ANALYSIS OF A PALEO-INDIAN OCCUPATION FLOOR AT THE DUCK RIVER SITE ELMB-10, MANITOBA

by

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ABSTRACT

This thesis deals with a proposed analytic procedure designed to aid in the analysis of marginal recovery sites, which present obstacles to analysis such as poor preservation or small sample size. ElMb-10, an Agate Basin site in Manitoba containing only lithic artifacts, was selected as the test case for the analysis. The analytic procedure consisted of cluster analysis, a technique for grouping data on the basis of similarity, and nearest-neighbour analysis, which generates a measure of spatial dispersion. The cluster analysis was used to investigate the nature of artifact production at the site and to generate sets of functional tools. The tool sets were combined into activity-related kits and submitted to the spatial analysis. The presence of activity areas is inferred from the results of the nearest-neighbour analysis.

The results of the flake cluster analysis indicate that no flake types were sought by the artisan(s), and a direct percussion knapping technique is inferred. The knapping technique is discussed in relation to technological parameters and the availability of raw materials. The second cluster analysis isolates several tool classes. When these are combined as tool kits and submitted to nearest-neighbour analysis the results indicate the spatial aggregation of three kits: butchering, hideworking and woodworking. Maps of the distribution of the kits delineate three activity areas. A rock configuration is also submitted to spatial analysis and the results indicate that it was a man-made structure--possibly a

windbreak. Interpretations of site structure are discussed in relation to environmental conditions and the analytic procedures are reviewed and evaluated.

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CHAPTER 1

INTRODUCTION

The reconstruction of past lifeways is almost always included in statements regarding the objectives of archaeology. This is in itself a broad topic of investigation even in the case of relatively simple extinct cultures - partly because the archaeological record does not easily lend itself to inferences on many aspects of cultural behaviour. The subject may be narrowed somewhat by a site-specific perspective. At this level of observation, given a single, short-term occupation, the reconstruction of past lifeways in confined to that which occurred at a single point in time and space. The remains excavated at a site constitute the archaeological record for that space for a given interval in time. They are the material byproducts of activities at the site.

Some sites pose problems for investigators who wish to draw inferences from the archaeological record regarding past cultural activities. These may be described as 'marginal-recovery' sites in that the excavated sample may for various reasons present serious obstacles to analysis. Factors that can operate to render interpretations difficult include poor preservation, post-depositional disturbance, small sample size and the nature of the remains themselves.

This last factor is pertinent to the work at hand. Whallon (1973b: 115-119) has contrasted 'expedient' and 'curative' technologies and the morphology of tool types associated with each. In a curative technology tools are designed for long-term, repeated use, and they exhibit a high degree of morphological similarity. On the other hand, tools of an expedient technology usually bear little morphological similarity, except in their most basic functional aspects. They are in a sense 'disposable' tools, to be made, used and discarded soon after use.

Sites at which tool production and use has been primarily expedient may easily be relegated to the marginal-recovery category, especially when lack of other remains prevents alternate means of reconstructing past activity from being employed. Such sites are rarely subjected to intensive analysis, yet a large percentage of sites investigated during the course of survey or testing fall within the marginal category.

This thesis examines several procedures by which the archaeological record at a single marginal-recovery site can be made to yield data pertinent to the reconstruction of the activities of the prehistoric inhabitants. In recent years a variety of methods has been developed to deal with such data. It would be too great a task to deal with even a sizeable proportion of them in this work. Consequently a procedure consisting of two previously developed methods will be proposed and considered throughout this text.

Three basic aspects of cultural activity present themselves for analysis in this case: tool production, use and distribution. The production of lithic tools begins with flake and core production. An examination of the technology of flake production at the site may reveal regularities (or a lack of them) in manufacturing procedures.

A number of researchers (Crabtree 1967a, 1967b, 1968, 1970, 1972, Bordes and Crabtree 1969, Speth 1972, 1975) have demonstrated the great degree of control which can be exercised by an artisan in the production of flakes. Certain regularities in flake morphology may be indicative of such control.

Further alteration or simple utilization of selected flakes results in the creation of tools related to one or more functions. In a curated technology these tools may be initially grouped together by simple morphological similarity under the assumption that form is directly related to function. The tools of an expedient technology, however, do not necessarily bear morphological similarity, except for certain attributes which pertain only to function. Thus in a curated technology one might expect small scrapers for use in skin softening to bear both stylistic as well as functional similarity. Tools of an expedient technology, on the other hand, are products of a momentary need. A variety of forms may be used as long as they meet some sort of functional requirements.

Tool use in an expedient technology will result in the deposition of artifacts in or near the areas in which they were used (Whallon 1973b: 118). The pattern of distribution of functional classes of tools may thus reflect the pattern of activities which took place at the site. If inferences about the patterning of activities are to be made, analysis must be designed to delineate and measure the patterns of artifact distribution.

Artifact distribution, tool production and tool use all reflect cultural behaviour, yet the kinds of analysis required for the investigation of the three modes are somewhat different. Typology is a major factor to be considered in production and use, whereas patterns of distribution require some sort of spatial analysis. These two facets of analysis--typology and spatial distribution--are related in that spatial analysis is dependent upon typology. In other words, one cannot effectively analyze spatial pattern without a classification. Spatial patterns alone are insufficient for analysis of activities unless they can be related to functional artifact categories.

This is especially true in the case of function-specific tool kits, in which combinations of various tools were used to perform certain tasks. Applications of techniques such as factor analysis (i.e. Binford and Binford 1966) have proven to be useful analytic tools in isolating tool kits. However, the tool assemblages at a given site may often be recombined to match several hypothetical tool kits. An analysis of spatial patterning, as Whallon (1973b) has noted, may show which tool categories are associated--presumably as part of a kit.

The technique chosen here for investigating flake production and tool use is known as cluster analysis. This term encompasses a wide array of procedures whose basic aim is to reduce a set of data to a smaller set containing one or more groups of similar items. Cluster analysis is, in effect, a procedure which accomplishes a

sorting task in a fashion similar to but more consistently than that a human observer might accomplish. It has been used in both Q-mode and R-mode types of analysis in archaeology (cf Hodson, Sneath and Doran 1966, Wilmsen 1970, Read 1974). Anderberg (1973: 18) has likened it to a form of nonstatistical factor analysis.
Thus cluster analysis provides a means of measuring the similarity of one item to another and of outlining the structure of the data set based upon those similarities. The observer can then examine the structure and derive from it a classification based upon those variables chosen.

The classification so derived may then be used in an analysis of spatial patterning. The distribution of each artifact type or combination of types can suggest inferences about specific activities. Such spatial analysis of occupation floors is not new in archaeology, and various interpretations have been made of site structure in recent years. The majority of these have been based upon visual study of plots of artifact distribution (cf Leakey 1971, de Lumley et al 1969, MacDonald 1968). Other studies have made use of density patterns of artifacts (cf Binford et al 1970, Grigor'ev 1967). Dacey (1973) has used another technique: dividing the living floor into cells and then comparing the frequencies of artifact types per cell for signs for spatial clumping or association. Whallon (1973a, 1973b) illustrates the use of dimensional analysis of variance, a technique that delineates the grid sizes corresponding to the scale of artifact patterning.

The technique chosen for this work is nearest-neighbour analysis, which was first presented in archaeology by Whallon (1973b, 1974), as a useful method of measuring artifact distribution. This method was first used in ecology by Clark and Evans (1954), although similar techniques were suggested earlier by Cottam and Curtis (1949) and Dice (1952). The method was originally applied to the study of plant population distribution and provided a statistical measure of spatial dispersion within the sampling universe.
An analysis of nearest-neighbour distances is also useful in that it allows the researcher to define the form of spatial aggregations based upon the statistical probability of items being randomly or nonrandomly distributed. These areas of concentration may then be compared with each other as part of an attempt to reconstruct the activities of the prehistoric occupants.

Cluster and nearest-neighbour analysis are independent techniques, although in the case of marginal-recovery sites, they can be used as a two-staged analytic team to gain insights which neither can accomplish by itself.

The procedure used in the analysis of a marginal-recovery site consisted essentially of the above two stages. Prior to the cluster analysis the data was coded to be usable by the clustering methods. This important preliminary stage included the selection of variables to be used and the form in which they were recorded. Following this the clustering procedures- each designed to investigate either flake or tool production and use- were applied. From this stage classes of tool types were then submitted to the spatial analysis, which generated data on the structure of the site. Finally, from information gathered from both the cluster and the spatial analyses, inferences about the activities which took place at the site were made.

The site chosen for the analysis was ElMb-10, one of a group of 13 sites near Duck River, Manitoba. It is a Paleo-Indian site lacking perishable remains, which makes it a good example of a marginal-recovery site. The remains consist almost entirely of waste flakes, utilized or worked flakes and limestone or granitic rocks. Very few tools were found which could be ascribed to conventional functional categories. The four projectile points recovered from the site have been described as Agate Basin (Pettipas 1970, Haug 1973).

As pointed out above, marginal-recovery sites such as ElMb-10 present serious obstacles to research. The lack of faunal or vegetal remains makes independent testing of hypotheses regarding activities virtually impossible. Inferences made here must remain hypotheses until tested at other sites where such remains are preserved.

CHAPTER 2

THE SITE AND ITS EXCAVATION

The Duck River Region

The Duck River Site is located on the Lake Agassiz Plain about nine kilometres west of the western shore of modern Lake Winnipegosis and about 22 kilometres northeast of the town of Pine River, Manitoba (Figure 1). The land in this region is remarkably flat but intersected from northwest to southeast by fossil beach ridges at irregular intervals. Ehrlich, Pratt and LeClaire (1959: 22) have described the region physiographically as the Manitoba Lowland Plain. It is bounded to the west by the Manitoba Escarpment and the Duck Mountains, a morainic highland underlain by late cretaceous bedrock. The Duck Mountains reach their highest elevation at Baldy Mountain, 831 metres asl, while the Lowland Plain ranges in altitude from 427 metres asl at the escarpment to 253 metres asl at Lake Winnipegosis in the east. The area is drained by three major westward-flowing rivers: the Pine, the Sclater and the Duck. All three flow northeastwards after leaving the escarpment and into Lake Winnipegosis. Drainage on the Plain is poorly developed, resulting in ponding of water and the formation of peat bags between the beach ridges.

The pre-settlement vegetation of the region has been described by Ehrlich, Pratt and LeClaire (1959: 26) as being composed of:

> aspen, black and balsam poplar [which] occur in pure associations or mixed with white spruce and white birch. In the northern portion of the area [the Lowland Plain and environs], where fires have not occurred

> in recent years, the prevailing forest cover is black spruce and tamarack with jack pine on the ridges.

Lowlying, wet meadows and bogs were widespread in early settlement times. According to local informants large numbers of beaver dams contributed to the maintenance of wetlands. The large herbivore fauna of the Manitoba Lowland Plain east of the Duck Mountains include moose, elk and white-tail deer. Bison, black bear, wolves and coyotes were formerly common within the region.

The Duck River Sites

The Duck River sites were first visited by Mr. T. Fiske of the University of Manitoba in 1964 after they had been brought to his attention by Mr. Martin Jalowica of Duck River. In the process of clearing and subsequent cultivation of the land, Mr. Jalowica had made a large number of surface finds, including projectile points, lithic tools and chipping debitage. Both the size and the variety of his collection prompted Fiske to investigate the area in June 1964.

He arrived with a crew of three people and spent a week collecting and testing the sites in the area. Surface investigations showed the sites to be largely confined to the northern half of Section 17, Range 20 West, Township 34 North. Within this half section, Fiske isolated six areas of lithic concentration (1964a), which he designated as subareas within a single site, to which he assigned the Borden number ElMb-1 (Figure 2).

Three of the areas were tested by excavation, and remains characteristic of several archaeological manifestations were recovered, including McKean, Oxbow, Pelican Lake, Besant and Avonlea (Fiske 1964b). Surface collections were carried out at the other three subareas, which yielded a variety of projectile points, lithic tools and chipping debitage. Area 1, near the centre of the section, was a surface site covering more than one hectare. From it had come three Paleo-Indian projectile points " . . . falling within the range of Hell Gap points and a couple are suggestive of Agate Basin points" (Fiske 1964a: 4).

The area in which the Duck River sites lay had originally been covered by a tamarack bog created by beaver dams (M. Jalowica, personal communication 1973). The peat deposits in the bog ranged in depth from 30 cm above the higher areas of buried soil to over 100 cm in the lower areas. Sometime prior to 1940 the dams were destroyed and the bogs drained. Two fires succeeded in clearing the tamaracks and peat, making cultivation possible--one in 1940 and the other in 1960.

Fiske's investigations occurred only four years after the second fire, before secondary growth of aspen and poplar began to dominate the uncultivated portions of the section. Farming activities kept the regrowth of forest down, and after Fiske's work even more of the land was opened to cultivation. It was during this period that Jalowica began to increase the size of his collection and find materials in hitherto unsearched areas which had been newly opened by the plough.

His continued correspondence with the Laboratory of Anthropology at the University of Manitoba, by this time with Mr. Leo Pettipas, resulted in a second investigation of the site in 1973. The major impetus behind the second visit was that one of the new sites, which lay in unploughed sod, was going to be cultivated in the near future.

Consequently the author and Mr. Stan Saylor of the University of Manitoba spent the summer of that year at Duck River. The bulk of the fieldwork concentrated on the excavation of the unploughed site, designated as Area 10, but surface collections and additions to Jalowica's collection were also made. In the course of the summer seven areas of prehistoric remains were recorded in addition to those of the 1964 field season.

In 1974 the site was renumbered by Saylor during a reorganization of the Manitoba Site Inventory. The 13 subareas of the site were reclassified as separate sites. The number ElMb-1 now refers to Fiske's Area 5, while ElMb-5 is the new number for Area 1. The remaining areas were assigned Borden numbers corresponding to their original area numbers. Thus Area 10, the main objective of the 1973 field season, was assigned the Borden number ElMb-10.

The Initial Excavations

ElMb-10 lies in the northwest extremity of Section 17, approximately 150 metres west of ElMb-3. It first came to the attention of Jalowica when a narrow strip of the land was broken by ploughing after the 1960 fire. The field directly to the north was also broken and the land cultivated. Jalowica noticed scattered debris in the plough furrows and he collected two complete lanceolate points (Plate 7 A,B). These points, along with the first two found at ElMb-5 have been described by Pettipas (1970) and Mayer-Oakes (1970).

By the beginning of the 1973 excavations the area around the site had become completely overgrown, so that little or no trace was visible of the fires which had destroyed the original tamarack and peat bog. The regrowth consisted of poplar and aspen in the unploughed strips of land and dense willow thickets and sweet clover in the ploughed or disturbed areas.

A datum point was fixed within the narrow, unploughed strip about eight metres wide near the spot where Jalowica had found the surface materials. Two baselines were surveyed from this point, and a map of the immediate site area was drawn (Figure 3). Actual excavations did not begin until midsummer due to the extremely wet condition of the site. When the site was first visited in mid-June very heavy rains had created a virtual flood situation, and water over 20 cm deep covered the site. Heavy rains during the following month retarded the drainage of the land (which is at best poor), and it was impossible to excavate before 16 July.

The first two excavation units were opened during the last half of July. They bisected the unploughed strip of land between the cultivated land to the north and the broken strip to the south. The exploratory trench across the strip was dug to confirm the existence of subsurface materials, for in its present state--overgrown by willows, clover and grass--no surface indications were present. Only Mr. Jalowica's collected materials and his practice of meticulously plotting the location of his finds gave any indication of its existence. The second objective of the trial trenches was to investigate the nature of the soils and their stratigraphic relationship to the artifacts.

Unit 1 yielded 11 flakes and what appeared to be a reworked projectile point. Unit 2 contained a large amount of chipping debitage which was concentrated in the northwest corner of the unit. This concentration was designated Feature 1, since the density of materials indicated the possibility of a knapping station (Plate 1). A third excavation unit was set up adjacent to Feature 1, but before it could be completed the work was interrupted by two days of heavy rain.

The Excavation Strategy

The unexpected rains cancelled the fieldwork for six days, which allowed the results of the work to date to be assessed. The major factors to consider were a) the relatively short amount of time left in the field season, b) the small size of the crew and c) the salvage situation of the site. First it was evident that a larger crew would be necessary at the site. To this end Mr. Pettipas arranged for three volunteer excavators to spend about two weeks at the site. The most crucial decision was that pertaining to the strategy necessary in further excavations at the site. Two choices were open: first, to attempt a sampling of the site area to determine its overall size and recover a meaningful sample of the artifact assemblage; and second, to confine excavations to the unploughed strip near the trial trench in an effort to remove as large a block as possible of what appeared to be a living floor. The second alternative was selected, the major consideration being the intention of the farmer who leased the land to break and cultivate the site area. A second consideration was that the situation offered the investigators an excellent chance to expose a large segment of a living floor. In Canada, Paleo-Indian living floors have rarely been found intact. Furthermore, no Paleo-Indian sites had at that time been excavated in Manitoba.

The excavation technique was by trowel and brush, with no screening of matrix. The damp, clayey soil had proven almost impossible to sift during the initial excavations, so it was decided that careful trowelling and in situ recording of all artifacts would provide an adequate recovery of materials. Natural stratigraphy was followed during the course of the digging.

The Block Excavations

Seventeen excavation units were laid out in August. Eleven were located adjacent to and west of the first three units (Plate 2). Those directly west of Unit 3 contained very little artifactual material. One unit, Excavation Unit 10, contained a dense concentration of the limestone cobbles which were abundant throughout the site. Beyond that point to the west, artifactual materials ceased to appear with any regularity in the units, and it was decided to terminate the westward expansion of the block with Unit 13, 20 metres west of the site datum.

Three units were excavated south of the baseline in a westward direction from Unit 1 (Plate 3). Flakes, many of them altered or utilized, occurred in some numbers within these units, mixed in with the usual complement of limestone cobbles. The end of the season arrived before any further units could be opened in this direction. Six units were excavated east of the initial trench as far as the datum stake. The first two, Units 9 and 11, were adjacent to the trial trench (Plate 4). They contained a large number of flakes, of which many showed signs of retouch or utilization, as well as a complete lanceolate projectile point and a small, disk-like scraper.

As work continued on these units and their neighbours to the east, what appeared to be an interesting pattern in the limestone cobbles was noticed. These formed an arc extending from the northern edge of Unit 9, curving to the southern edge of Unit 14 (Plate 5). To the east of the arc only one artifact was found, and the limestone rocks present in abundance throughout the rest of the living floor were virtually absent.

In all, the area excavated as a block was 20 metres in length by 4.3 metres in width north of the baseline. South of the baseline the excavated units measured 14 metres east to west and 3.35 metres north to south. The total excavated area of the living floor was 132.9 square metres.

Stratigraphy

The stratigraphic profile of ElMb-10 was divided into six levels, reflecting depositional history, soil formation and post-depositional history. A profile from Excavation Unit 13 is presented in Figure 4 and Plate 6.

Level I was weakly developed modern soil formed on the ashes and unburned remains of either the 1940 or 1960 fire. There was very little humus present, and occasional fragments of burned tamarack root or wood appeared in it. It varied in thickness from 0 to 5 cm.

Level II was a very fine tan coloured ash deposited during the fires and reworked by later wind action to form drifts of varying thicknesses. It was powdery when dry, and very greasy and sticky when wet. It was distributed rather discontinuously over the area from 0 to 20 cm in depth.

Level III was an incompletely burned black ash with a high organic component. It was very discontinuous and rarely exceeded 1 cm in thickness. Quite often it was underlain by unburned peat.

Level IV was a grey, gleyed 'A' horizon of a buried soil. It had originally been buried under the peat bog and was exposed in many places by the fires. It was composed of clay, silt and limestone cobbles, and it exhibited little or no evidence of structure. It was very uneven in its contact with Level V beneath it, which may be suggestive of frost heaving (cf Flint 1971: 282-283). It varied from 5 to 10 cm in thickness.

Level V was a medium to light grey soil horizon, probably the 'B' horizon of the buried soil. It varied from 3 to 15 cm in thickness.

Level VI was the silty clay parent material of the buried soil. In colour it ranged from off-white to bright tan where oxidation was present. Its contact with Level V, like that of Level V with Level IV, was very irregular.

Levels IV, V and VI all contained a high percentage of limestone and other rocks, likely components of the underlying till. J.C. Ritchie, in a letter to Fiske (1964b), described the soil as resembling a "wave winnowed sand." It seems likely that the buried soil was built upon a till which had been reworked by wave action from Glacial Lake Agassiz.

While no soil charts exist for the immediate site area, Ehrlich, Pratt and LeClaire (1959) have provided one for the region directly adjacent to the south. The soil at ElMb-10 most closely resembles that which they have designated 'Salina Sand, Till Substrate Phase'.

All of the artifacts from ElMb-10 recovered by excavation were found within Levels IV and V, but occasionally at the top of Level IV. The only item found within the upper levels was a large limestone cobble.

CHAPTER 3

DESCRIPTION OF RECOVERED MATERIALS

Procedures and Definitions

A total of 1615 items were recovered from the ElMb-10 living floor. The distribution for those recovered with provenience is depicted in Figure 5. The remains were divided into two categories: unaltered rocks and lithic artifacts. Lithic artifacts included all worked lithics, flakes and altered rocks (Table 1).

Lithic materials were subdivided into the following eight categories prior to further analysis:

<u>Projectile Points</u> Any bifacially worked lithic artifact which possesses a blunt end (proximal) and a pointed end (distal).

<u>Scrapers</u> Any unifacially worked lithic artifact having a convex or straight working edge with an edge angle in excess of 50°.

<u>Cores and Core Fragments</u> Nodules or broken fragments which display evidence of flake removal, usually without the intention of producing a tool from the exhausted nucleus (cf Haug 1976). The category may be separated into three classes: multifaceted, polyhedral and discoidal cores (cf MacDonald 1968, Crabtree 1972).

<u>Complete Utilized Flakes</u> Flakes which possess an intact striking platform and which exhibit traces of having been used as tools or having been altered for use as tools.

<u>Complete Unutilized Flakes</u> Flakes which possess an intact striking platform and which exhibit no traces of having been used as tools or having been altered for use as tools.

<u>Incomplete Unutilized Flakes</u> Flakes possessing no visible striking platform and exhibiting no traces of having been used as tools or having been altered for use as tools.

<u>Incomplete Utilized Flakes</u> Flakes possessing no visibly intact striking platforms and which exhibit traces of having been used as tools or having been altered for use as tools.

<u>Hammerstones</u> Rocks or exhausted cores which have been used as percussors in the production of flakes (Crabtree 1972). Characteristics include battering and breakage along a raised edge or on one or more ends of the rock.

The artifacts were further divided by lithic types. The criteria for establishing the lithic types consisted of a) texture, b) homogeneity, c) colour and d) composition. Nine categories were established:

<u>Type I Swan River Chert</u> Fine-grained chert of moderate homogeneity. Colour varies from orange to reddish-grey with streaked inclusions of white.

<u>Type II Swan River Chert</u> Fine-grained chert, somewhat more homogenous that Type I. Colours include reddish-orange, orange, pink, tan and yellow-orange. Grey is often a colour mixed in with the others. Contains many small, mottled white inclusions and tiny speckles of red in many cases.

<u>Red Swan River Chert</u> Fine-grained chert, usually of excellent homogeneity. It is red or brick-red in colour with white, speckled inclusions and occasionally large white inclusions.

<u>Mottled or Piebald Swan River Chert</u> Fine-grained, homogenous chert. In colour it is orange and white, occurring in about equal proportions in large patches.

<u>Coarse Swan River Chert</u> Course-grained, inhomogenous chert containing numerous impurities and inclusions, which render it very poor for knapping. Colours include orange, pink, grey and yellow, with mottled or streaked white inclusions.

<u>Yellow Chert</u> Fine-grained homogenous chert- probably a variety of Swan River Chert. Its colouration is generally bright yellow, tan or creamy yellow. It occasionally contains small, white or red inclusions less than 1 mm in diameter. Black, coarse inclusions or imperfections also occur.

Cathead and Fine-Grain Cherts Cathead Chert includes several varieties of mottled or banded chert of tan, light grey, brown and dark grey colour, although grey is the most common (Mayer-Oakes 1970). It is very fine-grained in texture, with only occasional inclusions. Materials which were similar to the described varieties of Cathead Chert, but which did not fit precisely within a category, were assigned to this category.

Quartzite A lithic type consisting of a granulose metamorphic rock composed mainly of quartz or a silicated sandstone (cf Geological Society of America 1962).

Granitic Any coarse or medium-grained igneous rock which is related to the granites or granite-type rock families (cf Geological Society of America 1962).

A few remarks are in order at this point concerning some of the lithic types. The first five categories are all types of Swan River Chert. This is a broad term denoting a wide variety of lithic types. Mayer-Oakes (1970: 106-108) described four varieties of Swan River Chert, having originally classified them under such diverse categories as quartzite, crystalline chert and smooth chert. His colour categories included a wide variety of pinks, reds, oranges and red-orange. None of them match the above set very well, although his Class 11, described as "smooth- pink, red orange mottled and bands" (1970: 106), is similar to Type I Swan River Chert. As a further comment on the diversity of the chert, N. Campling (personal communication) has tentatively indentified over 20 varieties of Swan River Chert, which he describes as a silicified or altered siltstone.

No source has been identified for Swan River Chert, although Mayer-Oakes (1970: 108) notes a concentration in the upper Assiniboine drainage basin. Presumably it was carried from its original source area by glacial transport and subsequently was redeposited by post-glacial drainage systems. Cathead Chert has been reported as being found in outcrops of the Ordovician limestones in the western Lake Winnipeg area (Tamplin 1968).

Raw Materials

Table 2 presents the raw counts and the relative percentages of the various artifact categories in relation to raw materials. Type I Swan River Chert contains by far the highest percentages of any lithic material at 48.7% of the total artifact inventory. The only other categories to claim more than 10% are Type II Swan River Chert and Cathead Chert, with 18.5% and 11.2%, respectively.

Among the flake artifact categories the percentages are much the same, except that Types I and II Swan River Chert are somewhat higher. Cathead Chert flake percentages are somewhat lower than for the total artifact inventory, since so many of the core fragments and other categories were made of it. Table 3 presents the totals of the utilized flakes and unutilized flakes by raw materials, while Table 4 shows the same in relative percentages. The tables indicate some differences in the proportion of raw materials selected for use from among the flakes produced. Both Type I and Type II Swan River Chert were utilized in higher proportions than other lithic categories, but Cathead Chert was actually utilized less than its total proportion. Although it is clear that Types I and II Swan River Chert and Cathead Chert were the most widely used lithic materials at ElMb-10, it is not known whether this resulted from conscious selection or differential availability of types.

Heat Treatment and Alteration of Raw Materials

It is not possible to determine if raw materials from ElMb-10 had been heat-treated prior to knapping. Heat from the 1940 and 1960 fires was intense enough to alter many of the artifacts- in fact many of them exhibit signs of colour change due to being heated within the soil. On the other hand, many flakes and artifacts show no visible traces of heat alteration- presumably because they were sufficiently deep to escape the most intense heat.

Such colour changes may be in part or totally responsible for the variations and classifications of Swan River Chert used in this work. The ferric minerals, which impart much of the red pigmentation to Swan River Chert, are especially vulnerable to colour changes due to heating (Collins and Fenwick 1974). Partial or complete vitrification and recrystallization due to heat from the fires may also have obliterated many wear patterns on the tools.

The Recovered Materials

Projectile Points Two projectile points were recovered from the ElMb-10 excavations. The first of these is a small, reworked lanceolate point (Plate 7 D) made of Yellow Chert. Its length is 45.3 mm, its width is 21.6 mm and its thickness is 8 mm. It weighs

7.1 g and has a thick, convex cross-section. The base has been broken off and now displays a hinge fracture, while the tip has been reworked. The retouching on the tip was poorly executed, resulting in its asymmetric form. Grinding is present along both lateral edges to lengths of 24 and 22.6 mm from the truncated base.

The second point (Plate 7 C) is also made of Yellow Chert. It was worked from a large flake or blade, and a trace of the original striking platform remains at one corner of the base. The point is lanceolate in shape, 18.4 mm wide base. Its width is 27.9 mm at a point about halfway up from the base, and it reaches a very sharp, well-formed tip. Its maximum length is 75.4 mm and it has a thickness of 9.6 mm. It weighs 17.4 g. A single short, thick flake was removed from both faces of the base to create a flat bevel. The base is not heavily ground, although it displays grinding to distances of 28.8 and 32.8 mm along the lateral edges.

The first point was found at the north end of Excavation Unit I and was not associated with any features or artifacts save a small flake of yellow chert. The second point was recovered in Unit 9 in association with both utilized and unutilized flakes and the rock alignment.

Scrapers One artifact was recovered which could readily be assigned to this category (Plate 7 E). It is made from a thick flake of Type II Swan River Chert and is steeply retouched around its entire circumference. Its edge angles vary from 50° to 80°. All retouch is unifacial, although several small use flakes have been removed from the flat ventral surface. No other signs of wear could be discerned. It is roughly round in outline, with a maximum width of 30.3 mm and a minimum width of 25.2 mm. It varies in thickness from a maximum of 9.9 mm to a minimum of 7.9 mm. It weighs 10.6 g. It was found in Excavation Unit 14, which contained many utilized flakes, just west of the stone structure.

Cores and Core Fragments Ten cores or core fragments were recovered, which represented a total of four whole cores. Four fragments fit together to make a complete nucleus of a Cathead Chert multifaceted core (Plate 8 D). Three of the fragments were found in Units 2 and 3 in Feature 1, while the fourth had no recorded provenience but was probably also from Feature 1. The reconstructed core has a weight of 112.6 g. The chert is a mottled grey colour and is of excellent quality. Four other fragments were all found within Feature 2, and they could also be reconstructed into a single piece (Plate 8 B). The material from which they are made is Red Swan River Chert. The core type is indeterminate but possibly discoidal. It is round and flat, and it weighs 42 g. Two complete cores were found on the living floor. One was found in Excavation Unit 10 (Plate 8 A). It is multifaceted, made of Cathead Chert, and it weighs 130 g. The last core (Plate 8 C) was found on the surface. It is made of Yellow Chert, and it is also a multifaceted core. It weighs 76 g.

Flakes- All Categories A total of 307 flakes were recovered from the living floor (Plates 9-15): 72% of them are incomplete and unutilized. Complete unutilized flakes comprise the second largest category with 13.4% of the total sample. Incomplete utilized and complete utilized flakes total 7.8% and 6.8% of the sample, respectively. Complete unutilized flakes are generally the largest, with an average weight of 15.4 g. They are followed by complete utilized, incomplete utilized and incomplete unutilized flakes with average weights of 14.7 g, 12.8 g and 7.2 g, respectively. The majority of the flakes were recovered from the central portion of the excavations, with the highest densities in Excavation Units 2, 3 and 9. The eastern and western margins of the excavation contained very few flakes.

Five of the flakes assigned to the utilized categories deserve some additional comment. All have been retouched along one or more edges, and their wear patterns allow an assessment of function. The first (catalog number 53A, Plate 14 D) is a rather long flake of Type I Swan River Chert. For a length of 54 mm along a lateral edge it has been unifacially retouched on its dorsal face, and several small use flakes are visible on the ventral face. The other lateral edge of the flake is blunted by both truncation and steep retouch. The angle of the working edge is about 45°, which could place it is either a light scraper or a heavy-duty knife category. Ventral and dorsal nibbling of the working edge is present to some extent, but not enough to discern orientation of use.

The second (55A, Plate 12 D) is classified as an incomplete utilized flake. The two lateral edges are both retouched dorsally.

The edge angles vary from about 50^{o} to 70^{o}, and the thickness of the working edges is about 3 mm. No striations were noted on the edges, but nibbling and use flaking are present on the dorsal face. A scraping function is inferred.

Another small flake fragment, (139A, Plate 13 H), is made of Type II Swan River Chert. It has been unifacially retouched on its ventral face. Dorsal nibbling is present, and both oblique and lateral striations appear on both faces. The edge angle is 27^{o}. and its thickness is 3 mm. These characteristics are indicative of a unifacial knife fragment.

The fourth flake was numbered 149A (Plate 15 A). It is a large specimen, weighing 33 g and is made from Cathead Chert. The distal end of the flake has been truncated in a very irregular pattern and has been unifacially retouched to form a very steep working edge with an angle of 60^{o} to 80^{o}. The thickness of the working edge varies from 10 mm to 5 mm. The only wear visible on the working edge is dorsal nibbling and use retouch. The nibbling and the other characteristics of the flake fit the general pattern of scrapers as described by Semenov (1964: 83-93).

The fifth flake (137A, Plate 15 K) is made of Type II Swan River Chert. It is 47 mm long by 20 mm wide and is lunate in outline. The convex, lateral edge has been bifacially retouched to form a denticulate working edge. The thickness of the edge is 2 mm and its angle is 25^{o}, although the actual edge is somewhat more blunt- possibly due to heavy use. Dorsal and ventral transverse striations and nibbling are present, and the retouch scars are polished in a manner which suggests a transverse back-and-forth motion. Some writers (e.g. Bordaz 1970: 42) have suggested a sawing function for denticulate tools, but such longitudinal motion of the edge would leave a different pattern of polish and striations (cf Semenov 1964). The transverse motion indicated by the wear patterns is more suggestive of a rubbing or shredding activity.

The flakes will be analyzed in greater detail in the following chapters. Cluster analyses will be employed to investigate flake production and to derive a functional classification of flake tools.

Hammerstones Five core fragments, in addition to those already described, bear signs of having been used as hammerstones. Three are of an indeterminate variety of Swan River Chert (Plate 16 A,B,D), and all appear to have been removed from their parent nodules either as decortication flakes or by shattering. Battering and crushing marks appear on the dorsal surface of each fragment, often in a linear arrangement along a raised ridge or edge. It is quite likely that they are exhausted cores which were subsequently used as hammers. Their weights are 40 g, 30 g and 19 g, and they were found in Units 2, 9 and 2, respectively. The fourth core fragment (Plate 16 C) is made of Cathead Chert. It displays marked battering along one edge, which may be indicative of either use as a hammer-stone or as a retoucher (cf Semenov 1964, Crabtree 1972). It weighs 11 g and was found on the surface. The last fragment (Plate 16 E) was found in Excavation Unit 16 and is made of Type I Swan River Chert. Battering and nicking appear on its dorsal surface, but not as extensively as on the other fragments. It weighs 10 g.

Five additional rocks recovered from the living floor exhibited traces of battering and nicking. Three of them were from Feature 1 (Plate 17 A,C,E). The first is a massive cobble of granite weighing 259 g. The second is a dense rock of jasper or Red Swan River Chert weighing 65 g. The third is a flat, water-worm pebble of granite which weighs 46 g. The final two rocks are also granitic. The first (Plate 17 D) was from Excavation Unit 1 and is badly weathered as well as battered. It weighs 156 g. The second (Plate 17 B) was from Excavation Unit 8. It is a very dense rock with traces of battering on several of its facets. It weighs 125 g.

<u>Miscellaneous Artifacts</u> One fragment of Cathead Chert (Plate 8 E) did not fit neatly into either the flake or core fragment categories. Flakes have been removed from its dorsal surface prior to its detachment from a parent nodule. The ventral surface is interesting in that it bears an unusual striking platform on which the point of contact with the percussor stands out in great detail. The cone-shaped path of the shock wave shows clearly upon the ventral face. It was found in Unit 16 and weighs 12 g.

<u>Non-Artifactual Rocks</u> A total of 1284 rocks were recovered on the living floor in addition to the 331 artifacts. 1224 of these are limestone cobbles and fragments, which were scattered thickly over

the surface of the block excavation. Sixty other rocks were found in the excavation block, of which the large majority are either quartzite or granite. Most of the rocks were found within the central area of the block- most notably in Excavation Units 2, 9 and 14. Another rather dense area of rocks was in the southwestern corner of the block, including Units 7, 10 and 19. Other areas, especially the northeast corner, contained few rocks.

Features

Feature 1 This was a dense collection of artifacts and rocks, from Units 2 and 3 (Plates 18-19). It contained 111 flakes, which amounted to 36.2% of the total sample. The reconstructed Cathead Chert multifaceted core discussed above was found in the feature, as were three of the hammerstones. Feature 1 formed a rough arc with its open end oriented towards the northwest. It measured 240 cm by 250 cm.

Feature 2 This feature consisted of a concentration of five artifacts of Red Swan River Chert located in the northeastern corner of Excavation Unit 2 (Plate 20). Four of the artifacts were the core fragments discussed above. The fifth item was an unrelated complete unutilized flake. The feature was small, measuring only 30 by 30 cm. It was noteworthy in that the artifacts were scattered throughout a depth of over 10 cm, an apparent indication of postdepositional displacement.

Feature 3 This feature contained the only faunal remains recovered. Small fragments of burned bone were found scattered in Unit 7 in an area measuring 50 cm by 45 cm. Upon further examination it became obvious that the bone was unrelated to the occupation. All the artifactual material from ElMb-10 was recovered within or below Level IV, but the bone from Feature 3 occurred only in Levels II and III. The fragments were probably the remains of a small mammal which had died either previous to or during the fire. None of the bones was large or complete enough to be identified.

The Rock Structure This feature consisted of an arc of limestone rocks stretching across Units 9, 11, 14, 15 and 17. The rocks within the structure were much higher in density than those outside it (Plates 5,21). The arc, which lay with its convex face oriented to the west, appeared to extend into the ploughed areas on the north and south faces of the excavation block, but this could not be verified by excavation. The structure was enhanced by the almost total lack of rocks or artifacts on the eastern side, and by what appeared to be a more or less random distribution of rocks to the west. The distributional significance of the feature will be discussed in Chapter 7.

CHAPTER 4

ANALYTIC TECHNIQUES

Measurement and Description of Artifacts

An analysis of flakes must first of all be concerned with measurement. Systematic description is necessary in any form of scientific inquiry to ensure that laboratory results, when performed by different investigators, will be essentially indentical. At the most basic level of the analysis in this paper, one must therefore be concerned with explicit techniques of artifact description. The first step in the analysis is to define the subject matter. A flake may be defined as "any piece of stone removed from a larger mass by the application of force- either intentionally, accidently, or by nature" (Crabtree 1972: 64).

The literature lacks an explicit definition of utilized flakes; but because discussion of this class of artifacts is of importance the use of the term must be specific. A 'utilized flake' may be defined as any flake which bears evidence of alteration from its raw state either prior to or as a result of its use as a tool in a culturally defined activity, and in which its ventral and/or dorsal surfaces can be identified. The formal description of the flakes is accomplished through an explicit set of variables or attributes. Clarke (1968: 186) paraphrases Sokal and Sneath (1963: 65) in defining an attribute as a "logically irreducible character of two or more states, acting as an independent variable within a specific artifact system." Each artifact may in effect be conceived of as consisting of a set of descriptive values wherein each attribute supplies a single bit of the total body of information.

Attribute sets pose a variety of problems with respect to the measurement of artifacts. One of the first problems facing the analyst is that of the relevance of attributes in description. Clarke (1968: 137) divides attributes into 'essential' and 'inessential' categories, based upon their relevance to any particular analysis. He asserts (1968: 142) that the essential attributes may be arbitrarily separated from the inessential as a preliminary step in analysis. Such arbitrary steps are, however, the weakest points in analysis and the most difficult to defend.

Sokal and Sneath (1963: 50-51) have approached the problem in a somewhat different manner. They assume that the classification of items is dependent upon a large number of attributes, and that no one of them is more or less important than any other. Consequently, they advocate the use of a large number of attributes to ensure the inclusion of enough 'relevant' ones to provide a useful classification. From this viewpoint, it is irrelevant to be concerned about the possibility that not all relevant variables have been included.

Another consideration involves the type of attribute to be used. Spaulding (1960: 63-67) divides attributes into 'metrical' and 'discrete' categories. The former is characterized by attributes to which "analysis and description by classical statistical techniques are appropriate," while the latter refers to those whose properties can be measured only by presence or absence for each item. Anderberg (1973: 26-28) suggests a much more specific classification which includes twelve different variable types. For this paper, the categories defined by Spaulding are adequate in discussing attributes-with the enlargement of 'discrete' to include those attributes having two or more states with no ranking of values.

The existence of two types of attributes presents a problem in the comparison of artifacts. No method exists at present which allows the quantitative comparison of metric and discrete attributes. Consequently one type must be altered or converted in such a manner as to make possible statistical comparison with the other. This can be accomplished through a wide variety of techniques. For the interested reader, Anderberg (1973) provides an extensive review of scaling and conversion methods. Commonly, metric attributes are converted to discrete ones through various methods. The techniques used to convert the metric attributes used in this work are discussed in the appendices which describe the attribute sets.

The weighting of attributes also requires discussion. Quite often it is desirable to give some attribute, or one of its states, more influence than others. Such weighting may be advisable in the case of a correlation between rare attribute states. However, a problem similar to relevance arises in determining whether the attribute or state is really important enough to be given extra consideration. Clarke (1968: 142) suggests giving attributes equal weight initially, as do Sokal and Sneath (1963: 50). Anderberg (1973: 99) points out that weighting of attributes is subjective, in the end, and that "the blind application of prescribed rules and 'standard formulas' cannot be expected to suffice. . ." Attribute weights for particular portions of this analysis are discussed on a case by case basis.

Two attribute sets have been developed for the analyses performed in this paper. The first set contains 21 attributes. It refers to the morphological characteristics of flakes and is used in the analysis in Chapter 5. It is described in detail in Appendix A, and the coded data for the complete flakes appear in Table 24. The second attribute set contains 18 attributes and is applied to the analysis of utilized flakes in Chapter 6. It is described in detail in Appendix B, and the coded data for the utilized flakes appear in Table 25.

Cluster Analysis

Formulating an attribute list and systematically recording information on the flakes is a preliminary but important step in analysis. The next step is to reduce the body of data to a useful grouping through cluster analysis.

Cluster analysis is basically a sorting technique- a systematic variation of the subjective means of grouping and classification of objects in which all people engage. Anderberg (1973: 3) has described it as being a technique where "the objective is to sort the observations into groups such that the degree of 'natural association' is high among members of the same group and low between members of different groups." Sokal and Sneath (1963: 52) provide a more detailed description:

> These numerical methods . . . are collectively called cluster analysis. By way of a formal description, they may be recognized as . . . methods for establishing and defining clusters of mutually high similarity coefficients among the entities in the resemblance matrix. These clusters may be likened to hills and peaks on a topographic chart, and the criteria for establishing the clusters are analogous to the contour lines of such a map.

Cluster analysis is a two-step procedure after the data have been codified. The first step is to compute a measure of similarity between the items which are to be clustered. Each item is compared to each other item in the data set, and the measure of similarity for each pair 'S_{ij}' is calculated. In its most basic form the similarity coefficient may be expressed as the ratio of matching attributes to the total number of attributes. Anderberg (1973: 123) provides nine such formulas for determining similarity. Variations in the S formulas are derived from variations in dealing with the treatment of two factors: whether or not to give more or less weight to the number of matches and nonmatches, and whether or not to include in the computation matches of 'missing' or 'not applicable' attribute states. Similarity coefficients are stored in a matrix which is very similar to a correlation matrix. It is usually a half-matrix of the form presented in Table 5. This matrix forms the basic data source for the cluster analysis. It displays the set of similarity coefficients in a highly visible format.

The cluster analysis itself is a rather simple process. The most similar pair or items in the matrix is located, and the items of that pair are then merged or combined to form a single entity. The matrix is then rearranged to reflect the collapsing number of entities, and the process is repeated until all members of the data set have been reduced to a single cluster. Variation in the technique arises in the particular method of clustering to be employed. Three basic approaches are generally used in cluster analysis: linkage, centroid and error sum of squares or variance methods (Anderberg 1973: 132). Linkage methods are generally the simplest to employ and interpret, and consequently were the ones selected for this analysis. Linkage methods are in turn divided into three general categories: single, complete and average. Average linkage is the procedure used in this work. For an excellent discussion of single and complete linkage techniques, the reader is referred to Hodson, Sneath and Doran (1966) or Anderberg (1973). Average linkage methods are in effect a compromise of the single and complete between candidate groups to take place only when the <u>average</u> coefficients of similarity of each group approach each other. Since within-group coefficients are averaged, statements of maximum or minimum similarity in the cluster on an empirical basis are not possible, as they are in the other methods. Anderberg (1973: 140) notes that average linkage methods generally produce results that are not remarkably different than those of complete linkage.

The results of a cluster analysis may be presented in either of two formats. The first is a merge list, which gives a step by step rendition of clustering of the items, information on similarities at the merge points and at what points the items clustered were last involved and will next be involved in clustering. From this list the membership of the clusters may be traced throughout the entire process. The merge list can be used to draw a dendrogram of the clustering results. This provides a graphic display of the clustering process and is very useful in outlining the relationship of the clustered items to each other and in suggesting further lines of investigation.

Interpreting the results of a cluster analysis is basically a subjective activity and is not nearly so mechanical as the clustering process itself. The results themselves are "devoid of any inherent validity or claim to the truth and . . . are always in need of interpretation . . ." (Anderberg 1973:176). The simplest evaluation of the results can come from a study of the dendrogram. Strong or poorly defined clustering may be apparent from even a cursory examination.

The dendrogram or cluster tree begins at the point at which the first merge takes place between items, and it ends at that of the final clustering merge, at which point all items have been subsumed into a single group. These beginning and end points form the upper and lower bounds of the similarity scale on the dendrogram. The scale in each dendrogram is divided into 25 equal segments or stages by the computer program for the purposes of further evaluation. If the rate of clustering is very even throughout the similarity scale, then a plot of the number of merges for each stage of the scale approaches a straight line sloping from N clusters of one item per cluster to one cluster containing N items. A well defined set of relatively dissimilar clusters should appear in such a graph as a very concave line, dropping steeply during the early stages of clustering and levelling off rather abruptly once the clusters have been defined. Figures 6 A and 6 B illustrate these examples.

The rate of absorbtion of unpaired items into other clusters is also indicative of clustering patterns. At the upper end of the similarity scale- prior to clustering- N free entities (FEs) exist. These are paired and absorbed into other clusters throughout the run until no FEs remain at the lower bound of the scale. Relatively homogenous data sets should pair off and absorb FEs quickly as the clustering begins, while those data sets which contain a number of very dissimilar items will maintain a rather highlevel of FEs well throughout the run. Such conditions may be plotted easily as a graph of FEs against the clustering stages, as is depicted in Figures 7 A and 7 B.

These interpretive aids may be used in the partitioning of the cluster results into a classification of entities. A classification or taxonomy for any given run may be delineated by the selection of a cutoff point on the similarity scale which in effect ignores any clustering beyond that point. This cutoff point has been described as the 'phenon line' (Sokal and Sneath 1963). No single 'best' method exists for the selection of a phenon line (cf Anderberg 1973: 200). Rubin and Friedman (1967) suggest an arbitrary selection of the phenon prior to analysis. However, the similarity scale in itself is of little value as a guide to interpretation, so such an approach to partition cannot be defended. Merge rates and FE absorbtion, which display elements of the patterns of clustering, are perhaps the simplest guides to selecting the phenon. Even with the use of the clustering rate graphs, there is no ideal point or set of conditions which may be used mechanically to determine a phenon. This is basically a subjective choice which must be made on the part of the investigator on the basis of the information available. The graphic aids described above provide a means of simplifying and clarifying such a choice.

When a phenon has been used to partition a dendrogram into a set of clusters at some given value on the similarity scale, it may also serve as a means to label the particular classification.

For this work, the titles chosen for each cluster run on the computer have been used in conjunction with the value of the phenon on the similarity scale as a labelling scheme. For example, a phenon set at a value of 0.46 on the similarity scale for Cluster Run XYZ would result in a designation of XYZ.46 for that particular partition. Each cluster within it, moving from the top of the dendrogram down, would be numbered sequentially- i.e. XYZ.46-1, XYZ.46-2 and so forth.

In comparing the results of different cluster runs or different partitions, the numerical degree of similarity on the similarity scale is not in itself significant. The various S measures are affected by factors such as the particular similarity coefficients, the clustering algorithms and the number of operative or relevant variables pertinent to the analysis and data set. For example, a relatively large number of inoperative variables in a data set will tend to enlarge the number of mismatches in the S measures, thus depressing the overall degree of similarity within the run. As irrelevant or inoperative variables are removed from the analysis S becomes higher, although in fact there is no actual change in real or relevant differences between items.

Results of different clustering runs may be compared using a contingency table and applying various measures of contingency when applicable. Anderberg (1973: 204-207) reviews several methods of evaluation but concludes that contingency tables seem to be the most interpretable.

Analysis of Nearest-Neighbour Distances

Analysis of nearest-neighbour distances is a statistical procedure designed to measure the distances between items in an N-dimensional space and to generate an index of spatial configuration. It is quite simple in the form described by Clark and Evans (1954). The average nearest-neighbour distance in a sample population is described by:

$$r_o = \frac{\sum_{i=1}^{N} r_i}{N} \quad ,$$

where r_1, r_2, $r_3 \ldots r_N$ are the nearest-neighbour distances and 'N' is the number of items in the sample population. The density of the items in the sampling area 'A' is given as:

$$d = \frac{N}{A} \quad ,$$

with the qualification that A be expressed in the same measurement scale (i.e. centimetres, metres, inches) as is used in the r measurements.

The expected average nearest-neighbour distance of items in a space with the same area for a hypothetically randomly distributed population is given by Clark and Evans as:

$$\bar{r}_e = \frac{1}{2\sqrt{d}} \quad ,$$

From these the ratio 'R' may be defined:

$$R = \frac{\bar{r}_o}{\bar{r}_e} \quad .$$

The R statistic provides a measure of the distribution of items in a given space. When the population is completely random, the value of R will equal 1, as aggregation increases R approaches 0, and as regularity increases in the spacing of items R will be greater than 1. Clark and Evans show that in a uniform, hexagonal distribution pattern, a maximum regularity of spacing, R is 2.1491. Significance of the R scores may be determined statistically, and Clark and Evans developed a method for generating a standardized normal variable 'z' by assuming that the distribution of nearest-neighbour distances in the sample population is approximately normal:

$$Z_{CE} = \frac{\bar{r}_o - \bar{r}_e}{\sigma_{\bar{r}_e}} \quad ,$$

where '$\sigma_{\bar{r}_e}$' is the standard error of the mean in the hypothetical random distribution. It is determined by:

$$\sigma_{\bar{r}_e} = \frac{.26136}{\sqrt{Nd}} \quad .$$

The z-score may be tested for significance of divergence from the null hypothesis as a two-tailed test.

However, several researchers (Thompson 1956, Pielou 1959, 1960, 1969, Dacey 1963) have determined that the distribution of nearest-neighbour distances is not normal for first or second order neighbours in small populations; rather it conforms to the Chi-square distribution. They suggest an alternate method which is more appropriate for such cases. It operates by converting the normally square units of area into circular areas:

$$\lambda = \pi d \quad ,$$

where 'λ' is the average number of items found within a circular area of radius 1 in a hypothetical random distribution.

From this a Chi-square statistic may be calculated:

$$\chi^2 = 2\lambda \sum_{i=1}^{N} r_i^2 \quad .$$

A standardized normal variable may be determined using the Chi-square:

$$Z_x = \sqrt{2\chi^2} - \sqrt{2F-1} \quad ,$$

where 'F' is the degrees of freedom, expressed by:

$$F = 2N \quad .$$

This standardized variable can then be evaluated for statistical significance in the same manner as that of Clark and Evans.

Both procedures allow the researcher to compute a measure of spatial dispersion and to test its significance. Whallon (1974: 23) has suggested a method of defining aggregated populations and plotting those aggregates on a map. If the distribution of nearest-neighbour distances is treated as normal, a standard deviation may be calculated:

$$\sigma_r = \sqrt{\overline{r^2} - \bar{r}^2} \quad .$$

Using this a cutoff distance 'C' is determined:

$$C = \bar{r}_o + \sigma_r K \quad ,$$

where 'K' is a confidence level expressed as a multiple of the standardized normal variate. For example, at a .95 level of confidence K would be equal to 1.65. A one-tailed criterion must be used since only those distances greater than C may be thought of as lying statistically outside the distances between items in the aggregations.

Aggregations which have been defined by this technique may then be plotted as a map by either of two methods. The first produces essentially a minimum area of spatial clustering (Whallon 1974: 23) by connecting together those items which lie at a distance of C or less from each other. The second method produces the maximum aggregation area. This consists of drawing a circle of radius C around each item and defining aggregations on the basis of the boundaries of the circles, or in the case of overlap, by the outside arcs of the contiguous circles.

Techniques for comparing spatial aggregates are not well developed. Whallon (1974: 24) has suggested the use of an index number derived by comparing the degree of spatial overlap between various classes of tools. These indexes may then be arranged into a similarity matrix and submitted to cluster analysis. This method, however, is only applicable to large samples of spatial aggregates, which is not the case in this analysis. An alternate procedure has been developed for this study, in which several activity-specific tool combinations (or tool kits) were developed from various sources in the literature. Two assumptions must be made: 1) that the tool combinations developed are actually valid for this site, and 2) that the tools involved would be deposited at or near their point of use. The tools of each combination may then be grouped together and submitted to analysis of nearest-neighbour distances. If results indicate that a particular combination is spatially aggregated it may mean that the associated tool types were in fact used as a kit. The real extent of the activity area may be defined by the latter of the mapping procedures described above.

Two of the weaknesses of nearest-neighbour analysis must be discussed. One problem is the boundary effect (cf Whallon 1974: 22-23), which refers to artificial boundaries imposed by excavation in relation to the 'actual' boundaries of a site. If excavation is much larger than the actual site area, the results of the spatial analysis may be greatly skewed towards aggregations. On the other hand, if the excavation is smaller than the site area, only those aggregations that are capable of fitting into the exposed area will be detected. Larger concentrations or patterns might pass unnoticed. This problem is probably minimized at ElMb-10 because the excavated area seems to correspond with the actual site boundaries. Further excavation in 1975 (D. Crowe-Swords, personal communication) has confirmed this insofar as very little material was recovered outside the limits of the 1973 block excavations. A second difficulty with the technique lies in the method of determining a cutoff point. Treating the nearest-neighbour distances as being normally distributed can overlook the possibility of multi-modal or skewed distributions. These can be indicative of more than one level of aggregation, and a cutoff point based upon a normal distribution will not accurately depict this state (cf Whallon 1974: 33-34).

Note on the Computer Programs

The cluster analysis program used in this work was adapted from Anderberg's (1973) selection of programs for various types of cluster analysis. The adapted routine was his core-stored similarity matrix program, including subroutines CNTRL, MTXIN, CLSTR, LFIND, METHOD (Version 5) and TREE. It was written onto a disk storage and retrieval system and entitled CMPCLST. Programs for computing similarity matrixes were written separately and channeled into CMPCLST at execution time.

The program which executed the analysis of nearest-neighbour distances was written by the author and entitled NAYBER. It differed from the prescribed statistical procedure in that it did not exclude items which lay closer to the excavation boundary than to their nearest neighbours. It was also designed to handle very large samples by allowing the user to subdivide the study area into smaller sections during the computation of the 'r' values, which led to greater economy in execution time.

CHAPTER 5

CLUSTER ANALYSIS OF FLAKE MORPHOLOGY

Introduction

Many different cluster analyses are possible in the ElMb-10 data set. By varying the number and combinations of attributes and similarity algorithms any number of hierarchical classifications may be generated. For the analysis of flake morphology, various possibilities for attributes related to morphology should be used in each computer run. None of the attributes or attribute states were weighted for any of the analyses. Since the clustering algorithm was fixed into the CMPCLST program, the sole means of manipulating the ElMb-10 data lay in various similarity algorithms. These may be used to alter the rates of clustering, to include or exclude nonapplicable matches between attributes and to give greater or less weight to certain classes of matches or mismatches. Three similarity algorithms were selected to construct the similarity matrixes. These and other detailed information on each computer analysis are discussed in Appendix C.

Comparison of the Cluster Partitions

Three classifications were generated by the cluster analyses: B.183, E.257 and F.251. Dendrograms and rate graphs for the respective classifications are presented in Figures 8-16.

It is apparent from examination of the dendrograms that all three cluster classifications lack a clear and obvious separation of their constituent clusters. In general, clustering tends to begin slowly and then increase its rate steadily to form a smooth, rather convex pattern. Free entities are usually absorbed at a somewhat faster rate, which is generally the case for at least the early stages of any run (as items are paired off into initial clusters). This creates an overall pattern for all three runs of an initial pairing of free entities to form many small clusters, followed by the slow absorbtion of other free entities into each cluster. Merges between clusters usually remain minimal until rather late in the runs, when most of the free entities have already been taken into one or another of the clusters.

All three runs tend to form two large clusters and several smaller ones. In each partition Cluster 1 is the largest, ranging in size from 44 items in F.251-1 to 38 in E.257-1. Three items failed in all runs to merge with any other group or item before the phenon was reached. A fourth item also failed to be absorbed in B.183 and F.251, although it joined Cluster 5 in E.257.

Contingency tables between the three partitions (Tables 6-8) are of aid in comparing them. While such measures of contingency and probability of association as Chi-square are not relevant in these cases due to the low expected cell frequencies, certain indications of the relationships between the partitions are observable.

The three partitions do not differ much from each other. This is not surprising, considering that the similarity algorithms for Runs B and F were virtually identical. However, the more distinctive algorithm used for Run E generated a similar classification. Assuming that none of the similarity algorithms resulted in a false or spurious representation of the data structure, all three partitions must be considered to be viable classifications of the flake morphology of ElMb-10.

None of the partitions, however, exhibits any discrete structure--no clearly-defined set of 'natural' flake types. Of the three F.251 shows the best separation of its component clusters. In addition, the contingency tables indicate that F.251 is closer to each of the other partitions than they are to each other. Consequently it was chosen for further consideration.

Analysis of the F.251 Clusters

The partition of Run F at a phenon of .251 resulted in six clusters. Cluster 1 contains 44 items, or more than 70% of the sample. F.251-2 is composed of 14 items for a total of 22.5% of the population. The remaining four clusters contain single unpaired entities.

The two major clusters are not very separated. Both formed at about .27 on the similarity scale, and they would have merged at roughly .23 on the scale. Cluster F.251-1 is a mixture of nested clusters and outlying absorbed free entities. A weak configuration of two clusters exists within it, although these merged to form Cluster 1 immediately after their individual resolution. Cluster 2 is somewhat better defined, consisting of two separate clusters which resolved themselves at similarity values of .32 and .30, respectively. These merged at .27 to form F.251-2. The remaining four entities are very dissimilar to both clusters and to each other. They did not merge with another cluster until about .20 on the similarity scale.

The clusters should, of course, display significant differences since such a result is the stated objective of the technique (cf Anderberg 1973: 15). Comparisons aimed at confirming differences between the component clusters of any partition are virtual tautologies. However, such examination is fruitful in explicating the fundamental causes of the partition. Clusters are separated from each other by virtue of their dissimilarity, and examination of the attribute states common to each of them should allow the investigator to outline the morphological characteristics which are unique to each.

Thirteen attributes appear to show no association with clusters. Both of the large clusters exhibit roughly proportionate distributions of the attribute states. Contingency tables were drawn for two attributes, which were unassociated with cluster separation. One of these, 'Lipping on Ventral Surface' (Attribute 5), was plotted in three different ways (Tables 9A-C), with the result that all three showed nonsignificance for the Chi-square test at the 5% level. The other attribute, 'Platform Preparation' (Number 3), was tested by Chi-square (Table 10) and also showed no association between states and clusters.

Five attributes exhibit an association between various states and clusters. 'Platform Length' (Attribute 12) was plotted in two contingency tables. The first table (Table 11 A) was tested by Chi-square and found to have a high probability of association between states and clusters, most likely between State 1 and Cluster 1. The second plot of the attribute and clusters (Table 11 B) was not valid for the application of the Chi-square because of low expected frequencies. However, the table exhibited tendency for State 2 to be associated with Cluster 2. 'Platform Width' (Attribute 13) seemed to be distributed such that Cluster 1 contained virtually only States 1 and 2, and Cluster 2 contained predominantly States 3 and 4. When plotted as a contingency table (Table 12) this division between attribute states and clusters became apparent, although the Chi-square was also not applicable. 'Maximum Flake Length' (Attribute 16) exhibited a similar distribution, with States 1 and 2 associated with Cluster 1 and States 3 and 4 with Cluster 2 (Table 13). A Chi-square test yielded a value of 7.34 with one degree of freedom, which indicated a highly significant probability of association between the attribute states and clusters. 'Bulb of Percussion Thickness' (Attribute 17) appeared to be divided such that Cluster 1 consisted entirely of States 1 and 2, while Cluster 2 contained mostly States 3-5. While the Chi-square test could not be applied in this case (Table 14), the association of states and clusters would seem most likely. 'Maximum Flake Thickness' (Attribute 20) appeared to be distributed with States 1 and 2 existing predominantly in Cluster 1 and States 3-6 in the other clusters. A Chi-square test of the contingency table (Table 15) yielded a value of 27.68 at one degree of freedom, which indicated a probability of association in excess of 99.9%.

Discussion

The five relevant variables from the cluster analysis are all categorized metric attributes and all refer to linear dimensions of the flakes. Those which involved angles, ratios and nominal qualities remained relatively nonoperative in the analysis. Two of the five variables, 28 and 31, are redundant in that the thickness of the bulb of percussion and the maximum thickness of the flake are generally identical.

On the basis of the analysis of the attributes and clusters, the various properties of Clusters 1 and 2 may be summarized as follows:

> Cluster 1: the striking platforms are rather small, falling into sizes of about 1-5 mm in length and 1-18 mm in width. The flakes generally range in length from 19-30 mm, while thickness is usually less than 10 mm.

> Cluster 2: striking platforms span a range of 6-10 mm in length and they are generally greater than 18 mm in width. Flake length is usually greater than 40 mm and thickness more than 10 mm.

The major difference between the clusters appears to be one of size. Cluster 1 is comprised largely of smaller, thinner flakes; Cluster 2 is made up of larger, thicker flakes. The difference in flake size between Cluster 1 and 2 may be more a matter of the way in which the data was coded than any 'natural' grouping. Dimensions were categorized by simply subdividing the range of metric measures into classes of equal size. Such codification ignored such elements as the shape of the distribution curve, a factor which if taken into account might have led to a better partition of the flakes.

The lack of clearcut flake grouping may indicate a lack of concern on the part of the artisan (or artisans) as to the degree of control exercised over the production of flakes. The use of a direct percussion technique with a hammerstone or baton would have resulted in less control over the production of uniform flakes than methods such as punching and pressure (cf Crabtree 1972: 11-13). The lack of association of lipping on the ventral edge of the striking platform with any particular cluster tends to confirm the direct percussion interpretation, since lipping is usually associated with controlled, indirect percussion techniques--although it can occur with direct percussion performed with a soft hammer.

Three of the four cores recovered from the ElMb-10 floor were multifaceted. A multifaceted core is more easily worked by direct percussion, either by baton or hammerstone, although an anvil may also be used in combination with a percussor. The shape of both the multi-faceted and discoidal cores is generally irregular, making it difficult to use with any punch or indirect percussion techniques.

It would not appear that the artisan was attempting to produce specific flake types. This is supported by an examination of the utilized and unutilized flakes. If no specific flakes were being produced for specific tool types one would not expect to find any difference in the selection of flakes for use from either of the clusters. The hypothesis of nonassociation is confirmed by a Chi-square test (Table 16). The test yields a value of .353, indicating a lack of association between utilized materials and flake clusters at the 5% level with one degree of freedom. Thus neither Cluster 1 nor Cluster 2 flakes were differentially selected for use.

The five attributes which are operative in the analysis are those of flake length, thickness and the dimensions of the striking platform. Speth (1974, 1975) has demonstrated the strong positive correlations between platform thickness and flake length, and between platform thickness and flake thickness in hard-hammer percussion knapping.

CHAPTER 6

CLUSTER ANALYSIS OF UTILIZED FLAKES

Introduction

As in Chapter 5, three computer-assisted cluster analyses were run on the data set. Characters from the Greek alphabet were assigned as labels for the individual runs; otherwise nomenclature was the same as in previous runs. The similarity algorithm from Run F in Chapter 5, which had apparently been the most successful in separating clusters, was chosen for all three of the present analyses:

$$S = \frac{A - D}{A-D+B} \quad .$$

Variation within the runs was accomplished through the use of different weighting schemes for the variables. These procedures, along with detailed discussion of the three runs, are presented in Appendix D.

Comparison of the Cluster Classifications

The cluster analyses generated three classifications of utilized flakes: Alpha.741, Beta.646 and Gamma.674. Dendrograms and rate graphs for each partition are depicted in Figures 17-25. All three partitions are similar in that they exhibit at least fair separation between clusters. Alpha shows perhaps the poorest separation, while Gamma has the clearest. In all three cases the clustering process seems to have been a fairly homogenous blend of absorbtion of free entities and reclustering of the groups. The merge rates and absorbtion rates also reflect this tendency toward homogeneity of process. They are not generally angular curves, and few sharp breaks in the rates appear. The merge rates are all very similar. That of Alpha is perhaps the least smooth and uniform, while Gamma is very regular and uniform. Alpha also shows a rather stepped absorbtion pattern, while Beta and Gamma are about equally regular.

It would appear from contingency tables (Tables 17-19) that the three partitions do not greatly differ from each other, although this must remain an unsupported speculation in the absence of applicable statistical tests. All three taxonomies are assumed to be viable representations of the structure of the data set. The clusters in the partitions show fair separation, and it might be said that partition Gamma.674 exhibits this feature most clearly. In fact, Gamma appears to be the best partition in relation to such factors as contingency between clusters of separate partitions and the number of free entity clusters per partition.

Analysis of Gamma.674

Gamma.674 is comprised of ten clusters. The first two, scanning from top to bottom in the dendrogram (Figure 23), are the largest.

Each contains 16 items or 30.7% of the population. Cluster 4 is the next largest, with eight items or 15.4%, followed by Clusters 3 and 5 with four and three members, respectively. Clusters 6 through 10 are all free entities.

None of the clusters is large enough to allow a reliable statistical examination of its attributes, although they are worthy of comment. Table 20 presents a summary of the attribute data for each cluster in Gamma.674. The metric attributes are assigned ranges based upon the standard deviation about the mean for Clusters 1 through 4, and upon the actual range (or single value in the case of free entity clusters) for the remaining clusters. Since all of the nominal attributes except Number 18 are presence/absence, these variables are listed in the table on the basis of the number of 'present' attribute states in each cluster.

Attribute 1 appears (Table 20) to influence the structure of the clusters in only one case. Cluster 4 is noticibly different than the others in the overall range of edge lengths. This same feature carries over in Attribute 2, in which Cluster 4 is composed of items having markedly concave working edges, compared to the rather straight edges of Clusters 1 and 2, and to the moderately convex edges of the Cluster 3 members. The members of Clusters 5, 6 and 10 also exhibit convex edges, although these are all very small clusters.

Attribute 3, the measure of working edge angle, shows its greatest difference in the large clusters between Cluster 2 and

Clusters 1, 3 and 4. The difference between Clusters 1 and 2 is especially noteworthy with regard to Attribute 3, since they exhibit few differences in other attributes.

Neither Attribute 4 (edge thickness) nor Attribute 17 (flake thickness) appear to be much different between the clusters. Perhaps the only exception to this might be Cluster 2, in which Attribute 4 would seem to be somewhat thinner than in the other clusters.

The categorical attributes are rather difficult to interpret. Generally, the number of 'present' states recorded for any cluster was not great, which renders comparison difficult. Attributes 7 and 8 are the only ones in which each cluster was well represented, if at all. In fact, Attribute 7 (dorsal nibbling) appeared on all but one item, making it an almost universal property of flake edges in the sample. 'Ventral Nibbling' (Attribute 8) was less common, although it occurred in about half the cases in Clusters 1 and 2 and on most specimens of Chapter 3.

Attributes 5 and 6, referring to dorsal and ventral edge polish, seem to occur jointly in four clusters and singly in only one. These were often both marked as 'present' when wear or polish occurred along the very edge of the flake, and thus this phenomenon probably reflects this coding to some degree. However, dorsal polish seems to have occurred with some greater frequency.

Attributes 9 through 14 all refer to striations on the utilized edges. Of the 29 cases of striations recorded in the data set, 22 or 76% occur in Clusters 1 and 2, and these are confined to lateral and transverse striations. Cluster 4 exhibits a solitary case of transverse dorsal striation, and the single member of Cluster 10 possesses transverse striations on both faces of the working edge. The free entity of Cluster 7 has dorsal and ventral lateral striations, and also the only recorded cases of dorsal or ventral oblique striations.

'Dorsal trimming of the working edge' (Attribute 15) occurs with some frequency in four clusters, although it does not appear to be a major factor in any of them, except perhaps in the case of Cluster 5, where all the items have been dorsally retouched. Clusters 6 and 10 also exhibit dorsal retouch, although these are free entities and generalization is not possible. Ventral retouch is even rarer than dorsal and occurs jointly with the latter in only Clusters 1, 5 and 10.

Attribute 18 refers to the texture of the working edge. Little can be said of the distribution of these attribute states except that more regular edges occur in clusters where working edges tend to be thick and steep-angled. The reverse is true of those clusters containing tools with thin, shallow edges. This phenomenon would be expected as a natural function of the thickness and durability of the working edge. Only one denticulate edge occurs, which is probably a reason that it formed the solitary member of Cluster 10.

In general, none of the attributes appears to have operated throughout the process as a major determinant in clustering. They appear rather to have been factors in separating or forming at most one or two clusters.

Discussion

It is possible at this point to infer minimally functional roles for the ten artifact clusters generated in the analysis. It should be kept in mind that the clusters should not be considered as a set of formal artifact types. They are relevant only to the data set used in the analysis and should be viewed within that context as a set of general functional categories. Individual artifacts within each cluster will vary in their conformity to the 'idealized' functional category.

The artifacts of Cluster 4 are easily separated from the others by their concave working edges. The rather short, concave edge has an angle of roughly 50^{o}. The flake near the edge tends to be rather thick, and wear patterns basically include dorsal nibbling or crushing and dorsal transverse striations. This notch or concavity generally consists of a single steep flake removed from the dorsal face of the flake. Such tools fall easily into the category of spokeshaves, whose use generally included trimming or working small-diameter shafts of wood or bone (Semenov 1964: 113).

Cluster 5 is composed of scraping tools. All exhibit moderately convex working edges with steep angles of retouch and generally thick working edges. Furthermore, polish is generally present along the working edge only, while nibbling of the edge is restricted to the dorsal face. This might be indicative of a single scraping motion toward the ventral face with the dorsal edge placed against the surface of the material being scraped.

Cluster 2 members may be classed as knives, based for the most part upon the shape and texture of the edge and upon the edge angle. Wilmsen (1970: 70) suggests that tools with edge angles in this range (less than 35^{o}) may have been used in such tasks as cutting meat and skin. Patterns of striations upon the cluster members are not dissimilar to those described by Semenov (1964: 104-106) for meat knives. The single member of Cluster 7 also falls within this category.

Cluster 1, while similar in edge shape and size to Cluster 2, is typified by much higher edge angles. Wilmsen (1970: 70) notes a high incidence of similar edge angles in Paleo-Indian artifacts and suggests that such tools may have been useful in a wide variety of functional roles. Possibilities include skinning and hide-scraping, sinew and plant fiber shredding, and heavy cutting of wood and bone. Many of the traits expressed in Cluster 1 are similar to those described by Semenov (1964: 109-111) as belonging to whittling knives. However, lack of sufficient evidence of striation and polishing preclude such a specific classification in this case.

Cluster 3 remains somewhat enigmatic. It is characterized by generally convex, long edges with moderate edge angles. The working edges tend to be thin, and signs of wear are bifacial. Perhaps a function similar to that of Cluster 2 might be suggested.

Clusters 8 and 9, each containing one flake, are in fact exactly alike, except that they are mirror images. They occur opposite each other on both sides of a truncation on the same flake. Functional possibilities for these edges are somewhat of a mystery. A scraping activity might be indicated by essentially unifacial nibbling of the edges, given that each edge was treated identically. It is also possible that the edges of other tools may have been scraped across it as a means of dulling or blunting a sharp edge.

The solitary member of Cluster 6 may be classified as a scraper. It is not dissimilar in shape to the members of Cluster 5, and it differs from them mainly in its thickness and somewhat irregular working edge. The rough edge might be indicative of either an unfinished tool or one which was used to scrape or shred a durable substance such as wood.

Cluster 10 also contains a single artifact. The major factor which separates it from other clusters is its decidedly denticulate working edge. Striations and bifacial polish suggest a two-way transverse motion, such that shredding would appear to be the most likely functional category.

In Chapter 3 five flakes were described and tentatively assigned functional classifications. The only two included in a cluster of more than one member were 53A and 55A, which were placed in Cluster 1. The others formed three separate clusters.

It might seem in retrospect that a tremendous amount of work was undertaken to assign the flakes into sets of rather obvious functional categories, and that it would have been much simpler to categorize the tools in a fashion similar to that used for the five flakes in Chapter 3. However, this line of reasoning presupposes that a priori functional classifications are indeed viable and relevant to the data set. Under these conditions, without the knowledge of the underlying structure of the data provided by the cluster analysis, the danger is greatly increased of isolating functional tool categories which might not in fact exist.

CHAPTER 7

SPATIAL ANALYSIS OF ARTIFACT DISTRIBUTION

Introduction

Thirty-two of the utilized flakes from the ten artifact classes isolated in the preceding chapter were recovered in situ (Figure 26). There are more tools than flakes because several have more than one utilized edge. The ten artifact classes may be collapsed into seven tool classes; each with a set of artifacts having provenience in each:

1.	(Cluster 1) Heavy Cutting and Shredding Tools	11
2.	(Clusters 2 and 7) Knives	12
3.	(Cluster 3) Convex-Edged Knives	2
4.	(Cluster 4) Spokeshaves	6
5.	(Clusters 5 and 6) Scrapers	4
6.	(Clusters 8 and 9) Unknown Function	1
7.	(Cluster 10) Denticulate	1

These tool classes together with hammerstones, cores, core fragments and the 1284 rocks recorded on the living floor form the data base for the spatial analysis.

Activity-Related Tool Combinations

As was discussed in previous chapters, the spatial analysis of functional classes of tools is intended to allow an interpretation of whether certain areas of the site were used for specific activities, and whether certain classes of tools co-occur within those areas. These combinations of functional artifacts, or tool kits, have received considerable attention in the literature, although very little formal analysis has been carried out to isolate them for particular archaeological units.

Wilmsen (1970: 75-80) has commented on the functional combinations of tool classes at eight Paleo-Indian sites. He infers that butchering activities utilized largely single-edged cutting tools; that various forms of hide or skinworking required shallow-angled endscrapers and single-edged cutting tools; that wood or bone working included the use of spokeshaves, gravers and tipped tools, and steep edge-angled tools; and that plant product processing (which apparently overlaps with woodworking) utilized such tools as steep edge-angled tools, spokeshaves and denticulates. Frison (1974: 92-95) has described the tool assemblage from the bison kill at the Casper Site in Wyoming. It consisted of four flake butchering tools with edge angles varying from 29° to 57°. The working edges were located on convex edges on the flakes, which places them in a similar category as the utilized flakes of Category 3 of this work. Other writers have described similar assemblages associated with kill or butchering activities. Wheat (1972) mentions flake knives and thin, utilized flakes as being conspicuous at the Olsen-Chubbuck Site, along with a single side-scraper and unutilized debitage. Agogino and Frankforter (1960) are not as specific but they describe the assemblage from the Simonsen Site as consisting of knives and scrapers.

While not specifically Paleo-Indian, data from other sites in the northern Plains are also helpful. Dyck (1970) suggests four artifact combinations at the Moon Lake Site, an Oxbow site in Saskatchewan. These include thin and thick bifacial knives and small endscrapers in cutting and butchering activities; small endscrapers, large endscrapers and steeply-retouched flakes for hideworking activities; and large bifaces with both cutting and flintknapping.

The author (1976) suggests two activities for combinations of tools at the Cherry Point Site, a McKean-Oxbow site in Manitoba. These include high and medium-angled scrapers, endscrapers and flake scrapers for hideworking activities, and flake knives for shallow use; instead of angled scrapers for skincutting and tailoring.

It may be generalized from the above discussion that certain functional categories of tools may be associated with specific cultural activities, which may be summarized below:

<u>Butchering</u>, including single-edged cutting tools with shallow edge angles and convex-edged knives (Tool Categories 2 and 3)

<u>Hideworking</u>, including shallow edge-angled scrapers, singled-edged cutting tools, medium-angled cutting tools (Tool Categories 1 and 2; or as a second set, Categories 1, 2, 5, and the tool formally classified as a scraper in Chapter 3).

<u>Bone or Woodworking</u>, including spokeshaves, burins, gravers and medium-angled cutting tools (Tool Categories 1 and 4).

<u>Plant Product Processing</u>, including denticulates and medium-angled cutting tools (Tool Categories 1 and 7).

<u>Flintknapping</u>, including hammerstones and core fragments utilized as hammerstones.

This list includes only lithic tools, and while these tool combinations can hardly be considered complete, either in total numbers of activities or in the total number of tool types in each category, they provide a base from which to perform further analysis.

Analysis of the Tool Combinations

The six tool combinations discussed above were submitted to analysis of nearest-neighbour distances. The results are presented in Table 21. Four of the combinations demonstrated significant tendencies toward spatial aggregation at the 95% level of probability. These were butchering, both sets of hideworking tools and those related to woodworking activities. The tests of significance for flintknapping and plant product processing tools did not indicate that either combination was aggregated; in fact, flintknapping tools appeared to be spaced rather uniformly across the living floor, although this may be due to bias given the small sample of tools in this category.

Of the aggregated combinations, all except woodworking tend to fall within the same three areas of the site. These may be designated for the sake of convenience as Areas I, II and III. Area I occupies portions of Excavation Units 2, 3 and 21; Area II lies in Units 11 and 14; and Area III in Units 12 and 16. Maximum distribution areas for each of the tool combinations are presented in Figures 27-30.

Area I contains tools from three combinations, including woodworking and both hideworking sets. Additional artifacts occurring within and about the area include flintknapping tools and the concentration of unutilized flakes in Feature 1.

Area II is composed of tools from all four sets. The woodworking tools, in fact, form a broad single area made up of both Areas I and II. Hammerstones and cores do not occur within the area, although unutilized flakes are relatively abundant, especially in the southwest corner.

The only tool set represented in Area III is that of butchering. Three of these flakes also bear spokeshaves, part of the woodworking set. Other tools found within this area include the denticulate of Category 7, a hammerstone and several unutilized flakes. The fact that the butchering set is composed of only two tool classes, and that spokeshaves and a denticulate are present in the immediate area, casts doubt upon the validity of an interpretation of butchering activities within the area. It is conceivable that another tool set, which has not been defined for this work, is present in this area.

The three areas of tool aggregation form a rough triangle. The space between them has been largely cleared of rocks and other artifacts, except in the north end towards Feature 1. The only tools to appear within this central area are the two projectile points. It does not seem unreasonable to postulate that activities at the site took place around the central area, in which an animal may have been butchered.

It is probable that hideworking took place in Areas I and II, and the presence of woodworking tools may be related to the stretching and drying of hides and the preparation of structures associated with those activities. Area III is not so clearly related to activities within the central area, but it appears that some sort of plant product processing was carried out there.

Distribution of Rocks on the Living Floor

It has been suggested previously that the distribution of the rocks on the living floor of the site lay in a nonrandom pattern. The structure may have been used as a windbreak of a hunting blind, or it may have been a natural feature such as a frost polygon or an ice stagnation feature.

A nearest-neighbour analysis was performed on the 1284 rocks (Table 22). With so large a sample, the distribution of nearest-neighbour distances approximate the normal, and the Clark and Evans statistics can be taken as valid. The results indicate a significant departure from a random distribution at the 5% level.

Both the cultural and natural alternatives would be expected to exhibit nonrandom distributions. However, cultural structures would be expected to exhibit differences in the size and weight of the rocks from within or without the structure. A natural feature such as an ice stagnation feature or a frost polygon, on the other hand, would not show any significant difference between those rocks within and outside of the features (cf Flint 1971:281-282, Easterbrook 1969: 220-221). In either a windbreak or a hunting blind the stones would presumably have served to anchor some sort of brush or skin structure, and larger stones would have been preferred.

To test this hypothesis, all of the rocks from the structure in Unit 14 and the rocks from Unit 13, at the far west end of the excavation block and furthest removed from the structure, were taken back to the laboratory. The rocks in each sample were weighed and descriptive statistics were computed for both (Table 23).

The sample means were then compared to test whether any significant difference existed between them. A standardized variable of -4.072 was obtained for the test, in which a score of -1.96 to 1.96 is sufficient to indicate a significant difference in means at the 5% level. Thus the mean weights of the two samples are significantly different; rocks from the structure are decidedly heavier.

This test result provides a support for the supposition that the structure was a product of cultural activity. That it was a windbreak seems the most logical alternative. During the summer months the major winds in the Manitoba Lowland Plain are strong westerlies and southerlies. The orientation of the structure was such that it would have afforded protection only to those on its eastern side, but not to the area of tool concentration. The area to its east is clear of rocks and would have been a suitable part of the camp for sleeping. Gould (1971: 166) has described a similar windbreak constructed by Australian aborigines.

CHAPTER 8

SUMMARY AND CONCLUSIONS

Comments on the Methodology Employed

On the whole the combined cluster analysis proved useful for isolating functional categories and relating them to activity areas. Drawbacks relate not to the procedure but to aspects of the component procedures.

The cluster analyses appear to have been successful, yeilding a body of relevant data for further use in the nearest-neighbour analysis. The attribute list employed was satisfactory, judging by its results in the various clustering procedures. The major difficulty lies in the lack of an independent test of its accuracy. The graphs of the rates of clustering and free entity absorbtion were an attempt to fill a current gap in interpretive aids for cluster analysis. They were unquestionably of use in deciding where to establish phenons in the cluster partitions. The use of several algorithms for weighting variables and partitioning data sets was also an advantage. While literally hundreds of combinations existed for this procedure, those selected appear to have been sufficient in deriving useful classifications of flakes and tools. The use of other combinations probably would not have yielded significantly different results.

The nearest-neighbour analysis suffered the greatest drawbacks. While it still proved to be a powerful tool in analyzing the structure of the site, its usefulness was hampered by two separate factors. The first was the extreme sensitivity of the Chi-square procedure to one or two large distances. This easily led to discrepancies in the tests of significance between it and the procedure developed by Clark and Evans. For large samples this discrepancy could be resolved without great difficulty. The second drawback to the method was the almost total lack of reliable interpretive aids. The method suggested by Whallon (1974) was not feasible given the small number of tool classes. The alternative involving combinations of tool classes was not wholly satisfactory due to the fact that such combinations or 'tool kits' have not yet been firmly established.

Problems in Dating and Environmental Reconstruction

While the methodology developed above for marginal-recovery sites appears to have been successful in inferring cultural activities and their spatial distribution at ElMb-10, the lack of corraborating data presents problems.

Any absolute dating of the site is rendered impossible by the absence of any organic remains. Relative dating is difficult as well. The position of the site in relation to the fossil beach ridges of Glacial Lake Agassiz offers some assistance, although the majority of the beaches cannot be traced in a continuous pattern in the Duck River area. The best developed of them include the Upper and Lower Campbell beaches near the town of Pine River and the Burnside and Ossawa Beaches just west of Lake Winnipegosis (Johnston 1921: 12).

According to maps available (Johnston 1946), ElMb-10 apparently lies beneath the Burnside Beach and above the Ossawa. An artifactual material from the site lies on top of an old soil surface, so it is unlikely that it was inundated by rising lake levels after its occupation. This would place the date of occupation after the Burnside Beach was last active. Elson (1967: 76) places the final phase of the Burnside at about 6500 B.C., so the site is unlikely to be any older than this.

No Agate Basin sites in Canada have yet been dated. In the United States they span a maximum range of 9500 to 6000 B.C. (Wheat 1972: 157, Irwin-Williams et al 1973: 52) at site on the Great Plains. If this time range is correct ElMb-10 was occupied somewhere near the end of the Agate Basin time range, although it is possible that the site may have been occupied much more recently. There are a number of Manitoba sites containing artifacts similar to assemblages to the south but dated 3000 to 5000 years later. Examples of such sites include the Swan River Site, FbMi-5 (Lowden, Wilmeth and Blake (1970: 475-476, 1972: 17, Lowden, Robertson and Blake 1971: 258-259), and the Cherry Point Site, DkMe-10 (Haug 1976: 44). Whatever mechanism may account for this phenomenon (cf Pettipas 1970:

16-17), it is conceivable that ElMb-10 could be dated as recently as 4000 to 3000 B.C.

No plant remains were recovered from the site, thus precluding interpretation of the local vegetation. J.C. Ritchie (1967) carried out palynological studies at several locations on the Manitoba escarpment on Riding Mountain. He concluded that during the probable period of occupation the area now characterized by aspen parkland was dominated by grassland (1967: 229). This reconstruction, however, was based upon upland sites, and it is probable that marshes dominated the poorly drained lowlands (cf Shay 1967: 247).

A marsh may have existed near the site, but the site area would have been better drained. The climate responsible for maintaining grasslands in the region has been described by Bryson and Wendland (1967) as having drier and warmer summers and winters that were probably somewhat colder and moister than at present.

While a rough idea of contemporary climate and environment can be pieced together for the ElMb-10 area, the season of occupation cannot be determined with any degree of certainty. A winter occupation of the site can probably be ruled out on ethnographic grounds. Evidence has shown the general lack of aboriginal utilization of open grasslands during winter in the northern plains, and it is likely that winter campsites occurred in more sheltered areas. The presumed windbreak at Duck River would have been better suited to the warmer months than to winter.

Summary

The lack of discrete flake groups produced by the cluster analysis is attributed to a direct percussion technique upon multi-faceted and discoidal cores. It is suggested that such techniques are a common occurrence in technologies of expedience. A relative abundance of lithic raw materials would tend to decrease the need for more controlled knapping procedures. It is quite likely also that the tools manufactured and used at the site also reflect a technology of expedience. With few exceptions they were produced with minimal attempt at standardization of form. This lack of standardization allowed only a minimal separation of tools into functional classes.

The small sizes of the tool categories prohibited the application of certain spatial analysis techniques, but an alternate procedure, in which activity-specific combinations of tool classes were derived, was applied to the data set. By this means three separate activity areas were isolated, and the specific activities which took place in them discussed.

Spatial analysis of the rocks at the site yielded uncertain results. Independent data on rock weights were tested, and these tended to support an interpretation of a nonrandom distribution of rocks. The linear arrangement of rocks, on the basis of the preceding tests and comparisons of several possibly explanations, was interpreted as the remains of a windbreak in which the rocks had served as an anchoring device.

The analyses point to ElMb-10 having been a small campsite which was occupied by a small group of hunter-gatherers; quite possibly by a single family unit. The length of occupation was not long, judging by the lack of any large accumulation of campsite debris. That the site was occupied during the warmer part of the year is most likely when the only shelter necessary was a windbreak.

Activities at the site included butchering perhaps a single large mammal. Apparently hideworking and woodworking also took place, and the inhabitants may have remained long enough to process the hide or hides and prepare a supply of preserved meat. The denticulate tool from Activity Area III may indicate some plant processing.

Marginal-recovery sites such as ElMb-10 probably comprise the majority of sites recorded in surveys, yet they comprise a distinct minority in the published literature because of the obstacles they present in analysis. It has been shown in this thesis that the paired technique of cluster and nearest-neighbour analysis has great potential in analyzing marginal-recovery sites and providing insights into this rarely exploited segment of the archaeological record.

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APPENDIX A

FLAKE ATTRIBUTE LIST

Introduction

The coding of the artifact attributes was designed to allow the data to be transferred to standard IBM punch cards for computer-assisted analysis. A specified number of columns on each card was set aside for the coded value of each attribute, including such information as was considered necessary to aid in the identification of the artifact and its provenience. The site datum, for the use of the computer, was relocated to the northwest corner of the block excavation, and all provenience of artifacts was recorded in relation to that datum.

Specific details regarding the observations and measurements made for each attribute are derived from Wilmsen (1970).

Identification Data

A.	Col. 1-3	Data card number
B.	Col. 4-8	Artifact catalogue number
C.	Col. 9-11	Provenience south of datum (in cm)
D.	Col. 12-15	Provenience east of datum (in cm)

Discrete Attributes and States

1. Col. 16 Striking platform:
    1. present
    2. absent

2. Col. 17 Lithic raw material:
0. indeterminate
1. Red Swan River Chert
2. Type I Swan River Chert
3. Piebald Swan River Chert
4. Cathead Chert and fine chert
5. quartzite
6. granitic rocks
7. Coarse Swan River Chert
8. Yellow Swan River Chert
9. Type II Swan River Chert

3. Col. 18 Platform preparation:
0. indeterminate
1. not applicable
2. lateral flake removal
3. transverse flake removal
4. multiple flake removal
5. abrasion
6. none (flat)

4. Col. 19 Crushing on dorsal surface at platform:
0. indeterminate
1. not applicable
2. present
3. absent

5. Col. 20 Lipping on ventral surface at platform:
0. indeterminate
1. not applicable
2. present
3. absent

6. Col. 21 Flake termination:
0. indeterminate
1. not applicable
2. stepped
3. hinged
4. feathered

7. Col. 22 Cortex on dorsal surface:
0. indeterminate
1. not applicable
2. primary
3. secondary
4. none

8. Col. 23 Dorsal flake removal pattern:
0. indeterminate
1. not applicable
2. unidirectional- longitudinal
3. transverse
4. bipolar- longitudinal
5. combination

9. Col. 24 Left lateral flake outline when viewed from dorsal surface with the proximal end at top:
    0. indeterminate
    1. not applicable
    2. irregular
    3. expanding towards distal end
    4. contracting towards distal end
    5. straight, parallel to medial axis
    6. concave to medial axis
    7. convex to medial axis

10. Col. 25 Right lateral flake outline when viewed from dorsal surface with the proximal end at top:

    same values

11. Col. 26 Longitudinal cross-section:
    0. indeterminate
    1. not applicable
    2. flat
    3. incurving towards dorsal surface
    4. outcurving towards ventral surface

Converted Metric Attributes and States

The metric attributes were originally recorded as raw data. They were converted to discrete attributes in order to make them compatible with the existing discrete attributes in the cluster analysis. This was done by determining the range of values for each attribute and subdividing it into five to ten classes of equal length. The number of classes into which each attribute was divided depended upon the magnitude of the range. If it was large, ten or so classes were used; smaller ranges had only five or six classes.

12. Col. 49 Platform length; maximum dimension ventral to dorsal:
    0. not applicable or missing value
    1. 1-5 mm
    2. 6-10 mm
    3. 11-15 mm
    4. 16-20 mm
    5. 21-25 mm

13. Col. 50 Platform width; maximum dimension left lateral to right lateral:

0. not applicable or missing value
1. 1-9 mm
2. 10-18 mm
3. 19-27 mm
4. 28-36 mm
5. 37-45 mm

14. Col. 51 Angle Alpha; formed by the striking platform and the longitudinal axis; dorsal or ventral aspect:

0. not applicable or missing value
1. $1\text{-}5^{o}$
2. $5\text{-}10^{o}$
3. $11\text{-}15^{o}$
4. $16\text{-}20^{o}$
5. $21\text{-}25^{o}$

15. Col. 52 Angle Beta; formed by the striking platform and the ventral plane of the flake; lateral aspect:

0. not applicable or missing value
1. $10\text{-}19^{o}$
2. $20\text{-}29^{o}$
3. $30\text{-}39^{o}$
4. $40\text{-}49^{o}$
5. $50\text{-}59^{o}$
6. $60\text{-}69^{o}$
7. $70\text{-}79^{o}$
8. $80\text{-}89^{o}$
9. 90^{o}

16. Col. 53 Maximum flake length; measured along the medial axis:

0. not applicable or missing value
1. 20-29 mm
2. 30-39 mm
3. 40-49 mm
4. 50-59 mm
5. 60-69 mm
6. 70-79 mm
7. 80-89 mm
8. 90-99 mm
9. 100-109 mm

17. Col. 54 Thickness of the bulb of percussion:

0. not applicable or missing value
1. 3-6 mm
2. 7-10 mm
3. 11-14 mm
4. 15-18 mm
5. 19-22 mm

18. Col. 55 Maximum flake width; measured perpendicular to the medial axis:
   0. not applicable or missing value
   1. 19-24 mm
   2. 25-30 mm
   3. 31-36 mm
   4. 37-42 mm
   5. 43-48 mm
   6. 49-54 mm

19. Col. 56 Maximum flake width position; expressed as the ratio of the distance from the platform to the point of maximum width divided by the maximum flake length:
   0. not applicable or missing value
   1. .25-.39
   2. .40-.54
   3. .55-.69
   4. .70-.84
   5. .85-.99

20. Col. 57 Maximum flake thickness:
   0. not applicable or missing value
   1. 1-5 mm
   2. 6-10 mm
   3. 11-15 mm
   4. 16-20 mm
   5. 21-25 mm
   6. 26-30 mm

21. Col. 58 Maximum flake thickness position; expressed as the ratio of the distance from the platform to the point of maximum thickness divided by the maximum flake length:
   0. not applicable or missing value
   1. .01-.11
   2. .12-.22
   3. .23-.33
   4. .34-.44
   5. .45-.55
   6. .56-.66
   7. .67-.77
   8. .78-.88
   9. .89-.99

APPENDIX B

UTILIZATION ATTRIBUTE LIST

Introduction

The data for the utilized flakes was coded for IBM punch cards to be used in cluster and spatial analysis. Each attribute was assigned a specific column or columns on the cards. Additional information regarding the identity of each artifact and its provenience was also entered onto each card. The list was prepared by the author (cf Haug 1976).

Identification Data

A.	Col. 1-4	Data card number
B.	Col. 6-10	Artifact catalogue number
C.	Col. 15-17	Provenience south of datum (in cm)
D.	Col. 19-22	Provenience east of datum (in cm)
E.	Col. 24-25	Excavation unit number

Discrete Attributes and States

5. Col. 40 — Dorsal edge polish:
   0. not applicable
   1. present
   2. absent

6. Col. 41 — Ventral edge polish:
   0. not applicable
   1. present
   2. absent

7. Col. 42 — Dorsal edge nibbling; tiny use flakes which have been removed from working edge:
   0. not applicable
   1. present
   2. absent

8. Col. 43 Ventral edge nibbling:
    0. not applicable
    1. present
    2. absent

9. Col. 44 Dorsal lateral striations; microscopic use scratches parallel to working edge:
    0. not applicable
    1. present
    2. absent

10. Col. 45 Ventral lateral striations:
    0. not applicable
    1. present
    2. absent

11. Col. 46 Dorsal transverse striations; microscopic use scratches perpendicular to working edge:
    0. not applicable
    1. present
    2. absent

12. Col. 47 Ventral transverse striations:
    0. not applicable
    1. present
    2. absent

13. Col. 48 Dorsal oblique striations; microscopic use scratches at an angle between about 10-80° to working edge:
    0. not applicable
    1. present
    2. absent

14. Col. 49 Ventral oblique striations:
    0. not applicable
    1. present
    2. absent

15. Col. 51 Dorsal retouch; pressure flakes removed from edge as opposed to simple utilization:
    0. not applicable
    1. present
    2. absent

16. Col. 52 Ventral retouch:
    0. not applicable
    1. present
    2. absent

18. Col. 57 Edge texture; appearance of utilized or worked edge:
    1. smooth
    2. irregular
    3. denticulate

Converted Metric Attributes and States

The five metric attributes were converted to discrete attributes for use in cluster analysis. This was accomplished by determining summary statistics for the raw data in each attribute and by plotting the raw values on histograms for each case. When the distribution was clearly bimodal or multimodal categorization was established by using troughs in the distribution as dividing points. In the more ambiguous cases categorization into three states was achieved by dividing the distribution one standard deviation above and below the mean value. Figures 31-35 document this procedure.

The categorization was executed by the cluster analysis program from the raw values entered on the data cards. The discrete values are presented here, and Table 25 presents them as raw data.

1. Col. 27-28 Working edge length:
    1. 7-19 mm
    2. 20-36 mm
    3. 37-54 mm

2. Col. 30-32 Working edge shape index; measured as the ratio of edge length to overall depth of the edge times 100; a positive value indicates a convex edge and a negative value indicates a concave edge:
    1. -31 - -9
    2. -8 - +23
    3. +23 - +60

3. Col. 34-35 Average angle of working edge; measured perpendicular to edge:
   1. 10-39^{o}
   2. 40-65^{o}
   3. 65-90^{o}

4. Col. 37-38 Maximum thickness of working edge; measured at the position of the innermost edge of the flake scars or at approximately 5 mm in cases of only use wear:
   1. 1-7 mm
   2. 8-13 mm

17. Col. 54-55 Maximum thickness of flake:
   1. 3-5 mm
   2. 6-12 mm
   3. 13-18 mm

APPENDIX C

RESULTS OF CLUSTER ANALYSES B, E AND F

Cluster Analysis B

Attributes 2-21 were used for this analysis. They were compared with the similarity algorithm:

$$S = \frac{A - D}{A - D + 2B} ,$$

which is derived from one given by Anderberg (1973: 123). This algorithm deletes nonrelevant or nonapplicable matches of attribute states 'D' from the total number of matched attributes 'A' in both the numerator and the denominator, and it assigns nonmatches 'B' twice the weight of matches. This has the effect of stretching the similarity scale at its lower end, thus slowing down clustering as the number of matches grows smaller.

The dendrogram for Run B is depicted in Figure 8. The rates of merging and FE absorbtion are presented in Figures 9-10. It is readily apparent from an examination of the figures that Run B contains no well-defined clusters. The rate of merges is quite smooth, starting off rather slowly after the first grouping of items and then increasing slowly. The period of greatest merge activity falls roughly between Stages 11 and 20. The curve never really levels off, although it is not nearly so steep after Stage 20 or so. The absorbtion of FEs is somewhat more precipitous, exhibiting its greatest activity between Stages 9 and 17. It levels off after Stage 20 and does not change from its value of four unpaired items until the end of the clustering process.

In general, Run B does not exhibit any clearly-defined clustering in the data. It appears to consist of pairs of items which slowly absorb FEs over the entire similarity scale. Groups of clusters do not form until relatively late in the process, and even then they are not well separated.

The merge and absorbtion rate graphs indicate that most of the clustering activity took place in a rather smooth process, and that it was essentially finished by the end of Stage 20, when S equaled .183. This point may serve as a phenon. The resulting taxonomy, B.183, contains nine clusters, although four of these consist of only free entities. Only two of the clusters, B.183-1 and B.183-5, contain more than five entities.

Cluster Analysis E

For this analysis the following similarity algorithm was used on Attributes 2-21:

$$S = \frac{A - D}{A + B} \quad .$$

The algorithm is derived from Coefficient Number 1 in Anderberg (1973: 123). It deletes nonapplicable matches from the numerator but not from the denominator. It produces in effect a measure of similarity based on the potential number of matches 'A + B' between attributes in each case, rather than on the number of applicable attributes.

Run E exhibits somewhat better separation of its clusters than Run B, as may be seen in the dendrogram (Figure 11). Merges spanned the similarity scale between about .70 and .14. The rate of merges is not considerably different than that of Run B (Figure 12). Like the other, merging of entities begins slowly, with little change until about Stage 5 or 6. The bulk of the merge activity takes place between Stages 7 and 21, and then it levels off. The curve is rather smooth and does not vary much from the straight line which would be expected for a totally homogenous population.

The curve of FE absorbtion (Figure 13) falls away in a more dramatic fashion than that of the merge rate, and in a rather staggered pattern. Its period of greatest activity begins at Stage 5 and ends with Stage 16, when the curve flattens out at a value of five free entities.

The general pattern of the clustering seems to have been one of alternating between the absorbtion of several free entities followed by the combining of clusters. None of the clusters are well separated from each other, except perhaps between .25 and .21 on the similarity scale, where only two large clusters exist along with three free entities.

The choice of a phenon for Run E was difficult. While the free entity absorbtion rate indicated that activity had largely ceased after Stage 16, the merge rate curve exhibited no dramatic or abrupt flattening. Eventually it was decided to accept the lower boundary of Stage 20, where S equals .257, as a phenon. The final classification at E.257 includes eight clusters. Only two of these, E.257-1 and E.257-3, contain more than five entities. Clusters 5-8 consist of free entities.

Cluster Analysis F

Attributes 2-21 were used in Run F. For the computation of the similarity matrix they were submitted to the similarity algorithm:

$$S = \frac{A - D}{A - D + B} \quad ,$$

which is presented as Coefficient Number 3 in Anderberg (1973: 123). It is also known as Jaccard's Coefficient. It is very similar to the algorithm used in Run B, except that none of the matching classes were weighted. It may be expected that the results of the analysis using this algorithm would not be radically different than Run B. The major difference lies in the lack of distortion of the similarity scale at its lower end, such that clustering between B and F would differ more and more as S decreases.

The dendrogram of Run F (Figure 14) exhibits somewhat better resolution between clusters than the preceding runs. The clustering ranged between .71 and .165 on the similarity scale.

The rate of merges (Figure 15) is very smooth, and it displays much similarity with the curves of Runs B and E. It begins very slowly until about Stage 6, when it drops at a steeper rate until it reaches Stage 21. It levels off for only a stage or two, and then finishes the clustering in the last three stages.

Free entitities are absorbed in Run F at a faster rate than in the previous runs (Figure 16). Absorbtion begins at a rapid rate in Stage 1 and proceeds swiftly until the end of Stage 17, when only four free entities remain. The curve exhibits a definite break at Stages 15-17 when it shifts from rapid to slow, a point at which almost all the free entities have been merged into one cluster or another.

The overall pattern of clustering in Run F is rather similar to that of Run B. Both the rate of absorbtion and the rate of merges proceed smoothly with little or no sign of staggering in the curves. Since the free absorbtion rates exceeds that of merges, the general tendency of the clustering is first to absorb most of the free entities with minimal merging between the clusters, which is followed by a decrease in absorbtion and a continued pattern of merging between clusters. This lag or gap between the termination of absorbtion and merges between clusters accounts for the somewhat better resolution between the clusters in Run F as compared to the previous runs.

Clustering had essentially ended by the end of Stage 21, which corresponded with a rather well-defined separation between the clusters. This provided a basis for a decision to use the lower boundary of Stage 21 as a phenon for the partition. The taxonomy generated by this phenon, F.251, contains six clusters. Two of these, F.251-1 and F.251-2, contain more than five items apiece, while the remaining four clusters consist of free entities.

APPENDIX D

RESULTS OF CLUSTER ANALYSES ALPHA, BETA AND GAMMA

The three computer-assisted cluster analyses of flake utilization all used attributes 1-18. They also used the same similarity algorithm:

$$S = \frac{A - D}{A - D + B} \quad .$$

Variation between the runs was accomplished through the use of various weighting schemes for the attributes, which are detailed below.

Cluster Analysis Alpha

No weighting was attempted for the 18 attributes on the first run. Instead it was felt that subsequent runs might be weighted after an examination of the results of Run Alpha.

The run itself resulted in a rather interesting dendrogram (Figure 17). In it clustering begins at an S value of 1.00 for the merges of six items into three groups. The lower bound of the similarity scale is .41. A general tendency appears for clusters to merge and remain well-separated from others, while newer clusters (with lower merge values on the similarity scale) are still forming. These tend to collapse upon themselves as new clusters join the older clusters and still newer ones form elsewhere.

The merge rate (Figure 18) descends in a rather smooth, concave curve. It exhibits no steep drops or abrupt changes, and hence no point at which the clustering procedure might be considered as ended. The rate of free entity absorbtion (Figure 19) duplicates this pattern to some extent, although two rather steep increases in activity in

Stages 3 and 8 are somewhat more magnified than in the merge rate curve. Another difference appears after Stage 12 when no more free entities are absorbed until Stage 23.

Since Stage 12 marks the end of the absorbtion of unpaired entities (except for four which are not absorbed until the end of the run), and since little activity takes place in the merging of clusters after that point, a phenon may be fixed at the end of Stage 12. The value of S at the end of Stage 12 is .741, so the partition is designated Alpha.741. 12 clusters are formed by this partition. Four are composed of single items, while only two clusters contain more than five items.

Cluster Analysis Beta

Six attributes were given extra weight for this run. Attributes 1-3 and 18 were all assigned three times the normal weight, and Numbers 4 and 17 were given a double weight. These variables are all converted metric attributes with the exception of Number 18. The attributes which were not weighted all refer to use wear patterns. They are in effect assigned less weight because patterns such as striations or polish may not always be present (or observable) on a utilized tool to the extent that they might be expected on a more thoroughly-used curated tool. Hence the attributes were often recorded as 'absent' more often on some tools than might actually have been the case. This would tend to weight the wear pattern variables in a negative fashion and dilute to some extent the effect of the other variables. The weights have been assigned in an attempt to offset any imbalance.

The dendrogram generated for Beta shows somewhat better separation of clusters than Alpha (Figure 20). Clustering begins at an S value of 1.00 and ends at .41. The pattern of clustering is clearer than in Alpha, and the clusters do not seem to nest together in the same serial fashion. This allows an easier interpretation and separation of the results.

The merge rate of Beta (Figure 21) is very smooth and uniform. It curves concavely from Stages 1 to 25 with no sharp changes in the rate, which indicates that clustering took place evenly throughout the entire process.

The rate of free entity absorbtion (Figure 22) is somewhat more dramatic. It drops steeply through Stage 5, and at a slightly slower rate through Stage 9. From that point it slows down, levelling off from Stage 15 to 19 and tapering to zero from that point.

The merge and absorbtion rates do not make clear any particular point at which to choose a phenon. However, a lengthy hiatus in absorbtion occurs after Stage 15, which is matched by a shorter one in the merge rate. This would indicate at least a break in the data structure which perhaps the program was not able to lucidly define, and it will serve to establish a phenon. The S value of the Stage 15 phenon is .646. Nine clusters are isolated in Beta.646. Six of these are free entities, and Clusters 1 and 2 both contain 10 or more items.

Cluster Analysis Gamma

Attribute weights were shifted once more for the third run. Attributes 4, 17 and 18 were reduced to weights of 1, Attribute 1 was reduced to a weight of 2, and Attributes 2 and 3 retained weights of 3.

The Gamma clusters appear to be well-separated in the dendrogram (Figure 23). The first merges occur at 1.00 on the similarity scale, and the run terminates at .42. Four or five clusters appear by about Stage 15, all of which are generally well-separated from each other. The majority of the entities fall into one large cluster by that point, and the rest coalesce into smaller clusters and free entities. In general, the dendrogram presents a clearer, more easily interpretable picture than the previous runs.

The merge rate (Figure 24) does not differ greatly from the previous ones. It descends in a gradual, concave arc with no sharp changes in rate. The graph of the free entity absorbtions (Figure 25) presents much the same picture. Entities are absorbed quite swiftly in the first seven stages, after which activity tapers off to nil at the end of Stage 16. The curve is very concave, with no real breaks in the rate.

The merge rate graph and the free entity absorbtion graph match each other very well. This is indicative of a rather homogenous process involving both the merging of clusters and the absorbtion of new members taking place simultaneously. The merge rate indicates no 'natural' point at which to establish a phenon. However, the free entity absorbtion rate shows a lack of activity after Stage 16. An earlier point would be advisable for a phenon, though, since the merge at Stage 16 involves only the absorbtion of a free entity into a cluster of three items. Stage 15 marks the merge of two large, previously well-separated clusters. However, the end of Stage 14 might be a better point in that two merges are completed, and the two clusters to be merged in Stage 15 are still well-separated. The value of S at that point is .674.

Ten clusters are generated by Gamma.674. Three contain more than five entities apiece: Gamma.674-1, Gamma.674-2 and Gamma.674-4. Five of the clusters consist of free entities.

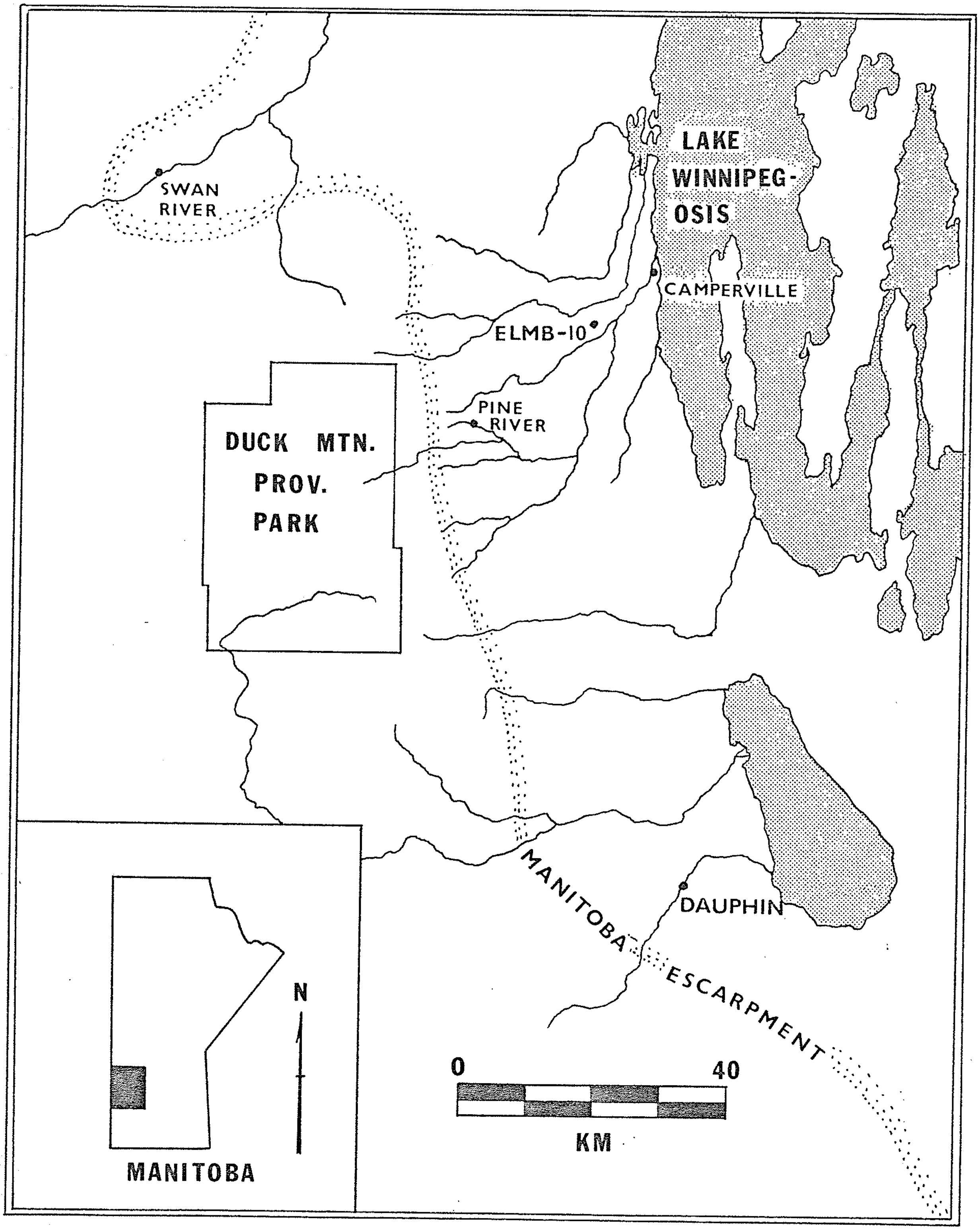


Figure 1. Map of the Pine River Area

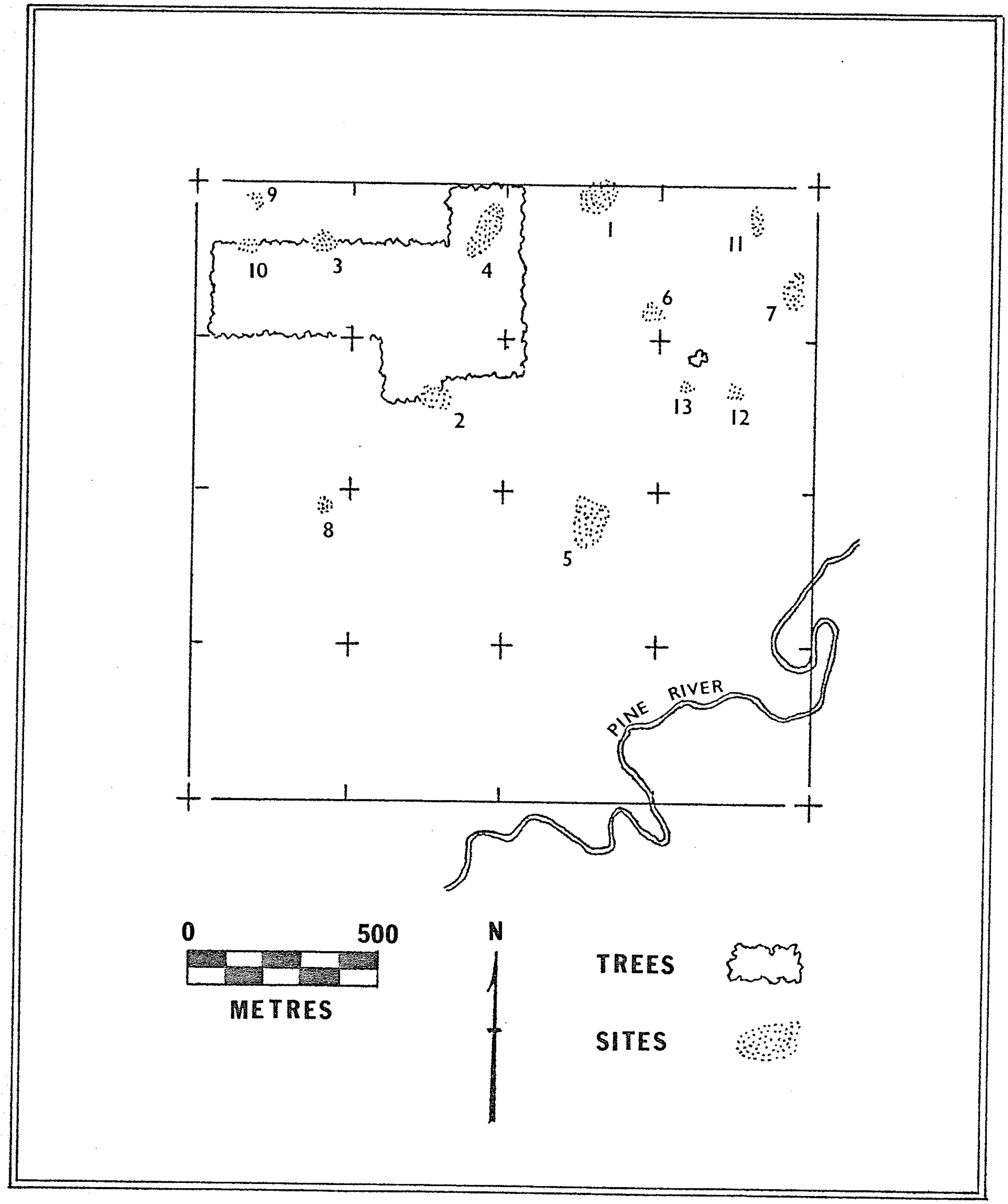


Figure 2. Map of Section 17, Township 34 North, Range 20 West, Showing the ElMb Sites

Figure 3. Plan of the ElMb-10 Excavations

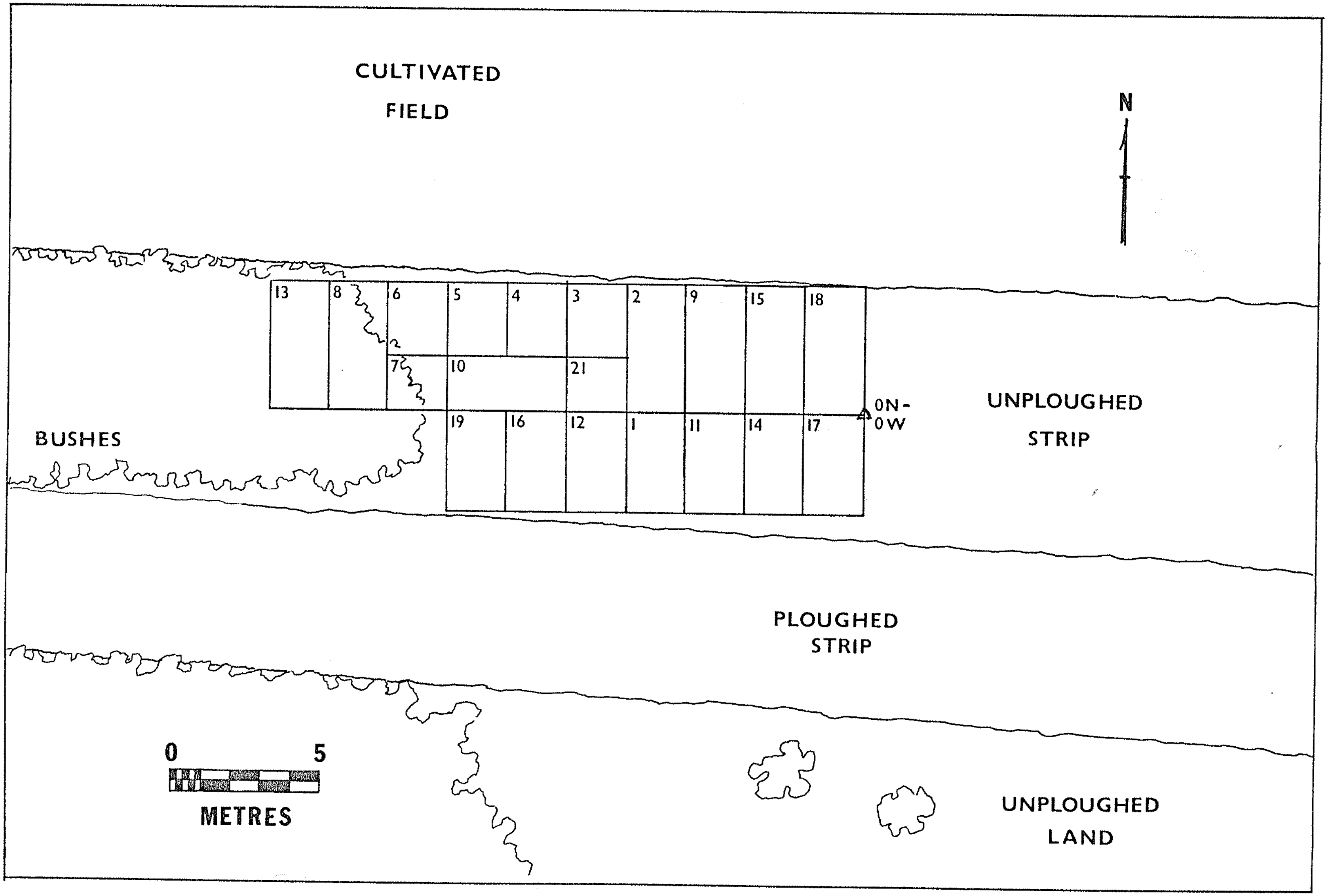


Figure 4. Stratigraphic Profile of ElMb-10 at the West Wall of Unit 13

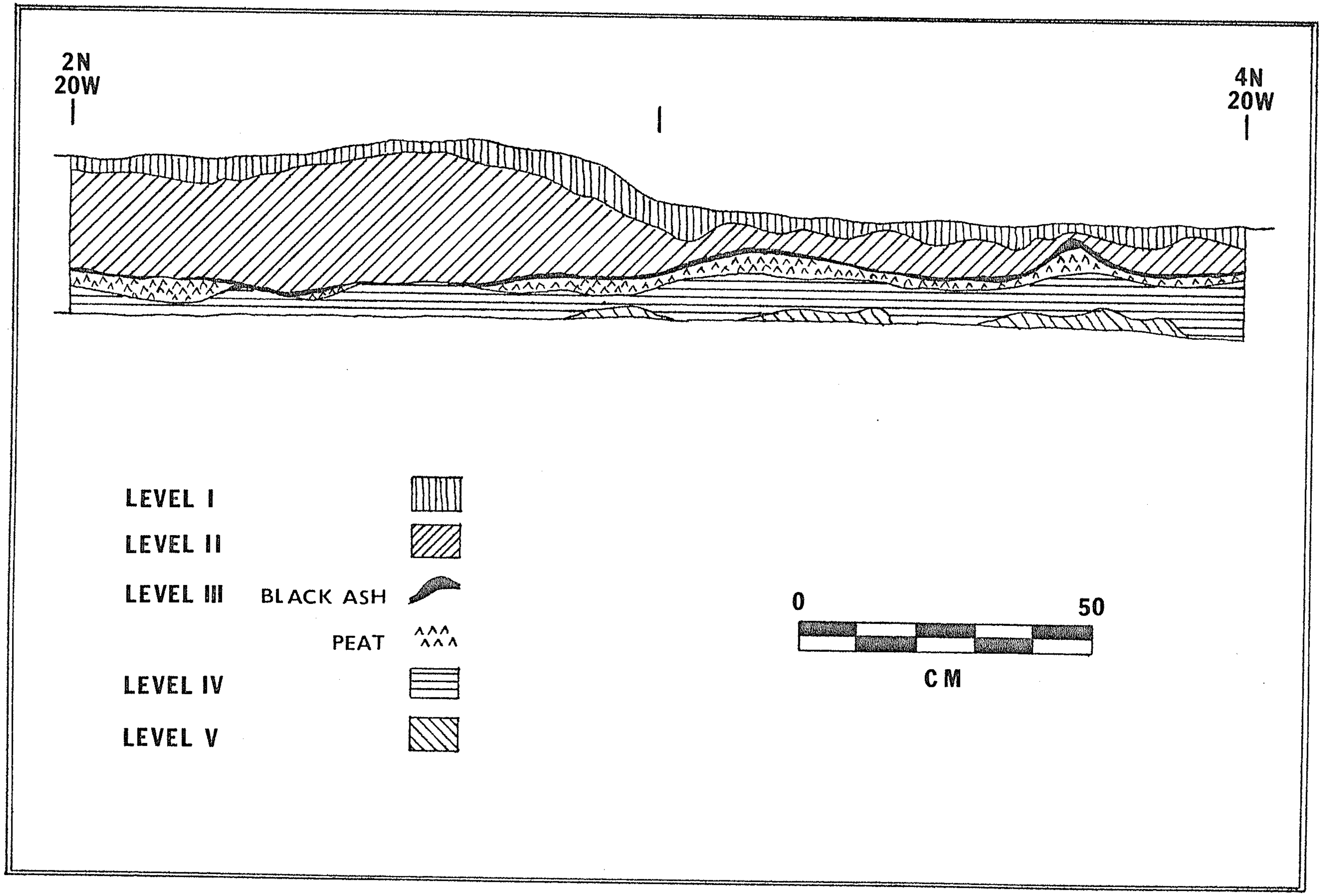
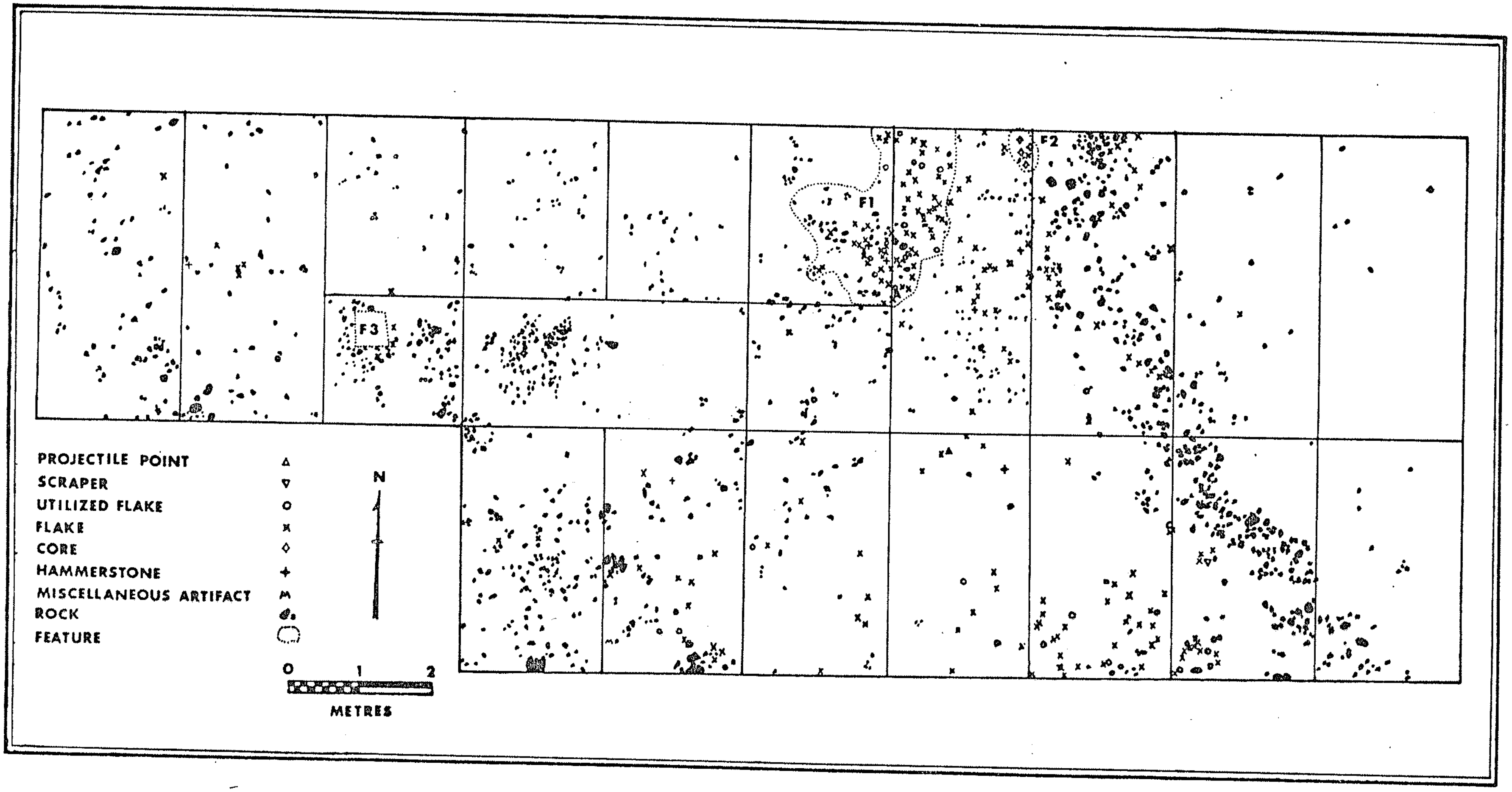


Figure 5. Plot of Artifact Distribution at ElMb-10



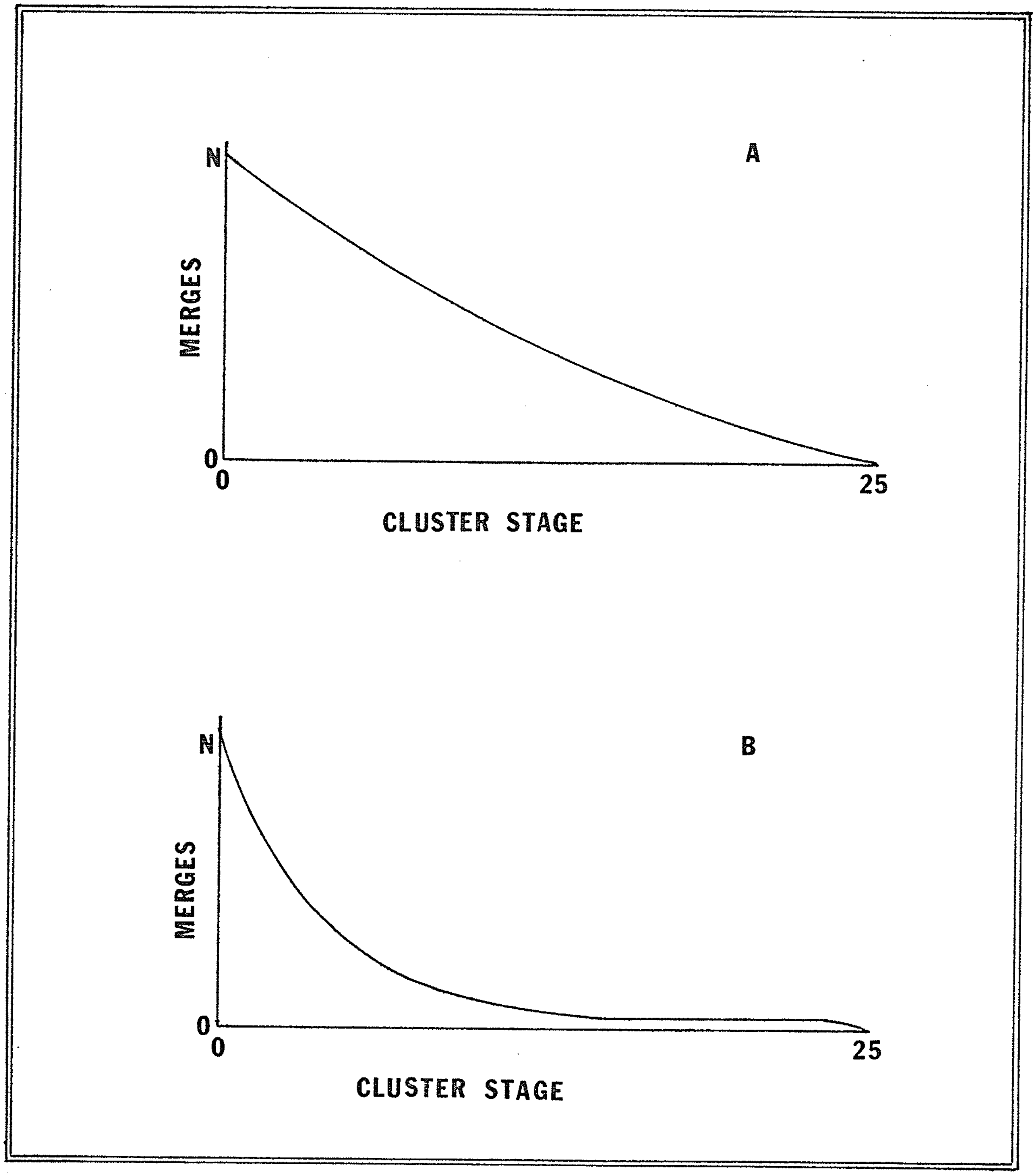


Figure 6. Sample Merge Rate Graphs; A) Poorly-Defined Clustering, B) Well-Defined Clustering

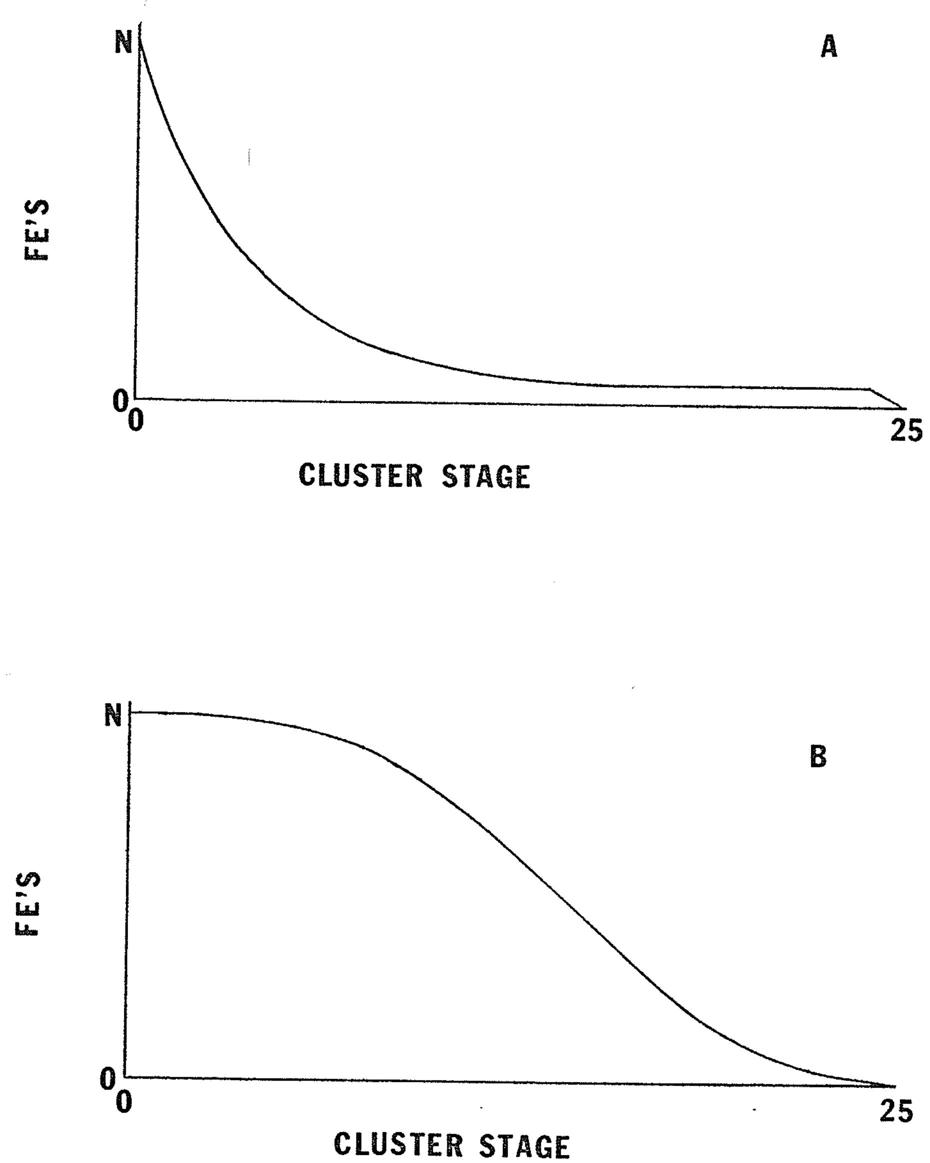


Figure 7. Sample Absorbtion Rate Graphs; A) Homogenous Data Set, B) Inhomogenous Data Set

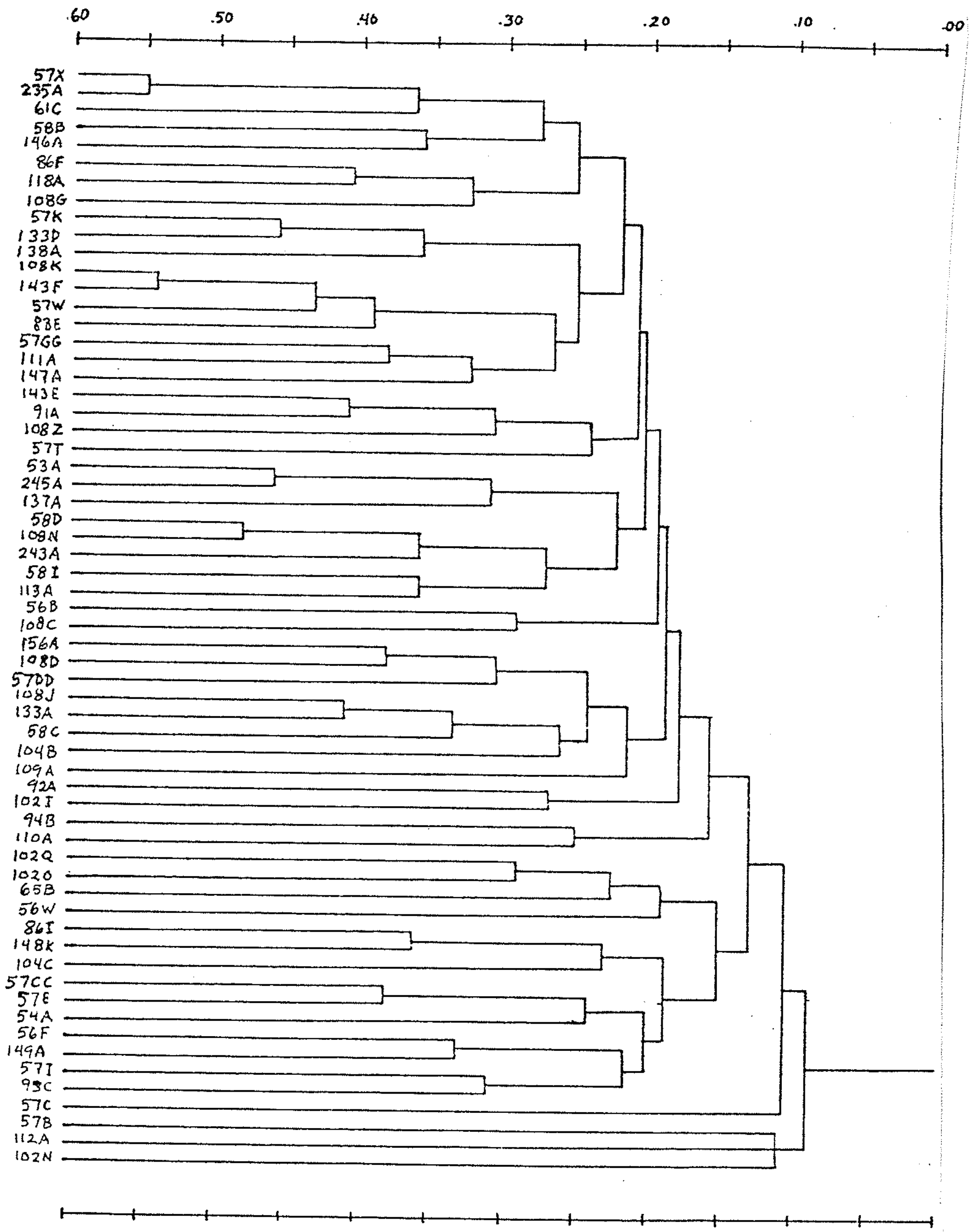


Figure 8. Dendrogram of Cluster Run B

Figure 9. Merge Rate Graph of Cluster Run B

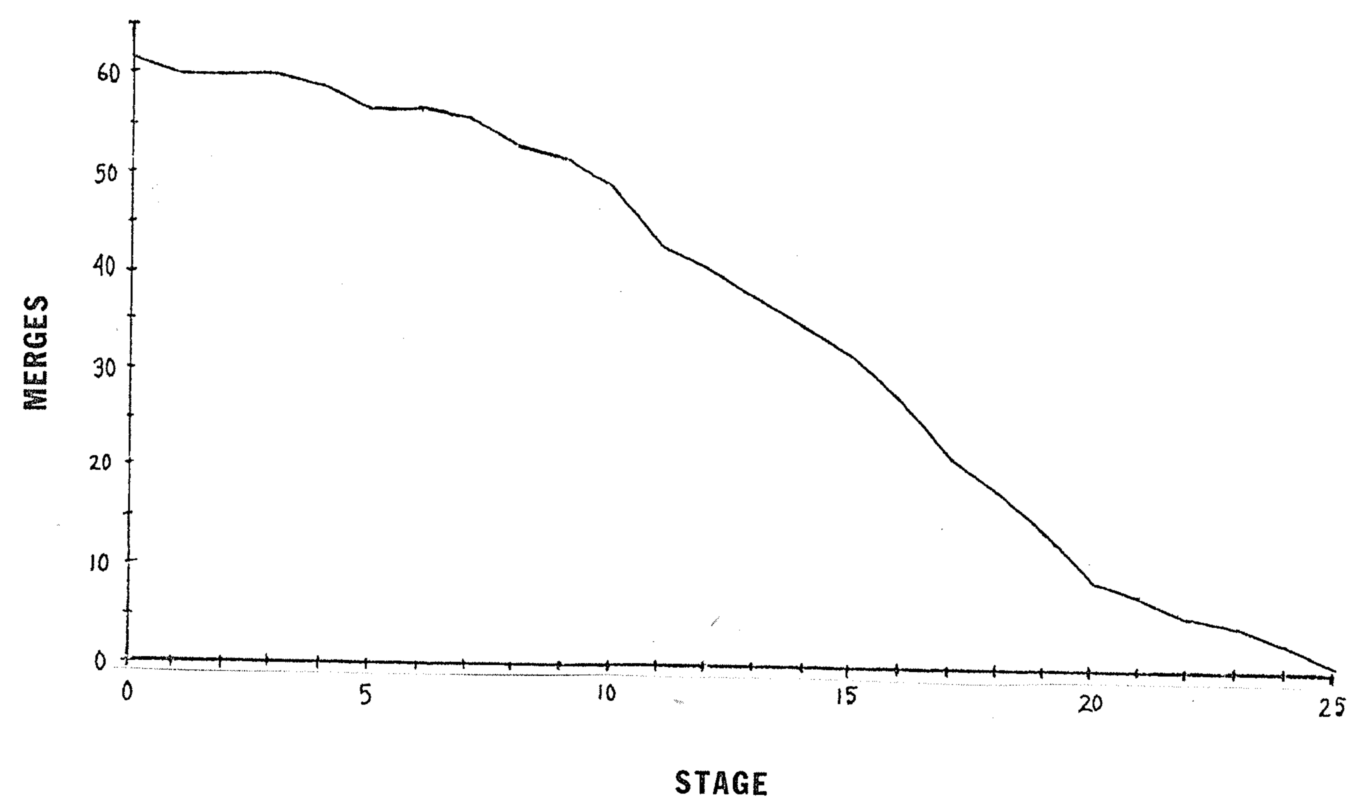
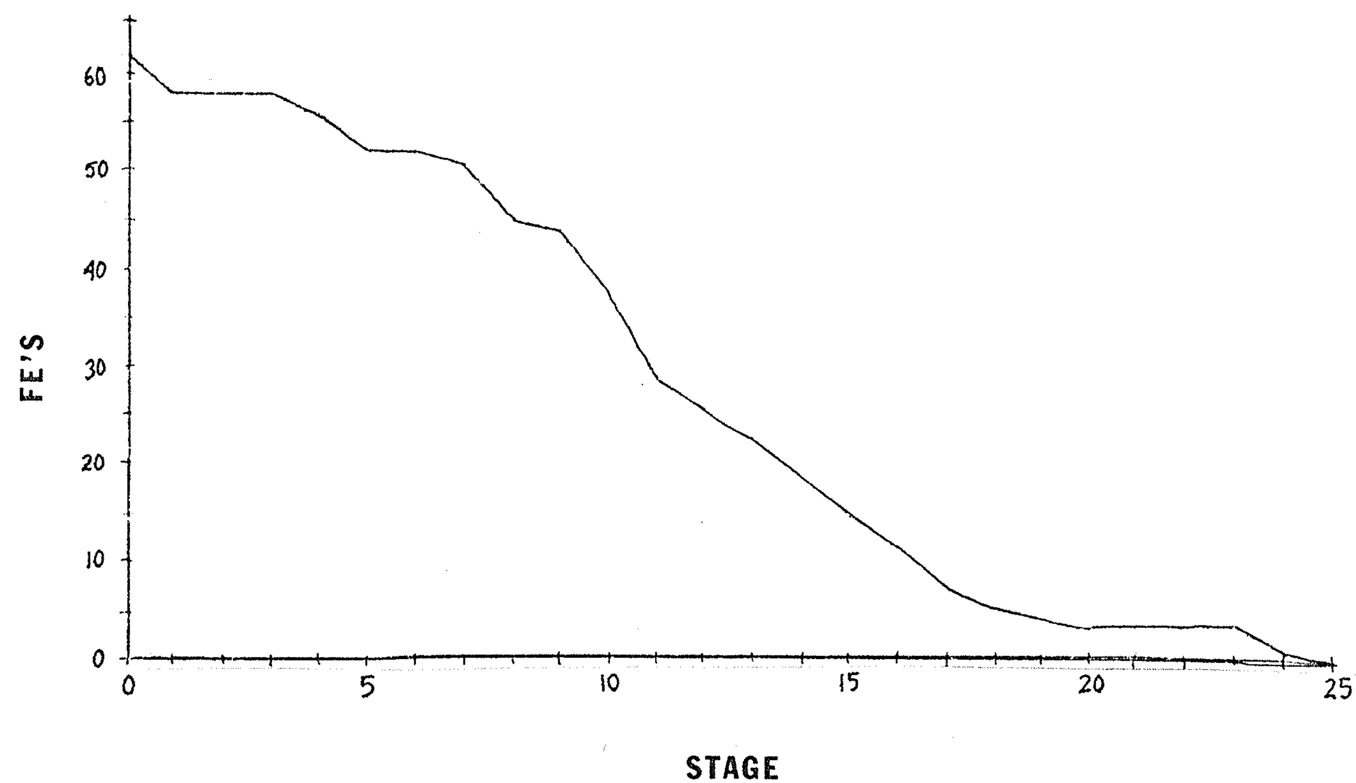


Figure 10. Absorbtion Rate Graph of Cluster Run B



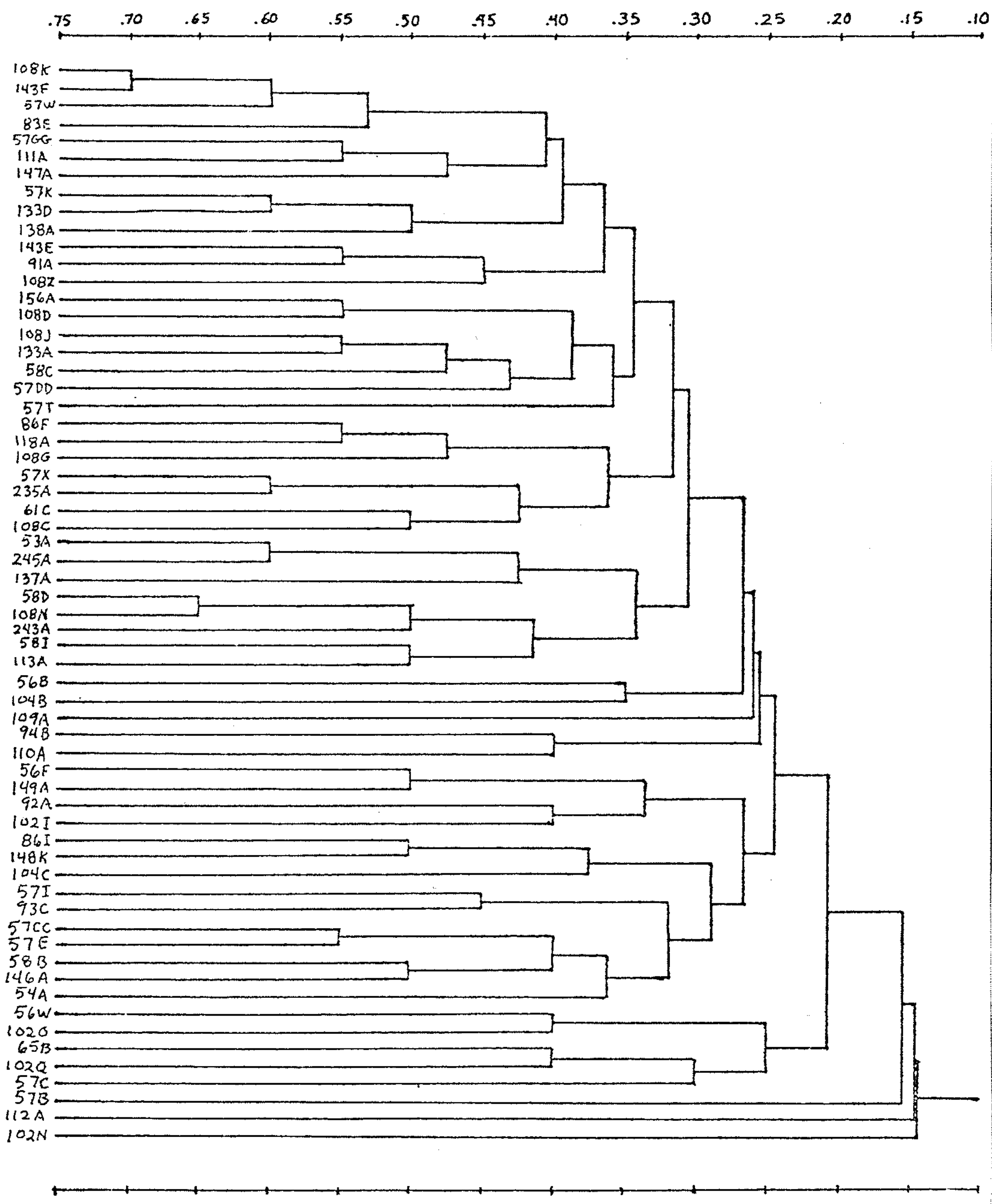


Figure 11. Dendrogram of Cluster Run E

Figure 12. Merge Rate Graph of Cluster Run E

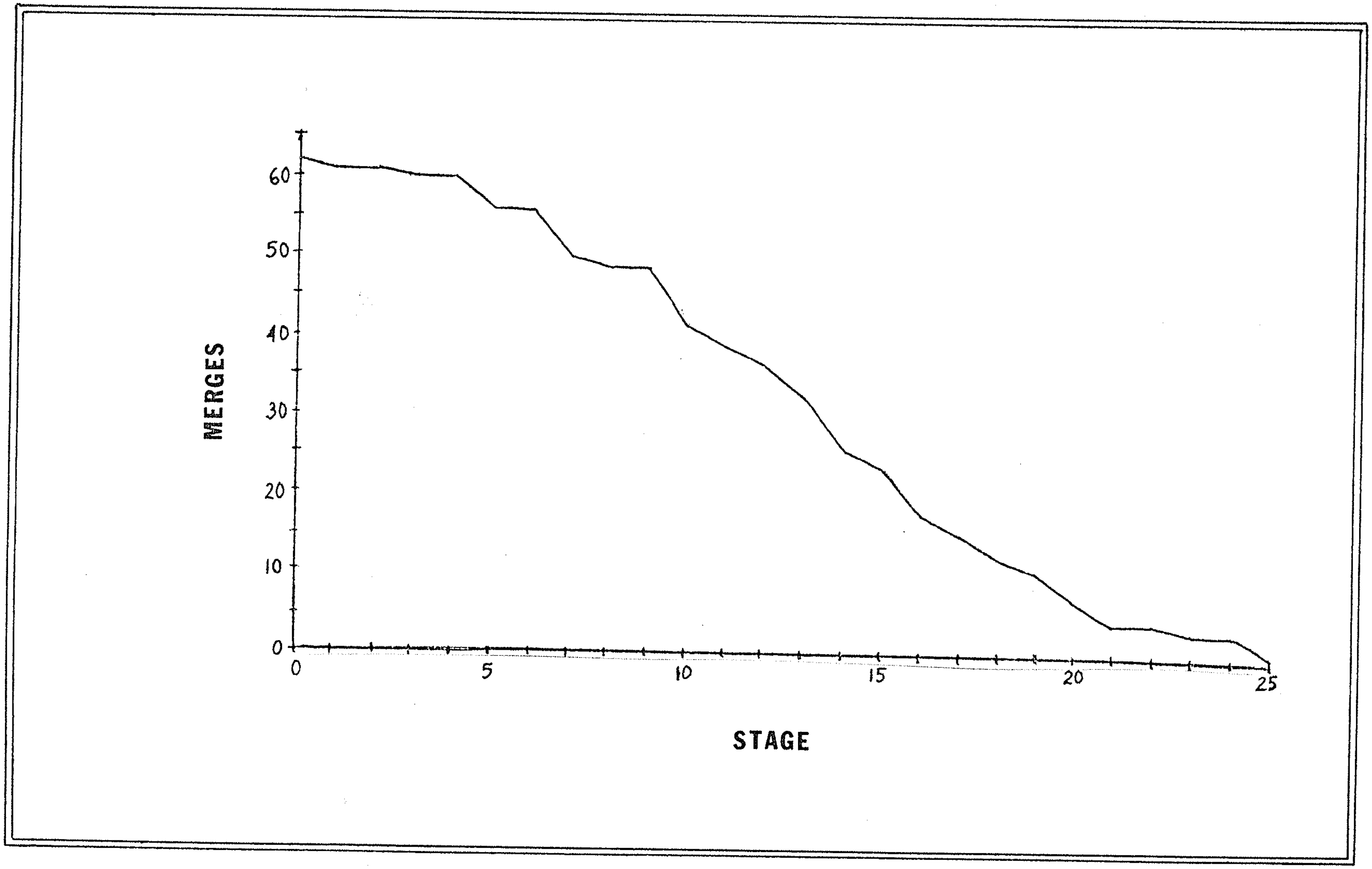
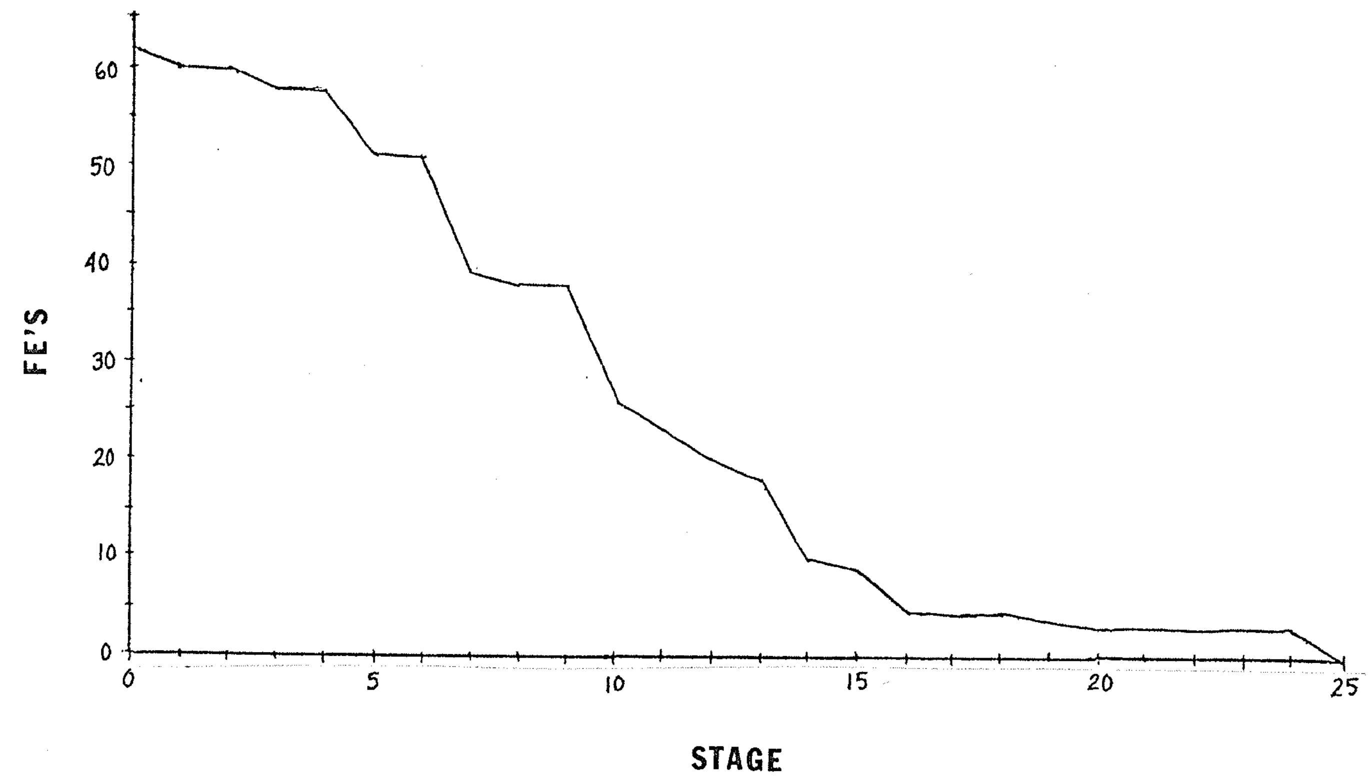


Figure 13. Absorbtion Rate Graph of Cluster Run E



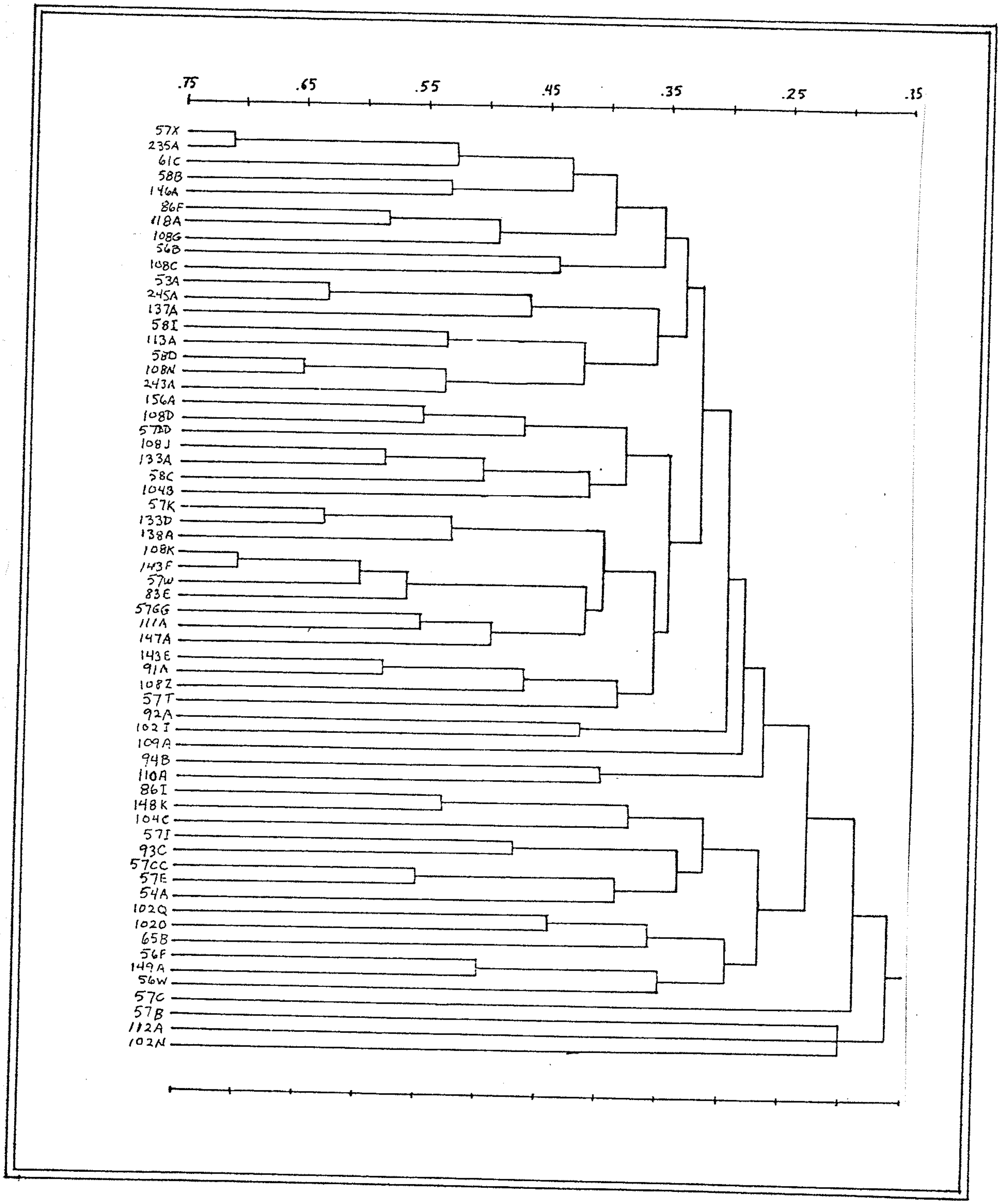


Figure 14. Dendrogram of Cluster Run F

Figure 15. Merge Rate Graph of Cluster Run F

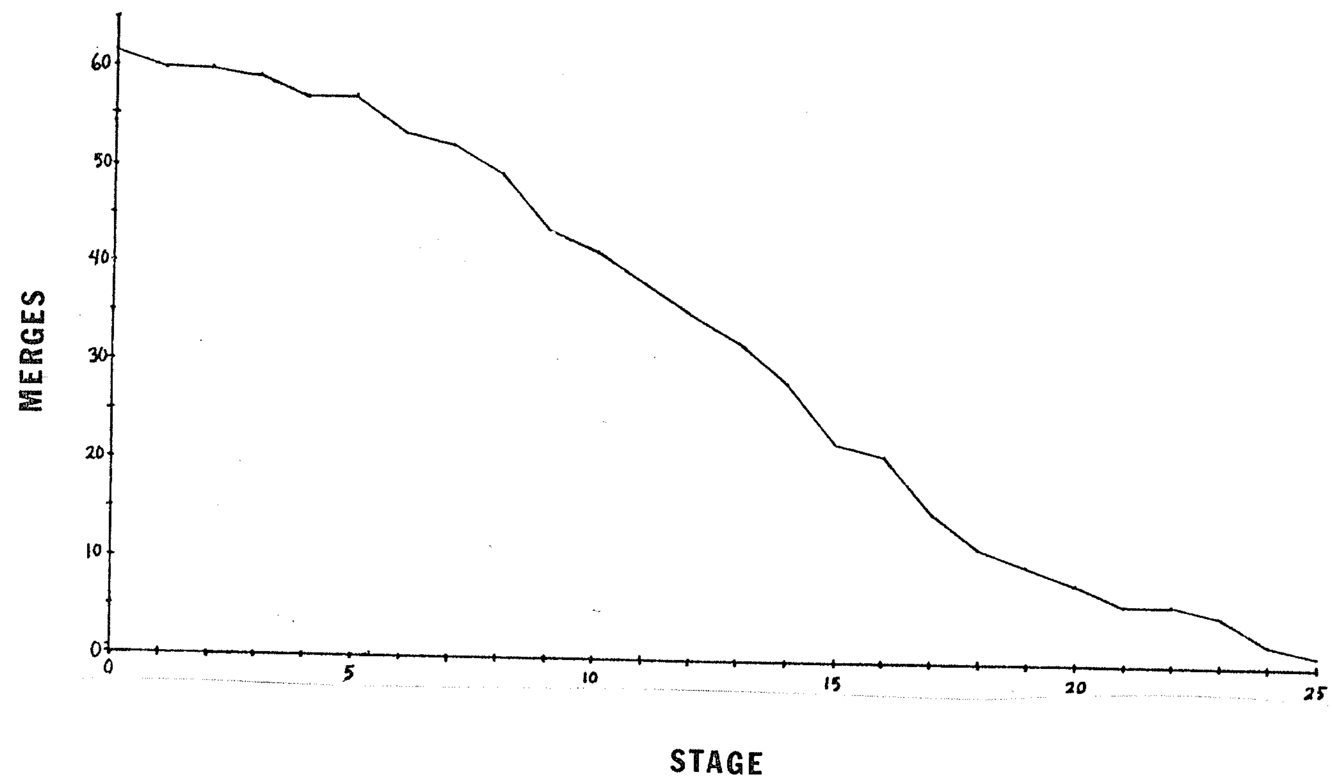
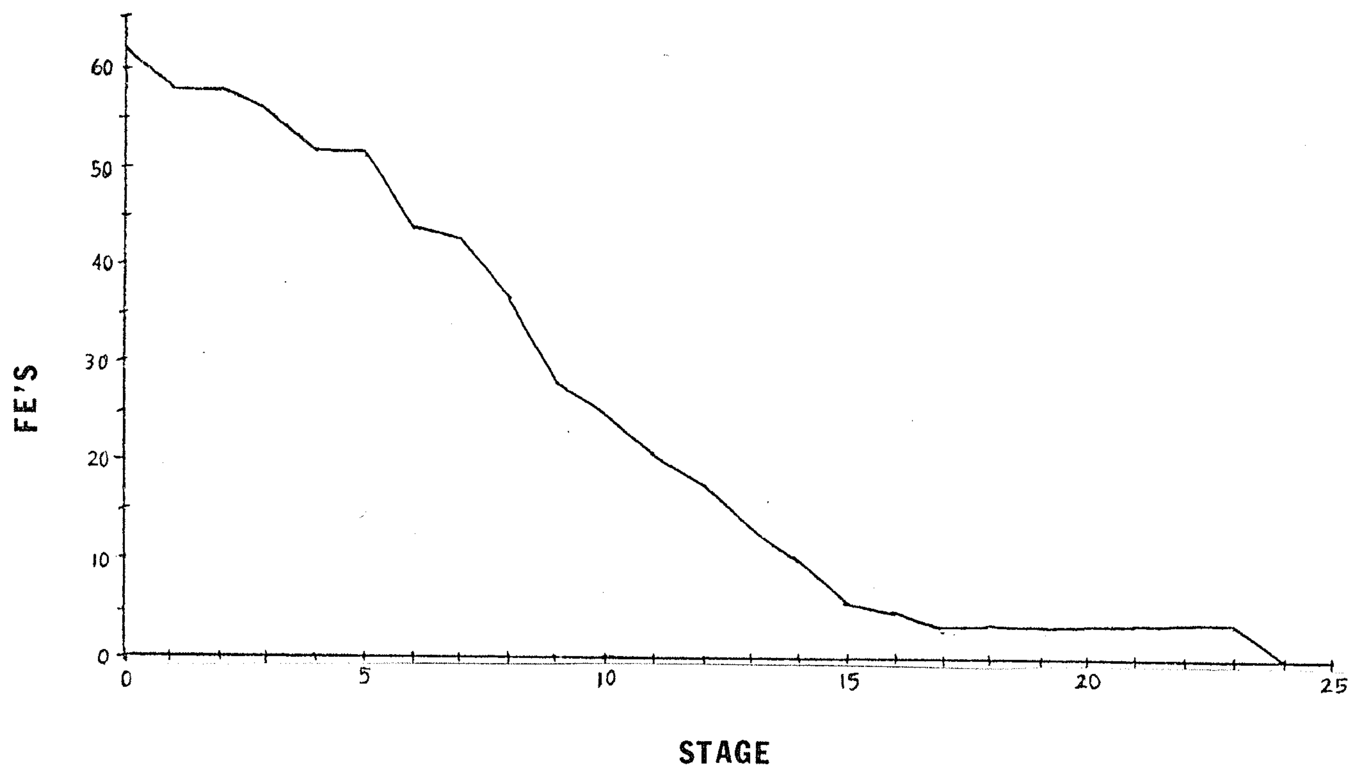


Figure 16. Absorbtion Rate Graph of Cluster Run F



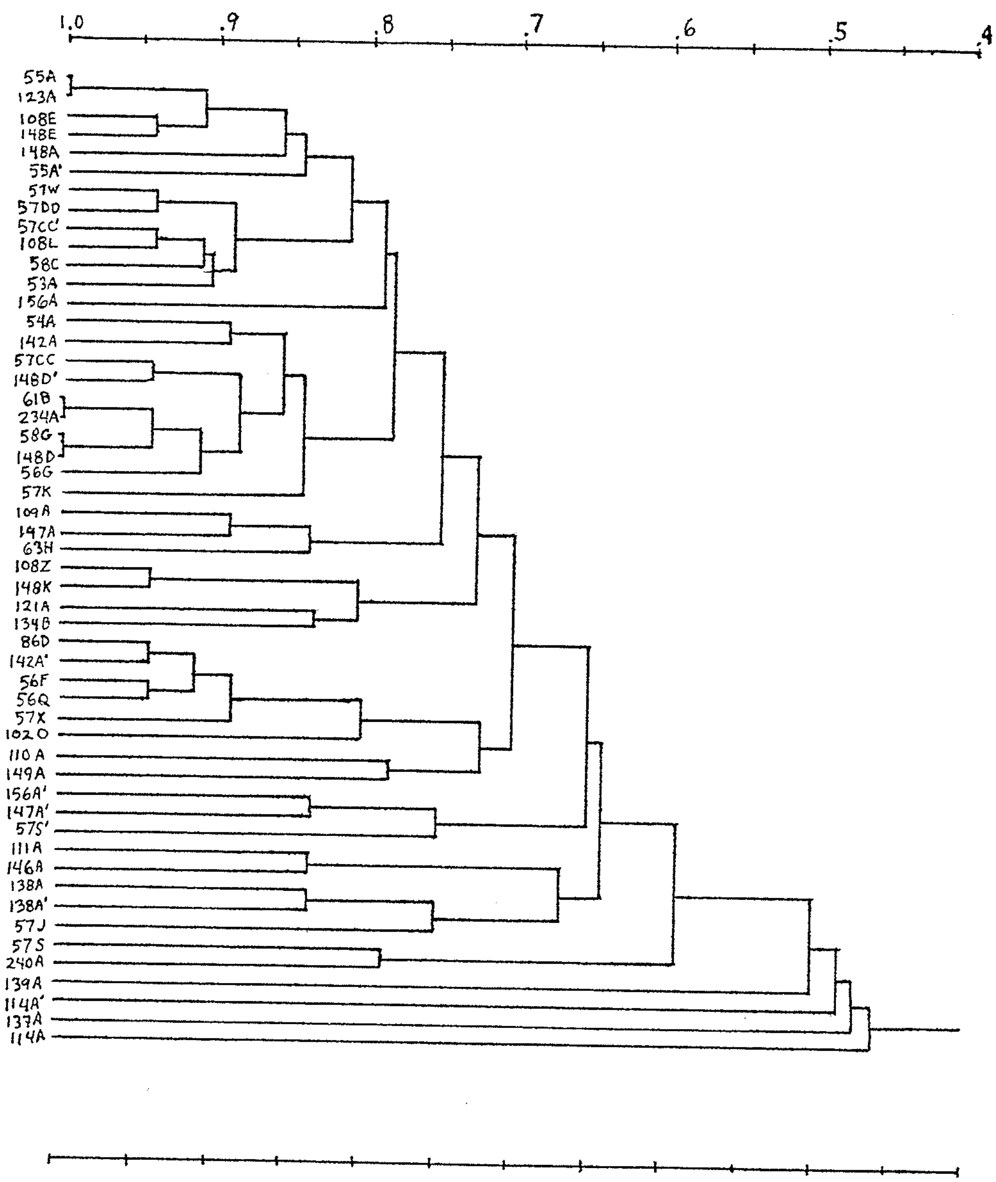


Figure 17. Dendrogram of Cluster Run Alpha

Figure 18. Merge Rate Graph of Cluster Run Alpha

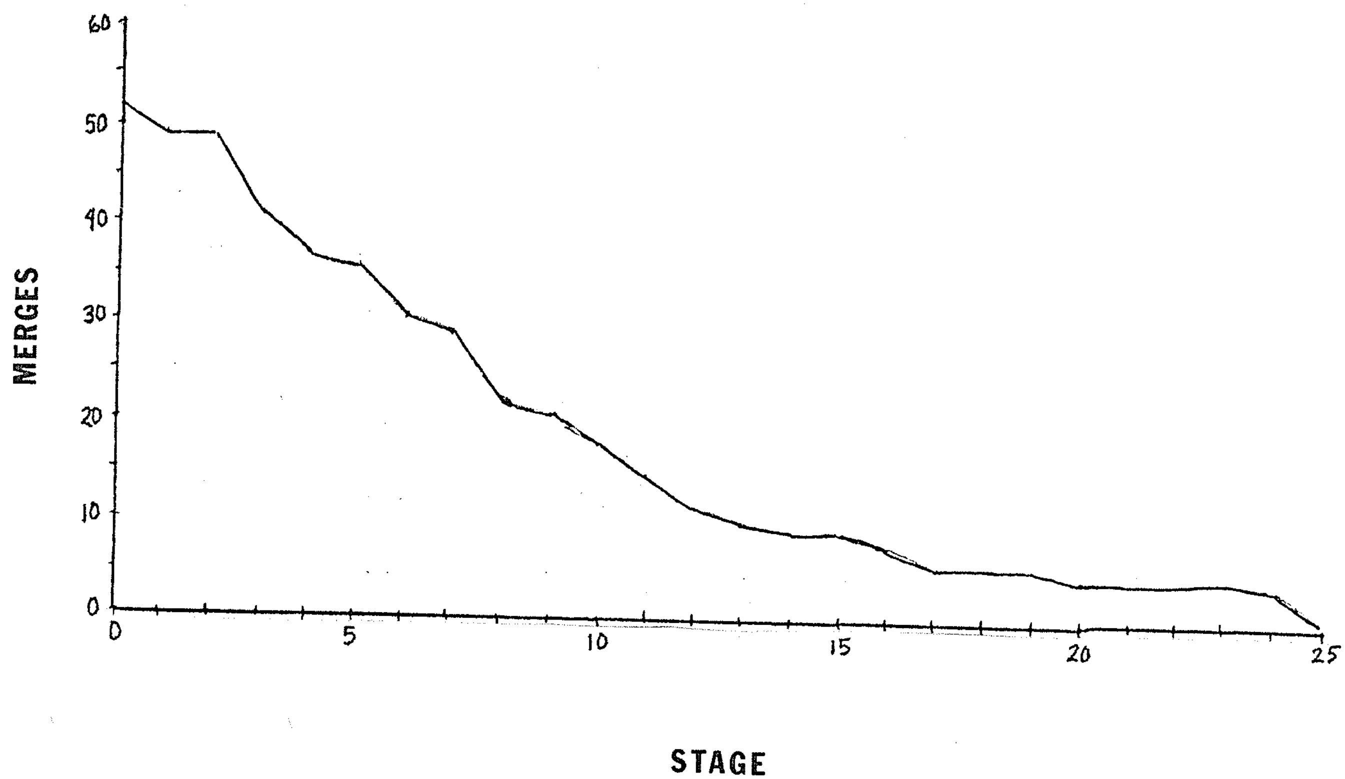
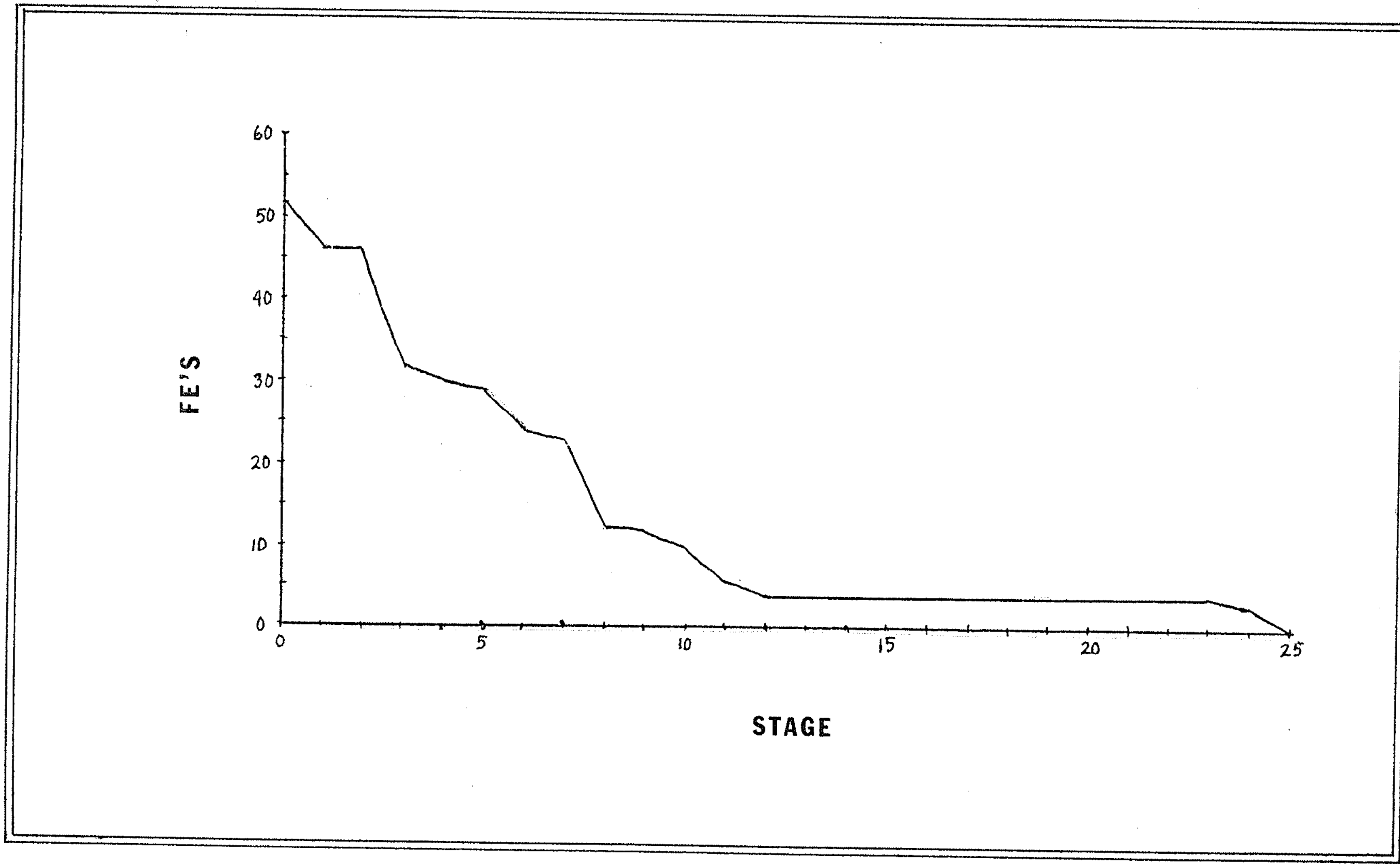


Figure 19. Absorbtion Rate Graph of Cluster Run Alpha



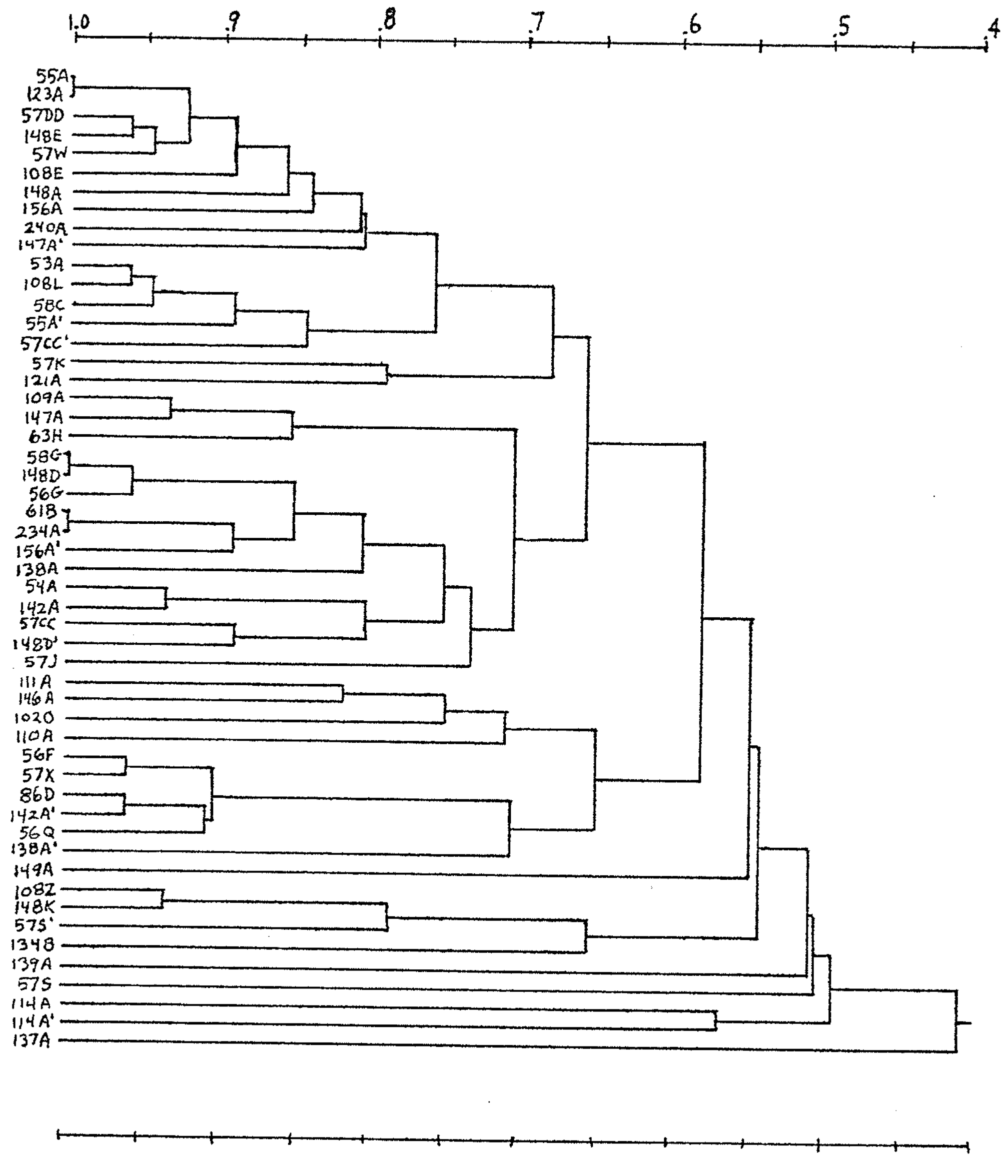


Figure 20. Dendrogram of Cluster Run Beta

Figure 21. Merge Rate Graph of Cluster Run Beta

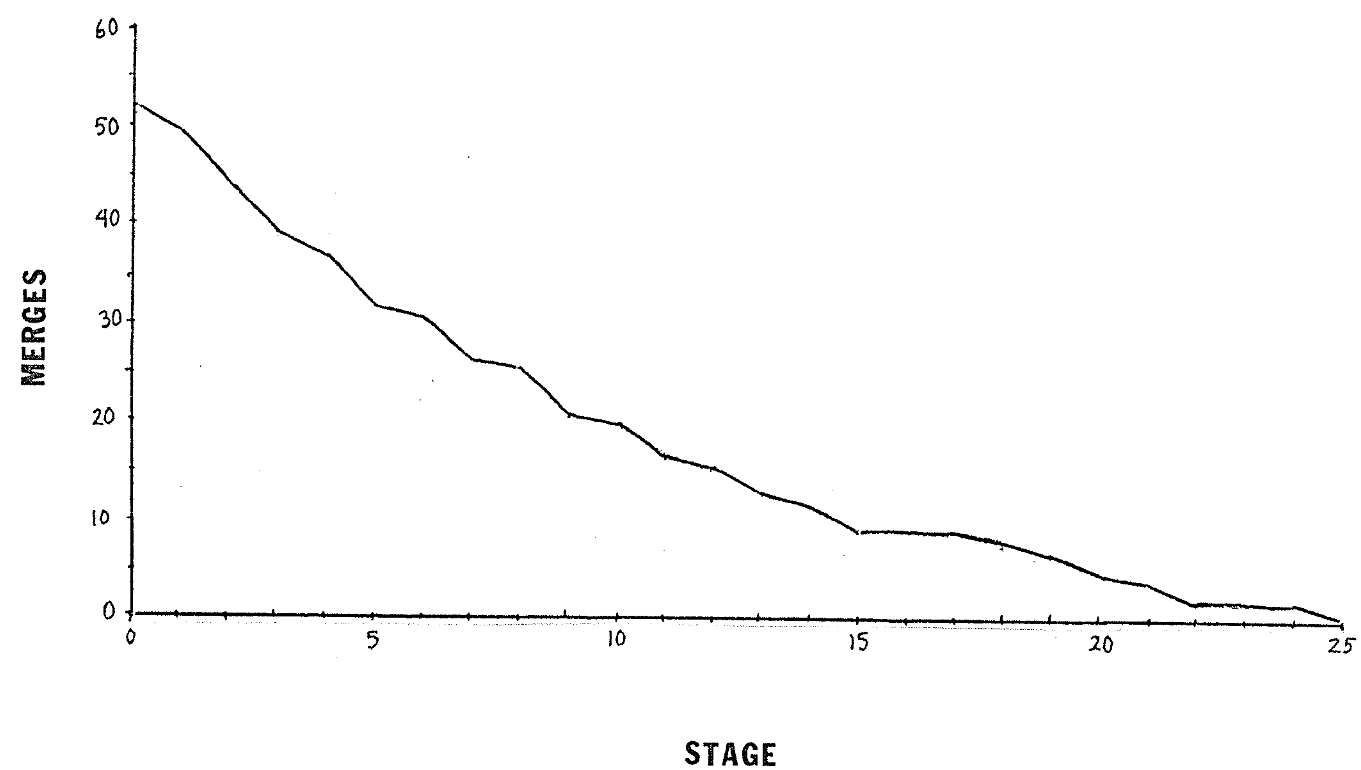
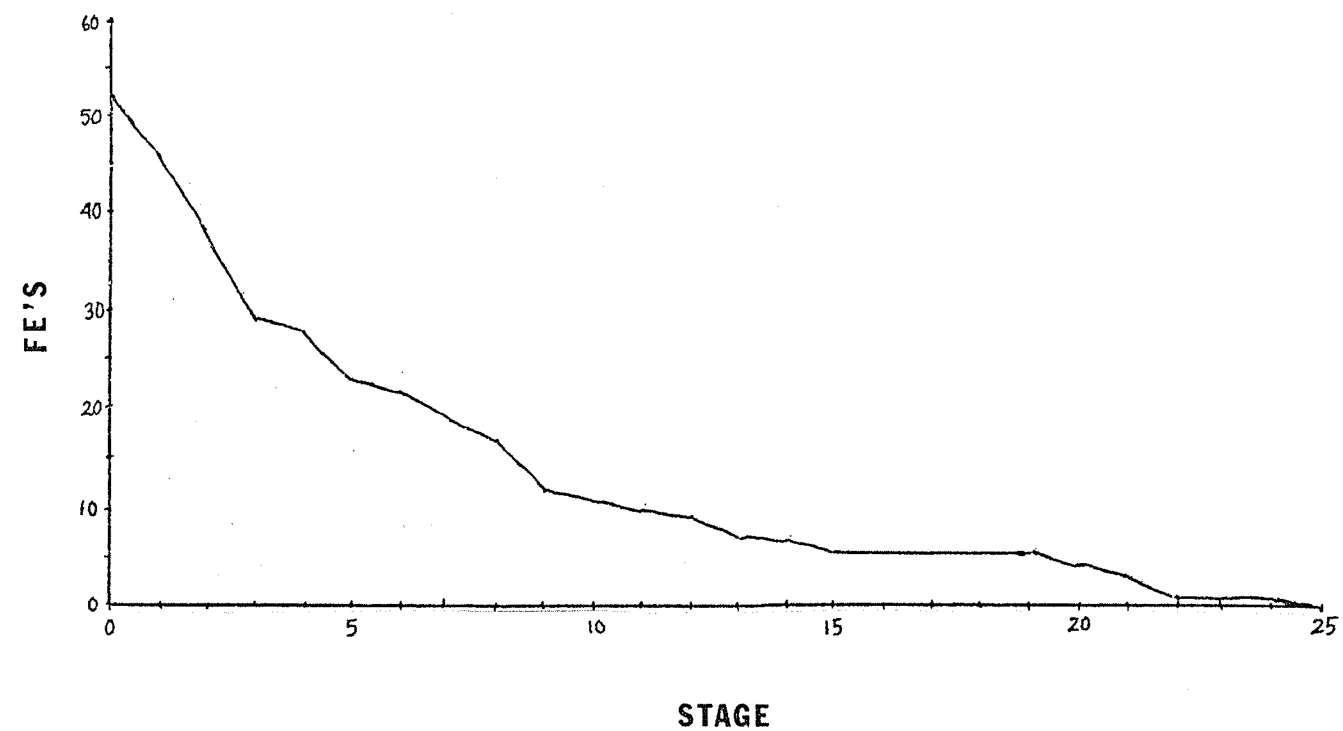


Figure 22. Absorbtion Rate Graph of Cluster Run Beta



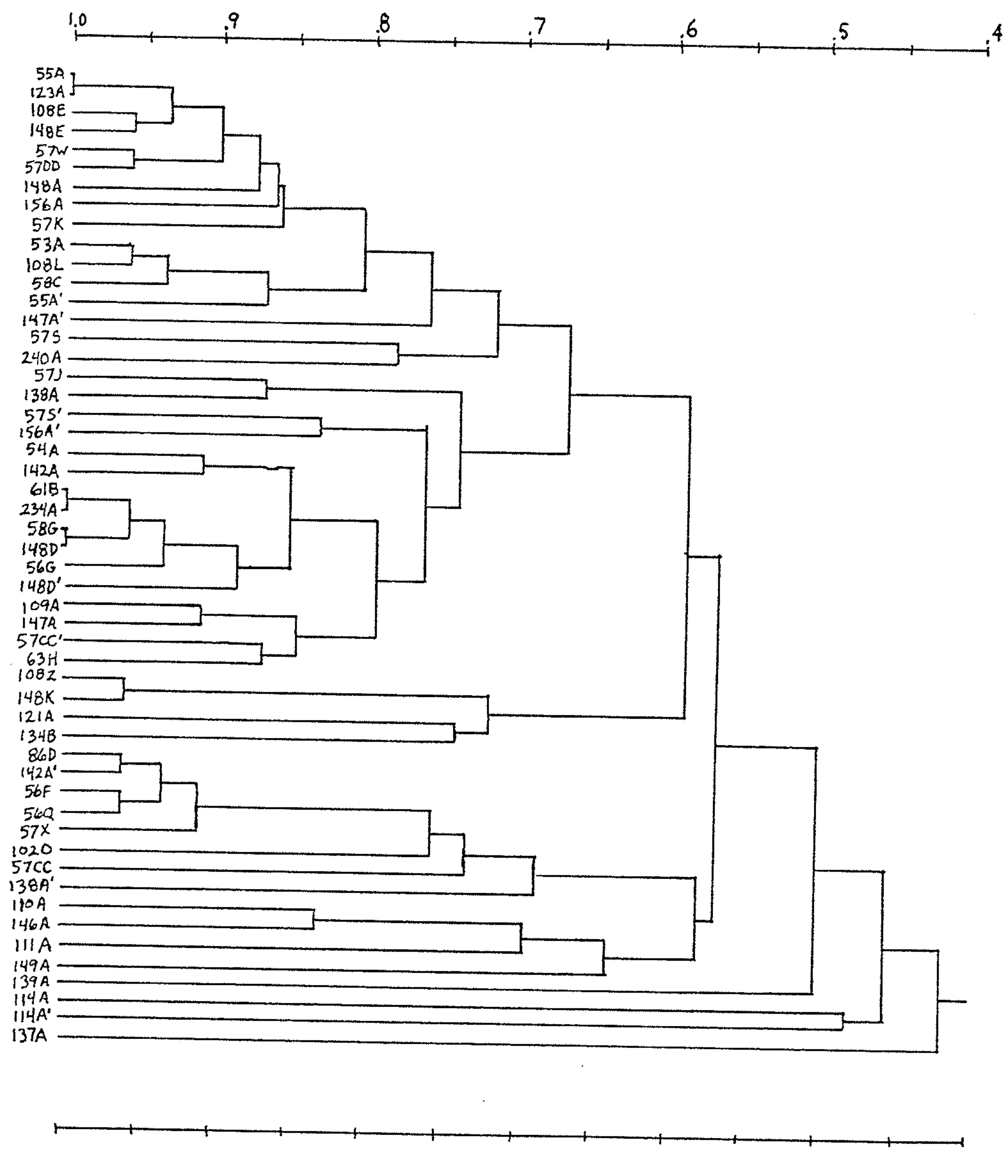


Figure 23. Dendrogram of Cluster Run Gamma

Figure 24. Merge Rate Graph of Cluster Run Gamma

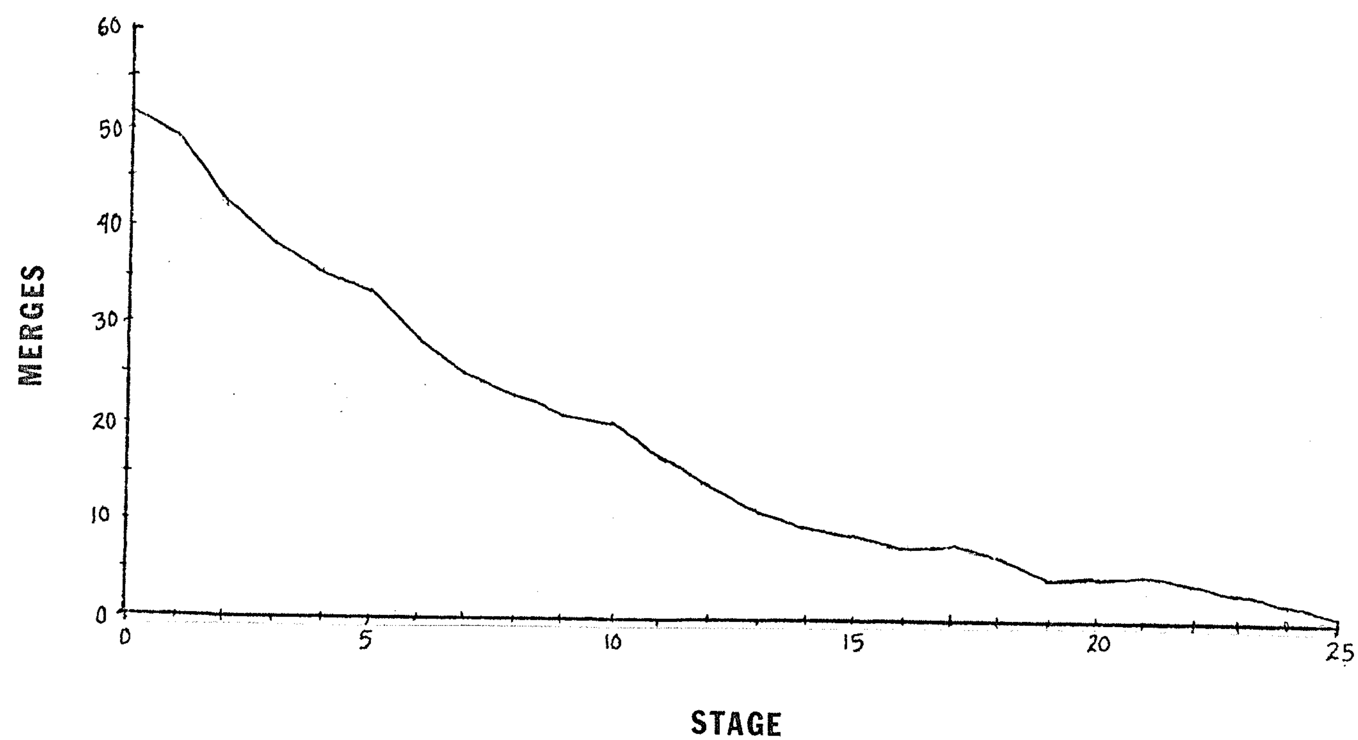


Figure 25. Absorbtion Rate Graph of Cluster Run Gamma

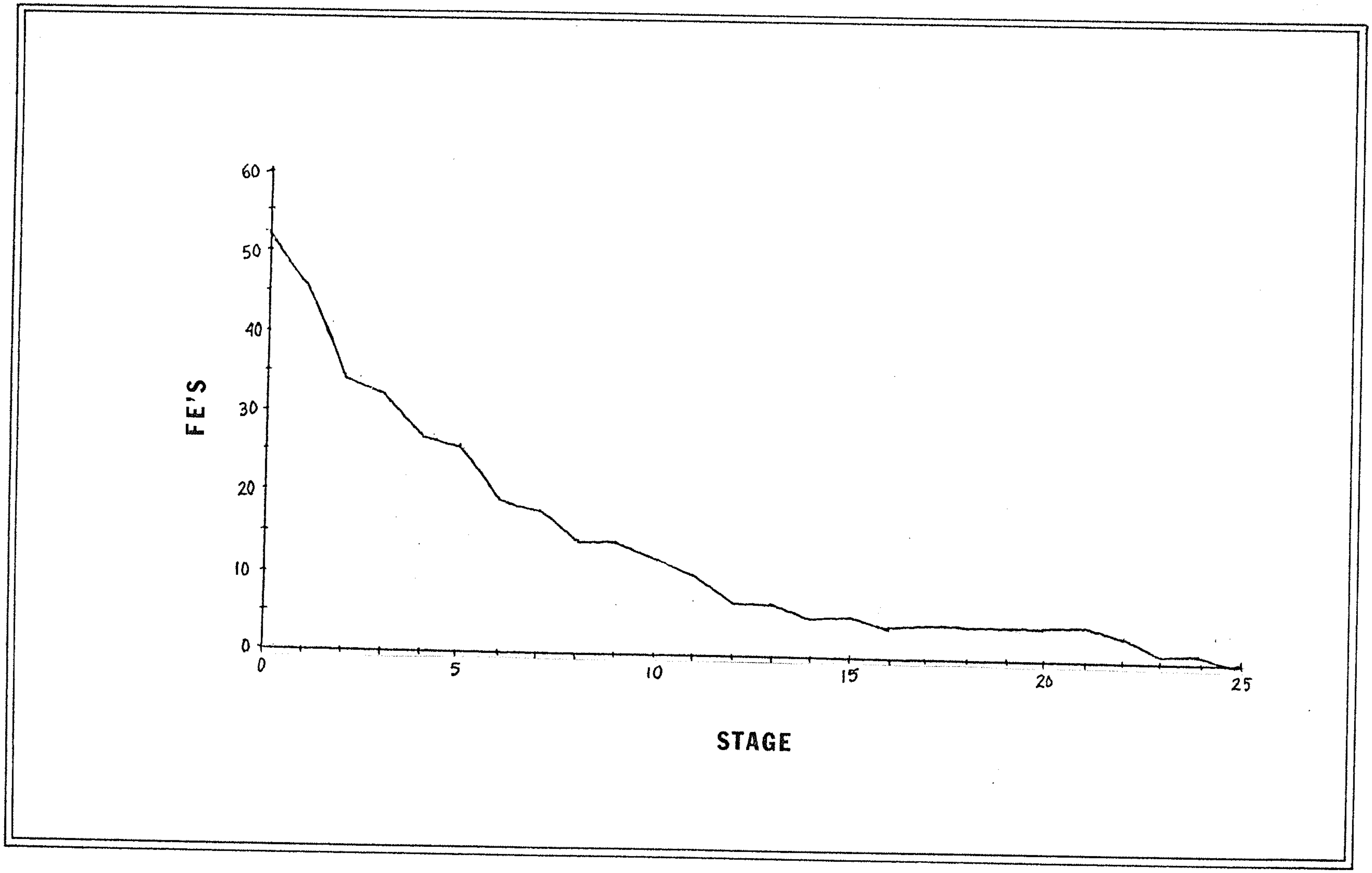


Figure 26. Plot of the Tools Derived by Cluster Analysis

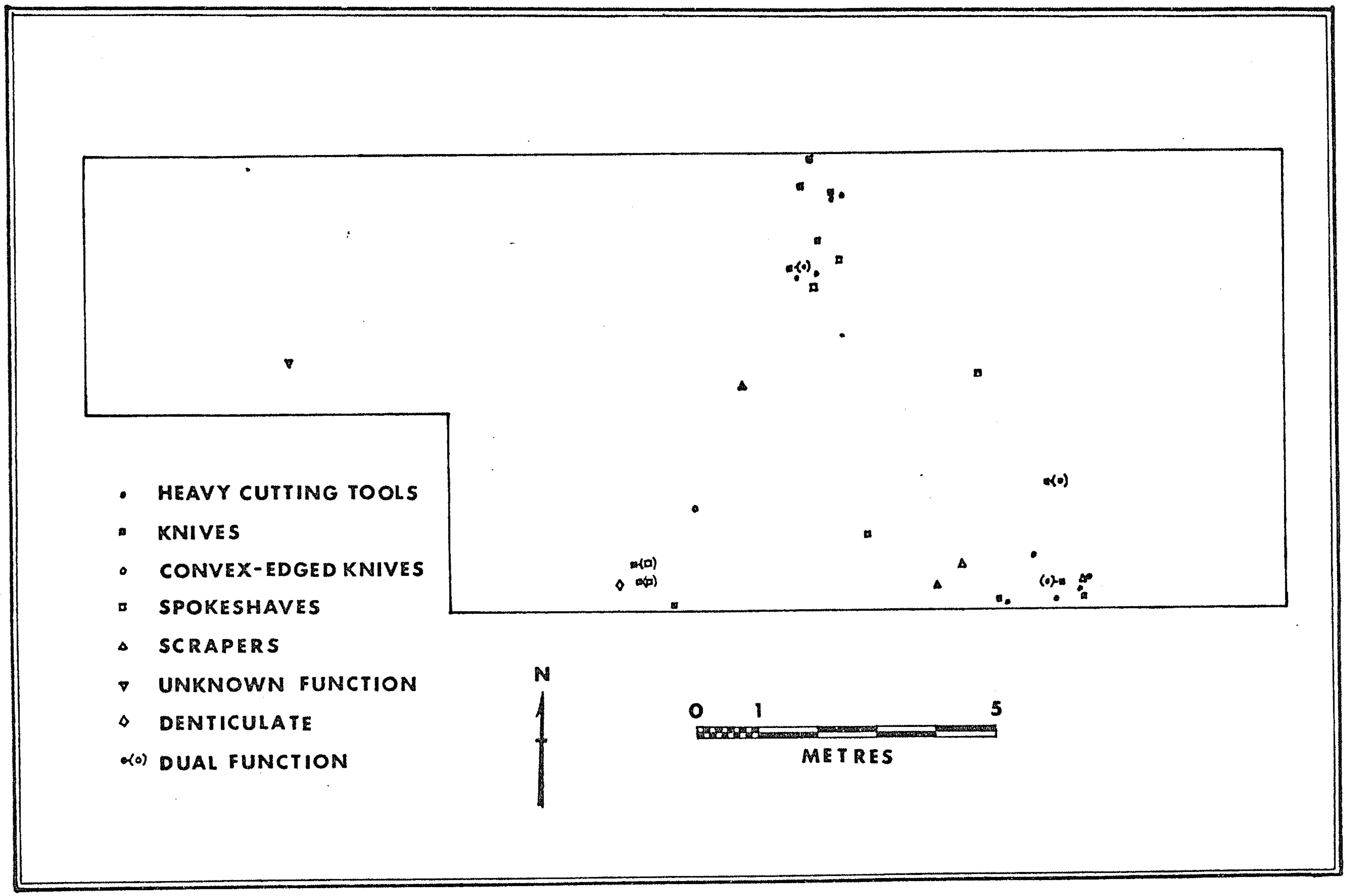


Figure 27. Plot of the Butchering Kit Tools and Activity Areas

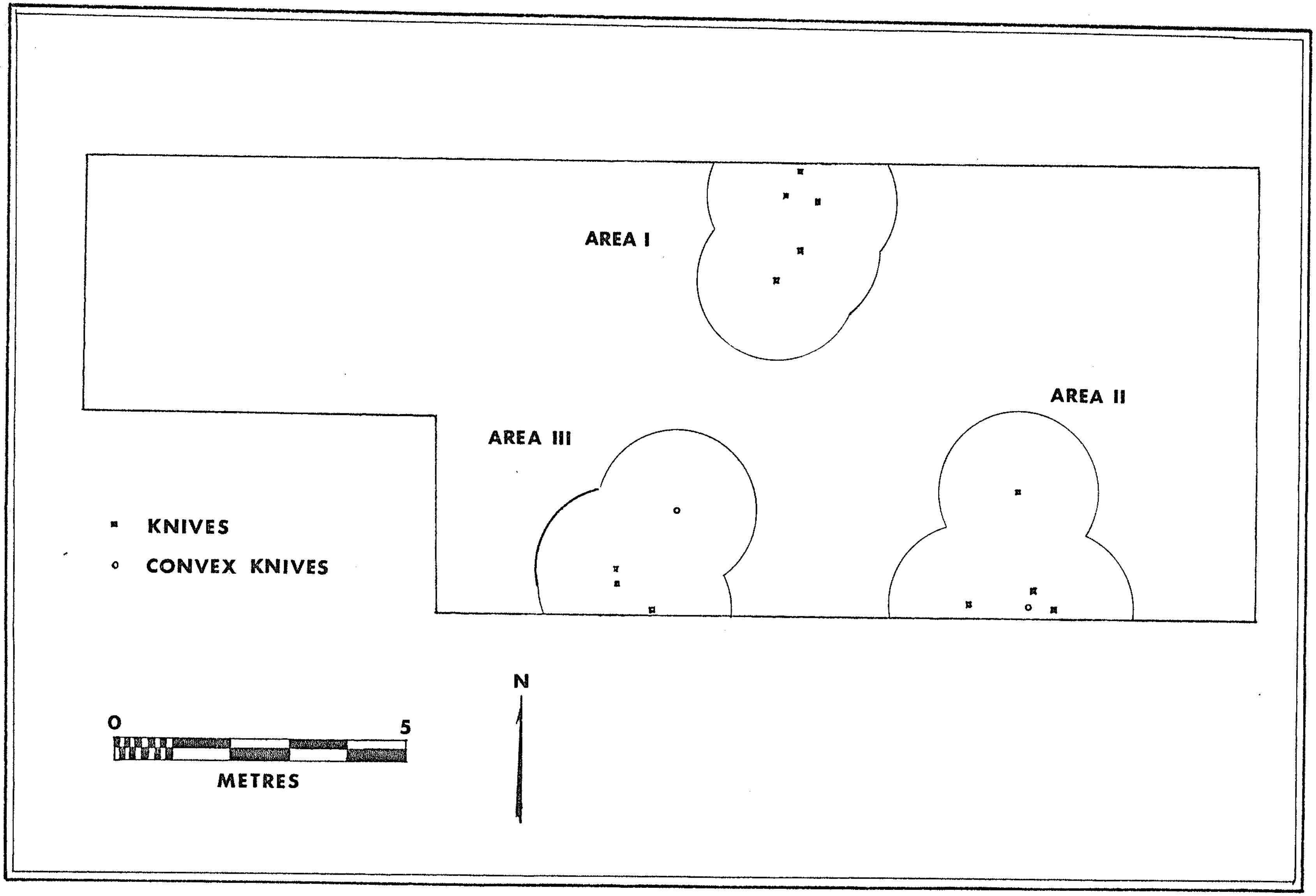


Figure 28. Plot of the Hideworking Kit I Tools and Activity Areas

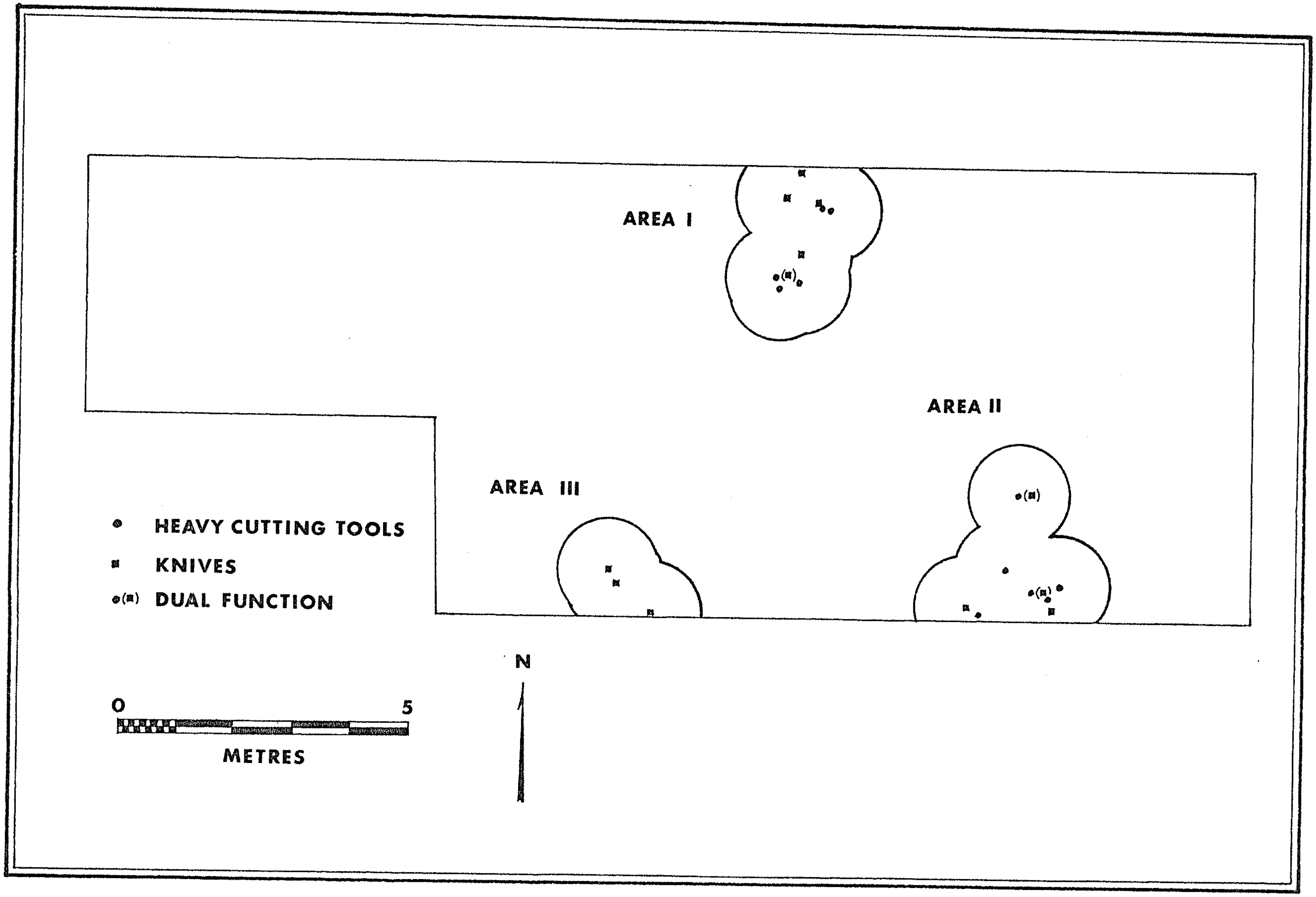


Figure 29. Plot of the Hideworking Kit II Tools and Activity Areas

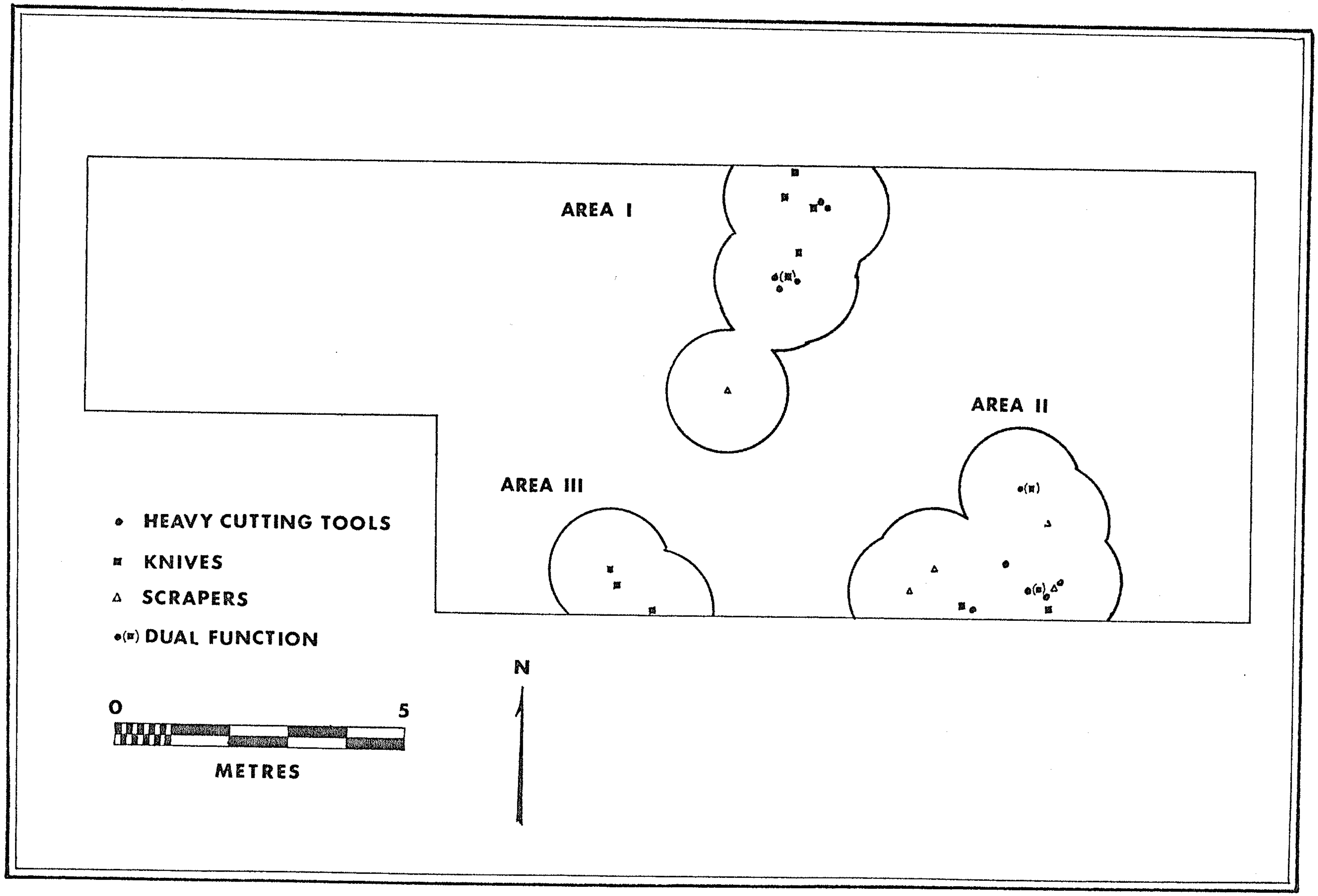
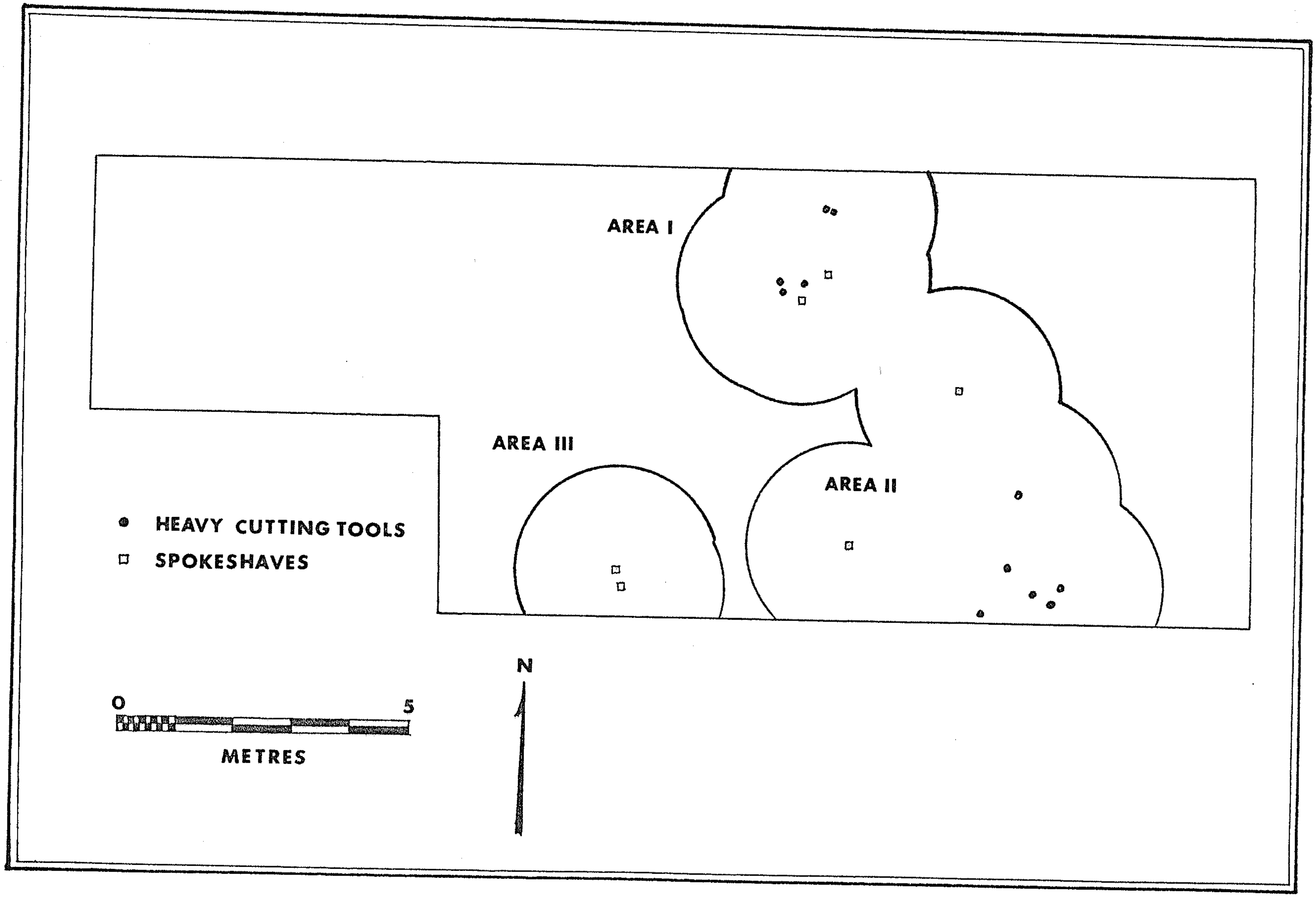
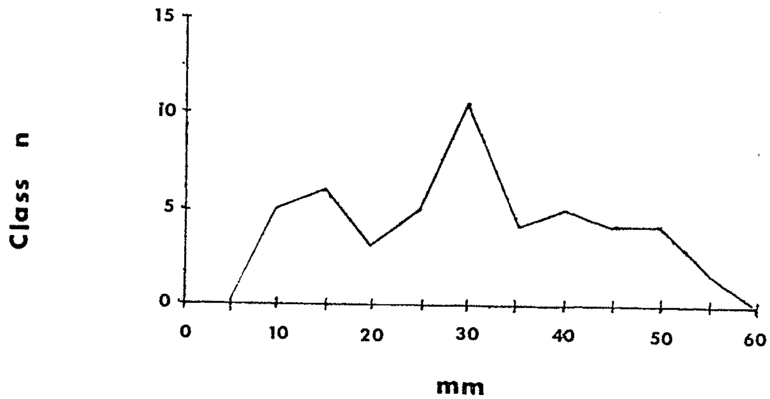


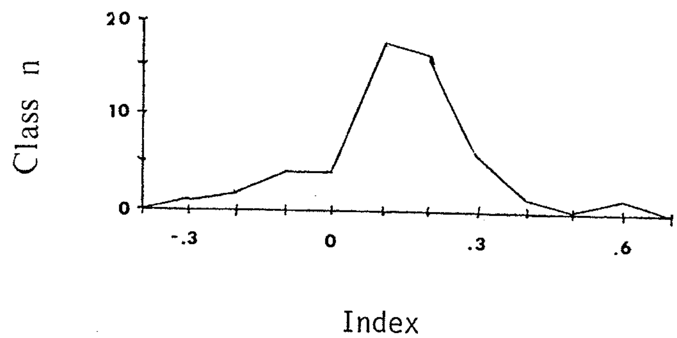
Figure 30. Plot of the Woodworking Kit Tools and Activity Areas





N = 52
$\bar{M}$ = 28.06
S = 12.8

Figure 31. Histogram of Utilized Flake Edge Length Values and Descriptive Statistics

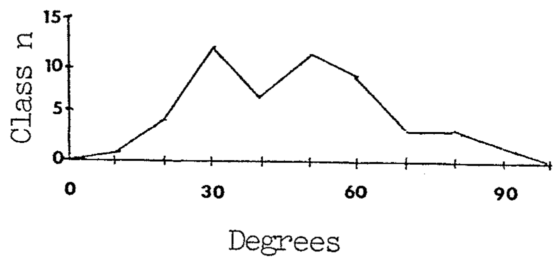


N = 52

$\bar{M}$ = .754

s = .160

Figure 32. Histogram of Utilized Flake Edge Index Values and Descriptive Statistics

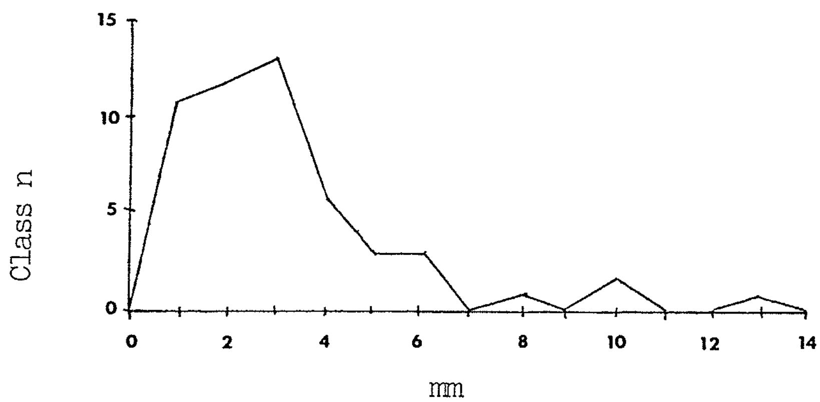


N = 52

$\overline{M}$ = 44.73

$\bar{s}$ = 19.197

Figure 33. Histogram of Utilized Flake Edge Angle Values and Descriptive Statistics

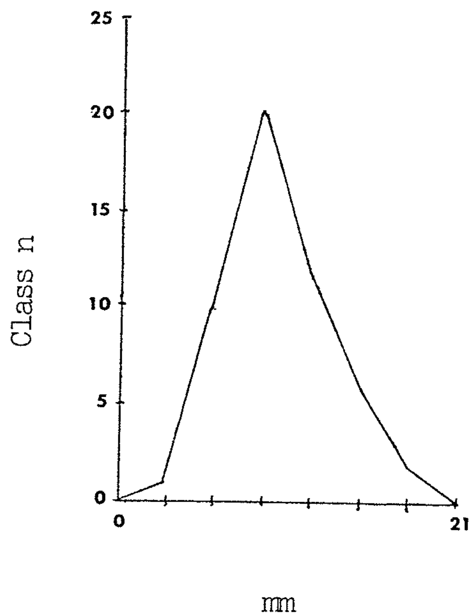


N = 52

$\overline{M}$ = 3.31

S = 2.454

Figure 34. Histogram of Utilized Flake Edge Thickness Values and Descriptive Statistics



N = 52

$\overline{M}$ = 8.96

S = 3.246

Figure 35. Histogram of Utilized Flake Thickness Values and Descriptive Statistics

Table 1. Artifacts from ElMb-10 by Excavation Units

Unit	Proj. Points	Scrapers	Cores	Hammer-stones	Incompl. Unutil. Flakes	Incompl. Util. Flakes	Compl. Unutil. Flakes	Compl. Util. Flakes	Misc.	Lime-stone Rocks	Other Rocks	Row Totals
1	1	0	0	1	9	1	2	0	0	3	1	18
2	0	0	0	2	29	0	3	0	0	86	2	122
3	0	0	0	0	2	0	0	0	0	12	0	14
4	0	0	0	0	0	0	0	0	0	25	0	25
5	0	0	0	0	0	0	0	0	0	35	0	35
6	0	0	0	0	1	0	0	0	0	15	2	18
7	0	0	0	0	2	0	1	0	0	96	2	101
8	0	0	0	1	3	1	1	0	0	50	2	58
9	1	0	0	1	24	0	5	1	0	162	17	211
10	0	0	1	0	0	0	0	0	0	155	0	156
11	0	0	0	0	29	4	7	5	0	30	0	75
12	0	0	0	0	6	1	2	0	0	31	0	40
13	0	0	0	0	1	0	0	0	0	78	1	80
14	0	1	0	0	13	3	0	3	0	143	1	164
15	0	0	0	0	3	0	0	0	0	31	3	37
16	0	0	0	1	8	2	2	2	1	71	6	93
17	0	0	0	0	0	0	0	0	0	27	9	36
18	0	0	0	0	0	0	0	0	0	5	0	5
19	0	0	0	0	2	0	0	0	0	136	13	151
21	0	0	0	0	1	0	0	1	0	33	1	36
F1	0	0	3	3	80	9	13	9	0	0	0	117
F2	0	0	4	0	0	0	1	0	0	0	0	5
Surf.	0	0	2	1	8	3	4	0	0	0	0	18
Column Totals	2	1	10	10	221	24	41	21	1	1224	60	1615

Table 2. Artifact Categories by Lithic Types (Upper Numbers are Raw Counts, Numbers in Parentheses are Relative Percentages)

Lithic Type	Proj. Points	Scrapers	Hammer-stones	Cores	Incompl. Unutil. Flakes	Incompl. Util. Flakes	Compl. Unutil. Flakes	Compl. Util. Flakes	Misc.
Indeterminate	0 0	0 0	4 (40.0)	0 0	6 (2.7)	2 (8.3)	2 (4.9)	0 0	0 0
Red S.R. Chert	0 0	0 0	0 0	4 (40.0)	7 (3.1)	1 (4.2)	4 (9.8)	0 0	0 0
Type I S.R. Chert	0 0	0 0	1 (10.0)	0 0	116 (51.5)	13 (54.2)	16 (39.0)	16 (76.2)	0 0
Piebald S.R. Chert	0 0	0 0	0 0	0 0	8 (3.6)	0 0	2 (4.9)	0 0	0 0
Cathead Chert	0 0	0 0	1 (10.0)	5 (50.0)	25 (11.1)	1 (4.2)	4 (9.8)	1 (4.8)	1 (100.0)
Quartzite	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
Granitic	0 0	0 0	4 (40.0)	0 0	0 0	0 0	0 0	0 0	0 0
Coarse S.R. Chert	0 0	0 0	0 0	0 0	15 (6.7)	0 0	1 (2.4)	0 0	0 0
Yellow Chert	2 (100.0)	0 0	0 0	1 (10.0)	10 (4.4)	0 0	0 0	0 0	0 0
Type II S.R. Chert	0 0	1 (100.0)	0 0	0 0	38 (16.9)	7 (29.1)	12 (29.3)	4 (19.0)	0 0
Total	2 (100.0)	1 (100.0)	10 (100.0)	10 (100.0)	225 (100.0)	24 (100.0)	41 (100.1)	21 (100.0)	1 (100.0)

Lithic Type	Utilized Flakes	Unutilized Flakes
Indeterminate	2	8
Red S.R. Chert	1	11
Type I S.R. Chert	29	131
Piebald S.R. Chert	0	9
Cathead Chert	2	28
Quartzite	0	0
Granitic	0	0
Coarse S.R. Chert	0	16
Yellow Chert	0	10
Type II S.R. Chert	11	47
Total	45	262

Table 3. Raw Counts of Lithic Types for Utilized and Unutilized Flakes

Lithic Type	Unutilized Flakes	Utilized Flakes
Indeterminate	0	
Red S.R. Chert	3.1	4.5
Type I S.R. Chert	4.2	2.2
Piebald S.R. Chert	50.0	64.4
Cathead Chert	3.4	0
Quartzite	0	0
Granitic	0	0
Coarse S.R. Chert	6.1	0
Yellow Chert	3.8	0
Type II S.R. Chert	18.7	24.4
Total	100.0	100.0

Table 4. Relative Percentages of Lithic Types for Utilized and Unutilized Flakes

	1	...	...	...	...	...	....
	2	S_{21}	...	...	...	...	....
	3	S_{31}	S_{32}	...	...	...	....
	4	S_{41}	S_{42}	S_{43}	...	...	....
Item	.	.	.	.	.		
	.	.	.	.	.		
	.	.	.	.	.		
	n	S_{n1}	S_{n2}	S_{n3}	S_{n4}	...	$S_{n(n-1)}$
		1	2	3	4	...	n
				Item			

Table 5. Sample Similarity Matrix

		E.257 Clusters								
		1	2	3	4	5	6	7	8	Total
B.183 Clusters	1	38	0	2	0	0	0	0	0	40
	2	0	0	2	0	0	0	0	0	2
	3	0	2	0	0	0	0	0	0	2
	4	0	0	0	2	2	0	0	0	4
	5	0	0	10	0	0	0	0	0	10
	6	0	0	0	0	1	0	0	0	1
	7	0	0	0	0	0	1	0	0	1
	8	0	0	0	0	0	0	1	0	1
	9	0	0	0	0	0	0	0	1	1
	Total	38	2	14	2	3	1	1	1	62

Table 6. Contingency Table for E.257 and B.183 Clusters

		B.183 Clusters									
		1	2	3	4	5	6	7	8	9	Total
F.251 Clusters	1	40	2	2	0	0	0	0	0	0	44
	2	0	0	0	4	10	0	0	0	0	14
	3	0	0	0	0	0	1	0	0	0	1
	4	0	0	0	0	0	0	1	0	0	1
	5	0	0	0	0	0	0	0	1	0	1
	6	0	0	0	0	0	0	0	0	1	1
	Total	40	2	2	4	10	1	1	1	1	62

Table 7. Contingency Table for B.183 and F.251 Clusters

		E.257 Clusters								
		1	2	3	4	5	6	7	8	Total
	1	38	2	4	0	0	0	0	0	44
	2	0	0	10	2	2	0	0	0	14
	3	0	0	0	0	1	0	0	0	1
F.251 Clusters	4	0	0	0	0	0	1	0	0	1
	5	0	0	0	0	0	0	1	0	1
	6	0	0	0	0	0	0	0	1	1
	Total	38	2	14	2	3	1	1	1	62

Table 8. Contingency Table for E.257 and F.251 Clusters

F.251 Clusters

		1	not 1	Total	
Attribute 5 States	0,2	36	12	48	A
	3	8	6	14	
	Total	44	18	62	

		1	not 1	Total	
Attribute 5 States	2	22	6	28	B
	0,3	22	12	34	
	Total	44	18	62	$X^2 = 1.39$

		1	not 1	Total	
Attribute 5 States	2	22	6	28	C
	3	8	6	14	
	Total	30	12	42	

Table 9. Contingency Tables for F.251 Cluster and Attribute 5 Combinations

		F.251 Clusters		
		1	not 1	Total
Attribute 3 States	5,6	26	9	35
	not 5,6	18	9	27
	Total	44	18	62

$X^2 = 0.46$

Table 10. Contingency Table for F.251 Cluster and Attribute 3

		F.251 Clusters				
		1	not 1	Total		
Attribute 12 States	1	37	4	41	$X^2 = 21.81$	A
	not 1	7	14	21		
	Total	44	18	62		

		2	not 2	Total	
Attribute 12 States	2	10	4	14	B
	not 2	4	44	48	
	Total	14	48	62	

Table 11. Contingency Tables for F.251 Clusters and Attribute 12 Combinations

		F.251 Clusters		
		1	not 1	Total
Attribute 13 States	1,2	40	5	45
	not 1,2	4	13	17
	Total	44	18	62

Table 12. Contingency Table for F.251 Clusters and Attribute 13

		F.251 Clusters		
		1	not 1	Total
Attribute 16 States	1,2	24	3	27
	not 1,2	20	15	35
	Total	44	18	62

$X^2 = 7.34$

Table 13. Contingency Table for F.251 Clusters and Attribute 16

		F.251 Clusters		
		1	not 1	Total
Attribute 17 States	1,2	44	6	50
	not 1,2	0	12	12
	Total	44	18	62

Table 14. Contingency Table of F.251 Clusters and Attribute 17

		F.251 Clusters		
		1	not 1	Total
Attribute 20 States	1,2	38	3	41
	not 1,2	6	15	21
	Total	44	18	62

$X^2 = 27.68$

Table 15. Contingency Table of F.251 Clusters and Attribute 20

		Utilized Flakes	Unutilized Flakes	Total
F.251 Clusters	1	15	29	44
	2	6	8	14
	Total	21	37	58

$$X^2 = 0.353$$

Table 16. Contingency Table of F.251 Clusters, Utilized Flakes and Unutilized Flakes

		Alpha.741 Clusters												
		1	2	3	4	5	6	7	8	9	10	11	12	Total
	1	13	0	0	0	1	0	0	2	0	0	0	0	16
	2	12	0	0	0	2	0	2	0	0	0	0	0	16
	3	0	4	0	0	0	0	0	0	0	0	0	0	4
	4	1	0	6	0	0	0	1	0	0	0	0	0	8
	5	0	0	0	1	0	2	0	0	0	0	0	0	3
Gamma.674 Clusters	6	0	0	0	1	0	0	0	0	0	0	0	0	1
	7	0	0	0	0	0	0	0	0	1	0	0	0	1
	8	0	0	0	0	0	0	0	0	0	0	0	1	1
	9	0	0	0	0	0	0	0	0	0	1	0	0	1
	10	0	0	0	0	0	0	0	0	0	0	1	0	1
	Total	26	4	6	2	3	2	3	2	1	1	1	1	52

Table 17. Contingency Table of Alpha.741 and Gamma .674 Clusters

		Alpha.741 Clusters												
		1	2	3	4	5	6	7	8	9	10	11	12	Total
	1	26	1	0	0	2	0	2	1	0	0	0	0	32
	2	0	0	6	1	0	2	1	0	0	0	0	0	10
	3	0	0	0	1	0	0	0	0	0	0	0	0	1
	4	0	3	0	0	1	0	0	0	0	0	0	0	4
Beta.646 Clusters	5	0	0	0	0	0	0	0	0	1	0	0	0	1
	6	0	0	0	0	0	0	0	1	0	0	0	0	1
	7	0	0	0	0	0	0	0	0	0	0	0	1	1
	8	0	0	0	0	0	0	0	0	1	0	0	0	1
	9	0	0	0	0	0	0	0	0	0	1	0	0	1
	Total	26	4	6	2	3	2	3	2	1	1	1	1	52

Table 18. Contingency Table of Alpha.741 and Beta.646 Clusters

		Gamma.674 Clusters										
		1	2	3	4	5	6	7	8	9	10	Total
	1	15	15	1	1	0	0	0	0	0	0	32
	2	0	0	0	7	3	0	0	0	0	0	10
	3	0	0	0	0	0	1	0	0	0	0	1
	4	0	1	3	0	0	0	0	0	0	0	4
Beta.646 Clusters	5	0	0	0	0	0	0	1	0	0	0	1
	6	1	0	0	0	0	0	0	0	0	0	1
	7	0	0	0	0	0	0	0	1	0	0	1
	8	0	0	0	0	0	0	0	0	1	0	1
	9	0	0	0	0	0	0	0	0	0	1	1
	Total	16	16	4	8	3	1	1	1	1	1	52

Table 19. Contingency Table of Gamma.674 and Beta.646 Clusters

Table 20. Attribute Summary for the Gamma.674 Clusters
(the Attributes are described in Appendix B)

Gamma.674 Clusters	N	Attributes 1* s range	2 s range	3 s range	4 s range	5 P	6 P	7 P	8 P	9 P	10 P	11 P	12 P	13 P	14 P	15 P	16 P	17 s range	18 R	18 I	18 D
1	16	26 to 44 mm	+.01 to +.14	43 to 59^{0}	1.1 to 7.3 mm	2	0	16	7	1	3	5	4	0	0	5	2	7 to 12 mm	15	1	0
2	16	17 to 40 mm	+.02 to +.15	18 to 32^{0}	0.9 to 2.5 mm	3	2	16	8	2	2	4	1	0	0	2	0	6 to 12 mm	8	8	0
3	4	20 to 46 mm	+.19 to +.49	26 to 64^{0}	1.4 to 3.6 mm	0	0	4	3	0	0	0	0	0	0	0	0	3 to 11 mm	0	4	0
4	8	8 to 20 mm	-.26 to -.13	39 to 63^{0}	2.2 to 5.6 mm	3	1	8	1	0	0	0	0	0	0	2	0	5 to 14 mm	7	1	0
5	3	16 mm 30 mm	+.19 to +.26 to	70 to 75^{0}	1.0 to 5.0 mm	2	2	3	1	0	0	0	0	0	0	3	1	6 to 8 mm	3	0	0
6	1	36 mm	+.22	70^{0}	10.0 mm	0	0	1	0	0	0	0	0	0	0	1	0	16 mm	0	1	0
7	1	19 mm	+.07	27^{0}	3.0 mm	0	0	1	0	1	1	0	0	1	1	0	1	5 mm	1	0	0
8	1	9 mm	+.16	90^{0}	6.0 mm	0	0	0	1	0	0	0	0	0	0	0	0	8 mm	1	0	0
9	1	9 mm	+.02	90^{0}	6.0 mm	0	0	1	0	0	0	0	0	0	0	0	0	8 mm	1	0	0
10	1	44 mm	+.29	25^{0}	2.0 mm	1	1	1	1	0	0	1	1	0	0	1	1	8 mm	0	0	1

* all ranges presented for metric attributes are based on one standard deviation 's' about the sample mean

all values presented for the categorical attributes are the raw counts per sample of present 'P', regular 'R', irregular 'I' and denticulate 'D'

Table 21. Nearest-Neighbour Analysis Results for the Tool Combinations

Tool Combination	N	Area	Density	r_e	r_o	R	Clark and Evans' z	X^2	X^2 z	5% Cutoff Distance
Butchering	14	1325000	.0000106	153.82	65.69	.427	-4.10	5.62	-4.06	134.40
Hideworking I	20	1325000	.0000151	128.69	36.89	.287	-6.10	4.06	-6.04	82.96
Hideworking II	25	1325000	.0000189	115.11	40.91	.355	-6.17	9.40	-5.61	104.74
Woodworking	17	1325000	.0000128	139.59	61.34	.439	-4.42	11.75	-3.34	175.76
Plant Product Processing	12	1325000	.0000091	166.15	86.69	.522	-3.17	21.44	-0.31	NONE
Flintknapping	7	1325000	.0000053	217.54	238.73	1.08	+0.49	26.90	+2.14	NONE

Table 22. Nearest-Neighbour Analysis Results for the Rock Structure

N	Area	Density	r_e	r_o	R	Clark and Evans' z	X^2	X^2 z
1284	1325000	.000969	16.06	12.33	.767	-15.95	2433.32	-1.90

Table 23. Descriptive Statistics for Rock Weights in Units 13 and 14

Sample drawn from:	N	Total Weight*	Average Weight*	Sum of Squared Weights	S.D. S.D
Excavation Unit 13	79	3040	38.48	441686	64.11
Rock Structure in Excavation Unit 14	157	16342	104.09	7699316	195.46

* all weights in grams

Table 20. Attribute Summary for the Gamma.674 Clusters
(the Attributes are described in Appendix B)

Gamma.674 Clusters	N	Attributes 1* s range	2 s range	3 s range	4 s range	5 P	6 P	7 P	8 P	9 P	10 P	11 P	12 P	13 P	14 P	15 P	16 P	17 s range	18 R	18 I	18 D
1	16	26 to 44 mm	+.01 to +.14	43 to 59°	1.1 to 7.3 mm	2	0	16	7	1	3	5	4	0	0	5	2	7 to 12 mm	15	1	0
2	16	17 to 40 mm	+.02 to +.15	18 to 32°	0.9 to 2.5 mm	3	2	16	8	2	2	4	1	0	0	2	0	6 to 12 mm	8	8	0
3	4	20 to 46 mm	+.19 to +.49	26 to 64°	1.4 to 3.6 mm	0	0	4	3	0	0	0	0	0	0	0	0	3 to 11 mm	0	4	0
4	8	8 to 20 mm	-.26 to -.13	39 to 63°	2.2 to 5.6 mm	3	1	8	1	0	0	0	0	0	0	2	0	5 to 14 mm	7	1	0
5	3	16 mm 30 mm	+.19 to +.26 to	70 to 75°	1.0 to 5.0 mm	2	2	3	1	0	0	0	0	0	0	3	1	6 to 8 mm	3	0	0
6	1	36 mm	+.22	70°	10.0 mm	0	0	1	0	0	0	0	0	0	0	1	0	16 mm	0	1	0
7	1	19 mm	+.07	27°	3.0 mm	0	0	1	0	1	1	0	0	1	1	0	1	5 mm	1	0	0
8	1	9 mm	+.16	90°	6.0 mm	0	0	0	1	0	0	0	0	0	0	0	0	8 mm	1	0	0
9	1	9 mm	+.02	90°	6.0 mm	0	0	1	0	0	0	0	0	0	0	0	0	8 mm	1	0	0
10	1	44 mm	+.29	25°	2.0 mm	1	1	1	1	0	0	1	1	0	0	1	1	8 mm	0	0	1

* all ranges presented for metric attributes are based on one standard deviation 's' about the sample mean

all values presented for the categorical attributes are the raw counts per sample of present 'P', regular 'R', irregular 'I' and denticulate 'D'

Table 21. Nearest-Neighbour Analysis Results for the Tool Combinations

Tool Combination	N	Area	Density	r_e	r_o	R	Clark and Evans' z	X^2	X^2 z	5% Cutoff Distance
Butchering	14	1325000	.0000106	153.82	65.69	.427	-4.10	5.62	-4.06	134.40
Hideworking I	20	1325000	.0000151	128.69	36.89	.287	-6.10	4.06	-6.04	82.96
Hideworking II	25	1325000	.0000189	115.11	40.91	.355	-6.17	9.40	-5.61	104.74
Woodworking	17	1325000	.0000128	139.59	61.34	.439	-4.42	11.75	-3.34	175.76
Plant Product Processing	12	1325000	.0000091	166.15	86.69	.522	-3.17	21.44	-0.31	NONE
Flintknapping	7	1325000	.0000053	217.54	238.73	1.08	+0.49	26.90	+2.14	NONE

Table 22. Nearest-Neighbour Analysis Results for the Rock Structure

N	Area	Density	r_e	r_o	R	Clark and Evans' z	X^2	X^2 z
1284	1325000	.000969	16.06	12.33	.767	-15.95	2433.32	-1.90

Table 23. Descriptive Statistics for Rock Weights in Units 13 and 14

Sample drawn from:	N	Total Weight*	Average Weight*	Sum of Squared Weights	S.D. S.D
Excavation Unit 13	79	3040	38.48	441686	64.11
Rock Structure in Excavation Unit 14	157	16342	104.09	7699316	195.46

* all weights in grams

Table 24. (continued)

Flake Number	Plate	Prov.* South	Prov.* East	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
137A	15K	714	884	1	9	0	3	3	0	3	0	7	5	3	1	1	4	7	3	1	1	4	2	4
138A	14F	685	907	1	2	3	2	2	0	4	5	7	3	3	1	2	4	6	2	2	2	4	2	3
143E	10P	735	961	1	9	6	2	2	0	4	0	0	3	2	1	2	1	7	2	1	4	4	2	4
143F	10J	737	978	1	9	0	3	3	0	3	3	2	2	3	1	1	2	6	2	2	4	4	3	4
146A	15G	709	1662	1	2	6	3	2	4	4	0	7	2	3	2	3	2	5	2	1	2	3	2	1
147A	15J	715	1623	1	2	6	3	0	4	4	3	4	7	2	1	1	4	8	3	2	1	1	2	2
148K	15C	742	1613	1	9	0	2	3	3	3	2	3	7	2	2	3	3	7	3	3	4	4	3	4
149A	15A	383	1095	1	4	6	2	3	0	4	2	5	5	2	4	4	1	7	3	4	4	2	4	1
156A	14I	551	1597	1	2	5	2	3	4	4	5	3	3	3	1	1	2	8	3	2	5	4	3	7
235A	10M	000	0000	1	2	0	3	3	0	4	0	2	2	2	1	1	3	7	1	1	1	3	1	2
243A	10N	000	0000	1	4	6	3	0	3	4	0	3	0	2	1	2	1	8	2	1	3	3	2	6
245A	11M	000	0000	1	2	5	3	3	0	3	0	3	2	3	1	1	3	7	3	1	4	4	2	5

* 000 and 0000 indicates surface collection or no provenience

Table 24. Attribute Values for All Complete Flakes
(the Attributes are described in Appendix A)

Flake Number	Plate	Prov.* South	Prov.* East	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
53A	14D	72	1262	1	2	5	0	0	4	4	0	3	2	3	1	1	3	7	5	1	2	3	2	5
54A	14A	144	1214	1	9	3	2	2	4	2	0	3	2	3	2	2	2	8	3	2	5	2	2	2
56B	10B	136	1262	1	1	5	0	2	0	4	0	2	6	3	1	1	2	8	4	1	3	3	3	8
56F	14C	218	1212	1	2	6	2	0	2	4	2	5	7	2	2	4	1	8	3	2	5	2	2	5
56W	9F	178	1157	1	2	6	3	3	3	3	2	7	7	2	5	5	1	6	4	5	6	2	6	1
57B	10I	000	0000	1	2	6	3	0	0	4	0	0	0	0	1	1	0	0	0	0	0	0	0	0
57C	9A	165	1202	1	2	3	3	0	0	4	5	5	5	3	3	4	3	8	9	4	4	1	4	3
57E	9G	000	0000	1	2	0	2	2	4	4	3	2	7	2	2	3	2	8	3	3	5	3	3	2
57I	9H	218	1193	1	2	6	2	2	0	4	2	5	5	2	2	3	2	1	2	2	4	5	3	8
57K	14B	000	0000	1	2	5	3	3	0	4	5	5	5	2	1	2	2	8	2	2	2	3	2	4
57T	9B	26	1244	1	7	5	3	2	2	4	0	3	3	0	1	2	3	7	5	2	5	4	4	4
57W	15E	69	1247	1	2	6	3	2	2	4	0	2	3	2	1	1	2	6	2	2	6	4	3	5
57X	14H	173	1257	1	2	0	3	0	0	4	0	2	2	2	1	2	2	7	2	1	3	3	1	2
57CC	15I	000	0000	1	2	3	0	0	3	4	0	2	7	2	2	3	1	7	3	1	5	3	2	2
57DD	15H	000	0000	1	2	0	2	0	2	4	0	3	0	2	1	2	1	9	3	2	4	4	2	2
57GG	9C	000	0000	1	2	6	3	0	4	4	5	2	0	2	1	3	3	6	4	2	4	1	2	5
58B	10K	62	1286	1	9	6	3	2	2	4	0	2	2	2	1	3	2	8	3	1	4	3	2	9
58C	15D	206	1180	1	2	6	2	0	2	4	2	4	3	2	1	2	2	5	5	2	3	3	4	4
58D	10D	192	1215	1	9	6	3	0	3	3	5	2	2	2	1	2	4	8	4	1	3	4	2	4
58I	11G	000	0000	1	9	6	0	2	0	4	3	0	0	3	1	2	3	6	2	1	3	2	2	5
61C	11D	178	1178	1	0	0	3	2	3	4	0	2	2	2	1	2	2	7	2	1	5	5	2	7
65B	10A	96	1225	1	2	6	3	2	0	0	0	7	2	2	3	4	1	8	1	4	6	3	3	5
83E	11I	25	1398	1	1	0	3	2	0	3	0	2	2	2	1	1	2	6	1	2	3	4	2	3
86F	11K	484	1245	1	9	0	2	2	3	4	5	3	2	2	1	2	1	5	1	1	3	5	1	3
86I	9E	678	1320	1	3	0	2	2	0	3	3	6	0	2	2	3	3	7	3	3	4	5	4	9

Table 24. (continued)

Flake Number	Plate	Prov.* South	Prov.* East	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
91A	10E	000	0000	1	2	6	2	2	4	4	0	2	0	0	1	2	5	7	2	2	4	3	2	4
92A	None	206	1395	1	4	6	2	2	0	4	2	5	5	3	2	2	3	6	4	2	2	1	2	5
93C	None	000	0000	1	2	3	2	0	0	4	0	0	0	2	2	3	2	7	1	3	2	5	3	5
94B	11C	28	1353	1	2	3	2	2	2	3	0	4	3	3	1	2	3	5	4	1	3	1	2	2
102I	10G	338	1569	1	4	6	0	3	0	4	2	2	2	3	1	1	2	7	1	2	1	1	2	9
102N	10O	328	1554	1	2	0	3	3	0	2	0	0	0	0	2	2	2	7	0	2	0	0	0	0
102O	15B	368	1480	1	2	6	3	3	0	3	0	2	7	3	2	2	2	6	4	3	4	3	3	2
102Q	10C	53	1550	1	4	6	3	3	0	4	0	2	2	2	3	4	4	7	3	3	4	3	3	3
104B	10F	237	1424	1	1	0	0	0	0	4	0	2	3	3	2	2	2	6	3	2	3	3	2	6
104C	11A	000	0000	1	1	6	3	2	2	0	0	7	7	2	2	3	1	7	3	3	3	1	4	3
108C	None	748	1560	1	3	5	0	2	0	4	4	6	6	2	1	1	2	7	2	1	2	5	2	2
108D	11B	658	1510	1	2	0	2	0	2	4	0	3	3	3	1	1	1	8	3	1	2	4	1	6
108G	11J	691	1554	1	2	5	2	2	2	4	0	5	7	3	1	2	2	4	1	1	2	4	1	3
108J	11L	646	1590	1	9	5	2	0	2	4	5	3	3	2	1	1	2	1	1	2	3	4	2	6
108K	11H	760	1406	1	9	6	3	2	2	4	3	2	2	2	1	1	2	6	2	2	4	4	2	4
108N	11F	464	1454	1	9	6	3	3	3	3	0	2	2	3	1	1	4	8	2	1	3	3	2	5
108Z	14G	000	0000	1	2	0	2	2	0	3	3	3	3	2	1	1	1	7	1	1	2	4	2	4
109A	14J	742	1513	1	9	0	2	0	0	4	0	3	0	2	0	1	2	0	1	1	1	3	2	6
110A	15F	718	1420	1	2	0	2	0	2	4	4	7	7	3	0	0	0	0	4	2	3	2	2	2
111A	14E	678	1460	1	2	5	2	2	4	4	0	2	7	2	1	1	2	6	2	1	4	1	2	5
112A	10L	000	0000	1	0	3	3	2	0	0	0	0	0	0	1	2	1	8	0	1	0	0	0	0
113A	11E	212	284	1	9	6	2	2	0	0	2	2	2	3	1	1	4	5	5	1	3	2	2	5
118A	10H	335	477	1	9	0	3	2	0	4	0	2	2	0	1	2	2	5	1	1	2	2	1	3
133A	None	696	1172	1	9	0	2	0	2	4	5	2	2	2	1	2	2	0	3	2	3	3	2	5
133D	9D	686	1162	1	2	3	3	2	0	4	5	2	2	2	1	2	2	8	4	2	2	2	2	3

Table 24. (continued)

Flake Number	Plate	Prov.* South	Prov.* East	Attribute 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
137A	15K	714	884	1	9	0	3	3	0	3	0	7	5	3	1	1	4	7	3	1	1	4	2	4
138A	14F	685	907	1	2	3	2	2	0	4	5	7	3	3	1	2	4	6	2	2	2	4	2	3
143E	10P	735	961	1	9	6	2	2	0	4	0	0	3	2	1	2	1	7	2	1	4	4	2	4
143F	10J	737	978	1	9	0	3	3	0	3	3	2	2	3	1	1	2	6	2	2	4	4	3	4
146A	15G	709	1662	1	2	6	3	2	4	4	0	7	2	3	2	3	2	5	2	1	2	3	2	1
147A	15J	715	1623	1	2	6	3	0	4	4	3	4	7	2	1	1	4	8	3	2	1	1	2	2
148K	15C	742	1613	1	9	0	2	3	3	3	2	3	7	2	2	3	3	7	3	3	4	4	3	4
149A	15A	383	1095	1	4	6	2	3	0	4	2	5	5	2	4	4	1	7	3	4	4	2	4	1
156A	14I	551	1597	1	2	5	2	3	4	4	5	3	3	3	1	1	2	8	3	2	5	4	3	7
235A	10M	000	0000	1	2	0	3	3	0	4	0	2	2	2	1	1	3	7	1	1	1	3	1	2
243A	10N	000	0000	1	4	6	3	0	3	4	0	3	0	2	1	2	1	8	2	1	3	3	2	6
245A	11M	000	0000	1	2	5	3	3	0	3	0	3	2	3	1	1	3	7	3	1	4	4	2	5

* 000 and 0000 indicates surface collection or no provenience

Table 25. Attribute Values for All Utilized Flakes
(the Attributes are described in Appendix B)

Flake Number	Plate	Prov.* South	Prov.* East	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
53A	14D	72	1262	54	+5	45	5	2	2	1	1	2	2	2	2	2	2	1	2	8	1
54A	14A	144	1214	46	+19	15	2	1	2	1	2	2	2	2	2	2	2	2	2	8	2
55A	12D	196	1214	35	+2	60	4	2	2	1	2	2	2	2	2	2	2	1	2	9	1
55A	12D	196	1214	41	+2	60	3	2	2	1	2	2	2	1	2	2	2	1	2	9	1
56F	14C	218	1212	8	-25	50	4	2	2	1	2	2	2	2	2	2	2	1	2	5	1
56G	12K	9	1208	29	+6	25	1	2	2	1	1	2	2	2	2	2	2	2	2	6	2
56Q	12A	000	0000	11	-18	45	4	2	2	1	2	2	2	2	2	2	2	1	2	18	1
57J	13F	66	1238	36	+5	30	2	1	1	1	2	2	2	1	2	2	2	2	2	14	2
57K	14B	000	0000	23	-4	50	3	1	2	1	2	2	2	2	2	2	2	2	2	7	2
57S	13A	188	1171	44	+19	60	13	2	2	1	1	2	2	1	1	2	2	1	1	13	1
57S	13A	188	1171	42	+9	30	3	2	2	1	1	1	1	2	2	2	2	2	2	13	2
57W	15E	69	1247	34	+8	40	5	2	2	1	1	2	1	2	2	2	2	2	2	11	1
57X	14H	173	1257	15	-20	50	3	1	2	1	2	2	2	2	2	2	2	1	2	4	1
57CC	15I	000	0000	19	-31	30	3	2	2	1	2	2	2	2	2	2	2	2	2	6	2
57CC	15I	000	0000	40	+14	25	1	2	2	1	1	2	2	2	2	2	2	2	2	6	1
57DD	15H	000	0000	29	+13	40	3	2	2	1	1	2	2	2	2	2	2	2	2	7	1
58C	15D	206	1180	54	+1	45	2	2	2	1	1	2	1	2	2	2	2	2	2	12	1
58G	13D	000	0000	25	+12	15	1	2	2	1	2	2	2	2	2	2	2	2	2	9	2
61B	13J	55	1187	27	+11	35	1	2	2	1	2	2	2	2	2	2	2	2	2	7	1
63H	13I	000	0000	18	+6	10	1	2	2	1	1	2	2	2	2	2	2	2	2	4	1
86D	13B	634	1306	7	-21	50	4	2	2	1	2	2	2	2	2	2	2	1	2	10	1
102O	15B	368	1480	14	-14	75	8	1	2	1	2	2	2	2	2	2	2	1	2	11	1
108E	12E	748	1530	36	+14	60	2	2	2	1	2	2	2	2	2	2	2	2	2	13	1
108L	13C	674	1579	40	+17	40	3	2	2	1	1	2	2	2	2	2	2	2	2	10	1
108Z	14G	000	0000	47	+26	35	4	2	2	1	1	2	2	2	2	2	2	2	2	7	2
109A	14J	742	1513	7	+14	25	3	2	2	1	1	2	2	2	2	2	2	1	2	7	1

Table 25. (continued)

Flake Number	Plate	Prov.* South	Prov.* East	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
110A	15F	718	1420	30	+26	70	5	2	2	1	2	2	2	2	2	2	2	1	2	8	1
111A	14E	678	1460	16	+19	70	4	1	1	1	1	2	2	2	2	2	2	1	1	7	1
114A	12I	340	337	9	+16	90	6	0	2	0	1	0	2	0	2	0	2	0	2	8	1
114A	12I	340	337	9	+2	90	6	2	0	1	0	2	0	2	0	2	0	2	0	8	1
121A	13K	000	0000	21	+60	45	3	2	2	1	2	2	2	2	2	2	2	2	2	4	2
123A	12H	000	0000	23	+4	55	2	2	2	1	2	2	2	2	2	2	2	1	2	8	1
134B	13G	590	1013	14	+25	75	1	2	2	1	1	2	2	2	2	2	2	2	2	3	2
137A	15K	714	884	44	+29	25	2	1	1	1	1	2	2	1	1	2	2	1	1	8	3
138A	14F	685	907	28	+2	20	2	1	1	1	1	2	2	1	2	2	2	2	2	8	1
138A	14F	685	907	27	-10	45	2	1	1	1	1	2	2	2	2	2	2	2	2	8	1
139A	13H	761	977	19	+7	27	3	2	2	1	2	1	1	2	2	1	1	2	1	5	1
142A	12G	712	912	48	-8	35	2	2	2	1	2	2	2	1	2	2	2	2	2	12	2
142A	12G	712	912	11	-16	60	3	2	2	1	2	2	2	1	2	2	2	1	2	12	1
146A	15G	709	1662	18	+39	75	1	1	1	1	2	2	2	2	2	2	2	1	2	6	1
147A	15J	715	1623	14	+14	25	1	2	2	1	1	2	2	1	1	2	2	1	2	7	1
147A	15J	715	1623	33	+6	50	3	2	2	1	1	1	1	1	1	2	2	2	2	7	1
148A	12J	725	1652	33	+12	44	1	2	2	1	2	2	2	1	2	2	2	2	2	5	1
148D	13E	744	1654	26	+12	20	1	2	2	1	2	2	2	2	2	2	2	2	2	12	2
148D	13E	744	1654	14	+4	30	2	2	2	1	2	2	2	2	2	2	2	1	2	12	2
148E	12C	704	1667	23	+11	58	2	2	2	1	2	2	2	2	2	2	2	2	2	8	1
148K	15C	742	1613	50	+24	25	2	2	2	1	1	2	2	2	2	2	2	2	2	13	2
149A	15A	383	1095	36	+22	70	10	2	2	1	2	2	2	2	2	2	2	1	2	16	2
156A	14I	551	1597	36	+11	60	10	2	2	1	2	2	2	2	1	2	2	2	2	11	1
234A	12F	000	0000	28	-4	27	1	2	2	1	2	2	2	2	2	2	2	2	2	11	1
240A	12B	000	0000	29	+1	55	6	2	2	1	2	2	2	1	1	2	2	2	1	14	1
156A	14I	551	1597	29	+14	35	3	2	2	1	1	1	1	2	2	2	2	2	2	11	1

* 000 and 0000 indicate surface collection or no provenience

Plate 1. Feature 1 (Scale is 25 cm, facing South)

Plate 2. Units to the West of Unit 2 (Facing West-Northwest)

Plate 3. South Half of Unit 19 (Scale is 25 cm, facing West)

Plate 4. South Half of Unit 9 (Scale is 25 cm, facing South, Projectile Point is to Right of Scale)

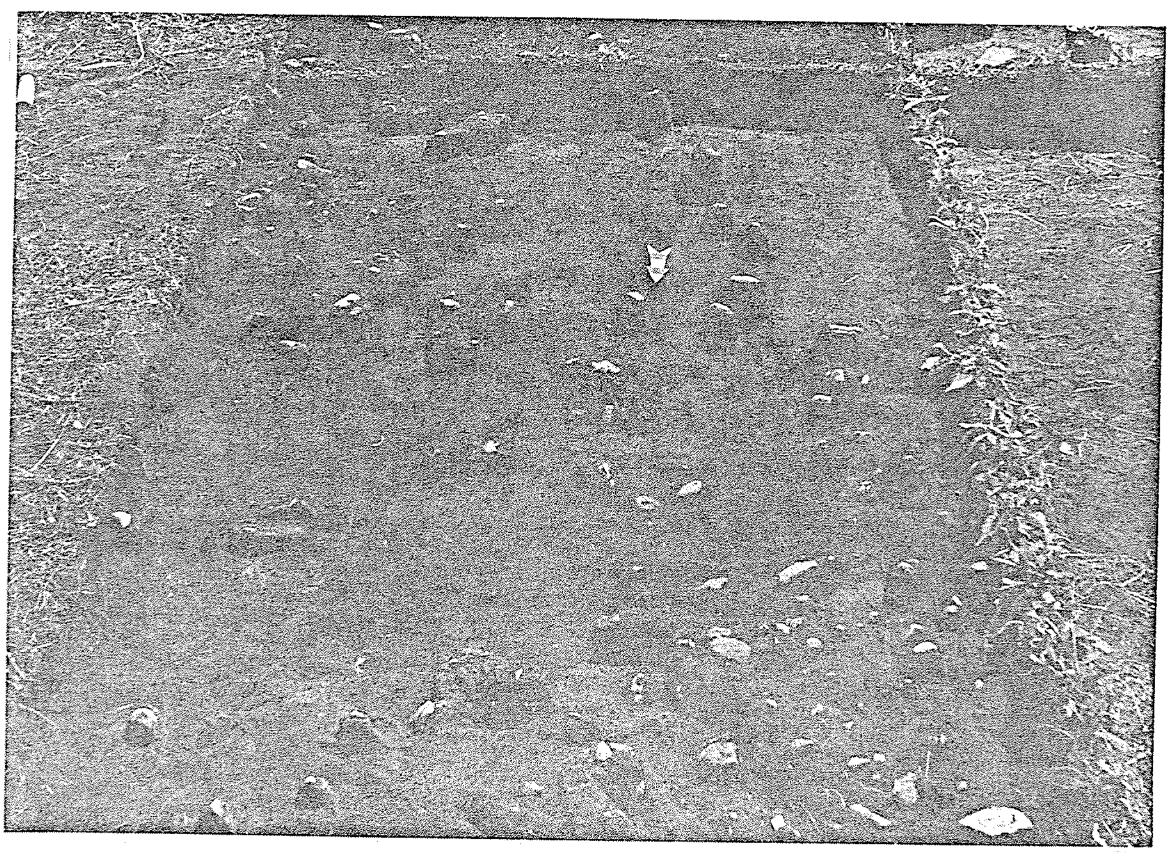
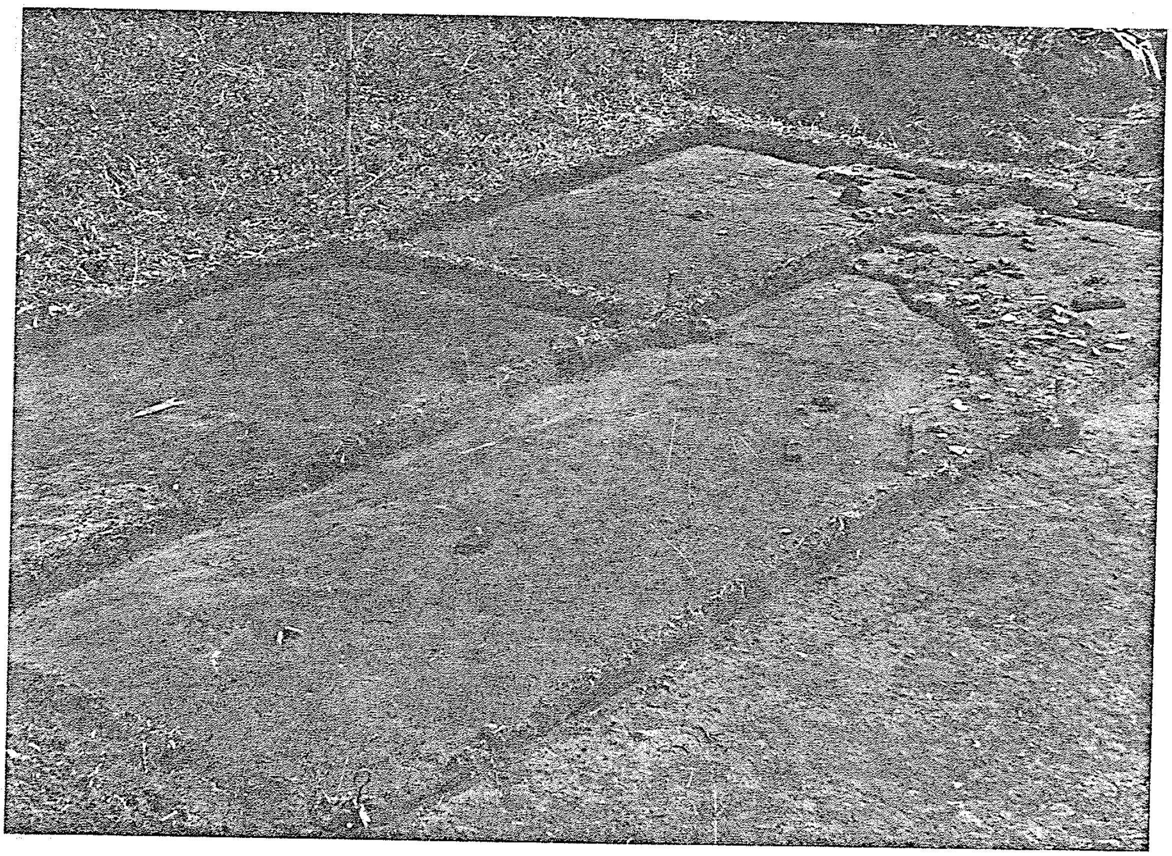
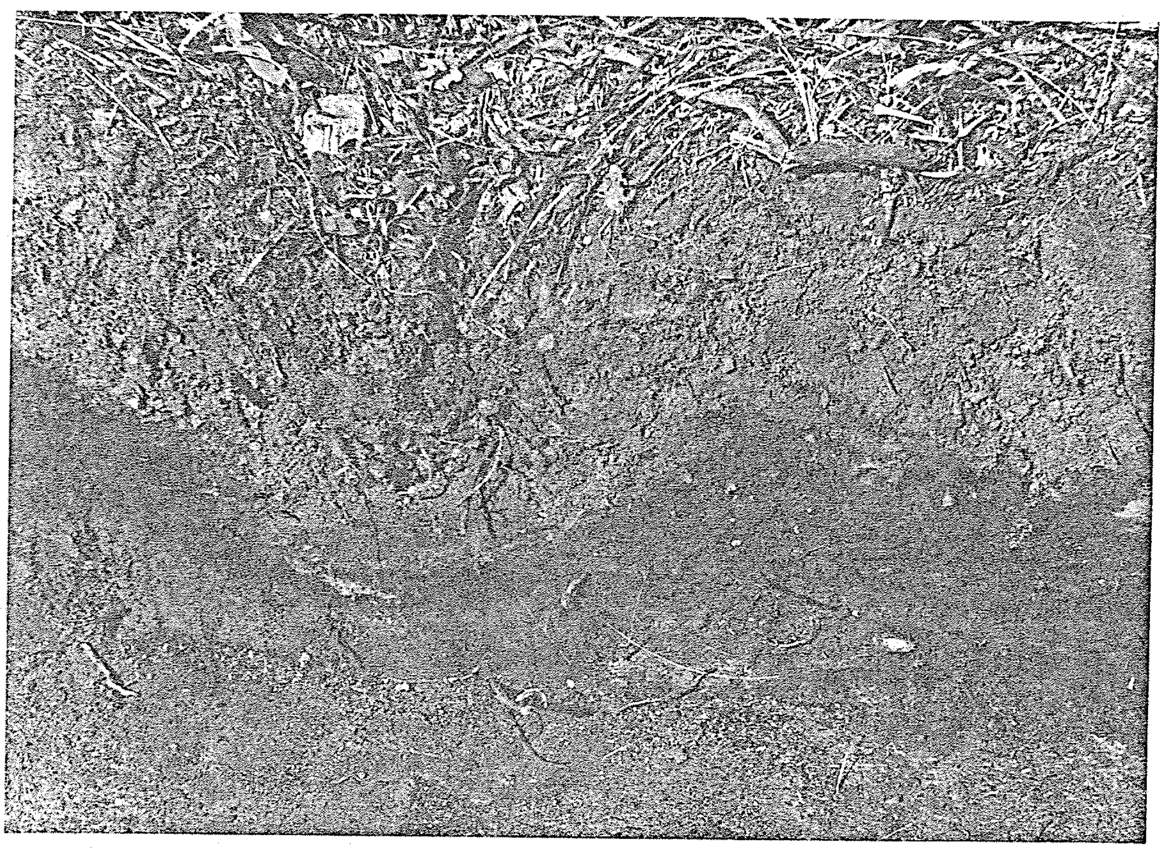


Plate 5. The Rock Structure in Units 14, 15, 17 and 18 (Scale is 25 cm, facing Southwest)

Plate 6. Soil Profile on West Wall of Unit 13 (facing West)





A. Projectile Point from Jalowica Collection

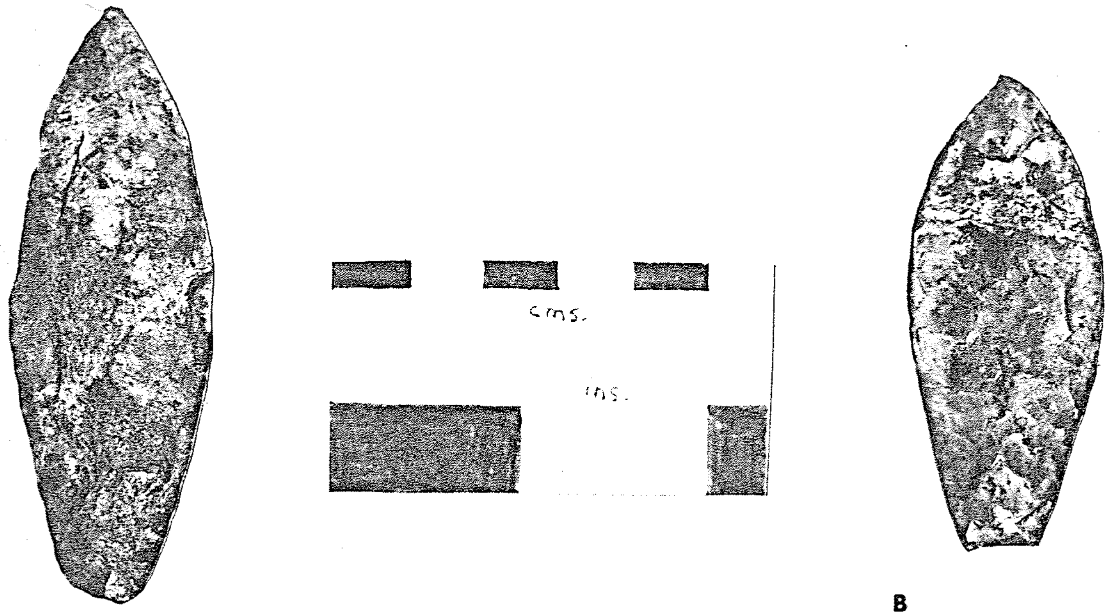
B. Projectile Point from Jalowica Collection

C. Projectile Point from Unit 9 (Catalog Number 99A)

D. Projectile Point from Unit 1 (Catalog Number 85A)

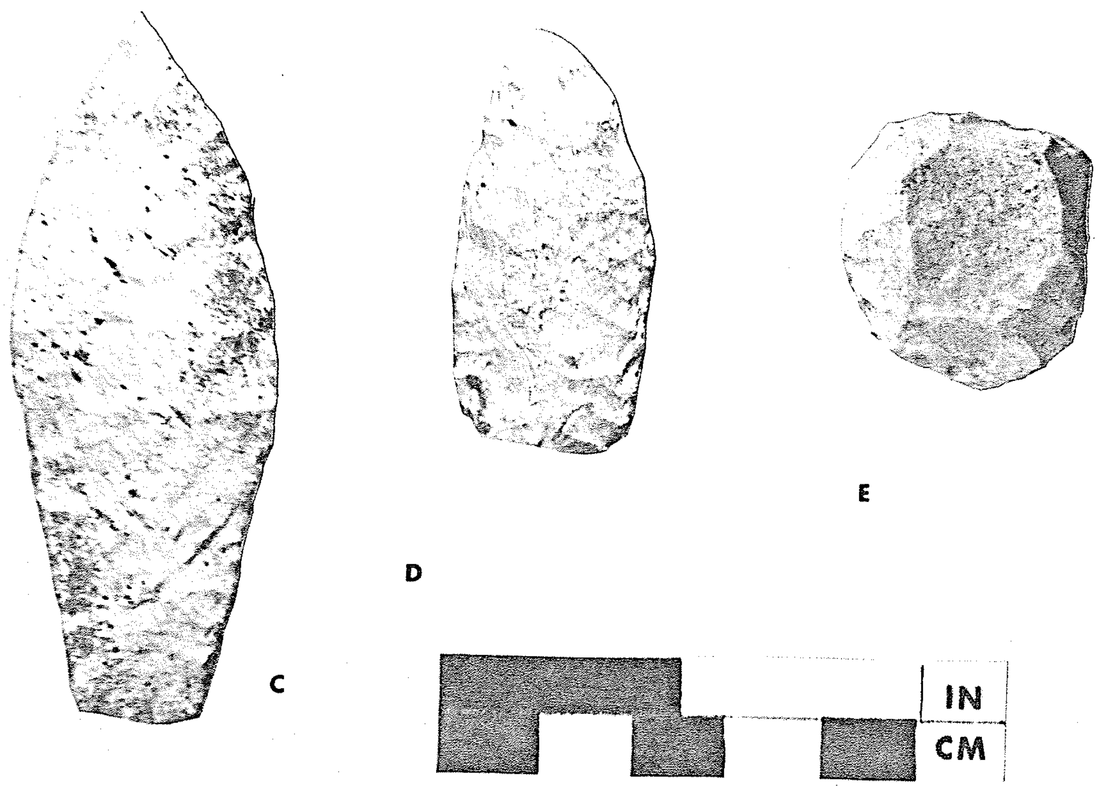
E. Scraper from Unit 14 (Catalog Number 145A)

Plate 7. Artifacts from ElMb-10



A

B



C

D

E

A. Core (122A)

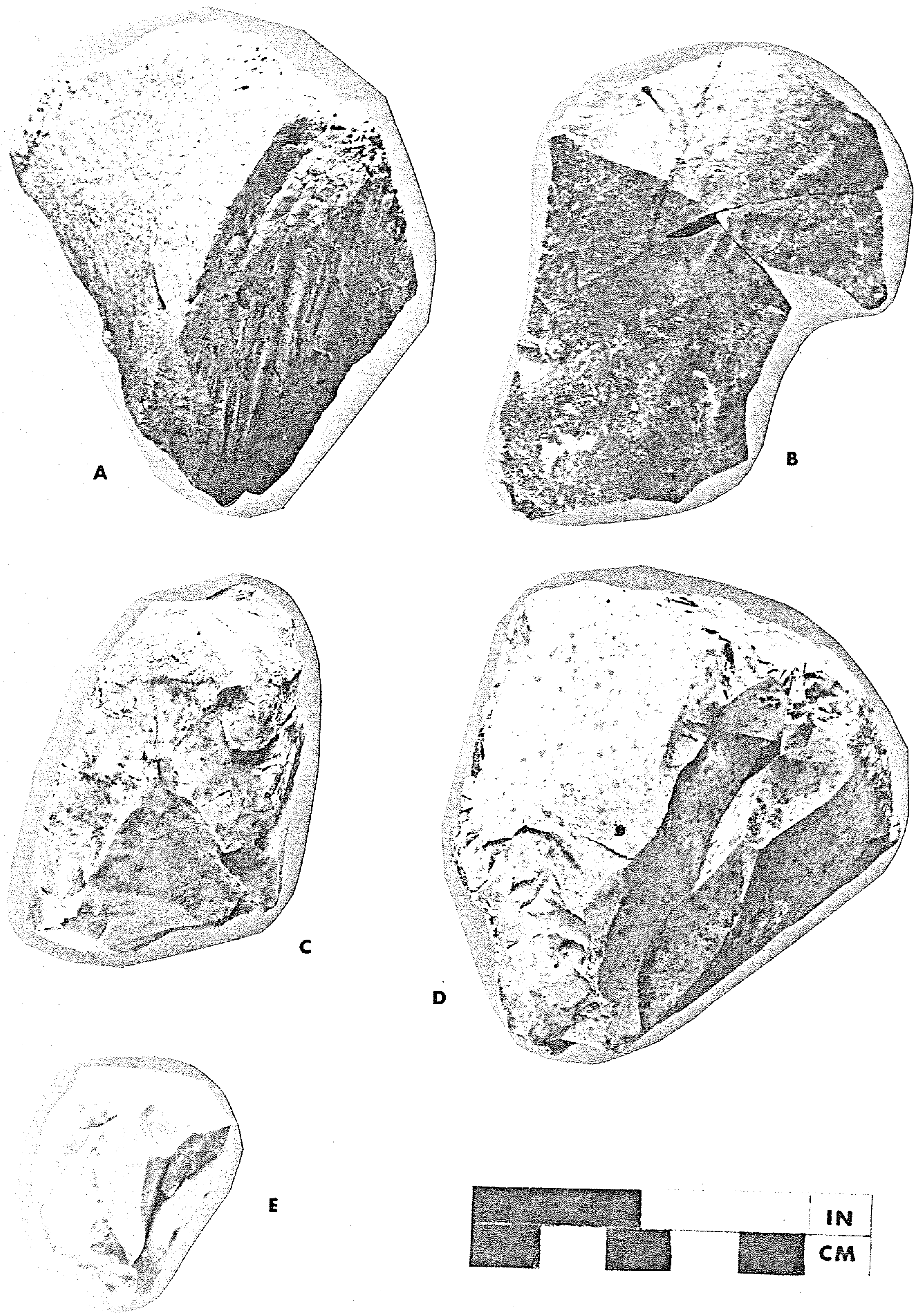
B. Reconstructed Core (83A, 83B, 83C, 83D)

C. Core (236A)

D. Reconstructed Core (60A, 60B, 60C)

E. Percussion Cone (141B)

Plate 8. Cores and the Percussion Cone


A
B
C
D
E
IN
CM

A. 57C

B. 57T

C. 57GG

D. 133D

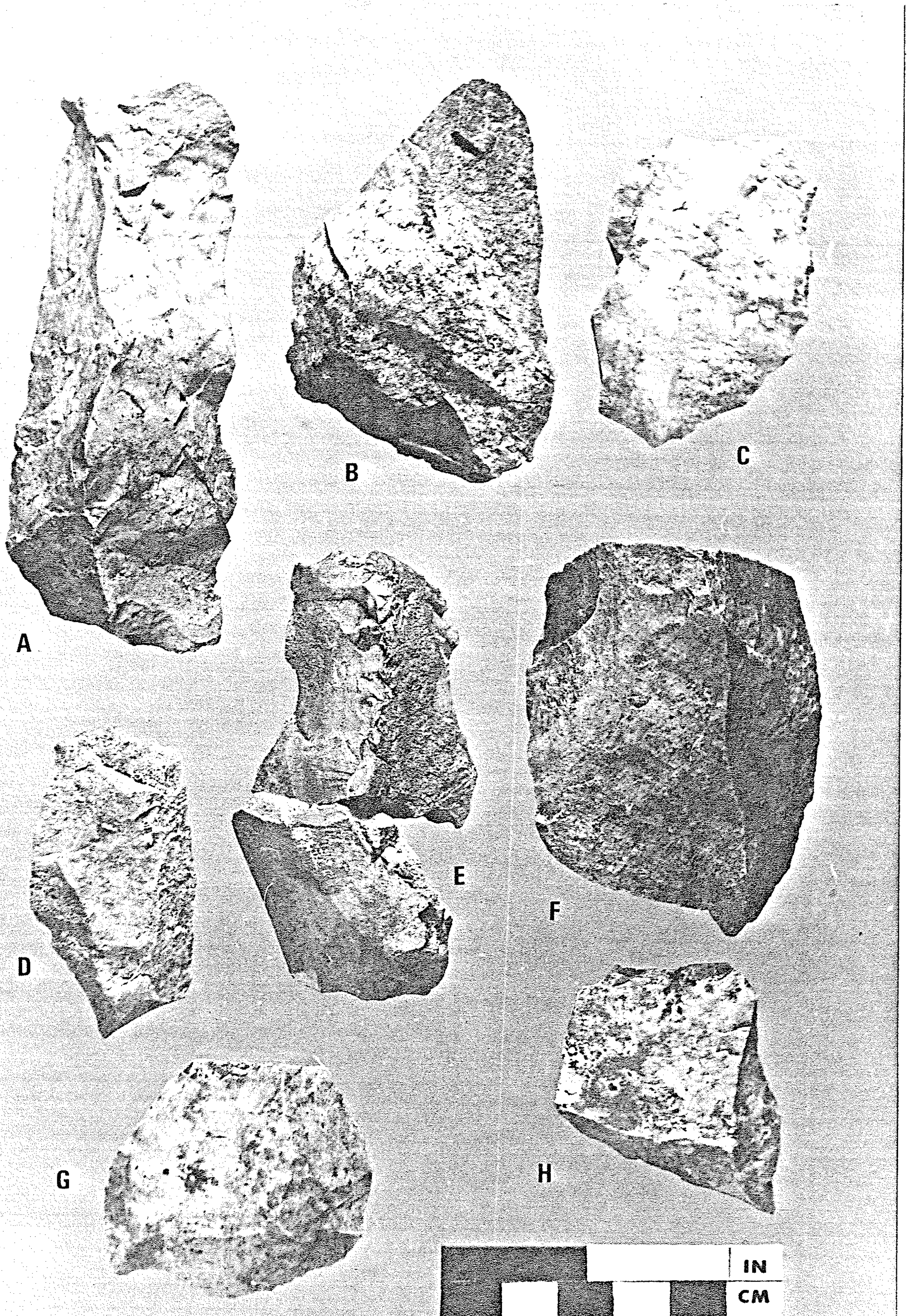
E. 86I, 86B

F. 56W

G. 57E

H. 57I

Plate 9. Complete Unutilized Flakes


A
B
C
D
E
F
G
H
IN
CM

A. 65A, 65B

B. 56B

C. 102Q

D. 58D

E. 91A

F. 104B

G. 102I

H. 118A

I. 57B

J. 143F

K. 58B

L. 112A

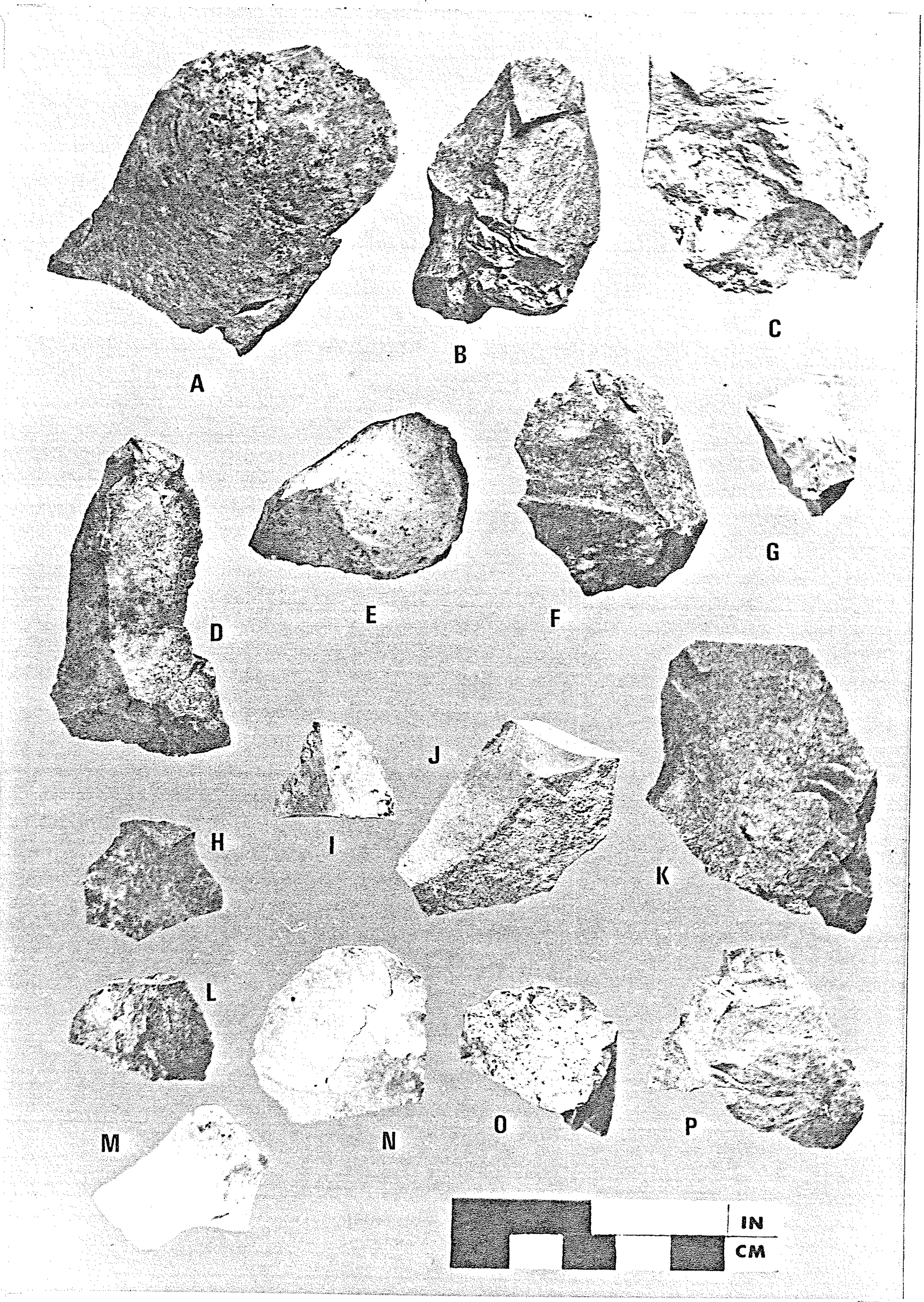
M. 235A

N. 243A

O. 102N

P. 143E

Plate 10. Complete Unutilized Flakes


A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
IN
CM

A. 96A, 104C

B. 108D

C. 94B

D. 61C

E. 113A

F. 108N

G. 58I, 58J

H. 108K

I. 83E

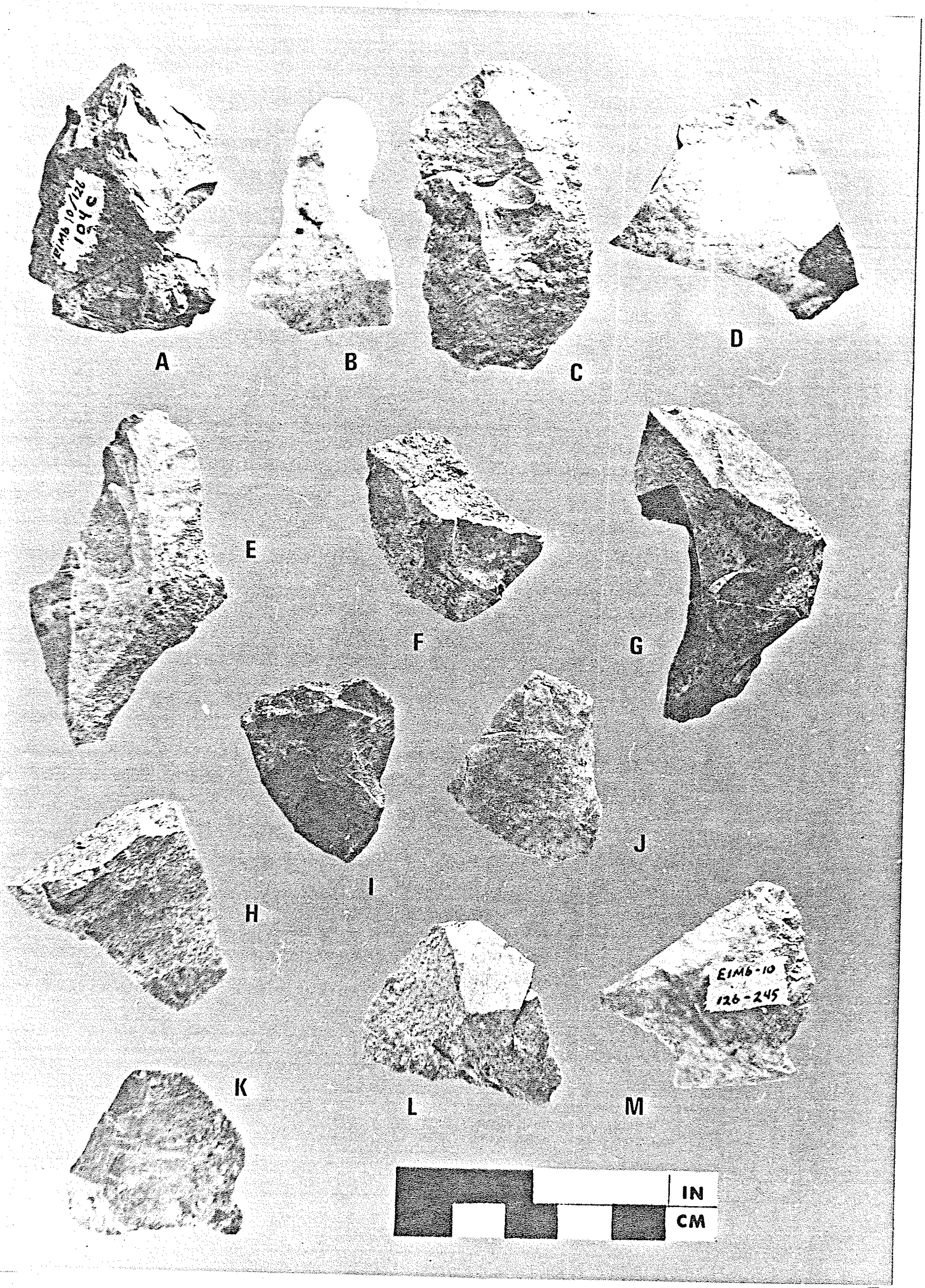
J. 108G

K. 86F

L. 108J

M. 245A

Plate 11. Complete Unutilized Flakes


A
B
C
D
E
F
G
H
I
J
K
L
M
EIMb-10
126-245
IN
CM

A. 56Q

B. 240A

C. 148E

D. 55A

E. 108E

F. 234A

G. 142A

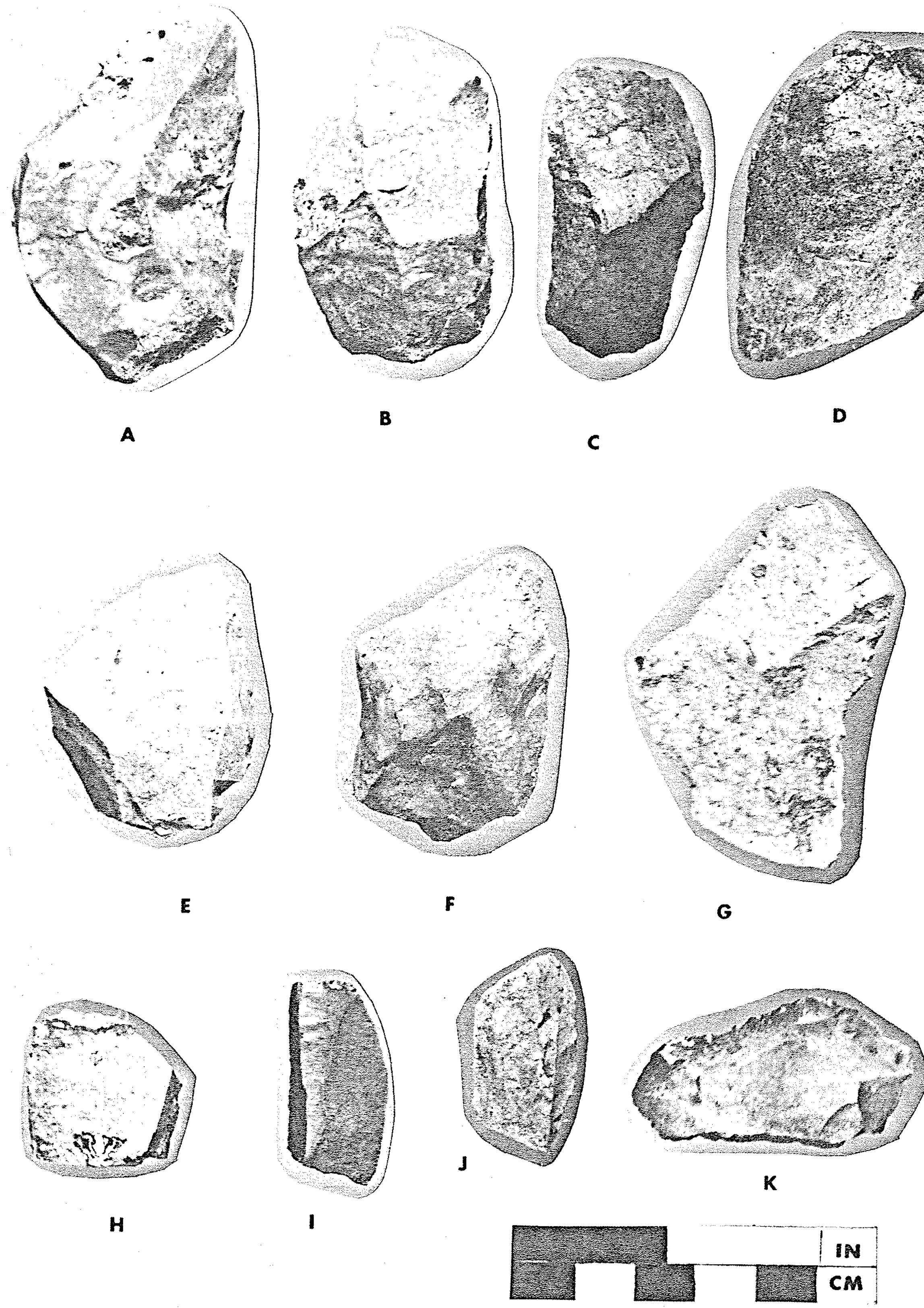
H. 123A

I. 114A

J. 148A

K. 56G

Plate 12. Incomplete Utilized Flakes


A
B
C
D
E
F
G
H
I
J
K
IN
CM

A. 57S

B. 86D

C. 108L

D. 58G

E. 148D

F. 57J

G. 134B

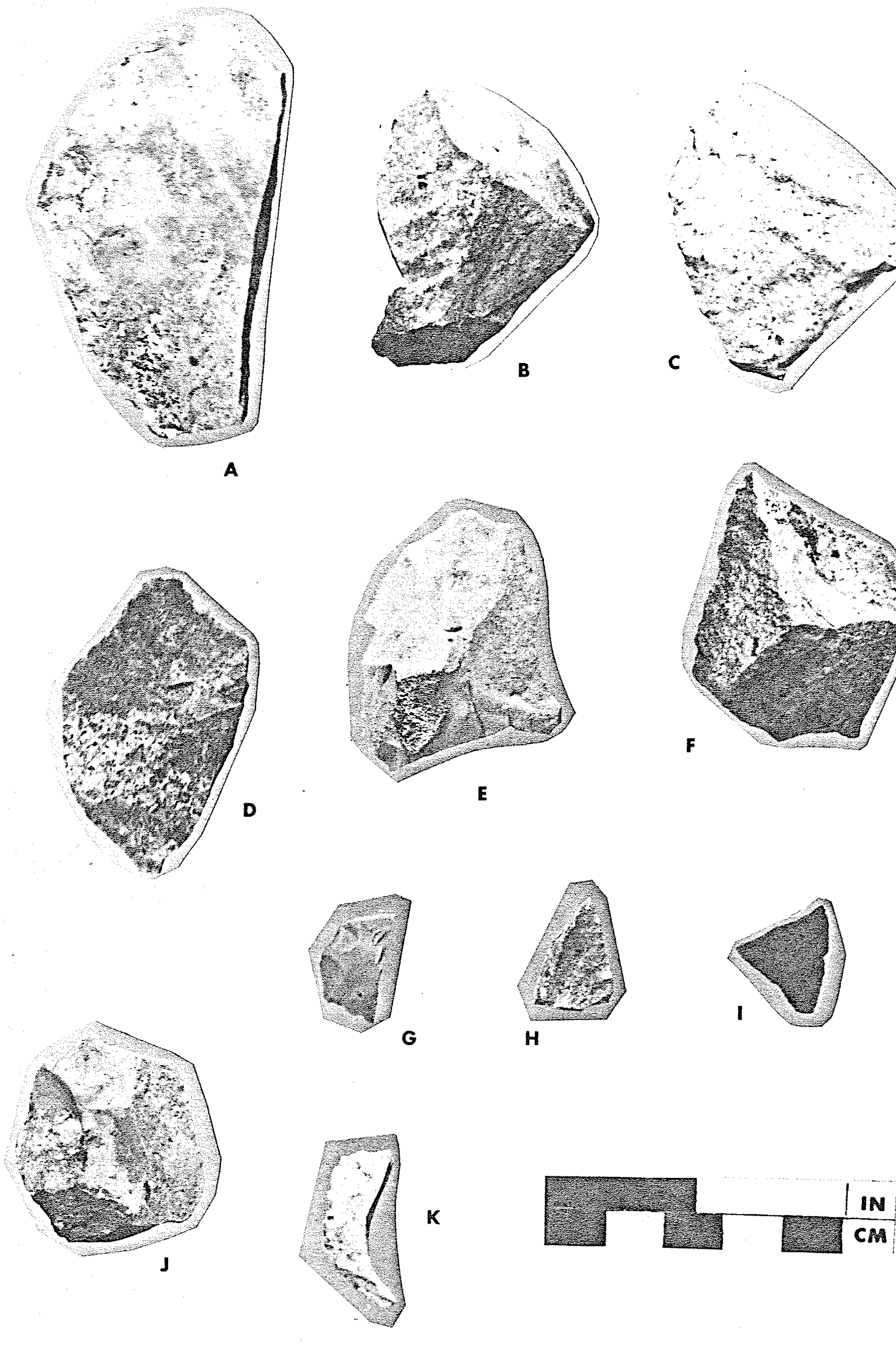
H. 139A

I. 63H

J. 61B

K. 121A

Plate 13. Incomplete Utilized Flakes


A
B
C
D
E
F
G
H
I
J
K
IN
CM

A. 54A, 56Z

B. 57K, 57G

C. 56F

D. 53A

E. 111A

F. 138A

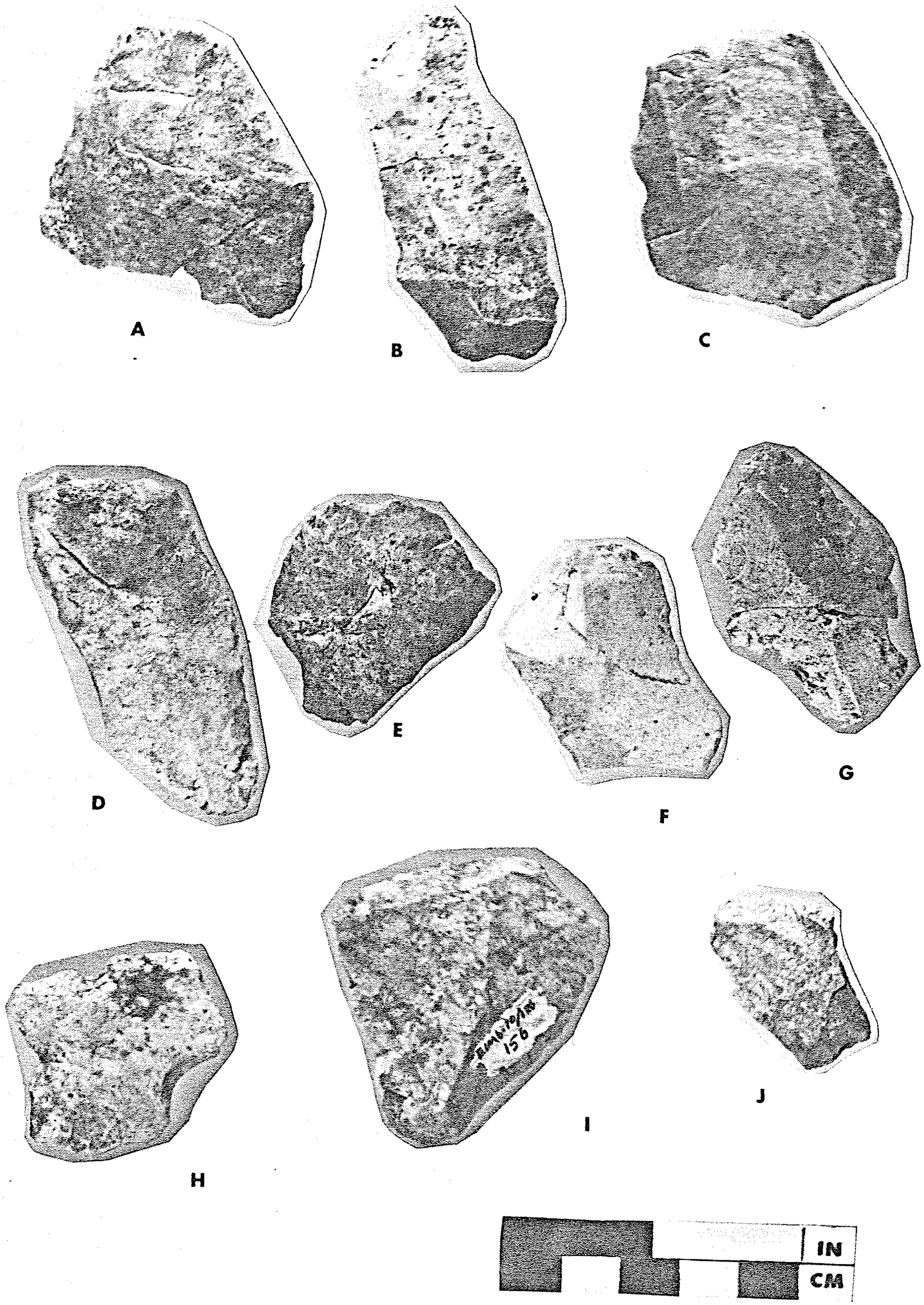
G. 108Z, 108AA

H. 57X

I. 156A

J. 109A

Plate 14. Complete Utilized Flakes


A
B
C
D
E
F
G
H
I
J
IN
CM

A. 149A

B. 102O

C. 148K

D. 58C

E. 57W

F. 110A

G. 146A

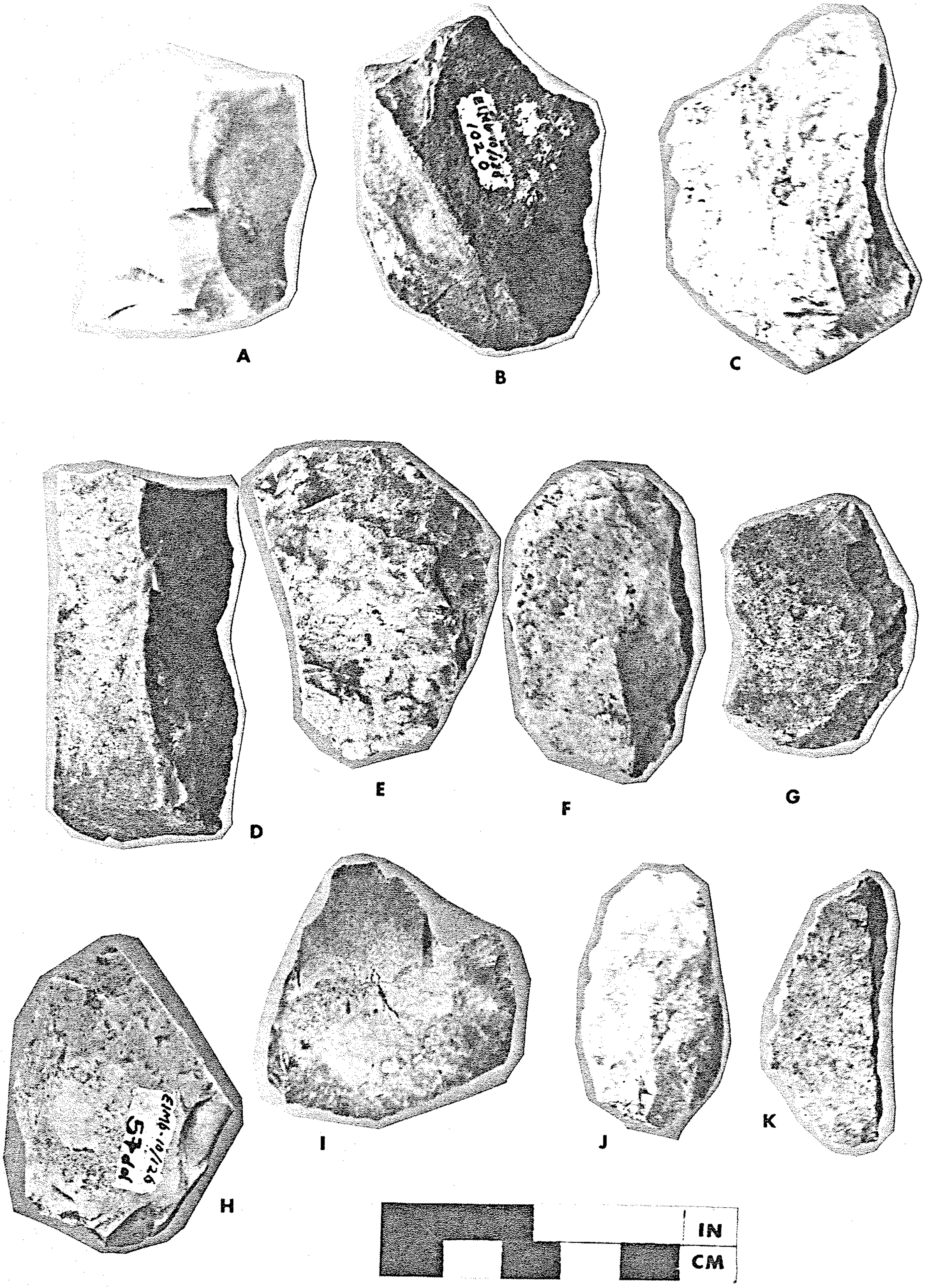
H. 57DD

I. 57CC

J. 147A

K. 137A

Plate 15. Complete Utilized Flakes


A
B
C
D
E
F
G
H
I
J
K
IN
CM

A. 97B

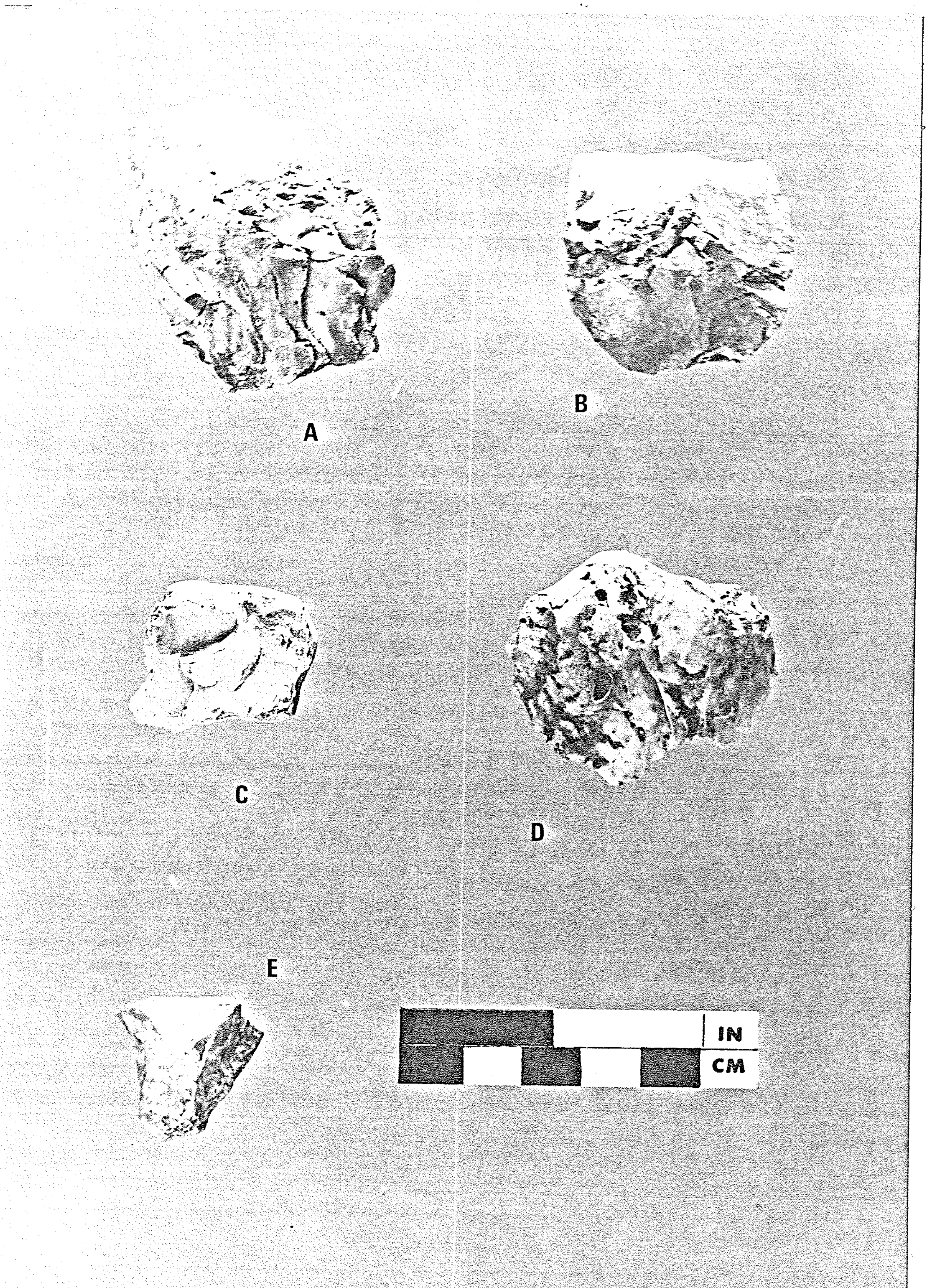
B. 102R

C. 244A

D. 97A

E. 143D

Plate 16. Core Fragment Hammerstones


A
B
C
D
E
IN
CM

A. 64A

B. 116A

C. 67A

D. 90A

E. 66A

Plate 17. Hammerstones

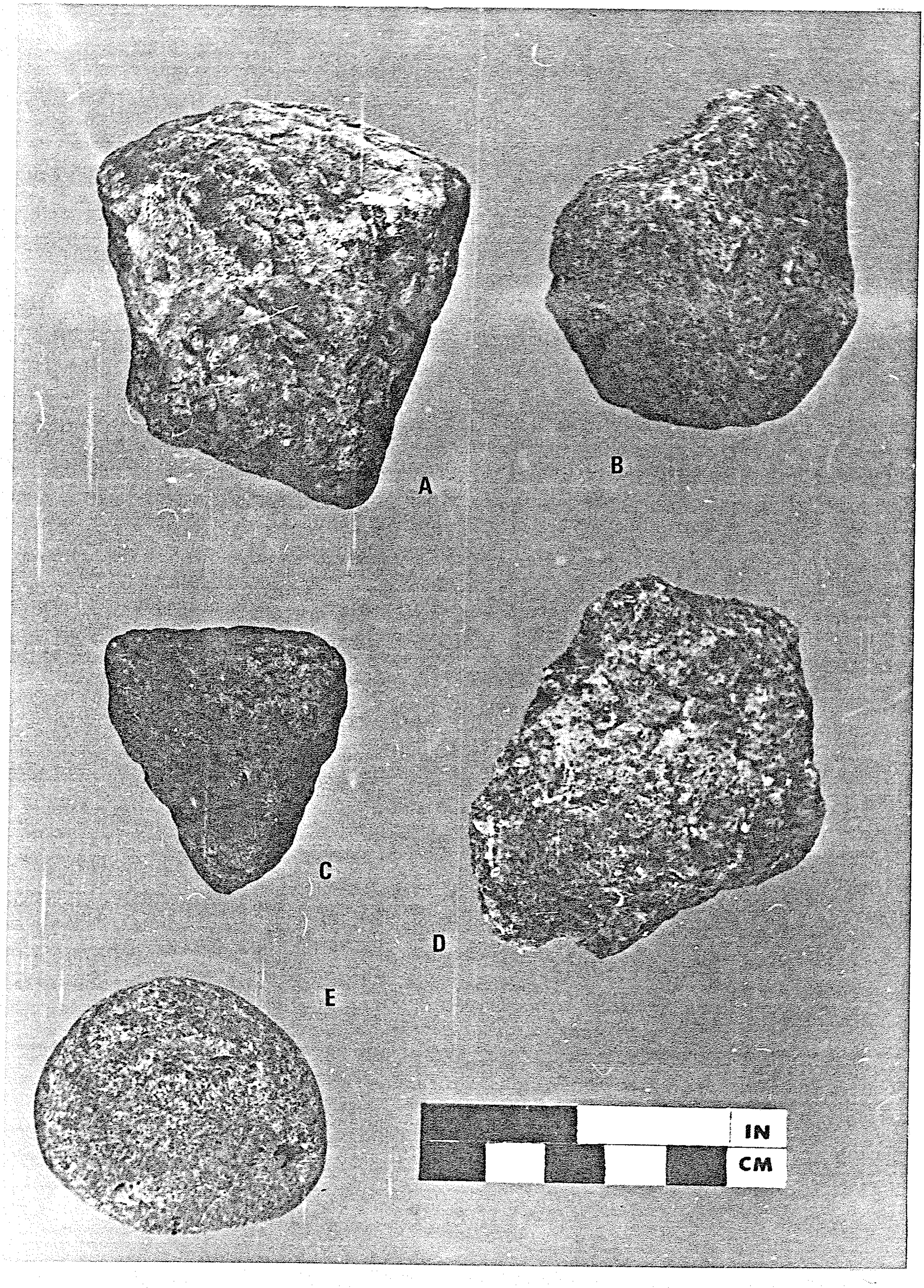
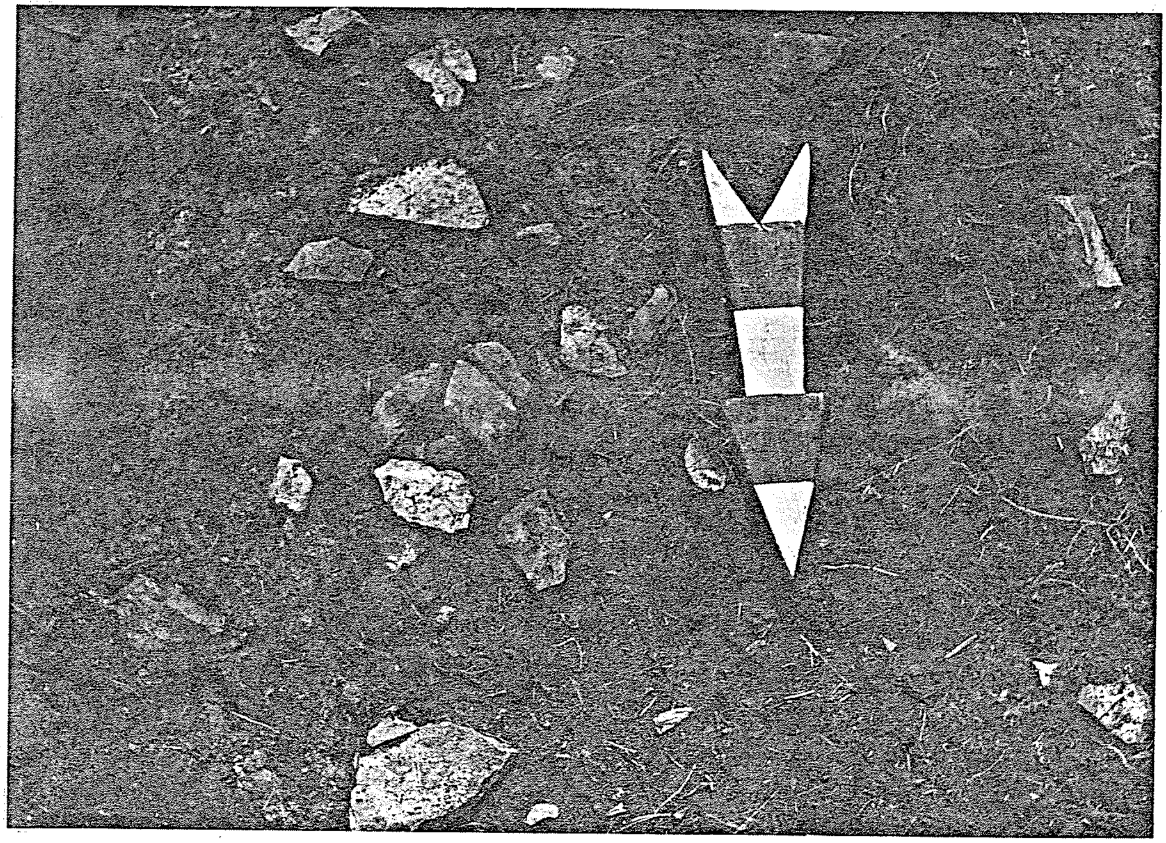

A
B
C
D
E
IN
CM

Plate 18. Feature 1 Detail (Scale is 25 cm)

Plate 19. Feature 1 Detail (Scale is 25 cm)



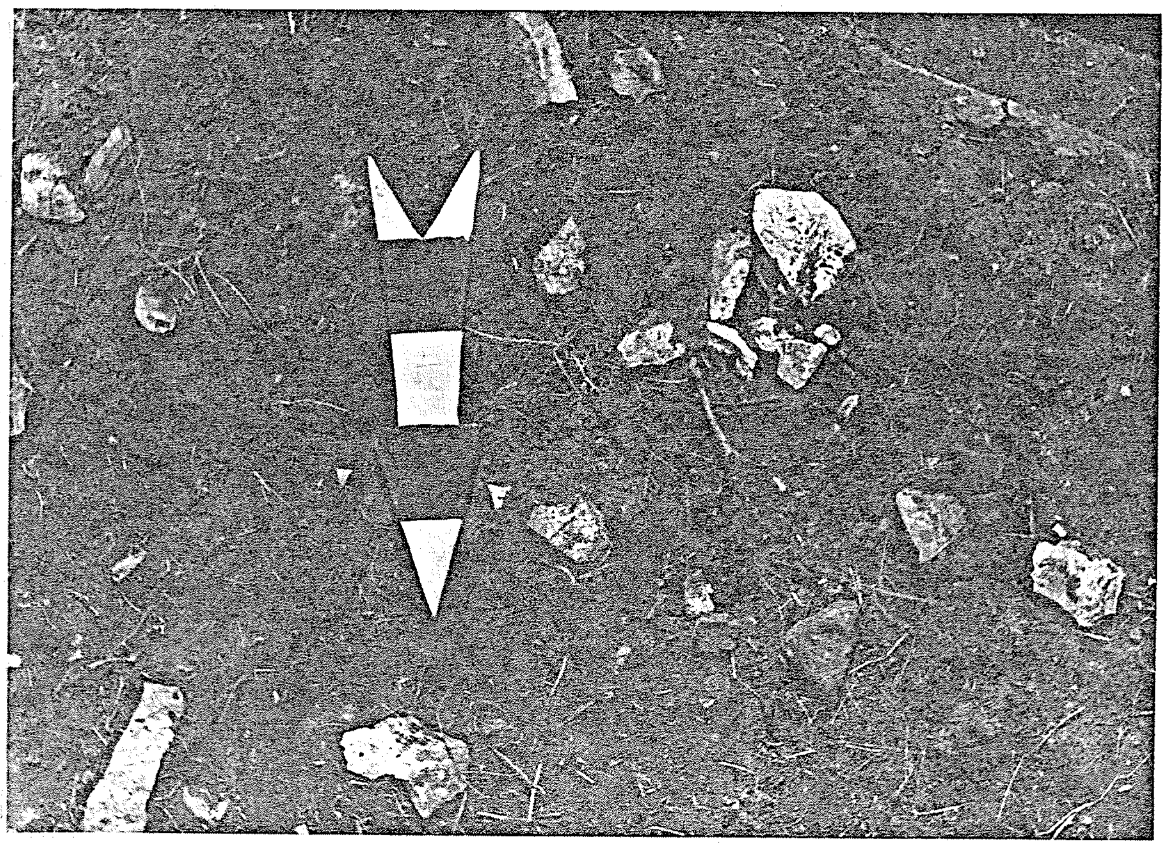


Plate 20. Feature 2 (Scale is 25 cm)

Plate 21. Detail of Rock Structure in Unit 14
(Scale is 25 cm, facing Southeast)