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Age Determination at Death from Osteon Counting by Means of Interactive Computer Graphics

Gale D. Slutzky
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To the Graduate Council:

I am submitting herewith a thesis written by Gale D. Slutzky entitled "Age Determination at Death from Osteon Counting by Means of Interactive Computer Graphics." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts, with a major in Anthropology.

William M. Bass, Major Professor

We have read this thesis and recommend its acceptance:

Fred H. Smith, Richard L. Jantz

Accepted for the Council:
Dixie L. Thompson

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

To the Graduate Council:

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We have read this thesis
and recommend its acceptance:

Accepted for the Council:

Vice Chancellor
~~Graduate Studies~~ and Research

AGE DETERMINATION AT DEATH FROM OSTEON COUNTING BY MEANS OF INTERACTIVE COMPUTER GRAPHICS

A Thesis

Presented for the

Master of Arts

Degree

The University of Tennessee, Knoxville

Gale David Slutzky

March 1981

DEDICATION

I dedicate this thesis to my father who passed away before its completion. In many ways I could never live up to his expectations, but in the last few years before his death I began to understand and appreciate the man who was Louis Slutzky.

ACKNOWLEDGMENTS

A special thanks is given to my thesis committee members: Dr. William M. Bass, my committee chairman; Dr. Richard L. Jantz; and Dr. Fred H. Smith. These individuals encouraged my interest in this project and generously aided my research in every way. Their office doors were always open for guidance and assistance.

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I would like to thank Dr. Douglas W. Owsley for proofreading the original draft of the text. The author also wishes to thank his fellow students, Mr. Steve Symes and Mr. Dwight Schmidt, for their assistance in the thin section laboratory and many helpful suggestions.

Lastly, I would like to thank my wife Toni for her patience and understanding during my preparation of this thesis. She assisted by proofreading the text during all phases of preparation. However,

without her love and support this project would never have been completed. I would also like to thank my parents who insisted that their children succeed to their fullest in whatever they attempt.

ABSTRACT

The purpose of this study is to show the feasibility of doing osteon counting on the computer. A sample of 11 specimens were prepared by thin section techniques in order to be photographed through a Reichert transmitted-light interface contrast Zetopan research microscope. After the photographs were mosaiced into a single representative picture of the field of vision, the picture was digitized and processed for age by the computer.

Digitizing the specimens is accomplished by the use of interactive computer graphics. Using a tablet with a cursor or pen, the picture is digitized and stored in a file of x and y coordinates on a magnetic disk by the computer. This file of stored data is used in other computer programs to measure dmax, centroid plots, area information on the individual features and calculate age at death for the specimen. Kerley and Ubelaker's (1978) regression formulas were utilized.

The major findings of the research concerned percent of circumferential lamellar bone and individual fields of vision. The regression formula for percent of circumferential lamellar bone as determined by the Kerley technique (1965) was not reliable with measured data of the computer. A new regression formula was calculated based on the measured data of the sample with eight out of eleven cases having the age range score bracketing the known age of the specimen. All three cases which were aged incorrectly were within plus or minus 10 years of the actual age.

Another finding revealed that one field of vision is not superior to another. Some anthropologists had implied that the posterior field

of vision, because of muscle attachment to the linea aspera, would yield faulty scores. My results show that the worst field is the medial view and not the posterior. When comparing individual field statistics to the four field total the results demonstrate that one field may be selected. The resulting age range calculated by the computer is as satisfactory as those age ranges produced from the four field total.

Since no special training is required to operate the computer and cost of the equipment is economical, a large group of researchers wanting to do osteon counting could utilize my procedure.

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CHAPTER I

INTRODUCTION

Physical anthropologists, forensic anthropoligists and archeologists have been concerned with age determination at death for skeletal material. Skeletal remains under 25 years of age can be readily determined by morphological changes such as tooth eruptions and epiphyseal closures of the long bones. However, by age 30 these closures are completed and it becomes difficult to age older specimens. Methods of aging these older specimens have consisted of examining the vertebral column for osteoarthritic conditions (Stewart, 1979) and cranial suture closures (Krogman, 1962). These methods are often inaccurate or not appropriate in aging skeletons greater than 50 years of age. Another procedure determines age from pubic symphyseal remodeling (McKern and Stewart, 1957). For those specimens under 50 years of age this procedure can give a reliable age, but like the morphological approaches older individuals cannot be aged accurately.

In attempting to overcome the problem of aging older specimens, anthropologists have turned their attention to a histological method. This method requires the destruction of a long bone for a cross-section analysis. The microscopic features of the cortical bone matrix were utilized by Kerley (1963) in development of his osteon counting technique.

One method for determining human age at death is from the microscopic analysis of a cross-section of bone. Microscopic features are counted visually and regression formulas applied to obtain the age at death of the specimen. The purpose of this thesis is to present a

technique of interactive computer graphics for obtaining an age estimate at death from the cross-section of human bone. The benefits of microscopic analysis or osteon counting by interactive computer graphics are numerous.

An interactive computer graphics approach does not require any additional training other than the basic understanding of the osteon counting procedure. Intra-observer error should be reduced by the interactive computer graphics approach as the operator decides on the features being digitized. The computer, however, applies the results to the appropriate regression formula to calculate an age estimate at death. One of the benefits of the interactive computer graphics approach would be the ability to analyze a large skeletal collection in a relatively short period of time for demographic information. Another benefit is the acquisition of measurements such as area data, centroid plots and maximum distances across a feature which are easily obtainable through the computer during the recording procedure. These measurements could be utilized in osteon counting techniques or in age and growth studies. Probably, the most important benefit concerns the cost of the computer graphics system. Since the cost of the interactive computer graphics system is more economical than the equipment necessary for a scanning histogram technique, it would be readily available to any institution doing osteon counting.

An interactive computer graphics approach consists of developing algorithms for the utilization of the tablet (a device to input information to a computer), development of slides and photographic techniques and verification that this approach was a practical and accurate means of doing osteon counting. These procedures are the foundation for

obtaining an age estimate at death from a histological method such as the Kerley technique.

My technique has a semi-automated system functioning, where picture mosaics are entered or digitized by tracing with a tablet cursor or pen, and the file of x and y coordinates recorded in a file stored on magnetic disk. This file, OSTOUT.DAT, is applied by the operator of the computer to the specific programs listed in the Appendices. A step-by-step procedure utilizing the interactive computer graphics approach will be discussed in Chapter 3. When a specimen is aged by the interactive computer graphics approach, the output consisted of: 1) a file of area data which are used to calculate percent of circumferential lamellar bone as well as containing area information on each feature entered; 2) a file of data which allows the field to be redrawn on the Cathode Ray Tube (CRT) screen with the centroids plotted for distance measurements; 3) and finally, data files of the actual age calculated by the regression formulas.

The computer method is slower than the visual counting technique, however, it does permit information to be gathered which previous has been overlooked such as dmax (the maximum distance across a feature), centroid plots (the calculated center of an object) and area values. Dmax, centroid plots and area values are difficult to measure from a standard microscope without expensive measuring attachments so all visual counting procedures ignore them. The results obtained for dmax, centroid plots and area values will be analyzed in a later paper after a significantly larger sample is obtained.

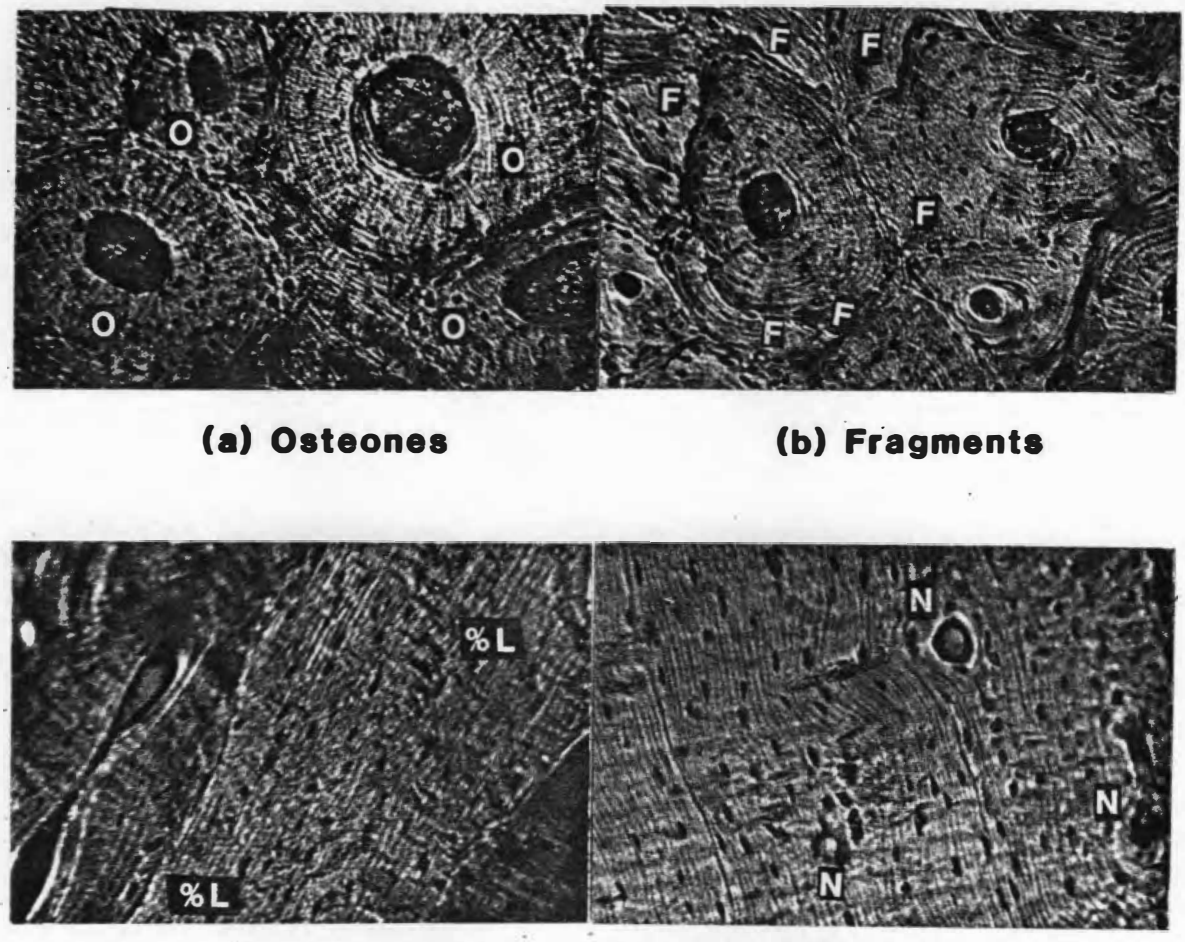
CHAPTER II

LITERATURE REVIEW

Kerley (1963, 1965) devised a method for age determination based on microscopic analysis of a bone sample using regression formulas to obtain the age of individual specimens. The data for these formulas were derived from microscopic examination of cross-sections of human long bones of 88 males and 29 females (Kerley, 1965: 151). In order to categorize these microscopic age changes and establish a system of age determination based on them, 126 ground cross-sections of the femur, tibia and fibula were examined microscopically (Kerley, 1965: 149). A bone sample was removed from the mid-shaft of a long bone for a specimen whose age, sex and medical record was known. This section was then thinned, ground, mounted on a slide and aged by microscopic examination. Osteones, Non-Haversian canals and fragments of osteones were counted for four fields of vision. Also, the percent of circumferential lamellar bone was estimated. Kerley (1965) defined these features in the following manner:

(1) Osteones - An Osteon or Haversian system (Fig. 1-a) is recognized in cross-section as a vascular canal surrounded by concentric lamellae, which contain rather evenly spaced osteocytes in their lacunae. Around the entire periphery of the osteon there is a reversal line that marks the area where osteoclastic resorption stopped and was followed by new bone formation.

(2) Fragments - As osteoclasts burrow channels through Haversian bone, fragments of old osteones (Fig. 1-b) may surround the edge of the



(a) Osteones (b) Fragments

(c) % Lamellar Bone (d) Non-Haversian Canals

Figure 1. The features of osteon counting.

channel and remain after resorption ceases and replacement begins. These fragments increase in number with age as more and more old osteones are partly destroyed. In old age, virtually every complete osteon is surrounded by the fragments of several older ones.

(3) Circumferential lamellar bone - Circumferential lamellar bone (Fig. 1-c) is composed of evenly spaced bands, or lamellae, that run parallel to each other around the outer part of the cortex. It appears as birefringent sheets in polarized light and can be distinguished by its long, parallel fibers. Circumferential lamellar bone is a prominent feature of childhood.

(4) Non-Haversian canals - All primary vascular channels, including those that have filled in partly with concentric lamellae to form primary osteones or pseudo-Haversian Systems, are vascular canals that are formed by the inclusion of small, peripheral blood vessels into bone by the rapid expansion of the cortex in the diameter of bone matrix (Fig. 1-d). Since these canals are formed at the same time as the surrounding lamellar bone, they represent unremodeled bone. Internal remodeling of the bone is represented by osteones which fill spaces left by osteoclastic reabsorption. Viewed with polarized light, the primary osteon can be distinguished from the secondary osteon by the lamellar bone surrounding it. The primary osteon has no sharp reversal or cement line around it, and the surrounding bone is vague and poorly defined. In the secondary osteon, the lamellae surrounding it run straight to the reversal line and stop abruptly (where they were destroyed by osteoclasts during the resorptive phase).

These values or counts are applied (four field total except percent of lamellae bone) to the appropriate regression formula to estimate age.

In the case of percent of lamellar bone an average is used for the estimated amounts of the four fields. Figure 2 shows a cross-section of the femur with Kerley's four fields. These fields were also used to examine the specimens of this research project. Kerley (1963, 1965) also set up a profile chart system which worked well when there were scores for more than one bone. Ubelaker (1978) and Stewart (1979) have an explanation of this scheme as well as the profile charts.

Anthropologists such as Ahlqvist and Damsten (1969), Ortner (1970, 1975, 1976) and Ubelaker (1977, 1978) have reworked and modified Kerley's original histological investigation. Ahlqvist and Damsten propose the use of an ocular square-ruled network because a round field such as Kerley used presents problems. A square-ruled network eliminates the need to move the microscope in order to see the features on the edge of the field, since only features in the 100 square network are counted. One difficulty concerns distinguishing osteones from fragments. There is always uncertainty in deciding in a cluster of osteones which is a whole osteon or a fragment in spite of Kerley's definition of an osteon. Kerley's definition of a recognizable osteon was one that contained 80% or more of its area and had the canal intact. Application of this criterion is difficult to determine in older aged individuals. Fragments include osteones that have discernible encroachment by subsequent generations of osteones and are exemplified by arcs of concentric lamellae between newer osteones (Kerley, 1965: 162). Secondly, the possibility exists for a rough estimation of the percent of circumferential lamellar bone in a circular field. To alleviate these problems, Ahlqvist and Damsten's technique require an ocular square-ruled network superimposed on the sections. The network contains 100 squares, and the

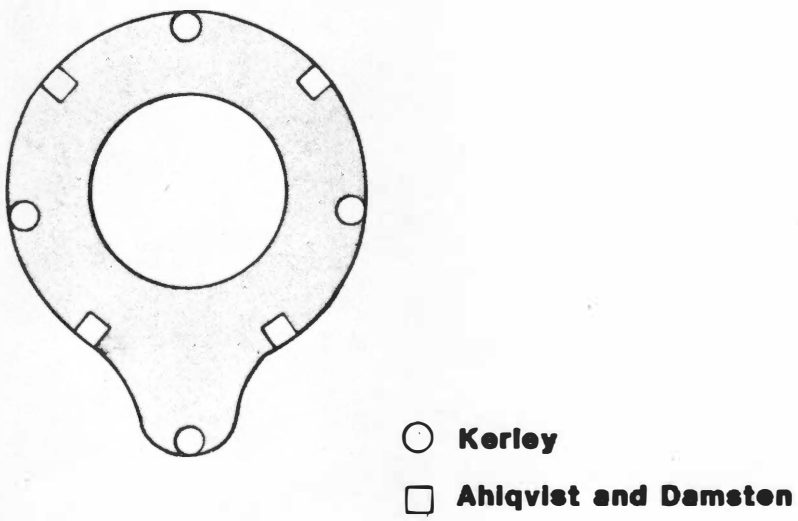


Figure 2. A cross-section of bone with the four fields of vision.

number of squares more than half filled with osteones and osteon fragments are counted. The percentage of bone covered by these structures is obtained directly from the determinations. Kerley never explained in his 1965 article how to estimate the percent of circumferential lamellar bone. In this way the determination of the type of those structures located along the borders of the visual field is easier in the Ahlqvist and Damsten method than with Kerley's original technqiue, since in the latter, one is often forced to move the specimen (Ahlqvist and Damsten, 1969: 207-8). Finally, there is difficulty in deciding the kind of structure in proximity of the limits of a circular visual field with dark edges without moving the specimen, the number of such structures being large in a visual field of this magnitude (Ahlqvist and Damsten, 1969:210). Another change made by Ahlqvist and Damsten is to reposition the fields (Fig. 2) to avoid the immediate region of the linea aspera, an area thought to contain more non-age related variability. Kerley used the linea aspera, where muscle attachment occurs, in his selection of fields. Most investigators feel that this field should not be used since more remodeling is apparent from this muscle attachment area.

Bouvier and Ubelaker (1977) compare the two methods of osteon counting. In their analysis precision and accuracy are tested. They note that Kerley's femoral method is based on an evenly distributed age sample and one of relatively large size, while a smaller sample and uneven distribution is found in Ahlqvist and Damsten's sample. This seems to have significantly affected the accuracy of age estimates obtained using Ahlqvist and Damsten's method. A present, Kerley's method is preferable for accuracy of age estimates (Bouvier and Ubelaker, 1977: 393-4). It should be noted that the samples used in the comparison

are of Kerley's original work and that none of Ahlqvist and Damsten's are used, possibly biasing the sample in Kerley's favor.

As the result of Ubelaker's re-analysis of Kerley's earlier work, the regression formulas now used are those in Kerley and Ubelaker (1978) or Ubelaker (1978). To resolve the problem of field size which occurred when Ubelaker attempted to use Kerley's formulas in his monograph (1974), Kerley and Ubelaker re-examined with a calibrated field size the sections used in the original Kerley study. After checking different microscopes thought to have been used by Kerley, the stage micrometer field size of 1.62mm was established instead of the 1.25mm field size as originally reported by Kerley. All counts were then compared with the original findings confirming that the field size was about 1.62mm (Kerley and Ubelaker, 1978: 545).

An approach applying osteon counting to disease was attempted by Ortner in his doctoral dissertation (1970). He used osteon counting to examine interrelationships between effects of aging and disease on micromorphology of human bone. Ortner demonstrated that alcoholism and arteriosclerosis effect bone development. Beyond these problems there are undoubtedly a number of disease processes which can simulate the effects of either alcoholism or arteriosclerosis (Ortner, 1970: 61). However, Ortner does not recommend utilizing them in any specific identification situation, but presents them to demonstrate the potential for saying something about the general health of the specimen.

Singh and Gunberg (1970) have also devised an alternative to the Kerley method of osteon counting. Their sample consisted of 59 cadavers with a 1cm by 1cm square section removed from the mandible. The count consisted of the total number of osteones in two fields (not an average),

the average number of lamellae per osteon in both fields and average Haversian canal diameter. These values were then applied to their regression formula to achieve an age estimate.

Most recently, Laughlin and his associate Thompson at the University of Connecticut have been using a core sampling technique to do osteon counting. Thompson (1979) states in a paper that the purpose of his study is to: 1) propose a histological method of estimating age at death in skeletons primarily beyond 50 years of age utilizing a small core of cortical bone; 2) to provide an objective method for quantifying cortical bone microstructures used in age estimation; 3) and to examine the feasibility of obtaining estimates of age at death from bones of the upper and lower extremities (Thompson, 1979: 2). In addition, Thompson's procedure also includes cortical thickness, bone density and bone mineral content, data which would be difficult for most individuals to acquire without expensive equipment and training. The use of the core technique would not destroy the bone specimen, since the drilled hold could be plugged to give strength to the bone, unlike the cross-section method where approximately 1 inch of bone is removed leaving the bone in pieces. The regression formulas do not exist for the general usage of the core technique. I feel that the core technique has potential, but the Kerley method of osteon aging was used. In my technique, specimen preparation consists of the cross-section style similar to Kerley's method.

CHAPTER III

METHODS AND PROCEDURES

Material in this study consists of four slides loaned to me by Ellis R. Kerley and seven Forensic Anthropology cases from the Anthropology Department at The University of Tennessee, Knoxville. The sample contains five females and six males with ages ranging from 17 to 83 years. Two of The University of Tennessee, Knoxville specimens are of estimated age based on other morphological criteria (Table 1). All of The University of Tennessee, Knoxville cases were prepared by me in the thin section laboratory of the Department of Anthropology.

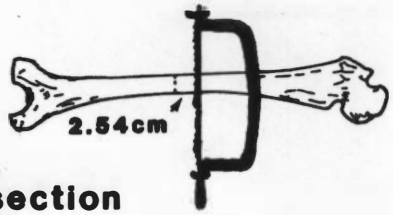
Approximately a 2.54cm section was removed from the midshaft of the left femur for each specimen. This section was cleaned and prepared for cutting on an Isomet slow speed saw manufactured by Buehler Ltd. Most samples were halved as the equipment could not cut a whole cross-section. All information pertaining to saw calibration was recorded so that each half specimen would be cut closely to its counterpart. After cutting, a metric micrometer was used to measure specimen thickness. A thickness of 70 to 105 microns is preferred. The Isomet saw was capable of consistently removing a 90 micron section. The hand grinding is done using 400 and 600 grid Buehler prepared grinding surfaces which are then used on the Minimet polisher. A final polish, using six micron diamond paste to remove scratches, was done before cleaning in an ultrasonic cleaner for 20 minutes. The last step was to permanently mount the specimen on a 1 by 3 inch slide using Paramount as a mounting medium. Figure 3 graphically illustrates the preparation and mounting of a specimen.

Table 1. Composition of the Sample.

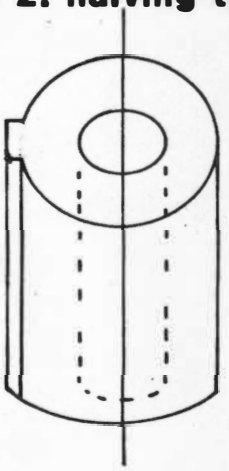
Case Number	Sex	Age	Race
940302	F	41	?
947366	F	79	American White
1062496	M	83	?
107440	M	69	American White
72-3	M	34	American White
73-1	F	(18-21)*	American Black
74-2	M	28	American White
74-5	F	43	American Black
75-3	F	(17-20)*	American Black
79-13	M	38	American White
80-6	M	65	American White

*Age determined by morphological criteria as actual age unknown.

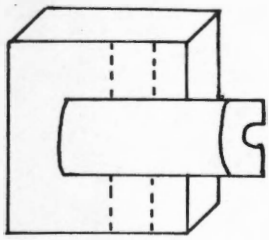
Step 1. removal of midshaft



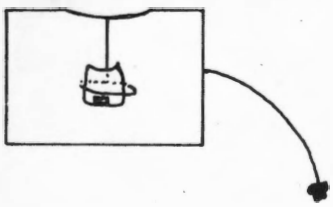
Step 2. halving the section

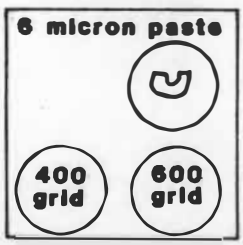


Step 3. cutting the thin section



Step 5. cleaning with ultrasonics





Step 4. hand grinding

Step 6. mounting specimen on slide

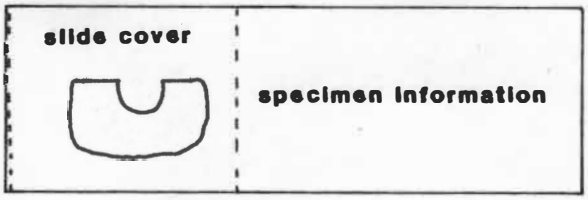


Figure 3. Specimen preparation.

A Reichert transmitted-light interfact contrast Zetopan research microscope was used to obtain the photographic record. This particular microscope does not have true polarized light, but its artificial polarized light works well enough for a visual observation; therefore, I feel there was no problem in the photographic process. The user of this type of microscope must be careful to get the settings correct since there are two separate optical units involved. Each has to be set on 10x so with the eyepiece of 10x, a 100 power field is examined. Attached to this microscope is a fully automatic Nikon photographic system. (Because of an interchangeable backing), this system allowed 35mm photography as well as Polaroid films. A more expensive type of film, 667 Polaroid coaterless, is used since a fixative does not have to be applied to the pictures after development. (Color pictures were taken with the notion that the edges of the features would be more apparent than in black and white photographs. However, color photographs did not enhance the details of the picture sufficiently to justify the expense of the film; therefore, all pictures are in black and white.) This type of film records one-third of the field at a time so nine pictures are required to photograph one field. Approximately two hours are necessary to photograph one sample.

After focusing the specimen so the periosteum is just visible in the image, the location of the field is sketched on a record sheet and the scale values of the stage platform recorded. The first picture, then represents the origin picture (center of the mosaic) for the nine total pictures. By moving the stage platform up and down and from side to side, each separate picture is recorded and taken. There is some overlap on the pictures which is used in mosaicing the individual pictures into a representative field (Fig. 4). Preparing the mosaic accurately again

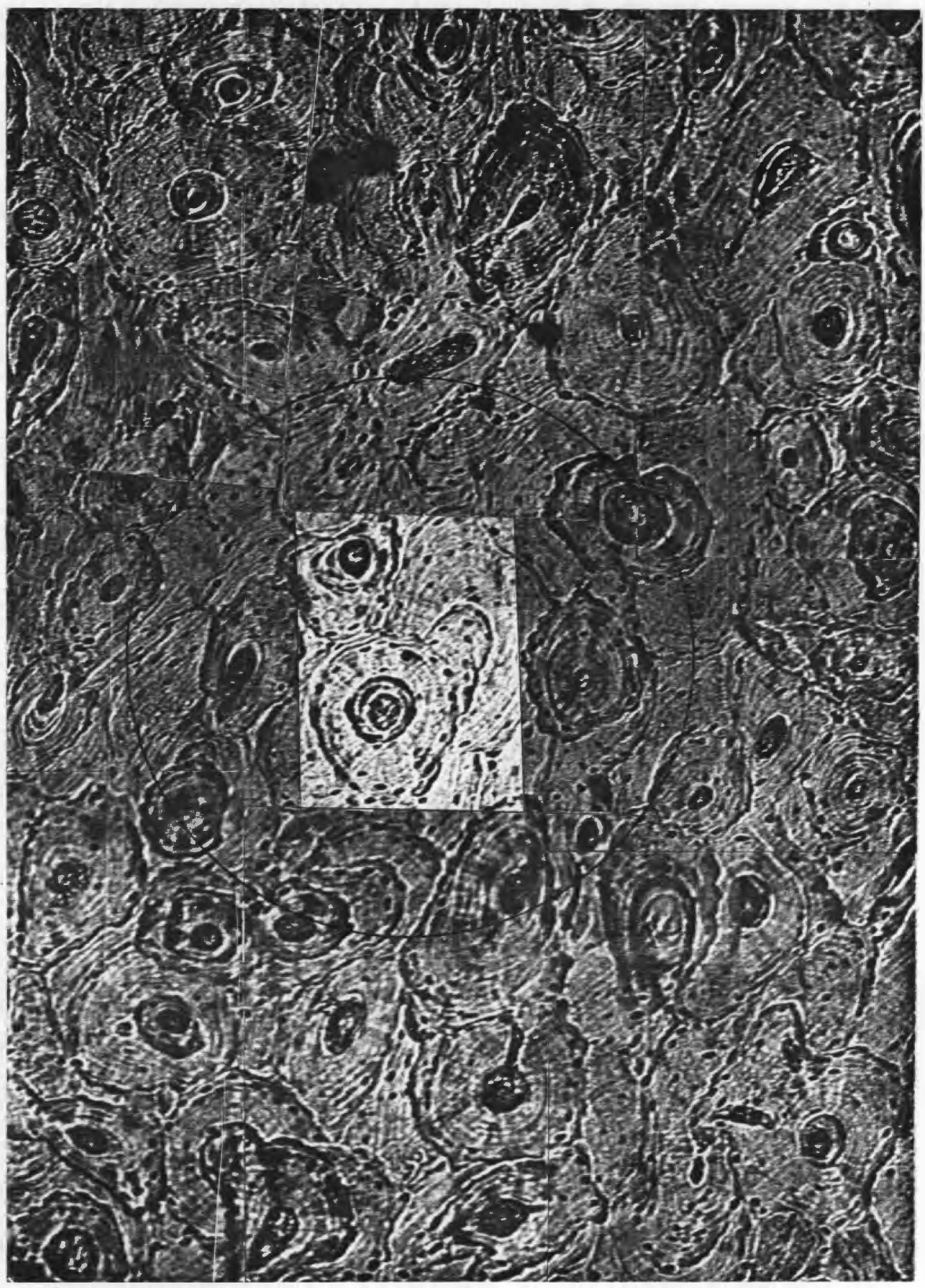


Figure 4. Mosaic of a typical field (reduced 50%).

requires approximately 45 minutes per field. The mosaic of the specimen is ready to be entered into the computer.

Computer Methodology

Using a PDP 11/40 minicomputer the picture mosaic is digitized and entered into the computer for further calculations. Appendix A, is the the listing of the program, TENTAB.FOR, by which the tablet allows the data to be digitized. These data bases are then applied to several other programs, OCANM, INTERP, UNITE and HOLMES, whose listings are Appendices B, C, D, and E, respectively.

Before actually digitizing a sample, one has to log onto the computer, allocate a disk drive and mount a magnetic disk in order to record the output from the computer. The picture mosaic is then taped to the tablet along with a miniature version of the menu (subroutines of commands for digitizing data, Fig. 5). RUN TENTAB will cause the computer to execute TENTAB.FOR, the program to digitize the data by means of an interactive graphics tablet. Since the CRT screen is used, a visual image as well as directives of the program appears on the screen for the users viewing. The directives are used to guide the user through the program.

First, the computer requires a name, OSTIN.DAT, for input information which is typed in at the terminal. Next. the menu is located from six points entered left to right and eight left side points top to bottom. To verify that the menu is entered correctly, the computer draws the menu on the CRT screen. If incorrect, the menu can be re-entered before proceeding. The program is ready for the options to be selected. Selecting the origin box permits the location of x and y coordinates to be recorded as well as drawn on the CRT screen. This option must be used with the

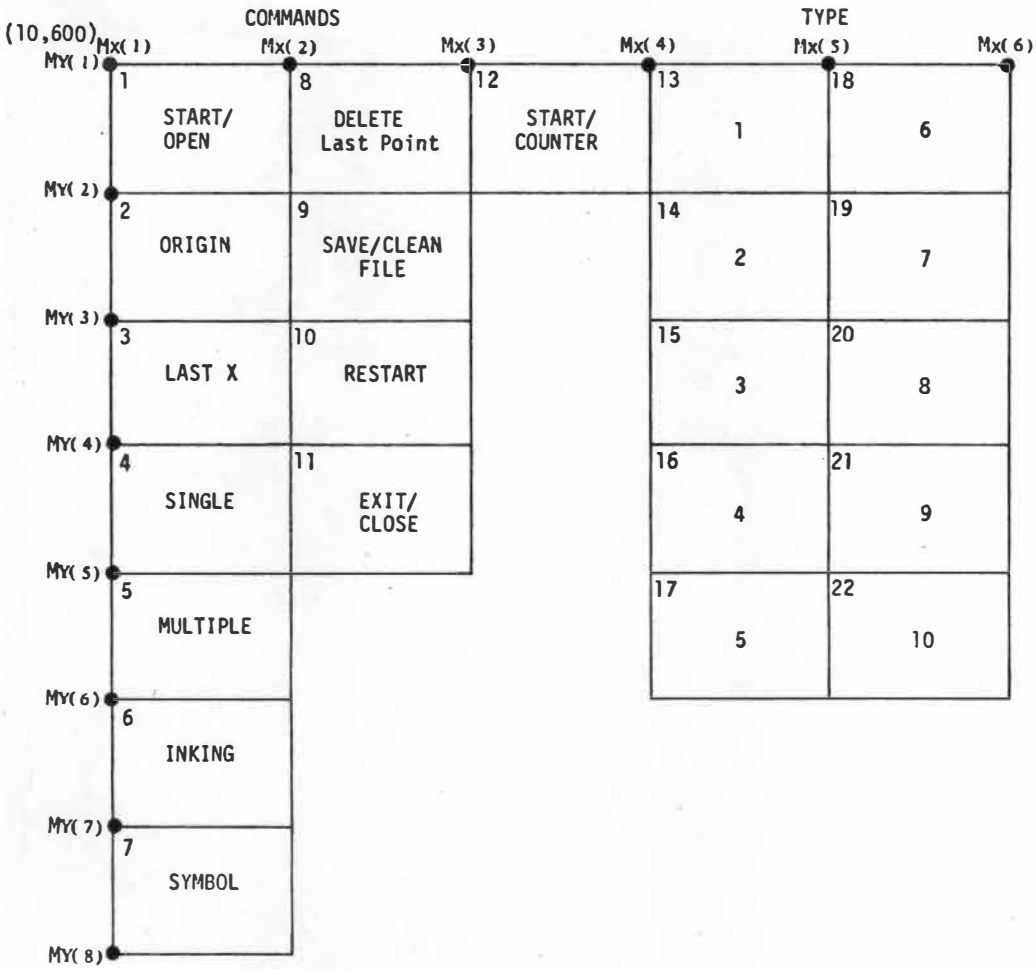


Figure 5. The control menu of TENTAB.FOR.

Xmax box which establishes the horizontal axis. A single point or multiple data points can be used to gather data. Because of the rate of transmission of data to the computer by the tablet, a single point mode is used. Another pair of options to use are the inking and symbol boxes. When chosen the CRT screen will draw the lines between data points and record a number there which refers to a type of osteon counting feature. Figure 6 represents a hardcopy of a typically entered field showing some of the options used. A final pair of options permits an accurate count (Icount) and type (Itype) of a feature. These are changed and incremented by the user when proceeding from one feature to another.

To determine that the exact field was entered into the computer, the stage micrometer was photographed. By means of mathematical equations which will be discussed later, the 1.48mm field size of this particular microscope represented a circle with a 7.45 inch diameter. To be certain of entering only this size diameter circular field, a template was made from clear acetate film which, when centered over the origin picture, recreates the field as viewed under the microscope. Each feature is recorded in the following system: 1) osteones; 2)Non-Haversian canals; 3) fragments; 4) osteones on the edge of the field; 5) reabsorption spaces or holes; 6) boundary of the field; 7) and unknown features. Type features one to five and seven must be digitized before number six boundary feature. When all features are entered, the file is stored on a magnetic disk by the menu selection save/clean box. The computer asks for an output file name (OSTOUT.DAT) which is typed in from the terminal. Finally, the exit/close box disengages the TENTAB.FOR program from the tablet.

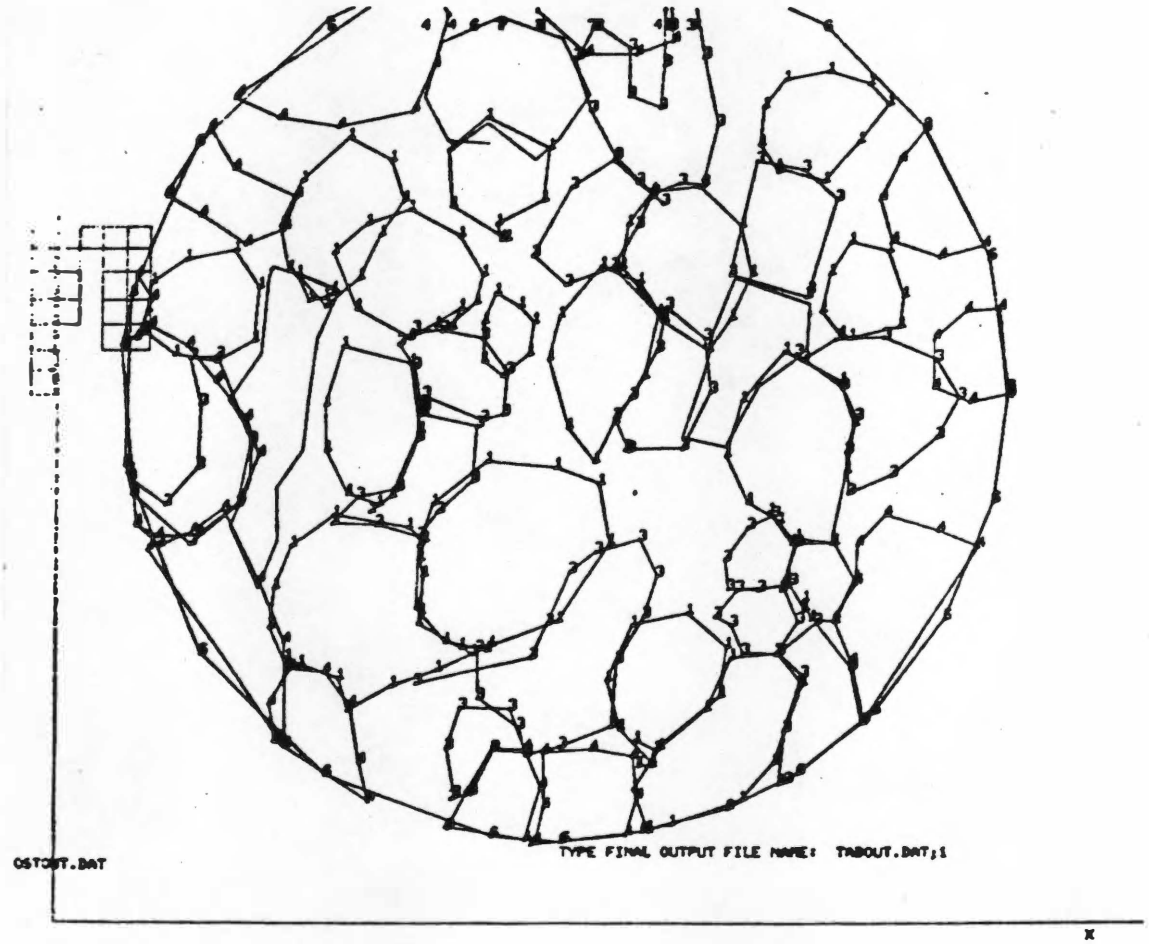


Figure 6. A typical digitized field (reduced 25%).

RUN OCANM is the next program in calculating an age estimate at death. This program redraws the points stored in the x and y coordinates of OSTOUT.DAT and calculates area and dmax while plotting the centroids (Fig. 7). Again the computer asks for an input file (OSTOUT.DAT) and two output file names (SIZE.DAT and DIAM. DAT) for recording area and maximum distance across an osteon counting feature. The SIZE.DAT information is used to calculate area information. The formula for this was based on arc setments.

$$\text{Area} = \tfrac{1}{2}[(X_1Y_2 + X_2Y_3 + \ldots + X_{N-1}Y_N + X_NY_1) - (X_2Y_1 + X_3Y_2 + \ldots + X_NY_{N-1} + X_1Y_N)]$$

This formula came from Chasen (1978: 190). DIAM.DAT is a file of maximum distances across an osteon counting feature. Because of a lack of sufficient sample size, neither DIAM.DAT nor the centroid plots were used in distance measurements.

The third step in calculating an estimate of age at death is to RUN INTERP. This program shows the number of osteon counting features and calculates the percent of circumferential lamellar bone. As a requirement of most computer programs again an output file (OSTOUT.DAT) is typed in at the terminal. This program also requires a separate input file (SIZE.DAT) to perform the percent of circumferential lamellar bone calculation. The results are stored in a file (RESULT.DAT) which in turn is entered when the computer prompts the user for it. While the calculations are being done, the terminal displays on the CRT screen the count and type of the individual features. Finally, the percent of circumferential lamellar bone is displayed on the CRT screen. The values of osteones, Non-Haversian canals, fragments, reabsorption spaces, other features and percent of circumferential lamellar bone are stored in

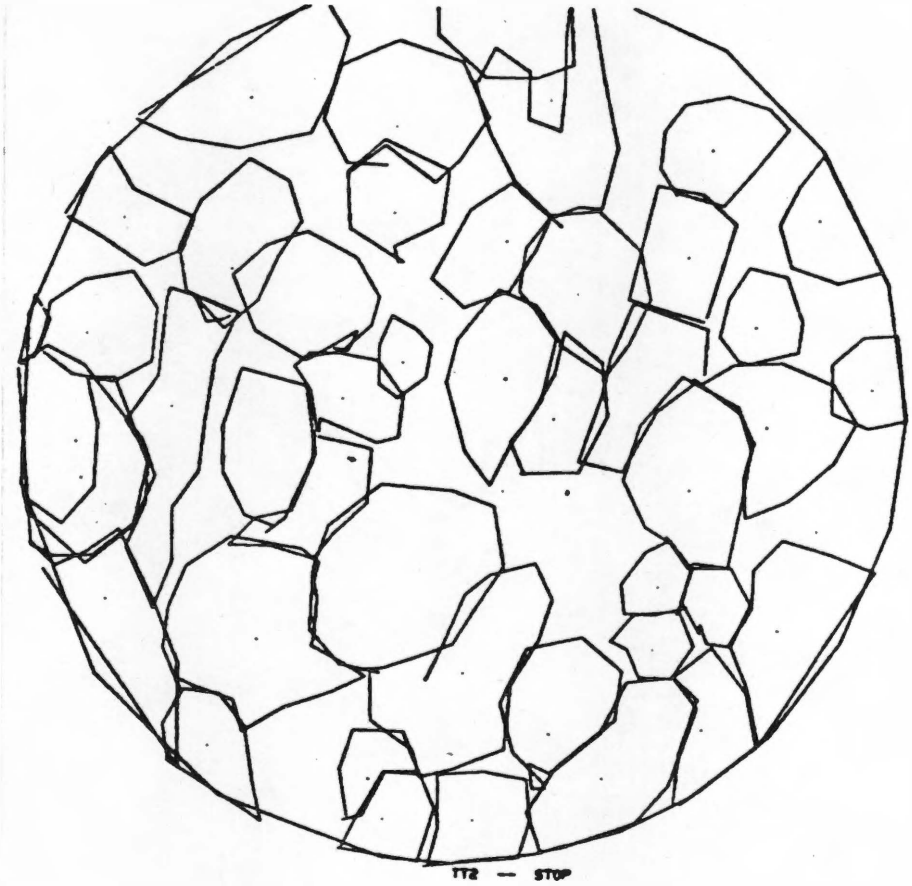


Figure 7. The centroid plots of Figure 6.

RESULT.DAT (Fig. 8). To obtain a printed copy of the results, type PRINT RESULT.DAT at the terminal.

After all four fields have been stored into the computer, the next program is used. The user types RUN UNITE. This program utilizes the four RESULT.DAT files which are numbered in sequence together so all four fields are represented by one total count and the percent of lamellar bone is an average for the four fields. First, all individual RESULT.DAT files are entered into the computer by typing them in at the terminal. The output from this coalition is stored into the output file (UNITE.DAT).

RUNE HOLMES executes the last and most important of the computer programs since the correcting factors are added here and the actual age is calculated. This program corrects for differences in unit size and differences in microscope field sizes. These values along with either individual RESULT.DAT files or UNITE.DAT file are applied correcting factors and then the computer calculates the age for the appropriate regression formula(s). The first step in this program is to enter either the RESULT.DAT OR UNITE.DAT file. The newly created output from this program is stored in HOLMES.DAT. Step two consists of correcting for scaling factors and converts all units to millimeters.

Part one of this problem is magnification for the radius of the microscope and that of the photograph. If r = microscope radius as measured from the stage micrometer and R = radius photograph measured across the picture in inches, one can change the photograph radius from inches to millimeters by multiplying by 25.4mm/in.

r = .74mm, this is one-half of 1.48mm field size

R = 3.725 in = 3.725 x 25.4 = 94.62mm photo to millimeters

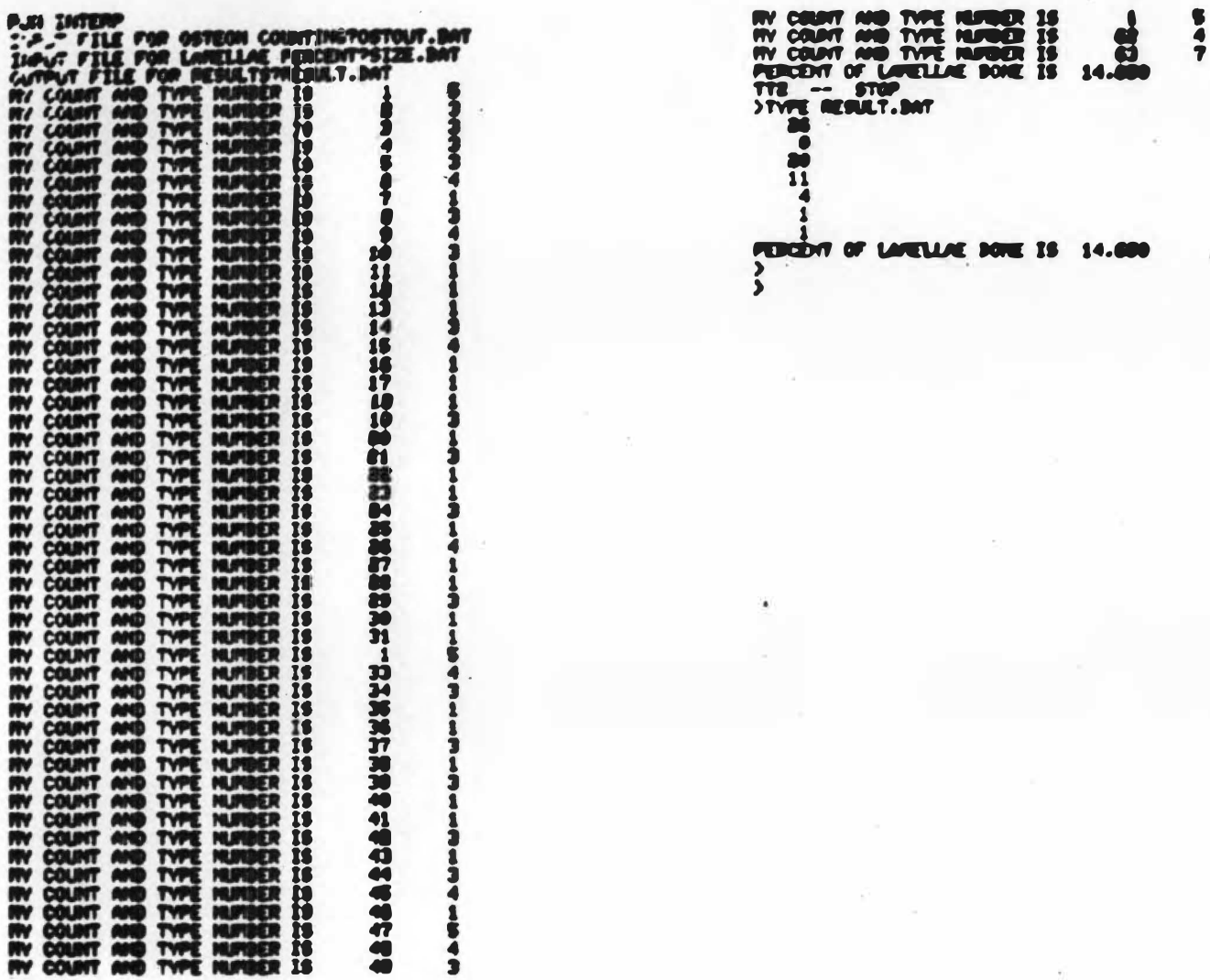


Figure 8. Typical output of a RESULT.DAT file.

Then the magnification ratio is:

$$M = \frac{R}{r} = \frac{94.62}{.74} = 127.86$$

A distance is magnified by the ratio M. Since $R = M_r$, therefore, an area is changed by the square of M. Thus, the two areas are equal.

$$A_{microscope} = \pi r^2 = \pi(\frac{R}{M})^2 = \frac{R^2}{M^2} = \frac{\text{Area on Photo}}{M^2}$$

$$A_{microscope} = \pi(.74)^2 = \pi(\frac{94.62}{127.86})^2$$

$$A_{microscope} = 3.1415927(0.5476) = (3.1415927)(.5476417)$$

$$A_{microscope} = 1.72mm = 1.72mm$$

The second part of this problem is discretization. The tablet contains 1024 points/10 inches and the points are .248mm apart. The tablet numbers are in inches x 100. So a radius $\int$ measured in tablet units must first be converted to millimeters to be equal to R.

3.725 x 100 is the radium in tablet numbers = 372.5

$$R = \frac{372.5}{100} \times 25.4 = 94.62mm$$

therefore, Area of Microscope $= \pi\frac{R^2}{M^2} = 3.1415927(\frac{8952.94}{16348.18}) = 1.72mm$

Because the areas calculated are the same, one can write a program computing area based on this information. HOLMES calculates area by two methods so the user types in 0, 1 or 2 at the terminal when prompted. The number two calculates area by both means. (Zero is derived on a method using number of points and one is derived from the photograph directly.) For the exact computer listing, see appendix on HOLMES.

Step three corrects the observer's microscope field size (measured by stage micrometer) to Kerley's revised data as established by Ubelaker's re-evaluation of the Kerley method (Kerley and Ubelaker, 1978). The value for stage field size correction is calculated by dividing

observer's area into Kerley's area and multiplying this value by the counts for osteones, fragments and Non-Haversian canals. According to Ubelaker and Kerley the percent of circumferential lamellar bone is not effected.

Step four is used only if one is using a RESULT.DAT file. Step four takes the individual field and multiplied osteones, fragments and Non-Haversian canals by four so the values can be used in the regression formula(s).

In step five the user selects bone type (femur, tibia or fibula) and the appropriate regression formula(s) associated with them. Once again the computer prompts the user by asking for bone type. The individual types 0 for femur, 1 for tibia or 2 for fibula at the terminal. After completing this, the computer displays on the CRT: YOUR REGRESSION FORMULA(S) ARE: 1 OSTEONES, 2 NON-HAVERSIAN CANALS, 3 FRAGMENTS and 4 PERCENT OF CIRCUMFERENTIAL LAMELLAR BONE. The user types in one of the numbers or any combination to calculate the age. The program gives an age in plus or minus standard deviation of years. Figure 9 depicts a typical HOLMES.DAT output file. To get a printing of the age values the user types PRINT HOLMES.DAT.

The next chapter will discuss the results obtained from analyses of the data generated from the HOLMES.DAT computations.

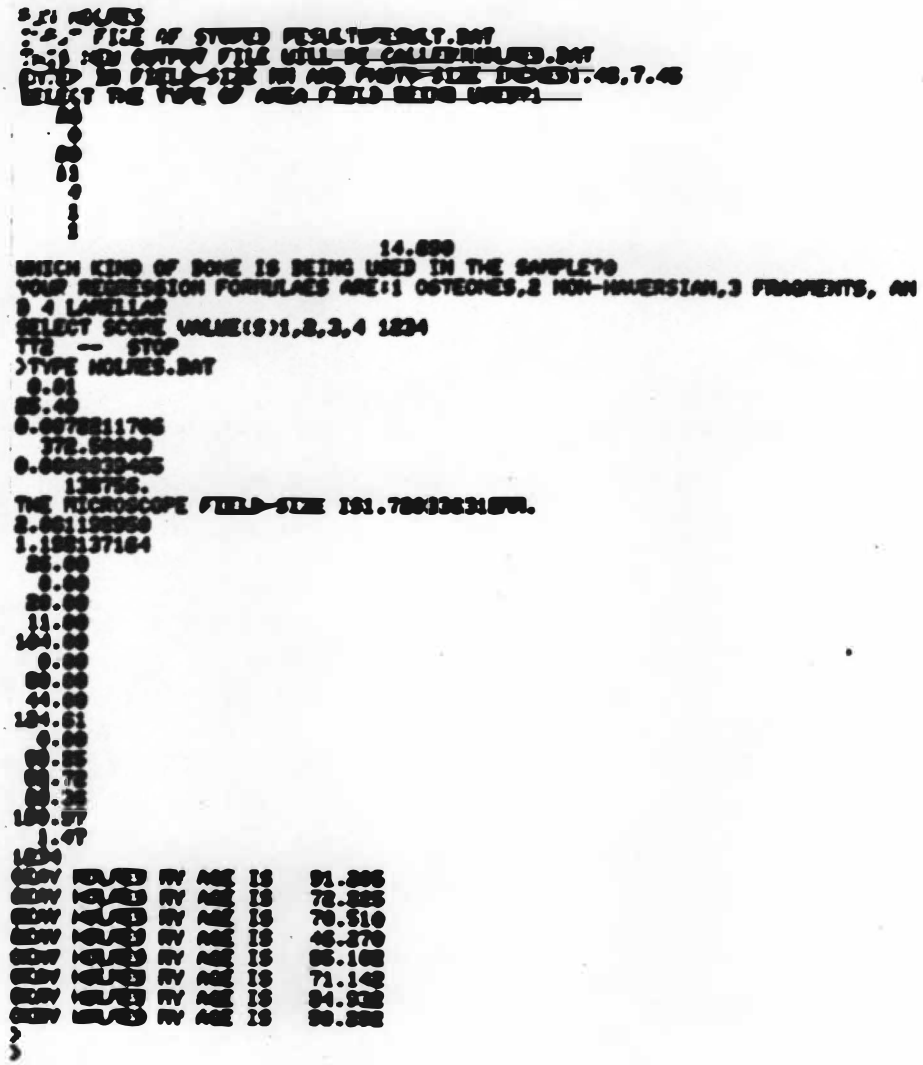


Figure 9. A hardcopy of a typical HOLMES.DAT file.

CHAPTER IV

RESULTS

Table 2 displays the raw data of the actual age and the computed age for each specimen examined. In all cases there is a four field total and a score for each individual field designated as A (anterior field), B (posterior field), C (medial field) and D (lateral field). In samples (73-1) and (75-3) there are two sets of values represented since they were aged morphologically. Six cases (940302, 107440, 73-1, 74-5, 75-3 and 79-13) of the 11 total have a range where all four fields bracketed the actual age. This represents a poor 55 percent. Individual fields A and B did worse than the four field total as they have 45 percent and 36 percent age ranges bracketing the known age. Field C is the least productive field and has only 18 percent of the ranges bracketing the known age. Finally, field D has a 45 percent score of ranges bracketing the known age. Only five cases have a range mean age value whose age is within plus or minus five years of the known age with case (940302) only .5 older than the actual age given. Three more cases are within plus or minus 10 years of the known age. At plus or minus 15 years of the known age only one cases is added. Only one case is within the plus or minus 20 years of the actual age category. There are two cases (947366 and 1062496) which are more than 20 years away from the known age. The individual four fields are similar to the four field total for range mean age value versus the known age.

Field A has three cases (73-1, 74-2 and 79-13) whose range mean age values are within plus or minus five years of the known age. Three

Table 2. Raw Data of Actual Age and Computed Age.

Case Number	Sex	Actual Age	Total Age Four Fields		Age Field A		Age Field B		Age Field C		Age Field D	
			Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$	Range	$\bar{x}$
940302	F	41	40-43	41.5	32	32	30-40	35	52-60	56	32-46	39
947366	F	79	53-56	54.5	61-72	66.5	18-46	32	51-75	63	55-75	65
1062496	M	83	52-53	52.5	50-51	50.5	27-46	36.5	53-60	56.5	68-70	69
107440	M	69	49-80	64.5	49-70	59.5	39-93	66	53-64	58.5	57-109	83
72-3	M	34	42-45	43.5	50-52	51	45-84	64.5	27-32	29.5	34-39	36.5
73-1	F	(18-21)*	20-25	22.5	21-23	22	30-41	35.5	23-55	39	12	12
74-2	M	28	14-19	16.5	19-32	25.5	27-46	36.5	4-15	9.5	15-21	18
74-5	F	43	25-46	35.5	19-46	32.5	23-46	34.5	31-46	38.5	19-46	32.5
75-3	F	(17-20)*	19-26	22.5	27-46	36.5	6-17	11.5	12-32	22	23-32	27.5
79-13	M	38	32-39	35.5	34-46	40	25-32	28.5	30-32	31	32-46	39
80-6	M	65	46	46	50-55	52.5	19-46	32.5	46-48	47	46-54	50

cases are within plus or minus 10 years of the known age. Plus or minus 15 years of the known age increases the results of the two cases. Three cases are within plus or minus 20 years of the known age. However, one case (1062496) is more than 20 years away from the actual age.

Field B has one case (107440) whose range mean age value is within plus or minus five years of the known age. Six cases are within plus or minus 10 years of the known age. Plus or minus 15 years of the known age adds two cases to the result scores. One case is within plus or minus 20 years of the known age, while three cases are more than 20 years away from the actual age.

Field C has three cases (72-3, 74-5 and 75-3) whose range mean age values are within plus or minus five years of the real age. Within plus or minus 10 years of the known age the count shows one case. Two cases are within plus or minus 15 years of the actual age. There are four cases within the 20 years of the known age category, and two cases are more than 20 years away from the actual age.

Field D has three cases (940302, 72-3 and 79-13) whose range mean age values are within plus or minus five years of the known age. Within plus or minus 10 years of the known age are four more cases. Six cases are within plus or minus 15 years of the actual age and no cases are within plus or minus 20 years of the known age. Finally, there are no cases more than 20 years away from the known age. This suggests that there may exist the possibility of using only one field for osteon counting, but further research will need to be done to see if this trend continues in a larger sample.

Some of the output data from the disk contains information on the individual osteon counting features. Their computed range and range mean

age values along with the known age are presented in Table 3. The results in the column labeled four field have been discussed previously. Osteones represent the first feature evaluated.

Osteones only have four cases with the range mean age values containing the actual age for a 36 percent accuracy score. The seven specimens missed showed five cases lower than the actual age and two cases higher than the known age. This suggests that either osteones were recorded as some other feature or an error (such as poor photograph quality) existed in recording features.

Non-Haversian canals did better with six cases containing the range mean age values for a 55 percent accuracy level. The five cases missed showed two lower than and three higher than the known age. However, three of the cases missed because the regression formula for Non-Haversian canal will result in an age of 46 to 71 years when a zero value is entered. If 71 is the lowest-maximum value of the age range and the sample is older than 71 years of age the program underages the specimen.

Again, fragments have only a 36 percent accuracy with only four cases bracketing the known age. Out of the seven cases missed, six are lower and only one case is higher than the actual age. This also suggests that fragments were not properly identified. They are either entered as something else or not located in the original photographs. As stated earlier, perhaps those disregarded features on the edge of the fields should have been added to fragments.

The percent of circumferential lamellar bone has the highest number of range mean age values bracketing the known age. There are seven cases bracketing the actual age for a 64 percent level of accuracy. All four specimens which are aged incorrectly are lower than the known

Table 3. Raw Data of Features Versus Actual Age.

Case Number	Sex	Actual Age	Total for Four Fields Range	$\bar{x}$	Osteones Range	$\bar{x}$	Non-Haversian Range	$\bar{x}$	Fragments Range	$\bar{x}$	% Lamellar Range	$\bar{x}$
940302	F	41	40-43	41.5	34-52	43	39-63	46	29-43	36	18-43	30.5
947366	F	79	53-56	54.5	48-66	57	46-71	58.5	56-70	63	28-53	40.5
1062496	M	83	52-53	52.5	43-61	52	46-71	58.5	53-67	60	26-52	39
107440	M	69	49-80	64.5	80-99	89.5	46-71	58.5	65-79	72	24-49	36.5
72-3	M	34	42-45	43.5	42-60	51	29-54	41.5	34-48	41	20-45	32.5
73-1	F	(18-21)*	20-25	22.5	18-36	27	11-35	23	25-39	32	0-20	10
74-2	M	28	14-19	16.5	12-30	21	14-39	26.5	5-19	12	3-28	15.5
74-5	F	43	25-46	45.5	7-25	16	46-71	58.5	11-25	18	20-45	32.5
75-3	F	(17-20)*	19-26	22.5	5-23	14	26-51	38.5	6-19	12.5	2-27	14.5
79-13	M	38	32-39	35.5	14-32	23	39-63	51	21-35	28	13-38	25.5
80-6	M	65	34-59	46.5	36-55	45.5	46-71	58.5	32-46	39	34-59	46.5

*Age determined by other morphological criteria.

age. The problem with this category of osteon counting feature will be discussed in detail in the next chapter.

Individual Field Data

First, the location of the field is examined to see if one is better than another for determining age. The results do not support any trend; however, the lateral field shows more promise than the other fields. I feel that the lateral field is the best for osteon counting since all the cases containing the actual age are within plus or minus 15 years of the known age. Of the fields whose range mean age values bracketed the known age the results show that the posterior field has four cases, medial two cases, and lateral and anterior have five cases each.

Table 4 lists the ranges and range mean age values for the individual fields and the actual age. There were a total of forty-four individual ranges for each osteon counting feature. Osteones had 18 out of 44 ranges containing actual age for a 41 percent accuracy, and those cases which are within plus or minus three years of the known age only improve accuracy to 23 out of 44 or 52 percent accuracy. The accuracy of ranges bracketing the real age for Non-Haversian canals was 45 percent. Adding plus or minus three years of the known age to the scores improved accuracy to 26 out of 44 or 60 percent. Fragments are the worst feature for accuracy as only 10 out of 44 scores or 23 percent contain the known age. Those ranges within plus or minus three years of the known age increase accuracy to 16 out of 44 or 36 percent. Again this suggests fragments are missing in the initial scoring. Kerley (1965) had suggested that at least fragments of the fibula would by itself generally predict age

Table 4. Individual Field Data Showing Range and Mean Values as Opposed to Real Age.

Case Number	Actual Age	Field #	Osteones Range	Osteones $\bar{x}$	Non-Haversian Range	Non-Haversian $\bar{x}$	Fragments Range	Fragments $\bar{x}$	% Lamellar Range	% Lamellar $\bar{x}$
940302	41	A	19-38	28.5	32-57	44.5	18-32	25	21-46	33.5
		B	36-55	45.5	46-71	58.5	60-74	67	27-52	39.5
		C	40-58	49	32-57	44.5	18-32	25	5-30	17.5
		D	43-61	52	46-71	58.5	18-32	25	22-47	34.5
947366	79	A	75-93	84	46-71	58.5	64-78	71	26-51	38.5
		B	0-18	9	46-71	58.5	13-27	20	0-25	12.5
		C	75-93	84	46-71	58.5	60-74	67	30-55	42.5
		D	71-89	80	46-71	58.5	72-86	79	36-61	48.5
1062496	83	A	55-74	64.5	46-71	58.5	70-84	77	43-68	55.5
		B	44-63	53.5	46-71	58.5	50-64	57	25-51	38
		C	35-53	44	46-71	58.5	60-74	67	48-73	60.5
		D	38-56	47	46-71	58.5	23-37	30	2-27	14.5
107440	69	A	109-128	118.5	46-71	58.5	71-85	78	32-57	44.5
		B	63-81	72	46-71	58.5	70-84	77	24-49	36.5
		C	63-81	72	46-71	58.5	64-78	71	28-53	40.5
		D	93-111	102	46-71	58.5	50-64	57	14-39	26.5
72-3	34	A	48-66	57	32-57	44.5	50-64	57	27-52	39.5
		B	21-39	30	32-57	44.5	34-48	41	24-49	36.5
		C	26-44	35	32-57	44.5	13-37	25	8-33	20.5
		D	84-102	93	21-45	33	40-54	47	23-48	35.5
73-1	(18-21)*	A	41-60	50.5	32-57	44.5	29-43	36	5-30	17.5
		B	6-25	15.5	12-37	24.5	55-69	62	0-23	11.5
		C	22-40	31	0-22	11	23-37	30	0-21	10.5
		D	7-26	16.5	12-37	24.5	0-12	6	0-18	9
74-2	28	A	26-44	35	46-71	58.5	13-27	20	29-54	41.5
		B	7-26	16.5	21-45	33	1-15	8	0-18	9
		C	14-32	23	32-57	44.5	5-19	12	19-44	31.5
		D	4-23	13.5	0-20	10	1-15	8	0-18	9

Table 4. (Continued)

Case Number	Actual Age	Field #	Ostones Range	Ostones $\bar{x}$	Non-Haversian Range	Non-Haversian $\bar{x}$	Fragments Range	Fragments $\bar{x}$	% Lamellar Range	% Lamellar $\bar{x}$
74-5	43	A	7-26	16.5	46-71	58.5	9-23	16	14-39	26.5
		B	12-31	21.5	46-71	58.5	29-43	36	32-57	44.5
		C	6-25	15.5	46-71	58.5	5-19	12	22-50	36
		D	3-21	12	46-71	58.5	5-19	12	13-38	25.5
75-3	(17-20)*	A	9-28	18.5	46-71	58.5	13-27	20	12-37	24.5
		B	14-32	23	32-57	44.5	9-23	16	13-38	25.5
		C	0-17	8.5	6-30	18	5-19	12	0-22	11
		D	1-19	10	32-57	44.5	0-12	6	0-20	10
79-13	38	A	18-37	27.5	46-71	58.5	34-48	41	9-34	21.5
		B	11-30	20.5	32-57	44.5	18-32	25	16-41	28.5
		C	6-25	15.5	32-57	44.5	13-27	20	2-27	14.5
		D	21-39	30	46-71	58.5	18-32	25	28-53	40.5
80-6	65	A	38-56	47	46-71	58.5	5-19	12	38-63	50.5
		B	32-50	41	46-71	58.5	34-48	41	27-53	40
		C	36-55	45.5	46-71	58.5	50-64	57	37-62	49.5
		D	41-60	50.5	46-71	58.5	40-54	47	34-59	46.5

*Aged by other morphological criteria as actual age unknown.

with good reliability. Finally, the accuracy for those ranges containing the actual age for the percent of circumferential lamellar bone is 43 percent. Those ranges within plus or minus 3 years of the known age increase percent of circumferential lamellar bone accuracy slightly with 23 out of 44 or 52 percent level of accuracy.

Statistical Results

Since the sample size is very small, there might be objections to performing a statistical analysis of the data. However, the paired t test can be utilized with a small sample. For purposes of the t test, the median age of the morphologically aged specimens is used to maintain independent sampling. The formulas used are from Baily (1968: 46).

$$\bar{x} = \frac{1}{n}\Sigma x$$

$$s^2 = \frac{1}{n}\{\Sigma x^2 - \frac{1}{n}(\Sigma x)^2\}$$

$$\frac{s}{\sqrt{n}}$$

$$t = \frac{\bar{x} - \mu}{s/\sqrt{n}}$$

The Null Hypothesis is the assumption that the actual age and the range mean age values will be the same, therefore $\mu = 0$. Then the t test is concerned with whether the mean $\bar{x}$ is significantly different from zero. For significance at the 5 percent level of confidence with 10 degrees of freedom (n-1) requies a t test value of 2.228 or more. The sign is ignored for the t test values. The confidence level used is $P < 0.05$ for the tests. Tables 5 - 9 contain the information obtained from the above calculations for the four field total score and the individual fields A - D. Analysis of the t tests shows that the four field total ($t = |-1.56|$) and the independent fields A($t = |-0.88|$), B($T = |-1.30|$),

Table 5. t test Data for Four Fields Total.

Case Number	Actual Age	Average Age 4 Field Total	x	x^2
940302	41	41.5	+ .5	.25
947366	79	54.5	-24.5	600.25
1062496	83	52.5	-30.5	930.25
107440	69	64.5	- 4.5	20.25
72-3	34	43.5	+ 9.5	90.25
73-1	19.5	22.5	+ 3	9
74-2	28	16.5	-11.5	132.25
74-5	43	45.5	+ 2.5	6.25
75-3	18.5	22.5	+ 4	16
79-13	38	35.5	- 2.5	6.25
80-6	65	46.5	-18.5	342.25
n = 11	518	445.5	-72.5	2153.26

$\bar{x} = -6.59$

$s^2 = 167.54$

$\frac{s}{\sqrt{n}} = 3.90$

$t = |-1.56|$ Degrees of freedom = 10 $P = < 0.05$

Table 6. t test Data for Field A (anterior).

Case Number	Actual Age	Average Age Range Field A	x	x^2
940302	41	32	- 9	81
947366	79	66.5	-12.5	156.25
1062496	83	50.5	-32.5	1056.25
107440	69	59.5	- 9.5	90.25
72-3	34	51	+17	280
73-1	19.5	22	+ 2.5	6.25
74-2	28	25.5	- 2.5	6.25
74-5	43	32.5	-10.5	110.25
75-3	18.5	36.5	+18	324
79-13	38	40	+ 2	4
80-6	65	52.5	- 7.5	56.25
n = 11	518	468.5	-44.5	2179.75

$\bar{x} = -4.05$

$s^2 = 199.97$

$\frac{s}{\sqrt{n}} = 4.26$

$t = |-0.88|$ Degrees of freedom = 10 P = < 0.05

Table 7. t test Data for Field B (posterior).

Case Number	Actual Age	Average Age Range Field B	x	x^2
940302	41	35	- 6	36
947366	79	32	-47	2209
1062496	83	36.5	-46.5	2162.25
107440	69	66	- 3	9
72-3	34	64.5	+30.5	930.25
73-1	19.5	35.5	+16	256
74-2	28	36.5	+ 8.5	72.25
74-5	43	34.5	- 8.5	72.25
75-3	18.5	11.5	- 7	49
79-13	38	28.5	- 9.5	90.25
80-6	65	32.5	-32.5	1056.25
n = 11	518	413	-105	6942.5

$\bar{x} = -9.55$

$s^2 = 594.02$

$\frac{s}{\sqrt{n}} = 7.34$

$t = |-1.30|$ Degrees of freedom = 10 P = < 0.05

Table 8. t test Data for Field C (medial).

Case Number	Actual Age	Average Age Range Field C	x	x^2
940302	41	56	+15	225
947366	79	63	-16	256
1062496	83	56.5	-26.5	702.25
107440	69	58.5	-10.5	110.25
72-3	34	29.5	- 4.5	20.25
73-1	19.5	39	+19.5	380.25
74-2	28	9.5	-18.5	342.25
74-5	43	38.5	- 4.5	20.25
75-3	18.5	22	+ 3.5	12.25
79-13	38	31	- 7	49
80-6	65	47	-18	324
n = 11	518	450.5	-67.5	2441.75

$\bar{x} = -6.14$

$s^2 = 202.75$

$\frac{s}{\sqrt{n}} = 4.29$

$t = |-1.43|$ Degrees of freedom = 10 P = < 0.05

Table 9. t test Data for Field D (lateral).

Case Number	Actual Age	Average Age Range Field D	x	x^2
940302	41	39	- 2	4
947366	79	65	-14	196
1062496	83	69	-14	196
107440	69	83	+14	196
72-3	34	36.5	+ 2.5	6.25
73-1	19.5	12	- 7.5	56.25
74-2	28	18	-10	100
74-5	43	32.5	-10.5	110.25
75-3	18.5	27.5	+ 9	81
79-13	38	39	+ 1	1
80-6	65	50	-15	225
n = 11	518	471.5	-46.5	1171.75

$\bar{x} = -4.23$

$s^2 = 97.52$

$\frac{s}{\sqrt{n}} = 2.97$

$t = |-1.42|$ Degrees of freedom = 10 P = < 0.05

C(t = |-1.43|) and D(t = |-1.42|) are not significant. This suggests that no field is superior to the others for osteon counting. This does not reject the argument that the posterior field should not be used because of the muscle attachment area of the linea aspera. However, I would recommend the posterior field as the least likely field to use as I saw most of the extreme cases of bone remodeling occurring here.

The t test is used to examine the relationship between age and the osteon counting features for the four field total. Tables 10 - 13 contain the data used in analysis of these features.

Analysis of the t test shows that osteones (t = |-1.37|) and Non-Haversian canals (t = |0.02|) are not significant. Fragments (t = |-2.36|) are slightly significant and will be discussed in the next chapter. Finally, the percent of circumferential lamellar bone (t = |-4.13|) is highly significant for a confidence level of $P < 0.05$. The implication of this t test score suggests that percent of circumferential lamellar bone is not a viable criterion of osteon aging. I feel that the problem originates with the fact that Kerley and Ubelaker's (1978) revised regression formula is derived from a visual estimate and the computer actually measures the percent of circumferential lamellar bone. For example, the visual percent of circumferential lamellar bone might be estimated as 3 to 5 percent, but the computer will register a higher percentage such as 8 to 10 percent. When applied to the regression formula the result for the computer will underage the subject. The higher the percent of circumferential lamellar bone calculated the younger the individual age estimate will be. Chapter 5 will discuss the problem of circumferential lamellar bone. Other general statements, however, can be made from the results.

Table 10. t test Data for Four Field Osteones.

Case Number	Actual Age	Average Age Range	x	x^2
940302	41	43	+ 2	4
947366	79	57	-22	484
1062496	83	52	-31	961
107440	69	89.5	+20.5	420.25
72-3	34	51	+17	289
73-1	19.5	27	+ 7.5	56.25
74-2	28	21	- 7	49
74-5	43	16	-27	729
75-3	18.5	14	- 4.5	20.25
79-13	38	23	-15	225
80-6	65	45.5	-19.5	380.25
n = 11	518	439	-79	3614

$\bar{x} = -7.18$

$s^2 = 304.66$

$\frac{s}{\sqrt{n}} = 5.26$

$t = |-1.37|$ Degrees of freedom = 10 P = < 0.05

Table 11. t test Data for Four Field Non-Haversian Canals.

Case Number	Actual Age	Average Age Range	x	x^2
940302	41	46	+ 5	25
947366	79	68.5	-20.5	420.25
1062496	83	58.5	-24.5	600.25
107440	69	58.5	-10.5	110.25
72-3	34	41.5	+ 7.5	56.25
73-1	19.5	23	+ 3.5	12.25
74-2	28	26.5	- 1.5	2.25
74-5	43	58.5	+15.5	240.25
75-3	18.5	38.5	+20	400
79-13	38	51	+13	169
80-6	65	58.5	- 6.5	42.25
n = 11	518	529	+ 1	2078

$\bar{x} = .09$

$s^2 = 207.7$

$\frac{s}{\sqrt{n}} = 4.34$

$t = |0.02|$ Degrees of freedoms = 10 $P = < 0.05$

Table 12. t test Data for Four Field Fragments.

Case Number	Actual Age	Average Age Range	x	x^2
940302	41	36	- 5	25
947366	79	63	-16	256
1062496	83	60	-23	529
107440	69	72	+ 3	9
72-3	34	41	+ 7	49
73-1	19.5	32	+12.5	156.25
74-2	28	12	-16	256
74-5	43	18	-25	625
75-3	18.5	12.5	- 6	36
79-13	38	28	-10	100
80-6	65	29	-36	1296
n = 11	518	403.5	-114.5	3337.25

$\bar{x} = -10.41$

$s^2 = 214.54$

$\frac{s}{\sqrt{n}} = 4.41$

$t = |-2.36|$ Degrees of freedom = 10 $P = < 0.05$

Table 13. t test Data for Four Field Percent Lamellar Bone.

Case Number	Actual Age	Average Age Range	x	x^2
940302	41	30.5	-10.5	110.25
947366	79	40.5	-38.5	1482.25
1062496	83	39	-44	1936
107440	69	36.5	-32.5	1056.25
72-3	34	32.5	- 1.5	2.25
73-1	19.5	10	- 9.5	90.25
74-2	28	15.5	-12.5	156.25
74-5	43	32.5	-10.5	110.25
75-3	18.5	14.5	- 4	16
79-13	38	25.5	-12.5	156.25
80-6	65	46.5	-18.5	342.25
n = 11	518	323.5	-194.5	5458.25

$\bar{x} = -17.68$

$s^2 = 201.91$

$\frac{s}{\sqrt{n}} = 4.28$

$t = |-4.13|$ Degrees of freedom = 10 P = < 0.05

The primary purpose of this thesis is to show the feasibility of doing osteon counting by computer. Unfortunately, a sample size of 11 cases, with several aged only by morphological criteria, does not permit as much insight as one might obtain from a sample of one hundred specimens. It is difficult to determine what is the cause when the computer age did not coincide with the actual age. Some of the error might be attributed to faulty logic in the programs or in the way data are digitized. Another possible source of error might be due to the lack of a complete medical history for the samples. Since Ortner (1970) has shown previously that alcoholism and arteriosclerosis affects osteon counting as well as other bone related diseases such as bone cancer, the lack of a medical history may play a large part in age differences. However, probably the key factor in age differences is in the way by which features are identified. In his study, Kerley (1965) moves the microscope to identify features on the edge of the field. This suggests that the field actually is enlarged. Therefore, in this study, features on the edge are counted independently with half being assigned to osteones. The other half is not used and perhaps in several cases when the fragment count appears low the disregarded amount should be used for fragment counts. Yet, another possibility of error is with the correcting factor described in Kerley and Ubelaker's (1978) article. After much debate, they finally decided on which microscope Kerley used in his initial investigation and then re-examined Kerley's material. The results seemed satisfactory so the field size was established at 1.62mm. This could still be in error and the result would show a difference between age calculated and the known age. One source of error related to the regression formula(s) is with the percent of circumferential lamellar bone.

Since the computer actually calculates the percent of circumferential lamellar bone instead of being a visual estimate, I feel there would be an error of some nature especially with the age of younger individuals. The error with the percent of circumferential lamellar bone does not involve the cases of younger individuals. Most of the trouble is with the age group over 60 years of age as the values tended to underage these specimens. To eliminate some of the problems with the percent of circumferential lamellar bone, I decided to develop a new regression formula for percent of lamellar bone. The next chapter will discuss the results of this formula.

CHAPTER V

DISCUSSION

Using percent of circumferential lamellar bone as an age determinant is shown to be questionable by the t test score (|-4.13|) of Table 13, when calculated by Kerley and Ubelaker's (1978) regression formula with my data. At the confidence level of $P = < 0.05$, this t test value is highly significant. Since the hypothesis was that computer age would be the same as the known age for the specimen, one has to speculate there is a problem in utilizing Kerley and Ubelaker's regression formula for femur percent of circumferential lamellar bone with the values calculated by the computer. Kerley and Ubelaker derived their formula on a series of visual estimates, while my percent of circumferential lamellar bone was measured mathematically by the computer. To verify that Kerley and Ubelaker's method for determining percent of circumferential lamellar bone does not work accurately with an actual percent of circumferential lamellar bone as measured by the computer, I developed a regression formula based on the sample data of this study.

Table 14 contains the data used in establishing my regression formula.

$Y = -1.40\ (x) + 92.38$ plus or minus 13.82

The slope of the line is -1.40 and the intercept of the line is 92.38. Standard error of estimation (plus or minus 13.82) is calculated from the mean square of the residuals. To check the reliability of the regression formula an F test for significance was done. The result ($F = 19.07$) when looked up in a table of values for F tests was significant

Table 14. Regression Formula Data.

x(%) Lamellar	y Age	x^2	y^2	xy	Deviation from mean x	Deviation from mean y	Squares x^2	Squares y^2	Products (xy)
30.9	41	954.81	1681	1266.9	3.182	6.091	10.125	37.1	19.382
22.7	79	515.29	6241	1793.3	11.382	-31.909	129.55	1018.184	-363.188
23.7	83	561.69	6889	1967.1	10.382	-35.909	107.785	1289.456	-372.807
25.8	69	665.64	4761	1780.2	8.282	-21.909	68.592	480.004	-181.450
29.2	34	852.64	1156	992.8	4.882	13.091	23.834	171.374	63.91
62.3	19.5	3881.29	380.25	1214.9	-28.218	27.591	796.256	761.263	-778.563
48.3	28	2332.89	784	1352.4	-14.218	19.091	202.152	364.466	-271.436
28.9	43	835.21	1849	1242.7	5.182	4.091	26.853	16.736	21.20
48.9	18.5	2391.21	342.25	904.7	-14.818	28.591	219.573	817.445	-423.661
36.2	38	1310.44	1444	1375.6	- 2.118	9.091	4.486	82.646	- 19.255
18	65	324	4225	1170	16.082	-17.909	258.631	320.732	-288.013
374.9	518	14625.11	29752.5	15060.6	0.0	0.0	1847.837	5359.406	-2593.881

n = 11
Σx = 374.11
$\bar{x}$ = 34.082
Σy = 518
$\bar{y}$ = 47.091
Σx^2 = 14,625.11
Σy^2 = 29,752.5
S.D. of y = 23.15
S.D. of x = 13.61

Sx = 1847.837
Sy = 5359.406
Sxy = -2593.881
Σxy = 15,060.6
Corr. = -.82
Slope = -1.40
Intcp. = 94.88
[y = -140 (x) + 92.38 $\pm$ 13.82]
S.E. of estimation = $\pm$ 13.817

	DF	SS	MS	F
Regression	1	3641.132	3641.132	19.07
Residual	9	1718.274	190.919	
Total	10	5359.406		

Degrees of freedom 1 & 9 P = < 0.05 (5.12)
P = < 0.01 (10.56)

for one degree by nine degrees of freedom. To be significant, the F value has to be greater than 5.12 for the 5 percent confidence level and 10.56 for the 1 percent confidence level. If a t test on the scores from the new regression formula also is significant, then one would assume that percent of circumferential lamellar bone is not a viable criterion of age determination. However, if the t test score is not significant then one would assume the problem is with the method of acquiring the percentage used in the test. I feel one cannot use a computed value with a regression formula established from visual observations. Examining the results would give more support to the supposition that calculated age for the percent of circumferential lamellar bone is more accurate than those age estimates produced by visual means.

Table 15 presents the data used to compile the new t test on percent of circumferential lamellar bone. The resulting value ($t = |-0.52|$) is not significant. Because my t test is not significant, I feel the problem is with the Kerley and Ubelaker formula. One cannot use measured data on a regression formula derived from estimated values.

The four field total is reduced from six cases having the age range bracketing the known age to only four cases bracketing the known age with the loss of cases (107440 and 73-1) dropping accuracy to a poor 36 percent. On the other hand, the percent of circumferential lamellar bone containing an age range bracketing the known age is improved from a 64 percent accuracy level to 73 percent accuracy level (8 out of 11 cases). The three cases (947366, 1062496 and 72-3) missed were all within plus or minus 10 years of the actual age. Individual scores for the percent of circumferential lamellar bone are also improved. Percent of circumferential lamellar bone for individual scores increased from

Table 15. t test for New Percent Lamellar Bone.

Case Number	Actual Age	Average Age Range	x	x^2
940302	41	49.5	+ 8.5	72.25
947366	79	60.5	-18.5	342.25
1062496	83	59	-24	576
107440	69	56	-13	169
72-3	34	51.5	+17.5	306.25
73-1	19.5	9.5	-10	100
74-2	28	25	- 3	9
74-5	43	52	+ 9	81
75-3	18.5	24	+ 5.5	30.25
80-6	65	67	+ 2	4
n = 11	518	496	-22	1706.0

$\bar{x} = -2.0$

$s^2 = 166.20$

$\frac{s}{\sqrt{n}} = 3.88$

$t = |-0.52|$ Degrees of freedom = 10 $P = < 0.05$

43 percent accuracy for those ranges containing the actual age to 22 out of 44 or 50 percent accuracy. Those scores which are within plus or minus three years of the known age enlarge the accuracy to 60 percent.

Since the sample size is small, a larger study needs to be done to verify that computer calculated percent of circumferential lamellar bone is more accurate and reliable in giving a true age estimate at death than those age esimates from visual observations.

The other osteon counting feature which is slightly significant are fragments ($t = |-2.36|$). As explained previously, I feel the error is in not locating enough fragments in the digitized pictures. If the disregarded counts from those osteones on the edge of the field are given to fragments as well as the number which is given to osteones, the problem would be eliminated. Since the fault is mine for the lack of fragments, I did not develop a new regression formula for fragments. Other counting variables will be discussed in the conclusion which might aid in osteon counting techniques along with other areas of further research.

CHAPTER VI

CONCLUSIONS

The first general statement I would like to make concerns the method of recognizing features on the edge of the fields. According to the Kerley technique, one has to move the microscope in order to view those features on the edge of the fields. During this study, features on the edge of the field are counted separately with half of the scores going to osteones. After re-examining my data, I have decided that those disregarded values from the edge of the fields should also be given to fragments, since the t test for fragments of osteones is slightly significant. This is an indication that my digitized fragments were insufficient to be utilized properly with the Kerley technique. I feel the error is my fault and no new regression formula was developed for fragments.

Next, I do not agree that the muscle attachment area of the linea aspera should be avoided as one of the four fields selected. The results of the t test for the four fields are not significant, and the medial field has the worst accuracy (of the fields) for predicting age. A further study could be done utilizing Hotelling's paired t analysis to examine the relationships between the pairs of fields.

Still another area of investigation concerns the use of dmax and individual area information. By doing an analysis on them, dmax and the area information could be examined to see if they might be used in improving the technique of osteon counting as viable features such as those used by Kerley in his technique. If dmax and area information

prove to be good features for osteon counting, then a more accurate and sophisticated procedure would be developed for doing osteon counting.

This new method would require algorithms to count regular shape particles in a digitized image or images. Then these data would be applied to counting the features in the cross-sections, so an age estimate at death could be obtained. An example of such a technique is that used by Casey (1977) in this thesis on "Automated Particle Counting with Applications to Neurology." After the slides of nerve cells are counted by the computer, in Casey's study, they are compared to manually counted nerve cells with a 90 percent accuracy rate for the three nerves used (Casey, 1977). After the pictures are digitized for each region, the system runs completely automatically, taking in data from magnetic tape and storing the results on magnetic disks. This algorithm demonstrates promise as a useful tool in any application where multiple particles such as osteon counting or nerve cell counting, are counted; therefore, this method should have a direct application in the field of anthropology. A fully automated scanning histogram technique for obtaining an age estimate at death from a cross-section of human bone would require no additional training since the computer decides on the features being scanned and applies the results to the appropriate regression formula. The only drawback to this procedure is monetary requirements. Up to 100,000 dollars worth of equipment would be required. However with the interactive computer graphics technique, roughly 10,000 dollars would be necessary. This makes the interactive computer graphics technique available to a larger population of users.

I would also like to do a study utilizing the core technique. I feel that one field could be used to perform osteon counting. A core

removed from the bone would not destroy the specimen such as the Kerley technique required. If all four fields are cored, then plugging the holes with wooden dowels or plastic wood would keep the bone from deteriorating and breaking. The cores would be easily mounted on one slide for photographing. When equipment funding became available a direct feed attachment from the microscope to the computer would eliminate the need of the photographic step. The use of the core technique would allow a large skeletal collection to be analyzed for a demographic study without destroying the sample.

After a larger sample has been analyzed by my procedure for calculating percent of circumferential lamellar bone, the results may suggest the use of this technique as being more reliable and accurate than the technique of visual observations.

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APPENDICES

APPENDIX A

```
,TENTAB.LST=TENTAB.FTN

0001            DIMENSION LBL1(1),LBL2(1),RARRAY(60),MENUX(6),MENUY(8)
0002           INTEGER*2 LBL(10),FNAME(12)
0003           COMMON /FNAME/FNAME
0004            COMMON/SWTCH/ICOUNT,IDEL,IRES,ISAVE,IEXIT
              1  ,ISTART,IORG,IXAXIS,ISING,MLT,INK,ISYB
              2 ,I1,I2,I3,I4,I5,I6,I7,I8,I9,I10,NUW,NUW2
0005            COMMON/GEN/IXS,IYS,IXO,IYO,IXZ1,IXZ2,IXSP,IYSP,IXM,IYM
              1  ,IXI,IYI,IXB,IYB,IXD,IYD,IXR,IYR,IXV,IYV,IXE,IYE
              2  ,IXC,IYC,IX1,IY1,IX2,IY2,IX3,IY3,IX4,IY4,IX5,IY5
              3  ,IX6,IY6,IX7,IY7,IX8,IY8,IX9,IY9,IX10,IY10
0006            COMMON/TYPE/ITYPE
0007            COMMON/LABEL/LBL
0008            COMMON/LATE/RARRAY
0009            COMMON/RECORD/IREC
0010            DATA LBL/'1','2','3','4','5','6','7','8','9','0'/
0011            DATA LBL1/89/
0012            DATA LBL2/88/
0013            DATA NO/'N'/
0014            DATA LNO/'N'/
      C         NUW IS THE OUTPUT FILE FOR MESSAGES, USUALLY TTY
0015            NUW=5
      C         NUW2 IS THE OUTPUT FILE FOR DATA, E.G. FOR01.DAT
0016            NUW2=1
      C
      C         ASK FOR OUTPUT FILENAME FOR TABLET DATA
      C
      C
0017            TYPE 9
0018  9         FORMAT(  TYPE INPUT FILE NAME IN FORM : FILENM.DAT;1')
0019            ACCEPT 19,FNAME
0020  19        FORMAT(12A2)
0021           FNAME(12)=0
0022            OPEN(UNIT=NUW2,NAME=FNAME,TYPE='NEW')
      C
      C
      C
      C
      C         INITIALIZE SWITCHES
      C
      C
0023            IOPT=1
0024            IDEL=0
```

```
0025            IRES=0
0026            ISYB=0
0027            ISAVE=0
0028            IEXIT=0
0029            ISTART=0
0030            IORG=0
0031            IXAXIS=0
0032            ITYPE=0
0033            ISING=0
0034            ICOUNT=0
0035            INK=0
0036            MLT=0
      C
      C
      C         INITIALIZE TERMINAL AND TABLET
      C
      C
0037            CALL INITT(960)
0038            CALL TABINT(1,0,0)
      C
      C
      C         LOCATE MENU
      C
      C
0039  1         CALL LMENU(MENUX,MENUY)
0040            CALL ERASE
0041            CALL DMENU(MENUX,MENUY)
0042            CALL SVSTAT(RARRAY)
0043            CALL MOVABS(0,780)
0044            CALL ANMODE
0045            WRITE(NUW,42)
0046  42        FORMAT(/,
     1   ' IS THE MENU OK? TYPE N FOR ANOTHER TRY ')
0047            ACCEPT 44,ION
0048  44        FORMAT(1A1)
0049            IF(ION.EQ.NO.OR.ION.EQ.LNO) GO TO 1
0051            CALL RESTAT(RARRAY)
0052            CALL ERASE
      C
      C
      C         NOW SELECT THE OPTIONS
      C
      C
0053            CALL SVSTAT(RARRAY)
0054            CALL MOVABS(0,780)
0055            CALL ERASE
0056            CALL ANMODE
0057            WRITE(NUW,40)
0058  40        FORMAT(//,
     1 '****************** OPTIONS*************')
      C
      C
      C         SELECT THE START OPTION TO BEGIN
```

```
      C
      C
0059          CALL SVSTAT(RARRAY)
0060          CALL MOVABS(0,780)
0061          CALL ANMODE
0062          WRITE(NUW,43)
0063  43      FORMAT(////,
     1    ' START BY SELECTING THE START OPTION BOX',/)
0064          CALL RESTAT(RARRAY)
0065          CALL BELL
0066          CALL ONEPNT(IXC,IYC)
0067          CALL BELL
0068          CALL MENU(MENUX,MENUY,IXC,IYC,ISW)
0069          CALL SVSTAT(RARRAY)
0070          CALL ANMODE
0071          CALL RESTAT(RARRAY)
0072          CALL ERASE
0073          CALL SVSTAT(RARRAY)
0074          CALL ANMODE
0075          WRITE(NUW,45)
0076  45      FORMAT(//,
     1 ' IF AN OPTION IS NOT DESIRED JUST ',
     2 /,' PICK ANY POINT ON THE TABLET AFTER THE BELL',
     3 /,' RINGS TO CONTINUE ')
0077          CALL ERASE
0078          WRITE(NUW,46)
0079  46      FORMAT(/,
     1 ' SELECT THE ORIGIN  BOX TO SET UP THE COORDINATE SYSTEM')
0080          CALL RESTAT(RARRAY)
0081          CALL BELL
0082          CALL ONEPNT(IXS,IYS)
0083          CALL BELL
0084          CALL MENU(MENUX,MENUY,IXS,IYS,ISW)
      C
      C
      C       ORIGIN OPTION
      C
      C
0085          CALL SVSTAT(RARRAY)
0086          CALL ANMODE
0087          WRITE(NUW,51)
0088  51      FORMAT(/,
     1    '  SELECT AN ORIGIN POINT AFTER THE BELL SOUNDS ')
0089          CALL RESTAT(RARRAY)
0090          CALL BELL
0091          CALL ONEPNT(IXO,IYO)
0092          CALL BELL
0093          CALL MENU(MENUX,MENUY,IXO,IYO,ISW)
      C
      C
      C       SELECT X AXIS POINT
      C
0094          CALL ERASE
```

```
0095            CALL SVSTAT(RARRAY)
0096            CALL ANMODE
0097            WRITE(NUW,56)
0098  56        FORMAT(////,
     1  '  PICK THE X BOX TO SELECT X MAXIMUM OPTION ')
0099            CALL RESTAT(RARRAY)
0100            CALL BELL
0101            CALL ONEPNT(IXZ1,IXZ2)
0102            CALL BELL
      C
0103            CALL SVSTAT(RARRAY)
0104            CALL ERASE
0105            CALL ANMODE
0106            WRITE(NUW,52)
0107  52        FORMAT(/,
     1  ' NOW SELECT THE MAXIMUM X AXIS POINT AFTER THE BELL ')
0108            CALL RESTAT(RARRAY)
0109            CALL BELL
0110            CALL ONEPNT(IXZ1,IXZ2)
0111            CALL BELL
0112            CALL MENU(MENUX,MENUY,IXZ1,IXZ2,ISW)
      C
      C!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
0113            GO TO 900
0114  903       CONTINUE
      C!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
      C
0115            CALL  SVSTAT(RARRAY)
0116            CALL MOVABS(0,780)
      C
      C
0117            CALL ERASE
0118            CALL ANMODE
0119            WRITE(NUW,50)
0120  50        FORMAT(//,
     1  ' IF A SYMBOL IS TO BE DRAWN AT EACH DATA POINT ')
0121            WRITE(NUW,60)
0122  60        FORMAT(//,
     1  ' THEN PICK THE SYMBOL FUNCTION AFTER THE BELL SOUNDS')
0123            CALL RESTAT(RARRAY)
0124            CALL BELL
0125            CALL ONEPNT(IXB,IYB)
0126            CALL BELL
0127            CALL MENU(MENUX,MENUY,IXB,IYB,ISW)
0128            CALL ERASE
      C!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
0129            GO TO 904
0130  902       CONTINUE
      C!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
0131            CALL SVSTAT(RARRAY)
0132            CALL MOVABS(0,780)
      C
      C
```

```
      C       INKING OPTION
      C
      C
0133          CALL ERASE
0134          CALL ANMODE
0135          WRITE(NUW,70)
0136  70      FORMAT(
           1 '  IF INKING IS DESIRED ,PICK THE INKING OPTION ')
0137          CALL RESTAT(RARRAY)
0138          CALL BELL
0139          CALL ONEPNT(IXI,IYI)
0140          CALL BELL
0141          CALL MENU(MENUX,MENUY,IXI,IYI,ISW)
      C#################################################################
0142          GO TO 903
0143  901     CONTINUE
      C#################################################################
0144          CALL ERASE
0145          CALL SVSTAT(RARRAY)
      C
      C
      C       MULTIPLE POINT ENTRY OPTION
      C
      C
0146          CALL MOVABS(0,780)
0147          CALL ANMODE
0148          WRITE(NUW,80)
0149  80      FORMAT(/,
           1  ' IF MULTIPLE POINT IS DESIRED, PICK MULTIPLE ')
0150          CALL RESTAT(RARRAY)
0151          CALL BELL
0152          CALL ONEPNT(IXM,IYM)
0153          CALL BELL
0154          CALL MENU(MENUX,MENUY,IXM,IYM,ISW)
      C#################################################################
0155          GO TO 902
0156  900     CONTINUE
      C#################################################################
0157          CALL ERASE
0158          CALL SVSTAT(RARRAY)
      C
      C
      C       SELECT SINGLE POINT MODE
      C
      C
0159          CALL MOVABS(0,780)
0160          CALL ANMODE
0161          WRITE(NUW,110)
0162  110     FORMAT('   SELECT SINGLE POINT IF DESIRED   ')
0163          WRITE(NUW,120)
0164  120     FORMAT(//,
           1 ' NOTE-ONLY ONE INPUT MODE CAN BE USED. IF YOU HAVE ',/,
           2 ' SELECTED BOTH, SINGLE WILL BE USED. ')
```

```
0165          CALL RESTAT(RARRAY)
0166          CALL BELL
0167          CALL ONEPNT(IXSP,IYSP)
0168          CALL BELL
0169          CALL MENU(MENUX,MENUY,IXSP,IYSP,ISW)
0170          IF(ISING.EQ.1.AND.MLT.EQ.1)MLT=0
      C#################################################################
0172          GO TO 901
0173  904     CONTINUE
      C#################################################################
0174          CALL ERASE
0175          CALL SVSTAT(RARRAY)
0176          CALL ANMODE
0177          WRITE(NUW,121)
0178  121     FORMAT(//,
           1  ' SELECT THE INITIAL ICOUNT, THIS MAY BE CHANGED',/,
           2  ' BY RESELECTION WHEN IN THE SINGLE POINT MODE ')
0179          CALL BELL
0180          CALL RESTAT(RARRAY)
0181          CALL ONEPNT(IXC,IYC)
0182          CALL MENU(MENUX,MENUY,IXC,IYC,ISW)
0183          CALL BELL
0184          CALL SVSTAT(RARRAY)
0185          CALL ERASE
0186          CALL ANMODE
0187          WRITE(NUW,122)
0188  122     FORMAT(///,
           1  ' SELECT THE INITIAL TYPE, THIS MAY ALSO BE CHANGED',/,
           2  ' AT ANY TIME WHWN IN THE SINGLE POINT MODE ')
0189          CALL RESTAT(RARRAY)
0190          CALL BELL
0191          CALL ONEPNT(IXT,IYT)
0192          CALL BELL
0193          CALL MENU(MENUX,MENUY,IXT,IYT,ISW)
      C
      C
      C*****************************************************************
      C
      C
      C       DATA ENTRY
      C
      C
0194          CALL ERASE
0195          CALL SVSTAT(RARRAY)
0196          CALL ANMODE
0197          WRITE(NUW,130)
0198  130     FORMAT(
           1  ' PREPARE TO ENTER DATA POINTS FROM THE TABLET ')
0199          WRITE(NUW,140)
0200          CALL RESTAT(RARRAY)
0201          CALL ERASE
0202  140     FORMAT( 'TO STOP DATA ENTRY PICK EXIT ')
      C       DRAW THE MENU
```

```
0203            CALL DMENU(MENUX,MENUY)
      C
      C
      C         DRAW THE X-Y AXIS ON THE SCREEN
      C
      C
      C         DRAW THE X-Y AXIS
0204            CALL MOVABS(IXO,IYO)
      C         DRAW THE Y AXIS
0205            CALL DRWABS(IXO,700)
0206            CALL MOVABS(IXO-20,700)
0207            CALL ANSTR(1,LBL1)
      C
      C         DRAW THE X AXIS
      C
0208            CALL MOVABS(IXO,IYO)
0209            CALL DRWREL(IXZ1-IXO,0)
0210            CALL MOVABS(900,IXZ2-20)
0211            CALL ANSTR(1,LBL2)
      C
      C         PICK DATA ENTRY METHOD
      C
0212            IOPT=0
0213            CALL BELL
0214            IF(MLT.EQ.0) CALL SINGLE(MENUX,MENUY,ISW)
0216            IF(MLT.EQ.1) CALL MULTI(MENUX,MENUY,ISW)
      C
      C
      C         GIVE 5 BEEPS TO INDICATE END OF PROGRAM
      C
      C
0218            CALL BELL
0219            CALL BELL
0220            CALL BELL
0221            CALL BELL
0222            CALL BELL
      C
      C
0223            CALL TINPUT(J)
0224            CALL FINITT(0,780)
0225            STOP
0226            END
      C*****************************************************************
0001              SUBROUTINE MENU(MX,MY,IX,IY,ISW)
0002            DIMENSION FNAME(12)
0003              DIMENSION MX(8),MY(8)
0004            COMMON /FNAME/FNAME
0005              COMMON/SWTCH/ICOUNT,IDEL,IRES,ISAVE,IEXIT
                1 ,ISTART,IORG,IXAXIS,ISING,MLT,INK,ISYB
                2 , I1,I2,I3,I4,I5,I6,I7,I8,I9,I10,NUW,NUW2
0006              COMMON/GEN/IXS,IYS,IXO,IYO,IXZ1,IXZ2,IXSP,IYSP,IXM,IYM
                1 ,IXI,IYI,IXB,IYB,IXD,IYD,IXR,IYR,IXV,IYV,IXE,IYE
                2 ,IXC,IYC,IX1,IY1,IX2,IY2,IX3,IY3,IX4,IY4,IX5,IY5
```

```
     3 ,IX6,IY6,IX7,IY7,IX8,IY8,IX9,IY9,IX10,IY10
0007          COMMON/TYPE/ITYPE
0008          COMMON/LATE/RARRAY(60)
0009          DATA ID/7777/
      C
      C       THIS ROUTINE SETS SWITCHES WHEN A FUNCTION AREA IS
      C       SELECTED ON THE MENU.
      C       THIS ROUTINE SETS THE OPTION SWITCHES TO 1
      C
      C       ZERO THE REPEATED SWITCHES
0010          ISW=0
0011          IEXIT=0
0012          ISAVE=0
0013          IRES=0
0014          IDEL=0
0015          ISTART=0
0016          IORG=0
0017          IXAXIS=0
      C       IF THE MENU SELECTED POINT IS IN A REGION
      C               EXIT IS TESTED FIRST
      C       FIRST SEE IF POINT COULD BE IN MENU
0018          IF(IX.LT.MX(1).OR.IX.GT.MX(6))RETURN
0020          IF(IY.LT.MY(8).OR.IY.GT.MY(1) )RETURN
      C       TEST FOR COMMAND OR TYPES
0022          IF(IX.LT.MX(4) ) GO TO 100
0024          INK=0
0025          ISYB=0
      C       TYPES OF DATA SPECIFIED
0026          IF(IX.GT.MX(5) ) GO TO 200
      C       NUMBER IS LESS THAN 6
0028          IF(IY.LT.MY(3) ) GO TO 300
0030          IF(IY.LT.MY(2)) GO TO 400
      C       TYPE 1
0032          I1=1
0033          ITYPE=1
0034          ISW=13
0035          RETURN
0036  400     I2=1
0037          ITYPE=2
0038          ISW=14
      C       TYPE 2
0039          RETURN
0040  300     IF(IY.GT.MY(4)) GO TO 500
0042          IF(IY.GT.MY(5)) GO TO 600
      C       TYPE 3
0044          ITYPE=3
0045          I3=1
0046          ISW=17
0047          RETURN
      C       TYPE 4
0048  600     I4=1
0049          ITYPE=4
0050          ISW=16
```

```
0051            RETURN
      C         TYPE 3
0052  500       I3=1
0053            ITYPE=3
0054            ISW=15
0055            RETURN
      C         DECODE TYPES 6 TO 10
0056  200       IF(IY.GT.MY(2) ) GO TO 1000
0058            IF(IY.GT.MY(3) ) GO TO 700
0060            IF(IY.GT.MY(4) ) GO TO 800
0062            IF(IY.GT.MY(5) ) GO TO 900
      C         TYPE 10
0064            ITYPE=10
0065            I10=1
0066            ISW=22
0067            RETURN
0068  900       I9=1
0069            ITYPE=9
0070            ISW=21
0071            RETURN
0072  800       I8=1
0073            ITYPE=8
0074            ISW=20
0075            RETURN
0076  700       I7=1
0077            ITYPE=7
0078            ISW=19
0079            RETURN
0080  1000      I6=1
0081            ITYPE=6
0082            ISW=18
0083            RETURN
      C                 COMMANDS SELECTED
0084  100       CONTINUE
0085            IF(IX.GT.MX(3).AND.IX.LT.MX(4).AND.
     1    IY.GT.MY(2).AND.IY.LT.MY(1)) GO TO 99
0087            GO TO 4
0088  99        ICOUNT=ICOUNT+1
0089            ISW=12
0090            IF(ICOUNT.GT.1)INK=0
0092            IF(ICOUNT.GT.1)ISYB=0
0094            RETURN
0095  4         IF(IX.LT.MX(2) ) GO TO 110
      C         SECOND COLUMN SELECTED
0097            IF(IY.GT.MY(3) ) GO TO 120
0099            IF(IY.GT.MY(4) ) GO TO 130
      C         EXIT SELECTED
0101            IEXIT=1
0102            ISW=11
0103            CLOSE(UNIT=NUW2)
0104            RETURN
0105  130       IRES=1
0106            CALL SVSTAT(RARRAY)
```

```
0107            OPEN(UNIT=NUW2,NAME=FNAME,TYPE='OLD')
0108            ISW=10
0109            CALL RESTAT(RARRAY)
0110            RETURN
0111  120       IF(IY.GT.MY(2) ) GO TO 140
0113            ISAVE=1
0114            CALL SVSTAT(RARRAY)
0115            CALL CLEAN
0116            CALL RESTAT(RARRAY)
      C         CLEAN UP ANY DELETED POINTS
0117            ISW=9
0118            RETURN
0119  140       IDEL=1
0120            WRITE(NUW2,141)ID
0121  141       FORMAT(1X,I6)
0122            ISW=8
0123            RETURN
      C         FIRST COLUMN
0124  110       IF(IY.GT.MY(4) ) GO TO 150
0126            IF(IY.GT.MY(6) ) GO TO 160
0128            IF(IY.GT.MY(7) ) GO TO 170
0130            ISYB=1
0131            ISW=7
0132            RETURN
0133  170       INK=1
0134            ISW=6
0135            RETURN
0136  160       IF(IY.GT.MY(5) ) GO TO 180
0138            MLT=1
0139            ISW=5
0140            RETURN
0141  180       ISING=1
0142            ISW=4
0143            RETURN
0144  150       IF(IY.GT.MY(2) ) GO TO 190
0146            IF(IY.GT.MY(3) ) GO TO 195
0148            IXAXIS=1
0149            ISW=3
0150            RETURN
0151  195       IORG=1
0152            ISW=2
0153            RETURN
0154  190       ISTART=1
0155            ISW=1
0156            RETURN
0157            END
      C*****************************************************************
0001            SUBROUTINE MULTI(MENUX,MENUY,ISW)
      C         MULTIPOINT DATA ENTRY
0002            DIMENSION MENUX(6),MENUY(8)
0003            DIMENSION MX(500),MY(500),IH(500)
0004            COMMON/SWTCH/ICOUNT,IDEL,IRES,ISAVE,IEXIT
               1 ,ISTART,IORG,IXAXIS,ISING,MLT,INK,ISYB
```

```
     2 ,I1,I2,I3,I4,I5,I6,I7,I8,I9,I10,NUW,NUW2
0005    COMMON/GEN/IXS,IYS,IXO,IYO,IXZ1,IXZ2,IXSP,IYSP,IXM,IYM
     1 ,IXI,IYI,IXB,IYB,IXD,IYD,IXR,IYR,IXV,IYV,IXE,IYE
     2 ,IXC,IYC,IX1,IY1,IX2,IY2,IX3,IY3,IX4,IY,IX5,IY5
     3 ,IX6,IY6,IX7,IY7,IX8,IY8,IX9,IY9,IX10,IY10
0006    COMMON/TYPE/ITYPE
0007  5 CALL BELL
0008    CALL MULPNT(500,NGT,IH,MX,MY)
0009    CALL BELL
0010    CALL BELL
0011    CALL BELL
0012    DO 500 I=1,NGT
0013    IX=MX(I)
0014    IY=MY(I)
0015    CALL MENU(MENUX,MENUY,IX,IY,ISW)
0016    IF(IH(I).EQ.29)CALL MOVABS(IX,IY)
0018    IF(IH(I).EQ.26.AND.INK.EQ.1)CALL DRWABS(IX,IY)
0020    IF(IH(I).EQ.26.AND.INK.NE.1)CALL MOVABS(IX,IY)
0022    IF( (IH(I).EQ.29.OR.IH(I).EQ.26).AND.ISYB.EQ.1)
     1  CALL SYMBOL
0024    IX=IX-IXO
0025    IY=IY-IYO
0026    WRITE(NUW2,10)ICOUNT,ITYPE,IX,IY
0027 10 FORMAT(1X,4I6)
0028 500 CONTINUE
0029    IZI=9999
0030    WRITE(NUW2,10)IZI
0031    GO TO 5
0032 1000 CONTINUE
0033    RETURN
0034    END
C*************************************************'*****************
0001    SUBROUTINE SINGLE(MENUX,MENUY,ISW)
0002    DIMENSION MENUX(6),MENUY(8)
0003    DIMENSION RARRAY(60)
0004    COMMON/SWTCH/ICOUNT,IDEL,IRES,ISAVE,IEXIT
     1 ,ISTART,IORG,IXAXIS,ISING,ALT,INK,ISYB
     2 ,I1,I2,I3,I4,I5,I6,I7,I8,I9,I10,NUW,NUW2
0005    COMMON/GEN/IXS,IYS,IXO,IYO,IXZ1,IXZ2,IXSP,IYSP,IXM,IYM
     1 ,IXI,IYI,IXB,IYB,IXD,IYD,IXR,IYR,IXV,IYV,IXE,IYE
     2 ,IXC,IYC,IX1,IY1,IX2,IY2,IX3,IY3,IX4,IY4,IX5,IY5
     3 ,IX6,IY6,IX7,IY7,IX8,IY8,IX9,IY9,IX10,IY10
0006    COMMON/TYPE/ITYPE
0007    ICNT=0
0008    INEW=1
0009    IKOUNT=0
0010  5 CALL BELL
0011    CALL ONEPNT(IX,IY)
0012    IKOUNT=ICOUNT
0013    CALL BELL
0014    ITT=ITYPE
0015    CALL MENU(MENUX,MENUY,IX,IY,ISW)
0016    IF(IKOUNT .NE. ICOUNT .AND. ITT .EQ. ITYPE)INEW=1
0018    IF(ITT.NE.ITYPE.AND.INK.EQ.0)INEW=1
```

```
0020            IF(IEXIT.EQ.1)GO TO 1000
0022            IF(ICNT.NE.0.AND.INK.EQ.1.AND.ISW.EQ.0.AND.INEW.NE.1)
              1 CALL DRWABS(IX,IY)
0024            IF(ICNT.NE.0.AND.INK.EQ.1.AND.ISW.EQ.0.AND.INEW.EQ.1)
              1 CALL MOVABS(IX,IY)
0026            IF(ICNT.NE.0.AND.ISYB.EQ.1.AND.INK.EQ.0.AND.ISW.EQ.0
              1 .AND.INEW.NE.1)CALL MOVABS(IX,IY)
0028            IF(ICNT.NE.0.AND.INK.NE.1.AND.ISW.EQ.0.AND.INEW.EQ.1)
              1 CALL MOVABS(IX,IY)
0030            IF(ICNT.EQ.0) CALL MOVABS(IX,IY)
0032            IF(ISYB.EQ.1.AND.ISW.EQ.0)CALL SYMBOL
0034            IF(ISW.EQ.0.AND.INEW.EQ.1)INEW=0
      C         SUBTRACT THE COORDINATE ORIGIN FROM THE DATA
0036            IX=IX-IXO
0037            IY=IY-IYO
0038            CALL SVSTAT(RARRAY)
0039            CALL ANMODE
0040            IF(ISW.EQ.0)WRITE(NUW2,10)ICOUNT,ITYPE,IX,IY
0042            CALL RESTAT(RARRAY)
0043            IF(ISW.EQ.0)ICNT=ICNT+1
0045  10        FORMAT(1X,4I6)
0046            GO TO 5
0047  1000      CONTINUE
0048            III=9999
0049            CALL SVSTAT(RARRAY)
0050            CALL ANMODE
0051            WRITE(NUW2,10)III
0052            CALL RESTAT(RARRAY)
0053            RETURN
0054            END
      C*****************************************************************
0001            SUBROUTINE SYMBOL
0002            INTEGER*2 LBL(10)
0003            COMMON/TYPE/ITYPE
0004            COMMON/LABEL/LBL
0005            COMMON/LATE/RARRAY
      C         DRAW A SYMBOL AROUND EACH DATA POINT
0006            CALL SVSTAT(RARRAY)
0007            CALL MOVREL(-1,-1)
0008            CALL DRWREL(1,2)
0009            CALL DRWREL(1,-2)
0010            CALL DRWREL(-2,0)
0011            CALL DRWREL(1,1)
0012            CALL ANSTR(1,LBL(ITYPE ) )
0013            CALL RESTAT(RARRAY)
0014            RETURN
0015            END
      C*****************************************************************
0001            SUBROUTINE LMENU(MX,MY)
      C         SUBROUTINE TO LOCATE COMMAND MENU POINTS AND DISPLAY
      C         MENU ON SCREEN
0002            DIMENSION MX(6),MY(8),RARRAY(60)
0003            COMMON/SWTCH/ICOUNT,IDEL,IRES,ISAVE,IEXIT
```

```
          1   ,ISTART,IORG,IXAXIS,ISING,MLT,INK,ISYB
          2   ,I1,I2,I3,I4,I5,I6,I7,I8,I9,I10,NUW,NUW2
0004          COMMON/GEN/IXS,IYS,IXO,IYO,IXZ1,IXZ2,IXSP,IYSP,IXM,IYM
          1   ,IXI,IYI,IXB,IYB,IXD,IYD,IXR,IYR,IXV,IYV,IXE,IYE
          2   ,IXC,IYC,IX1,IY1,IX2,IY2,IX3,IY3,IX4,IY4,IX5,IY5
          3   ,IX6,IY6,IX7,IY7,IX8,IY8,IX9,IY9,IX10,IY10
0005          COMMON/LATE/RARRAY
0006          CALL MOVABS(0,780)
0007          CALL BELL
0008          CALL BELL
0009          CALL SVSTAT(RARRAY)
      C       THE FIRST STEP IS TO DEFINE THE MENU POINTS
0010          CALL ANMODE
0011          WRITE(NUW,10)
0012  10      FORMAT(/,
          1   ' LOCATE 6 TOP MENU POINTS, LEFT TO RIGHT ',/,
          2   ' AFTER THE BELL SOUNDS ')
0013          CALL RESTAT(RARRAY)
0014          CALL BELL
0015          DO 20 I=1,6
0016          CALL ONEPNT(MX(I),II)
0017  20      CALL BELL
0018          CALL ERASE
0019          CALL SVSTAT(RARRAY)
0020          CALL ANMODE
0021          WRITE(NUW,30)
0022  30      FORMAT(/,
          1   ' NOW LOCATE THE 8 LEFT SIDE MENU POINTS, TOP TO BOTTOM ',/,
          2   ' AFTER THE BELL SOUNDS ')
0023          CALL RESTAT(RARRAY)
0024          CALL BELL
0025          DO 40 I=1,8
0026          CALL ONEPNT(II,MY(I) )
0027  40      CALL BELL
0028          RETURN
0029          END
      C*************************************************************
0001          SUBROUTINE DMENU(MX,MY)
0002          DIMENSION MX(6),MY(8)
      C                 THE MENU IS NOW DETERMINED
      C       DRAW THE MENU ON THE SCREEN AT (10,600) AND DOWN
0003          CALL MOVABS(10,600)
      C       NOTE THE USE OF RELATIVE VECTORS
0004          CALL DRWREL( MX(6)-MX(1),0)
0005          CALL MOVABS(10,600)
0006          CALL DRWREL(0,MY(8)-MY(1))
0007          CALL MOVABS(10,600-(MY(1)-MY(2)) )
0008          CALL DRWREL(MX(6)-MX(1),0)
0009          CALL MOVABS(10,600-( MY(1)-MY(3) ) )
0010          CALL DRWREL( MX(3)-MX(1),0)
0011          CALL MOVREL( MX(4)-MX(3),0)
0012          CALL DRWREL(MX(6)-MX(4),0)
0013          CALL MOVABS(10,600- ( MY(1)- MY(4) ) )
```

```
0014            CALL DRWREL(MX(3)-MX(1),0)
0015            CALL MOVREL(MX(4)-MX(3),0)
0016            CALL DRWREL(MX(6)-MX(4),0)
0017            CALL MOVABS(10,600-( MY(1)-MY(5) ) )
0018            CALL DRWREL(MX(3)-MX(1),0)
0019            CALL MOVREL(MX(4)-MX(3),0)
0020            CALL DRWREL(MX(6)-MX(4),0)
0021            CALL MOVABS(10,600-( MY(1)-MY(6) ) )
0022            CALL DRWREL(MX(2)-MX(1),0)
0023            CALL MOVREL(MX(4)-MX(2),0)
0024            CALL DRWREL(MX(6)-MX(4),0)
0025            CALL MOVABS(10,600-( MY(1)-MY(7) ) )
0026            CALL DRWREL(MX(2)-MX(1),0)
0027            CALL MOVABS(10,600-(MY(1)-MY(8) ) )
0028            CALL DRWREL(MX(2)-MX(1),0)
      C         NOW DRAW THE VERTICAL LINES
0029            CALL DRWREL(0,MY(1)-MY(8) )
0030            CALL MOVREL(MX(3)-MX(2),0)
0031            CALL DRWREL(0,MY(5)-MY(1) )
0032            CALL MOVREL(MX(4)-MX(3),MY(6)-MY(5) )
0033            CALL DRWREL(0,MY(1)-MY(6) )
0034            CALL MOVREL(MX(5)-MX(4),0)
0035            CALL DRWREL(0,MY(6)-MY(1) )
0036            CALL MOVREL(MX(6)-MX(5),0)
0037            CALL DRWREL(0,MY(1)-MY(6) )
      C         MENU SHOULD NOW BE DRAWN ON SCREEN
0038            RETURN
0039            END
      C*************************************************************
0001            SUBROUTINE CLEAN
0002            INTEGER*2 FNAME(6)
0003            INTEGER*2 ONAME(12)
0004            DIMENSION ICT(2000),ITY(2000),IXX(2000),IYY(2000)
      C         NOTE THAT ONLY 2000 POINTS CAN BE CLEANED
0005            COMMON/SWTCH/ICOUNT,IDEL,IRES,ISAVE,IEXIT
           1    ,ISTART,IORG,IXAXIS,ISING,MLT,INK,ISYB
           2    ,I1,I2,I3,I4,I5,I6,I7,I8,I9,I10,NUW,NUW2
0006            COMMON/TYPE/ITYPE
0007            COMMON/LINE/RARRAY(5,9)
0008            CALL SYSTAT(RARRAY)
0009            CALL BELL
0010            CALL BELL
0011            CALL BELL
0012            CALL ANMODE
0013            NUW3=NUW2+1
0014            IPT=0
0015            ITYPE 15
0016  15        FORMAT(' TYPE FINAL OUTPUT FILE NAME:  TABOUT.DAT;1')
0017            ACCEPT 16,ONAME
0018  16        FORMAT(12A2)
0019            ONAME(12)=0
0020            OPEN(UNIT=NUW3,NAME=ONAME,TYPE='NEW')
0021            REWIND NUW2
```

```
      C
      C
      C       READ AND CLEAN UP DELETED POINTS
      C
      C
0022            NPT=0
0023  1         IPT=IPT+1
0024            READ(NUW2,10,END=99)ICT(IPT),ITY(IPT),IXX(IPT),IYY(IPT)
0025  10        FORMAT(1X,4I6)
0026            NPT=NPT+1
0027            IF(ICT(IPT).EQ.9999) GO TO 99
0029            IF(ICT(IPT).EQ.7777) GO TO 50
0031            GO TO 60
0032  50        NPT=NPT-2
0033            IPT=IPT-2
0034  60        CONTINUE
0035            IF(IPT.GT.2000)GO TO 99
0037            GO TO 1
0038  99        CONTINUE
0039            DO 30 I=1,NPT
0040            IF(ICT(I).EQ.0)GO TO 35
0042            WRITE(NUW3,10,END=30)ICT(I),ITY(I),IXX(I),IYY(I)
0043  35        CONTINUE
0044  30        CONTINUE
0045            CLOSE(UNIT=NUW2)
0046            CLOSE(UNIT=NUW3)
0047            CALL RESTAT(RARRAY)
0048            RETURN
0049            END
```

APPENDIX B

```
OCANM.OBJ;OCANM.LIS=OCANM.FTN

      C     THIS PROGRAM DISPLAYS DATA OBTAINED PREVIOUSLY BY THE
      C     TENTAB TABLET ROUTINE AND CALCULATES SOME MEASUREMENTS
      C     WHICH HAVE NOT BEEN USED PREVIOUSLY FOR OSTEON COUNTING.
      C
      C     WRITTEN BY GALE DAVID SLUTZKY  1979 AS PART OF
      C     FULLFILLMENT OF MASTER THESIS.
      C
0001        REAL     X,Y,DMAX
0002        REAL     XSUM,YSUM,AREA,SUB,UPPER,LOWER,TOTAL
0003        INTEGER  INEW,IOLD,ICOUNT,JTYPE,N,R
0004        INTEGER  KXCOR(100),LYCOR(100)
0005        REAL  SIZE(250),DIAM(250)
0006        LOGICAL*1  FNAME(15)
0007        DIMENSION  RARRAY(60)
      C
      C     OPEN ALL FILES.
      C
0008        DO 5 I=1,15
0009          FNAME(I)=0
0010      5 CONTINUE
0011        TYPE 10
0012     10 FORMAT('$INPUT FILE?')
0013        ACCEPT 15, FNAME
0014     15 FORMAT (15A1)
0015        OPEN(UNIT=2,NAME=FNAME,TYPE='OLD',ACCESS='SEQUENTIAL',
           1READONLY,FORM='FORMATTED ',DISPOSE='SAVE')
0016        DO 20 I=1,15
0017          FNAME(I)=0
0018     20 CONTINUE
0019        TYPE 25
0020     25 FORMAT('$OUTPUT FILE1?')
0021        ACCEPT 15, FNAME
0022        OPEN(UNIT=3, NAME=FNAME,TYPE='NEW',ACCESS='SEQUENTIAL',
           2FORM='FORMATTED ',DISPOSE='SAVE')
0023        DO 30 I=1,15
0024          FNAME(I)=0
0025     30 CONTINUE
0026        TYPE 35
0027     35 FORMAT('$OUTPUT FILE2?')
0028        ACCEPT 15, FNAME
0029        OPEN (UNIT=4,NAME=FNAME,TYPE='NEW',ACCESS='SEQUENTIAL',
           3FORM='FORMATTED',DISPOSE='SAVE')
      C
```

```
      C     INITIALIZE VARIABLES.
      C
0030        CALL INITT(240)
0031        R=0
0032        INEW=-1
0033        CHECK=0
0034        N=0
0035        IOLD=1000
0036        XSUM=0.0
0037        YSUM=0.0
0038     45 CALL SVSTAT(RARRAY)
0039        READ(2,50,END=54)ICOUNT,JTYPE,KXCOR(N+1),LYCOR(N+1)
0040     50 FORMAT(1X,4I6)
0041        CALL RESTAT(RARRAY)
0042        INEW=ICOUNT
0043        N=N+1
0044        IF(INEW .EQ. IOLD)CALL DRWABS(KXCOR(N),LYCOR(N))
0046        IF(INEW .NE. IOLD)CALL MOVABS(KXCOR(N),LYCOR(N))
0048        IF(INEW .GT. IOLD)GOTO 55
0050        AN=N
0051        XSUM=XSUM+KXCOR(N)
0052        YSUM=YSUM+LYCOR(N)
0053        IOLD=INEW
0054        GOTO 45
      C
      C     THE DATA STORED IN XSUM,YSUM IS USED TO CALCULATE
      C     POINTS OF THE CENTROID.
      C
0055     54 CHECK=1
0056     55 X=XSUM/AN
0057        Y=YSUM/AN
0058        CALL MOVEA(X,Y)
0059        CALL DRAWA(X,Y)
0060        CALL MOVABS(KXCOR(N),LYCOR(N))
0061        AREA=0.0
0062        SUB=0.0
      C
      C     THE PROGRAM NOW COMPUTES THE AREA OF THE OCTAGON
      C     AND STORES THE VALUE IN AN ARRAY FOR LATER USE.
      C
0063        XC1=KXCOR(N-1)
0064        XC2=KXCOR(1)
0065        YC1=LYCOR(1)
0066        YC2=LYCOR(N-1)
0067        AREA=XC1*YC1
0068        SUB=XC2*YC2
0069        DO 60 I=2,N-1
0070          XC1=KXCOR(I-1)
0071          XC2=KXCOR(I)
0072          YC1=LYCOR(I)
0073          YC2=LYCOR(I-1)
0074           AREA=AREA+XC1*YC1
0075           SUB=SUB+XC2*YC2
```

```
0076      60 CONTINUE
0077         UPPER=AREA/2.0
0078         LOWER=SUB/2.0
0079         TOTAL=(UPPER-LOWER)/10000.0
0080         TOTAL=ABS(TOTAL)
0081         R=R+1
0082         WRITE(3,65)TOTAL
0083      65 FORMAT(F8.3)
0084         SIZE(R)=TOTAL
         C
         C     SIZE IS A VALUE WHICH WILL BE USED TO CALCULATE THE
         C     PERCENT OF LAMELLAE BONE BY TAKING THESE STORED
         C     AREAS AND SUBTRACTING THEM FROM THE TOTAL AREA OF THE
         C     SAMPLE.
         C
         C
         C     THE NEXT CALCULATION IS A ROUGH ESTIMATE FOR THE
         C     DIAMETER.  IT IS CALLED DMAX.
         C
0085         DMAX=-999.0
0086         N1=N-2
0087         DO 70 I=1,N1
0088           I1=I+1
0089           DO 75 J=I1,N-1
0090             XC1=KXCOR(I)
0091             XC2=KXCOR(J)
0092             YC1=LYCOR(I)
0093             YC2=LYCOR(J)
0094             D=SQRT((XC1-XC2)**2+(YC1-YC2)**2)
0095             IF(D .GT. DMAX)DMAX=D
0097      75     CONTINUE
0098      70   CONTINUE
0099         DMAX=DMAX/100.0
         C
         C     STORE THE VALUES OF DMAX IN AN ARRAY TO BE USED LATER,
         C     PERHAPS IN A GROWTH STUDY.
         C
0100         WRITE (4,80)DMAX
0101      80 FORMAT(F8.3)
0102         DIAM(R)=DMAX
         C
         C     AT THIS STAGE ONE OSTEON COUNTING FEATURE HAS BEEN
         C     DISPLAYED WITH ITS AREA STORED IN AN ARRAY CALLED
         C     SIZE,THE FILE DIAM CONTAINS THE DIAMETERS, AND
         C     THE CENTROID HAS BEEN PLOTTED. NOW THE PROGRAM
         C     STARTS OVER ON THE NEXT SERIES OF DATA POINTS.
         C
0103         XSUM=KXCOR(N)
0104         YSUM=LYCOR(N)
0105         KXCOR(1)=KXCOR(N)
0106         LYCOR(1)=LYCOR(N)
0107         N=1
0108         IOLD=INEW
```

```
0109          IF(CHECK .EQ. 0)GOTO 45
0111          CLOSE(UNIT=2,DISPOSE='SAVE')
0112          CLOSE(UNIT=3,DISPOSE='SAVE')
0113          CLOSE(UNIT=4,DISPOSE='SAVE')
0114          CALL TSEND
0115          CALL ANMODE
0116          END
```

APPENDIX C

```
INTERP,OBJ,INTERP,LIS=INTERP,FTN

      C
      C     THIS PROGRAM SHOWS THE NUMBER OF OSTEON COUNTING
      C     FEATURES AND CALCULATES THE PERCENT OF LAMELLAE
      C     BONE. TWO PREVIOUSLY CREATED FILES ARE USED. ONE
      C     IS THE TENTAB FILE (OSTOUT.DAT) AND THE SECOND IS
      C     (SIZE.DAT) OR THE AREA MEASUREMENTS.
      C
0001        REAL TOTAL(100),T,SUM,PERCNT
0002        INTEGER IKIND(250),JKIND(250),ICOUNT(100),JTYPE(100)
0003        INTEGER  CHECK,R,N,ICHANG,ISTART,A,B,C,D,E,F,G
0004        LOGICAL*1 FNAME(15)
      C
      C     OPEN ALL FILES.
      C
0005        DO 5 I=1,15
0006          FNAME(I)=0
0007    5   CONTINUE
0008        TYPE 10
0009    10  FORMAT('$INPUT FILE FOR OSTEON COUNTING?')
      C
      C     THIS IS THE OUTPUT FILE FROM THE TENTAB TABLET
      C     PROGRAM WHICH WILL BE CALLED OSTOUT.DAT.
      C
0010        ACCEPT 15,FNAME
0011    15  FORMAT (15A1)
0012        OPEN(UNIT=2,NAME=FNAME,TYPE='OLD',ACCESS='SEQUENTIAL',
           1READONLY, FORM='FORMATTED', DISPOSE='SAVE')
0013        DO 20 I=1,15
0014          FNAME(I)=0
0015    20  CONTINUE
0016        TYPE 25
0017    25  FORMAT('$INPUT FILE FOR LAMELLAE PERCENT?')
      C
      C     THIS IS THE DATA STORED IN SIZE.DAT OR THE
      C     AREA MEASUREMENTS.
0018        ACCEPT 15,FNAME
0019        OPEN (UNIT=3, NAME=FNAME, TYPE='OLD', ACCESS='SEQUENTIAL',
           2READONLY, FORM='FORMATTED', DISPOSE='SAVE')
0020        DO 30 I=1,15
0021          FNAME(I)=0
0022    30  CONTINUE
0023        TYPE 35
```

```
0024    35  FORMAT('$OUTPUT FILE FOR RESULTS?')
      C
      C     THIS FILE WILL BE CALLED RESULT.DAT.
      C
0025        ACCEPT 15,FNAME
0026        OPEN(UNIT=4, NAME=FNAME, TYPE='NEW', ACCESS='SEQUENTIAL',
           3FORM='FORMATTED', DISPOSE='SAVE')
      C
      C     INITIALIZE ALL VARIABLES.
      C
0027        N=0
0028        R=0
0029        ICHANG=1000
0030        ISTART=0
0031        A=0
0032        B=0
0033        C=0
0034        D=0
0035        E=0
0036        F=0
0037        G=0
0038        T=0.0
0039        SUM=0.0
      C
0040        CHECK=0
0041    40  READ(2,45,END=100)ICOUNT(N+1),JTYPE(N+1)
0042    45  FORMAT(1X,2I6,12X)
0043        ISTART=ICOUNT(N+1)
0044        N=N+1
0045        IF(ISTART .GT. ICHANG)GOTO 50
0047        ICHANG=ISTART
0048        GOTO 40
0049    100 CHECK=1
0050        N=N+1
0051    50  R=R+1
0052        IKIND(R)=ICOUNT(N-1)
0053        JKIND(R)=JTYPE(N-1)
0054        TYPE 55,IKIND(R),JKIND(R)
0055    55  FORMAT(' MY COUNT AND TYPE NUMBER IS',1X,2I6,12X)
0056        ICHANG=ICHANG+1
0057        N=N-1
0058        IF(CHECK .EQ. 0)GOTO 40
      C
      C     AT THIS POINT WE NEED TO TALLY UP THE DIFFERENT
      C     FEATURES BY THEIR TYPES.
      C     TYPE A REFERS TO OSTEONES.
      C     TYPE B REFERS TO NON-HAVERSIAN CANALS.
      C     Type C refers to fragments of osteones.
      C     Type D refers to osteones on the edge of the fields.
      C     TYPE E REFERS TO REABSORPTION HOLES.
      C     TYPE F REFERS TO THE BOUNDARY OF THE PICTURE SAMPLE.
      C     TYPE G REFERS TO ANY UNKNOWN FEATURE.
      C
```

```
      C     SPECIAL NOTE!!! TYPES A,B,C,D,E,AND G MUST BE LISTED
      C     BEFORE F IS ENTERED IN THE TENTAB ROUTINE.!!!
      C
0060        DO 105 I=1,R
0061          IF(JKIND(I) .EQ. 1)A=A+1
0063          IF(JKIND(I) .EQ. 2)B=B+1
0065          IF(JKIND(I) .EQ. 3)C=C+1
0067          IF(JKIND(I) .EQ. 4)D=D+1
0069          IF(JKIND(I) .EQ. 5)E=E+1
0071          IF(JKIND(I) .EQ. 6)F=F+1
0073          IF(JKIND(I) .EQ. 7)G=G+1
0075    105 CONTINUE
0076        WRITE(4,110)A
0077    110 FORMAT(I6)
0078        WRITE(4,110)B
0079        WRITE(4,110)C
0080        WRITE(4,110)D
0081        WRITE(4,110)E
0082        WRITE(4,110)F
0083        WRITE(4,110)G
      C
      C     NOW TO CALCULATE THE PERCENT OF LAMELLAE BONE.
      C
0084    115 READ(3,120,END=125)TOTAL(T+1.0)
0085    120 FORMAT(F8.3)
0086        T=T+1.0
0087        GOTO 115
0088    125 CONTINUE
0089        PERCNT=TOTAL(T)
0090        IT=T
0091        DO 130 I=1,(IT-1)
0092          SUM=SUM+TOTAL(I)
0093    130 CONTINUE
0094        PERCNT=(PERCNT-SUM)/TOTAL(T)
0095        PERCNT=PERCNT*100
0096        WRITE(4,135)PERCNT
0097        TYPE 135,PERCNT
0098    135 FORMAT('PERCENT OF LAMELLAE BONE IS',F8.3)
      C
      C     CLOSE ALL FILES.
      C
0099        CLOSE(UNIT=2, DISPOSE='SAVE')
0100        CLOSE(UNIT=3, DISPOSE='SAVE')
0101        CLOSE(UNIT=4, DISPOSE='SAVE')
0102        STOP
0103        END
```

APPENDIX D

```
,UNITE,LIS=UNITE.FTN

      C
      C     THIS PROGRAM TAKES FOUR RESULT.DAT FILES NUMBERED IN
      C     sequence together so all four fields are represented
      C     BY ONE TOTAL COUNT AND THE PERCENT OF LAMELLAR BONE IS AN
      C     AVERAGE FOR THE FOUR FIELDS.
      C
0001        REAL RPARTA,RPARTB,RPARTC,RPARTD,LAML
0002        INTEGER N,OST,NHV,FRA,COR
0003        INTEGER PARTA(5),PARTB(5),PARTC(5),PARTD(5)
0004        LOGICAL*1 FNAME(15)
      C
      C     OPEN ALL FILES.
      C
0005        DO 5 I=1,15
0006          FNAME(I)=0
0007      5 CONTINUE
0008        TYPE 10
0009     10 FORMAT('$INPUT FILE  RESULT1.DAT FOR TOTAL SCORE')
      C
      C     THIS IS FIELD A FOR THE SAMPLE BEING TESTED.
      C
0010        ACCEPT 15,FNAME
0011     15 FORMAT(15A1)
0012        OPEN(UNIT=1,NAME=FNAME,TYPE='OLD',ACCESS='SEQUENTIAL',
           1READONLY,FORM='FORMATTED',DISPOSE='SAVE'
0013        DO 20 I=1,15
0014          FNAME(I)=0
0015     20 CONTINUE
0016        TYPE 25
0017     25 FORMAT('$INPUT FILE RESULT2.DAT FOR TOTAL SCORE')
      C
      C     THIS IS FIELD B FOR THE SAMPLE BEING TESTED.
      C
0018        ACCEPT 15,FNAME
0019        OPEN(UNIT=2,NAME=FNAME,TYPE='OLD',ACCESS='SEQUENTIAL',
           2READONLY,FORM='FORMATTED',DISPOSE='SAVE'
0020        DO 30 I=1,15
0021          FNAME(I)=0
0022     30 CONTINUE
0023        TYPE 35
0024     35 FORMAT('$INPUT FILE RESULT3.DAT FOR TOTAL SCORE')
      C
```

```
      C     THIS IS FIELD C FOR THE SAMPLE BEING TESTED.
      C
0025        ACCEPT 15,FNAME
0026        OPEN(UNIT=3,NAME=FNAME,TYPE='OLD',ACCESS='SEQUENTIAL',
           3READONLY,FORM='FORMATTED',DISPOSE='SAVE')
0027        DO 40 I=1,15
0028          FNAME(I)=0
0029     40 CONTINUE
0030        TYPE 45
0031     45 FORMAT('$INPUT FILE RESULT4.DAT FOR TOTAL SCORE')
      C
      C     THIS IS FIELD D FOR THE SAMPLE BEING TESTED.
      C
0032        ACCEPT 15,FNAME
0033        OPEN(UNIT=4,NAME=FNAME,TYPE='OLD',ACCESS='SEQUENTIAL',
           4READONLY,FORM='FORMATTED',DISPOSE='SAVE')
0034        DO 50 I=1,15
0035          FNAME(I)=0
0036     50 CONTINUE
0037        TYPE 55
0038     55 FORMAT('$THE OUTPUT FILE OF TOTAL COUNTS WILL BE?')
      C
      C     THIS FILE WILL BE CALLED UNITE.DAT.
      C
0039        ACCEPT 15,FNAME
0040        OPEN(UNIT=8,NAME=FNAME,TYPE='NEW',ACCESS='SEQUENTIAL',
           5FORM='FORMATTED',DISPOSE='SAVE')
      C
      C     INITIALIZE ALL VARIABLES.
      C
0041        N=0
0042        OST=0
0043        NHV=0
0044        FRA=0
0045        EDG=0
0046        LAML=0.0
0047        READ(1,60,END=65)(PARTA(N+1),N=0,3)
0048     60 FORMAT(4(I4/))
0049        OST=OST+PARTA(1)
0050        NHV=NHV+PARTA(2)
0051        FRA=FRA+PARTA(3)
0052        EDG=EDG+PARTA(4)
0053     65 CONTINUE
0054        READ(1,70,END=72)RPARTA
0055     70 FORMAT(////////28X,F8.3)
0056     72 CONTINUE
0057        LAML=LAML+RPARTA
0058        N=0
0059     75 READ(2,60,END=80)(PARTB(N+1),N=0,3)
0060        OST=OST+PARTB(1)
0061        NHV=NHV+PARTB(2)
0062        FRA=FRA+PARTB(3)
```

```
0063          EDG=EDG+PARTB(4)
0064     80   CONTINUE
0065          READ(2,70,END=82)RPARTB
0066     82   CONTINUE
0067          LAML=LAML+RPARTB
0068          N=0
0069     85   READ(3,60,END=90)(PARTC(N+1),N=0,3)
0070          OST=OST+PARTC(1)
0071          NHV=NHV+PARTC(2)
0072          FRA=FRA+PARTC(3)
0073          EDG=EDG+PARTC(4)
0074     90   CONTINUE
0075          READ(3,70,END=92)RPARTC
0076     92   CONTINUE
0077          LAML=LAML+RPARTC
0078          N=0
0079     95   READ(4,60,END=100)(PARTD(N+1),N=0,3)
0080          OST=OST+PARTD(1)
0081          NHV=NHV+PARTD(2)
0082          FRA=FRA+PARTD(3)
0083          EDG=EDG+PARTD(4)
0084    100   CONTINUE
0085          READ(4,70,END=102)RPARTD
0086    102   CONTINUE
0087          LAML=LAML+RPARTD
0088          COR=EDG/2
0089          OST=OST+COR
0090          LAML=LAML/4.0
0091          WRITE(8,105)OST
0092    105   FORMAT(1X,I6)
0093          WRITE(8,105)NHV
0094          WRITE(8,105)FRA
0095          WRITE(8,110)LAML
0096    110   FORMAT(1X,'PERCENT OF LAMELLAE BONE IS ',F8.3)
      C
      C       CLOSE ALL FILES.
      C
0097          CLOSE(UNIT=1,DISPOSE='SAVE')
0098          CLOSE(UNIT=2,DISPOSE='SAVE')
0099          CLOSE(UNIT=3,DISPOSE='SAVE')
0100          CLOSE(UNIT=4,DISPOSE='SAVE')
0101          CLOSE(UNIT=8,DISPOSE='SAVE')
0102          STOP
0103          END
```

APPENDIX E

```
,HOLMES.LIS=HOLMES.FTN

      C
      C     THIS PROGRAM MAKES ALL ADJUSTMENTS FOR DIFFERENT MICROSCOPES
      C     BY CORRECTING FIELD-SIZE TO KERLEY'S REVISED 1.62MM AFTER
      C     UBELAKER'S RE-ANALYSIS OF KERLEY'S DATA.  ALSO ALL
      C     MEASUREMENTS ARE CORRECTED FOR SCALING  SO THAT THE UNIT
      C     TERMS ARE IN MILIMETERS.  FINALLY, THE CHOICE OF TYPE IS
      C     given so the appropriate regression formula(s) may be chosen
      C     AND THE AGE GIVEN.
      C
      C
      C     LIST OF VARIABLES.
      C
0001        LOGICAL*1 FNAME(15)
0002        REAL PI,CORFA,CORFB,CORFC,FSIZE,PSIZEA
0003        REAL RMICRO,NPOINT,SQUAR1,SQUAR2,AREAA,AREAB,RADB
0004        REAL KDIAM,KRAD,KAREA,OAREA,CVMSF,PERCNT,FPERCT
0005        REAL Y,X,AGE1,AGE2,EDGEN
0006        REAL PKIND(10),FCOUNT(10)
0007        INTEGER JKIND(10),SCORE(10),NUMBER,VALUE,TAB
      C
      C     OPEN ALL FILES.
      C
0008        DO 5 I=1,15
0009          FNAME(I)=0
0010      5 CONTINUE
0011        TYPE 10
0012     10 FORMAT('$INPUT FILE OF STORED RESULTS')
      C
      C     THIS IS THE RESULT.DAT FILE OR UNITE.DAT
      C     UNITE.DAT IS THE TOTAL SCORES FOR 4 FIELDS
      C
0013        ACCEPT 15,FNAME
0014     15 FORMAT(15A1)
0015        OPEN(UNIT=2,NAME=FNAME,TYPE='OLD',ACCESS='SEQUENTIAL',
           1READONLY,FORM='FORMATTED',DISPOSE='SAVE')
0016        DO 20 I=1,15
0017          FNAME(I)=0
0018     20 CONTINUE
0019        TYPE 25
0020     25 FORMAT('$THIS NEW OUTPUT FILE WILL BE CALLED?')
      C
      C     IN HONOR OF A GREAT SLEUTH,THIS FILE WILL BE CALLED HOLMES.DAT.
      C
```

```
0021          ACCEPT 15,FNAME
0022          OPEN(UNIT=3,NAME=FNAME,TYPE='NEW',ACCESS='SEQUENTIAL',
             2FORM='FORMATTED',DISPOSE='SAVE')
      C
      C       INITIALIZE ALL VARIABLES.
      C
0023          PI=3.141592654
0024          FSIZE=0.0
0025          PSIZEA=0.0
0026          X=0.0
      C
      C       THE FIRST STEP IS TO CORRECT FOR SCALING FACTORS AND GET
      C       ALL UNIT TERMS INTO MILIMETERS.
      C
0027          TYPE 30
0028       30 FORMAT('$ENTER IN FIELD-SIZE MM AND PHOTO-SIZE INCHES')
0029          ACCEPT 35,FSIZE,PSIZEA
0030       35 FORMAT(2F8.3)
0031          CORFA=1.0/100.0
0032          CORFB=25.4/1.0
0033          WRITE(3,36)CORFA
0034       36 FORMAT (1X,F5.2)
0035          WRITE(3,36)CORFB
0036          CORFC=FSIZE/(PSIZEA * 25.4)
0037          WRITE(3,37)CORFC
0038       37 FORMAT (1X,F12.10)
0039          RMICRO=FSIZE/2.0
0040          NPOINT=RMICRO/(CORFA*CORFB*CORFC)
0041          WRITE(3,38)NPOINT
0042       38 FORMAT (1X,F11.5)
      C
      C       WE NEED THE TERMS SQUARED(CORFA*CORFB*CORFC*CORFD)AND NPOINTS.
      C
0043          SQUAR1=(CORFA*CORFB*CORFC)**2
0044          WRITE(3,37)SQUAR1
0045          SQUAR2=NPOINT**2
0046          WRITE(3,37)SQUAR2
0047       39 FORMAT (1X,F11.0)
0048          TYPE 40
0049       40 FORMAT('$SELECT THE TYPE OF AREA FIELD BEING USED?')
      C
      C       THIS WILL BE 0=FORMULA A NPOINTS,1= FORMULA B PICTURE DIRECT.
      C        2=CALCULATE BOTH OF THE AREAS.
      C
0050          ACCEPT 45,NUMBER
0051       45 FORMAT(I1)
0052          IF(NUMBER .EQ. 1)GOTO 50
0054            AREAA=PI*SQUAR1*SQUAR2
0055          WRITE(3,47)AREAA
0056       47 FORMAT (1X,F11.9)
0057          IF(NUMBER .EQ. 0)GOTO 35
0059       50 PSIZEA=PSIZEA*(FSIZE/PSIZEA)
0060          RADB=PSIZEA/2.0
```

```
0061          AREAB=PI*RADB**2
0062          WRITE(3,52)AREAB
0063       52 FORMAT(1X,'THE MICROSCOPE FIELD-SIZE IS'F11.9,'MM.')
0064       55 CONTINUE
      C
      C       THE SECOND STEP CORRECTS THE OBSERVERS MICROSCOPE FIELD
      C       SIZE (MEASURED BY STAGE MICROMETER) AND CORRECTS TO
      C       KERLEY'S REVISED DATA AS ESTABLISHED BU UBELAKER'S RE-
      C       EVALUATION OF KERLEY'S STUDY.
      C
0065          KDIAM=1.62
0066          KRAD=1.62/2.0
0067          KAREA=PI*KRAD**2
0068          WRITE(3,47)KAREA
0069          OAREA=AREAA
0070          IF(NUMBER .EQ. 1)OAREA=AREAB
      C
      C       STAGE FIELD CORRECTING VALUE IS CALCULATED BY DIVIDING
      C       OBSERVER'S AREA INTO KERLEY'S AREA AND MULTIPLYING IT
              with osteones, fragments, and non-Halversian canals.
      C       LAMELLAE BONE AND OTHER FEATURES ARE NOT EFFECTED.
      C
      C
      C       CVMSF STANDS FOR CORRECTING VALUE MICROSCOPE STAGE FIELD.
      C
0072          CVMSF=KAREA/OAREA
0073          WRITE(3,47)CVMSF
      C
      C       OBTAIN NECESSARY INFORMATION FROM RESULT.DAT.
      C
0074          TYPE 56
0075       56 FORMAT('$ SELECT WHETHER DOING RESULT.DAT OR UNITE SAMPLE?')
      C
      C       THIS WILL BE 0 FOR RESULT.DAT RUN AND 1 FOR DOING UNITE RUN.
      C
0076          ACCEPT 57,TAB
0077       57 FORMAT(I1)
0078          IF (TAB .EQ. 0)GOTO 60
0080          READ(2,58,END=999)(JKIND(K),K=1,3),PERCNT
0081       58 FORMAT(3(I6,/),28X,F8.3)
0082          TYPE 58,(JKIND(K),K=1,3),PERCNT
0083          DO 59 I=1,3
0084            PKIND(I)=FLOAT(JKIND(I))
0085       59 CONTINUE
0086          WRITE(3,72)PKIND(1)
0087          WRITE(3,72)PKIND(2)
0088          WRITE(3,72)PKIND(3)
0089          DO 61 I=1,3
0090            FCOUNT(I)=PKIND(I)*CVMSF
0091       61 CONTINUE
0092          WRITE(3,72)FCOUNT(1)
0093          WRITE(3,72)FCOUNT(2)
0094          WRITE(3,72)FCOUNT(3)
```

```
0095          GOTO 79
0096       60 READ(2,65,END=999)(JKIND(K),K=1,7),PERCNT
0097       65 FORMAT(7(I6,/),28X,F8.3)
0098          TYPE 65,(JKIND(K),K=1,7),PERCNT
0099          DO 70 I=1,4
0100            PKIND(I)=FLOAT(JKIND(I))
0101       70 CONTINUE
0102          WRITE(3,72)PKIND(1)
0103       72 FORMAT(1X,F6.2)
0104          WRITE(3,72)PKIND(2)
0105          WRITE(3,72)PKIND(3)
0106          WRITE(3,72)PKIND(4)
         C
         C     PKIND(I)CONTAINS CORRECT VALUES OF OSTEONS AND FRAGMENTS
         C     JKIND(5) CONTAINS NUMBER OF REABSORPTION HOLES
         C     JKIND(6) CONTAINS BOUNDARY AREA
         C     JKIND(7) CONTAINS NUMBER OF OTHER FEATURES
         C     PERCNT CONTAINS THE UNEFFECTED LAMELLAE BONE
         C
         C
         C     THE THIRD STEP IS TO MULTIPLY THE VALUES BY 4 SINCE
         C     KERLEY'S REGRESSION FORMULAES ARE BASED ON 4 FIELD
         C     AREAS OF VISION AND WE ARE ONLY USING ONE.
         C
0107          DO 75 I=1,4
0108            FCOUNT(I)=PKIND(I)*4.0
0109       75 CONTINUE
0110          WRITE(3,72)FCOUNT(1)
0111          WRITE(3,72)FCOUNT(2)
0112          WRITE(3,72)FCOUNT(3)
0113          WRITE(3,72)FCOUNT(4)
0114          DO 77, I=1,4
0115            FCOUNT(I)=FCOUNT(I)*CVMSF
0116       77 CONTINUE
0117          WRITE(3,72)FCOUNT(1)
0118          WRITE(3,72)FCOUNT(2)
0119          WRITE(3,72)FCOUNT(3)
0120          WRITE(3,72)FCOUNT(4)
0121          EDGEN=FCOUNT(4)/2.0
0122          WRITE(3,72)EDGEN
0123          FCOUNT(1)=FCOUNT(1)+EDGEN
0124          WRITE(3,72)FCOUNT(1)
0125       79 FPERCT=PERCNT/10.0
0126          WRITE(3,72)FPERCT
         C
         C     NOW IN THE LAST STEP ONE SELECTS THE BONE TYPE AND
         C     REGRESSION  formulas TO BE USED.
         C
0127          TYPE 80
0128       80 FORMAT('$WHICH KIND OF BONE IS BEING USED IN THE SAMPLE?')
0129          ACCEPT 85,VALUE
0130       85 FORMAT(I1)
         C
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      C     THE VALUES REPRESENTED ARE 0=FEMUR,1=TIBIA,2=FIBULA.
      C
0131        IF(VALUE .GT. 0)GOTO 95
0133        TYPE 90
0134     90 FORMAT(1X,'YOUR REGRESSION formulas ARE:1 OSTEONES,
           12 NON-HAVERSIAN,3 FRAGMENTS, AND 4 LAMELLAR')
0135        GOTO 115
0136     95 IF(VALUE .GT. 1)GOTO 105
0138        TYPE 100
0139    100 FORMAT(1X,'YOUR REGRESSION formulas ARE:1 OSTEONES,
           12 NON-HAVERSIAN,3 FRAGMENTS, AND 4 LAMELLAR')
0140        GOTO 150
0141    105 TYPE 110
0142    110 FORMAT(1X,'YOUR REGRESSION formulas ARE:1 OSTEONES,
           12 NON-HAVERSIAN, 3 FRAGMENTS, AND 4 LAMELLAR')
0143        GOTO 175
0144    115 CONTINUE
      C
      C     NOW TO COMPUTE THE AGE FROM THE REGRESSION FORMULA(s)
      C     FOR THE VALUE SELECTED ONE MUST THEN CHOICE THE APPROPRIATE
      C     REGRESSION formulas    INDIVIDUAL SCORE OR IN COMBINATIONS.
      C     SELECT SCORE VALUE(S)1,2,3,4.
      C
0145        TYPE 117
0146    117 FORMAT('$SELECT SCORE VALUE(S)1,2,3,4')
0147        DO 120 I=1,4
0148          SCORE(I)=0
0149    120 CONTINUE
0150        ACCEPT 125, (SCORE(I),I=1,4)
0151        WRITE(3,125)(SCORE(I),I=1,4)
0152    125 FORMAT(1X,4I1)
0153        DO 147 I=1,4
0154        IF(SCORE(I) .NE. 1)GOTO 130
0156          X=FCOUNT(1)
0157        Y=2.378+0.187*X+0.00236*X**2
0158        AGE1=Y+9.19
0159        AGE2=Y-9.19
0160        WRITE(3,135)AGE1
0161        WRITE(3,135)AGE2
0162    135 FORMAT(1X,'OKAY HOLMES M: AGE IS',1X,F8.3)
0163    130 CONTINUE
0164        IF(SCORE(I) .NE. 2)GOTO 140
0166        X=FCOUNT(2)
0167        Y=28.390-3.184*X+0.0628*X**2-0.00036*X**3
0168        AGE1=Y+12.12
0169        AGE2=Y-12.12
0170        WRITE(3,135)AGE1
0171        WRITE(3,135)AGE2
0172    140 CONTINUE
0173        IF(SCORE(I) .NE.3)GOTO 145
0175        X=FCOUNT(3)
0176        Y=5.241+0.509*X+0.017*X**2-0.00015*X**3
0177        AGE1=Y+6.98
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0178         AGE2=Y-6.98
0179         WRITE(3,135)AGE1
0180         WRITE(3,135)AGE2
0181     145 CONTINUE
0182         X=FPERCT
0183         IF(SCORE(I) .NE. 4)GOTO 147
0185          Y=75.017-1.790*X+0.0114*X**2
0186         AGE1=Y+12.52
0187         AGE2=Y-12.52
0188         WRITE(3,135)AGE1
0189         WRITE(3,135)AGE2
0190     147 CONTINUE
0191         GOTO 200
0192     150 CONTINUE
0193         TYPE 117
0194         DO 155 I=1,4
0195           SCORE(I)=0
0196     155 CONTINUE
0197         ACCEPT 125, (SCORE(I),I=1,4)
0198         WRITE(3,125)(SCORE(I),I=1,4)
0199         DO 172 I=1,4
0200         IF(SCORE(I) .NE. 1)GOTO 160
0202         X=FCOUNT(1)
0203         Y=13.4218+0.660*X
0204         AGE1=Y+10.53
0205         AGE2=Y-10.53
0206         WRITE(3,135)AGE1
0207         WRITE(3,135)AGE2
0208     160 CONTINUE
0209         IF(SCORE(I) .NE. 2)GOTO 165
0211         X=FCOUNT(2)
0212         Y=67.872-9.070*X+0.440*X**2-0.0062*X**3
0213         AGE1=Y+10.19
0214         AGE2=Y-10.19
0215         WRITE(3,135)AGE1
0216         WRITE(3,135)AGE2
0217     165 CONTINUE
0218         IF(SCORE(I) .NE. 3)GOTO 170
0220         X=FCOUNT(3)
0221         Y=-26.977+2.301*X-0.014*X**2
0222         AGE1=Y+8.42
0223         AGE2=Y-8.42
0224         WRITE(3,135)AGE1
0225         WRITE(3,135)AGE2
0226     170 CONTINUE
0227         X=FPERCT
0228         IF(SCORE(I) .NE. 4)GOTO 172
0230         Y=80.934-2.281*X+0.019*X**2
0231         AGE1=Y+14.28
0232         AGE2=Y-14.28
0233         WRITE(3,135)AGE1
0234         WRITE(3,135)AGE2
0235     172 CONTINUE
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0236        GOTO 200
0237    175 CONTINUE
0238        TYPE 117
0239        DO 180 I=1,4
0240          SCORE(I)=0
0241    180     CONTINUE
0242        ACCEPT 125, (SCORE(I),I=1,4)
0243        WRITE(3,125)(SCORE(I),I=1,4)
0244        DO 197 I=1,4
0245        IF(SCORE(I) .NE. 1)GOTO 185
0247        X=FCOUNT(1)
0248        Y=-23.59+0.74511*X
0249        AGE1=Y+8.33
0250        AGE2=Y-8.33
0251        WRITE(3,135)AGE1
0252        WRITE(3,135)AGE2
0253    185 CONTINUE
0254        IF(SCORE(I) .NE. 2)GOTO 190
0256        X=FCOUNT(2)
0257        Y=62.33-9.776*X+0.5502*X**2-0.00704*X**3
0258        AGE1=Y+14.62
0259        AGE2=Y-14.62
0260        WRITE(3,135)AGE1
0261        WRITE(3,135)AGE2
0262    190 CONTINUE
0263        IF(SCORE(I) .NE. 3)GOTO 195
0265        X=FCOUNT(3)
0266        Y=-9.89+1.064*X
0267        AGE1=Y+3.66
0268        AGE2=Y-3.66
0269        WRITE(3,135)AGE1
0270        WRITE(3,135)AGE2
0271    195 CONTINUE
0272        X=FPERCT
0273        IF(SCORE(I) .NE.4)GOTO 197
0275        Y=124.09-10.92*X+0.3723*X**2-0.00412*X**3
0276        AGE1=Y+10.74
0277        AGE2=Y-10.74
0278        WRITE(3,135)AGE1
0279        WRITE(3,135)AGE2
0280    197 CONTINUE
0281        GOTO 200
0282    200 CONTINUE
        C .
        C     CLOSE ALL FILES.
        C
0283        CLOSE(UNIT=2,DISPOSE='SAVE')
0284        CLOSE(UNIT=3,DISPOSE='SAVE')
0285    999 STOP
0286        END
```

VITA

Gale David Slutzky was born in Omaha, Nebraska on March 13, 1952. He attended elementary schools in Cheyenne, Wyoming, and was graduated from Cheyenne Central High in May 1970. The following September he entered Colorado State University but transferred to the University of Wyoming. He took several years off from his studies and returned to the University of Wyoming in August 1973, and in May 1976 he received a Bachelor of Arts degree in Anthropology. In the fall of 1976 he started graduate school at The University of Tennessee, Knoxville and began study toward a Master's degree. This degree was awarded in March 1981.

Gale is a member of the American Association of Physical Anthropologists, Tennessee Anthropological Association and the American Academy of Forensic Sciences. He has worked for the Image Pattern and Analysis Laboratory in the Department of Electrical Engineering at The University of Tennessee, Knoxville while obtaining his Master's degree.

He is married to the former Toni McDonald of Cheyenne, Wyoming, and they have one daughter, Ilana Rae.