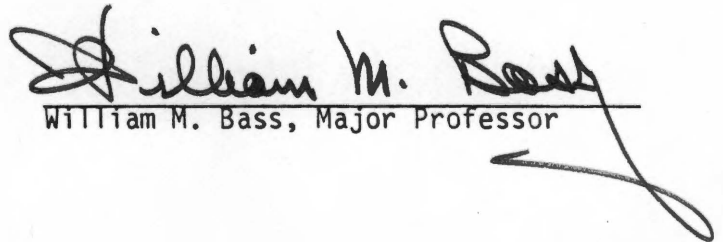
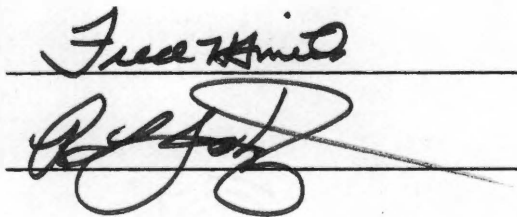


To the Graduate Council:

I am submitting herewith a thesis written by Gale O. Slutzky entitled "Age Determination at Death from Osteon Counting by Means of Interactive Computer Graphics." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master Arts, with a major in Anthropology.

  
William M. Bass, Major Professor

We have read this thesis  
and recommend its acceptance:



Accepted for the Council:

\_\_\_\_\_  
Vice Chancellor  
Graduate Studies and Research

24p  
(599)

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.

Sincere appreciation is extended to Dr. Douglas H. Ubelaker and his staff at the Smithsonian Institution in Washington, D. C. who taught me the basics of osteon counting and allowed me the use of their equipment during my visits.

I would like to thank Dr. Ellis R. Kerley of the University of Maryland who made his specimen slides available for me.

The author is indebted to Dr. David M. Lipscomb of the Department of Speech and Hearing who made his microscope available for my use and gave assistance in photographic techniques.

My most sincere appreciation goes to Dr. Ernest L. Hall and his staff in the Image Pattern and Analysis Laboratory. He made the laboratory's computer facilities accessible to me and gave excellent consultation concerning the area of computer graphics.

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.

## TABLE OF CONTENTS

| CHAPTER                               | PAGE |
|---------------------------------------|------|
| I. INTRODUCTION . . . . .             | 1    |
| II. LITERATURE REVIEW. . . . .        | 4    |
| III. METHODS AND PROCEDURES . . . . . | 12   |
| Computer Methodology . . . . .        | 17   |
| IV. RESULTS. . . . .                  | 28   |
| Individual Field Data. . . . .        | 33   |
| Statistical Results. . . . .          | 36   |
| V. DISCUSSION . . . . .               | 49   |
| VI. CONCLUSIONS. . . . .              | 54   |
| REFERENCES CITED. . . . .             | 57   |
| APPENDICES. . . . .                   | 60   |
| APPENDIX A . . . . .                  | 61   |
| APPENDIX B . . . . .                  | 76   |
| APPENDIX C . . . . .                  | 80   |
| APPENDIX D . . . . .                  | 83   |
| APPENDIX E . . . . .                  | 86   |
| VITA. . . . .                         | 93   |

## LIST OF TABLES

| TABLE                                                                                     | PAGE |
|-------------------------------------------------------------------------------------------|------|
| 1. Composition of the Sample. . . . .                                                     | 13   |
| 2. Raw Data of Actual Age and Computed Age. . . . .                                       | 29   |
| 3. Raw Data of Features Versus Actual Age . . . . .                                       | 32   |
| 4. Individual Field Data Showing Range and Mean Values as<br>Opposed to Real Age. . . . . | 34   |
| 5. t test Data for Four Fields Total. . . . .                                             | 37   |
| 6. t test Data for Field A (anterior) . . . . .                                           | 38   |
| 7. t test Data for Field B (posterior). . . . .                                           | 39   |
| 8. t test Data for Field C (medial) . . . . .                                             | 40   |
| 9. t test Data for Field D (lateral). . . . .                                             | 41   |
| 10. t test Data for Four Field Osteones. . . . .                                          | 43   |
| 11. t test Data for Four Field Non-Haversian Canals. . . . .                              | 44   |
| 12. t test Data for Four Field Fragments . . . . .                                        | 45   |
| 13. t test Data for Four Field Percent Lamellar Bone . . . . .                            | 46   |
| 14. Regression Formula Data. . . . .                                                      | 50   |
| 15. t test for New Percent Lamellar Bone . . . . .                                        | 52   |

## LIST OF FIGURES

| FIGURE                                                            | PAGE |
|-------------------------------------------------------------------|------|
| 1. The Features of Osteon Counting. . . . .                       | 5    |
| 2. A Cross-Section of Bone with the Four Fields of Vision . . . . | 8    |
| 3. Specimen Preparation . . . . .                                 | 14   |
| 4. Mosaic of a Typical Field (Reduced 50%). . . . .               | 16   |
| 5. The Control Menu of TENTAB.FOR . . . . .                       | 18   |
| 6. A Typical Digitized Field (Reduced 25%). . . . .               | 20   |
| 7. The Centroid Plots of Figure 6 . . . . .                       | 22   |
| 8. Typical Output of a RESULT.DAT File. . . . .                   | 24   |
| 9. A Hardcopy of a Typical HOLMES.DAT File. . . . .               | 27   |

## CHAPTER I

### INTRODUCTION

Physical anthropologists, forensic anthropologists 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.

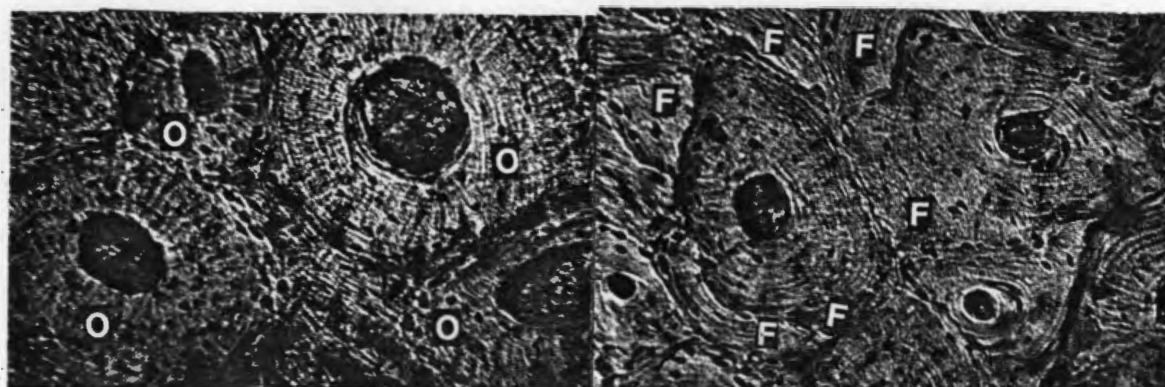
## CHAPTER II

### 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:

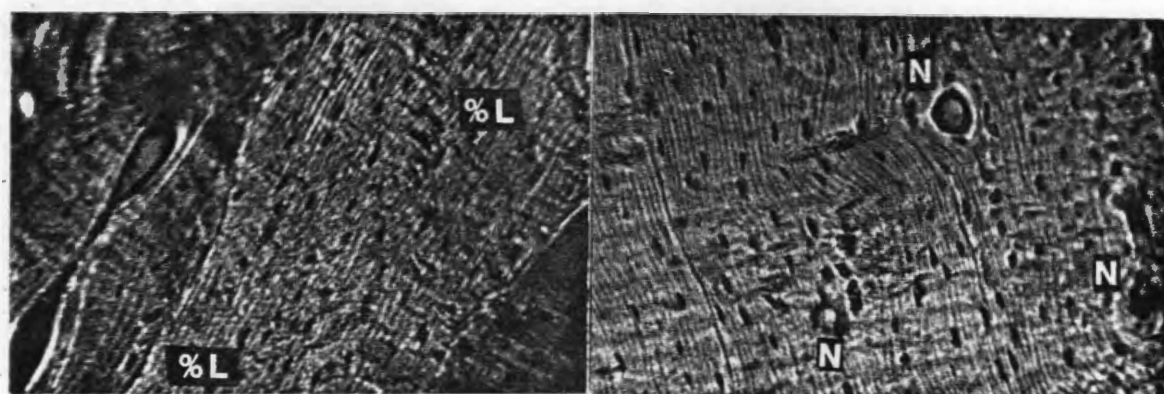
(1) Osteones - An Osteon or Haversian system (Fig. 1-a) is recognized in cross-section as a vascular canal surrounded by concentric lamellae, which contain rather evenly spaced osteocytes in their lacunae. Around the entire periphery of the osteon there is a reversal line that marks the area where osteoclastic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

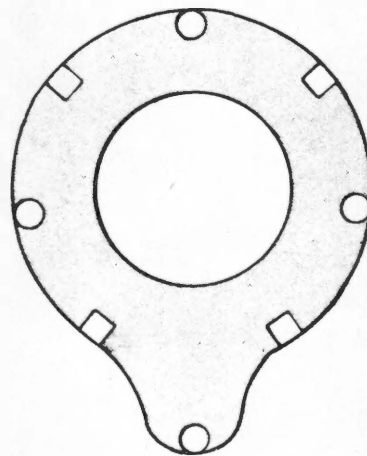
(3) Circumferential lamellar bone - Circumferential lamellar bone (Fig. 1-c) is composed of evenly spaced bands, or lamellae, that run parallel to each other around the outer part of the cortex. It appears as birefringent sheets in polarized light and can be distinguished by its long, parallel fibers.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



○ Kerley

□ Ahlqvist and Damsten

**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 technique, 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. At 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 hole 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

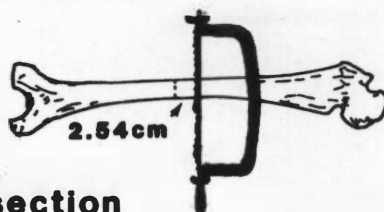
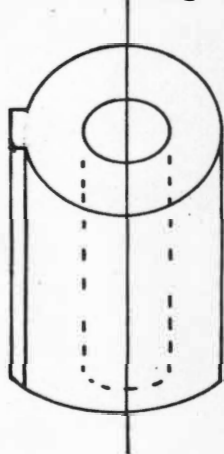
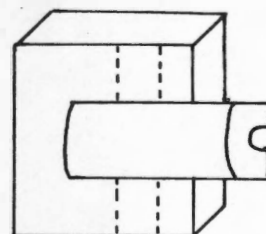
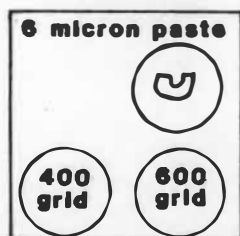
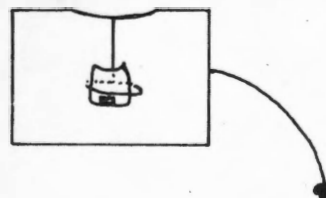
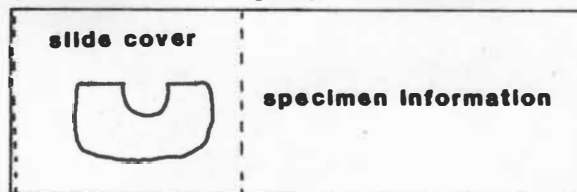
Material in this study consists of four slides loaned to me by Ellis R. Kerley and seven Forensic Anthropology cases from the Anthropology Department at The University of Tennessee, Knoxville. The sample contains five females and six males with ages ranging from 17 to 83 years. Two of The University 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

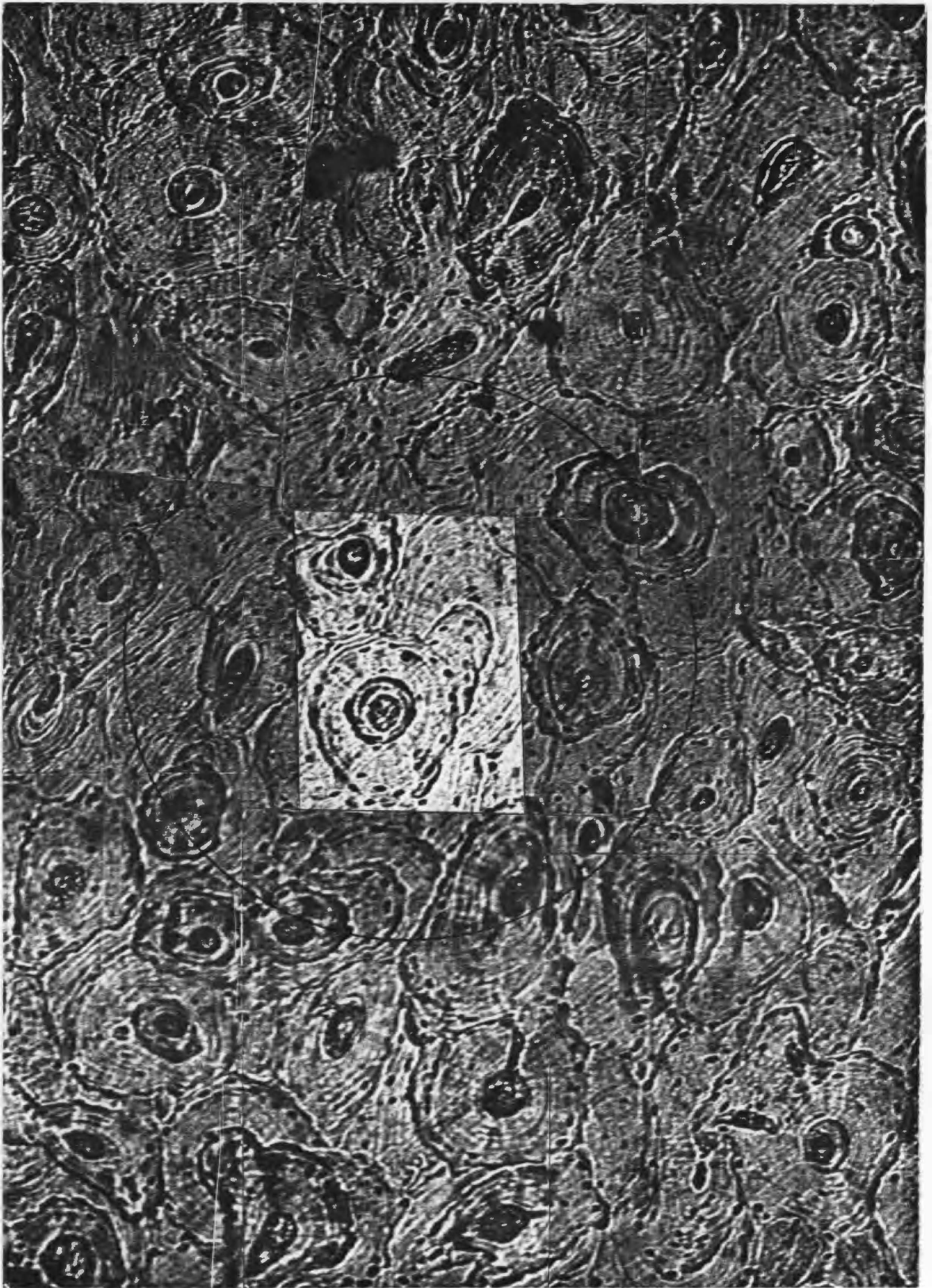


**Figure 4. Mosaic of a typical field (reduced 50%).**

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

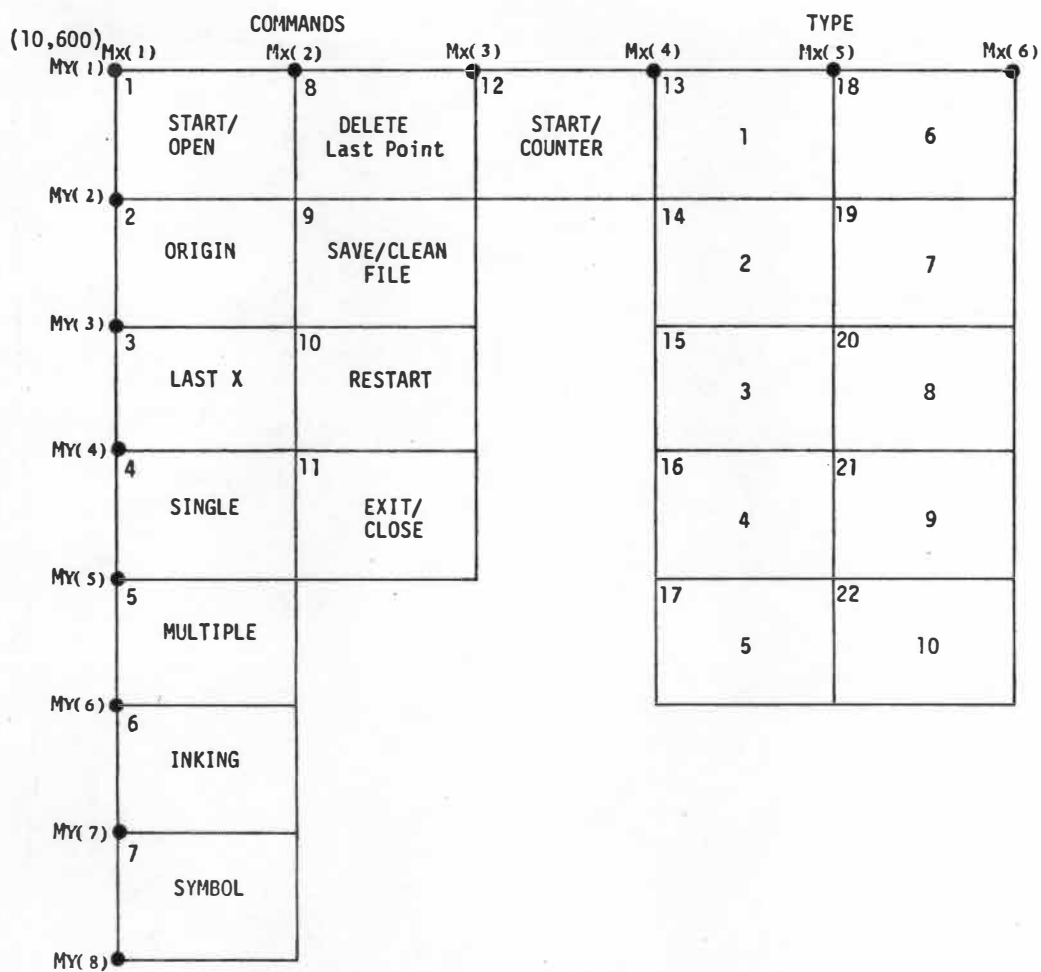


**Figure 5. The control menu of TENTAB.FOR.**

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.

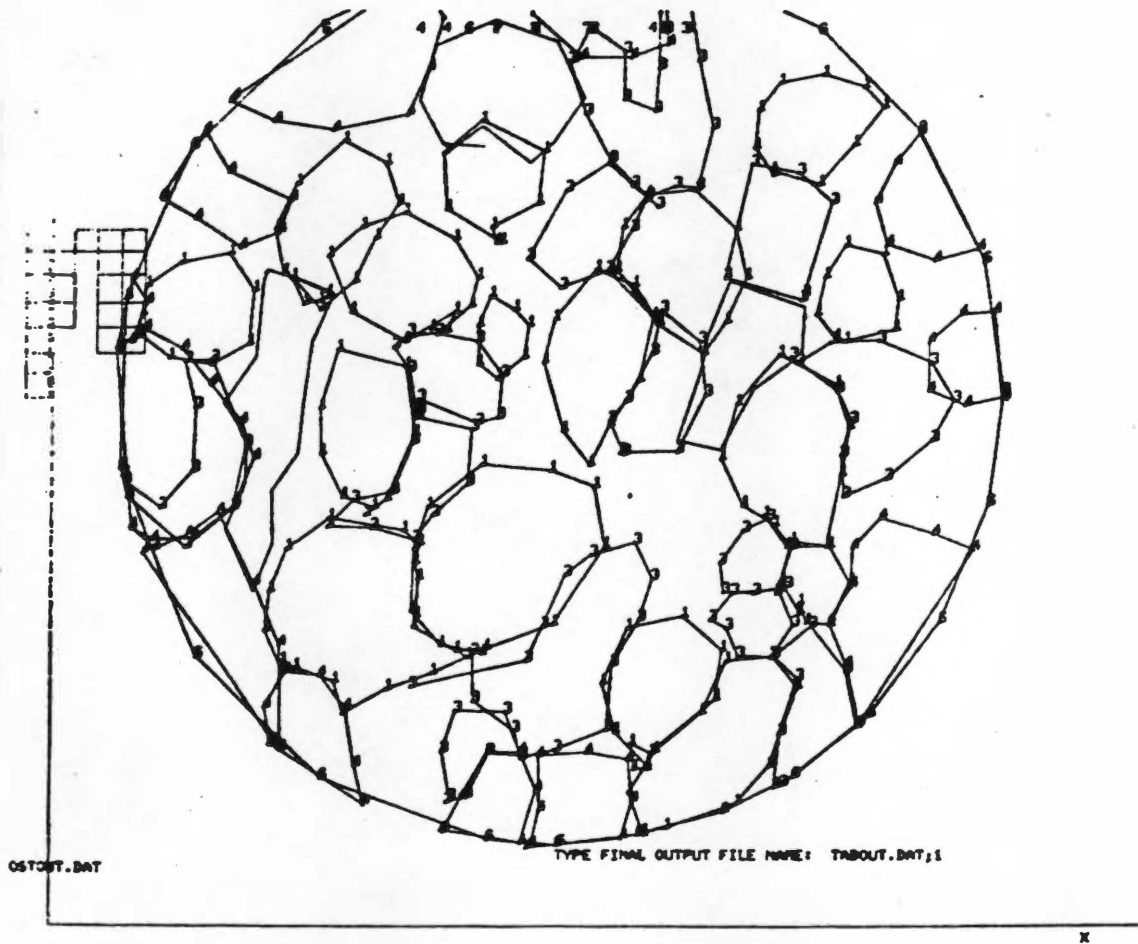


**Figure 6. A typical digitized field (reduced 25%).**

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 (OSTQUT.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.

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

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

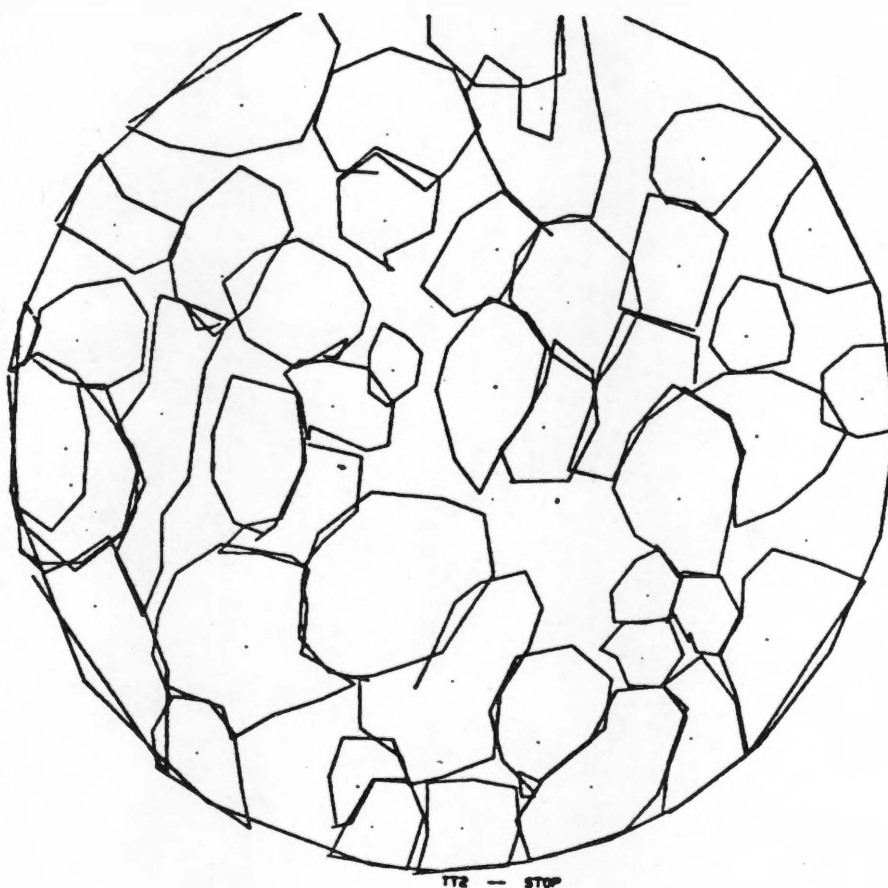


**Figure 7. The centroid plots of Figure 6.**

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.

$r = .74\text{mm}$ , this is one-half of 1.48mm field size

$R = 3.725 \text{ in} = 3.725 \times 25.4 = 94.62\text{mm}$  photo to millimeters

```

9-30 INTERP
*** - FILE FOR OSTEON COUNTING SOFTWARE.DAT
*** - FILE FOR LABELLING PERCENTAGE SIZE.DAT
**** - FILE FOR RESULT TYPE.DAT
RV COUNT AND TYPE NUMBER IS 1
RV COUNT AND TYPE NUMBER IS 2
RV COUNT AND TYPE NUMBER IS 3
RV COUNT AND TYPE NUMBER IS 4
RV COUNT AND TYPE NUMBER IS 5
RV COUNT AND TYPE NUMBER IS 6
RV COUNT AND TYPE NUMBER IS 7
RV COUNT AND TYPE NUMBER IS 8
RV COUNT AND TYPE NUMBER IS 9
RV COUNT AND TYPE NUMBER IS 10
RV COUNT AND TYPE NUMBER IS 11
RV COUNT AND TYPE NUMBER IS 12
RV COUNT AND TYPE NUMBER IS 13
RV COUNT AND TYPE NUMBER IS 14
RV COUNT AND TYPE NUMBER IS 15
RV COUNT AND TYPE NUMBER IS 16
RV COUNT AND TYPE NUMBER IS 17
RV COUNT AND TYPE NUMBER IS 18
RV COUNT AND TYPE NUMBER IS 19
RV COUNT AND TYPE NUMBER IS 20
RV COUNT AND TYPE NUMBER IS 21
RV COUNT AND TYPE NUMBER IS 22
RV COUNT AND TYPE NUMBER IS 23
RV COUNT AND TYPE NUMBER IS 24
RV COUNT AND TYPE NUMBER IS 25
RV COUNT AND TYPE NUMBER IS 26
RV COUNT AND TYPE NUMBER IS 27
RV COUNT AND TYPE NUMBER IS 28
RV COUNT AND TYPE NUMBER IS 29
RV COUNT AND TYPE NUMBER IS 30
RV COUNT AND TYPE NUMBER IS 31
RV COUNT AND TYPE NUMBER IS 32
RV COUNT AND TYPE NUMBER IS 33
RV COUNT AND TYPE NUMBER IS 34
RV COUNT AND TYPE NUMBER IS 35
RV COUNT AND TYPE NUMBER IS 36
RV COUNT AND TYPE NUMBER IS 37
RV COUNT AND TYPE NUMBER IS 38
RV COUNT AND TYPE NUMBER IS 39
RV COUNT AND TYPE NUMBER IS 40
RV COUNT AND TYPE NUMBER IS 41
RV COUNT AND TYPE NUMBER IS 42
RV COUNT AND TYPE NUMBER IS 43
RV COUNT AND TYPE NUMBER IS 44
RV COUNT AND TYPE NUMBER IS 45
RV COUNT AND TYPE NUMBER IS 46
RV COUNT AND TYPE NUMBER IS 47
RV COUNT AND TYPE NUMBER IS 48
RV COUNT AND TYPE NUMBER IS 49
RV COUNT AND TYPE NUMBER IS 50
PERCENT OF LAMELLAE DONE IS 14.000
TYPE -- STOP
>TYPE RESULT.DAT

```

**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.

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

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

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

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

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  $f$  measured in tablet units must first be converted to millimeters to be equal to  $R$ .

$$3.725 \times 100 \text{ is the radius in tablet numbers} = 372.5$$

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

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

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-HAVERSIA 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.

[illegible]

**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 case 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 |           | Osteones |           | Non-Haversian |           | Fragments |           | % Lamellar |           |
|-------------|-----|------------|-----------------------|-----------|----------|-----------|---------------|-----------|-----------|-----------|------------|-----------|
|             |     |            | Range                 | $\bar{x}$ | Range    | $\bar{x}$ | Range         | $\bar{x}$ | Range     | $\bar{x}$ | 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 |           | Non-Haversian |           | Fragments |           | % Lamellar |           |
|-------------|------------|---------|----------|-----------|---------------|-----------|-----------|-----------|------------|-----------|
|             |            |         | Range    | $\bar{x}$ | Range         | $\bar{x}$ | Range     | $\bar{x}$ | Range      | $\bar{x}$ |
| 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 |           | Non-Haversian |           | Fragments |           | % Lamellar |           |
|-------------|------------|---------|---------|-----------|---------------|-----------|-----------|-----------|------------|-----------|
|             |            |         | Range   | $\bar{x}$ | Range         | $\bar{x}$ | Range     | $\bar{x}$ | Range      | $\bar{x}$ |
| 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).

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

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

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

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

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) requires 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 <sup>2</sup> |
|-----------------------------------------------------|------------|---------------------------|-------|----------------|
| 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 <sup>2</sup> |
|------------------------------------|------------|---------------------------|-------|----------------|
| 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 <sup>2</sup> |
|------------------------------------|------------|---------------------------|-------|----------------|
| 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 <sup>2</sup> |
|------------------------------------|------------|---------------------------|-------|----------------|
| 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 <sup>2</sup> |
|---------------------------------------------------------------------|------------|---------------------------|-------|----------------|
| 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 <sup>2</sup> |
|------------------------------------|------------|-------------------|-------|----------------|
| 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 <sup>2</sup> |
|---------------------------------------------------------------------|------------|-------------------|-------|----------------|
| 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 <sup>2</sup> |
|---------------------------------------------------------------------|------------|-------------------|--------|----------------|
| 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 <sup>2</sup> |
|---------------------------------------------------------------------|------------|-------------------|--------|----------------|
| 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.

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

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(%)<br>Lamellar            | y<br>Age | x <sup>2</sup>                 | y <sup>2</sup> | xy      | Deviation from mean |                          | Squares        |                    | Products<br>(xy) |      |
|-----------------------------|----------|--------------------------------|----------------|---------|---------------------|--------------------------|----------------|--------------------|------------------|------|
|                             |          |                                |                |         | x                   | y                        | x <sup>2</sup> | y <sup>2</sup>     |                  |      |
| 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                      |          | Sx = 1847.837                  |                |         |                     | DF                       |                | SS                 | MS               | F    |
| Σx = 374.11                 |          | Sy = 5359.406                  |                |         |                     | Regression 1             |                | 3641.132           | 3641.132         | 19.0 |
| $\bar{x}$ = 34.082          |          | Sxy = -2593.881                |                |         |                     | Residual 9               |                | 1718.274           | 190.919          |      |
| Σy = 518                    |          | Σxy = 15,060.6                 |                |         |                     | Total 10                 |                | 5359.406           |                  |      |
| $y = 47.091$                |          | Corr. = -.82                   |                |         |                     | Degrees of freedom 1 & 9 |                | P = < 0.05 (5.12)  |                  |      |
| Σx <sup>2</sup> = 14,625.11 |          | Slope = -1.40                  |                |         |                     |                          |                | P = < 0.01 (10.56) |                  |      |
| Σy <sup>2</sup> = 29,752.5  |          | Intcp. = 94.88                 |                |         |                     |                          |                |                    |                  |      |
| S.D. of y = 23.15           |          | [y = -140 (x) + 92.38 + 13.82] |                |         |                     |                          |                |                    |                  |      |
| S.D. of x = 13.61           |          | S.E. of estimation = ± 13.817  |                |         |                     |                          |                |                    |                  |      |

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 <sup>2</sup> |
|---------------------------------------------------------------------|------------|-------------------|-------|----------------|
| 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 estimates 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  $d_{max}$  and individual area information. By doing an analysis on them,  $d_{max}$  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  $d_{max}$  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.

## REFERENCES CITED

## REFERENCES CITED

- Ahlqvist, J. and O. Damsten  
1969 A Modification of Kerley's Method for the Microscopic Determination of Age in Human Bone. *Journal of Forensic Sciences* 14:205-212.
- Baily, N. T.  
1968 *Statistical Methods in Biology*. London: The English Universities Press Ltd.
- Bouvier, M. and D. H. Ubelaker  
1977 A Comparison of Two Methods for the Microscopic Determination of Age at Death. *American Journal of Physical Anthropology* 46:391-395.
- Casey, M. E.  
1977 Automated Particle Counting with Applications to Neurology. Unpublished manuscript on File in Department of Electrical Engineering, The University of Tennessee, Knoxville.
- Chasen, S. H.  
1978 *Geometric Principles and Procedures for Computer Graphic Applications*. New Jersey: Prentice-Hall, Inc.
- Kerley, E. R.  
1963 The Microscopic Determination of Age in Human Bone. University of Michigan Doctoral Dissertation, University Microfilms Ann Arbor. No. 62-3247. Abstracted in: *American Journal of Physical Anthropology* 21:404.  
  
1965 The Microscopic Determination of Age in Human Bone. *American Journal of Physical Anthropology* 23:149-164.
- Kerley, E. R. and D. H. Ubelaker  
1978 Revisions in the Microscopic Method of Estimating Age at Death in Human Cortical Bone. *American Journal of Physical Anthropology* 49:545-546.
- Krogman, W. M.  
1962 *The Human Skeleton in Forensic Medicine*. Springfield: Charles C. Thomas.
- McKern, T. W. and T. D. Stewart  
1957 Skeletal Age Changes in Young American Males Analyzed from the Standpoint of Identification, Report EP45. Natick: Headquarters of the Quartermaster Research and Development Command.
- Ortner, D.  
1970 The Effects of Aging and Disease on the Micromorphology of Human Compact Bone. Doctoral Dissertation, Department of Anthropology, The University of Kansas, Lawrence.

Ortner, D.

1975 Age Effects on Osteon Remodeling. *Calcified Tissue Research* 18:27-36.

1976 Microscopic and Molecular Biology of Human Compact Bone: An Anthropological Perspective. *Yearbook of Physical Anthropology* 20:35-44.

Singh, I. J. and D. L. Gunberg

1970 Estimation of Age at Death in Human Males from Quantitative Histology of Bone Fragments. *American Journal of Physical Anthropology* 33:373-381.

Stewart, T. D.

1979 *Essentials of Forensic Anthropology*. Springfield: Charles C. Thomas.

Thompson, D. D.

1979 The Core Technique in the Determination of Age at Death in Skeletons. Paper presented to the 31st Annual Meeting of the Academy of Forensic Sciences, Atlanta, Georgia, February.

Ubelaker, D. H.

1974 Reconstruction of Demographic Profile from Ossuary Skeletal Samples: A Case Study from the Tidewater Potomac. *Smithsonian Contributions to Anthropology* No. 18, Washington.

1977 Problems in the Microscopic Determination of Age at Death. *American Academy of Forensic Science, Book of Abstracts* (Annual Meeting, San Diego, California), No. 128, February.

1978 *Human Skeletal Remains: Excavation, Analysis, Interpretation*. Aldine Manuals on Archaeology. Chicago: Aldine Publishing Company.

## 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/SWCH/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
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
      C
      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
      C
      C
0094      SELECT X AXIS POINT
      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(ISTNG.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      DRAW THE X-Y AXIS
0204      CALL MOVABS(IX0,IY0)
      C      DRAW THE Y AXIS
0205      CALL DRWABS(IX0,700)
0206      CALL MOVABS(IX0-20,700)
0207      CALL ANSTR(1,LBL1)
      C
      C      DRAW THE X AXIS
      C
0208      CALL MOVABS(IX0,IY0)
0209      CALL DRWREL(IXZ1-IX0,0)
0210      CALL MOVABS(900,IXZ2-20)
0211      CALL ANSTR(1,LBL2)
      C
      C      PICK DATA ENTRY METHOD
      C
0212      IDPT=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(6),MY(8)
0004      COMMON /FNAME/FNAME
0005      COMMON/SWTC/ICOUNT,IDEL,IRES,ISAVE,IEXIT
1      ,ISTART,IORG,IXAXIS,ISING,MLF,INK,ISYB
2      , I1,I2,I3,I4,I5,I6,I7,I8,I9,I10,NUW,NUW2
0006      COMMON/GEN/IXS,IYS,IX0,IY0,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 100 I2=1
0037 ITYPE=2
0038 ISW=14
C TYPE 2
0039 RETURN
0040 300 IF(I1.GT.MY(4)) GO TO 500
0042 IF(IY.GT.MY(5)) GO TO 600
C TYPE 3
0044 ITYPE=3
0045 IS=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/SWTC/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  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)ICDUNT,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/SWCH/ICOUNT,IDEL,IRES,ISAVE,IEXIT
1 ,START=IDRG,IXAXIS,ISING,MLI,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-IX0
0037      IY=IY-IY0
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/SWCH/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,IXU,IYU,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/SWITCH/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/I TYPE
0007      COMMON/LITE/IRARRAY(0)
0008      CALL GUSTAT(IRARRAY)
0009      CALL BELL
0010      CALL BELL
0011      CALL BELL
0012      CALL ANMODE
0013      NUW3=NUW2+1
0014      IPT=0
0015      IYPE=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
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('$INPUT FILE?')
0013          ACCEPT 15, FNAME
0014      15 FORMAT (13A1)
0015          OPEN(UNIT=2,NAME=FNAME,TYPE='OLD',ACCESS='SEQUENTIAL',
0016              IREADONLY,FORM='FORMATTED',DISPOSE='SAVE')
0017          DO 20 J=1,15
0018              FNAME(J)=0
0019      20 CONTINUE
0019          TYPE 25
0020      25 FORMAT('$OUTPUT FILE1?')
0021          ACCEPT 15, FNAME
0022          OPEN(UNIT=3, NAME=FNAME,TYPE='NEW',ACCESS='SEQUENTIAL',
0023              2FORM='FORMATTED',DISPOSE='SAVE')
0023          DO 30 K=1,15
0024              FNAME(K)=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',
0030              3FORM='FORMATTED',DISPOSE='SAVE')

```

```

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 ISTEON
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      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 OSTEDN 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 JNMODE  
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',
0013       1 READONLY,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.
C
0018   ACCEPT 15,FNAME
0019   OPEN (UNIT=3, NAME=FNAME, TYPE='OLD', ACCESS='SEQUENTIAL',
0020       2 READONLY, FORM='FORMATTED', DISPOSE='SAVE')
0020   DO 30 I=1,15
0021       FNAME(I)=0
0022   30  CONTINUE
0023       TYPE 35

```

```

0024      33  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=50+IKIND(R)+JKIND(R)
0055      33  FORMAT('MY COUNT AND TYPE NUMBER IS',1X,2I6,12X)
0056      ICHANG=ICHANG+1
0057      N=
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(1X, '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('$INPUT FILE  RESULT1.DAT FOR TOTAL SCORE')
C
C   THIS IS FIELD A FOR THE SAMPLE BEING TESTED.
C
0010   ACCEPT 15,FNAME
0011   15  FORMAT(15A1)
0012   OPEN(UNIT=1,NAME=FNAME,TYPE='OLD',ACCESS='SEQUENTIAL',
0013       1READONLY,FORM='FORMATTED',DISPOSE='SAVE')
0013   DO 20 I=1,15
0014       FNAME(I)=0
0015   20  CONTINUE
0016       TYPE 25
0017   25  FORMAT('$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',
0020       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=5,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(I4,1))
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(2,80,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('$INPUT FILE OF STORED RESULTS')
C
C   THIS IS THE RESULT.DAT FILE OR UNITE.DAT.
C   UNITE.DAT IS THE TOTAL SCORES FOR 4 FIELDS.
C
0013   ACCEPT 15,FNAME
0014   15 FORMAT(15A1)
0015   OPEN(UNIT=2,NAME=FNAME,TYPE='OLD',ACCESS='SEQUENTIAL',
        IREADONLY,FORM='FORMATTED',DISPOSE='SAVE')
0016   DO 20 I=1,15
0017       FNAME(I)=0
0018   20 CONTINUE
0019       TYPE 25
0020   25 FORMAT('$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 MILLIMETERS.
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
0053      AREAA=PI*SQUAR1*SQUAR2
0054      WRITE(3,47)AREAA
0055      47 FORMAT (1X,F11.9)
0056      IF(NUMBER.EQ. 0)GOTO 35
0057      50 PSIZEA=PSIZEA*(FSIZE/PSIZEA)
0058      RADB=PSIZEA/2.0
0060

```

```

0061      AREAB=PI*RADB**2
0062      WRITE(3,52)AREAB
0063      52 FORMAT(1X,'THE MICROSCOPE FIELD-SIZE IS',F11.9,'MM.')
```

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

C **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('4 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 50
0080      READ(2,58,END=999)(JKIND(K),K=1,3),PERCENT
0081      58 FORMAT(3(I6,/),28X,F8.3)
0082      TYPE 58,(JKIND(K),K=1,3),PERCENT
0083      DO 39 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 FORMULAE 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

```

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
0155          X=FCOUNT(1)
0156          Y=2.278+0.187*X+0.00235*X**2
0157          AGE1=Y+9.17
0158          AGE2=Y-9.19
0159          WRITE(3,135)AGE1
0160          WRITE(3,135)AGE2
0161
0162      135 FORMAT(1X,'OKAY HOLMES M: AGE IS',1X,F8.3)
0163      130 CONTINUE
0164      IF(SCORE(I) .NE. 2)GOTO 140
0165      X=FCOUNT(2)
0166      Y=8.390-3.184*X+0.0628*X**2-0.00036*X**3
0167      AGE1=Y+12.12
0168      AGE2=Y-12.12
0169      WRITE(3,135)AGE1
0170      WRITE(3,135)AGE2
0171
0172      140 CONTINUE
0173      IF(SCORE(I) .NE. 3)GOTO 145
0174      X=FCOUNT(3)
0175      Y=5.241+0.509*X+0.017*X**2-0.00015*X**3
0176      AGE1=Y+6.98
0177

```

```

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+2.501*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

```

```

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=PPERCT
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.