	2.09	0.08
S8N1	0.06	LOGCS	0.37	0.68	0.89	0.12
S8N2	0.04	LOGEU	-0.05	0.05	0.14	0.05
S9	0.05	LOGHF	0.66	0.78	0.88	0.06
S10	0.06	LOGSC	0.94	1.07	1.21	0.06
S12	0.04	LOGTH	0.99	1.11	1.28	0.08
S15	0.08					
S16	0.05					
S21	0.05					
S22	0.09					
S27	0.07					
S29	0.08					
S32	0.08					
S50	0.05					
S51	0.05					
S52	0.12					
S53N1	0.06					
S53N2	0.06					
S54	0.04					
S55	0.06					
S56	0.06					
S57	0.05					
S59	0.06					

CLUSTER NUMBER: 2

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S33	0.13	LOGBA	2.08	2.35	2.60	0.16
S34	0.09	LOGLA	0.67	0.78	0.94	0.09
S35	0.10	LOGLU	-1.48	-1.32	-1.08	0.14
S37	0.10	LOGSM	-0.29	-0.21	-0.12	0.06
S38	0.08	LOGY	-0.61	-0.48	-0.30	0.10
S39	0.12	LOGCE	0.84	0.92	1.03	0.06
S40	0.11	LOGCS	-0.90	-0.70	-0.46	0.15

9 Clusters Specified (cont'd)

	LOGEU	-0.97	-0.89	-0.81	0.05
	LOGHF	-0.16	0.01	0.10	0.09
	LOGSC	-0.59	-0.46	-0.32	0.09
	LOGTH	-0.21	-0.10	0.03	0.09

CLUSTER NUMBER: 3

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S43	0.08	LOGBA	2.17	2.34	2.43	0.10
S45	0.10	LOGLA	0.88	1.02	1.11	0.10
S47	0.10	LOGLU	-1.11	-0.95	-0.81	0.13
S60	0.07	LOGSM	0.04	0.19	0.29	0.10
		LOGY	-0.32	-0.16	-0.09	0.09
		LOGCE	1.40	1.50	1.61	0.08
		LOGCS	0.26	0.32	0.36	0.04
		LOGEU	-0.74	-0.61	-0.48	0.10
		LOGHF	0.13	0.20	0.30	0.06
		LOGSC	0.48	0.55	0.64	0.06
		LOGTH	0.45	0.57	0.69	0.09

CLUSTER NUMBER: 4

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S46	0.00	LOGBA	1.55	1.55	1.55	0.00
		LOGLA	0.44	0.44	0.44	0.00
		LOGLU	-1.49	-1.49	-1.49	0.00
		LOGSM	-0.45	-0.45	-0.45	0.00
		LOGY	-0.79	-0.79	-0.79	0.00
		LOGCE	0.87	0.87	0.87	0.00
		LOGCS	0.03	0.03	0.03	0.00
		LOGEU	-1.30	-1.30	-1.30	0.00
		LOGHF	-0.27	-0.27	-0.27	0.00
		LOGSC	-0.04	-0.04	-0.04	0.00
		LOGTH	0.03	0.03	0.03	0.00

CLUSTER NUMBER: 5

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S44	0.00	LOGBA	2.87	2.87	2.87	0.00
		LOGLA	1.66	1.66	1.66	0.00
		LOGLU	-0.52	-0.52	-0.52	0.00
		LOGSM	0.79	0.79	0.79	0.00
		LOGY	0.31	0.31	0.31	0.00
		LOGCE	2.03	2.03	2.03	0.00
		LOGCS	1.13	1.13	1.13	0.00
		LOGEU	-0.03	-0.03	-0.03	0.00
		LOGHF	0.66	0.66	0.66	0.00
		LOGSC	1.30	1.30	1.30	0.00
		LOGTH	1.16	1.16	1.16	0.00

CLUSTER NUMBER: 6

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S30	0.00	LOGBA	2.83	2.83	2.83	0.00
		LOGLA	1.24	1.24	1.24	0.00
		LOGLU	-0.88	-0.88	-0.88	0.00

APPENDIX E (cont'd)

K-means Clusters Using 11 Elements

9 Clusters Specified (cont'd)

	LOGSM	0.33	0.33	0.33	0.00
	LOGY	-0.01	-0.01	-0.01	0.00
	LOGCE	1.50	1.50	1.50	0.00
	LOGCS	0.54	0.54	0.54	0.00
	LOGEU	-0.31	-0.31	-0.31	0.00
	LOGHF	0.46	0.46	0.46	0.00
	LOGSC	0.66	0.66	0.66	0.00
	LOGTH	0.73	0.73	0.73	0.00

CLUSTER NUMBER: 7

MEMBERS			STATISTICS			
CASE	DISTANCE	VARIABLE	MINIMUM	MEAN	MAXIMUM	ST.DEV.
S3	0.11	LOGBA	2.62	2.74	2.87	0.07
S11	0.12	LOGLA	1.28	1.45	1.57	0.09
S13	0.09	LOGLU	-0.64	-0.56	-0.50	0.04
S14	0.06	LOGSM	0.50	0.65	0.74	0.08
S17	0.04	LOGY	0.21	0.31	0.38	0.05
S18	0.05	LOGCE	1.62	1.73	1.83	0.06
S23	0.07	LOGCS	0.26	0.54	0.74	0.13
S24	0.07	LOGEU	-0.22	-0.04	0.06	0.08
S25	0.07	LOGHF	0.55	0.70	0.82	0.06
S26	0.08	LOGSC	0.83	0.93	1.01	0.06
S31	0.06	LOGTH	0.80	0.92	1.13	0.09
S41	0.09					
S42	0.06					
S48	0.06					
S58	0.08					

CLUSTER NUMBER: 8

MEMBERS			STATISTICS			
CASE	DISTANCE	VARIABLE	MINIMUM	MEAN	MAXIMUM	ST.DEV.
S28	0.00	LOGBA	2.36	2.36	2.36	0.00
		LOGLA	1.51	1.51	1.51	0.00
		LOGLU	-0.44	-0.44	-0.44	0.00
		LOGSM	0.72	0.72	0.72	0.00
		LOGY	0.41	0.41	0.41	0.00
		LOGCE	1.89	1.89	1.89	0.00
		LOGCS	0.79	0.79	0.79	0.00
		LOGEU	-0.03	-0.03	-0.03	0.00
		LOGHF	0.90	0.90	0.90	0.00
		LOGSC	1.03	1.03	1.03	0.00
		LOGTH	1.20	1.20	1.20	0.00

CLUSTER NUMBER: 9

MEMBERS			STATISTICS			
CASE	DISTANCE	VARIABLE	MINIMUM	MEAN	MAXIMUM	ST.DEV.
S36	0.00	LOGBA	2.30	2.30	2.30	0.00
		LOGLA	0.70	0.70	0.70	0.00
		LOGLU	-0.98	-0.98	-0.98	0.00
		LOGSM	-0.21	-0.21	-0.21	0.00
		LOGY	-0.12	-0.12	-0.12	0.00
		LOGCE	0.90	0.90	0.90	0.00
		LOGCS	-0.72	-0.72	-0.72	0.00
		LOGEU	-0.90	-0.90	-0.90	0.00
		LOGHF	-0.03	-0.03	-0.03	0.00

9 Clusters Specified (cont'd)

	LOGSC	-0.39	-0.39	-0.39	0.00
	LOGTH	-0.14	-0.14	-0.14	0.00

APPENDIX E (cont'd)

K-means Clusters Using 11 Elements

10 Clusters Specified

SUMMARY STATISTICS FOR 10 CLUSTERS

VARIABLE	BETWEEN SS	DF	WITHIN SS	DF	F-RATIO	PROB
LOGBA	3.650	9	0.364	49	54.568	0.000
LOGLA	5.499	9	0.273	49	109.561	0.000
LOGLU	5.612	9	0.262	49	116.777	0.000
LOGSM	7.558	9	0.256	49	160.509	0.000
LOGY	6.472	9	0.165	49	213.517	0.000
LOGCE	6.883	9	0.261	49	143.481	0.000
LOGCS	13.136	9	0.785	49	91.137	0.000
LOGEU	7.861	9	0.214	49	199.548	0.000
LOGHF	5.387	9	0.177	49	165.616	0.000
LOGSC	16.085	9	0.211	49	414.123	0.000
LOGTH	10.512	9	0.360	49	159.097	0.000

CLUSTER NUMBER: 1

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S1	0.06	LOGBA	2.74	2.84	2.96	0.06
S2	0.08	LOGLA	1.48	1.56	1.79	0.06
S4	0.12	LOGLU	-0.54	-0.45	-0.34	0.05
S5	0.08	LOGSM	0.64	0.75	0.90	0.06
S6	0.05	LOGY	0.35	0.41	0.54	0.05
S7	0.05	LOGCE	1.77	1.89	2.09	0.08
S8N1	0.06	LOGCS	0.37	0.68	0.89	0.12
S8N2	0.04	LOGEU	-0.05	0.05	0.14	0.05
S9	0.05	LOGHF	0.66	0.78	0.88	0.06
S10	0.06	LOGSC	0.94	1.07	1.21	0.06
S12	0.04	LOGTH	0.99	1.11	1.28	0.08
S15	0.08					
S16	0.05					
S21	0.05					
S22	0.09					
S27	0.07					
S29	0.08					
S32	0.08					
S50	0.05					
S51	0.05					
S52	0.12					
S53N1	0.06					
S53N2	0.06					
S54	0.04					
S55	0.06					
S56	0.06					
S57	0.05					
S59	0.06					

CLUSTER NUMBER: 2

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S34	0.09	LOGBA	2.08	2.32	2.60	0.16
S35	0.10	LOGLA	0.67	0.75	0.87	0.06
S37	0.10	LOGLU	-1.48	-1.34	-1.08	0.13
S38	0.08	LOGSM	-0.29	-0.20	-0.12	0.06
S39	0.11	LOGY	-0.61	-0.52	-0.38	0.07
S40	0.10	LOGCE	0.84	0.90	0.99	0.05
		LOGCS	-0.90	-0.70	-0.46	0.16

10 Clusters Specified (cont'd)

	LOGEU	-0.94	-0.88	-0.81	0.05
	LOGHF	-0.04	0.04	0.10	0.05
	LOGSC	-0.59	-0.44	-0.32	0.09
	LOGTH	-0.21	-0.12	0.02	0.07

CLUSTER NUMBER: 3

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S43	0.08	LOGBA	2.17	2.34	2.43	0.10
S45	0.10	LOGLA	0.88	1.02	1.11	0.10
S47	0.10	LOGLU	-1.11	-0.95	-0.81	0.13
S60	0.07	LOGSM	0.04	0.19	0.29	0.10
		LOGY	-0.32	-0.16	-0.09	0.09
		LOGCE	1.40	1.50	1.61	0.08
		LOGCS	0.26	0.32	0.36	0.04
		LOGEU	-0.74	-0.61	-0.48	0.10
		LOGHF	0.13	0.20	0.30	0.06
		LOGSC	0.48	0.55	0.64	0.06
		LOGTH	0.45	0.57	0.69	0.09

CLUSTER NUMBER: 4

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S46	0.00	LOGBA	1.55	1.55	1.55	0.00
		LOGLA	0.44	0.44	0.44	0.00
		LOGLU	-1.49	-1.49	-1.49	0.00
		LOGSM	-0.45	-0.45	-0.45	0.00
		LOGY	-0.79	-0.79	-0.79	0.00
		LOGCE	0.87	0.87	0.87	0.00
		LOGCS	0.03	0.03	0.03	0.00
		LOGEU	-1.30	-1.30	-1.30	0.00
		LOGHF	-0.27	-0.27	-0.27	0.00
		LOGSC	-0.04	-0.04	-0.04	0.00
		LOGTH	0.03	0.03	0.03	0.00

CLUSTER NUMBER: 5

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S44	0.00	LOGBA	2.87	2.87	2.87	0.00
		LOGLA	1.66	1.66	1.66	0.00
		LOGLU	-0.52	-0.52	-0.52	0.00
		LOGSM	0.79	0.79	0.79	0.00
		LOGY	0.31	0.31	0.31	0.00
		LOGCE	2.03	2.03	2.03	0.00
		LOGCS	1.13	1.13	1.13	0.00
		LOGEU	-0.03	-0.03	-0.03	0.00
		LOGHF	0.66	0.66	0.66	0.00
		LOGSC	1.30	1.30	1.30	0.00
		LOGTH	1.16	1.16	1.16	0.00

CLUSTER NUMBER: 6

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S30	0.00	LOGBA	2.83	2.83	2.83	0.00
		LOGLA	1.24	1.24	1.24	0.00
		LOGLU	-0.88	-0.88	-0.88	0.00

APPENDIX E (cont'd)

K-means Clusters Using 11 Elements

10 Clusters Specified (cont'd)

	LOGSM	0.33	0.33	0.33	0.00
	LOGY	-0.01	-0.01	-0.01	0.00
	LOGCE	1.50	1.50	1.50	0.00
	LOGCS	0.54	0.54	0.54	0.00
	LOGEU	-0.31	-0.31	-0.31	0.00
	LOGHF	0.46	0.46	0.46	0.00
	LOGSC	0.66	0.66	0.66	0.00
	LOGTH	0.73	0.73	0.73	0.00

CLUSTER NUMBER: 7

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S3	0.11	LOGBA	2.62	2.74	2.87	0.07
S11	0.12	LOGLA	1.28	1.45	1.57	0.09
S13	0.09	LOGLU	-0.64	-0.56	-0.50	0.04
S14	0.06	LOGSM	0.50	0.65	0.74	0.08
S17	0.04	LOGY	0.21	0.31	0.38	0.05
S18	0.05	LOGCE	1.62	1.73	1.83	0.06
S23	0.07	LOGCS	0.26	0.54	0.74	0.13
S24	0.07	LOGEU	-0.22	-0.04	0.06	0.08
S25	0.07	LOGHF	0.55	0.70	0.82	0.06
S26	0.08	LOGSC	0.83	0.93	1.01	0.06
S31	0.06	LOGTH	0.80	0.92	1.13	0.09
S41	0.09					
S42	0.06					
S48	0.06					
S50	0.08					

CLUSTER NUMBER: 8

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S28	0.00	LOGBA	2.36	2.36	2.36	0.00
		LOGLA	1.51	1.51	1.51	0.00
		LOGLU	-0.44	-0.44	-0.44	0.00
		LOGSM	0.72	0.72	0.72	0.00
		LOGY	0.41	0.41	0.41	0.00
		LOGCE	1.89	1.89	1.89	0.00
		LOGCS	0.79	0.79	0.79	0.00
		LOGEU	-0.03	-0.03	-0.03	0.00
		LOGHF	0.90	0.90	0.90	0.00
		LOGSC	1.03	1.03	1.03	0.00
		LOGTH	1.20	1.20	1.20	0.00

CLUSTER NUMBER: 9

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S36	0.00	LOGBA	2.30	2.30	2.30	0.00
		LOGLA	0.70	0.70	0.70	0.00
		LOGLU	-0.98	-0.98	-0.98	0.00
		LOGSM	-0.21	-0.21	-0.21	0.00
		LOGY	-0.12	-0.12	-0.12	0.00
		LOGCE	0.90	0.90	0.90	0.00
		LOGCS	-0.72	-0.72	-0.72	0.00
		LOGEU	-0.90	-0.90	-0.90	0.00
		LOGHF	-0.03	-0.03	-0.03	0.00

10 Clusters Specified (cont'd)

	LOGSC	-0.39	-0.39	-0.39	0.00
	LOGTH	-0.14	-0.14	-0.14	0.00

CLUSTER NUMBER: 10

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S33	0.00	LOGBA	2.51	2.51	2.51	0.00
		LOGLA	0.94	0.94	0.94	0.00
		LOGLU	-1.16	-1.16	-1.16	0.00
		LOGSM	-0.24	-0.24	-0.24	0.00
		LOGY	-0.30	-0.30	-0.30	0.00
		LOGCE	1.03	1.03	1.03	0.00
		LOGCS	-0.74	-0.74	-0.74	0.00
		LOGEU	-0.97	-0.97	-0.97	0.00
		LOGHF	-0.16	-0.16	-0.16	0.00
		LOGSC	-0.58	-0.58	-0.58	0.00
		LOGTH	0.03	0.03	0.03	0.00

APPENDIX E (cont'd)

K-means Clusters Using 11 Elements

11 Clusters Specified

SUMMARY STATISTICS FOR 11 CLUSTERS

VARIABLE	BETWEEN SS	DF	WITHIN SS	DF	F-RATIO	PROB
LOGBA	3.651	10	0.363	48	48.262	0.000
LOGLA	5.538	10	0.234	48	113.788	0.000
LOGLU	5.621	10	0.253	48	106.795	0.000
LOGSM	7.608	10	0.206	48	177.011	0.000
LOGY	6.496	10	0.141	48	221.171	0.000
LOGCE	6.927	10	0.217	48	152.891	0.000
LOGCS	13.230	10	0.690	48	91.977	0.000
LOGEU	7.867	10	0.208	48	181.193	0.000
LOGHF	5.388	10	0.176	48	146.710	0.000
LOGSC	16.093	10	0.204	48	379.407	0.000
LOGTH	10.554	10	0.318	48	159.502	0.000

CLUSTER NUMBER: 1

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S1	0.06	LOGBA	2.74	2.85	2.96	0.06
S2	0.07	LOGLA	1.48	1.54	1.65	0.04
S6	0.04	LOGLU	-0.54	-0.46	-0.35	0.04
S7	0.06	LOGSM	0.64	0.74	0.81	0.05
S8N1	0.06	LOGY	0.35	0.40	0.51	0.04
S8N2	0.04	LOGCE	1.77	1.87	2.03	0.06
S9	0.05	LOGCS	0.54	0.71	0.89	0.09
S10	0.05	LOGEU	-0.05	0.05	0.14	0.05
S12	0.05	LOGHF	0.66	0.77	0.88	0.05
S15	0.08	LOGSC	0.94	1.07	1.21	0.06
S16	0.05	LOGTH	0.99	1.09	1.22	0.07
S21	0.05					
S22	0.07					
S29	0.07					
S32	0.08					
S50	0.05					
S51	0.04					
S53N1	0.05					
S53N2	0.06					
S54	0.05					
S55	0.06					
S56	0.06					
S57	0.04					
S59	0.07					

CLUSTER NUMBER: 2

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S34	0.09	LOGBA	2.08	2.32	2.60	0.16
S35	0.10	LOGLA	0.67	0.75	0.87	0.06
S37	0.10	LOGLU	-1.48	-1.34	-1.08	0.13
S38	0.08	LOGSM	-0.29	-0.20	-0.12	0.06
S39	0.11	LOGY	-0.61	-0.52	-0.38	0.07
S40	0.10	LOGCE	0.84	0.90	0.99	0.05
		LOGCS	-0.90	-0.70	-0.46	0.16
		LOGEU	-0.94	-0.88	-0.81	0.05
		LOGHF	-0.04	0.04	0.10	0.05
		LOGSC	-0.59	-0.44	-0.32	0.09
		LOGTH	-0.21	-0.12	0.02	0.07

11 Clusters Specified (cont'd)

CLUSTER NUMBER: 3

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S43	0.08	LOGBA	2.17	2.34	2.43	0.10
S45	0.10	LOGLA	0.88	1.02	1.11	0.10
S47	0.10	LOGLU	-1.11	-0.95	-0.81	0.13
S60	0.07	LOGSM	0.04	0.19	0.29	0.10
		LOGY	-0.32	-0.16	-0.09	0.09
		LOGCE	1.40	1.50	1.61	0.08
		LOGCS	0.26	0.32	0.36	0.04
		LOGEU	-0.74	-0.61	-0.48	0.10
		LOGHF	0.13	0.20	0.30	0.06
		LOGSC	0.48	0.55	0.64	0.06
		LOGTH	0.45	0.57	0.69	0.09

CLUSTER NUMBER: 4

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S46	0.00	LOGBA	1.55	1.55	1.55	0.00
		LOGLA	0.44	0.44	0.44	0.00
		LOGLU	-1.49	-1.49	-1.49	0.00
		LOGSM	-0.45	-0.45	-0.45	0.00
		LOGY	-0.79	-0.79	-0.79	0.00
		LOGCE	0.87	0.87	0.87	0.00
		LOGCS	0.03	0.03	0.03	0.00
		LOGEU	-1.30	-1.30	-1.30	0.00
		LOGHF	-0.27	-0.27	-0.27	0.00
		LOGSC	-0.04	-0.04	-0.04	0.00
		LOGTH	0.03	0.03	0.03	0.00

CLUSTER NUMBER: 5

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S44	0.00	LOGBA	2.87	2.87	2.87	0.00
		LOGLA	1.66	1.66	1.66	0.00
		LOGLU	-0.52	-0.52	-0.52	0.00
		LOGSM	0.79	0.79	0.79	0.00
		LOGY	0.31	0.31	0.31	0.00
		LOGCE	2.03	2.03	2.03	0.00
		LOGCS	1.13	1.13	1.13	0.00
		LOGEU	-0.03	-0.03	-0.03	0.00
		LOGHF	0.66	0.66	0.66	0.00
		LOGSC	1.30	1.30	1.30	0.00
		LOGTH	1.16	1.16	1.16	0.00

CLUSTER NUMBER: 6

MEMBERS CASE	DISTANCE	VARIABLE	STATISTICS MINIMUM	MEAN	MAXIMUM	ST.DEV.
S30	0.00	LOGBA	2.83	2.83	2.83	0.00
		LOGLA	1.24	1.24	1.24	0.00
		LOGLU	-0.88	-0.88	-0.88	0.00
		LOGSM	0.33	0.33	0.33	0.00
		LOGY	-0.01	-0.01	-0.01	0.00
		LOGCE	1.50	1.50	1.50	0.00
		LOGCS	0.54	0.54	0.54	0.00

APPENDIX E (cont'd)

K-means Clusters Using 11 Elements

11 Clusters Specified (cont'd)

	LOGEU	-0.31	-0.31	-0.31	0.00
	LOGHF	0.46	0.46	0.46	0.00
	LOGSC	0.66	0.66	0.66	0.00
	LOGTH	0.73	0.73	0.73	0.00

CLUSTER NUMBER: 7

MEMBERS			STATISTICS			
CASE	DISTANCE	VARIABLE	MINIMUM	MEAN	MAXIMUM	ST.DEV.
S3	0.11	LOGBA	2.62	2.74	2.87	0.07
S11	0.12	LOGLA	1.28	1.45	1.57	0.09
S13	0.09	LOGLU	-0.64	-0.56	-0.50	0.04
S14	0.06	LOGSM	0.50	0.65	0.74	0.08
S17	0.04	LOGY	0.21	0.31	0.38	0.05
S18	0.05	LOGCE	1.62	1.73	1.83	0.06
S23	0.07	LOGCS	0.26	0.54	0.74	0.13
S24	0.07	LOGEU	-0.22	-0.04	0.06	0.08
S25	0.07	LOGHF	0.55	0.70	0.82	0.06
S26	0.08	LOGSC	0.83	0.93	1.01	0.06
S31	0.06	LOGTH	0.80	0.92	1.13	0.09
S41	0.09					
S42	0.06					
S48	0.06					
S58	0.08					

CLUSTER NUMBER: 8

MEMBERS			STATISTICS			
CASE	DISTANCE	VARIABLE	MINIMUM	MEAN	MAXIMUM	ST.DEV.
S28	0.00	LOGBA	2.36	2.36	2.36	0.00
		LOGLA	1.51	1.51	1.51	0.00
		LOGLU	-0.44	-0.44	-0.44	0.00
		LOGSM	0.72	0.72	0.72	0.00
		LOGY	0.41	0.41	0.41	0.00
		LOGCE	1.89	1.89	1.89	0.00
		LOGCS	0.79	0.79	0.79	0.00
		LOGEU	-0.03	-0.03	-0.03	0.00
		LOGHF	0.90	0.90	0.90	0.00
		LOGSC	1.03	1.03	1.03	0.00
		LOGTH	1.20	1.20	1.20	0.00

CLUSTER NUMBER: 9

MEMBERS			STATISTICS			
CASE	DISTANCE	VARIABLE	MINIMUM	MEAN	MAXIMUM	ST.DEV.
S36	0.00	LOGBA	2.30	2.30	2.30	0.00
		LOGLA	0.70	0.70	0.70	0.00
		LOGLU	-0.98	-0.98	-0.98	0.00
		LOGSM	-0.21	-0.21	-0.21	0.00
		LOGY	-0.12	-0.12	-0.12	0.00
		LOGCE	0.90	0.90	0.90	0.00
		LOGCS	-0.72	-0.72	-0.72	0.00
		LOGEU	-0.90	-0.90	-0.90	0.00
		LOGHF	-0.03	-0.03	-0.03	0.00
		LOGSC	-0.39	-0.39	-0.39	0.00
		LOGTH	-0.14	-0.14	-0.14	0.00

11 Clusters Specified (cont'd)

CLUSTER NUMBER: 10

MEMBERS			STATISTICS			
CASE	DISTANCE	VARIABLE	MINIMUM	MEAN	MAXIMUM	ST.DEV.
S33	0.00	LOGBA	2.51	2.51	2.51	0.00
		LOGLA	0.94	0.94	0.94	0.00
		LOGLU	-1.16	-1.16	-1.16	0.00
		LOGSM	-0.24	-0.24	-0.24	0.00
		LOGY	-0.30	-0.30	-0.30	0.00
		LOGCE	1.03	1.03	1.03	0.00
		LOGCS	-0.74	-0.74	-0.74	0.00
		LOGEU	-0.97	-0.97	-0.97	0.00
		LOGHF	-0.16	-0.16	-0.16	0.00
		LOGSC	-0.58	-0.58	-0.58	0.00
		LOGTH	0.03	0.03	0.03	0.00

CLUSTER NUMBER: 11

MEMBERS			STATISTICS			
CASE	DISTANCE	VARIABLE	MINIMUM	MEAN	MAXIMUM	ST.DEV.
S4	0.06	LOGBA	2.79	2.83	2.92	0.05
S5	0.05	LOGLA	1.57	1.65	1.79	0.09
S27	0.06	LOGLU	-0.45	-0.41	-0.34	0.05
S52	0.08	LOGSM	0.80	0.86	0.90	0.04
		LOGY	0.45	0.48	0.54	0.03
		LOGCE	1.90	1.98	2.09	0.07
		LOGCS	0.37	0.54	0.67	0.12
		LOGEU	0.06	0.09	0.12	0.02
		LOGHF	0.72	0.79	0.88	0.06
		LOGSC	0.99	1.02	1.05	0.02
		LOGTH	1.11	1.20	1.28	0.06

APPENDIX F

APPENDIX F

Elements Detected by INAA and Used in Pottery Paste Analyses

Michigan Memorial Phoenix Project / Ford Neuclear Reactor (Dunn)

1. Pneumatic Tube (1 minute irradiation)

   NOT USED FOR POTTERY SAMPLES

   a. Count after 13 minutes of decay (half-lives up to 30 min):

      Aluminum, Bromine, Chlorine, Copper, Iodine, Magnesium, Niobium, Palladium, Titanium, Vanadium

   b. Count after 2 hours of decay (half-lives up to 1 1/2 days):

      Arsenic, Dyaprosium, Erbium, Gallium, Germanium, Manganese, Nickel, Potassium, Praseodynium, Sodium, Tungsten

2. Quartz Tube (Irradiated for 6 hours):
   a. Counted after 1 week of decay (half-lives 1-10 days):

      Barium, Bromine, Cadmium, Lanthanum, Luthenium, Molybdenum, Neodymium, Samarium, Uranium, Ytterbium

      Excluded: Bromine, Cadmium, Molybdenum, Neodymium, Uranium

      Used: Barium, Lanthanum, Luthenium, Samarium, Ytterbium

      Diagnostic Elements: none

   b. Counted after 5 weeks of decay (half-lives 15 days to 5 years)

      Antimony, Cerium, Cesium, Chromium, Cobalt, Europium, Gadolinium, Hafnium, Indium, Iron, Mercury , Nickel, Rubidium, Scandium, Selerium, Strontium, Tantalum, Terbium, Thorium, Thulium, Tin, Zinc, Zirconium

      Excluded: Antimony, Chromium, Cobalt, Gadolinium, Indium, Iron, Mercury , Nickel, Rubidium, Selerium, Strontium, Tantalum, Terbium, Thulium, Tin, Zinc, Zirconium

      Used: Cerium, Cesium, Europium, Hafnium, Scandium, Thorium

      Diagnostic Elements: none

APPENDIX F (cont'd)

Elements Detected by INAA and Used in Pottery Paste Analyses

Clark (1991):

1. Pneumatic Tube (Irradiated for 5 seconds)
   a. Counted after 25 minutes of decay:

      Aluminum, Barium, Calcium, Dyaprosium, Potassium, Manganese, Sodium, Titanium, Vanadium

      Excluded:Aluminum, Calcium, Potassium, Sodium

      Used: Barium, Dyaprosium, Potassium, Manganese, Sodium, Titanium, Vanadium

      Diagnostic Elements: rare earth elements

2. Quartz Tube (Irradiated for 24 hours):
   a. Counted after 1 week of decay :

      Arsenic, Lanthanum, Luthenium, Neodymium, Samarium, Uranium, Ytterbium

      Excluded:Arsenic, Neodymium, Uranium

      Used: Lanthanum, Luthenium, Samarium, Ytterbium

      Diagnostic Elements: rare earth elements

   b. Counted after 5 weeks of decay :

      Antimony, Cerium, Cesium, Chromium, Cobalt, Europium, Hafnium, Iron, Nickel, Rubidium, Scandium, Strontium, Tantalum, Terbium, Thorium, Zinc, Zirconium

      Excluded: Cesium, Chromium, Cobalt, Hafnium, Nickel, Strontium, Tantalum, Zinc, Zirconium

      Used: Antimony, Cerium, Europium, Iron, Rubidium, Scandium, Terbium, Thorium,

      Diagnostic Elements: rare earth elements + Iron and Scandium

APPENDIX F (cont'd)

Elements Detected by INAA and Used in Pottery Paste Analyses

Gunneweg and Mommsen (1990):

Method not described (used intermediate and long-lived isotopes):

Arsenic, Barium, Cerium, Cesium, Chromium, Cobalt, Europium, Hafnium, Iron, Lanthanum, Lutetium, Potassium, Rubidium, Samarium, Scandium, Sodium, Strontium, Tantalum, Terbium, Thorium, Ytterbium, Zinc

Excluded: none reported

Used: all

Diagnostic Elements: Cerium, Cesium, Europium, Iron, Lanthanum, Samarium, Scandium, Sodium

Hancock, et *al.* (1989):

Short Irradiation (1 minute or longer, based on sample weight) with
Short Decay (counted after 19 minutes of decay):

Aluminum, Barium, Calcium, Chlorine, Dyaprosium, Magnesium, Manganese, Sodium, Titanium, Uranium

Excluded: Barium, Chlorine, Magnesium, Uranium

Used: Aluminum, Calcium, Dyaprosium, Manganese, Sodium, Titanium

Diagnostic Elements: none reported

Long Irradiation (10-20 minutes) with
Long Decay (counted after overnight decay):

Europium, Potassium, Samarium, Sodium [sic]

Excluded: none

Used: all

Diagnostic Elements: none reported

APPENDIX F (cont'd)

Elements Detected by INAA and Used in Pottery Paste Analyses

Minc, et *al.* (1989):

Method not described (used intermediate and long-lived isotopes):

Antimony, Barium, Calcium, Cerium, Cesium, Chromium, Cobalt, Europium, Gadolinium, Hafnium, Iron, Lanthanum, Lutetium, Neodymium, Nickel, Potassium, Rubidium, Samarium, Scandium, Sodium, Tantalum, Terbium, Thorium, Titanium, Uranium, Ytterbium

Excluded: none reported

Used: all

Diagnostic Elements: Cerium, Cesium, Chromium, Cobalt, Iron, Hafnium, Lanthanum, Rubidium, Scandium, Tantalum, Thorium, Titanium, Uranium, Ytterbium

Olin and Blackman (1983):

Irradiation Not Described
Short Decay (counted after 5 day decay)

Antimony, Arsenic, Barium, Bromine, Calcium, Lanthanum, Lutetium, Neodymium, Potassium, Samarium, Sodium, Tungsten, Uranium, Ytterbium,

Excluded: none reported

Used: all

Diagnostic Elements: none

Irradiation Not Described
Long Decay (counted after 30 day decay)

Cerium, Cesium, Chromium, Cobalt, Europium, Hafnium, Iron, Rubidium, Scandium, Strontium, Tantalum, Terbium, Thorium, Zirconium, Zinc,

Excluded: none reported

Used: all

Diagnostic Elements: Chromium, Iron, Scandium

APPENDIX F (cont'd)

Elements Detected by INAA and Used in Pottery Paste Analyses

Bieber, et *al.* (1976):

Short Irradiation and Decay (irradiation and decay times not reported):

Lanthanum, Manganese, Potassium, Sodium

Excluded: none reported

Used: all

Diagnostic Elements: Lanthanum, Manganese, Potassium, Sodium

Long Irradiation and Decay (irradiation and decay times not reported):

Antimony, Barium, Cerium, Cesium, Chromium, Cobalt, Europium, Hafnium, Iron, Luthenium, Rubidium, Scandium, Tantalum, Thorium

Excluded: none reported

Used: all

Diagnostic Elements: Cerium, Hafnium

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